Feasibility Analysis of Recycling Radioactive Scrap Steel

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Under U.S. Department of Energy
Contract DE-AC22-88ID12735

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Recycling Radioactive
Scrap Steel***

Prepared for

**U.S. Department of Energy
Western Environmental Technology Office
Under Contract DE-AC22-881D12735**

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PREFACE

MSE intended that this report, *Feasibility Analysis of Recycling Radioactive Scrap Steel*, reflect a "common sense" approach to radioactive scrap steel (RSS) recycling. Although recycling is widely viewed as the responsible thing to do, MSE believed that it was unrealistic to expect taxpayer or ratepayer support for recycling if costs prove exorbitant. Therefore, cost containment was a high priority throughout the feasibility analysis work effort.

Since burial is the predominant low-cost means of RSS disposal, common sense implied that a successful recycling concept would need to be cost-competitive with burial. Additionally, the project team understood that worker safety, the environment, and sound technical judgement were paramount issues that could not be compromised for any reason, economic or otherwise.

Early in the program it became apparent that economies of scale and proven commercial technologies held the keys to an affordable solution. To provide adequate volume, and thus enhance the facility's commercial viability, MSE selected a design-basis production level that was compatible with perceived recycling needs of the western United States. As the project progressed, a preliminary conceptual design emerged that could economically achieve the required 30,000 tons per year output on a day shift only basis. Thus, the proposed facility could potentially serve nation-wide needs by simply increasing the number of operating shifts.

The report shows how the cost of converting scrap into useable product can compare very favorably with costs of disposal by burial. Additionally, if ways can be found to more fully utilize the proposed facility, recycling costs can be further reduced. This suggests two possible initiatives that could enhance recycling economics: 1) promote recycling of all domestic low-level contaminated steel that will be salvaged in the demolition of government and commercial nuclear facilities; and 2) promote the concept of a commercially operated central recycling facility that is co-funded by both industry and government.

Plant capital costs associated with the production of sheet and plate are estimated at \$140 million. Potentially, capital costs could be reduced to \$50 million if steel slab is the only product. A variety of intermediate product possibilities exist within these two extremes. *It should be noted that these estimates represent "worst case" costs; product mix and design refinements are expected to further reduce capital costs.*

After the initial publication of this report, MSE began tests to determine the decontamination efficiencies of methods proposed herein. These preliminary tests indicate that melt/decontamination alone can potentially remove radionuclide contaminants to levels below the standards proposed for international free-release. It is likely that these preliminary test results will apply to a high percentage of RSS material. Thus, if reasonable free-release standards are established in the United States, melt/decontamination could largely eliminate the need for expensive surface decontamination.

In summary, the *Feasibility Analysis of Recycling Radioactive Scrap Steel* shows how "smart recycling" can potentially offer a profitable, cost-effective alternative to burial and/or surface decontamination.

Executive Summary

This work was sponsored by the U.S. Department of Energy (DOE) Office of Technology Development and the Decommissioning and Decontamination focus area to investigate the feasibility of recycling low-level radioactive scrap metal (RSM) in a regional Radioactive Scrap Steel (RSS) mill located in the western United States.

The purpose of this study is:

1. establish a conceptual design that integrates commercial steel mill technology with RSM scrap processing to produce carbon and stainless steel sheet and plate at a grade suitable for fabricating into radioactive waste containers;
2. determine the economic feasibility of building a 'micro-mill' in the Western United States to process 30,000 tons of RSM per year from both DOE and the nuclear utilities; and
3. provide recommendations for implementation.

The proposed facility will occupy a 60 acre site, cost \$140 million, and produce finished carbon and stainless steel plate and sheet from RSM input materials. A production level of 30,000 tons per year will be achieved by operating 7 days per week, 1 shift per day, operating at 71% efficiency. Given these operating parameters, conversion costs for producing finished product at this rate from like-alloy scrap is \$1130/ton. This cost includes capital recovery and decommissioning escrow account charges.

The cost of burial figures heavily into the feasibility equation and differs greatly between the nuclear utilities and DOE. As can be seen by the figure, the cost of disposal varies between disposal methods and price of burial. The proposed RSS recycling process exceeds the

competing options for disposal with the exception of high density package burial at the Nevada Test Site (NTS). Currently, burial rates range from \$17/ft³ at the NTS to a predicted \$500/ft³ for the Ward Valley Site in California. The best position is to be able to achieve a packing density of 80 lb/ft. and bury at the NTS for \$17/ft³. This is not a possibility for commercial generators. Many other DOE sites have their own disposal facilities that are more expensive than NTS. Also, achieving a package density of 80 lb/ft. requires more costly packaging techniques.

Charging the generator a price of \$1500/ton and charging 70% of commercial value to the purchasers of 16 gauge sheet, the production from the RSS facility is economically feasible. This analysis shows the RSS production costs \$1130/ton to produce products and generates a return on investment of 22 to 64% (depending on output selected). These data support the conclusion that an RSS facility fashioned after mini-mill technology is feasible and can be profitable.

Key to successful completion is licensing of the operation. Solutions to the technical issues of licensing are all achievable. The biggest issue is stakeholder acceptance and support. The stakeholders must be involved in the siting process.

Recycling of RSM in the RSS facility is feasible technically and economically; it can be supported by stakeholders as an environmentally sound solution to disposal of radioactive contaminated scrap metal.

Additional study and refinement is necessary to solidify details of the conceptual design. Validation of market demand within the nuclear industry, validation of the supply of RSM, and commitment by the DOE to support the generation of RSM through decommissioning activities are necessary steps to solidify the conceptual design.

Technical refinements to casting methods, post-melt product configuration, Vacuum Induction Melt furnace (VIM) refractory life, post-melt radiation impact on workers, and surface decontamination requirements prior to melt are necessary to proceeding with preliminary design.

In summary, it is recommended that the project move forward as a feasible solution to disposal of RSM. Refinements and decisions should be made early to meet the objectives of a plant becoming operational by the year 2000.

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Abbreviations

AC	Air Conditioning
acfm	Actual cubic feet per minute
ACU	Air-conditioning Unit
AIM	Air Induction Melting Furnace
AISI	American Iron and Steel Institute
ALARA	As Low As Reasonably Achievable
AOD	Argon Oxygen Decarburization
ASTM	American Society of Testing Materials
bHp	Brake Horsepower
BMS	Building Management System
BOF	Basic Oxygen Furnace
Bq	Becquerels
CCTV	Closed Circuit Television
cfm	Cubic Feet Per Minute
CFR	Code of Federal Regulations
CPU	Central Processing Unit
D&D	Decommissioning and decontamination
dpm	Disintegrations Per Minute
DOE	Department of Energy
DOT	Department of Transportation
EAF	Electric Arc Furnace
EDTA	Ethylene Diamine Triamine
E.O.T. crane	Electric Overhead Traveling Crane
ERDA	Energy Research and Development Administration
fc	Foot Candles
fpm	Feet Per Minute
ft ³	Cubic Foot
ft ³ /min	Cubic Foot Per Minute
g	Gram
gpm	Gallons Per Minute
HEPA	High-efficiency Particulate Air
HLW	High-level Waste
Hp	Horsepower
HPS	High-pressure Sodium
HVAC	Heating, Ventilating, and Air-conditioning System
HVU	Heating and Ventilating Unit
IES	Illuminating Engineering Society
INEL	Idaho National Engineering Laboratory
Kg	Kilogram
kV	Kilovolt

kVA	Kilovolt-amperes
kW	Kilowatt
kWh	Kilowatt hours
Lbs.	Pounds
LLRW	Low-Level Radioactive Waste
LLW	Low-Level Waste
LMS	Ladle Metallurgy Station
M&O	Maintenance & Operating
MCC	Motor Control Centers
MDA	Minimum Detectable Activity
MGDS	Mined Geological Disposal Site
MPC	Multi-purpose Canister
MRS	Monitored Retrievable Storage
MSC	Manufacturing Sciences Corporation
MVA	Megavolt-amperes
NCPP	National Conversion Pilot Project
NIST	National Institute of Science and Technology
NORM	Naturally Occurring Radioactive Material
NPP	Nuclear Power Plant
NRC	National Regulatory Commission
NTS	Nevada Test Site
NUREG	Nuclear Regulation Commission Regulation
PA	Public Address
PLC	Programmable Logic Controller
RCRA	Resource Conservation and Recovery Act
ROI	Return On Investment
RSM	Radioactive Scrap Metal
RSS	Recycled Scrap Steel
Sec.	Second
SEG	Scientific Ecology Group
SS	Stainless Steel
tph	Tons Per Hour
tpy	Tons Per Year
TRU	Transuranic Waste
VIM	Vacuum Induction Melt
VOD	Vacuum Oxygen Decarburization
WIPP	Waste Isolation Pilot Plant

Acknowledgments

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Section I: Project Overview and Summary

I-1.0 Introduction

This work was sponsored by the U.S. Department of Energy (DOE) Office of Technology Development and the Decommissioning and Decontamination focus area to investigate the feasibility of recycling low-level radioactive scrap metal (RSM) in a regional Radioactive Scrap Steel (RSS) mill located in the western United States.

The purpose of this study is:

1. establish a conceptual design that integrates commercial steel mill technology with RSM scrap processing to produce carbon and stainless steel sheet and plate at a grade suitable for fabricating into radioactive waste containers;
2. determine the economic feasibility of building a "micro-mill" in the Western United States to process 30,000 tons of RSM per year from both DOE and the nuclear utilities; and
3. provide recommendations for implementation.

For purposes of defining the project, it is divided into phases.

- ◆ Phase I - Economic Feasibility & Conceptual Design
- ◆ Phase II - Preliminary Design
- ◆ Phase III - Detail Design
- ◆ Phase IV - Construction
- ◆ Phase V - Operation

This study comprises the bulk of Phase I. It is divided into four sections. *Section I* provides the reader with a complete overview extracting pertinent data, recommendations and conclusions from the remainder of the report. *Section II* defines the variables that impact the design requirements. These data form the baseline to create a preliminary conceptual design that is technically sound, economically viable, and capitalizes on economies of scale. Priorities governing the design activities are: 1) minimizing worker exposure to radionuclide hazards, 2) maximizing worker safety, 3) minimizing environmental contamination, 4) minimizing secondary wastes, and 5) establishing engineering controls to insure that the plant will be granted a license in the state selected for operation. *Section III* provides details of the preliminary conceptual design that was selected. The cost of project construction is estimated and the personnel needed to support the steel-making operation and radiological and environmental control are identified. *Section IV* identifies the operational costs and supports the economic feasibility analysis. A detailed discussion of the resulting conclusions and recommendations are included in this section.

I-1.1 Scope of Work.

Operations unique to RSM processing are integrated with state-of-the-art steel production methods to conceptualize a facility capable of processing RSS materials. The objective was to assess the costs associated with building and operating a turnkey, independent processing facility capable of characterizing, storing, processing, and fabricating RSS into semi-finished products. Specific guidance regarding direction was provided by MSE, Inc. in the contract. Specifically:

1. Define an efficient, optimized process for charging, melting, decontaminating, refining, and casting RSS materials into high-quality semi-finished products suitable for further processing into radioactive waste containers; estimate corresponding capital and operating costs.
2. Define processes to minimize secondary waste; estimate costs of radioactive waste management.
3. Define systems that enhance plant safety and minimize worker exposure to radionuclide hazards.
4. Process elements downstream of refining operations will not differ significantly from those of comparably sized commercial facilities. Less emphasis is required for downstream operations. Identify requirements and predict capital and operating costs.
5. Evaluate possible processes and equipment, including specialized modifications.
6. Evaluate processes on the basis of capital cost, cost of operation, and other factors, including environmental issues of waste minimization, energy efficiency, and worker exposure to radionuclide hazards.

I-1.2 Facility and Process Overview.

The proposed facility will occupy a 60 acre site, cost \$140 million, and produce finished carbon and stainless steel plate and sheet from RSM input materials. A production level of 30,000 tons per year will be achieved by operating 7 days per week, 1 shift per day, operating at 71% efficiency. Given these operating parameters, conversion costs for producing finished product at this rate from like-alloy scrap is \$1130/ton. This cost includes capital recovery and decommissioning escrow account charges.

The facility will accept RSM in 15 ton land-sea containers and provide covered storage for a two month supply of RSM feedstock. The containerized scrap is moved from storage, as needed, into the scrap processing area and discharged onto one of two parallel cutting lines. Scrap is then cut to a maximum diagonally measured size of 48 inches and fed into a tumble type grit-blast precleaner.

Scrap from the precleaner is loaded into charge containers and placed on a carousel for charging under vacuum into the 30 ton vacuum induction melt (VIM) furnace. Six charges are required per heat. A tap-to-tap time of 132 minutes provides for charging, melting, decontaminating, decarburizing, sampling, alloying, and pouring. The process described

above will produce molten metal to specifications from like-kind RSS scrap at a cost of about \$550/ton.

The processes above received major emphasis in this study because they lay the foundation for future work. Once it is shown that molten metal within specification can be made at a reasonable cost, doors open to a wide array of products. Accordingly, the processes below were de-emphasized because they can be easily refined and changed to address evolving market needs as design work progresses.

Molten metal is tapped from the VIM into ladles and batch poured into a continuous slab caster where it is converted into a 4 in. x 54 in. x 90 ft. slab in 18.4 minutes. The hot slab is cut to length by plasma torch, reheated to the required rolling temperature, and rolled in a 12,000 Hp four-high reversing Steckel Mill.

The Steckel Mill provides the flexibility to produce 1/2 inch plate through 16 gauge sheet in widths up to 54 inches. Maximum rolling time for converting a 30 ton heat to 16 gauge coiled sheet is 19.4 minutes. Sheet (16 gauge) will be made in 13,500 pound coils measuring 44 in. OD x 28 in. ID x 54 in. wide.

Although cold finishing processes are not shown, allowances were made for \$12 million in capital costs and \$74/ton in operating costs in order to estimate the cost to produce the semi-finished product.

I-1.2.1 Scrap Handling:

Scrap is received in 15-ton land-sea vans and stored in the receiving area. The receiving area can hold a two-month supply (5,000 tons) of scrap. This is approximately 360 land-sea van containers. The containers are placed on transfer cars and moved into the scrap-preparation area through an airlock. Here the containers are dumped into one of two parallel cutting lines that cut and pre-clean the scrap. A diagonal measurement of 48 in. (maximum) per piece is required to avoid jamming the scrap during furnace charging.

Two factors for scrap processing are paramount in achieving good melt quality; proper size and cleanliness. Much of the carbon steel received will have paint and rust. Some will have a contamination "fixant" sprayed to keep surface contamination from becoming airborne while in transit. Considering the level of incoming debris and contaminants, cleaning the scrap through a grit blast system (or other similar system) will make the melt specifications easier to maintain.

Two types of tumblast systems are available for this application: a barrel system or a pitless system. These systems offer sufficient cleaning, depending on the material size and shape. Both systems come in a variety of sizes and cleaning capacities. An advantage of the barrel system is its ability to clean multiple pieces at one time. A drawback is its inability to adequately tumble certain materials such as round objects or longer material.

The result is less than total coverage by the shot, leaving uncleaned material. The pitless system can handle all configurations of material, but is a slower operation than the barrel system because the material must be loaded separately.

The conceptual design incorporates both systems. A barrel system efficiently handles the smaller material, while a pitless system handles larger items and those that could not be properly cleaned in the barrel system.

I-1.2.2 Melting Systems:

Four major assumptions regarding melting are made in this analysis:

1. A 'micro-mill' producing 30,000 tpy of restricted steel products exclusively from radioactive-contaminated scrap.
2. Heat size sufficient to cast 4-in. thick x 54-in. wide slabs.
3. Best available technology for containment of pollution and radioactivity.
4. Minimal waste byproducts.

Three technologies are available to perform the melting and refining requirements of the facility. These are:

1. Vacuum induction melting furnace (VIM)
2. Air induction melting furnace (AIM)
3. Electric arc furnace (EAF)

Each melting system (EAF, AIM, and VIM) was evaluated against the criteria of achieving licensing in the states identified, secondary waste to be generated, and efficiencies in production. The EAF was eliminated because of the tremendous amount of mixed waste generated, noise, fume generation, and lack of ability to contain the fumes. The air induction system was eliminated because it generates significant quantities of secondary waste, difficult fume control, and excess exposure to the workers. Additionally, the regulatory offices in the states reviewed voiced a strong desire to achieve maximum waste containment through a VIM rather than open-air melting. The VIM process has no media for combustion, generates no fumes, and controls the collection of dust. The process does not directly expose personnel to the molten low-level radiation contaminated metal. It minimizes the radioactive waste disposal. Table I-1.1 summarizes and compares the three technologies.

Table I-1.1: Melting Technology Comparison.

	VIM	AIR INDUCTION	EAF
<i>Heat Size</i>	30 Ton	30 Ton	30 Ton
<i>Power Requirements</i>	550 KWH/Ton	550 KWH/Ton	520 KWH/Ton
<i>Transformer Size</i>	13000 KVA	13000 KVA	20000 KVA
<i>Tap to Tap Time</i>	2.2 Hours	2.2 Hours	1.5 Hours
<i>Scrap Size</i>	48" Maximum	48" Maximum	Up to 72" long
<i>Number of Charges</i>	Continuous	Continuous	2 Bucket Charges
<i>Slag-off</i>	Minimal	Slag Skimmer	Yes
<i>Facility Decontamination</i>	Least Difficult	More Difficult	Most Difficult
<i>Lining Life</i>	40-50 Heats	40-50 Heats	Heats: 150 Sidewall Heats: 500 Bottom
<i>Noise</i>	None	Low	High
<i>Labor</i>	Moderate	Moderate	Moderate
<i>Reline Time</i>	24 Hours	24 Hours	16 Hours Sides 72 Bottom
<i>Fumes Generated</i>	None	Minimized over EAF	Extreme
<i>Air Pollution Control</i>	Excellent	Contained	Difficult
<i>Refining Capability</i>	Excellent	Limited	None
<i>Slag Waste</i>	2#/Ton	40#/Ton	80#/Ton
<i>Dust Waste</i>	0-2#/Ton	15#/Ton	25#/Ton
<i>Tapping Method</i>	Spout & Bottom	Spout & Bottom	Spout
<i>Equipment Cost</i>	\$13M	\$4.5M	\$5M
<i>Facility Costs for Pollution Control</i>	\$10M	\$20M	\$25M
KWH = Kilowatt hour kVA = Kilovolt-ampere M = Million	GOOD	MARGINAL	PROBLEMATIC

I-1.2.3 Casting Systems:

The continuous-slab-casting machine, designed to cast 4-in.-thick x 54-in.-wide slabs, is a low-head, straight-mold machine with a 16-ft. radius withdrawal section. The hot metal is fed from the ladle into the tundish through a slide-gate nozzle mounted on the bottom of the ladle. With a 30-ton heat size and a nominal casting speed of 60 inches per minute, it takes 18.37 minutes to cast a slab that is approximately 90-feet long. The slab is withdrawn from the mold and the caster spray chamber by a withdraw-straightener. The

4-in. x 54-in. slab is then cut to the required length by a plasma torch cut-off device. The cut-to-length slabs are conveyed by roller table to the reheat furnace.

I-1.2.4 Rolling Operations:

The pusher-type, slab-reheat furnace, which is designed for end charging and discharging, is located at one end of the melt-shop building. The reheat furnace is used when the temperature of the slab falls below the required rolling temperature. Normal operations introduce hot metal directly into the rolling mill from the cast station. The reheat furnace has radiant-type, natural-gas-fired, roof-mounted burners that are complete with recuperator, waste-gas system, valves, regulators, and controls. It is designed to heat approximately 30 tons of slab to a rolling temperature of 2,200°F in 50 minutes. The slabs are removed individually from the furnace by extractor arms and placed on the rolling-mill tables in the mill building.

The rolling-mill building houses a 56-in. wide four high-reversing Steckel mill with a 12,000 HP drive that operates at 1,500 fpm. The Steckel mill has hot-coil boxes on both ends to produce the 0.075-in. strip material. This mill gives the plant the flexibility to produce 0.075-in. strip to 0.50-in. thick plate.

I-1.2.5 Equipment Utilization:

Table I-1.2 shows the use of each of the major components. As can be seen by this comparison, the VIM furnace is the bottleneck.

Table I-1.2: Facility Equipment, Time, and Utilization Percentages.

Facility	Time	Utilization*
<i>Rolling Mill</i>	19.5	15%
<i>Caster</i>	18.37	13%
<i>VIM</i>	132	100%

* At 100% yield.

I-1.3 Competition - Burial.

Waste generators need to dispose of their metal at the least cost. The proposed process must meet or exceed the competing options for disposal. The cost of burial figures heavily into the feasibility equation and differs greatly between the utilities and DOE. A separate discussion on burial costs is covered in Section II-9.0. Several methods exist for disposition of RSM:

- a) Burial of bulk RSM.
- b) Burial of size reduced RSM.
- c) Compaction and burial.
- d) Metal melting and direct burial.
- e) Metal melting and use as a shield block.
- f) Surface decontaminate metal, free release, melt for disposal residuals.
- g) Metal melting and production of a high-quality steel product (this study).

It is necessary to compare how the relative costs of different processing techniques are impacted by the cost of disposal. The economic viability of processing waste depends primarily upon the avoided cost of burial. Currently, burial rates range from \$17/ft³ at the Nevada Test Site (NTS) to a predicted \$500/ft³ for the Ward Valley Site in California. On-site DOE disposal costs also vary greatly between sites. Current political issues challenging DOE at Nevada and Idaho may change or alter the ability of the government to accept any new waste at the sites located in these states.

Figure I-1.1 graphically shows the relative costs when holding the burial price constant. The price for burial was arbitrarily chosen to be \$100/ft.³. The feasibility of producing products from an RSS facility must compete with those alternatives. To illustrate the complex nature of the market place Figure I-1.2 takes the same data and adds the variable of burial price. Few generators have access to the low cost of burial at the NTS while some generators will be forced to use the high cost of disposal at Ward Valley.

Figure I-1.1 Variation in Cost of Disposal Methods Holding the Burial Price Constant at \$100/ft³.

Figure I-1.2 Cost of Disposal Methods at Variable Burial Prices.

As can be seen by the two figures that the cost of disposal varies greatly between methods and price of burial. The best position is to be able to achieve a packing density of 80 lb/ft.³ and bury at the NTS for \$17/ft.³. This is not a possibility for any of the commercial generators. Many of the DOE sites have their own disposal facilities that are more expensive than NTS. Achieving a package density of 80 lb/ft.³ is also not likely without resorting to more costly packaging techniques. Therefore, under the cost possibilities presented today, a bottom price for disposal for most generators is no less than \$1500/ton and likely much higher. Extrapolate these data to the year 2000 and beyond and the cost will likely continue to rise.

I-1.4 Capital Costs.

The project requires a significant capital investment. It is believed that the capital investment will come from a combination of sources. The best approach is to have the users (i.e., DOE and the utilities) invest in the facilities. The utilities may be interested in funding a joint venture, provided they receive special consideration in processing their metal. Special consideration would include reducing the capital-recovery costs from their price and/or other cost-cutting measures. The other investor in the project is DOE, which has no location to process scrap metal such as that described in this project. Funding this project offers DOE the possibility of saving many millions of dollars by avoiding burial and burial-site-management costs. The third potential investor in this project is private industry. Several RSM processors are interested. There are no steel-mill companies currently interested. Not being a part of their core business and the liabilities associated with processing radioactive material tend to scare the steel companies away as investors.

Table I-1.3 summarizes the capital costs of construction and estimates that the conceptual design selected would cost approximately \$140,000,000.

Table I-1.3: Construction Cost Summary.

No.	Expense Item	Material (\$000)	Labor (\$000)	Total (\$000)
1	Process Mechanical Equipment	44,680	13,817	58,497
2	Building Slabs & Process Foundations	5,819	7,112	12,931
3	Heating, Ventilating, and Air Conditioning (Process)	9,316	3,240	12,557
4	Buildings	11,497	0	11,497
5	Construction Management & Owner	0	9,424	9,424
6	Process Water Systems	5,924	1,046	6,970
7	Sitework, Utilities & Roads	4,880	1,474	6,354
8	Secondary Plant Electrical Equipment	3,417	1,210	4,627
9	Overhead Cranes	3,267	170	3,437
10	Radiological Equipment	1,026	22	1,048
11	Main Plant Power Distribution	925	19	944
12	Temporary Facility & General Conditions	202	0	202
13	Permits	0	0	0
14	Land Acquisition	0	0	0
15	Contingency	0	0	0
16	Cold Finishing Area (Estimated)	8,000	4,000	12,000
Total Line Item Cost		98,955	41,534	140,489

I-1.5 Operating Costs.

Operating costs for the RSS facility are the same whether processing stainless steel, carbon steel, or high nickel alloys. The RSS facility operation baseline includes the following costs:

- ◆ Manpower costs
- ◆ Electrical costs
- ◆ Consumable costs
- ◆ Cold-finishing costs
- ◆ Other utility costs
- ◆ Waste disposal costs
- ◆ Capitalization recovery
- ◆ Decommissioning surcharge

Figure I-1.3 shows the costs that were calculated for each operating cost element.

Figure I-1.3: Operational Cost Elements

Using the operating costs as a baseline several products can be manufactured.

1. Ingots for Burial
2. Carbon Steel from Carbon Steel RSM
3. Stainless Steel from Stainless Steel RSM
4. Stainless Steel from Carbon Steel RSM
5. Stainless Steel from Carbon Steel RSM and Nickel RSM
6. Stainless Steel from Carbon Steel using high Nickel alloy RSM as feed stock to recover Nickel and some Chrome

In addition to the operating costs identified in Figure I-1.3, raw material costs are to be added depending upon output except for ingots for burial and products from like-feed stock.

I-1.5.1 Ingots for Burial:

Tables I-1.4 and I-1.5 examine the scenario of melting the metal for volume reduction and subsequent disposal, which requires a less expensive facility (\$40 million for processing and \$10 million for scrap sorting). The capitalization recovery charge for this less expensive facility is \$167/ton over a 10-year period and a reduction in decommissioning charges result from having a smaller facility.

large variations in burial prices and their instability, melting for disposal is a feasible option. Table I-1.5 shows that it yields a reasonable ROI at any burial price when the charge to the generator varies with the disposal site available. The charges to the generators in all cases fall below that which is being paid for any other option available today. Anything less than 10 per cent annual ROI is considered unsatisfactory, and values greater than 20 per cent indicate the project is feasible. If you keep the charge to the generator constant at the presumed price of \$1500/ton the production of burial blocks becomes economically unfeasible for burial prices over \$170/ft³.

Table I-1.4: Financial Analysis of Facility for Melting for Volume Reduction and Burial.

Total Cost Summary:		Production Costs (\$/ton)				
Cost Element:	Burial @ \$17/Cu. ft.	Burial @ \$30/Cu. ft.	Burial @ \$70/Cu. ft.	Burial @ \$170/Cu. ft.	Burial @ \$315/Cu. ft.	Burial @ \$500/Cu. ft.
Waste Disposal	98	163	363	863	1588	2513
Manpower (\$301/ton):						
Scrap and Melting	190	190	190	190	190	190
Casting	111	111	111	111	111	111
Rolling	0	0	0	0	0	0
Cold Finishing	0	0	0	0	0	0
Raw Material	0	0	0	0	0	0
Electrical	33	33	33	33	33	33
Other Utilities	1	1	1	1	1	1
Consumables	21	21	21	21	21	21
Capitalization Recovery	167	167	167	167	167	167
Decommissioning Surcharge	31	31	31	31	31	31
Total Cost Per Ton	\$ 651	\$716	\$916	\$1,416	\$2,141	\$3,066
Cost Per Pound	\$ 0.33	\$0.36	\$0.46	\$0.71	\$1.07	\$1.53

Table I-1.5: Return on Investment for Melting for Volume Reduction and Burial.

Net Margin Summary:						
Charge Generators for Disposal	Burial @ \$17/Cu. ft.	Burial @ \$30/Cu. ft.	Burial @ \$70/Cu. ft.	Burial @ \$170/Cu. ft.	Burial @ \$315/Cu. ft.	Burial @ \$500/Cu. ft.
Cost Element:						
Production Cost per Ton	\$651	\$716	\$916	\$1,416	\$2,141	\$3,061
Production Cost per Lb.	\$0.33	\$0.36	\$0.46	\$0.71	\$1.07	\$1.53
Income:						
Charge to generator	835	900	1100	1600	2325	3250
Net Margin (\$)	\$184	\$184	\$184	\$184	\$184	\$184
Net Margin (%)	22%	20%	17%	11%	8%	6%
Return on Investment	25%	26%	26%	26%	26%	26%

I-1.5.2 Manufacturing a Product:

Figure I-1.4 illustrates manufacturing stainless steel from carbon steel requires significant alloy additions. Raw material costs to convert carbon steel to stainless steel are \$1935/ton. Addition of nickel from the gaseous diffusion plant or incorporating high nickel alloys into the melt reduces the cost of alloy addition. However, the bulk of the costs are from purchasing chrome.

Figure I-1.4 Raw Material Cost/Ton to Make 304 SS from Carbon Steel RSM.

Table I-1.6 summarizes the net margins and ROIs for a facility that produces a product to sell rather than simply melting for consolidation and disposal. The table assumes the generators are willing to pay \$1500/ton for taking their metal because recycling is less costly. The chart also assumes that the product produced by the RSS facility can be sold at significantly lower cost (30 per cent less) than virgin material.

Table I-1.6: Net Margin Summary and Return on Investment: Facility Producing Product to Sell at 70% of Commercial Price.

Net Margin Summary:					
Sell Products @ 70% Charge Generators \$0.75 for disposal	304 Stain-less from Carbon Steel Scrap	304 Stainless from Carbon Steel Scrap plus Nickel Scrap	304 Stainless from Inconel 600 Scrap and Carbon Steel	304 Stain-less from 304 Stain-less Scrap	Carbon Steel from Carbon Steel Scrap
Cost Element:					
Production Cost per ton	\$3,065	\$2,502	\$2,334	\$1,135	\$1,131
Production Cost per Lb.	\$1.53	\$1.25	\$1.17	\$0.57	\$0.57
Income:					
Charge to generator	1500	1500	1500	1500	1500
Sell Product @ 70% of Commercial Price	2128	2128	2128	2128	235
Net Margin (\$)	\$563	\$1,126	\$1,294	\$2,493	\$604
Net Margin (%)	16%	31%	36%	69%	35%
Return on Investment	22%	34%	38%	64%	23%

Assuming income of \$1,500/ton for accepting generator waste and product sales at \$1.06/lb., conversion of carbon steel to stainless steel generates an ROI that is acceptable. A reduction in price for the output is necessary to support the downstream radiological controls that are required of a fabrication facility. The selling price incentive is assumed to be material sold at 70% of commercial price.

The ROI improves as sources of nickel or chrome become available. If the DOE stockpile of nickel is used, a ROI of 34 per cent is realized. Using a contaminated source of Inconel 600, a ROI of 38 per cent is realized. The best return on investment comes from stainless steel input material and to make stainless steel products. The ROI is 64%. Carbon steel from carbon steel also shows a favorable ROI of 23%.

I-1.6 Conclusions.

For purposes of determining feasibility, the preliminary conceptual design has overstated the building and equipment requirements. The preliminary conceptual design liberally applies current steel making technology. The RSS facility is designed for expansion to a plant that can be operated at 120,000 tpy by increasing the operating time to 3 shifts per day; seven days per week. For the sheet and plate products, the process equipment selected can be replaced with alternatives that are less expensive but increase the manpower required to operate or increase the waste generated. Other products can be made from the molten metal created that are less capital intensive than the sheet and plate products chosen for preliminary conceptual design.

The RSS facility capacity is based on limited data. These data suggest that the through-put is 30,000 tpy. The types and kinds of material, degree of contamination of material to be received, and total quantity of metal available requires a detail review to validate the supply of input material.

The products selected for output were chosen based on limited market data. The market demand will determine the final product mix both in terms of types of steel to be produced (stainless or carbon grades) and the product form (sheet, plate, rod, etc.). The product mix chosen for the study was the most capital and labor intensive resulting in a position that supports feasibility of operation.

The only competition is that of NTS. The issue is how the government treats that disposal site. NTS buries B-25 boxes at maximum weight for about \$760/ton (including the cost of the container). NTS also buries entire land-sea vans for about \$1924/ton (including the cost of the container). The total cost of disposal at NTS is not reported and only an incremental cost is incurred. All other burial sites (DOE and commercial) are at or above \$2000/ton for burial. An expected competitive price was chosen at \$1500/ton for disposal of RSM. This analysis places the RSS production at \$1130/ton to produce products and generated a return on investment of 22 to 64% (depending on output selected). These data support the conclusion that an RSS facility fashioned after mini-mill technology is feasible and can be profitable.

Key to successful completion is the licensing of operation. Air and water emissions must be maintained through an internal water treatment plant and all air exhausted through HEPA filters. Worker exposure is reduced through point source control and remote operations. Vacuum induction melting (VIM) assures environmental compliance and worker safety while reducing secondary waste to near zero.

Solutions to the technical issues of licensing are all achievable. The single biggest issue to success of the project within a particular state is stakeholder acceptance and support. The stakeholders must be involved and kept informed to maintain support.

I-1.7 Recommendations.

The over-riding recommendation is that the project proceed with the next phases and achieve completion. Recycling of RSM in the RSS facility is feasible technically, economically, and can be supported by stakeholders as an environmentally sound solution to disposal of radioactive contaminated scrap metal.

Additional study and refinement is necessary to solidify a conceptual design that can proceed to the next phase. A market study must be performed that defines the output form and product mix expected. A decision on product form and product mix will result in refinement of the conceptual design configuration.

Validation of the supply of RSM and commitment by the DOE to support the generation of RSM through decommissioning activities is necessary to solidify the through-put decision. Without sufficient RSM being generated, the RSS plant will operate at less than full capacity. Market forces by competitive pricing will direct RSM to the RSS facility. The RSS conceptual design supports the "Recycle 2000" concept that a large majority of RSM generated will be processed into products by the year 2000.

Early decisions on site location should be made by down-selecting the two most probable sites. Through public involvement, bring the site stakeholders into the process.

Continue technical refinements to casting methods, post-melt product configuration, VIM refining output, post-melt radiation impact on workers, and surface decontamination requirements prior to melt. The results of these refinements are necessary to define the project prior to proceeding with preliminary design.

In summary, it is recommended that the project move forward as a feasible solution to disposal of RSM. Refinements and decisions should be made early to meet the objectives of a plant becoming operational by the year 2000.

Section II: Alternatives / Issues

II-1.0 Purpose and Scope

The main objective of Phase I is to determine if it is cost effective to spend the capital required to build an RSS facility compared with other alternatives. The alternatives currently available for RSM are: 1) direct burial, 2) compaction and burial, 3) volume reduction by melting and burial, or 4) decontamination and free release.

This investigation identifies a preliminary conceptual design of a plant that is an integrated process to recycle RSM materials into high-quality sheet and plate. The product is intended to meet both carbon steel and stainless steel material specifications. The approach was to select a preliminary conceptual design that was the most capital-intensive (worst case). If the return on investment (ROI) can be shown to be acceptable for this mill, future refined designs that are less capital intensive will improve the ROI.

Products will be classified as bulk-contaminated material for restricted use in products distributed to DOE, the nuclear utilities, and commercial processors of radioactive waste. These products will most likely be radioactive waste containers of various types and sizes.

The mini-mill steel-making process used by the highly successful commercial mini-mills was used as the baseline. The hypothesis is that with the proper design for radiological controls, the mini-mill process can be modified to safely produce steel products at a price below the cost of disposal. The baseline used in this study adapts the operating philosophy of these mills, using RSM as the feed material and integrating radiological-control technology adapted to making steel.

This study evaluates the following processes: scrap handling, melt refining, casting, and rolling to a semi-finished product. Pricing of the resultant product is compared to commercial steel pricing. Fabrication costs of specific products were not a part of the study.

Many specific applications were identified as potential products. They were not intended to be all inclusive. Sheet and plate were assumed to be the most likely forms to be used by the nuclear industry. Market demand was briefly analyzed to justify the selection of sheet and plate as an output product, but a complete market study is necessary to determine the true demand in terms of quantity and product mix. Such a market study is required to validate that demand is sufficient to support the production rates assumed.

Information regarding the quantity of scrap material that is available varies greatly. Estimates of RSM processed by DOE in the next 20 years range from 1 to 1.5 million tons. The time frame of material availability depends upon budget constraints on

decommissioning. Additional data are necessary to develop the raw material/feed stock availability. The impact of this variable is that the specific plant size, which is based on throughput, cannot be accurately determined. A capacity of 30,000 tpy (tons per year) was assumed for this study. The assumptions that were made in selecting this capacity are discussed in detail.

II-2.0 Philosophy of Operation

This study assumes that the project will be constructed as a commercial operation from a green-field site in the Western United States. Operation at government sites is not excluded, nor is the analysis the exclusive providence of the Western United States.

This study is equally applicable to any other location capable of providing manpower and utilities at the rates assumed for the study. Changes in construction cost would also vary depending upon location selected.

Construction on a government owned facility will likely impact the operational costs negatively. Although selection of a site where equipment and facilities already exist could significantly reduce the capital investment required for start up. Within the Western United States the three major government sites that could provide equipment and facilities are:

1. Idaho National Engineering Laboratory,
2. Hanford Nuclear Reservation, and
3. Nevada Test Site.

Other government sites exist within the Western United States, but fall outside of the contingent of states that have expressed an interest in having the project sited in their state.

Initial licensing and long-term success of this facility depend upon presenting the project as an environmentally conscious design which protects the environment, the neighbors, and the workers. In order to achieve licensing and reduce the long-term risks, a conservative approach was taken in developing radiological control, but at the same time eliminating the approach dictated by DOE orders which has been imposed in the past. The project is designed as a commercial venture operating under licensing from either the Nuclear Regulatory Commission (NRC) or the state in the case of an "agreement state."

Worker protection is accomplished through diligent use of engineered-control systems rather than administration controls. The design provides for point-source control to minimize worker exposure. An example of point-source control is the selection of vacuum induction melting (VIM) to produce liquid steel. Contaminated fumes, dust, and sparks are eliminated in the VIM process. Facility airflow is designed to ensure that the contaminated air moves away from workers. The need to use "moon suits" is eliminated for production personnel and is only required for certain furnace turnover activities.

Contaminant releases to air and water discharge systems have been eliminated. All process-area exhaust is filtered through High-efficiency Particulate Air (HEPA) filters. The building process areas are kept at a negative pressure relative to the external environment and all air is exhausted through a single stack. No building process-area air escapes without being filtered and monitored.

Water emissions are controlled by having closed-water systems and an internal water-treatment facility. Approximately 8,000 gpm (gallons per minute) of water are used in the process. About 4 per cent of that amount is brought in as make-up water, which is needed because of evaporation. Water vapors in the air are extracted by the air-collection system and exhausted through the HEPA-filtration system. No process water is discharged directly to the sewer system. Runoff water does not come in contact with contaminated material. Land-sea vans, scrap-metal containers measuring 20 ft. x 8 ft. x 8 ft. (1,280 ft³), loaded with feed material are stored under covered roof. Empty vans are cleaned, surveyed, repaired as necessary prior to leaving the facility, and stored awaiting distribution for the next load of material. When a van becomes contaminated and cannot be certified clean, it will be introduced into the mill as feed material and melted.

Minimizing secondary waste is important in RSM processing. Disposal cost is a major issue today as well as the future. Waste issues that may be acceptable and justifiable today likely will not be in the future. Additionally, the cost contribution of secondary wastes is significant.

Mixed waste is not produced by the proposed facility. The use of VIM to melt steel eliminates most of the mixed and radioactive waste. The typical KO61 hazardous waste (KO61 is an EPA hazardous waste classification) associated with the baghouse dust from the electric arc furnace (EAF) would be classified as a mixed waste and a significant contributor to an already difficult environmental control problem.

II-2.1 Radioactive Scrap Metal Disposal Costs.

Waste generators need to dispose of their metal at the least cost. The proposed process must meet or exceed the competing options for disposal. The cost of burial figures heavily into the feasibility equation and differs greatly between the utilities and DOE. A separate discussion on burial costs is covered in Section II-9.0. Several methods exist for disposition of RSM:

- a) Burial of bulk RSM.
- b) Burial of size reduced RSM.
- c) Compaction and burial.
- d) Metal melting and direct burial.
- e) Metal melting and use as a shield block.
- f) Surface decontaminate metal, free release, melt residuals.
- g) Metal melting and production of a high-quality steel product (this study).

It is necessary to compare how the relative costs of different processing techniques are impacted by the cost of disposal. The economic viability of processing waste depends primarily upon the avoided cost of burial. Currently, burial rates range from \$17/ft³ at the Nevada Test Site (NTS) to a predicted \$500/ft³ for the Ward Valley Site in California.

On-site DOE disposal costs also vary greatly between sites. Current political issues challenging DOE at Nevada and Idaho may change or alter the ability of the government to accept any new waste at the sites located in these states.

The cost of burying RSM in a radioactive waste repository, like all other types of low-level radioactive waste (LLW), is based on the volume occupied by the waste container in the repository, not the weight that is disposed. The cost also strongly depends upon the burial site as described in Section II-9.0. Since the cost of disposing LLW is based on the volume, the density of the RSM at the point of disposal has a direct impact on the cost of disposal. RSM is typically disposed of in "B-25" boxes measuring 4 ft. by 4 ft. by 6 ft., which occupy 96 cubic feet, or land-sea van containers, which occupy about 1,280 ft³. The effective density of the RSM disposed in such containers depends primarily on the form of the material.

The maximum weight accepted for B-25 boxes is 7000 lbs. and the maximum over-the-road limits the land-sea container to approximately 43,000 lbs. These weight limits impact the actual RSM weight by the weight of the box and land-sea van. This result is an effective weight of disposal of 6300 lbs. of RSM for the B-25 boxes and 33,000 lbs. of RSM for the land-sea vans. Therefore, the maximum disposal compaction density for RSM at any facility is 66 lbs./ft³ for B-25 boxes and 26 lbs./ft³ for land-sea vans. Techniques of compaction in special boxes can improve this density.

Further, the cost of disposal discussed as disposal costs do not include the cost of the B-25 box or the land-sea van. Each are consumed at the disposal site. The cost of cutting and sizing at the generators' site to achieve maximum packing density is also not considered and varies widely for material being processed.

II-2.1.1 Burial of Bulk RSM:

Bulk RSM is scrap that is merely placed in the container as it is removed from use. With bulk RSM, no additional costs are incurred to package the material. Records obtained for 172 shipments made from the DOE plants in Oak Ridge in 1993 and 1994 show that 3,528,192 lbs. of RSM occupied 217,824 ft³. This corresponds to an average density of 16.2 lbs./ft³. Data collected by a commercial waste processor on representative shipments of "as-removed" RSM (e.g., duct work, conduit, light-gauge metals and other building decommissioning debris) show that densities in land-sea van containers from generators ranged from 13 to 16 lbs./ft³.

II-2.1.2 Burial of Size-Reduced Radioactive Scrap Metal:

One of the easiest forms of waste-volume minimization of RSM is to cut it or otherwise compact it prior to placing it into the waste container. This can be done at the waste

generator's site to increase the volume sent per shipment. Typically, land-sea van containers are limited to 33,000 lbs. of contents for over-the-road shipments. If the entire 1,280-ft³ container is disposed of along with the contents, this corresponds to a disposal density of 26 lbs./ft³. Experience in commercial industry suggests that fully-loaded B-25-type boxes may contain anywhere from 3,000 lbs. to 6,300 lbs. of RSM, depending on the effectiveness of size reduction. Since the B-25 boxes contain a volume of 96 cubic feet, this corresponds to a disposal density ranging from 30 to 66 lbs./ft³. In order to achieve these nominal densities, additional volume reduction over placing material in the box randomly is required. Expenditures for such additional sizing are typically ignored in reporting the cost of disposal. Achieving 80 lbs./ft³ may involve compaction or, at a minimum, significant size reduction by cutting, adding the costs of manpower and equipment. Typically, the cost of disposal is discussed without recognition that the generation contributes additional costs in the packaging stage for size-reduction and cutting.

II-2.1.3 Burial With Compaction:

Compaction is a specialized process and only a few commercial facilities in the U.S. have that capability and range in cost from \$1.00 to \$1.25/lb. Compaction increases the density of steel to between 80 and 150 lbs./ft³. Achieving such a high packing density requires special processes, equipment, and considerable manpower in the volume-reduction process.

II-2.1.4 Metal Melting and Direct Burial:

Current pricing for metal melting ranges from \$1.25 to \$3.50/lb., depending upon the quantity of metal provided by the project, the condition of the metal, and the amount of up-front handling required. The density of metal melted for disposal is about 450 lbs./ft³, which corresponds to about 5 ft³/ton (The density of high grade steel is 490 lbs./ft³). The total disposal cost for one ton of RSM includes the charge for disposal of waste.

II-2.1.5 Metal Melting and Use as a Shield Block:

Current pricing for metal melting and fabrication into a shield block ranges from \$1.00 to \$2.50/lb. Some believe the market for shield blocks is limited and may be saturated soon.

II-2.1.6 Surface Decontaminate Metal, Free Release, Melt for Residuals:

Commercial surface decontamination, free release of available metal, and disposal of remaining waste by melting residuals have been priced at \$1.00 to \$2.50/lb., resulting in a range between \$2,000 and \$5,000/ton.

II-2.1.7 RSM Disposal Methods Cost Summary:

Figure II-2.1 graphically shows the relative costs when holding the burial price constant. The price for burial was arbitrarily chosen to be \$100/ft.³. The feasibility of producing products from an RSS facility must compete with those alternatives. To illustrate the complex nature of the market place Figure II-2.2 takes the same data and adds the variable of burial price. Few generators have access to the low cost of burial at the Nevada Test Site (NTS) while some generators will be forced to use the high cost of disposal at Ward Valley.

Figure II-2.1 Variation in Cost of Disposal Methods Holding the Burial Price Constant at \$100/ft³.

Figure II-2.2 Cost of Disposal Methods at Variable Burial Prices.

As can be seen by the two figures that the cost of disposal varies greatly between methods and price of burial. The best position is to be able to achieve a packing density of 80 lb/ft. and bury at the NTS for \$17/ft³. This is not a possibility for any of the commercial generators. Many of the DOE sites have their own disposal facilities that are more expensive than NTS. Achieving a package density of 80 lb/ft. is also not likely without resorting to more costly packaging techniques. Therefore, under the cost possibilities presented today, a bottom price for disposal for most generators is no less than \$1500/ton and likely much higher. Extrapolate these data to the year 2000 and beyond and the cost will likely continue to rise.

II-2.2 Capacity.

The key factor for mini-mills in effectively keeping costs in line is to achieve economies of scale in processing. The smallest commercial mini-mills are efficiently run at about 300,000 tpy. However, the RSS mill cannot be run at rates high enough to achieve maximum utilization of all equipment and take advantage of economies of scale.

The quantity of RSM resulting from DOE decommissioning, nuclear utility waste from normal operation, and decommissioning of nuclear utility plants is thought to be large. It is estimated that, beginning in 1999-2000, approximately 120,000 tpy of metal will be available for burial or recycling. Approximately 60,000 tpy of this will come from the gaseous-diffusion plants in the eastern U.S. and for this study are assumed to be unavailable for processing in the Western United States. The remaining 60,000 tpy of metal are assumed to be equally distributed from DOE facilities in the East and the West. The result

is that approximately 30,000 tpy of scrap metal are available for processing in the western U.S. Nuclear plant decommissioning is estimated to add an average of 10,000 tpy for the western U.S. Metal from the ongoing operations of the nuclear power plants adds an additional estimated 3,000 tpy.

Factors affecting these data are: 1) the potential for utilities to have more frequent shutdowns in the later stages of the operating life thereby increasing their potential contribution, and 2) the unknown of DOE's budget cycle likely reducing the dollars available for decommissioning; thereby, reducing the total quantity of metal available from the DOE. It is concluded that between 25,000 and 30,000 tpy of RSM are available to supply the input material for a western-region RSS mill. In this design, the supply of input RSM is assumed to be 30,000 tpy.

Dual use of the facility operating at commercial mini-mill efficiency and production rate (100,000 tpy) was evaluated. As proposed, the dual-purpose mill was to produce both RSS (restricted-use) products and virgin steel (unrestricted-use) products. The purpose was twofold. First, a dual-purpose mill would operate at efficiencies that approach the mini-mill environment. Second, the mill would be capable of consuming a variable amount of RSS available in a given year and the additional capacity could be used to produce virgin (non-contaminated) steel. This flexibility would allow economies of scale to be applied to RSS and clean-steel operations.

The biggest obstacle to this approach is the separation of the RSS and the clean-steel operations. Current producers of clean steel are horrified at the possibility of cross contamination. Potential purchasers of the clean metal gave indications that the material would be suspect and, therefore, they would probably not buy the products. Regulators in several of the candidate states expressed environmental and regulatory concerns that amplify an already difficult problem of licensing. Most importantly, the preliminary calculations of cost of operations are a factor of two higher for the clean steel. An additional burden is added to the disposal of waste for both product streams. Because of these issues, dual use will be not considered further.

II-2.3 Processing Methods.

Licensed commercial facilities that have metal-melt capability are operated by MSC, Westinghouse-Scientific Ecology Group (SEG), and Carolina Metals. Differences in the type of operation are centered on two issues: 1) whether or not decontamination is necessary before the melting operation and 2) the quality of ingot formed in the casting process. Current operations at MSC focus on decontamination services and free release to the clean scrap-metal market. MSC's melting process consolidates any remaining metal into a metallurgically sound rolling ingot. Melting and fabricating augment MSC's decontamination services to further reduce secondary waste and burial volume from the process, as well as deliver a product for reuse.

Westinghouse-SEG operations focus on consolidation and volume reduction. SEG consolidates the metal into a shield block that has density requirements, but does not meet specific metallurgical properties necessary for subsequent fabrication. With the shield-block market becoming saturated, SEG may change their approach to metal melting. Carolina Metals has been using their new melting system for less than six months and it is not known what technical approach and strategy they are pursuing.

The metals processors have a different purpose and strategy than does a mini-mill. Each approaches the processing of RSM from a radiological viewpoint—attempting to avoid burial—and produce steel as a byproduct. The use of steel-mill technology, however, allows an inexpensive steel product to be produced as the primary purpose for the plant's operation. The assumption is that necessary radiological controls can be added to the commercial mini-mill design. Although this increases the price of processing, it should still be considerably lower than the cost of processing using current methods.

II-2.4 Decontamination Prior to Melting.

Feed material will be received with a considerable amount of rust, scale, and paint. Removal of the foreign matter prior to melting will reduce refining requirements and reduce the secondary waste generated. An automated grit-blast system for the scrap was chosen for the conceptual design for the purpose of pre-cleaning scrap. Prior to the start of the preliminary design data that are not yet available regarding the cost benefits of surface decontamination prior to melting must be examined.

The level of contamination of the bulk material after melting depends upon the level and type of contamination prior to melting. The issue of whether to decontaminate or how much decontamination before melting is a matter of economics and relates directly to whether or not de minimus limits have been set for use in the United States. De minimus limits are defined as concentrations of radionuclides that "the government does not take notice of or concern itself". De minimus limits exist for surface contamination but not for bulk contaminated (melted) material. The EPA, NRC, and DOE are currently working to draft a de minimus standard for bulk contaminated material. It is not known how long it will be before this standard is completed.

Contaminants that are trapped on the surface and surface layers can be removed through adequate surface cleaning devices. If there is no free release criteria for material that have bulk contaminants, the degree of contamination removal is in question after achieving the removal of rust, scale, and other loose foreign matter. If a subject metal is heavily laden with Cesium, Strontium, the lanthanides and the actinides either at the surface or activated, they can be removed in the melt process to levels below 1 ppm by the addition of slags and free oxygen. However, cobalt, iron, manganese, technetium, and nickel will be homogeneously mixed in the metal matrix during melt and cannot be removed. The

distribution of contaminated cobalt, nickel, iron, manganese, and technicium at the surface of the RSM is key to the decision to surface decontaminate. At the same time, Cesium, Strontium, the actinide, and lanthanide elements do not need to be removed at the surface and could be removed during the melt. As can be seen by Table II-2.3, the metal coming from the utilities is heavily laden with active elements that would support surface decon prior to melt.

Table II-2.3 Radionuclide Composition of Internal Surface Contamination*.
Composition in Percent of Total Activity Decay Corrected to Shutdown Date

Radionuclide	BWRs			BWRs		
	Humboldt Bay	Dresden-1	Monticello	Indian Point-1	Turkey Point-3	Rancho Seco
Mn-54	3	0.9	1	4	0.4	4
Fe-55	90	28	1	67	31	28
Co-57	---	---	---	---	43	24
Co-60	6	46	11	15	24	18
Ni-59	---	0.09	---	0.02	0.004	0.1
Ni-63	0.2	5	0.04	2	0.1	19
Zn-65	---	19	84	11	1	0.09
Sr-90	0.004	0.007	0.002	0.0007	0.0008	<0.01
Nb-94	<0.004	<0.003	<0.1	0.0008	<0.004	<0.004
Tc-99	3×10^{-4}	4×10^{-5}	8×10^{-5}	8×10^{-5}	0.008	<0.005
Ag-110m	---	---	---	---	---	4
I-129	$<3 \times 10^{-6}$	$<1 \times 10^{-5}$	$<1 \times 10^{-6}$	2×10^{-5}	<0.003	$<1 \times 10^{-5}$
Cs-137	0.5	0.004	2	0.5	---	0.4
Ce-144	---	1	---	---	0.2	<0.04
TRU**	0.005	0.1	0.008	0.002	0.006	0.001
Total Plant Inventory (Curies)	596	2,350	448	1,070	2,580	4,460

Source: NUREG/CR-4289

* Excludes highly activated metal components of the reactor pressure vessel and internals, and activated concrete.

** Transuranic alphas-emitting radionuclides with half-lives greater than 5 years, include Pu-238, Pu-239, Pu-240, Am-241, Am-243, and Cm-244.

By contrast the typical DOE RSM holds surface products of uranium, plutonium, americium, and neptunium. These elements can be removed through the melt refining steps.

LITCo, Oregon Graduate Institute, and Montana Tech have been studying the issue of reduction through slag additions and refining. Work is continuing to develop the best approach to refining to remove contamination.

Evidence points to the conclusion that most metal coming from the nuclear industry is surface contaminated. Notwithstanding refining for specific elements that can be removed, the single biggest reduction of bulk contamination in the final product is eliminating contamination prior to melting. Surface decontamination prior to melting would be beneficial in producing low levels of contamination in the final product. This process has particular importance for two reasons:

1. Reduction of bulk contamination reduces risks to workers of operations downstream of melting and for the user of the products made from the metal.
2. If de minimus standards are set and can be met by reducing the surface contamination prior to melt, then a new unrestricted market becomes available for the mill's output.

II-3.0 Input Materials

II-3.1 Types and Quantities Available.

Several studies have generated a plethora of wide-ranging data. No two studies agree on the total, and few instances occur where the quantities for a given site agree. Some studies failed to recognize material that was not yet "excessed" but still a significant part of the overall material to be disposed. None of the studies compared the amount of metal in buildings not yet destined for decommissioning because they were not yet "excessed." The single biggest issue is the current practice at many DOE sites to bury metal as soon as it becomes available for disposal without considering recycling as an option.

Additional study of the input material, types, quantity and schedule is needed to refine the data on feed-stock supply. However, it is known that RSM is generated by a number of government and commercial sources as listed below:

- Government Sources
 - Gaseous-diffusion plants
 - Production and research reactors
 - Nuclear laboratories
 - Nuclear weapons manufacturing facilities
 - Military test ranges
 - Nuclear navy
- Commercial Sources
 - Nuclear power plant maintenance
 - Nuclear power plant decommissioning
 - Nuclear-fuel manufacturing facilities
 - Naturally occurring radioactive material (NORM) contamination from oil drilling

Estimates of RSM expected to come from the decommissioning of DOE facilities range from 1 to 1.5 million tons. Two estimates of DOE RSM inventories have been documented. Whitfield (1991) found in excess of 130,000 tons of RSM in storage at various DOE sites. At that time, Whitfield estimated an ongoing generation rate of 15,000 tons/year until major decontamination and decommissioning (D&D) projects begin. At that time, the rate is expected to dramatically increase to over 90,000 tons/year. The need to dispose of a total of 1.5 million tons of RSM was projected. Duda (1993) reported an inventory made from public documents and telephone surveys of all DOE sites and field offices. A total of 991,000 tons of potential RSM was identified in that study.

About 15,000 tons of RSM are generated annually from ongoing maintenance of nuclear power plants in the U.S. This estimate is based upon estimates from business activity in the low-level waste processing industry. Decommissioning of power reactors and systems will produce large quantities of RSM. Mizia and Wahnschaffe (1994) identified 89,670 tons of recyclable stainless steel from eventual decommissioning of 122 reactors. Atteridge (1993) found the total for all reusable metal from U.S. reactor decommissioning to be about 760,000 tons.

A summary of metal becoming available from continuing operations or decommissions from utilities and DOE sources is shown in Figure II-3.1. This figure shows a level output of feed stock for RSM recycling to be approximately 120,000 tpy for the next 15 years. It is expected that the RSM will be processed over a longer period, stretching out the DOE budget for an extra 5-10 years. It is also unlikely that DOE will simply run out of RSM at the end of the 20-year projection date (1994-2014).

Figure II-3.1: RSM from DOE and Utilities.

II-3.2 Most Likely Input Materials.

RSM has been a subject of DOE concern. Historically it has represented a liability to DOE and the nuclear power industry. Currently, there is debate about how that liability can be converted into a resource to return economic benefit to DOE. RSM can be deemed a

resource only if there is a market for products manufactured from the metal and if there is sufficient quantity available to meet a market demand.

Four avenues of disposition of RSM from D&D of nuclear facilities are evident:

1. Release to unrestricted commercial use after first removing contaminants from the surface or by refining bulk-contaminated metals (resource-recycling approach);
2. Recycle contaminated material to useful new products that are restricted in end use (resource-recycling approach);
3. Consolidate by compaction or melting, then store or bury (liability approach); and
4. Package and burial (liability approach).

Decontamination and release provides an economical approach in cases where there is no internal contamination and surfaces can be easily accessed. Unrestricted release of bulk-contaminated metals presently is not an option in the U.S. due to the lack of an accepted standard for unrestricted release. Consolidation and storage or burial are becoming increasingly less attractive as the cost of repository storage and burial costs increase. This approach also presumes the metals are a liability.

All RSS mill input materials will be in one of four categories:

1. Carbon steel
2. Stainless steel
3. High-nickel alloy, e.g. Hastalloy or Inconel
4. Pure nickel

All scrap feed material will be classified as Low Specific Activity (LSA) low level waste and will not contain contaminated high-level waste. Carbon steel will have paint, rust, and special coatings to fix the contamination in place. The scrap should be relatively free from oils, grease, and dirt.

Scrap will be received in either land-sea van containers or B-25 boxes. Shipments will meet the applicable Department of Transportation regulations for shipment of low-level waste. The outside of each container will be surveyed to insure that "smearable" contamination is within all limits and then may be stored outside. Once received in the RSS facility, however, it will be stored indoors.

Scrap will be sorted by alloy type at the point of loading. It is expected that the ratio of metal available across the nuclear complex is as depicted in Figure II-3.2.

Figure II-3.2: Distribution of RSM Type Between DOE and Utilities.

As can be seen in Figure II-3.2, the predominance of metal is carbon steel (approximately 75%). A significant amount of pure nickel (50,000 tons) will be extracted from the gaseous-diffusion plants. Another estimated 30,000 tons of high-nickel alloys will be extracted from DOE sites. The combination of 50,000 tons of pure nickel and 30,000 tons of high nickel (40%) is a significant resource for making additional stainless steel. Nickel alloys and large quantities of carbon steel suggest a plant that combines these resources to make 304 grade stainless steel (8-10.5% nickel). Approximately 775,000 tons of stainless could be produced as a recycle product.

$$[50,000 \text{ tons (Ni)} + 30,000 \text{ tons (40\% Ni)}] \div 8\% \text{ Ni (304 SS)} = 775,000 \text{ Tons of 304 SS}$$

This scenario consumes approximately 575,000 tons of carbon steel, 50,000 tons of nickel and 30,000 tons of high-nickel alloys, totaling 655,000 tons of RSM. Given that the RSM plant in this study is designed to process 30,000 tpy on a single-shift operation, that would equal approximately 22 years of operation making the single product, 304 stainless steel.

II-3.3 Potential Product Markets.

II-3.3.1 Spent-Reactor-Fuel Containers:

A multi-purpose canister (MPC) for dry storage and eventual disposal of spent nuclear fuel will be developed by DOE starting in 1995. This concept will require the manufacture of 10,000 canisters over a 20-year period. The 190-in. by 68-in. diameter cylinder will average approximately five tons each. Depending upon the design, the end enclosures will weigh from one ton to five tons each. Current designs of the MPC require either 316L or Inconel 825 heavy-walled cylindrical components to make up the corrosion-resistant shell.

Using Inconel 825 is costly. Recycled Inconel 825 from RSM could lower the cost of fabrication significantly and maintain corrosion resistance. A range of 60,000 to 100,000 tons of stainless steel are needed by the MPC program.

Material costs for the MPC program are estimated at nearly \$200 million. If this plant performs as predicted by producing metal at one-half the cost of virgin metal, the cost savings for the MPC program alone could be \$100 million. This is almost equal to the cost of the plant, while using only 17 per cent of the lifetime capacity. Avoiding burial of 100,000 tons of metal at \$2,000/ton avoids \$50 million in disposal costs (\$2000/ton for burial less \$1500/ton RSS processing fee times 100,000 tons of metal). This single project could justify the cost of the RSS facility, which would have 80 per cent of its design life remaining. DOE would have to decide to link the MPC project material procurement to the RSS plant making Inconel 825 or a similar alloy needed to support the MPC program.

II-3.3.2 High-Level Waste (HLW) Containers:

About 500,000 yds³ of HLW are in storage at four DOE sites: Hanford, Savannah River, INEL, and West Valley. Some of the HLW will be concentrated to about 10 per cent of its existing volume, vitrified using borosilicate glass, and poured into stainless steel containers. The vitrification-program plan calls for construction of plants at Hanford, West Valley, and Savannah River. DOE has projected a need for 7,680 containers over 17 years. The containers are about 9.8 feet long and 2 feet in diameter and weigh 1100 lbs. The first 500 containers have been purchased for the Savannah River vitrification plant at a price of \$7,000 each. Each was fabricated from 0.375 inch (9.5 millimeters) thick AISI [American Iron and Steel Institute] 316L stainless steel. Using a 25 per cent waste concentration in glass and 1.05 yds³ effective volume of the container, this approach will only accommodate 4 per cent of the existing HLW, leading to the conclusion that nearly 200,000 such containers consuming 110,000 tons of stainless alloy may be required for DOE high-level waste. In this application, the proposed RSS project could save DOE approximately \$100 million in material costs, \$175 million in burial costs, and consume only 20 per cent of the plant capacity.

II-3.3.3 Transuranic-Waste Containers:

Transuranic (TRU) waste is defined as that containing more than 100 nanocuries per gram (37 Bq/g) of alpha-emitting transuranium radionuclides with half-lives greater than 20 years. DOE has about 50,000 yds³ of such waste in storage and generates additional waste at the rate of 2,600 yds³/year (DOE, 1991). The Waste Isolation Pilot Plant (WIPP) in New Mexico is designed to contain up to 225,000 yds³ of TRU waste, but its opening has been repeatedly delayed and temporary storage of TRU waste at various DOE sites has been a crisis-level problem over the past several years. At the WIPP, waste will be stored in drums and boxes. Much of the existing waste must be repackaged before shipment to meet the WIPP requirements. Because some of the existing waste consists of acid and

caustic residues, and corrosion and leakage of drums is common, use of corrosion-resistant alloys for waste containers made from RSM is a market potential. From investigations, the TRU waste will be stored in carbon steel 55-gallon drums and placed in the WIPP when it opens. Approximately 600,000 drums will be purchased, consuming 15,000 tons of RSM products. There is no requirement to store in stainless.

II-3.3.4 Low-Level-Waste Containers:

The total quantity of low-level waste that will come from DOE D&D activities is not known with any precision. The estimated volume of LLW accumulated at the Fernald site, not including waste expected to be generated during cleanup, is 300,000 yds³. Assume the 300,000 yds³ was spread over 10 years that represents the total DOE decommissioning activity for any one year yielding 30,000 yds³ per year of waste to be buried. The 1991 burial volume of commercially generated LLW at the Barnwell, Beatty, and Richland sites was about 85,000 yds³. Assume that better burial practices reduce the yearly burial quantity to 50,000 yds³ per year. The total volume to be buried is 80,000 yds³. Further, assume that the burial is in B-25 boxes which have a higher density than land-sea vans. The B-25 burial density is a very conservative 100 lbs./ft³. The weight limit for a burial box is 6300 lbs., netting 3.15 tons per B-25 box. Using 100lbs/ft³ (1.35 tons/yds³) as the material density applied to 50,000 yds³ of material would yield 67,500 tons of material for burial. Dividing the total material for burial (67,000 tons) by the B-25 box capacity (3.15 tons/box) yields approximately 21,270 B-25 boxes per year. Each box weighs 660 lbs (.33 tons). Apply the box weight to 21,270 boxes and the result is a consumption of approximately 7,000 tons of RSM per year.

II-4.0 Low-level Radioactive Scrap Metal

Low-level radioactive waste (LLW) is defined as any radioactive waste that does not belong in one of the other three categories of waste. Specifically, LLW is not:

- ◆ High-level waste (HLW, greater than 10 nanocuries/gram),
- ◆ Uranium mining and milling residues (called "mill tailings"), or
- ◆ Waste with greater-than-specified quantities of elements heavier than uranium (transuranics).

HLW is spent nuclear fuel or the radioactive waste produced if spent fuel is reprocessed. Uranium-mill tailings are the rock, soil, and washings that remain after uranium has been removed from the ore that was mined from the earth. Radioactive waste that contains more than a specified concentration of transuranics is not classified as low-level radioactive waste. All other radioactive waste is LLW.

II-4.1 DOE and Commercial Low-Level Waste Metal.

LLW is generated by both "commercial" operations and "non-commercial" U.S. government operations. Low-level radioactive waste is generated at facilities such as hospitals, educational and research institutions, nuclear power plants, and other industrial facilities. It includes radioactive materials used in various processes as well as supplies and equipment that have been contaminated with radioactive materials. Low-level metal waste products can include:

- ◆ Contaminated hand tools, components, piping, and other equipment from nuclear power plants and other industries.
- ◆ Contaminated containers, equipment, and radioactive devices.
- ◆ Metal derived from maintenance activities at either a DOE or utility site.
- ◆ Metal that results from equipment, facilities, and building demolition as part of the utility or DOE decommissioning and dismantling operation.

II-4.2 Disposal.

The federal government is responsible for disposal of LLW generated by DOE nuclear weapons research, development and manufacturing operations, and from the nuclear reactors that power naval vessels. DOE typically has different radionuclide concentrations than waste from non-commercial activities. For this reason, DOE scrap must be kept separate from commercial nuclear power plant (NPP) scrap. This segregation must be consistent to maintain responsibility of waste that is produced during processing. Responsibility is dictated by the classification of the waste, which dictates where it may be buried. Waste will result from material that cannot be melted due to higher-than-desirable radiation levels and/or disposal of secondary waste resulting from processing the waste.

The individual state's generators are responsible for disposal of low-level waste from:

- ◆ Organizations such as hospitals, educational and research institutions, utilities and other industries, and
- ◆ Non-weapons-related government facilities such as veterans' hospitals, military hospitals, U.S. Public Health Service, Department of Agriculture laboratories, and federal low-level radioactive waste (LLRW) resulting from certain clean-up activities.

II-4.3 Transportation.

Three classes of commercial low-level radioactive waste are defined in the Code of Federal Regulations, Title 10, Part 61 (10 CFR 61). Those classes are Class A, Class B, and Class C. Section 10 CFR 61.55 lists the limits on concentrations of specific radioactive materials allowed in each low-level waste class. Radioactive waste not meeting the criteria for these classes falls into a fourth class, known as "Greater-than-class C," which is the responsibility of the federal government.

- ◆ Class A low-level radioactive waste contains the lowest concentration of radioactive materials. Most of these materials have half-lives of less than five years or are concentration limited. Most radioactive scrap metals fall in this category.
- ◆ Class B contains the next lowest concentration of radioactive materials and contains a higher proportion of materials with longer half-lives. Class B-defined metal must be examined relative to exposure to personnel to determine if it is desirable to process it in the RSS facility.
- ◆ Class C low-level waste has the highest concentration of radioactive material allowed to be buried in a LLRW disposal facility. Class C waste will not be processed in the facility because of the hazards posed to employees.
- ◆ The concentration of radioactive materials in Greater-than-class C wastes exceeds the limits for Class C waste specified in 10 CFR 61.55. All Greater-than-class C waste is the responsibility of the federal government and must be disposed of in a manner consistent with its hazard. It will not be accepted for processing at the RSS facility.

Transportation of LLW is regulated primarily by two government agencies. They are the U.S. Department of Transportation—Office of Motor Carriers (under authority of the Motor Carrier Act) and the NRC (under authority of the Atomic Energy Act and the Energy Reorganization Act of 1974). The Code of Federal Regulations contains the regulations written by both agencies.

The U.S. Department of Transportation specifies regulations for container safety, labeling, routing, and emergency response for the transportation of LLW. The regulations can be found in the "Hazardous Materials" section of 49 CFR.

LLW may be packaged for transportation in three types of containers. Materials with low radiation levels may be transported in what the regulations refer to as a "strong, tight container." An example of a strong, tight container is a steel drum secured at the lid or a secured steel box. The land-sea van used by the RSS facility is in this category. Materials with higher radiation levels must be shipped in Type A or Type B containers. Type A containers are typically steel drums. Type B containers, used in transporting waste with high radiation levels, are heavy engineered metal or concrete containers called casks and will never be received at the RSS facility.

II-5.0 Site Locations and Selection Issues

A key element to successful implementation of this plan is to have a location in a state of interest willing to allow the siting and licensing of a radioactively contaminated material processing facility. Experience has shown that obtaining a license for radioactive material processing is not an easy task.

The following states were contacted through economic development managers at the state-government level: Oregon, Washington, Idaho, Nevada, Utah, Arizona, New Mexico, and Wyoming. California, Montana, and Colorado were also considered, but because of a strong perception that the public is unlikely to favor nuclear activities, these states were eliminated from consideration.

The state of California has had a ten-year battle with the implementation of a low-level waste disposal site at Ward Valley. The RSS project cannot afford the legal complications nor the time required to get the state's public supporters in line to accept the licensing for this type of facility.

The state of Montana was not considered, based in part, on an awareness that it has declared itself a nuclear-free zone and would not consider this project as a viable business entity for licensing within the state.

Stakeholders in the state of Colorado have raised concerns of importation of RSM. Low-level waste processing within the state may be limited to local material (Rocky Flats). Progress must be shown in cleaning up Rocky Flats before stakeholders will consider a more global approach that would include bringing RSM into the state from other states for processing. Considering these issues, Montana, California, and Colorado were eliminated from consideration.

II-5.1 Overview.

Washington, Oregon, Nevada, Arizona, Idaho, and Wyoming have significant interest in this project being located within their state. Washington, Oregon, and Idaho have had reviews with the Department of Environmental Quality and all consider this project to be licensable from a technical standpoint, provided zero emissions are released to air and water. If the RSS facility design were to use air induction or electric arc furnaces, obtaining approval by these states is unlikely. However, approval of VIM's "zero" emission design is an excellent prospect.

Issues not discussed, but relevant to siting, are such items as stakeholder support, tax incentives, availability of local fabrication facilities, availability of industrial-revenue bonds, site-infrastructure improvements, land incentives, and other incentives provided by the states competing for the site. These specifics are to be addressed in Phase II.

While this project appears to be licensable in several states from a technical perspective and meeting licensing requirements does not appear to be an issue, the issue consistent throughout each state is the political/social issue of "not in my back yard." Having radioactive materials transported from outside the state for processing is overcome by the approach that the RSS plant is a processing facility and, "what comes in, goes out". Any RSM already within the state will likely be removed after processing, thereby reducing the net radionuclides within the state.

Oregon has a similar situation regarding importation of waste. This issue is less of a problem if the material is considered in process and ownership remains with the generator until a new product is created and the ownership transferred to the buyer of the product. Idaho and Wyoming expressed the same conclusions as discussed in the sections addressing Washington and Oregon issues. Arizona has not mentioned either issue as yet. When other candidate states have discussions regarding importation and ownership, the results will likely be the same.

Nevada has a different situation. That state is the future site for either a Monitored Retrievable Storage (MRS) site and/or the Mined Geological Disposal Site (MGDS) at Yucca Mountain for the nation's high-level waste. Given that Nevada has accepted one or both of these HLW projects, the impact of the RSS facility, which handles only LLW, is minor. The technical issue of air and water emission control remains the same.

In all cases, the siting, design, and operation of this facility must have stakeholder acceptance from the start. In addition to the specific project, the issue of importation must be addressed. The facility must not be considered in any way a repository for metal. It must be stressed that all metal brought into the facility will be either processed and formed into new products that are shipped to new customers or processed and shipped to approved burial sites for hazardous or radioactive material.

While Phase I has demonstrated that this project appears to be licensable from a technical perspective, and several sites have indicated an interest in such a facility, significant siting issues must be resolved in Phase II activities. For example, in order to successfully site a RSS facility, a meaningful public participation program needs to be conducted. The program must educate the public about risks and alternatives, and actively solicit questions, concerns and suggestion from the public. Such a proactive public participation process can be used to build public trust and confidence in the project.

Without such a public participation effort, the siting process could face an uphill battle as evident in the importation of waste issues already raised. Several states expressed concerns regarding the transportation of radioactive waste into their state from other sources. It appears they are concerned that material may be stored at the RSS facility, making the host state a defacto low-level waste repository. This particular concern has been addressed with state officials as they learn that all metal to be brought into the RSS facility will either be

processed., formed into new products and shipped to new customers, or shipped to existing licensed hazardous or radioactive burial repositories. A similar education process will be required to address concerns of other Stakeholders.

During Phase II other siting issues must be resolved. For example, technical issues must be examined surrounding air and water emissions of local fabrication facilities. Additionally, site infrastructure capabilities, costs of infrastructure upgrades or installation, and potential incentive packages must be explored in specific detail on a state-by-state basis prior to the actual siting of the RSS facility.

Community involvement and education programs should begin immediately. The stakeholders must be identified early in the project as participants in a solution rather than remaining on the outside of a problem. It should be stressed that, because the radiation already exists, the RSS recycling project does not generate any new waste while reducing the total impact on the environment. It is important to present this project for what it is—recycling to conserve natural resources.

II-5.2 Oregon.

Oregon has indicated that the project as designed is licensable, especially if a VIM system is installed. The state currently has steel mills licensed for operation using EAF. The Department of Environmental Quality has indicated that EAF processing will not be acceptable. Oregon personnel did not say they would not license the facility without it being a vacuum system, but indicated that licensing would be extremely difficult otherwise. A letter has been forwarded to the governor's office requesting support for continuing the state's involvement in this project, with the extensive evaluation to take place during the next phase.

During the next phase the necessary infrastructure modifications and specific site locations will be identified. At present, Oregon considers the area at the states' borders near the Hanford site to be the politically and socially acceptable site for this type of work. The local communities near Hanford are already accustomed to waste-processing facilities and have an understanding of the nuclear activities that have taken place there over the years. The remainder of the state is rather conservative, however, and the governor will have to deal with the siting of a radioactive scrap-metal-processing facility as a political issue before approval. The promise of zero emissions from air and water make this system licensable. Additionally, although not necessary for this project, a Resource Conservation and Recovery Act (RCRA) Type B permit is possible within the state for processing any of the waste stream materials.

II-5.3 Washington.

Washington has indicated a strong interest in the project and has also identified the area around the Hanford reservation as being the prime location for this project for many of the same reasons stated above. The personnel around the Hanford site and the infrastructure necessary to support a radioactive processing plant are already in place. Washington may have an advantage over Oregon by virtue of its site at the Hanford reservation 50 miles inside the Washington border. The state of Washington has passed an action item to their Department of Environmental Quality to evaluate the project further. In telephone discussions with the Department of Environmental Quality, there were no significant road blocks raised to the successful licensing of the facility. As a side note, ATG, a local (Hanford) environmental company has recently acquired a site license near the Hanford location for high temperature disposal of waste.

Washington is considered a candidate for the implementation of this project, and the state will identify specific sites and any necessary infrastructure modifications during Phase II of the project. The local Economic Development Organization in the Tri-Cities area is actively seeking privatization of activities that can address problems currently existing at the Hanford site.

II-5.4 Idaho.

Idaho, specifically the area around Idaho Falls and the INEL, embraces the project. Idaho has reviewed the plans of the project and considers VIM to be the single biggest step in convincing the governor that this project should be supported.

The governor is concerned about the importation of nuclear materials. This concern stems from the current debate over INEL's acceptance of the Navy's spent fuel, which is classified as high-level waste. Idaho's position is that they do not wish to be a permanent repository for any nuclear waste. However, if DOE finds and commits to a permanent storage site somewhere other than Idaho for the Navy's spent fuel, they are willing to accept it on a temporary basis. Until this much larger issue is resolved, the effect of the political fallout on the RSS project, even though it is with low-level radioactive material, only complicates the issue.

Nevertheless, Idaho is considered a significant player in this project, which will not be completed until the year 2000. The Navy-fuel issue will be resolved in the near future. As is the case with Oregon and Washington, zero emissions for air and water are paramount in obtaining a licensing. A cursory review of the INEL was conducted and found to possess a rolling mill that could be incorporated into the preliminary conceptual design. Many issues surround this facility. It is funded by the Department of Army and its capacity appears to be limited to the Army consuming the large majority through the year 2002. Excess manpower and operation costs are also issues.

II-5.5 Nevada.

Nevada is one of the locations that expressed an interest in the project. No discussion has taken place with the state's regulatory body regarding licensing. The state is interested in pursuing the project near the Nevada Test Site and considers the NTS site a significant advantage due to community reuse of the existing DOE facilities and land. Nevada will provide specific proposals regarding site locations and infrastructure modifications necessary to support this project as it proceeds into Phase II.

II-5.6 Arizona.

Arizona is one of the locations that expressed an interest through its economic development organization. No discussion has taken place with the state's regulatory body regarding licensing. Arizona wants to pursue the project and locate it near the Palo Verde Nuclear Power Plant. The existing infrastructure near the Palo Verde plant and community acceptance of nuclear-related businesses are significant advantages in siting near the Palo Verde Plant. Other sites within the state of Arizona are also being considered.

II-5.7 New Mexico.

New Mexico was contacted, as well as a representative from the Mescalero Indian tribe. The current activities within the Mescalero Indian tribe to site an interim-storage facility have their focus and they expressed no interest. New Mexico's Economic Development Department also expressed no interest. There was no feedback, positive or negative, from either the Mescaleros or the state of New Mexico.

II-5.8 Utah.

Utah's Economic Development Authority examined this project and indicated that the state was not interested. Another project, which had a significantly higher concentration level of radioactive materials (assumed to be a storage facility), had been submitted to the state for licensing and was turned down. Although the RSS mill will handle low-level radioactivity only, the previously rejected project tainted the local population and state officials.

II-5.9 Wyoming.

Wyoming economic development issues are different from the states discussed previously. The other states focus the decision of project support at the governor's office, which determines if a project like the RSS facility is licensable and desirable. Wyoming's approach is different. It considers the local population to have control of its own destiny and allows a community to determine by self-rule if a specific project should be permitted. The governor's office stays out of the decision-making process, not wishing to make it a state political issue.

The director of the economic development group from Casper, Wyoming, has indicated a strong desire to be the site location for the project. The group has asked significant technical questions and has generated local interest in this project moving forward. The main consideration is whether minimal emissions are attainable; the group also strongly supports the use of VIM. Specific site locations and infrastructure will be generated in Phase II for evaluation and final selection.

II-6.0 Release Limits

Although the RSS facility is not designed to "free release" material meeting surface contaminated limits, it is helpful to understand the overall release requirements in relation to bulk contamination. Metal that is processed through the RSS facility will be defined as bulk contaminated.

Metal can become bulk contaminated in two ways: 1) when contaminated metal is melted, the radiation is distributed homogeneously in the output product, and 2) when metal is exposed to high radiation fields, elements within the metal composition become "activated" and emit radiation.

Current regulations exist for the control and free release to unrestricted markets of low-level surface-contaminated metals. Surface-contaminated metals are those that have been in contact with radioactive material, but only to the extent that the surface holds any residual radioactive contaminants. Several processes can be used to decontaminate the surface, such as by grit blast, dry-ice blast, or chemical-solution stripping. If this surface metal meets the minimum-radiation levels, it may be released to the unrestricted scrap-metal market.

Although surface-release limits exist, no de minimus release limits have been established for bulk-contaminated material within the United States. De minimus limits are levels of radionuclides present in the metal below which the government is not concerned. Most European countries have defined bulk-contamination limits. Currently in the United States, there is a push to establish these de minimus limits. Should this happen, it would expand the possibilities for products produced at the RSS facility, significantly improving the viability of the project. The release criteria for bulk-contaminated radioactive metals have been, and are likely to continue being, debated among the regulatory bodies for several years. The EPA, NRC, and DOE are currently working on drafting proposed de minimus limits.

II-6.1 Surface Contamination.

For commercially regulated facilities the document that defines a release standard is Nuclear Regulatory (NUREG) Guide 1.86. A table from Reg. Guide 1.86, which establishes standards for fixed contamination and smearable contamination on the surfaces of metals, is presented in Table II-6.1. It is isotope dependent and only considers surface contamination. Typically, regulating bodies allow free release to commerce when Reg. Guide 1.86 is applied with a proviso. That proviso, in addition to the guidelines, is that the contamination present is "as low as reasonably achievable" (ALARA).

In RSM recycling facilities that have a free-release program, it is important to understand that none are allowed to release at the maximum level stated in Reg. Guide 1.86. There is some "reasonableness" to this rationale. If clean metals are brought into a controlled-metal recycling facility and contaminated with radioactive materials (albeit to low levels), regulators are not likely to allow the metal to be released to commerce after the maximum contamination allowed by Reg. Guide 1.86 has been added. This leads to an interactive arrangement between regulators and their licensed users. The expected future trend is to lower the release criteria to more restrictive levels as instrumentation and methods outdistance Reg. Guide 1.86.

Table II-6.1: Criteria for Unrestricted Release of Metals.

Radioactive Material	Removable (dpm/100 cm²)	Total: Fixed + Removable (dpm/100 cm²)	Maximum: Hot Spot (dpm/100 cm²)
U-natural, U-235, U-238, and associated decay products	1,000 α	5,000 α	15,000 α
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20 α or β	500 α or β	300 α or β
Th-natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	200 α or β	1,000 α or β	3000 α or β
β - γ emitters (nuclides with decay modes other than α emission or spontaneous fission) except Sr-90 and others noted above; includes mixed fission products containing Sr-90	1,000 β - γ	5,000 β - γ	15,000 β - γ

Source: Based on NRC Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors*, U.S. Nuclear Regulatory Commission, 1974.

While the United States is debating the various options of release criteria, the international community is moving forward on clear guidelines. A preliminary draft of those guidelines is presented in Table II-6.2. It is expected that U.S. standards, when finally agreed upon, will be more restrictive than those presented below in Table II-6.2

Table II-6.2: Nuclide-Specific Clearance Levels for Scrap Metal Recycling.

Nuclide	Mass Specific (Bq/g)	Surface Specific (Bq/cm ²)
³ H	1,000	100,000
¹⁴ C	100	1,000
⁵⁴ Mn	1	10
⁵⁵ Fe	10,000	10,000
⁶⁰ Co	1	10
⁵⁹ Ni	10,000	10,000
⁶⁵ Ni	10,000	1,000
⁶⁵ Zn	1	100
⁹⁰ Sr	10	1
⁹⁴ Nb	1	10
⁹⁹ Tc	100	1,000
¹⁰⁶ Ru	1	10
^{108m} Ag	1	10
^{110m} Ag	1	10
¹²⁵ Sb	10	100
¹³⁴ Cs	0.1	10
¹³⁷ Cs	1	100
¹⁴⁷ Pm	1,000	1,000
¹⁵¹ Sm	10,000	1,000
¹⁵² Eu	1	10
¹⁵⁴ Eu	1	10
²³⁴ U	1	0.1
²³⁵ U	1	0.1
²³⁸ U	1	0.1
²³⁷ Np	1	0.1
²³⁸ Pu	1	0.1
²³⁹ Pu	1	0.1
²⁴⁰ Pu	1	0.1
²⁴¹ Pu	10	1
²⁴¹ Am	1	0.1
²⁴⁴ Cm	1	0.1

II-6.2 Bulk Contamination.

Metals that are activated with fission products within the bulk or that have been melted, trapping contamination in the bulk, have no outlet to unrestricted commerce in the U.S. The consequence is that metals contaminated in the bulk either must be disposed of in burial sites or turned into restricted end-use products that are used by licensed facilities.

The international community does have guidelines, and they vary depending on country from 1 to 37 Bq/g. Proposed new international regulations are more lenient than those previously accepted. A brief summary of the proposed regulations is shown below in Table II-6.3.

Table II-6.3: Proposed International Standards for Release of Bulk Contaminated Metal.

Range of Activity Concentration (Bq/g)	Radionuclides	Representative Single Values of Activity Concentration (Bq/g)
Between 0.1 and 1.0	^{134}Cs , ^{23}Na , ^{24}Na , ^{54}Mn , ^{60}Co , ^{65}Zn , ^{94}Nb , $^{110\text{m}}\text{Ag}$, ^{124}Sb , ^{137}Cs , ^{152}Eu , ^{210}Pb , ^{226}Ra , ^{223}Ra , ^{230}Th , ^{233}Th , ^{231}Th , ^{234}U , ^{235}U , ^{238}U , ^{237}Np , ^{239}Pu , ^{240}Pu , ^{241}Am , ^{244}Cm	0.3
Between 1.0 and 10	^{58}Co , ^{59}Fe , ^{90}Sr , ^{106}Ru , ^{111}In , ^{131}I , ^{192}Ir , ^{198}Au , ^{240}Pu	3
Between 10 and 100	^{51}Cr , ^{57}Co , $^{99\text{m}}\text{Tc}$, ^{122}I , ^{123}I , ^{129}I , ^{144}Ce , ^{201}Tl , ^{241}Pu	30
Between 100 and 1,000	^{14}C , ^{32}P , ^{36}Cl , ^{55}Fe , ^{89}Sr , ^{90}Y , ^{109}Cd , ^{99}Tc	300
Between 1,000 and 10,000	^3H , ^{35}S , ^{45}Ca , ^{65}Ni , ^{147}Pm	3000

II-6.3 Radiation Survey Techniques.

A monitoring technique known as scanning is used to locate residual areas of surface contamination. Scanning is a manual technique used to detect and identify the location of

elevated areas of contamination (i.e., hot spots) and does not result in a quantitative measurement of surface activity. Scanning is usually carried out with the detector signal feeding into a rate-meter instrument with an audible output. If the count rate increases, the rate of movement of the detector is decreased or stopped over the area in question so that a localized survey can be performed to identify if a true hot spot exists.

The importance of this to the RSS facility is that when all material-transport containers (land-sea vans) are emptied, they will be scanned for certification for reuse. Any smearable contamination is analyzed to verify that the container meets the free-release limits stated above.

II-6.4 Segregation.

RSM generators mandate that DOE scrap be separate from commercial nuclear power plant (NPP) scrap. The importance in discrimination is that some isotopes found in DOE metals are not found in NPP metals and vice versa. Additionally, the outlet for disposal of the secondary waste is different for each. Since the generator is usually responsible for any secondary wastes associated with RSM recycling, nuclear power plant clients do not want DOE waste.

II-6.5 Melt Decontamination.

Partitioning is the process of separating different elements as part of a refining process. Elements may be partitioned (separated) into the slag or into the molten metal destined for the ingot. These separations occur as elements either volatilize into the off gas, migrate into the crucible lining, move to the slag through chemical attraction, or remain with the molten metal. Each element reacts differently depending upon temperature and other elements present to "attract" the specific element in question. The majority of partitioning information on nuclear power plant steel melting comes from the international community, while partitioning of isotopes of uranium and transuranic elements from steel melting comes from DOE activities (Mautz, 1975).

Partitioning of radioactive elements and other metallic species between the slag and the melt is a function of thermodynamic tendencies (e.g., temperature, free energy, and vapor pressure) and transport mechanisms (e.g., air turbulence, liquid melt turbulence, and density). Partitioning varies based on the differences in processing temperatures. Partitioning also varies due to the dynamics of the melting process. In EAF practices, steel directly beneath the arc will see much higher temperatures than the actual bath itself. This discontinuity in melt temperature affects partitioning. In induction melting, this local superheating above the liquidus temperature does not occur.

II-7.0 Radiological Controls

There are two types of radiological hazards associated with melting and casting radioactive steel: contact exposure and inhalation. Contact exposure occurs when personnel are sufficiently close to ionizing radiation to have an interaction with the body. As a philosophy in this steel facility, ALARA practices (as low as reasonably achievable) are employed through engineering controls, not administrative controls. Inhalation exposure is breathing in and retaining radioactive debris from dust in the air of the work place. Engineering controls and designs are used to minimize worker exposure. This requirement mandates that containment of emissions and exposure be controlled at source.

Engineering controls consist of large volumes of air being pulled through the facility from clean areas to areas of increasing contamination and the use of a VIM furnace for point source control of contamination emanating from the melt. All processing apparatus that emits fumes is covered and fumes are extracted directly to the HEPA-filtration system. The major reason to choose VIM processing is to minimize baghouse requirements and personnel exposure and to eliminate airborne contamination during melting. VIM processing by its nature occurs in a contained vessel allowing handling of small air volumes, which keep contamination confined to low volumes of waste. The steel VIM chamber also shields operators from alpha, beta, and weak gamma emissions during processing. There is also no exposure to thermal radiation as is typical in hot-metal shops.

Ladles filled in the vacuum chamber are covered and removed so that potential airborne contamination is captured at the liquid-metal surface during transport to the slab caster. This design prevents "smoke" from billowing from a ladle and contaminating the shop air. Similar point-source controls are at the casting station, plasma cutter, reheat furnace, rolling mill, and shear. Personnel performing routine operations are not required to use respirators and shielding to perform work. This philosophy has a twofold advantage in that exposure is minimized and worker productivity is high. While there are no routine operations that require respiratory aids and burdensome protective clothing, some maintenance activities may.

II-8.0 Output Products

Because the scope of the contract for this study did not include a market study, the most costly product to fabricate has been used as the baseline for analysis. It is also the most probable candidate for material that would be produced from existing RSM supplies.

The proposed mill will have the capability of producing both carbon and stainless steel products. A rolling mill that has the capability of producing 0.075-in. (16-gauge) sheet to 0.5-in. plate was chosen because of the likelihood of fabricating boxes, storage and transport containers, drums, and vitrification containers from this type of material. These are not the only products that can be produced for the DOE-restricted market, merely the ones selected for the baseline case in this study.

A look at the output products requires an understanding of the market place itself. The potential markets for output products are: 1) restricted end-use products, 2) limited-unrestricted-use products, 3) unrestricted products, and 4) melt for consolidation purposes. The first three examples constitute recycling in its purest form and offer the greatest beneficial use of the resource. The last option, melting for volume reduction only, does not constitute the full or optimal use of the resources available.

Restricted-use products are those consumed by the nuclear industry, such as boxes, drums, and containers to store radioactively contaminated products. The *limited unrestricted use* market is for those products used in casting marine engines and equipment, ship-building materials, and construction steel for bridges and roads. Typically, limited unrestricted markets are found in Europe, but are not in the U.S. because of the lack of de minimus release limits for bulk-contaminated metals. Potential *unrestricted-use* products include plate, sheet, and rod or bar to be used by commercial manufacturers that produce a myriad of products distributed widely throughout the marketplace. The last option, *melting for consolidation*, involves melting the radioactive scrap metal for volume reduction only and burying the product.

Work is presently underway to establish release limits for bulk-contaminated material within the United States. However, those limits will not be established within the next two to three years. Therefore, the products considered for fabrication are only those that would be subject to restricted use only.

The decision on what type of plant to build depends upon the market analysis on what types of products are desired by the marketplace. Therefore, due to lack of a better assumption, this economic analysis assumes the use of the most capital-intensive equipment. However, in order to properly design the facility, the market study and decision of what type of plant to be built must be revisited. If de minimus limits are established, the products produced by this plant can be sold in all markets at competitive prices.

As discussed in detail later in this report, alternate manufacturing techniques can be used, depending upon the end product desired. End products and product processing are integrally linked. Therefore, use of different casting and/or extrusion systems is dictated by market needs. Processes such as Osprey spray casting, centrifugal casting, rod and bar manufacturing, plate manufacturing, and sheet manufacturing all require different types of plants using significantly different types of equipment. Table II-8.1 below lists a sampling of the potential end-use products and the processes required to produce them.

Table II-8.1: Potential Products and Manufacturing Processes Required.

Applications	Process(es)
B-25 Boxes	Sheet or Plate
Land-sea Vans for RSM Use	Sheet or Plate
Vitrification Containers	Osprey Spray Casting, Centrifugal Casting, Plate, or Sheet (depending on wall thickness requirements).
PIT Containers	Osprey Spray Casting, Centrifugal Casting, Plate, or Sheet (depending on wall thickness requirements).
Navy Reactor-fuel Containers	Osprey, Centrifugal Casting, and Plate
Multi-purpose Canisters (DOE Design)	Osprey, Centrifugal Casting, and Plate
Multi-purpose Canisters (Commercial Products)	Osprey, Centrifugal Casting, and Plate
Drums (33/55/83/85 gallon)	Sheet
Rebar for Construction at New Mexico Storage Facility (Mescalero Indian Tribe)	Rebar
Plate Material for Construction for New Mexico Storage Facility (Mescaleros)	Sheet or Plate
Rebar for Construction of Monitored Retrievable Storage Facility	Rebar
Construction of Monitored Retrievable Storage Facility	Sheet or Plate
Rebar for Yucca Mountain Repository	Rebar
Construction of Yucca Mountain Repository	Sheet or Plate
Hot-cell Walls	Sheet
Specialized Castings for Nuclear Industry	Casting

II-8.1 Material Specifications.

This study evaluates the production of a finished product between 0.075-in. to 0.5-in. thick and up to 54-in. wide. The plant's design allows the production of:

1. Carbon steel plate and sheet made from carbon steel scrap,
2. Stainless steel plate and sheet made from stainless steel scrap, or
3. Stainless steel plate and sheet made from carbon steel scrap, or
4. Stainless steel made from carbon steel scrap and nickel scrap from the gaseous-diffusion plant.

The mix of steel scrap available within DOE is estimated to be 75 per cent carbon steel and 25 per cent stainless steel. Of the stainless steel that is available, approximately 20 per cent of that will be of high-nickel alloys and will provide additional high-cost alloying elements (chromium) in the conversion process. It is expected that the plant's most efficient operation will be in the production of 304, 304L, 316, and 316L materials. Most of the stainless steel scrap that comes from the nuclear industry will be of that same type. Carbon-steel products will be converted to 304 and 316 grades of stainless with the addition of alloys. With the use of a VIM furnace, the grade of stainless steel scrap introduced will be the grade of steel produced. Other furnace types will require addition of alloying elements because of the process interaction with air.

II-8.2 Stainless Steel Grades.

It is possible to produce stainless steel from carbon steel scrap. However, most producers of stainless steel prefer to stay with stainless steel scrap because of economics. This reduces alloying costs incurred from the addition of ferro-chromium, chrome, and/or nickel to carbon steel scrap. The exact formulation depends upon the grade of stainless steel being produced.

In the common grades of austenitic stainless steels, present specifications limit phosphorus to 0.03 to 0.05 per cent, copper and molybdenum to 0.05 per cent, and lead and tin to traces. The continued recycling of scrap has caused P, Cu, Mo, An, and Sn to rise to the upper limits of the steel specifications and, thus, some carbon steel scraps are added for the dilution of residual elements. However, for these grades stainless steel scrap is preferred.

With ferritic stainless steels, nickel is also limited to 0.50 per cent. With high-nickel scrap, care must be taken to avoid harmful residual alloys. Carbon-steel scrap is mostly used to make ferritic stainless steels.

A common classification of available scrap and their AISI equivalents are as follows:

No. 1 Cr Scrap	AISI 403, 410, 430, 446
No. 2 Cc Mo Scrap	AISI 501, 502
No. 3 NiCr Scrap*	AISI 302, 304, 305, 308, 309, 310 and 321
No. 4 NiCr Mo Scrap*	AISI 316
No. 5 NiCr Co Scrap*	AISI 347 and 348
No. 6 NiCr Mn Scrap*	AISI 201 and 202
No. 7 Cr Mn Scrap	16-II-17 and other new grades of 1% maximum Ni, 14-17% Mn Steels

* Denotes austenitic grades

II-8.3 Demand vs. U.S. Capacity.

Last year the stainless steel market in the U.S. was 1,677,000 tons (including $\pm$ 20% imports). The growth rate for stainless steel reflects a steady growth rate of 4 per cent. Many producers see the need for additional production and have taken steps to increase output at their facilities while many new facilities are being brought on line in the U.S. and abroad.

Some of the U.S. producers are:

Allegheny Ludlum	Butler, PA
Armco Group	Coshocton, PA
North American Stainless	Mansfield, OH
Lukens, Inc.	Coatsville, PA
	Washington, PA
Carpenter Technology	Reading, PA
Timken Company	Canton, OH
Republic Engineered Steels	Canton, OH
J & L Specialty Products Corp.	Midland, PA
Nucor	Crawfordsville, IN
Al-Tech	Waterviet, NY

The quantities in tons of stainless steel products sold in 1994 in the U.S. are listed below:

Sheet and Strip	1,200,000 tons
Plate	193,000 tons
Bars	174,000 tons
Rod	69,000 tons
Wire	41,000 tons
TOTAL	1,677,000 tons

II-9.0 Burial Costs/Projections

Between 1978 and the end of 1992, commercial low-level radioactive waste was disposed of at one of three operating disposal facilities in the United States: Beatty, Nevada; Richland, Washington; and Barnwell, South Carolina. In 1979, the governors of those states temporarily closed or severely restricted access to their facilities to generators of low-level radioactive waste outside their own state boundaries. They threatened permanent closure if the federal government did not make provisions for future low-level radioactive-waste disposal and a more equitable distribution of disposal responsibility.

Following the actions by the three governors, the National Governors' Association held meetings to discuss low-level-waste disposal. A special committee chaired by then-Governor Bruce Babbitt of Arizona was established to develop recommendations on the issue. Its members included then-Governor (now President) Bill Clinton of Arkansas.

The result was a proposal that led to the 1980 passage of the Low-level Radioactive Waste Policy Act, which required states to take responsibility for disposal of their own commercial low-level waste. The Low-level Radioactive Waste Policy Act encouraged states to form interstate compacts, or regional associations of states, for the purpose of low-level radioactive waste disposal. States that are not members of any compact are referred to as unaffiliated states.

In 1985, Congress extended the deadline for providing disposal capacity and added incentives to encourage states to comply with the act by passing the Low-level Radioactive Waste Policy Amendments Act.

II-9.1 Compact Structure.

The Low-level Radioactive Waste Policy Act defines a "compact" as a legal agreement between two or more states to share in the disposal of low-level radioactive waste. It is essentially a contract between states. For a state to become a member of a compact, its state legislature must enact the compact agreement as a statute. After the legislatures of all states in a compact enact the agreement, Congress must also consent to it. Each compact is responsible for the development of disposal capacity for commercial LLW generated within the members' borders.

The United States is organized into thirteen compacts consisting of small clusters of states for the purpose of low-level radioactive waste management. The relationship each state has with the compact is determined by its state legislature. Compacts are managed by commissions with members appointed by the governors of the states within the compact. The commissions are the administrative bodies responsible for the implementation of the compact.

Within each is a "host" state that has agreed to site a repository that accepts wastes from other member states of the compact. Each compact must either designate a host state to be the first in which the compact's disposal facility will be located or must otherwise provide for disposal of the waste (for example, through a contractual arrangement with another compact). The host state agrees to take waste from all the compact states for a designated period of time after which another state must build and operate a facility.

As can be seen in Table II-9.1, there are only two compacts with active disposal sites, the Northwest and the Southeast. At present, nine of the proposed thirteen regional compacts have actually been formed and approved by Congress. A tenth compact was formed in 1994, but to date has not been ratified by Congress.

Because the U.S. Constitution provides Congress the authority to regulate interstate commerce, only Congress can restrict such commerce. The Low-level Radioactive Waste Policy Act gives compacts the authority to exclude waste from a compact's disposal facility if the waste was generated outside the compact's borders. This congressional exemption of compacts from the Interstate Commerce clause of the Constitution was provided to encourage the formation of compacts. The Act does not give unaffiliated states the right to exclude waste generated outside the state's borders. This exclusionary authority is currently being exercised by the Northwest Compact and by the Southeast Compact.

Table II-9.1: Compact Organization and Disposal Site Status.

Compact	Host State	Status	Anticipated Operational Year
<i>Appalachian</i>	Pennsylvania	Site selection in progress.	1999
<i>Central States</i>	Nebraska	In license review. Litigation has stalled process.	None projected
<i>Central Midwest</i>	Illinois	Task group developing siting criteria.	None projected
<i>Midwest</i>	Ohio	Formative stages.	None projected
<i>Northeast</i>	Connecticut and New Jersey	Site selection.	2001
<i>Northwest</i>	Washington	Operational.	N/A
<i>Rocky Mountain</i>	None	Agreement in place to send to NW compact.	None
<i>Southeast</i>	North Carolina	South Carolina site (Barnwell) still operational.	1998 projected (Some question)
<i>Southwestern</i>	California	Site selected, some legal issues pending.	1997
<i>Texas</i>	Texas	License application complete, design in progress.	1997
<i>District of Columbia</i>	None	Seeking arrangements with other compacts.	None anticipated
<i>Massachusetts</i>	Massachusetts (Unofficial)	Siting in progress.	2000
<i>New York</i>	New York (Unofficial)	Potential sites being examined.	None projected

II-9.2 Current Price for Each Open Site.

There are two general categories of repositories: those operated by DOE and those managed by commercial operators as authorized under the compact structure described above. Sites operated by DOE will only accept wastes that originate in the DOE complex. Costs for those in the western U.S. are listed below:

Nevada Test Site	\$17/ ft ³ (incremental cost only).
Idaho National Engineering Laboratory	\$70/ ft ³ (estimate). (All costs are overhead; not accounted for on a cubic foot basis.)
Hanford Nuclear Reservation	\$35/ ft ³ , current surcharge. (Actual cost estimates vary, total cost not reported as a line item cost.)

Two commercial repositories are currently operating in the United States: Chem-Nuclear at Barnwell, South Carolina, operates for the Southeast compact and U.S. Ecology at Richland, Washington, operates for the Northwest compact. Although Barnwell was scheduled to close in December 1995, the state of South Carolina has indicated that it will stay open at least until the new Southeast Compact site in North Carolina opens. To further confuse the issue, Barnwell has "reopened" its site to waste from any compact. Costs for each are as follows:

Chem-Nuclear, Barnwell, SC	\$315/ ft ³ , now open and accepts material from anyone.
U.S. Ecology, Richland, WA	\$60/ ft ³ , with variable surcharges.

Costs for the commercial sector are notably higher than those quoted by DOE sources. A possible reason for this difference is that all incurred costs are not reflected in DOE rates (i.e., rates may be subsidized) and significant gate fees are applied by the state as a revenue-generating tactic. Accordingly, private-sector rates are more likely to be indicative of actual costs.

Note that a study (DOE/OR/2013) performed by Kapline Enterprises, Inc. (KEI) estimated the actual cost to DOE of on-site disposal of LLW mixed waste. KEI estimated that on-site shallow-land burial costs \$87/ft³ and on-site engineered disposal costs \$169/ft³. Engineered-disposal cost is comprised of two components: front-end support and disposal cost. The cost for a shallow-land disposal consists of three components: front-end capital cost, disposal O&M cost, and site-closure cost. These cost estimates do not include all costs (e.g., land) that are reflected in the commercial rates.

II-9.3 Sites Open by the Year 2000.

Of the sites shown in Table II-9.1 that could potentially be open by the year 2000, the most probable candidates are California and Texas; these sites are the furthest along in their licensing and design processes. Others such as Nebraska and Pennsylvania are either just getting started or have run into legal challenges that have stalled the licensing process.

II-9.4 Projected Costs.

As mentioned above, perhaps the most important issue in the recycle/bury decision is future burial costs. Regulations governing disposal facilities are becoming more stringent due to political pressures. As a result, licensing cycles are lengthening and, consequently, costs of building and operating burial facilities are rising. This trend can be illustrated by shifts in facility design. Those that have been planned for some time (e.g., California and Texas) propose shallow-landfill technology. Those recently planned (e.g., Nebraska and North Carolina) tend toward more expensive earth-mounded concrete-vault technology. Cost projections for each type are as follows:

Shallow Landfill	\$350-\$400/ft ³
Earth-mounded Vault	\$400-\$675/ ft ³

Table II-9.2: Historical Burial Prices. Where Are They Headed?

Location	Packaging Density (lbs./ft ³)	1985 Price		1990 Price		1995 Price	
		\$1 ft ³	\$/Ton	\$1 ft ³	\$/Ton	\$1 ft ³	\$/Ton
NTS	25	7	560	10	800	17	1360
Hanford, U.S. Ecology	80	10	250	25	625	70	1750
Barnwell	80	25	625	125	3125	315	7875
Barnwell	120	25	400	125	2075	315	5229

Burial at even the lowest-price DOE site (i.e., NTS) is approximately \$1,360/ton with a packaging density of 25 lbs./ft³. The question is will the NTS remain open to take waste and for how long? The next best rate is at Hanford (U.S. Ecology) at \$1,750/ton with a packaging density up to 80 lbs./ft³. A best guess of the price for commercial burial in the year 2000 is not less than \$2,000/ton and likely much higher. If the generator is a commercial utility, disposal costs are likely to soar for some disposal sites to \$500/ft³ or no less than \$10,000/ton.

Figure II-9.1: Current Burial Rates and Techniques Employed Produce the Need for Greater Recycling

(Note: Scale changes at \$100/ft³.)

II-10.0 RSM-processing Technology

Processing technology can be divided into three segments: 1) decontamination before melting, 2) foundry or melting operations, and 3) post-melt processing.

II-10.1 Decontamination Before Melting.

Decontamination is defined as the process of removing radioactive contamination from metals. A variety of mechanical and chemical processes may be used to decontaminate metals. When melting RSM, two philosophies exist: 1) clean the metals to remove scale, paint, organic contamination, and a large majority of radionuclides trapped at the surface of metals, or 2) throw everything in the melt as received and use pyro-metallurgical methods to handle undesirable contaminants. The first method is preferred when minimization of secondary waste and environmental cleanliness are desirable. The second is used when high productivity is paramount and secondary waste issues are minor.

II-10.1.1 Mechanical Methods:

Mechanical decontamination methods can be used to remove surface contaminants from metals. Mechanical decontamination techniques vary from simple hand wiping of surface powders and dusts to aggressive removal of metal surfaces with grit or ultra-high-pressure water.

Mechanical cleaning methods can be viewed as surface-cleaning or surface-removal processes. Surface-cleaning methods are used when debris is limited to near-surface material (e.g., loose surface powders or dust or embedded oxide, carbonate, silicate, or other surface layers associated with metals). Surface-removal methods are used for tightly adhering contamination such as surface oxide, carbonate, and/or silicate layers. Mechanical decontamination methods may be used as an alternative to chemical decontamination methods, simultaneously with chemical decontamination methods, or sequentially with chemical decontamination methods.

Mechanical cleaning methods require that the surface of the metal be accessible (i.e., generally free of crevices and corners that the process equipment cannot easily or effectively access). Thus, disassembly, sectioning, or other preparatory handling is necessary.

Remote handling and isolation should be used to minimize external and internal exposures during mechanical cleaning. Grit-blast cleaning methods frequently produce airborne dusts that can spread radioactive contamination and increase the risk of inhalation exposure to workers. Processing must be confined in installed containments with auxiliary ventilation and treatment systems to minimize risk.

II-10.1.2 Chemical Methods:

The use of chemical methods should be limited to minimize the generation of liquid waste. Chemical cleaning methods to remove fixed contamination from surfaces of ferrous and non-ferrous metals are generally metal specific. The effectiveness of a chemical cleaning method generally increases with contact time, concentration, temperature, and agitation. At times, a controlled sequence of different chemical formulations is needed to effectively clean the metals.

Chemical cleaning technology was developed in the chemical processing industry and was adapted for use by the nuclear industry. An extensive health and safety practices database has been developed for this technology. Non-aqueous solvents have been used throughout the industry to clean metals, although they generally yield RCRA wastes. Because of this, their use is limited. Table II-10.1 shows a typical list of chemicals used for cleaning metals.

Table II-10.1: Chemical Decontamination Methods.

Chemical Type	Description	Uses	Hazards
<i>Water</i>	Liquid with or without surfactants	Removal of bulk salts, grease and oil	slight
<i>Mineral Acids</i>	Hydrochloric, nitric, sulfuric and phosphoric used alone or in combination	dissolve metal oxide films	highly corrosive, incompatible with many materials
<i>Weak Organic & Inorganic Acids</i>	citric, oxalic, sulfuric acids	non-destructive cleaning	highly corrosive, incompatible with many materials
<i>Bases</i>	solutions of sodium or potassium hydroxide	removal of grease, oil, paint, mild rust	reactive, incompatible with some materials
<i>Salts</i>	both acidic and alkaline salts such as sodium bisulfate, ammonium oxalate, sodium carbonate	mild decontamination, softening paint	less corrosive than above but special handling still required
<i>Complexing Agents</i>	EDTA, HEDTA, etc.	trapping of removed metal ions in above solutions	must be broken down prior to disposal
<i>Oxidizing Agents</i>	Hydrogen peroxide potassium permanganate	assist dissolution of above solutions	reactive

II-10.2 Foundry Operations.

On the simplest level, melting a surface-contaminated metal will separate the contamination among ingot, slag, crucible residue, and exhaust. The remaining contamination within the ingot is bound within the matrix and is thus "fixed" contamination, thereby becoming bulk-contaminated material. A variety of metallurgical processes have been developed that remove contaminants from molten metals. In the liquid state, some contaminants are only partly miscible. Materials can be added to the mix to further reduce miscibility and allow the contaminants to be removed with the slag.

During metal melting, radioactive constituents are partitioned among the ingot slag, crucible residue, and off-gas. The partitioning depends upon the temperature of the furnace, the chemistries of the various materials at that temperature, and the presence of any scavenging agents designed to remove specific constituents. Figure II-10.1 provides an overview of the behavior of radiological constituents typically found in ferrous alloys during the metal-melting processes.

Figure II-10.1: Simplified Steel Melt Model.

The melting process partitions any radioactivity among four possible paths: the off-gas from the furnace, residues left in the crucible, and the slag. Remaining radioactivity is homogeneously distributed within the ingot.

II-10.3 Post-Melt Processing.

Metal that has been melted and solidified has partitioned radioactivity. Any remaining contamination is fixed in the ingot. Processes downstream of the melt are not likely to produce the migration of radioactive elements from the ingot. Operations such as forming, rolling, machining, shearing, and drilling should not release radiation that could be inhaled

or consumed by the workers. Operations that constitute selective remelting, such as welding or plasma cutting, may not be harmful, but are suspect. Additional study needs to be completed to verify that downstream fabrication operations do not harm factory workers.

The impact of the post-melt processing and the level of control is critical to how this RSS plant is implemented. If data are generated that support the hypothesis that post-melt contamination hazards are non-existent, then existing fabrication facilities may be "certified" with little to no controls on the fabrication activities. Local fabrication shops can be used, eliminating the need to develop fabrication capabilities. If the hazards are greater, then certain fabrication shops may be licensed for operation using the RSS feed stock. The worst case is that additional facilities may be required to be a part of the RSS for fabrication.

II-10.4 Fabrication.

Fabrication is assumed to take advantage of lower raw material costs provided by the RSS mill over that of virgin-metal producers. Table II-10.2 compares the cost of RSS fabrication with that of virgin metal.

Table II-10.2: Suggested Cost Comparison of RSS Fabrication Price Versus Virgin Metal Fabrication Prices.

Condition	Virgin Material	RSS Material
Hypothetical Carbon-steel Box	\$1.25/lb.	\$1.13/lb.
Hypothetical Stainless-steel Box	\$2.75/lb.	\$1.75/lb.

Examine the case of a carbon steel box that weighs 750 lbs. and costs \$950 to purchase (approximately \$1.25/lb.). The same box fabricated out of stainless steel weighs the same and costs \$2,060 (\$2.75). These are hypothetical boxes, but these estimates are close to actual fabrication prices for a B-25 box.

In the case of carbon steel, the raw-material cost is about 20 per cent of the total fabricated-product price of \$1.25/lb., which consists of \$1.00/lb. for fabrication plus \$0.25/lb. for raw materials. Assuming the RSS mill provides material at 50 per cent of the cost of virgin material, or \$0.13/lb., the price for the fabricated box is \$1.13/lb., 10 per cent less than one made from virgin raw materials.

Raw materials for stainless steel products are considerably higher in alloy content for the same product described above. The raw-material price is about 66 per cent of the total cost: \$1.50/lb. raw material cost and \$1.25/lb. fabrication costs. Making the same assumptions that the RSS mill can provide raw material at 70 per cent of virgin material

prices or \$1.00/lb., the box costs \$2.75/lb. or 30 per cent less than a similar box fabrication from virgin steel.

Assuming the above analysis applies to other carbon and stainless steel products, and also that the RSS plant can actually produce material at 50 to 70 per cent of the cost of virgin material, it appears that fabrication using RSS can be feasibly justified as a competitive process.

II-11.0 Steel Making Technology

Four assumptions are made in this analysis:

1. A 'micro-mill' producing 30,000 tpy of restricted use steel products exclusively from radioactive-contaminated scrap.
2. Heat size sufficient to cast 4-in. thick x 54-in. wide slabs.
3. Best available technology for containment of pollution and radioactivity.
4. Minimal waste byproducts.

Three technologies are available to perform the melting and refining requirements of the facility. These are:

1. Vacuum induction melting furnace (VIM)
2. Air induction melting furnace (AIM)
3. Electric arc furnace (EAF)

In addition to these melting systems, this section discusses, cold finishing, fabrication, and scrap processing.

II-11.1 Melting Systems.

Each melting system (EAF, AIM, and VIM) was evaluated against the criteria of achieving licensing in the states identified, secondary waste to be generated, and efficiencies in production. The EAF was eliminated because of the tremendous amount of KO61 mixed waste generated, noise, fume generation, and lack of ability to contain the fumes. KO61 is an EPA classification of hazardous waste for the EAF. Combine the radiation elements with KO61 waste and it results in a classification of mixed waste. The air induction system was eliminated because it generates significant quantities of secondary waste, difficult fume control, and excess exposure to the workers. Additionally, the regulatory offices in the states reviewed voiced a strong desire to achieve maximum waste containment through a VIM rather than open-air melting. The VIM process has no media for combustion, generates no fumes, and controls the collection of dust. The process does not directly expose personnel to the molten low-level radiation contaminated metal. It minimizes the radioactive waste disposal elements.

Tables II-11.1, II-11.2, and II-11.3 compare the three technologies. Table II-11.1 provides a general comparison, Table II-11.2 compares the quantity of secondary waste generated by each, and Table II-11.3 compares the secondary waste burial costs.

Table II-11.1: Melting Technology Comparison.

	VIM	AIR INDUCTION	EAF
<i>Heat Size</i>	30 Ton	30 Ton	30 Ton
<i>Power Requirements</i>	550 KWH/Ton	550 KWH/Ton	520 KWH/Ton
<i>Transformer Size</i>	13000 KVA	13000 KVA	20000 KVA
<i>Tap to Tap Time</i>	2.2 Hours	2.2 Hours	1.5 Hours
<i>Scrap Size</i>	48" Maximum	48" Maximum	Up to 72" long
<i>Number of Charges</i>	Continuous	Continuous	2 Bucket Charges
<i>Slag-off</i>	Minimal	Slag Skimmer	Yes
<i>Facility Decontamination</i>	Least Difficult	More Difficult	Most Difficult
<i>Lining Life</i>	40-50 Heats	40-50 Heats	Heats: 150 Sidewall Heats: 500 Bottom
<i>Noise</i>	None	Low	High
<i>Labor</i>	Moderate	Moderate	Moderate
<i>Reline Time</i>	24 Hours	24 Hours	16 Hours Sides 72 Bottom
<i>Fumes Generated</i>	None	Minimized over EAF	Extreme
<i>Air Pollution Control</i>	Excellent	Contained	Difficult
<i>Refining Capability</i>	Excellent	Limited	None
<i>Slag Waste</i>	2#/Ton	40#/Ton	80#/Ton
<i>Dust Waste</i>	0-2#/Ton	15#/Ton	25#/Ton
<i>Tapping Method</i>	Spout & Bottom	Spout & Bottom	Spout
<i>Equipment Cost</i>	\$13M	\$4.5M	\$5M
<i>Facility Costs for Pollution Control</i>	\$10M	\$20M	\$25M
KWH = Kilowatt hour kVA = Kilovolt-ampere M = Million	GOOD	MARGINAL	PROBLEMATIC

Table II-11.2: Quantity of Secondary Waste.

Secondary Waste	Slag lbs./ton	Dust lbs./ton	Refractory Reline lbs./ton	Scale lbs./ton	TOTAL lbs./ton
EAF*	80	25	4	2	111
AIM	40	15	14	2	71
VIM	4	0.67	14	2	19

* Note: The EAF dust is classified by the EPA KO61 as mixed waste when operated in a radiological environment.

Table II-11.3: Secondary Waste Disposal Costs.

Waste Disposal Cost		Burial Costs Per Ton of Steel Produced (\$/Ft ³) Density: 100 lbs. / Ft ³			
	Waste lbs/Ton	70 (\$/ft ³)	150 (\$/ft ³)	300 (\$/ft ³)	500 (\$/ft ³)
EAF*	111	77.70	166.50	333.00	555.00
Air Induction	71	49.70	106.50	213.00	355.00
VIM	19	13.30	28.50	57.00	95.00

* Mixed waste disposal not possible for waste containing transuranics.

II-11.1.1 Electric Arc Furnace:

The most common method of stainless steel production today is the use of the electric arc furnace. In most melt shops today, the EAF is used to quickly melt the metal in one hour or less. The melt is then transferred to a refining vessel [i.e., argon oxygen decarburization (AOD), vacuum oxygen decarburization (VOD), etc.], where it is refined to the grade of steel desired. While stainless steel can be produced entirely in the EAF, it generally is not done because of process economics.

High air-volume rates are required to remove arc furnace fumes and dust. Process fumes and dust are difficult to contain, especially during the charging operations. Therefore, the EAF process is not suitable for melting low-level radioactive materials. As compared to air induction, the loss of metallics is also greater in the EAF process. Disposal costs due to the baghouse are significant.

Air volumes are much greater than the other processes, which lead to larger baghouses and fan horsepower. Additionally, baghouse dust is classified as a hazardous waste (KO61) in a clean steel mill. Using this process in a radiological environment changes the classification of baghouse dust from KO61 to mixed waste, which has no outlet for disposal if transuranics are present.

II-11.1.2 Air Induction Melting Furnace:

Melting low-level radioactive-contaminated steel in the atmosphere in an air induction furnace poses many of the same problems experienced by melting in an EAF. The fumes and off-gassing of the melting materials are difficult to contain and/or collect, thereby spreading radiation throughout the interior of the plant. Refining is limited due to reactions with the atmosphere. Blowing oxygen for decarburization has the potential of creating a carbon boil, which could result in an explosive reaction. Refractory reaction with the melt and atmosphere shortens refractory life considerably. Slag buildup at the melt-line area

results in accelerated slag-line attack and shortening of refractory life. Open-air melting creates large volumes of air to be filtered through a baghouse and, subsequently, through a HEPA-filtration system, creating large volumes of radioactive waste for disposal.

II-11.1.3 Vacuum Induction Melting Furnace:

The vacuum induction melting process has excellent pollution control and minimizes waste. In the past, the VIM process was limited to either small batch sizes or long melt cycles. This was due primarily to the use of high-frequency-motor generator power supplies (60 Hertz), which had low power densities per ton of metal. The combination made the VIM process slow, tedious, and expensive. With the advent of the solid-state medium-frequency power supplies, shorter melt times can be used, improving process economics.

At present, a 12-ton VIM unit that uses an older-generation 3,600-kW, 180-Hertz power supply operates at Cartech (Reading, Pennsylvania). The lining life is 20 heats and it is changed every week to insure no interruptions during weekday operations. The company melts high-manganese-base alloys, which are the most demanding on refractory linings. Melting austenetic materials, such as those evaluated in this study, should dramatically increase refractory life. There are a number of 15- to 30-ton installations in the U.S. that use past-generation power supplies to melt austenetic steels and high-nickel-base alloys. A number of 10- to 25-metric-ton capacity units with solid-state power supplies operate in Europe, Japan, and Russia.

II-11.2 Cold Finishing.

The RSS-facility design selected as the baseline for this study does not have the cold-finishing operations needed to produce a product that is ready for fabrication. Capital equipment and facilities needed for annealing/quenching, slitting, and descaling operations are not included. It is estimated that an additional \$12 million covers these costs. The production cost for the cold-finish operation is estimated to be \$74/ton.

II-11.3 Fabrication.

The RSS-facility design does not include fabrication. Post-melt fabrication was discussed in Section II-10.4.

Fabrication facilities may or may not exist at the selected site. It is estimated that this work could add an additional 100 jobs to the selected community. A significant part of the evaluation criteria for site selection is access to firms that are willing to commit to producing the products defined by the market study. However, the key to allowing the individual fabrication firms to work with the RSS material is licensing. Data from studies on post-melt radiation hazards are necessary to support the licensing discussion.

II-11.4 Scrap Processing.

Allowances have been made for scrap storage, removing scrap from land-sea van containers, and sizing and loading the VIM charging canisters. The necessary grit-blast tumblers were sized to process a minimum of 15 tons/hour. Efforts to define the effects of grit blasting should be a part of Phase II.

Two factors for scrap processing are paramount in achieving good melt quality, proper size and cleanliness. Barnes Steel uses two 10-ton air induction furnaces and recommends cutting all scrap to a minimum size and processing only clean scrap. Much of the carbon steel received will have paint and rust. Some will have a contamination "fixant" sprayed to keep surface contamination from becoming airborne while in transit. Considering the level of incoming debris and contaminants, cleaning the scrap through a grit blast system (or other similar system) will make the melt specifications easier to maintain and reduce secondary waste.

12.0 Waste Control: International RSS Processing Experience

The use of RSM systems has been reported in France, Germany, Japan, Sweden, the United Kingdom, and the United States. However, large-tonnage commercial steel-making methods are not being used.

It is important to note that France is the only country currently using the EAF to melt RSM. The product from this 15-ton unit is cast iron, not high-quality steel. Mautz (US 1975) reported on melting steel contaminated with uranium in a 20-ton EAF. The total weight melted was 27,000 tons of carbon steel and 2,200 tons of stainless steel. This melt shop is no longer operational.

Other countries use coreless induction furnaces to generate liquid metal, the largest being a 20-ton unit used by Siempelkamp in Germany. The product from this furnace is also iron. Of the induction melting furnaces, Sweden's Studsvik melting facility is the only one where steel scrap is melted and steel ingots are produced. In all active melt shops, there is no attempt to refine melts with an active slag, whether it is EAF or AIM. The active RSM facilities do not use converters.

Section III: Preliminary Conceptual Design Details

III-1.0 Introduction

This preliminary design report describes the recycling facilities required for receiving, storing, melting, casting, and rolling radioactively contaminated steel scrap into plate and sheet. The study is based upon the premise that the most cost-effective way to produce steel is to use the same processes used by companies now producing high-quality steel. The project started with known processes and modified them for use with RSM. The latest radioactive contamination-control technologies were added to the steel-mill technology. The process selected for this study is a conventional process using a VIM furnace for melting, alloying, refining, decarburizing, and superheating. A continuous caster is used for producing long cast slabs and a Steckel mill/coiler is used for rolling the slabs into thin-gauge sheet.

Although the selected processes are conventional, the dusts, fumes, and cooling water normally generated in the production of steel will contain radioactive contaminants that cannot be discharged into the environment after treatment by conventional methods. Therefore, this study presumes that all process fumes, building dusts, and vapors are cycled through a baghouse and a nuclear-grade HEPA-filtration facility prior to discharge.

Some of the equipment costs (e.g., Steckel mill) have been based on used equipment that may not be available at a later date, which makes the budget estimates provisional. Site-development costs depend on geographical plant location.

III-2.0 Facility: Operational Definition

This project evaluates current technology for melting and processing radioactively contaminated metals and integrates that technology with the currently available technology in the steel industry. It is presupposed that the steel industry's cost-efficient techniques can be applied with a one-to-one conversion to process radioactive scrap metal. The main issues are melting and casting the RSM material and, especially, controlling emissions. Typical commercial melting operations use a large-capacity electric arc furnace to make the molten metal needed for continuously casting billets. The continuous-casting system depends upon large quantities of metal for maintaining continuous operations.

During the study, it was determined that the emissions for melting operations could not be effectively handled in an electric arc furnace or an open-air induction environment without requiring personnel to work in special clothing. The emissions from an electric arc furnace and/or an air induction furnace also require extreme monitoring measures. All the states where the mill might be located indicated that it would be difficult to obtain licensing if these furnaces were used. The technology with the best chance of licensing is vacuum induction melting.

VIM furnaces are typically small and require specialized feed mechanisms to maintain the vacuum during the feed cycle. All furnaces require multiple feeds to complete an entire melt of any given size. Therefore, there is a period of time that the VIM furnace is open to the atmosphere unless special modifications and feed systems are applied. Such feed systems are available commercially and have been applied to this design. The result is the selection of a 30-ton VIM furnace operating with one melt every 132 minutes, which is referred to as the tap-to-tap time. The facility is expected to make 30,000 tpy, operating with one shift per day, five days per week.

The 30-ton VIM furnace presents problems with casting on a 132-minute turn. The smallest continuous-casting operation that can be operated effectively requires approximately 18 minutes per 30-ton cast. The 30-ton VIM furnace does not keep up with the throughput requirements of a continuous caster, and using a larger VIM furnace is not practical. Because continuous casting will have start and stop operations with every melt, it is not clear that the continuous caster is the most efficient technique to use. Additional work must be done to develop casting systems that are consistent with batch processing. The overall goal in designing a new system is to maintain heat temperatures so that reduction operations begin on hot metal rather than cold metal. Cold metal must be reheated before processing.

III-2.1 Facility.

The facility occupies four distinct areas: scrap, melting, casting/rolling, and cold finishing. The first area—scrap processing, storage, and receiving—is designed for storing a two-month supply of feed stock. Keeping the same size and reconfiguring the layout can easily increase storage capacity to three months. The storage facility is under-roof in order to prevent rain water from coming into contact with the shipping containers being received. The storage facility allows segregation of land-sea van containers in order to separate DOE material from utility material. No details of the cold finishing area are provided because it was beyond the scope of the contract.

All water systems within the building are closed systems; no water escapes without having been processed, tested, and treated as appropriate. All air coming through the facility process area is exhausted through HEPA-filtration systems. The water/cooling system is self-contained and only make-up water is added as required due to evaporation.

III-2.2 Life Expectancy.

The overall life of the building is predicted to be 20 years, although a 10-year period was assumed for calculating return on investment (ROI) in Section IV-1.0. It is expected that the 20-year project will turn into a much longer project. Current funding constraints may cause decommissioning to slide into the future, not allowing metal to be processed at the same rate as currently predicted. This potential change will result in an overall useful-life extension of the project up to 30 years with insignificant changes in capital investment.

III-2.3 Size.

The capacity of the plant as designed is 30,000 tpy with an operation of one shift per day, seven days a week, 50 weeks per year. Should three shifts become necessary, its output would be about 100,000 tpy. Throughput is limited by melting furnace capacity (30-ton) and tap-to-tap time (132 minutes).

III-2.4 Transportation.

It is assumed that all material coming into the facility is transported by truck. The standard process for decontamination and decommissioning of a facility is to cut and place the material in land-sea vans and deliver to the burial site or a RSM-processing facility. Rail or barge transportation is not supported, so all outputs of the facility will be shipped by truck.

III-2.5 Restricted versus Unrestricted Use.

Also evaluated was a higher capacity (100,000 tpy) steel mill producing products for both restricted and unrestricted use—a plant that produces clean, virgin steel in the same facility that produces RSS. Being closer to mini-mill capacities, the facility would run more efficiently, achieving a lower cost of operation.

The mixed-output facility concept was abandoned because of several issues. One is that customers of steel mills are not interested in purchasing clean steel from a mill that performs RSM processing unless there is a considerable price break. The second issue is cost. It is not possible, using less than full mini-mill production techniques (i.e., VIM, underutilized continuous casters, etc.), to produce clean steel at the same cost as commercial manufacturers. Third is the difficulty faced in procuring a license for a facility with dual operation. Because of these issues, the project team decided to focus this study on a 30,000-tpy restricted end-use facility.

III-2.6 Property.

Sixty acres are required to support an adequate buffer zone between the processing plant and its neighbors. The building segments can be adjusted in orientation and relationship to each other to provide for a better footprint to match the actual site location selected.

III-2.7 Utility Usage.

III-2.7.1 Electricity:

The electricity requirements for the plant constitute a significant portion of the total cost of the products produced. As such, the cost for electricity is a significant element in the calculation for cost effectiveness. The electricity price assumed is \$0.04 per kilowatt hour that included demand and usage charges.

Demand usage can be accommodated by the facility by operating much like the Barnes Steel unit in Butler, PA. Barnes Steel has negotiated with the utilities company a low-demand rate based on usage between 9:00 P.M. and 9:00 A.M. Since the RSS facility is an operation with one shift per day, seven days a week, it is expected that a similar arrangement could be negotiated with the utility operating at the site location selected.

III-2.7.2 Gas:

Natural gas is used at the rate of 69 ft³/ton. The total annual gas usage is approximately 2.2 million cubic feet.

III-2.7.3 Water:

All water is in a closed-loop system, circulating approximately 8,000 gallons per minute. The water used for cooling during the casting and rolling operation is recovered. Water evaporated as a result of direct contact with hot metal is collected and exhausted through the HEPA-filtration system with the moisture being condensed prior to entering the HEPA-filtration system.

The water consumed by the plant is primarily make-up water needed to replace that lost through evaporation. Make-up water requirements are about 320 gallons per hour.

III-2.8 Closure Techniques.

A decommissioning plan is required as part of the final proposal in order to obtain project approval and licensing. The state selected as a site location will require bonds placed on the project to ensure future funding for decommissioning. A decommissioning surcharge is proposed similar to the way the nuclear utilities fund decommissioning of nuclear plants.

It is expected that this facility will not be decommissioned for 20 to 30 years. The anticipated

method of decommissioning is to begin cleanup in the storage area, remove the entire building structure, and melt it in the existing melting system. The next step is to take the reduction equipment (i.e., rolling mills) and melt those into ingots, leaving only the melt shop. As the facility reduces in size, the melting system becomes the last item to require decommissioning. Decommissioning costs are assumed to be approximately \$100/ft² of building. The RSS facility design has approximately 200,000 square feet. The costs are estimated to be \$20 million. A surcharge on each ton of metal processed will be collected and placed in an escrow account. For purposes of the surcharge calculation, it is assumed that 20-year life is achieved and 80 per cent capacity is maintained for the full 20 years. A surcharge of \$41/ton is required for decommissioning costs.

III-2.9 Ownership.

The project requires a significant capital investment. It is believed that the capital investment will come from a combination of sources. The best approach is to have the users (i.e., DOE and the utilities) invest in the facilities. The utilities may be interested in funding a joint venture, provided they receive special consideration in processing their metal. Special consideration would include reducing the capital-recovery costs from their price and other cost-cutting measures. The other potential investor in the project is DOE, which has no location to process scrap metal such as that described in this project. Funding this project offers DOE the possibility of saving many millions of dollars by avoiding burial and burial-site-management costs. The third potential investor in this project is private industry, although there are no steel-mill companies currently interested. Several RSM processors are interested. Not being a part of their core business and the liabilities associated with processing radioactive material tend to scare the steel companies away as investors.

III-2.10 Operation.

The facility is designed as a commercial operation. DOE orders, and control through DOE, will raise the capital equipment estimate by a factor of two. Operational costs will also be increased. A reassessment of feasibility is required if the facility is operated under DOE oversight.

III-3.0 Facility Description

III-3.1 Baseline.

The RSS facility is located on a 60-acre greenfield site with truck access and water, natural gas, and high-voltage electrical services. The plant is assumed to have an annual capacity of 30,000 tpy. The melt shop and rolling mill are assumed to produce either plate or thin-gauge strip in rolls.

For this study, the preliminary conceptual design is based upon the "mini-mill" concept using both new and used equipment. The plant is designed to melt RSM in a VIM furnace and to take the molten metal to a continuous-casting machine, where 4-in.-thick x 54-in.-wide steel slabs are produced. The slabs are then conveyed on a roller table to the reversing hot mill for production of 1/2-in. x 54-in. plates, approximately 20 ft. in length down to 16-gauge (0.075 in.) strip in 1,200 ft. rolls.

Three types of furnaces are considered in the study: EAF, VIM furnace, and AIM furnace. The VIM furnace is preferred due to its ability to contain fumes and its ability to refine, alloy, and degas. Melting in a vacuum also reduces the amount of slag produced (as compared to the arc process) and produces less furnace dust. This reduces the amount of baghouse dust to be handled and treated. Decarburization is performed only to remove the carbon present in the scrap. It is done in a vacuum, eliminating the possibility of a carbon boil.

It was assumed that scrap is received in 15-ton land-sea vans and stored in the receiving area. The receiving area can hold a two-month supply (5,000 tons) of scrap. This is approximately 360 land-sea van containers. The containers are placed on transfer cars and moved into the scrap-preparation area through an airlock. Here the containers are dumped into one of two parallel cutting lines that cut and pre-clean the scrap. A diagonal measurement of 48 in. (maximum) per piece is required to avoid jamming the scrap during furnace charging.

It is assumed that all contaminated scrap is separated by metal type prior to arrival at the facility. A pulpit control room allows personnel to control the loading and transfer in a controlled atmosphere in order to minimize radiation exposure. After cutting and pre-cleaning, the scrap is loaded into charging containers, which are then placed on the charging carrousel. The scrap-charging system consists of:

- ◆ Carrousel with track to transfer scrap from prep area to melt shop,
- ◆ Load cells mounted on the carrousel with readout to a scoreboard display, and
- ◆ Charge-container feed system mounted directly on the VIM furnace.

The scrap is fed to the furnace with the boom charger located on the furnace. The scrap charging is done through the isolation valve in the furnace hood. This minimizes the radiation exposure to the surrounding environment. The furnace chamber is pumped down to the desired vacuum level and melting is initiated. Five additional charges are added while maintaining vacuum as the melt progresses. The material is given a final superheat and the molten metal is transferred to the ladle. The full ladle is transferred to the caster tundish.

III-3.1.1 Surface Pre-Cleaning/Decontamination:

A preliminary investigation of the tumbling-grit-blast (tumblast) system was conducted to determine the feasibility of pre-cleaning scrap in order to remove low-level radiation. In this system, a high-velocity rotating wheel propels shot or abrasive onto the material being cleaned/decontaminated. The shot is then recirculated, separated from the contaminants, and reused.

Two types of tumblast systems are available for this application: a barrel system or a pitless system. These systems offer sufficient cleaning, depending on the material size and shape. The barrel system incorporates a chamber in which the contaminated scrap is "tumbled" by an interior belt to insure total coverage of the cleaning media. The scrap is cleansed by shot being propelled by a single wheel. In the pitless system, the scrap is passed through a cleaning chamber by a monorail or conveyor. The material is cleaned by shot propelled by multiple wheels configured to guarantee total coverage.

Both tumblast systems come in a variety of sizes and cleaning capacities. An advantage of the barrel system is its ability to clean multiple pieces at one time. A drawback is its inability to adequately tumble certain materials such as round objects or longer material. The result is less-than-total coverage by the shot, leaving uncleaned material. The pitless system can handle all configurations of material, but is a slower operation than the barrel system because the material must be loaded separately.

In order to select and size a pre-cleaning system, it is important to accurately know the sizes and configurations of the material to be cleaned. The preliminary conceptual design incorporates both systems. A barrel system efficiently handles the smaller material, while a pitless system handles larger items and those that could not be properly cleaned in the barrel system.

Many companies offer this type of cleaning equipment. Three companies that provided information are Rapid Blast, Pangborn, and Wheelabrator. A complete decontamination system that incorporates both the barrel and pitless type cleaners costs approximately \$1,500,000 installed. More information is required, such as shape, size, and tonnage of material, to obtain a more accurate estimate.

An additional cost to be considered is shot replacement, which is estimated to be \$1000 to \$2,000 per week. Reuse of the shot can be accomplished by separating the spent steel shot from other debris and using the exhausted media as feed stock for the VIM furnace.

III-3.1.2 Vacuum Induction Melting Furnace:

For the proposed 30,000 tpy facility, the design includes a 30-ton, 12-megawatt VIM unit. This unit will be installed with a spare 30-ton furnace assembly to allow linings to be changed outside the VIM chamber.

Refining time in a VIM furnace can be quite long. To accelerate this process, a low-frequency signal can be superimposed on the coil to increase agitation of the molten metal bath. This feature is

incorporated in the preliminary conceptual design and will result in lower tap-to-tap times, which increase throughput.

The continuous decarburization process uses scale (oxide) metered into the melt cycle after reaching 2,900°F. Final decarburization is achieved by adding scale during the refining/alloying phases. Scale addition to the VIM results in a nominal carbon reduction of 0.015 per cent per minute. The reaction is much more rapid at initial reduction and slows as the carbon content becomes small. Carbon steel (1020) containing 0.2 per cent carbon is reduced to 0.01 per cent in 30 minutes.

A complete timeline for the 30-ton furnace in the RSS is presented in Figure III-3.1. Melting occurs at about 1,000 pounds per minute. The initial charge (10 tons) is 50 per cent melted before the next charge of four tons is added. A total of five charges is added every eight minutes, allowing two minutes each for charging. The total melt time and time to temperature is 75 minutes. Samples and results are taken during the heat phase after full melting is achieved. Because of the stirring action of the VIM, homogeneous mixing is achieved rapidly after all metal is melted. Full decarburization is achieved in 30 minutes for a 0.2 per cent reduction in carbon. Alloying is begun during the last five minutes of the decarburization cycle. The alloy is sampled and tested; trim is added as required. The total tap-to-tap time is 132 minutes.

Scale addition as a method of decarburization in a 30-ton VIM has not been validated. A survey of 25- to 30-ton VIMs using decarburization techniques must be part of the Phase II effort to validate the timeline.

Figure III-11.1: VIM Process Timeline for Melt (132 minutes).

Melting identical grades of scrap maintain refractory life and minimize alloying and refining times. An alternative to this is to start with the lowest grade stainless and proceed to higher grades (i.e., 304 to 308 to 316). Least desirable, in terms of refractory life, is starting with carbon steel and making

stainless.

The above system reduces costs by eliminating the need for argon-oxygen decarburization (AOD) or a ladle metallurgy station (LMS). AOD or LMS equipment produces additional slags, fumes, and gases.

Pouring to the ladle is done in a vacuum, which minimizes personnel exposure to radiation and fumes. The molten metal is poured into a ladle tundish, which carries it out of the melt chamber and into the ladle. The ladle station is in a separate vacuum-lock enclosure. There is an isolation valve on the tundish to maintain the vacuum during melting and allow the ladle to be removed without affecting the process time. A lid is placed over the ladle, which is moved to the caster.

III-3.1.3 Casting Systems:

The VIM pours molten metal into a ladle system inside the vacuum. A lid covers the ladle during transport from the ladle airlock to the cast system. The ladle then bottom pours into a tundish that feeds the casting process.

The selected design is the most common in the steel industry. A continuous-cast system forms the rolling billet and feeds hot metal directly to the rolling mill. Current technology suggests that this process manufactures the best finished surfaces with no need for scalping. By eliminating the scalping process, recycling large quantities of metal chip is avoided.

The biggest drawback to the continuous caster being used in the RSS mill is that it consumes the 30-ton melt in 18 minutes. The rate may be modified some, but not to 132 minutes (the tap time of the VIM). Therefore, this design element will be used very inefficiently, at about only 13 per cent of its capacity. Because of this inefficiency, the continuous caster is referred to as a long-slab caster to avoid confusion. A single 90-ft. (plus) casting is the output of each 30-ton melt.

Another advantage of the long-slab caster is its flexibility. The width can be adjusted to produce sheet and plate at widths between 30 inches and 54 inches. In addition, the length of the casting varies with cast weight. Considering the variable product output required and uncertain input material, being able to adjust width and melt volume are important considerations. An ingot-cast system requires a different mold for each configuration to be cast.

Additional capital cost is associated with the continuous caster, but it improves production costs because of lack of reheat, machining, and recycle of chips.

The process replaces an ingot-casting process that requires cool down, ingot conditioning (machining four sides), reheating, and subsequent rolling. Assuming the castings are 4 in. x 54 in. x 6 ft., a 30-ton melt makes 15 castings in such a system. Each ingot requires 0.150 in. to be machined from each surface; the volume removed from each ingot is:

Top/Bottom (2)	54-in. x 72-in. x 0.150-in.	2 x 583 in. ³	1,166 in. ³
Sides (2)	4-in. x 72-in. x 0.150-in.	2 x 43 in. ³	86 in. ³
Total Volume Removed Per Ingot			<u>1,252 in.³</u>

Assuming the density of the chips to be 0.28 lbs./in.³, the net volume to be recycled is:

$$15 \text{ ingots} \times 1,252 \text{ in.}^3 \times 0.28 \text{ lbs./in.}^3 = 5,268 \text{ lbs. recycle/30-ton cast} \\ = 175 \text{ lbs. recycle/ton cast}$$

This is a significant quantity of material to be reprocessed, which adds to the cost of manpower and equipment to machine, reheat, and handle the ingots. Not counting the machine time and equipment costs, chip recycling adds about \$80/ton.

The ingot-cast system has an advantage over the continuous-cast process by reducing cooling-water requirements for the cool-down process. All cooling water used for the molds is non-contact water.

The continuous-slab-casting machine, designed to cast 4-in.-thick x 54-in.-wide slabs, is a low-head, straight-mold machine with a 16-ft. radius withdrawal section. The hot metal is fed from the ladle into the tundish through a slide-gate nozzle mounted on the bottom of the ladle. With a 30-ton heat size and a nominal casting speed of 60 inches per minute, it takes 18.37 minutes to cast a slab that is approximately 90-feet long. The slab is withdrawn from the mold and the caster spray chamber by a withdrawal-straightener. The 4-in. x 54-in. slab is then cut to the required length by a plasma torch cut-off device. The cut-to-length slabs are conveyed by roller table to the reheat furnace.

III-3.1.4 Rolling Operations:

The pusher-type, slab-reheat furnace, which is designed for end charging and discharging, is located at one end of the melt-shop building. The reheat furnace is used when the temperature of the slab falls below the required rolling temperature. Normal operations introduce hot metal directly into the rolling mill from the cast station. The reheat furnace has radiant-type, natural-gas-fired, roof-mounted burners that are complete with recuperator, waste-gas system, valves, regulators, and controls. It is designed to heat approximately 30 tons of slab to a rolling temperature of 2,200°F in 50 minutes. The slabs are removed individually from the furnace by extractor arms and placed on the rolling-mill tables in the mill building.

The rolling-mill building houses a 56-in. wide four high-reversing Steckel mill with a 12,000 Hp drive that operates at 1,500 fpm. The Steckel mill has hot-coil boxes on both ends to produce the 0.075-in. strip material. This mill gives the plant the flexibility to produce 0.075-in. strip to 0.50-in. thick plate. The 0.075-in. coils are 44-in. o.d., 28-in. i.d., 54-in. wide, and weigh approximately 13,500 lbs. A tentative rolling schedule is shown in Table III-3.2. The plant is designed to produce five coils per heat. The equipment is serviced by one 30/10-ton E.O.T. crane. The crane-rail elevation is approximately 30 ft. above floor level and has a rail span of 55 ft. The plates rolled on the mill are side discharged from the mill tables onto a 25-ft.-wide x 60-ft.-long cooling bed.

The coils are removed from the coiler and placed in the storage area.

Table III-3.1: Rolling Schedule for 16-Gauge (0.075-in.) Coils.

PASS SCHEDULE									
For 4-in. x 54-in. x 18-ft. 9-in. Coils									
Pass	Del. Thk. (In)	Length (Ft)	Total Elong (%)	Temp. (°F)	Del. Vel. (FPM)	Motor (H.P.)	Pass Time (Sec)	Delay Time (Sec)	Total Time (Sec)
0	4.00"	18.75'		2200				20	
1	2.66"	28.25'	1.51%	2150	400	12000	4.23	3	
2	1.77"	41.25'	2.25%	2135	600	13000	4.12	3	
3	1.047"	64.17'	3.65%	2100	600	13000	6.42	3	
4	.680"	109.97'	5.78%	1960	600	10000	11.0	3	
5	.422"	177.21'	9.32%	1850	600	8000	17.72	3	
6	.262"	283.43'	15.02%	1720	1000	9000	17.00	3	
7	.162"	462.96'	24.29%	1640	1000	9000	27.78	3	
8	.101"	742.57'	38.95%	1570	1500	7000	29.70	3	
9	.0625"	1200.00'	62.95%	1500	1500	6000	48.00		
<i>Shear</i>								6	
<i>Runout</i>								18	
							165.9	68	233.97 or 3.90 min.
<i>5 Coils per 30 Ton Heat</i>									19.4 min.

III-3.1.5 Utilization Factors:

Table III-3.1 shows the use of each of the major components. As can be seen by this comparison, the VIM furnace is the bottleneck.

Table III-3.2: Facility Equipment, Time, and Utilization Percentages.

Facility	Time	Utilization
<i>Rolling Mill</i>	19.5	15%
<i>Caster</i>	18.37	13%
<i>VTM</i>	132	100%

III-3.2 Mechanical.

III-3.2.1 General:

The utility-support systems required for the RSS facility consist of potable water, process water, natural gas, compressed air, above ground process drainage, underground drainage for the non-process areas, and sanitary sewer. Process-equipment utility systems for handling oxygen, argon, and de-ionized water are described in the process equipment description. Mechanical systems consist of: 1) air conditioning for the office area, electrical-control room, laboratory area, scrap pulpit, control room, and miscellaneous worker retreats within the process area; 2) heating and ventilating for all process areas except the scrap-receiving area; 3) process exhaust for the process area and process equipment; and 4) ventilation for the scrap-receiving area.

III-3.2.2 Plumbing and Piping:

Water

Water is routed from the site service main and split into fire-water and potable-water mains. The potable-water main is routed through a city/county water meter located in a concrete pit, then to a utilities building for the facility. This main is split again into potable-water and process-water main with a back-flow preventer. The potable water services the office areas and, with a back-flow preventer, the locker/change rooms. The process-water main services manufacturing operations. The fire-water main is routed to an above ground "hot box" where parallel double-check valves with in/out valving are located. Parallel valves are used to maintain partial flow when one fails. The fire-water main is routed to a fire-water loop that surrounds the facility. The fire-water loop services the hydrants and building fire-water risers for the facility.

Natural Gas

Natural gas is routed to an open shed for an above ground American Gas Association-approved gas train that reduces the pressure to 40 psig. This is split to process and non-process distribution lines.

The non-process line is routed through another pressure-reducing station to lower the pressure to 10 psig before being routed to use ports. The process line is routed to use ports with a line pressure of 40 psig.

Compressed Air

Compressed air is provided for the facility by an air compressor that is located in the utilities building. The air compressor provides 125-psig air, which is split into a 125-psig high-pressure

main and a 35-psig low-pressure main. The high-pressure air is used for process equipment, service drops, and process-exhaust baghouse, which use 90-psig compressed air. The low-pressure main is used for control systems. The system uses a drier and an oil/water filter. Receivers for the system are sized to keep the compressor cycle time to 20 minutes per hour.

Drainage

Process drainage is above ground. Water tight concrete trenches with drains are provided for floor-mounted equipment. These drains are routed below the floor level. Tanks are provided for process pits and are located in watertight concrete pits. Process water to be discharged to the city sewer system is routed through a process-water-treatment system located at the facility. The discharge for the system is routed to a holding tank to permit testing to confirm water quality prior to release.

III-3.2.3 Heating, Ventilating, and Air Conditioning:

Heating, ventilating, and air conditioning (HVAC) systems are operated from a controlled facility having restricted entrances and exits. The facility radiological areas are controlled spaces. Along with the controlled-access concept, the facility air pressure, with respect to atmosphere, is negative. The air pressure is designed to be progressively more negative as one proceeds from a clean area to a dirty area, and from the dirty area to a dirtier area. Another feature of the controlled-access concept is a single-point HEPA-filtered exhaust for the process-exhaust system. The office area, electrical-control room, motor-ventilation rooms, and scrap-receiving area are non-radiological spaces that will not be contaminated and will not have controlled space pressure with respect to atmosphere.

Air Conditioning

Air conditioning is provided for the office areas, electrical-control room, laboratories, scrap pulpit, control room, and miscellaneous worker retreats within the process area. In general, the temperature will be maintained at 76°F in the summer and 72°F in the winter. However, the electrical-control-room temperature will be 105°F in the summer and 65°F in the winter.

The office area and electrical-control room, which are non-radiological areas, are both served by a roof-mounted air conditioning unit (ACU). The ACUs have a gas-fired heating system and an air-cooled refrigeration system. A variable-air-volume system is provided for the office area. Through-the-wall ACUs are provided for the small office, laboratory, and worker retreats. Any areas located on an outside wall or next to a non-conditioned area are provided electric heat. Each air conditioned area is provided outside air to maintain positive pressure with respect to the surrounding areas. Filtration for the office area and electrical-control-room ACUs will have a minimum efficiency of 35 per cent. Normal filtration is provided for the remaining ACUs.

Heating and Ventilating

Heat and ventilation are provided for the following areas: scrap preparation, container-rework station, VIM furnace, casting area, rolling mill, HEPA-filtration buildings, and utilities building. The scrap-receiving area is ventilated with an exhaust system. The heating and ventilating units (HVUs) provide 100 per cent outside air to the facility. The roof-mounted HVUs are gas fired,

and pressure regulators are provided with the HVUs to drop the supply pressure to the unit-required pressure. Filters for the HVUs are 65 per cent efficient. Ductwork for these areas is routed down the walls to supply air within eight feet of the floor. Summer space temperature will be maintained at 10°F above outside ambient at five feet above the floor; winter space temperature will be 65°F at five feet above the floor.

A motor-ventilation system is provided for each motor. Each system consists of a ventilation fan (located in a basement below the motors and electrical-control room), a cooling coil using cooling-tower water to cool ventilation air (located in the basement), roll filters (located in the basement), and controls. Roll filters for the motor-ventilation system are at least 35 per cent efficient. The controls are through the building-management system (BMS). Ductwork for the motor-ventilation system is routed directly to the motor stands and discharged outside the building. Heating and ventilation for the motor-ventilation room is provided by the motor-ventilation system.

The system uses ambient air, cooled by the cooling coil, to control the temperature of the motor; exit air temperature is maintained at 105°F (110°F maximum). As part of the motor-ventilation system, a carbon-brush exhaust system is provided for each motor. Each carbon-brush exhaust system consists of a dust collector and exhaust fan, which discharges outside the building.

The process exhaust for the facility provides, to the greatest extent possible, point-source control of dust and fumes generated by the equipment. Water cooling is provided for the exhaust ducts for high-temperature exhaust air stream hoods as indicated below. Exhaust hoods are provided for the following areas:

- ◆ Scrap preparation: vibrating conveyors, sheers, bandsaws;
- ◆ Rework station: induction furnace reline station, tundish rework station, ladle and tundish cleanout, and slag thimbles;
- ◆ VIM furnace area (high temperature): scrap-charging entrance, ladle entrance, and furnace entrance;
- ◆ Caster area (high temperature, except for the runout tables and cooling bed): tundish preheat station, ladle preheat station, ladle pour station, slab plasma torch area, casting runout tables, caster cooling bed, and caster holding furnace;
- ◆ Rolling mill: runout table, hydraulic descale and cooling bed; and
- ◆ Baghouse/HEPA-filter housing building: baghouse drum stations and general area.

All process exhaust is routed through HEPA filters prior to discharge to the environment. Process exhaust from the rework-station area, ladle-pour station, slab-cast area, plasma-torch area, melt shop select areas, and the equipment exhaust (i.e., vacuum-system exhaust for the VIM furnace) is routed through a baghouse in addition to the HEPA filters.

Exhaust streams from the VIM-furnace vacuum system and other hot air streams are provided an air wash to reduce the temperature to below 300°F. (Nomex bags for the baghouse are limited to 400°F and HEPA filters are limited to 500°F maximum.) If an air wash is used to reduce the air temperature, the use of a demister and reheat coil downstream will be evaluated for HEPA-filter protection. The reheat coil is either an indirect gas-fired duct heater or an electric coil. Exhaust

ductwork is water cooled at some locations.

Three process-exhaust streams enter the only exhaust stack that is monitored. One stream (melt shop selected areas) is routed through a baghouse and HEPA-filter housing. Two others (rolling mill process exhaust and scrap preparation with melt shop non-select areas process exhaust) are routed through a HEPA-filter housing only. It is desirable to maintain the separation of the baghouse and non-baghouse exhaust streams due to the pressure difference. The reason for this is that the exhaust fans for the line without the baghouse require less horsepower.

The baghouse and HEPA-filter housings for each process-exhaust stream have a backup section for maintenance. The exhaust fans for each process-exhaust stream are connected in parallel with a backup fan for maintenance. The HEPA-filter housing consists of a 95 per cent efficient pre-filter, HEPA-filter testing section, first-stage HEPA filter, HEPA-filter testing section, a second-stage HEPA filter, and HEPA-filter testing section. The HEPA-filter housings allow external maintenance and filter removal. This requires the housing depth to be at least that of the width of three filters. The filter housings are six filters high (a maximum for one unit); this requires a movable scissors platform (5 ft. wide x 6 ft. long) for maintenance. The baghouse discharges are tied together in one duct before being separated for the HEPA-filter housings. This permits one baghouse section or HEPA-filter housing to be removed without affecting the other. This gives maintenance the flexibility of testing the HEPA-filter housings during filter replacement.

An area exhaust system is provided for the scrap-receiving area. The system is sized as required by the *Industrial Ventilation Manual* to accommodate truck exhaust and space ventilation.

A distributed-control-type BMS system is provided to control the HVAC systems, including the rolling mill and prep./melt shop process-exhaust systems. The Building Management System (BMS) is used to control building pressure, space temperature, and monitor various HVAC system conditions. The BMS controls facility airflow reduction during non-operating shifts. A central direct-digital control system is the basis of the BMS. A monitor and central processing unit (CPU) are located in the facility engineer's office along with a printer to record alarm events. Software is provided to diagram each HVAC system, permit setpoint adjustment, monitor system conditions, record alarm conditions, and identify alarm situations. Compressed air is used to power actuators.

III-3.3 Electrical.

III-3.3.1 Site Power:

Consideration of the available electrical utility service will be a factor in site selection. The design assumes that high-voltage (69 kV - 250 kV) transmission lines, installed by the local utility from the nearest high-voltage source to an outdoor substation, are located on the facility grounds. An electrical contractor will be responsible for the substation installation and power distribution from the substation to the facility.

III-3.3.2 Outdoor Substation:

The final design and construction will most likely be done by a turnkey contractor experienced in

designing and installing substations. The outdoor substation is to be a three-phase, 70 megavolt-ampere (MVA) nominal substation that steps down from 141 kV to 34.5 kV. Power is distributed throughout the facility at 34.5 kV, which is the primary voltage used by the mill. Staged cooling for the delta-wye grounded transformer bank is required. The substation sits on a concrete pad inside a fenced enclosure large enough to contain all high-voltage equipment and supports. The ground inside the fence is graveled.

III-3.3.3 Power Distribution:

The substation distributes power to the entire facility. Two outdoor 35-MVA three-phase transformers distribute power to the entire facility through two main 1,000-A busses. One bus serves the furnace operations. The other bus serves the balance of the facility. A normally open tie switch connects the two busses. A study of the power system for harmonic flicker and power factors should be conducted by the contractor. The substation designer and installer will guarantee the final performance of the harmonic filters after the filters are installed.

A 13,000-kVA transformer supplies the 30-ton VIM furnace. Unit substations with transformers are installed in remote locations in the building. This provides a means to distribute lower voltages throughout the facility, keeping feeder-circuit distances at a minimum.

Production loads involving the ladle and caster operation have a utilization voltage of 4,160 volts. Motors (200 Hp and above) such as the 6,000 Hp tandem rolling mill motors also operate at 4,160 volts. This includes other 200 Hp and above motors that operate the runout tables, plate shearer and leveler, etc. All motors less than 200 Hp operate at the appropriate low voltage. Motor-control centers (MCCs) house the controls for the low-voltage motors. These are located in the electrical-control room. Non-fusible disconnect switches are provided at all low-voltage motor loads.

The variable-speed alternating current (AC) drives for the rolling-mill motors and other production-line motors are to be designed and installed by a turnkey contractor specializing in motor-drive control for steel mills.

Building loads include, but are not limited to, the office building, melt-shop service building, metallurgical and quality-control laboratory, and other miscellaneous buildings located on the site grounds. Building loads usually operate at low voltages. Exceptions to this are large motors operating cooling-tower pumps or exhaust fans located near the HEPA-filter buildings.

III-3.3.4 Lighting:

Exterior lighting is provided around the steel-mill structure and at locations where personnel are likely to be during evening hours as needed for security. Light levels are based on the recommendations of the Illuminating Engineering Society (IES) of North America. Floodlights around the building are 100-W high-pressure-sodium (HPS) lamps. The lighting for the parking lot is 400-W HPS lamps supported by steel poles.

Interior lighting within the main production facility and other high-bay areas is with 1,000-W HPS high-bay fixtures. The general light level is 40 foot-candles (fc). High-bay lighting is mounted to the bottom of roof joists. Switching methods are manual. Emergency lighting is installed throughout the main production facility to allow evacuation in emergencies.

Within the indirect production facilities, fluorescent lighting is used to provide a general lighting level of 40 fc. Switching is performed by electronic controls. Emergency lighting is installed to provide evacuation in emergencies. Energy-saving products such as electronic ballasts and T8 fluorescent lamps are used to reduce energy consumption.

III-3.3.5 Auxiliary Systems:

Fire-alarm systems are installed in the indirect production facilities. As a minimum, the fire-alarm system consists of photoelectric smoke and/or heat detectors, pull stations, and local and remote annunciation. The nearest municipal fire department is tied into the alarm system. Alarms sound in all control pulpits, crane cabs, offices, service areas, and laboratories.

Public address (PA) speakers, telephones, and data outlets are installed throughout the entire steel-mill facility. PA speakers are installed inside crane cabs and at all control pulpits.

Closed-circuit television (CCTV) is used to monitor areas for security purposes. CCTV systems are being considered as a means to view inside the VIM furnace.

III-3.3.6 Grounding:

A building ground grid is installed around all buildings. Consideration is being given to tying the building rebar to the building ground grid, based on soil conductivity at the selected site. Site fencing is grounded and all buried ground connections are thermally welded.

III-3.4 Architectural.

Auxiliary spaces to support the process areas within the facility include an administrative area, a small office area, three locker areas, four boundary-control stations, a lunchroom, a storage area, and maintenance-support offices.

The main office area is single story and consists of hard-walled offices for approximately 28 people. This area is the public-access point into the facility, and it has the main receptionist area as well as a guard station. Personnel are required to enter and exit the process area through monitoring stations (referred to in this document as boundary-control stations).

The secondary office area consists of eight modular, open-office cubicles of approximately 100 square feet each. The area is accessible from the building exterior, but it does not have a lobby or reception area. It has both men's and women's locker rooms as well as a boundary-control station at its interface with the process area.

The melt-shop and caster areas are supported by a locker room and boundary-control station. The locker rooms are sized to accommodate 25 male employees and 5 female employees. Both locker rooms are entered from the building exterior. Access between the locker areas and process areas are through a boundary-control station.

The mill, maintenance, and fabrication areas have supporting locker rooms, lunchroom, storage area, boundary-control station, and maintenance-support offices. The locker rooms, storage area, maintenance-support offices, and boundary-control station are located on the ground floor. There is a lobby/entry area into these supporting spaces from the building exterior. There is also a lunchroom in this area that is located on the second floor. Access to the lunchroom is through the lobby/entry area only. Employees exiting the process area are monitored in the boundary-control area before being allowed access to the lunchroom.

The following is a discussion of the materials of construction for auxiliary spaces:

The typical exterior walls of the office and locker areas are precast concrete painted to ten feet above finished floor and metal siding continuous to the roof line. The metal panels consist of 24-gauge (minimum), ribbed, pre-finished and factory-coated steel panels over steel framing.

The roofing over the office and locker areas is single-ply membrane roof over rigid insulation on metal deck-and-steel framing. The minimum roof slope is 1/4-inch per foot. The roof materials and assembly comply with the requirements of Factory Mutual Class I, fire-rated Roof Deck Construction and I-60 Windstorm Classification, and with Underwriter's Laboratory, Inc., for Class A roof covering. The roof is tested and certified for a 20-year warranty.

All exterior walls in the offices and locker areas are furred out with metal studs, batt insulation, and gypsum board. All interior walls in these areas are metal-stud and gypsum-board construction. Interior walls that separate the office or locker areas from process areas are insulated with sound-attenuation blankets.

The exterior exit doors in the office and locker areas are insulated hollow metal with pressed hollow-metal frames. Exterior doors must have controlled access or be equipped with exit-only hardware. Interior doors within the office and locker areas are natural-finish solid-core wood doors in pressed hollow-metal frames. Interior doors between office or locker areas and process areas are hollow metal in pressed hollow-metal frames. Where doors required for exit egress pass from dirty areas into clean areas, the doors are equipped with alarms and exit-only devices. Non-emergency access and egress into process areas are through boundary-control stations equipped with radiation-monitoring equipment.

Exterior windows in the office and locker areas are 1-in. insulated glass in pre-finished, inoperable aluminum frames. Locker-area windows have translucent glazing to permit natural

light into the areas, but to obscure views inside. Interior windows in the office areas are 1/4-in. tempered glass in painted hollow-metal frames.

The ceilings in the office areas are 2-ft. x 2-ft. suspended acoustical tile. Ceilings in the locker areas are painted, suspended, moisture-resistant gypsum board. The ceiling heights in both areas are 10 ft. above finished floor.

The floor finish in the office areas is carpet with vinyl base. The floor finish in the locker areas is seamless sheet vinyl. The floor finish in the shower stalls is ceramic tile.

The locker rooms have toilet and shower facilities as well as changing areas. The changing areas have metal lockers, wooden-bench seating, and frameless mirrors mounted on the walls over the sinks.

III-3.5 Structural.

Load combinations and allowable stresses are in accordance with the Uniform Building Code unless local codes result in a more stringent design. Due regard is given to all building and equipment loads as well as provisions for wind and seismic loadings.

The structural framing for the facility consists of steel frames with metal roof decking and siding. The structural frames are a combination of moment-resisting frames and braced frames consisting of rolled-shape steel beams and columns. The roof-support system consists of bar-joist purlins supported by the steel-frame members. Building clearances provide an operating envelope for all gantry and top-running cranes.

The facility foundations consist of reinforced concrete supported by grade or a pile or pier system, depending on site location. The equipment foundations, trenches, and pits also consist of reinforced concrete as does the building slab.

III-3.6 Radiological Monitoring.

Controls to minimize the spread of radiological contamination are included in this facility design. This section discusses the instrumentation necessary to monitor the radiological condition of the facility areas and provides the assessment of these conditions.

III-3.6.1 Airborne Radiation Monitoring:

Each area of the facility is monitored for airborne radionuclides. This is accomplished by drawing ambient air across a filter and monitoring the level of radionuclides collected. Each area, as defined by the HVAC design, has a minimum of one airborne-radiation monitor. Clean areas are monitored to verify that the level of radiation remains acceptably low. In addition to the interior of the facility, selected exterior sites are monitored for airborne radionuclides. Each monitor alarms in its area as well as reports to a central location that has a data logger and alarm.

III-3.6.2 Dose Monitoring:

Radiation-dose levels are monitored in the scrap preparation, VIM furnace, and rework station

areas. Detector probes are mounted to provide coverage of these areas and report to the central data logger through the appropriate electronics units.

III-3.6.3 Stack Monitoring:

Ventilation air exiting through the exhaust stack is monitored for radionuclide and radiation level. The sample-collection system, an isokinetic stack, is required by air-permitting authorities with jurisdiction of the plant site. The air sample is pulled through a nuclide-specific particulate-radiation monitor that detects alpha, beta, and gamma. The monitoring system provides a means of record keeping by logging and reporting the measured data.

III-3.6.4 Boundary Control:

Boundary-control stations are provided for personnel access to the contaminated areas of the facility. Each boundary-control station is provided with personnel radiological-contamination monitors that allow individuals to monitor themselves as they exit these areas. Administrative procedures describe the method of passage through the station.

III-3.7 Civil.

Excavation is needed to establish sub-grades for building pads and footings. Land designated as parking areas, entrance roads, and loading docks is graded to allow for construction of these areas and to allow storm-water management for surface runoff.

A detention pond is required to control storm-water runoff, which is increased due to additional impervious areas caused by construction. The detention pond is large enough to prevent an increase in the rate of runoff after the facility is completed.

Potable-water and sanitary-sewer service are assumed to be available within one-quarter mile from the facility. The potable water connects to the utility system with a meter and backflow preventer in a hot box above grade.

A branch connection with a backflow preventer provide water for the fire loop and building sprinkler system. These water lines are 10 inches in diameter and are installed underground with a minimum of 30 inches of cover as required for frost protection.

The gravity-fed sanitary-sewer line running from the building to the public-collection system is an 8-inch-diameter line (minimum) with 300-foot manhole spacing.

The natural-gas service requires an underground 2 inch line (minimum) that runs to a connection point one-quarter mile from the building.

The entrance road needed to access the facility is assumed to be one-quarter mile long with two 12-foot lanes. The road has six inches of asphalt pavement on a ten-inch aggregate base, concrete curbs, and gutters.

Asphalt-paved parking is provided for a minimum of 150 cars with 365 square feet of pavement per space. This allows 100 cars for the first shift with a 50-car overlap at shift changes. Loading-dock areas are constructed with heavy-duty concrete in truck turnaround areas and loading-dock aprons. Each truck bay requires 140 square yards of concrete pavement.

III-4.0 Alternate Possibilities

III-4.1 Heat Recovery.

The mechanical systems for a steel mill typically discharge a large quantity of heat to the environment that could be recovered. The mechanical systems for this facility are no different. The following areas should be examined during the conceptual-design stage for heat recovery.

- ◆ The process-exhaust system discharges a tremendous amount of hot air that might be used for tempering make-up air for the heating and ventilating systems.
- ◆ The use of an air wash to reduce the air temperature from the process hot spots could be changed to an air-to-water heat exchanger for tempering make-up air for the heating and ventilating systems.

In addition to heat recovery, reducing the air temperature will probably reduce the amount of equipment needed for exhausting the air. This will need to be evaluated during the conceptual-design stage.

III-4.2 Osprey Process.

The Osprey process, which is considered an alternate to the continuous-slab-casting process, is comprised of the following steps: 1) alloy melting, 2) gas atomization to form molten-metal droplets, and 3) collecting the droplets on a surface where they recombine to form a high-density, semi-finished or finished product.

The Osprey process is generally used to produce small to large diameter tubes, but it can also be used to cast square ingots for rolling. This process is more economical than conventional casting processes because of the significantly reduced number of process steps. Automated processes can be used to cut the tubes to the desired size and return the trim material for remelting. The finished product from this process could be used in canister production.

Safety considerations, which are of extreme importance in the RSS project, are a major benefit of the Osprey process. Processing is performed in a controlled atmospheric chamber with no exposure to working personnel. The off-spray is collected within the chamber and returned to the furnace for reprocessing.

A VIM system is still needed with the Osprey process, which replaces the continuous caster and rolling mill in the initial proposal. Cost of equipment to produce 15 tph is approximately \$20 million dollars, which includes:

- ◆ Gas atomizer and control systems.
- ◆ Vacuum-dispensing system, including an induction-powered ladle.
- ◆ Controlled-atmosphere chamber complete with performing mechanism, collector, product-support rollers, exhaust-gas treatment (overspray removal), and the associated control systems.
- ◆ On-site training by Osprey personnel.
- ◆ Supervision of commissioning.

Other comments:

- ◆ The Osprey equipment requires considerably less space than a caster and rolling mill. This reduces the cost of buildings, electricity, and air-removal/circulation equipment.
- ◆ A licensing fee must be negotiated with Osprey Metals LTD.

III-4.3 Rod Rolling.

Another option is the continuous casting of billet stock to produce steel, rod, or rebar, which also requires a VIM furnace for the melting process. The yields on rebar produced from continuous casting are in excess of 90 per cent and require little manpower to produce. The output from a continuous-billet caster would be fed to a rod-rolling mill that produces 1/4-in. to 1 1/2-in. steel rebar. Producing a 4-in. round billet requires a molten metal feed rate of 12 to 15 tph.

If this process is to be used in the proposed 30,000-tpy facility, the rate needs to be closer to 15 tph. A single-strand caster is able to operate at this rate. Both a traditional bend caster and a horizontal continuous caster should be considered. Depending on the features of the bend caster, the price ranges from \$6 million to \$10 million. The horizontal caster cost ranges from \$3 million to \$5.5 million.

Other comments:

- ◆ When selecting a caster, the following should be considered:
 - a) The horizontal caster takes up less headroom, reducing building height and, in turn, reducing building costs.
 - b) The horizontal caster requires no open-water cooling. All cooling is done in the mold or open air.
- ◆ To maintain a continuous throughput of 15 tpy, two 15-ton VIM furnaces are required with a 9,000-KW power supply for each furnace.
- ◆ The casting and rolling bays require less width and length. This reduces building costs.

III-4.4 Pressure Casting.

Pressure-mold casting is another method of producing slabs to be rolled into product. It is used instead of the slab-casting process discussed previously. In pressure-mold casting, a water-cooled mold is built to the desired slab size. The preassembled mold is filled with molten metal from the ladle of a 30-ton VIM furnace via a pressure system, bottom pour ladle, bottom feed mold. The

slab is allowed to cool in the mold until it reaches a temperature that allows the mold to be disassembled and the slab handled. Slab sizes can be optimized to meet the rolling mill's maximum width.

Other comments:

- ◆ This process does not require open water for cooling the slabs; therefore, special handling and water collection is not required.
- ◆ The slab, as produced, does not have a suitable surface and requires machining. This adds to the cost of producing the slab and handling the material machined from the slab.
- ◆ The additional machining reduces the yield of the slab.
- ◆ Additional heating is needed to roll the slab to finished product.
- ◆ Amstead, the pressure-pour system's original manufacturer, is currently out of the business. However, Oregon Steel offers a modified Amstead pressure system. Modifications were needed to make the system productive.

III-5.0 Equipment List—Baseline

1. One— 30-ton VIM system with 13,000-kVA transformer, heat time 2.2 hours for ASTM 304L stainless steel. System to include PLC melt control incorporating load cells and power automation. The system will include hydraulically operated head lift and rollaway drive mechanism, sightports, and charger. One closed-loop water system to adequately cool the power supply, furnace, vacuum chamber, and power cables.
2. One— 30-ton spare furnace body, including shunts and coil to allow for quick change of furnace when a new lining is required.
3. One— Vacuum-pumping system to allow furnace and ladle chamber to operate at a vacuum during final melt down, refining, and pouring.
4. One— System to charge the 30-ton induction melting system at the rate of 30 tons per hour. System includes 18 charging containers, carrousel, track, load cells, and scoreboard readout of tonnage charged.
5. Five— 30-ton hot-metal ladles with bottom-pour slide gate. Dimensions: 7-ft. 6-in. top diameter x 7-ft. 6-in. high.
6. Two— 30-ton ladle bales.
7. One— 4-in. x 54-in. straight mold-slab caster for 30-ton ladles; approximate radius 16-ft. withdrawal section.
8. One— 25-tph slab-holding pusher furnace with extractor. Capacity: Six 54-in x 4-in. x 20-ft.-long slabs. Approximate rate: 36,000,000 BTU/Hr.
9. One— 56-in. wide four-high reversing Steckel mill with 12,000 Hp drive at 1,500 fpm. Mill is complete with hot-box coilers on both ends.
10. One— 56-in.-wide mill roller table from the slab-holding furnace with high-pressure hydraulic descale box. About 135-ft. long table.
11. One— 56-in.-wide mill delivery roller table about 175-ft. long with plate shear and gauge for cutting up to 25-ft.-long plates to length.
12. One— 56-in.-wide hot 11-roll leveler with pinch and backup rolls, mounted on 150-ft. adjustable speed-leveler table with end stop; for leveling 25-ft.-long 304L stainless steel plates at ambient temperature up to 1,800°F.
13. One— 25-ft.-wide x 60-ft.-long cooling bed for handling up to 4-ft. 6-in.-wide x 25-ft.-

long plates at a rate of 25 tph. Thickness range— $\frac{1}{4}$ -in. to $1\frac{1}{4}$ -in.; maximum transfer velocity 30 fpm; incoming temperature 1,800°F; cooled temperature 400°F.

14. One— 56-in.-wide cooling bed exit-roller table about 66-ft. long.
15. One— 56-in.-wide upcoiler to produce 16-gauge (0.075-in.) 13,500-lb. coils with 44-in. o.d., 28-in. i.d. x 54-in. wide.
16. One— 20-ton capacity plate piler for handling up to $\frac{1}{4}$ -in. to $1\frac{1}{4}$ -in.-thick x 56-in. x 25-in.-long plates in lifts up to 10-in. thickness.
17. One— 90/15-ton hot-metal crane x 55-ft. span with 60-ft. lift. 8 to 1 safety factor on cables. Hoist speed of 20 fpm preferred.
18. One— 65/15-ton melt shop crane x 55-ft. span with 60-ft. lift. 8 to 1 safety factor on cables. Hoist speed of 25 fpm preferred.
19. Two— 15/5-ton scrap-yard cranes with 30-ft. lift. 5 to 1 safety factor on cables. Hoist speed of 60 fpm preferred. One in scrap-preparation area with 80-ft. span, one in container-refurbishment area with 50-ft. span.
20. One— 30/10-ton mill crane x 55-ft. span with 30-ft. lift.
21. One— 20/5-ton product handling crane x 55-ft. span with 30-ft. lift. 5 to 1 safety factor on cables. Hoist speed of 40 fpm preferred.
22. One— 20/5-ton product-handling crane x 80-ft. span with 30-ft. lift, 5 to 1 safety factor on cables. Hoist speed of 40 fpm preferred.
23. Two— Miscellaneous jib cranes.
24. One— 54-in. x 25-ft. cold depiler.
25. Two— Tundish-preheat stations.
26. Two— Ladle-preheat stations.
27. Two— Ladle-reline stations.
28. One— Roll grinder.
29. One— Roll lathe.
30. One— Lot miscellaneous machine tools.

31. Three— 5 Cu. Ft. slag pots.
32. Two— Slag pot cars.
33. Two— 40-ton gantry cranes for handling scrap-storage containers in the scrap-receiving area. Cranes to be rail mounted and have 95-ft. span.
34. One— Transfer car and track assembly with drive winch. Car to be designed to move two storage containers from the receiving area, through an airlock, and into the preparation area.
35. Two— Scrap-receiving hoppers in the scrap-preparation area.
36. Two— Scrap shears.
37. Two— Sets of powered roller tables.
38. Two— Two scrap-loading stations.
39. Two— Scrap grapples.
40. Lot— Caster mold cooling-water system consisting of 2,000 gpm pumps, cooling tower, and all interconnecting piping and valves.
41. Lot— Caster spray and reheat furnace cooling-water system consisting of 2,500 gpm pumps, cooling tower, and all interconnecting piping and valves.
42. Lot— Rolling-mill spray cooling-water system consisting of 3,500 gpm pumps, cooling tower, and all interconnecting piping and valves.
43. One— Air compressor and air dryer.
44. Lot— Mobile equipment including bobcat, forklift, trucks, etc.
45. 13— Rolling-mill filter housings: bag-in/bag-out stainless steel housing 3-filters wide by 6-filters high; each mounted on a 6-inch channel; composed in the following sequence in the direction of air flow: 95 per cent efficient filter, HEPA-filter section, first HEPA-filter stage, HEPA-filter section, second HEPA-filter stage, HEPA-filter test section.
46. Three— Rolling mill exhaust fans: 104,500 acfm, 16 inches w.g., 150°F, 343.2 bHp.
47. Two— Melt-shop baghouses: 70,000 acfm, bric dust collector with 11,733 square feet of

14-16 oz. Nomex filter media, flanged material-discharge hopper, weatherproof discharge plenum with hinged maintenance-personnel door for bag replacement, tubes with snap-back collars, tube cages, NEMA-4 control panel, designed for +/- 20 inches w.g. and 100-mph wind loading, screw conveyor and rotary airlock valves for 432 cubic feet per hour, bolted structural-steel support, access platform, and OSHA-type access ladder.

- 48. 36— Melt-shop filter housings: bag-in/bag-out stainless steel housing 3-filters wide by 6 filters high; each mounted on a 6-inch channel; composed in the following sequence in the direction of air flow: 95 per cent efficient filter, HEPA-filter section, first HEPA-filter stage, HEPA-filter section, second HEPA-filter stage, HEPA-filter test section.
- 49. Three— Melt-shop exhaust fans: 280,000 acfm, 28 inches w.g., 300°F, 1,645 bHp.
- 50. Three— Melt-shop baghouse fans: 20,000 acfm, 28 inches w.g., 300°F, 118 bHp.

III-6.0 Personnel Requirements

Table III-6.1: Personnel Requirements: Main Office.

Position	Number
Plant Manager	1
Assistant Manager	1
Purchasing Agent	1
Plant Engineer	1
Electrical Engineer	1
Mechanical Engineer	1
Quality Control Manager	1
Metallurgist	2
Safety Manager	1
Manager Community Relations	1
Radiation Safety Officer	1
Safety Engineer	1
Health Physicists (Working Sprvsrs)	3
Health Physicists	6
Personnel Manager	1
Receptionist / Secretary	1
Janitor	2
Guard	10
Shipping / Receiving Clerks	2
Secretaries	2
Radiation Technicians	6
Transportation Manager/Technician	2
Waste Manager	1
SECTION TOTAL	49 people

Table III-6.2: Personnel Requirements: Maintenance/Roll Shop, Locker Room.

Position	Number
Foreman	1
Machinist/Roll Grinder	2
Bearing Assembler	2
Millwrights	4
Electricians	4
Instrument Man	2
Tool Room Support	2
Radiation Instrument Technician	2
Laundry Personnel	2
HVAC/HEPA Service Techs	2
SECTION TOTAL	23 people

Table III-6.3: Personnel Requirements: Melt Shop.

Position	Number
Superintendent	1
Foreman	1
Melters	2
Slag Man	2
Slide Gate Repairman	1
Refractory Repairmen	3
Scrap Stockers	3
Scrap Yard Cranemen	3
Melt Shop Craneman	2
Tractor Operator	2
Laborer	2
Lab Technician	2
SECTION TOTAL	24 people

Table III-6.4: Personnel Requirements: Caster.

Position	Number
Foreman	1
Mold Operator	2
Ladlemen	2
Torch Table Operator	1
Tundish Repairmen	2
Caster Craneman	2
Tractor Operator	2
Mold Repairman	2
SECTION TOTAL	14 people

Table III-6.5: Personnel Requirements: Hot Mill.

Position	Number
Superintendent	1
Foreman	1
Furnace Stocker	1
Craneman	1
Furnace Operator	1
Roller	2
Roller Helper	2
Shearman	2
Leveller Operator	2
Cooling Bed Operator	2
Marker	1
Piler Operator	1
SECTION TOTAL	17 people

Table III-6.6: Personnel Requirements: Total Facility.

Facility Division	People Required	
Main Office	49	
Maintenance/Roll Shop, Locker Room	23	
Melt Shop	24	
Caster	14	
Hot Mill	17	TOTAL = 127

III-7.0 Project Capital Cost Estimates

Engineering efforts are based on the baseline described in Section III-3.1. Detailed design estimates are provided along with construction and construction-management costs. Detailed cost estimates for conceptual design efforts are not reported since that would compromise the team's competitive position.

III-7.1 Conceptual Design.

It is anticipated that the following items are required in the conceptual design.

- ◆ Conceptual plant layouts, utility flow diagrams, electrical single-line diagrams, etc.
- ◆ Equipment selection and costs
- ◆ Equipment installation costs
- ◆ Environmental considerations
- ◆ Material costs
- ◆ Engineering costs
- ◆ Construction management costs
- ◆ Project construction schedule
- ◆ Production manpower requirements
- ◆ Operating costs

It is necessary to develop better costing for the overall project in the following areas:

- A. Equipment purchase
- B. Equipment installation
- C. Site preparation
- D. Building purchase
- E. Building installation
- F. Process equipment purchase
- G. Process equipment installation
- H. Environmental equipment purchase
- I. Environmental equipment installation
- J. Manpower requirements
- K. Estimated cost of production:
 - a. Cost per ton of liquid steel
 - b. Cost per ton of cast slabs
 - c. Cost per ton of rolled product

III-7.2 Preliminary Design.

III-7.2.1 Electrical:

Preliminary design and drawings are needed for the following:

1. Incoming power distribution, including:
 - A. Substation and switchgear
 - B. Transformers
 - C. Substation and switchgear buildings
 - D. Small power requirements
2. Single-line and elementary diagrams
3. Grounding plans
4. Conduit and cable schedules
5. Communication systems
6. Scrap receiving and preparation requirements
7. Melt shop requirements
8. Rolling mill requirements
9. Itemized cost estimate and installation scope of work

III-7.2.2 Mechanical:

Preliminary design and drawings are needed for:

1. Installation drawings defining equipment and location
2. Piping layout and size requirements
3. HVAC requirements
4. Overhead crane sizing and requirements
5. Induction furnace sizing and requirements
6. Slab caster sizing and requirements
7. Rolling mill sizing and requirements
8. Pollution control equipment sizing and requirements
9. Itemized cost estimate and installation scope of work

III-7.2.3 Civil and Structural:

Civil and structural elements that must be provided include:

1. Design and basic building outline drawings
 - A. Scrap receiving and preparation
 - B. Melt shop structure
 - C. Rolling mill structure
 - D. Dust collection structure
 - E. Rail and roadways conceptual layouts

2. Itemized cost estimate and installation scope of work

III-7.2.4 Drawings:

The total estimated number of drawings needed for a preliminary design is 74. The following is a summary of the drawings:

1. Material process flow diagrams

- (1) Scrap preparation facility
- (1) Melt shop facility
- (1) Rolling mill facility

2. Mechanical/facility drawings

- (1) Plot plan and site layout
- (4) Scrap receiving & preparation—general arrangements & sections
- (2) Melt shop facility—general arrangement plan
- (4) Melt shop facility—elevations & sections
- (2) Rolling mill facility—general arrangement plan
- (4) Rolling mill facility—elevations & sections
- (1) Air pollution control flow diagram
- (2) Air pollution facilities plan and elevations

3. Electrical Drawings

- (1) Main substation general arrangement
- (1) High- and low-voltage distribution diagram
- (1) Single-line diagram No. 1—vacuum induction furnace
- (1) Single-line diagram No. 2—continuous casting
- (1) Single-line diagram No. 3—rolling mill
- (1) Single-line diagram No. 4—air pollution control
- (1) Single-line diagram No. 5—water cooling and treatment
- (1) Single-line diagram No. 6—cranes and auxiliary equipment
- (1) Single-line diagram No. 7—vacuum equipment
- (2) Grounding plans
- (3) Power distribution
- (1) Communications
- (2) Plant lighting, melt shop, and rolling mill

4. Piping Drawings

- (1) VIM furnace cooling water flow diagram
- (1) Slab casting machine mold and contact water flow diagram
- (1) Rolling mill contact water/cooling water flow diagram

- (1) Water treatment flow diagram
- (1) Cooling water and treatment flow facilities locations drawings
- (1) Oxygen, nitrogen, and argon flow diagram
- (1) Natural gas flow diagram
- (1) Plant air supply flow diagram

5. Civil Structural Drawing

- (2) Scrap receiving building
- (2) Scrap preparation building
- (2) Melt shop facilities foundation outlines
- (2) Rolling mill facilities foundation outlines
- (3) Melt shop facilities building design
- (2) Rolling mill facilities building design
- (4) Air pollution control canopy and duct routing
- (2) Site surface water control scheme
- (2) Plant offices general arrangements plan

6. Process Control/Instrumentation, Piping and Instrumentation

- (1) Water treatment
- (1) VIM furnace cooling water
- (1) Air pollution control
- (1) Slab casting machine cooling water
- (1) Rolling mill equipment cooling water

III-7.3 Detail Design.

The detail design can be started after the conceptual design of the plant is finished and approved. At this time, however, it is virtually impossible to accurately estimate the cost of the detail design required for this project. Many things are likely to change during the conceptual-design phase. For a plant of this size, the following is a typical list of the type and number of documents required:

Drawings

General Arrangements	50
Civil/Site	30
Structural	250
Architectural	40
Process Flow Diagrams	25
Mechanical Flow Diagrams	25
Piping	95
Lubrication	40
HVAC/Plumbing/Fire Protection	45
Electrical	150

Instrumentation..... 40

FULL SIZE TOTAL.....790

Loop Drawings (11x17).....600

Specifications

General Plant 1

Structural/Civil..... 82

Mechanical..... 48

Electrical..... 22

TOTAL.....153

TOTAL ESTIMATED COST FOR DETAIL DESIGN \$4,000,000

III-7.4 Project Management During Construction.

Currently, a construction duration of 25 months is anticipated. This is based on 60 weeks for induction furnace delivery. At least one project manager is required in the field during construction. Technical coordinators, which are listed in Table III-7.1, are to be assigned to the construction manager. The cost for project management during construction is estimated to be \$1,500,000, with an average cost per man month of \$12,097.

Table III-7.1: Project Management Costs During Construction.

Management	Man Months
<i>Technical Coordinators</i>	88
<i>Civil/Structural</i>	6
<i>Mechanical</i>	6
<i>Electrical</i>	12
<i>Melting/Casting</i>	6
<i>Rolling/Finishing</i>	4
<i>Piping</i>	10
<i>Process</i>	6
<i>Instrumentation</i>	12
<i>Computerization</i>	8
<i>Safety</i>	18
<i>Project Manager</i>	25
Subtotal	113
<i>Contingency (10%)</i>	11
Total	124

III-7.5 Construction Costs.

The tables presented in this section itemize the construction-cost estimate for the RSS mini-mill that is discussed in this report. Table III-7.2 summarizes the major components of the line-item cost that was estimated. Tables III-7.3 to III-7.14 provide the detailed costs that make up the total line-item cost. The following list summarizes some of the assumptions that have been made in determining the cost:

1. No site or geographical location has been selected for this project. Site-development costs are estimated as a percentage of total direct construction.
2. Building costs are estimated on a cost-per-square-foot basis based on data from similar projects.
3. Process HVAC, electrical, and foundations costs are based on preliminary information.
4. Engineering, construction management, and owner costs are estimated as a percentage of direct construction. Owner costs are intended to cover the cost of an unidentified "operating contractor" during the construction phase.
5. The estimate assumes that the project would be let as one fixed-price construction contract to a major general-contracting firm. This firm would construct buildings and subcontract the remaining work.
6. The project schedule indicates a preliminary-design start of 7/16/96 and a detail-design start of 6/2/97 (for a total 19.5-month duration) and a construction start of 3/1/98 (with a duration of 25 months). Escalation costs have not been included.
7. Contingency has not been included to cover unknowns at this preliminary level of the project.

Table III-7.2: Cost Summary Report.

No.	Expense Item	Material (\$000)	Labor (\$000)	Total (\$000)
1	Process Mechanical Equipment	44,680	13,817	58,497
2	Building Slabs & Process Foundations	5,819	7,112	12,931
3	Heating, Ventilating, and Air Conditioning (Process)	9,316	3,240	12,557
4	Buildings	11,497	0	11,497
5	Construction Management & Owner	0	9,424	9,424
6	Process Water Systems	5,924	1,046	6,970
7	Sitework, Utilities & Roads	4,880	1,474	6,354
8	Secondary Plant Electrical Equipment	3,417	1,210	4,627
9	Overhead Cranes	3,267	170	3,437
10	Radiological Equipment	1,026	22	1,048
11	Main Plant Power Distribution	925	19	944
12	Temporary Facility & General Conditions	202	0	202
13	Permits	0	0	0
14	Land Acquisition	0	0	0
15	Contingency	0	0	0
16	Cold Finishing Area (Estimated)	8,000	4,000	12,000
	Total Line Item Cost	98,955	41,534	140,489

Table III-7.3: Process Mechanical Equipment Costs.

New Buildings and Additions
Fixed-price Construction

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
** Major Equipment **							
1	Vacuum Induction Melting System - 30 ton, 13,000 kVA, W/ PLC Melt Control, Hydr. Head Lift, Drive Mechanism, and Closed-loop Water System	Matl. Labor	1.00 108,696	EA XX	11,304,350.00 40.00	11,304,350 4,347,840	15,652,190
2	Spare Furnace - 30 ton (Included in Item #1)	Matl. Labor	1.00 0	EA	0.00 0.00	0 0	0
3	Vacuum Pumping System (Included in Item #1)	Matl. Labor	1.00 0	EA	0.00 0.00	0 0	0
4	Charge System - 30 ton, w/18 Charging Containers, Carousel, Track, Load Cells and Scoreboard Readout of Tonnage Charged	Matl. Labor	1.00 6,522	EA XX	1,043,480.00 40.00	1,043,480 260,880	1,304,360
5	Hot Metal Ladles - 30 ton w/ Bottom Pour Gate	Matl. Labor	5.00 0	EA	26,090.00 0.00	130,450 0	130,450
6	Ladle Bales - 30 ton	Matl. Labor	2.00 0	EA	13,040.00 0.00	26,080 0	26,080
7	Straight Mold Slab Caster - 30 ton, 4 in. x 54 in.	Matl. Labor	1.00 32,609	EA XX	9,130,430.00 40.00	9,130,430 1,304,360	10,434,790
8	Slab Mold Pusher Furnace w/ Exc-tractor, 52 TPM	Matl. Labor	1.00 6,522	EA XX	1,043,480.00 40.00	1,043,480 260,880	1,304,360
9	Steckel Mill - 12,000 Hp Drive @ 1,500 fpm Complete w/Hot Box Coilers on Both Ends	Matl. Labor	1.00 152,174	EA XX	17,391,305.00 40.00	17,391,305 6,086,960	23,478,265
10	Mill Roller Table (Included in Item #9)	Matl. Labor	1.00 0	EA	0.00 0.00	0 0	0

Continued...

Table III-7.3 (Cont.): Process Mechanical Equipment Costs.

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
11 - Mill Delivery Roller Table (Included in Item #9)	Matl. Labor	1.00 0	EA	0.00 0.00	0 0	0	
12 - Roller Leveler w/ Pinch Rolls and Backup Rolls Mounted on Ad- justable Speed Leveler Table w/ End Stop (In- cluded in Item #9)	Matl. Labor	1.00 0	EA	0.00 0.00	0 0	0	
13 - Cooling Bed (In- cluded in Item #9)	Matl. Labor	1.00 0	EA	0.00 0.00	0 0	0	
14 - Cooling Bed Exit Roller Table (In- cluded in Item #9)	Matl. Labor	1.00 0	EA	0.00 0.00	0 0	0	
15 - Upcoiler (In- cluded in Item #9)	Matl. Labor	1.00 0	EA	0.00 0.00	0 0	0	
16 - Plate Piler - 20-ton Capacity	Matl. Labor	1.00 109	EA XX	43,480.00 40.00	43,480 4,360	47,840	
17 - Tundish Preheat Stations (Included in Above)	Matl. Labor	2.00 0	EA	0.00 0.00	0 0	0	
18 - Ladle Preheat Station	Matl. Labor	2.00 544	EA XX	43,480.00 40.00	86,960 21,760	108,720	
19 - Ladle Reline Station	Matl. Labor	2.00 435	EA XX	8,700.00 40.00	17,400 17,400	34,800	
20 - Roll Grinder	Matl. Labor	1.00 217	EA XX	130,435.00 40.00	130,435 8,680	139,115	
21 - Roll Lathe	Matl. Labor	1.00 217	EA XX	86,960.00 40.00	86,960 8,680	95,640	
22 - Misc. Machine Tools	Matl. Labor	1.00 0	LOT	217,400.00 0.00	217,400 0	217,400	
23 - Slag Pot - 45 CF Capacity	Matl. Labor	3.00 0	EA	17,390.00 0.00	52,170 0	52,170	
24 - Slag Pot Car	Matl. Labor	2.00 0	EA	30,435.00 0.00	60,870 0	60,870	

Continued...

Table III-7.3 (Cont.): Process Mechanical Equipment Costs.

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
25 -	Transfer Car & Track Assembly w/ Drive Winch, Capable of Hold- ing, Moving Two Storage Con- tainers from Re- ceiving to Prep- aration Area	Matl. Labor	1.00 652	EA XX	260,870.00 40.00	260,870 26,080	286,950
26 -	Scrap Receiving Hoppers	Matl. Labor	2.00 10,870	EA XX	1,304,350.00 40.00	2,608,700 434,800	3,043,500
27 -	Scrap Shears (Included in Item #26)	Matl. Labor	2.00 0	EA	0.00 0.00	0 0	0
28 -	Powered Roller Blades (Included in Item #26)	Matl. Labor	2.00 0	EA	0.00 0.00	0 0	0
29 -	Scrap Loading Stations (In- cluded in Item #26)	Matl. Labor	2.00 0	EA	0.00 0.00	0 0	0
30 -	Scrap Grapples	Matl. Labor	2.00 0	EA	21,740.00 0.00	43,480 0	43,480
31 -	Air Compressor and Air Dryer	Matl. Labor	1.00 217	EA XX	65,220.00 40.00	65,220 8,680	73,900
32 -	Mobile Equip- ment: Bobcat, Forklift, Truck, Etc.	Matl. Labor	1.00 0	LOT	347,830.00 0.00	347,830 0	347,830
33 -	Testing, TAG & Inspection	Matl. Labor	1.00 640	LOT XX	88,183.00 40.00	88,183 25,600	113,783
34 -	Scrap Pre-Cleaning Equipment	Matl. Labor	1.00 0	LOT	500,000 1,000,000.00	500,000 1,000,000	1,500,000
Bill of Material Summary			Material		Labor		Total Cost (M + L)
TOTAL			44,679,533		(320,424 hrs.) 13,816,960		58,496,493

Table III-7.4: Building Slabs & Process Foundations Costs.

New Building and Additions

Fixed-price Construction

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
A - Process foundations and building slabs for all buildings. Price based on an estimated allow- ance by the LGT structural engineer	Matl. Labor	1.00 177,803	LS XX	5,819,000.00 40.00	5,819,000.00 7,112,120.00	12,931,120	
Bill of Material Summary		Material		Labor		Total Cost (M + L)	
TOTAL		5,819,000		(177,803 hrs.) 7,112,120		12,931,120	

Table III-7.5: Heating, Ventilating, and Air Conditioning (Process) Costs.

New Buildings and Additions

Fixed-price Construction

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
** Baghouse & HEPA Filtration **							
1	Dust Collector - 70,000 ACFM, Welded C.S.	Matl. Labor	2.00 240	EA SM	127,120.00 26.50	254,240 6,360	260,600
2	Bag In/Bag Out HEPA-filter Housing, 304 SS (Total Airflow 560,000 ACFM)	Matl. Labor	18.00 2,160	EA SM	268,250.00 26.50	4,828,500 57,240	4,885,740
3	Butterfly Damper	Matl. Labor	40.00 480	EA SM	5,000.00 26.50	200,000 12,720	212,720
4	Slide Gate Damper	Matl. Labor	3.00 72	EA SM	50,000.00 26.50	150,000 1,908	151,908
5	Fan - 280,000 ACFM	Matl. Labor	3.00 192	EA SM	83,700.00 26.50	251,100 5,088	256,188
6	Fan - 20,000 ACFM	Matl. Labor	3.00 120	EA SM	12,000.00 26.50	36,000 3,180	39,180
7	Slide Gate Damper	Matl. Labor	3.00 48	EA SM	5,000.00 26.50	15,000 1,272	16,272
** HEPA Filtration System **							
8	Bag In/Bag Out HEPA-filter Housing, 304 SS (Total Airflow 190,000 ACFM)	Matl. Labor	6.00 720	EA SM	268,250.00 26.50	1,609,500 19,080	1,628,580
9	Butterfly Damper	Matl. Labor	12.00 144	EA SM	4,200.00 26.50	50,400 3,816	54,216
10	Slide Gate Damper	Matl. Labor	3.00 72	EA SM	37,000.00 26.50	111,000 1,908	112,908
11	Fan - 104,500 ACFM	Matl. Labor	3.00 192	EA SM	50,140.00 26.50	150,420 5,088	155,508
12	Crane Allowance	Matl. Labor	1.00 160	EA OP	7,500.00 25.25	7,500 4,040	11,540
** Process Ductwork - All Welded, Stainless Steel **							
13	Rolling Mill (Inside)	Matl. Labor	76,140.00 11,421	LBS SM	1.50 26.50	114,210 302,657	416,867
14	Butterfly Dampers - 12-in.	Matl. Labor	20.00 240	EA SM	5,000.00 26.50	100,000 6,360	106,360
15	Rolling Mill (Outside)	Matl. Labor	75,630.00 11,345	LBS SM	1.50 26.50	113,445 300,643	414,088

Continued...

Table III-7.5 (Cont.): Heating, Ventilating, and Air Conditioning (Process) Costs.

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
16 - Duct Insulation	Matl.		5,310.00	SF	0.50	2,655	
	Labor		266	SM	26.50	7,049	9,704
17 - Melt Shop (Inside)	Matl.		152,820.00	LBS	1.50	229,230	
	Labor		22,923	SM	26.50	607,460	836,690
18 - Butterfly Dampers - 12-in.	Matl.		20.00	EA	5,000.00	100,000	
	Labor		240	SM	26.50	6,360	106,360
19 - Melt Shop (Outside)	Matl.		315,070.00	LBS	1.50	472,605	
	Labor		47,261	SM	26.50	1,252,417	1,725,022
20 - Duct Insulation	Matl.		5,310.00	SF	0.50	2,655	
	Labor		266	SM	26.50	7,049	9,704
21 - Scrap Preparation (Inside)	Matl.		107,570.00	LBS	1.50	161,355	
	Labor		16,136	SM	26.50	427,604	588,959
22 - Butterfly Dampers - 24 in.	Matl.		16.00	EA	7,500.00	120,000	
	Labor		256	SM	26.50	6,784	126,784
23 - Stack - 16 ft. x 90 ft.	Matl.		1.00	EA	144,000.00	144,000	
	Labor		480	X	0.00	0	144,000
24 - System Balance	Matl.		1.00	LOT	0.00	0	
	Labor		3,780	SM	26.50	100,170	100,170
25 - Testing, TAG & Inspection	Matl.		0.00		0.00	0	
	Labor		2,384	XX	26.39	62,918	62,918
26 - Supporting Items, Breakage, & Waste	Matl.		1.00	LOT	46,119.00	46,119	
	Labor		1,192	XX	26.39	31,459	77,578
27 - Bolts, Fasteners, and Supplies	Matl.		1.00	LOT	46,119.00	46,119	
	Labor		0		0.00	0	46,119
Bill of Material Summary			Material		Labor		Total Cost (M + L)
TOTAL			9,316,053		(122,790 hrs.) 3,240,630		12,556,677

III-7.6 Building Costs.

Buildings to house and support the new facility are estimated on a cost-per-square-foot basis due to the preliminary nature of the estimate. Square-foot costs are based on data from LGE Dallas for buildings of similar construction and use. Unit costs represent total installed cost. Slab and foundation costs are included in previous table. Mechanical, process water, compressed air, gases, potable water, and fire-protection cost are included. Lighting/Switches & Receptacles allowance includes fixtures, devices, wire, and conduit from panels.

Table III-7.6: Buildings Costs.

New Buildings and Additions

Fixed-price Construction

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
1 - Scrap Receiving Building	Matl. Labor	60,800.00 0	SF	41.00 0.00	2,492,800 0	2,492,800	
2 - Lighting/Switches & Recep Allowance	Matl. Labor	60,800.00 0	SF	4.50 0.00	273,600 0	273,600	
3 - Ventilating Allowance	Matl. Labor	60,800.00 0	SF	1.20 0.00	72,960 0	72,960	
4 - Scrap Preparation Building	Matl. Labor	22,500.00 0	SF	41.80 0.00	940,500 0	940,500	
5 - Lighting/Switches & Recep Allowance	Matl. Labor	22,500.00 0	SF	4.50 0.00	101,250 0	101,250	
6 - Heating & Ven-tilating Allowance	Matl. Labor	22,500.00 0	SF	6.00 0.00	135,000 0	135,000	
7 - Melt Shop (High Bay) Building	Matl. Labor	18,150.00 0	SF	95.80 0.00	1,738,770 0	1,738,770	
8 - Lighting/Switches & Recep Allowance	Matl. Labor	18,150.00 0	SF	4.50 0.00	81,675 0	81,675	
9 - Heating & Ven-tilating Allowance	Matl. Labor	18,150.00 0	SF	6.00 0.00	108,900 0	108,900	
10 - Office Building	Matl. Labor	7,200.00 0	SF	68.80 0.00	495,360 0	495,360	
11 - Lighting/Switches & Recep Allowance	Matl. Labor	7,200.00 0	SF	0.00 0.00	0 0	0	
12 - Heating & Ven-tilating Allowance	Matl. Labor	7,200.00 0	SF	0.00 0.00	0 0	0	
13 - Mill & Maintenance Locker Room	Matl. Labor	7,200.00 0	SF	68.80 0.00	495,360 0	495,360	
14 - Lighting/Switches & Recep Allowance	Matl. Labor	7,200.00 0	SF	0.00 0.00	0 0	0	

Continued...

Table III-7.6 (Cont.): Buildings Costs.

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
15 - Heating & Ven- tilating Allowance	Matl. Labor	7,200.00 0	SF	0.00 0.00	0 0	0	
16 - Low-bay Areas	Matl. Labor	67,000.00 0	SF	41.80 0.00	2,800,600 0	2,800,600	
17 - Lighting/Switches & Recep Allowance	Matl. Labor	67,000.00 0	SF	4.50 0.00	301,500 0	301,500	
18 - Heating & Ven- tilating Allowance	Matl. Labor	67,000.00 0	SF	6.00 0.00	402,000 0	402,000	
19 - Melt Shop Bag- house Building	Matl. Labor	1,225.00 0	SF	41.80 0.00	51,205 0	51,205	
20 - Lighting/Switches & Recep Allowance	Matl. Labor	1,225.00 0	SF	4.50 0.00	5,513 0	5,513	
21 - Heating & Ven- tilating Allowance	Matl. Labor	1,225.00 0	SF	2.00 0.00	2,450 0	2,450	
22 - Melt Shop HEPA- Filter Building	Matl. Labor	12,800.00 0	SF	41.80 0.00	535,040 0	535,040	
23 - Lighting/Switches & Recep Allowance	Matl. Labor	12,800.00 0	SF	4.50 0.00	57,600 0	57,600	
24 - Heating & Ven- tilating Allowance	Matl. Labor	12,800.00 0	SF	2.00 0.00	25,600 0	25,600	
25 - Rolling Mill HEPA-Filter Bldg.	Matl. Labor	4,000.00 0	SF	41.80 0.00	167,200 0	167,200	
26 - Lighting/Switches & Recep Allowance	Matl. Labor	4,000.00 0	SF	4.50 0.00	18,000 0	18,000	
27 - Heating & Ven- tilating Allowance	Matl. Labor	4,000.00 0	SF	2.00 0.00	8,000 0	8,000	
28 - Scrap Receiving Office	Matl. Labor	1,500.00 0	SF	68.80 0.00	103,200 0	103,200	
29 - Lighting/Switches & Recep Allowance	Matl. Labor	1,500.00 0	SF	0.00 0.00	0 0	0	
30 - Heating & Ven- tilating Allowance	Matl. Labor	1,500.00 0	SF	0.00 0.00	0 0	0	
31 - Scrap Receiving Office	Matl. Labor	1,200.00 0	SF	68.80 0.00	82,560 0	82,560	
32 - Lighting/Switches & Recep Allowance	Matl. Labor	1,200.00 0	SF	0.00 0.00	0 0	0	

Continued...

Table III-7.6 (Cont.): Buildings Costs.

33 - Heating & Ventilating Allowance	Matl. Labor	1,200.00 0	SF	0.00 0.00	0 0	0
Bill of Material Summary		Material		Labor		Total Cost (M + L)
TOTAL		11,496,643		(0 hrs.) 0		11,496,643

Table III-7.7A: Construction Management, Engineering, and Owner Costs.

(Part I)

Engineering

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
	Allowance for Engineering Cost Estimated as 5% of Total Direct Construction Cost	Matl. Labor	1.00 96,152	LOT XX	0.00 70.00	0 6,730,640	6,730,640
Bill of Material Summary		Material		Labor		Total Cost (M + L)	
TOTAL		0		(96,152 hrs.) 6,730,640		6,730,640	

Table III-7.7B: Construction Management, Engineering, and Owner Costs.

(Part II)

Construction Support Services

Operating Contractor

Item	Description	Matl. / Labor	Quantity / Hours	Unit / Craft	Unit Price / Rate	Total Material/ Total Labor	Total Cost M + L
	Allowance for Owner (Operating Contractor) Cost Estimated as 2% of Total Direct Construction Cost	Matl. Labor	1.00 38,476	LOT XX	0.00 70.00	0 2,693,320	2,693,320
Bill of Material Summary		Material		Labor		Total Cost (M + L)	
TOTAL		0		(38,476 hrs.) 2,693,320		2,693,320	

Table III-7.8: Process Water Systems

Costs.

New Building and Additions
Fixed-price Construction

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
1 -	Caster Mold Cooling-water System - 2,000 gpm w/Pumps, Cooling Tower, Interconnecting Piping and Valves	Matl. Labor	1.00 6,522	EA XX	173,900.00 40.00	173,900 260,880	434,780
2 -	Caster Spray & Reheat Furnace Cooling-water System - 2,500 gpm Complete	Matl. Labor	1.00 8,696	EA XX	217,390.00 40.00	217,390 347,840	565,230
3 -	Rolling Mill Spray Cooling-water System - 3,500 gpm Complete	Matl. Labor	1.00 10,870	EA XX	304,350.00 40.00	304,350 434,800	739,150
4 -	Allowance for Water Treatment Facility (Based on Information from LGE Dallas for Similar Project)	Matl. Labor	1.00 0	LS	5,217,000.00 0.00	5,217,000 0	5,217,000
5 -	Testing, TAG & Inspection	Matl. Labor	1.00 52	LOT XX	11,825.00 40.00	11,823 2,080	13,905
Bill of Material Summary			Material		Labor		Total Cost (M + L)
TOTAL			5,924,465		(26,140 hrs.) 1,045,600		6,970,065

Table III-7.9: Sitework, Utilities & Roads Costs.

Improvements to Land
Fixed-price Construction

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
B -	Allowance for sitework, utilities, roads, and railroads estimated as a percentage of total direct construction (based on similar project since a specific site or geographical region has not been selected). Estimated at 4.7% of total direct construction.	Matl. Labor	1.00 36,853	LOT XX	4,880,000.00 40.00	4,880,000 1,474,120	6,354,120
Bill of Material Summary			Material		Labor		Total Cost (M + L)
TOTAL			4,880,000		(36,853 hrs.) 1,474,120		6,354,120

Table III-7.10: Secondary Plant Electrical Equipment Costs.

New Building and Additions

Fixed-price Construction

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
1 -	Transformer - 13000 kVA, 3 Hp, 34.5 kV Primary	Matl. Labor	1.00 160	EA E	260,000.00 25.95	260,000 4,152	264,152
2 -	Transformer - 10000 kVA, 3Hp, 34.5 kV - 4.16kV	Matl. Labor	3.00 480	EA E	200,000.00 25.95	600,000 12,456	612,456
3 -	Medium Voltage Switchgear, 4.16 kV Nominal, 3000 A Continuous Rating	Matl. Labor	3.00 420	EA E	38,160.00 25.95	114,480 10,899	125,379
4 -	Motor Control Center - 480V (Allowance)	Matl. Labor	7.00 980	EA E	60,200.00 25.95	421,400 25,431	446,831
5 -	Power Distribu- tion: Conductors & Raceways	Matl. Labor	201,750.00 18,158	SF E	5.00 25.95	1,008,750 471,200	1,479,950
** Auxiliary Systems **							
6 -	Fire Alarm	Matl. Labor	201,750.00 4,035	SF E	1.20 25.95	242,100 104,708	346,808
7 -	PA/Telephone	Matl. Labor	201,750.00 8,070	SF E	1.50 25.95	302,625 209,417	512,042
8 -	Data/Computer	Matl. Labor	201,750.00 8,070	SF E	1.65 25.95	332,888 209,417	542,305
9 -	Security	Matl. Labor	201,750.00 2,018	SF E	0.50 25.95	100,875 52,367	153,242
10 -	Testing, TAG & Inspection	Matl. Labor	0.00 4,239	 XX	0.00 25.95	0 110,002	110,002
11 -	Bolts, Fasteners, and Supplies	Matl. Labor	1.00 0	LOT	33,831.00 0.00	33,831 0	33,831
Bill of Material Summary			Material		Labor		Total Cost (M + L)
TOTAL			3,416,949		(46,630 hrs.) 1,210,049		4,626,998

Table III-7.11: Overhead Cranes Costs.

New Buildings and Additions
Fixed-price Construction

Item	Description	Matl/ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
** Overhead Cranes **							
1	- Hot Metal Crane - 90/15-ton, 55-ft. span, 60-ft. lift	Matl. Labor	1.00 870	EA XX	652,170.00 40.00	652,170 34,800	686,970
2	- Melt Shop Crane - 65/15-ton, 55-ft. span, 60-ft. lift	Matl. Labor	1.00 652	EA XX	434,780.00 40.00	434,780 26,080	460,860
3	- Scrap Yard Crane - 15/5-ton, 80-ft. span, 30-ft. lift	Matl. Labor	1.00 435	EA XX	217,390.00 40.00	217,390 17,400	234,790
4	- Mill Crane - 30/10-ton, 55-ft. span, 30-ft. lift	Matl. Labor	2.00 435	EA XX	304,350.00 40.00	304,350 17,400	321,750
5	- Product Handling Crane - 20/5-ton, 55-ft. span, 30-ft. lift	Matl. Labor	1.00 435	EA XX	260,870.00 40.00	260,870 17,400	278,270
6	- Product Handling Crane - 20/5-ton, 80-ft. span, 30-ft. lift	Matl. Labor	1.00 435	EA XX	304,350.00 40.00	304,350 17,400	321,750
7	- Jib Cranes	Matl. Labor	2.00 109	EA XX	21,740.00 40.00	43,480 4,360	47,840
8	- Gantry Crane - 40- ton, 95-ft. span (Scrap-receiving area)	Matl. Labor	2.00 870	EA XX	521,740.00 40.00	1,043,480 34,800	1,078,280
9	- Testing, TAG & Inspection	Matl. Labor	1.00 8	LOT XX	6,522.00 40.00	6,522 320	6,842
Bill of Material Summary			Material		Labor		Total Cost (M + L)
TOTAL			3,267,392		(4,249 hrs.) 169,960		3,437,352

Table III-7.12: Radiological Equipment Costs.

New Buildings and Additions

Fixed-price Construction

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
1 - Airborne Radiation Monitor—Alpha	Matl.	33.00	EA	5,800.00	191,400		
	Labor	264	E	25.95	6,851		198,251
2 - Airborne Radiation Monitor—Beta/Gamma	Matl.	33.00	EA	6,600.00	217,800		
	Labor	264	E	25.95	6,851		224,651
3 - Dose Radiation Monitor	Matl.	11.00	EA	3,600.00	39,600		
	Labor	88	E	25.95	2,284		41,884
4 - Drive-through Radiation Monitor	Matl.	2.00	EA	20,000.00	40,000		
	Labor	32	E	25.95	830		40,830
5 - Stack Radiation Monitor	Matl.	1.00	EA	120,000.00	120,000		
	Labor	24	E	25.95	623		120,623
6 - Boundry Control Station	Matl.	4.00	EA	96,300.00	385,200		
	Labor	128	E	25.95	3,322		388,522
7 - Central Monitoring Control System	Matl.	1.00	EA	30,000.00	30,000		
	Labor	16	E	25.95	415		30,415
8 - Testing, TAG & Inspection	Matl.	1.00	LOT	2,048.00	2,048		
	Labor	41	XX	25.95	1,064		3,112
Bill of Material Summary		Material		Labor		Total Cost (M + L)	
TOTAL		1,026,048		(857 hrs.) 22,240		1,048,288	

Table III-7.13: Main Plant Power Distribution Costs.

New Building and Additions
Fixed-price Construction

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
1 -	Transformer - 35 MVA Nominal, 141 kV - 34.5 kV, 3Hp	Matl. Labor	1.00 240	EA E	875,000.00 25.95	875,000 6,228	881,228
2 -	Medium-voltage Switchgear, 34.5 kV Nominal, 1,000 A Continuous Rating	Matl. Labor	2.00 280	EA E	15,300.00 25.95	30,600 7,266	37,866
3 -	Allowance for Cable & Connections	Matl. Labor	1.00 160	LOT E	10,000.00 25.95	10,000 4,152	14,152
4 -	Testing, TAG & Inspection	Matl. Labor	0.00 68	XX	0.00 25.95	0 1,765	1,765
5 -	Bolts, Fasteners, and Supplies	Matl. Labor	1.00 0	LOT	9,156.00 0.00	9,156 0	9,156
Bill of Material Summary			Material		Labor		Total Cost (M + L)
TOTAL			924,756		(748 hrs.) 19,411		944,167

Table III-7.14: Temporary Facility & General Conditions Costs.

New Buildings and Additions

Fixed-price Construction

Item	Description	Matl./ Labor	Quantity/ Hours	Unit/ Craft	Unit Price/ Rate	Total Material/ Total Labor	Total Cost M + L
A - Allowance for general conditions estimated as 0.15% of total direct construction (based on similar projects)	Matl. Labor	1.00 0	LOT		202,000.00 0.00	202,000.00 0	202,000.00
Bill of Material Summary		Material		Labor		Total Cost (M + L)	
TOTAL		202,000.00		0		\$202,000	

III-8.0 Schedule

Section IV: Results

IV-1.0 Project Operational Cost Estimates

The RSS facility operation baseline includes the following costs:

- ◆ Manpower costs
- ◆ Electrical costs
- ◆ Consumable costs
- ◆ Cold-finishing costs
- ◆ Other utility costs
- ◆ Waste disposal costs
- ◆ Capitalization recovery
- ◆ Decommissioning surcharge

IV-1.1 Manpower Costs.

The average rate for employees performing direct labor is estimated to be \$13.00/hour. This rate assumes that the site selected offers low wage rates, as is the case with many of the areas under consideration. Fringe benefits consistent with industry standards are accounted for with a 35 per cent factor. Overhead is calculated by taking all of the non-direct labor and allocating the cost across the direct labor charge. Additional overhead burden is added for administrative support such as telephones, supplies, computers, etc. Sales and marketing costs are estimated to be 4 per cent of the total overhead and direct-labor charges. This percentage is typical of the metals processing industry. General and administrative (G&A) expenses are estimated to be 12 per cent. Based on these assumptions, the overall labor rate (without profit) is \$49.47/hour. Table IV-1.1 shows these calculations.

Table IV-1.1: RSS Facility Labor Rate Calculations.

Labor Cost Calculations (thru G & A costs)		
Functions	Calculation Rate	Total Cost
<i>Base Rate</i>	\$13.00	\$13.00
<i>Fringe Benefits</i>	35%	\$4.55
<i>Overhead</i>	142%	\$24.92
<i>Cost of Sales</i>	4%	\$1.70
<i>General and Admin. Expense</i>	12%	\$5.30
Expected Labor Rates		\$49.47

The labor rate calculations are distributed between the melt shop, casting operations, and rolling. Table IV-1.2 shows the labor cost per ton of product.

Table IV-1.2: RSS Facility Labor Cost Per Ton.

Labor Rate (\$/hour)	Facility Capacity (Tons/Year)	Total Personnel	Labor Cost of Operations (\$ / Ton Produced)
\$49.47	30,000	127 Total	
Legend: ☐ Input Data ☒ Calculated Data		Activity	
		Melting - 24	190
		Casting - 14	111
		Rolling - 17	135
		Total	436

If the labor rate is not actually what was assumed, the data in Figure IV-1.1 can be used to make the appropriate changes to the calculation. Figure IV-1.1 shows how the labor cost per ton of steel varies with facility labor rate.

Figure IV-1.1: Production Labor Costs Based on Facility Labor Rates.

IV-1.2 Electrical Cost.

Table IV-1.3A shows electricity costs due to melting. Table IV-1.3B shows the costs due to auxiliary functions.

Table IV-1.3A: Electricity Costs: Melting.

Legend:				
Input Data				
Calculated Data				
Operations, assumptions and givens:	Tap-to-tap Time (Min.)	Shift (Hrs.)	Turns/Shift	Turns/Week
	132	8	4	28
	Furnace Capacity (Tons)	Shifts per Week	Tons per Week	Tons per Year
	30	7	840	42000
MELT SHOP (kWh/Ton of Steel)	Tons of Steel per heat	Hours of Operation Per Week	Price of Electricity (\$/kWh)	Cost per Ton of Steel
770	30	56	0.04	\$31

*Note: The actual kWh/ton is 550. the figure 770 is used to adjust for 7 day/week operations @ 71% capacity.

Table IV-1.3B: Electricity Costs: Auxiliary.

Function:	Usage Per Hour (kW)	Hours of Operation Per Week	Electricity Rate (\$/kWh)	Total Cost Per Week (\$)
HEPA & Baghouse	2451	56	0.04	5490
HEPA & Baghouse at Idle	255	112	0.04	1142
Cooling Water # 1	298	56	0.04	668
Air Compressor	112	56	0.04	251
Casting System	323	56	0.04	724
Rolling Mill	8940	56	0.04	20026
Cooling Water # 2	373	56	0.04	836
Plant Lighting	67200	1	0.04	2688
Transformer no load loss	43680	1	0.04	1747
Substation 1 load loss	8400	1	0.04	336
Office usage	2700	1	0.04	108
Substation 2 load loss	8400	1	0.04	336
Total Aux. Electricity/Week				\$34,351
Auxiliary Electricity (\$/Ton)				
Auxiliary Use				41
Melting Use				31
Total Electricity Use				72

IV-1.3 Raw Material Costs.

Raw materials usage depends upon the product being made and the input scrap composition. The most likely candidates are analyzed below. Table IV-1.4 presents the raw material costs for stainless steel (Grade 304) production from carbon scrap. Table IV-1.5 shows the raw material costs for stainless steel (Grade 304) production from carbon steel and nickel scrap from the DOE dismantlement of the gaseous-diffusion plant. As apparent from the data presented in Table IV-1.6, there is virtually no cost for raw materials in the production of stainless steel (Grade 304) using scrap stainless steel as input. Table IV-1.7 shows the costs of carbon steel production using carbon steel scrap is also virtually no cost for raw material. Table IV-1.8 presents the raw material costs to produce stainless steel using carbon steel and nickel scrap from the DOE stock piles and Inconel RSM (Grade 600).

Table IV-1.4: Raw Material Costs for Stainless Steel (304) Production from Carbon Steel Scrap.

Raw Material Input for Stainless Steel Production From Carbon Scrap:			
Raw Material	Quantity Per Ton of Stainless Steel (Lbs.)	Raw Material Cost (\$/lb.)	Cost Per Ton of Stainless Steel Produced (\$/Ton)
<i>Nickel</i>	163	3.45	\$562.35
<i>Chrome</i>	360	3.75	\$1,350.00
<i>Manganese</i>	26	0.50	\$13.00
<i>Silicon</i>	13	0.67	\$8.71
<i>Carbon</i>	13	0.08	\$1.04
<i>Zircon Sand</i>	0.62	0.25	\$0.16
Total Raw Materials			Cost Per Ton \$1,935.26

Table IV-1.5: Raw Material Costs for Stainless Steel (304) Production from Carbon Steel and Nickel Scrap.

Raw Material Input for Stainless Steel Production From Carbon Scrap with Nickel Supplied by DOE Contaminated Nickel Stockpiles:			
Raw Material	Quantity Per Ton of Stainless Steel (Lbs.)	Raw Material Cost (\$/lb.)	Cost Per Ton of Stainless Steel Produced (\$/Ton)
<i>Nickel</i>	163	0	\$0
<i>Chrome</i>	360	3.75	\$1,350.00
<i>Manganese</i>	26	0.5	\$13.00
<i>Silicon</i>	13	0.67	\$8.71
<i>Carbon</i>	13	0.08	\$1.04
<i>Zircon Sand</i>	0.62	0.25	\$0.16
Total Raw Materials			Cost Per Ton \$1,372.91

Table IV-1.6: Raw Material Costs for Stainless Steel (304) Products from Carbon Steel Scrap.

Raw Material Input for Stainless Steel Production From Stainless Steel Scrap:			
Raw Material	Quantity Per Ton of Stainless Steel (Lbs.)	Raw Material Cost (\$/lb.)	Cost Per Ton of Stainless Steel Produced (\$/Ton)
<i>Nickel</i>	0	3.45	\$-
<i>Chrome</i>	0	3.75	\$-
<i>Manganese</i>	0	0.50	\$-
<i>Silicon</i>	0	0.67	\$-
<i>Carbon</i>	0	0.08	\$-
<i>Zircon Sand</i>	0	0.25	\$-
<i>Misc. Allowance</i>			\$5.00
Total Raw Materials			Cost Per Ton \$5.00

Table IV-1.7: Raw Material Costs for Carbon Steel Production from Carbon Steel Scrap.

Raw Material Input for Carbon Steel Production From Carbon Steel Scrap:			
Raw Material	Quantity Per Ton of Stainless Steel (Lbs.)	Raw Material Cost (\$/lb.)	Cost Per Ton of Stainless Steel Produced (\$/Ton)
Misc.	Allow		\$1.00
Total Raw Materials			\$1.00

Table IV-1.8: Raw Material Costs for Stainless Steel (304) Production from Carbon Steel Scrap and 291 Lbs. Inconel 600 Per Ton of Steel.

Raw Material Input for Stainless Steel Production From Carbon Scrap and 291 Lbs/Ton of Inconel 600 RSM Scrap Feed Stock			
Raw Material	Quantity Per Ton of Stainless Steel (Lbs.)	Raw Material Cost (\$/lb.)	Cost Per Ton of Stainless Steel Produced (\$/Ton)
Nickel	163	0	\$-
Chrome	315	3.75	\$1,181.25
Manganese	26	0.5	\$13.00
Silicon	13	0.67	\$8.71
Carbon	13	0.08	\$1.04
Zircon Sand	0.62	0.25	\$0.16
Total Raw Materials			Cost Per Ton \$1,204.16

IV-1.4 Consumables Purchase Costs.

Table IV-1.9 identifies the purchase cost for consumables associated with maintaining and relining the refractory. The worst case of relining once a week was chosen for refractory life. Note that these costs do not include the cost of spent-consumables disposal, which is discussed in Section IV-1.7. Although this table presents the quantity of waste generated by maintenance activities on a per-ton-of-steel basis, this cost is not included in the analysis presented in this table.

Table IV-1.9: Consumables Purchase Costs/Ton of Steel.

Maintenance Activity	Heats Per Life	Steel Produced Per Life at 30 Tons/heat (Tons)	Secondary Waste (Lbs./maint.)	Secondary Waste (Lbs./ton of steel)	Total Purchase Cost (\$)	Purchase Cost Per Ton of Steel
VIM Furnace Refractories	20	600	7700	12.83	6,815.00	11.36
Ladle Refractory:						
Safety Lining	120	3600	550	0.15	500	0.14
Working Lining	60	1800	500	0.28	8000	4.44
Misc. Lining	allow					0.50
Ladle Slide Gates:						
Well Block	15	450	50	0.11	250	0.56
Ladle Inter Nozzle	5	150	25	0.17	15	0.10
Upper and Lower Plate	2	60	25	0.42	60	1.00
CNXT Nozzle	2	60	25	0.42	40	0.67
Mortar	allow					0.16
Misc. Process Supplies:						
Temp Tips	60	1800	0	0.00	250	0.14
Subtotal				14.39		19.06
TOTAL ASSUMING 92% YIELD						20.72

IV-1.5 Cold Finishing Costs.

Cold-finishing operations were not a part of this study. However, to make effective comparisons, the cost must be included. Using the data and rationale described in Section I-11.3, the estimated production charge for stainless steel cold finishing is \$74/ton. Carbon steel has no cost for finishing operations.

IV-1.6 Other Utility Costs.

Water, gas, and oxygen are used in the process. Table IV-1.10 shows the cost of these utilities.

Table IV-1.10: Other Utility Costs.

Utilities:			
Resource	Cubic Feet Per Ton	Cost Per Cubic Foot	Cost Per Ton of Steel (\$)
<i>Water</i>	482	0.00131	\$0.63
<i>Oxygen</i>	65	0.0175	\$1.13
<i>Natural Gas</i>	75	0.0047	\$0.35
<i>Misc.</i>	Allow		\$0.50
<i>Air</i>	Allow		\$0.05
	Yield	94%	
			Cost Per Ton
			\$2.78

IV-1.7 Waste Disposal Costs.

Secondary-waste disposal is a significant element of the total production cost. Table IV-1.11 assumes the burial cost is \$70/ft³, the rate currently charged by U.S. Ecology in Richland, WA. This is a reasonable assumption because most of the potential plant sites are in the Northwest and would use U.S. Ecology for waste disposal.

Table IV-1.11: Disposal Costs.

Disposal Costs:		
Waste:	Pounds of Waste Per Ton of Steel	Disposal Rate @ U.S. Ecology
<i>Refractory</i>	14	\$/Cubic Foot 70
<i>Scale Disposal</i>	2	Packaging Density
<i>Filter Housings</i>	2	
<i>Bag House Dust</i>	0.2	Lbs./Cubic Ft. 100
<i>Slag</i>	2	
	19	
Total Volume To Be Buried (Ft³/Ton)	0.19	Total Cost of Burial (\$/Ton of Waste) \$13.30

With disposal rates on the rise, and the cost of disposal unknown for the future, VIM was selected over AIM and EAF, which are even greater liabilities than shown here. Facility costs for additional HEPA filters and baghouses are an additional \$10 million in construction costs.

Although EAF and AIM were not chosen, it is worthwhile to review the cost of disposal and compare the relative differences at the various disposal rates. Table IV-1.12 compares the waste generated by each process, and Table IV-1.13 demonstrates the effect of changing disposal rates on disposal costs. Recognize that EAF dust is a KO61 mixed waste and cannot be disposed of as radioactive waste. Although the cost of disposal is greater, it is assumed to be the same for this example.

Table IV-1.12: Types and Quantities of Secondary Waste.

<i>Secondary Waste</i>					
Melting Technology	Slag lbs./ton	Dust lbs./ton	Refractory Reline lbs./ton	Scale lbs./ton	TOTAL lbs./ton
EAF	80	25	4	2	111
Air Induction	40	15	14	2	71
VIM	4	0.67	14	2	19

*Note: The EAF dust is classified by the EPA KO61 as mixed waste when operated in a radiological environment.

Table IV-1.13: Secondary Waste Disposal Costs.

<i>Waste Disposal Cost</i>			Burial Costs (\$/Foot) Density @ 100 lbs./Cubic Foot Per Ton of Steel Produced		
Melting Technology	Waste lbs/Ton	70 (\$/ft ³)	150 (\$/ft ³)	300 (\$/ft ³)	500 (\$/ft ³)
EAF	111	77.70	1665	333.00	555.00
Air Induction	71	49.70	106.50	213.00	355.00
VIM	19	13.30	28.50	57.00	95.00

IV-1.8 Capitalization Recovery.

It is assumed that capitalization is recovered in 10 years, although commercial facilities recover it even sooner. A ten-year period is justified because this project is intended to be a long-term investment in nuclear decontamination and decommissioning activities. Including the cost for the cold-finishing mill (\$12 million), the total cost of the project is in the range of \$140 million. Therefore, recovery in 10 years requires a charge to the project of \$470/ton.

IV-1.9 Decommissioning Surcharge.

Decommissioning the RSS facility, which was discussed in Section III-2.8, requires a surcharge of \$41/ton.

IV-1.10 Total Production Costs.

Table IV-1.14 summarizes the production cost for five different operating scenarios being considered. It is important to note that, as the price of burial increases, the margins and ROI improve for products produced by the RSS facility to sell, but diminish for melting for volume reduction and burial.

The production cost differences presented in Table IV-1.14 are driven by the raw-material price, which was discussed in Section IV-1.3. Of the raw materials, chrome has the greatest impact—both in terms of quantity required and price. Therefore, a source of radioactively contaminated chrome would lower the cost significantly. The figures presented in Table IV-1.14 assume that the high-value raw materials, nickel and chrome, which make up 26 per cent of the product's raw materials, come from commercial sources. Use of radioactively contaminated nickel and/or chrome improves the economics.

Table IV-1.14: Production Cost Summary.

Total Cost Summary:	STAINLESS STEEL PRODUCTION				CARBON
Cost Element:	304 Stainless from Carbon Steel Scrap	304 Stainless from Carbon Steel Scrap plus Nickel Scrap	304 Stainless from Inconel 600 Scrap and Carbon Steel	304 Stainless from 304 Stainless Scrap	Carbon Steel from Carbon Steel Scrap
<i>Manpower:</i>					
Scrap and Melting	\$190	\$190	\$190	\$190	\$190
Casting	\$111	\$111	\$111	\$111	\$111
Rolling	\$135	\$135	\$135	\$135	\$135
Cold Finishing	\$74	\$74	\$74	\$74	\$74
Raw Material	\$1,935	\$1,373	\$1,204	\$5	\$1
Electrical	\$72	\$72	\$72	\$72	\$72
Other Utilities	\$3	\$3	\$3	\$3	\$3
Consumables	\$21	\$21	\$21	\$21	\$21
Waste Disposal	\$13	\$13	\$13	\$13	\$13
Capitalization Recovery	\$470	\$470	\$470	\$470	\$470
Decommissioning Surcharge	\$41	\$41	\$41	\$41	\$41
Total Cost Per Ton	\$3,065	\$2,502	\$2,334	\$1,135	\$1,131
*Cost Per Pound	\$1.53	\$1.25	\$1.17	\$0.57	\$0.57

* Commercial sell price of equivalent 304 SS steel (16 gauge x 54" wide) on 8/10/95 was \$1.51/lb. and carbon steel sheet was \$10.28/lb.

IV-1.11 Volume Reduction and Disposal.

Tables IV-1.15 and IV-1.16 examine the scenario of melting the metal for volume reduction and subsequent disposal, which requires a less expensive facility (\$40 million for processing and \$10 million for scrap sorting). The capitalization recovery charge for this less expensive facility is

\$167/ton over a 10-year period and a reduction in decommissioning charges result from having a smaller facility..

Because of the wide differential (252 per cent) between cost of disposal at NTS and Ward Valley, Table IV-1.15 shows the total production cost as a function of burial cost. Even with large variations in burial prices and their instability, melting for disposal is a feasible option. Table IV-1.16 shows that it yields a reasonable ROI at any burial price when the charge to the generator varies with the disposal site available. The charges to the generators in all cases fall below that which is being paid for any other option available today. Anything less than 10 per cent annual ROI is considered unsatisfactory, and values greater than 20 per cent indicate the project is feasible. If you keep the charge to the generator constant at the presumed price of \$1500/ton the production of burial blocks becomes economically unfeasible for burial prices over \$170/ft³.

Table IV-1.15: Financial Analysis of Facility for Melting for Volume Reduction and Burial.

Total Cost Summary:		Production Costs (\$/ton)				
Cost Element:	Burial @ \$17/Cu. ft.	Burial @ \$30/Cu. ft.	Burial @ \$70/Cu. ft.	Burial @ \$170/Cu. ft.	Burial @ \$315/Cu. ft.	Burial @ \$500/Cu. ft.
Waste Disposal	98	163	363	863	1588	2513
Manpower (\$301/ton):						
Scrap and Melting	190	190	190	190	190	190
Casting	111	111	111	111	111	111
Rolling	0	0	0	0	0	0
Cold Finishing	0	0	0	0	0	0
Raw Material	0	0	0	0	0	0
Electrical	33	33	33	33	33	33
Other Utilities	1	1	1	1	1	1
Consumables	21	21	21	21	21	21
Capitalization Recovery	167	167	167	167	167	167
Decommissioning Surcharge	31	31	31	31	31	31
Total Cost Per Ton	\$ 651	\$716	\$916	\$1,416	\$2,141	\$3,066
Cost Per Pound	\$ 0.33	\$0.36	\$0.46	\$0.71	\$1.07	\$1.53

Table IV-1.16: Return on Investment for Melting for Volume Reduction and Burial.

Net Margin Summary:						
Charge Generators for Disposal	Burial @ \$17/Cu. ft.	Burial @ \$30/Cu. ft.	Burial @ \$70/Cu. ft.	Burial @ \$170/Cu. ft.	Burial @ \$315/Cu. ft.	Burial @ \$500/Cu. ft.
Cost Element:						
Production Cost per Ton	\$651	\$716	\$916	\$1,416	\$2,141	\$3,066
Production Cost per Lb.	\$0.33	\$0.36	\$0.46	\$0.71	\$1.07	\$1.53
Income:						
Charge to generator	835	900	1100	1600	2325	3250
Net Margin (\$)	\$184	\$184	\$184	\$184	\$184	\$184
Net Margin (%)	22%	20%	17%	11%	8%	6%
Return on Investment	26%	26%	26%	26%	26%	26%

IV-1.12 Manufacturing a Product.

Table IV-1.17 summarizes the net margins and ROIs for a facility that produces a product to sell rather than simply melting for consolidation and disposal. The table assumes the generators are willing to pay \$0.75/lb. for taking their metal because recycling saves them the cost of burial plus processing costs, which range up to \$2.50/lb. The chart also assumes that the product produced by the RSS facility can be sold, but at 30 percent less cost than virgin material for stainless steel and 50 per cent less than virgin carbon steel. In these calculations, capitalization costs are a maximum as a result of the assumed 10 year payback period, while operational costs are assumed to be close to real costs.

Table IV-1.17: Net Margin Summary and Return on Investment: Facility Producing Product to Sell at 70% of Commercial Price.

Net Margin Summary:					
Sell Products @ 70% Charge Generators \$0.75 for disposal	304 Stain-less from Carbon Steel Scrap	304 Stainless from Carbon Steel Scrap plus Nickel Scrap	304 Stainless from Inconel 600 Scrap and Carbon Steel	304 Stain-less from 304 Stain-less Scrap	Carbon Steel from Carbon Steel Scrap
Cost Element:					
Production Cost per ton	\$3,065	\$2,502	\$2,334	\$1,135	\$1,131
Production Cost per Lb.	\$1.53	\$1.25	\$1.17	\$0.57	\$0.57
Income:					
Charge to generator	1500	1500	1500	1500	1500
Sell Product @ 70% of Commercial Price	2128	2128	2128	2128	235
Net Margin (\$)	\$563	\$1,126	\$1,294	\$2,493	\$604
Net Margin (%)	16%	31%	36%	69%	35%
Return on Investment	22%	34%	38%	64%	23%

Assuming income of \$1,500/ton for accepting generator waste and product sales at \$1.06/lb., conversion of carbon steel to stainless steel generates an ROI that is acceptable. A reduction in output is necessary to support the downstream radiological controls that are required of a fabrication facility. The selling price incentive is assumed to be material sold at 70% of commercial price.

The ROI improves as sources of nickel or chrome become available. If the DOE stockpile of nickel is used, a ROI of 34 per cent is realized. Using a contaminated source of Inconel 600, a ROI of 38 per cent is realized. The best return on investment comes from stainless steel input material and to make stainless steel products. The ROI is 64%. Carbon steel from carbon steel also shows a favorable ROI of 23%.

Table IV-1.18 examines the same data as Table IV-1.17, except that the output product is "given away" to the fabricator. With this assumption, conversion of carbon steel scrap to stainless steel is not feasible. However, producing 304 stainless steel from radioactively contaminated 304 stainless steel and producing carbon steel from carbon steel scrap each have an 18% ROI. The ROI of 18% at worst case is considered to be a near acceptable return and supports the conclusion this process is feasible.

**Table IV-1.18: Net Margin Summary and Return on Investment: Facility
Producing Product to Give Away.**

Net Margin Summary:					
Worst Case Product Return:	304 Stainless from Carbon Steel Scrap	304 Stainless from Carbon Steel Scrap plus Nickel Scrap	304 Stainless from Inconel 600 Scrap and Carbon Steel	304 Stainless from 304 Stainless Scrap	Carbon Steel from Carbon Steel Scrap
Give Away Product Charge Generators \$0.75 for Disposal					
Cost Element:					
Production Cost per ton	\$3,065	\$2,502	\$2,334	\$1,135	\$1,131
Production Cost per Lb.	\$1.53	\$1.25	\$1.17	\$0.57	\$0.57
Income:					
Charge to generator	1500	1500	1500	1500	1500
Sell Product @ 0% of Commercial Price	0	0	0	0	0
Net Margin (\$)	\$(1,565)	\$(1,002)	\$(834)	\$365	\$369
Net Margin (%)	-104%	-67%	-56%	24%	25%
Return on Investment	-23%	-11%	-8%	18%	18%

IV-2.0 Conclusions

During the course of the study, conclusions were derived from data gleaned from many sources. These conclusions were the basis for assumptions that are an integral part of the baseline that is the conceptual design for this study.

For purposes of determining feasibility, the conceptual design has overstated the building and equipment requirements. The conceptual design liberally applies current steel making technology. The RSS facility is designed for expansion to a plant that can be operated at 120,000 tpy by increasing the operating time to 3 shifts per day, seven days per week. For sheet and plate products, the process equipment selected can be replaced with alternatives that are less expensive but increase the man power required to operate or increase the waste generated. Other products can be made from the molten metal created that are less capital intensive than the sheet and plate products chosen for conceptual design.

The RSS facility capacity is based on limited data. These data suggest that the through-put is 30,000 tpy. The types and kinds of material, degree of contamination of material to be received, and total quantity of metal available requires a detail review to validate the supply of input material.

The products selected for output were chosen based on limited market data. The market demand will determine the final product mix both in terms of types of steel to be produced (stainless or carbon grades) and the product form (sheet, plate, rod, etc.). The product mix chosen for the study was the most capital and labor intensive resulting in a position that supports feasibility of operation.

The only competition is that of NTS. The issue is how the government treats that disposal site. The Nevada Test Site (NTS) buries B-25 boxes at maximum weight for about \$760/ton (including the cost of the container). NTS also buries entire land-sea vans for about \$1924/ton (including the cost of the container). The total cost of disposal at NTS is not reported and only an incremental cost is incurred. All other burial sites (DOE and commercial) are at or above \$2000/ton for burial. An expected competitive price was chosen at \$1500/ton for disposal of RSM. Using this price, the analysis places the RSS production at \$1130/ton to produce products and generated a return on investment of 22 to 64% (depending on output selected). These data support the conclusion that an RSS facility fashioned after mini-mill technology is feasible and can be profitable.

Key to successful completion is the licensing of operation. Air and water emissions must be maintained through an internal water treatment plant and all air exhausted through HEPA filters. Worker exposure is reduced through point source control and remote operations. Vacuum induction melting (VIM) assures environmental compliance and worker safety while reducing secondary waste to near zero.

Solutions to the technical issues of licensing are all achievable. The single biggest issue to success of the project within a particular state is stakeholder acceptance and support. The stakeholders must be involved and kept informed to maintain support.

IV-2.1 Licensing.

Licensing can be accomplished in any of the states that have expressed an interest in the project. However, specific technical issues must be addressed as the licensing process begins. Because the technical issues appear to have solutions, the biggest obstacles to licensing are political issues. Will the state's stakeholders support this project, or will a significant "not in my back yard" contingent derail the project? Specifically, recommendations are:

- ◆ Continue to develop strong ties with the states and their local constituents prior to site selection.
- ◆ Narrow the selection choices to two sites so that engineering work can proceed.
- ◆ Keep the final site-selection options open as long as feasible while developing stakeholder support. The biggest road block to the project's success—perhaps even more so than cost or technical issues—is community support.
- ◆ Learn from the National Conversion Pilot Project. Apply the philosophy of community development that was used successfully for that project.

IV-2.2 Worker Protection.

In order to meet licensing requirements, control of worker hazards must be paramount in the design and operation of the RSS facility. Engineered controls and point-source emission control must be maintained as the primary engineering directive in the design and construction of the RSS facility.

IV-2.3 Facility Siting.

This study identifies six states that appear to be interested in this project. Continued refinement for site location is mandatory to understand the details for the facility's conceptual design. The states should be given the opportunity early to develop proposals. An initial screening to determine the two leading candidates is necessary to support the conceptual design and licensing processes as well as determine infrastructure requirements and facility operation and construction costs.

IV-2.4 Emissions and Environmental Impact.

It is necessary to maintain air and water output as "zero" emissions and to monitor all outputs to ensure that local standards are met. All air emissions must be filtered through HEPA filters, and water discharges only after being treated in the water treatment plant. All process water must be treated and held in storage until test samples are approved for release. Part of the processing requirements are the on-site stabilization of secondary waste. Mixed waste cannot be a byproduct of the plant.

IV-2.5 Plant Capacity.

Plant capacity is driven by two factors: 1) availability of raw material as feed stock and 2) a market demand for the products produced. A capacity of 30,000 tpy was chosen assuming that the

feed material will be available. A study must be performed to verify that 30,000 tpy of feed stock is available, where it can be obtained, the specific quantities of each type of metal, the contamination levels, the potential radionuclides present, and the condition of the metal (rust, paint, fixants, etc.). Defining what input materials are available for use as raw materials is critical to validating the size of the facility and deciding what equipment to specify.

IV-2.6 Market Demand.

Demand for the products is the fundamental cornerstone of the feasibility study. A review was made of product demand to insure that a market does exist. This information is critical because the size of the market dictates capacity of the facility, regardless of the quantity of input material that is available (assuming the minimum supply is available). Therefore, a thorough market study is necessary to complete the determination of feasibility.

IV-2.7 Plant Configuration.

The RSS mill design is based on a partially supported theory that market demand is sufficient to buy 30,000 tpy of 0.075-in. to 0.50-in. plate and sheet. The plant's configuration and costs of construction would change dramatically if the demand for products is different than the products chosen as the basis for the design. Therefore, before Phase II work begins, the baseline configuration first must be validated so that the conceptual design can be reconfigured as required.

It is important to note that the configuration chosen for this analysis is the most capital intensive. Therefore, if the feasibility hypothesis is accepted for this facility, then other less expensive designs will only improve the results of the economic analysis.

IV-2.8 Decontamination Prior to Melting.

Cleaning for decontaminating prior to melting was not adequately analyzed due to lack of available data. No data currently exist to determine the impact on contamination levels as the result of cleaning. Cleaning to remove rust, paint, grease, oil, and fixants is included to maintain melt quality. The degree of decontamination and/or cleaning that is needed for the project is unknown.

IV-2.9 Deminimus Release Limits.

This plant would benefit from the establishment of deminimus release limits for bulk-contaminated material. The effect would be expanded markets available for its products. Therefore, DOE should support such activities.

IV-2.10 VIM Decarburization.

Data indicate that VIM decarburization through the incremental addition of scale (FeO) is achievable. This same data also suggests that the timeline for decarburization can be achieved at the rate of 0.015% reduction in carbon per minute. However, there is a degree of uncertainty about this process. It is recommended that testing and additional data from current processing in

VIM be acquired to validate this technique. Additional data is needed from other manufacturers on how they decarburize in the VIM and the timeline associated with the process.

IV-2.11 Casting System.

Several issues are involved in selecting the casting system. First, and foremost, is the need to understand and validate the final product requirements. Plate and sheet casting apparatus is significantly different from that needed for rebar. One could conclude that adding a rebar production line is appropriate to consume the large amount of carbon steel and use the product by DOE for construction.

A second issue with the casting system is efficiency. As shown in Table III-3.1, the system baseline uses a continuous-casting system that operates only 13 per cent of the time. This system was selected because it introduces hot metal directly into a rolling mill and produces quality stainless steel without ingot conditioning while representing current steel making, mini-mill technology. Notwithstanding the product market affecting the choice of delivery of molten metal, other means of casting are available at capital costs less than the one chosen. Because the productivity is so low compared to the other system components, this suggests that another system may be better suited to this facility design. A trade study must be performed to decide this issue.

IV-2.12 Cold Finishing Operations.

Cold-finishing operations may or may not be required, depending upon the product mix dictated by the market analysis. If stainless steel sheet and plate are the products, a cold-finishing plant is required. The RSS mill analysis includes capital costs of \$12 million and production costs of \$74/ton for this operation, but no design configuration is provided. Validation of the need and the costs must be completed to support the conceptual design in Phase II.

IV-2.13 Rolling Mill.

The design chosen was the most efficient found in modern "mini-mill" designs. However, it may be overkill—Table III-3.1 shows only 15 per cent utilization. Replacing the Steckel mill with a standard four-high rolling mill with reheat capability may be sufficient and will likely require less capital.

IV-2.14 Fabrication.

The unknowns in the fabrication process that should be addressed are:

1. How much residual radiation is present?
2. How will it be released from the resulting melted RSM product?
3. How may a worker be exposed?
4. Will the state license local shops for production?
5. Do specific RSS fabrication facilities need to be included in the RSS plant's baseline design?

IV-2.15 Production.

Tables IV-1.5 to IV-1.8 show that production in this facility depends upon the mix of scrap and how the material is processed. It has been shown that the project has high return on investment for several manufacturing approaches. Keep open all options of output metal for production.

IV-3.0 Recommendations.

The over-riding recommendation is that the project proceed with the next phases and achieve completion. Recycling of RSM in the RSS facility is feasible technically, economically, and can be supported by stakeholders as an environmentally sound solution to disposal of radioactive contaminated scrap metal.

Additional study and refinement is necessary to solidify a conceptual design that can proceed to the next phase. A market study must be performed that defines the output form and product mix expected. A decision on product form and product mix will result in refinement of the conceptual design configuration.

Validation of the supply of RSM and commitment by the DOE to support the generation of RSM through decommissioning activities is necessary to solidify the through-put decision. Without sufficient RSM being generated the RSS plant will operate at less than full capacity. Market forces by competitive pricing will direct RSM to the RSS facility. The RSS conceptual design supports the "Recycle 2000" concept that a large majority of RSM generated will be processed into products by the year 2000.

Early decisions on site location should be made by down-selecting to the two most probable sites. Through public involvement, bring the site stakeholders into the process.

Continue technical refinements to casting methods, post-melt product configuration, VIM refining output, post-melt radiation impact on workers, and surface decontamination requirements prior to melt. The results of these refinements are necessary to define the project prior to proceeding with preliminary design.

In summary, it is recommended that the project move forward as a feasible solution to disposal of RSM. Refinements and decisions should be made early to meet the objectives of a plant becoming operational by the year 2000. Table IV-3.1 provides a listing of all specific recommendations.

Table IV-3.1: RSS Facility Recommendations

1. Continue the project as a feasible project by funding additional studies and later phases.
2. Perform a market demand study. Correlate the demand to similar process requirements. Revise, as required, the preliminary conceptual design that is supported by demand.
3. Determine material specification demand in products. Correlate these data to a product mix by material specification.
4. Validate the supply of RSM, its pedigree, and timing for future decommissioning.
5. Support "Recycle 2000" concept of recycling 50% of RSM into products by the year 2000.
6. Support the establishment of de minimus limits for bulk contaminated products.
7. By additional market research, validate the choice of a "sell price" of \$1500/ton at the DOE sites in lieu of burial.
8. Down select to two candidate sites and create a public involvement plan for implementation at each site.
9. Refine the casting operation by considering the Amstead casting system, standard slab casting, and other techniques that provide sound ingots into the rolling mill or other process.
10. Correlate demand of the market study to the specific process equipment required to meet output demand.
11. Make an early decision on what the post-melt product configuration will be so that appropriate process and fabrication equipment can be defined.
12. Continue work currently under way to define the post-melt fabrication radiation exposure for workers.
13. Determine the effects of surface decontamination prior to melt.
14. Examine refractory life of a 30 ton VIM processing stainless steel with refining and decarburization taking place in the VIM.
15. Validate the 132 minute tap-to-tap time. Determine if scale addition, O ₂ introduction or CO ₂ porous plug decarburization techniques support the decarburization time.
16. Further evaluate the DOE sites for available land, buildings, and equipment.
17. Maintain the project as a "commercial venture." If DOE facilities are to be used, determine a method for placing the facilities "outside" the DOE fence.

BIBLIOGRAPHY

1. **Assessment of Methodologies for the Remelting of Stainless and Carbon Steel Radioactive Scrap Metals**, Atteridge, Shendye, Webster, Buckentin, and Dyer, Oregon Graduate Institute of Science and Technology, March 1995.
2. *Chem-Nuclear Rate Schedule for Barnwell Low-level Radioactive Waste Management Facility*, Rev. July 1994.
3. *Clean Steelmaking, Dirt Cheap*, Dick Swaney, Uhlsteel, 1995.
4. **Decontamination of Metals by Melt Refining/Slagging**, Worcester, Twidwell, Paolini, Weldon, DOE, Idaho National Engineering Laboratory, Westinghouse Idaho Nuclear Company, Inc., WINCO-1138, July 1993.
5. **Decontamination of Metals by Melt Refining/Slagging**, Worcester, Twidwell, Paolini, Weldon, and Mizia, Lockheed Idaho Technologies Company, INEL-95/0123, January 1995.
6. **Decontamination of Metals by Melt Refining/Slagging: First Year Progress Report**, Worcester, Twidwell, Paolini, Weldon, and Mizia, DOE, Idaho National Engineering Laboratory, Westinghouse Idaho Nuclear Company, Inc., WINCO-1198, March 1994.
7. **Development of Steelmaking Technology for Small Sized Special Grades**, Proceedings of The Sixth International Iron and Steel Congress, 1990.
8. **Economics of Spray Forming Pipe, Rolls, and Bimetallic Billets**, Chesney, Madden, and Mascolino, 1995.
9. **Electric Arc Furnace Proceeding**, "*Induction Ladle Metallurgy: An Alternative to the Arc.*", Richard Swaney, Inductosteel Corp., 1987.
10. **Electric Furnace Conference Proceedings**, "*Technoeconomic Assessment: Electric Arc and Coreless Induction As Melters*", Richard Swaney, Inductosteel, 1988.
11. **Engineering Study for a Melting, Casting, Rolling, and Fabrication Facility for Recycled Contaminated Stainless Steel**, Alpha Engineering Inc., Centerline Engineering Corp., J.L. May, and S.D. Wahnschaffe, Lockheed Idaho Technologies Company, INEL-94/0242, January 1994.
12. **INEL Metal Recycle Annual Report FY-94**, INEL-94/0067, T.E. Bechtold, Lockheed Technologies Company, September 1994.

13. **Low-Level Radioactive Waste Management: The California Story**, James G. Tripodes, Nekita O. Hobson, et. al., University of California, Irvine, California, May 1995.
14. **Metal Producing**, "*North American Mini-Mill/Market Mill Directory*", November 1994, Pages 31-42.
15. **Modern Casting**, "*Batch Melting: Advancing Induction Furnace Technology*", John H. Mortimer, Inductotherm Corp., Rancocas, NJ, September 1987.
16. **NESD Packaging and Transportation Guide**, DOE, Office of National Defense Programs, Albuquerque Operations Office, SG 500, May 1995.
17. **New Steel**, "*Iron Age: Scrap Price Bulletin*", May 1995, Pages 36-38.
18. **Nickel and Its Alloys**, W. Betteridge, Butler and Tanner Ltd., London, England, 1977.
19. **Radioactive Scrap Metal Market Study: Use of RSM by Electric Utility Industry for Spent Fuel Storage**, Oregon Graduate Institute of Science and Technology, R. Mizia, and S. Wahnschaffe, DOE, Idaho National Engineering Laboratory, Westinghouse Idaho Nuclear Company, Inc., WINCO-1190, January 1994.
20. **Radionuclides in U.S. Commercial Nuclear Power Reactors**, N.C. Dyer, T.E. Bechtold, DOE, Idaho National Engineering Laboratory, Westinghouse Idaho Nuclear Company, Inc., WINCO-1191, January 1994.
21. **Reclamation and Reduction of Nuclear Residues**, South Carolina Research Authority, Arthur D. Little Inc., Battelle, Duke Engineering and Services Inc., et. al., October 1994.
22. **Refining Technology for the Recycling of Stainless Steel Radioactive Scrap Metals FY-94 Bi-Annual Report**, Atteridge, Buckentin, Carter, Davis, Devletian, Scholl, Turpin, Webster, and Mizia, DOE, Idaho National Engineering Laboratory, Westinghouse Idaho Nuclear Company, Inc., WINCO-1224, August 1994.
23. **Restricted RSM Market Assessment - "Use of RSM to Store, Transport, and Dispose of Radioactive Wastes"**, J.N. Dalzell, David G. Atteridge, Department of Materials Science and Engineering, Oregon Graduate Institute of Science and Technology, December 1994.
24. **Specific Manufacturing Capability**, Lockheed Idaho Technologies Company, 1995.
25. **Steel in the 21st Century**, William T. Hogan, S.J., Lexington Books, New York, 1994.
26. Telephone conversation between D. Rosholt, MSE, and D. Wilkinson, INEL, Feb. 16, 1995.

27. Telephone conversation between D. Rosholt, MSE, and N. Willis, Westinghouse Hanford, Feb. 23, 1995.
28. Telephone conversation between D. Rosholt, MSE, and P. Smith, INEL, Mar. 1, 1995.
29. Telephone conversation between D. Rosholt, MSE, and W. Bliss, NTS, Feb. 21, 1995.
30. **U.S. DOE Scrap Metal Inventory Report for the Office of Technology Development**, Office of Environmental Management, Parsons Engineering Science, Inc., RMI Environmental Services, and U.S. Steel Facilities Redeployment Group, DOE/HWP-167, March 1995.
31. *U.S. Ecology Rate Schedule for Washington Nuclear Center Radioactive Waste Disposal Center*, Effective Jan. 1, 1995.
32. **WINCO Metal Recycle Annual Report - FY 1993**, T.E. Bechtold, DOE, Idaho National Engineering Laboratory, Westinghouse Idaho Nuclear Company, Inc., WINCO-1172, December 1993.

 

Appendix A

VIM Furnace Photographs and Sketch

Figure A-1: VIM Furnace in Closed Position.

Figure A-2: VIM Furnace in Open Position.

Appendix B

Preliminary Conceptual Design Drawings

Appendix B

Preliminary Conceptual Design Drawings

Western United States Radioactive Scrap Steel Mill

LOCKWOOD GREENE
1000 2ND ST. S.W. ALBUQUERQUE, N.M. 87102

BUILDING SIZES	
SCRAP RECEIVING	60,800 SQ.FT.
SCRAP PREPARATION	28,100 SQ.FT.
MELT SHOP	28,400 SQ.FT.
ROLLING MILL INCLUDING PRODUCT STORAGE AREA	55,200 SQ.FT.
SCRAP AREA OFFICES	2500 SQ.FT.
MELT SHOP LOCKER ROOM	3000 SQ.FT.
MARSH OFFICES	4500 SQ.FT.
ROLLING MILL AND MAINTENANCE LOCKER ROOM	4500 SQ.FT.
MILL ELECTRICAL CONTROL ROOM	4500 SQ.FT.
WATER TREATMENT	8600 SQ.FT.
SLAG PITS & COOLING TOWER	10500 SQ.FT.
TOTAL	204,600 SQ.FT.

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14052-913-9000 199509051035

CHARGE MATERIALS

ALLOY ADDITIONS & REFINING

CENTERLINE ENGINEERING CORPORATION				CENTERLINE ENGINEERING CORPORATION			
4052-913-9001				Client: MANUFACTURING SCIENCES CORPORATION			
PROJECT ACCOUNT DOCUMENT				Subject:			
TYPE DESCRIPTION B BIDDING A FOR APPROVAL I INFO/REF M MATERIAL ORDERING P PRELIMINARY R REVISION C CONSTRUCTION				FEASIBILITY STUDY RADIOACTIVE SCRAP STEEL PROCESS DIAGRAM			
B SEPT-5-95 P A JUN-28-95 P C		DATE TYPE		Project no. 4052		Client Proj. no.	
ISSUE RECORD		APPROVED		Date 9-20-95		Scale NTS	
REV		By		Date		DWG. NO. 4052-9001	

J:\4052\40529001 19950905.1038

FOR CONTINUATION OF
SCRAP PREP./RECEIVING AREA
SEE DWG 4052-9006

CENTERLINE ENGINEERING CORPORATION			
4052-913-9002			
DATE	BY	CHK'D	APP'D
SEP-5-95	P		
JUN-8-95	P		
	C		
ISSUE RECORD			
APPROVED			

REV	By	Date

C CENTERLINE ENGINEERING CORPORATION

Client: MANUFACTURING SCIENCES CORPORATION			
Subject: FEASIBILITY STUDY RADIOACTIVE SCRAP STEEL MELT SHOP PLAN			
Project no. 4052	Client Proj. no.	Location	
Des. HED	Date 6-22-95	Scale 1/16"=1'-0"	App'd
Chk'd	Date	DWG NO. 4052-9002	

J:\4052\40529002 199509050906

bays @ 30'-0" = 480'-0"

4052 913 9003		C CENTERLINE ENGINEERING CORPORATION	
PROJECT ACCOUNT BILLING		Client: MANUFACTURING SCIENCES CORPORATION	
TYPE DESCRIPTION		Subject: FEASIBILITY STUDY	
B BIDDING		RADIOACTIVE SCRAP STEEL	
A FOR APPROVAL		PLAN VIEW - ROLLING MILL	
I INFO/REF		Project no. 4052	
M MATERIAL ORDERING		Client Proj. no.	
P PRELIMINARY		Location	
R REVISION		Den MED Date 6-27-95 Scale 1/16"=1'-0" App'd	
C CONSTRUCTION		Ch'd Date	
ISSUE RECORD		DWG. NO. 4052-9003	
APPROVED		REV By Date	

I:\4052\40529003 19950818.1034

4052 913 9004		
PROJECT	ACCOMP	REV/DATE
TYPE	DESCRIPTION	
B	BIDDING	
A	FOR APPROVAL	
J	INFO/REF	
M	MATERIAL ORDERING	
P	PRELIMINARY	
R	REVISION	
C	CONSTRUCTION	
A	6/28/95	P
DATE	DATE	TYPE
ISSUE RECORD		
APPROVED _____		

CENTERLINE ENGINEERING CORPORATION			
Client: MANUFACTURING SCIENCES CORPORATION			
Subject: FEASIBILITY STUDY RADIOACTIVE SCRAP STEEL ELEVATION THRU MELT SHOP			
Project no. 4052		Client Proj. no.	
Location			
Des: HED	Date: 6-27-95	Scale: 1/8"=1'-0"	App'd:
Ch'd:	Date:	DWG NO. 4052-9004	
REV	By	Date	

J:\4052\4052-9004 19950818 1042

13'-0"

10'-0"
58'-0"
(TO TOP OF RAIL)
68'-0"

INDUCTION
FURNACE
TRANSFORMERS

MELT SHOP
HEPA FILTER BLDG.
(2-FLOORS)

21'-0"

			4052	913	9005
			PROJECT	ACCOUNT	DOCUMENT
			TYPE	DESCRIPTION	
		B	BIDDING		
		A	FOR APPROVAL		
		I	INFO/REF		
		M	MATERIAL ORDERING		
		P	PRELIMINARY		
		R	REVISION		
		C	CONSTRUCTION		
A	6/28/95	P			
SCALE	DATE	TYPE			
ISSUE RECORD			APPROVED _____		

Client: MANUFACTURING SCIENCES CORPORATION			
Subject: FEASIBILITY STUDY 'A' RADIOACTIVE SCRAP STEEL MELT SHOP SECTION AT FURNACE			
Project no. 4052		Client Proj. no.	
Date 6-27-95		Scale 1/8"=1'-0"	
Don HED		App'd	
REV By Date		DWG NO 4052-9005	

\\4052\40529005 199508211422

SECTION "A-A"
THIS DWG.
SCALE: 1" = 20'-0"

CENTERLINE ENGINEERING CORPORATION	<p style="font-size: small;">THIS DRAWING AND ALL INFORMATION CONTAINED HEREIN IS THE PROPERTY OF CENTERLINE ENGINEERING CORPORATION AND MUST BE RETURNED UPON REQUEST. NEITHER THIS DRAWING NOR ANY INFORMATION CONTAINED HEREIN IS TO BE LOANED, REPRODUCED, COPIED, OR FURNISHED TO OTHERS WITHOUT THE PRIOR WRITTEN CONSENT OF CENTERLINE ENGINEERING CORPORATION.</p>
CENTERLINE ENGINEERING CORPORATION
4052-913-9006		Client: MANUFACTURING SCIENCES CORPORATION
PROJECT ACCOUNT DOCUMENT		Subject:
TYPE DESCRIPTION		FEASIBILITY STUDY
B	BIDDING	RADIOACTIVE SCRAP STEEL
A	FOR APPROVAL	RECEIVING/PREPARATION AREA
M	INFO/REF	
P	MATERIAL ORDERING	
A	PRELIMINARY	
A	REVISION	
P	CONSTRUCTION	
C		
B SEPT-5-95 P A AUG-1-95 P		Project no. 4052
ISSUE RECORD		Client Proj. no.
APPROVED		Location
REV By Date		Date 8-1-95
SCALE		Scale AS NOTED
APPR'D		Appr'd
4052-913-9006		4052-9006

4052\40529006 19950905 0913