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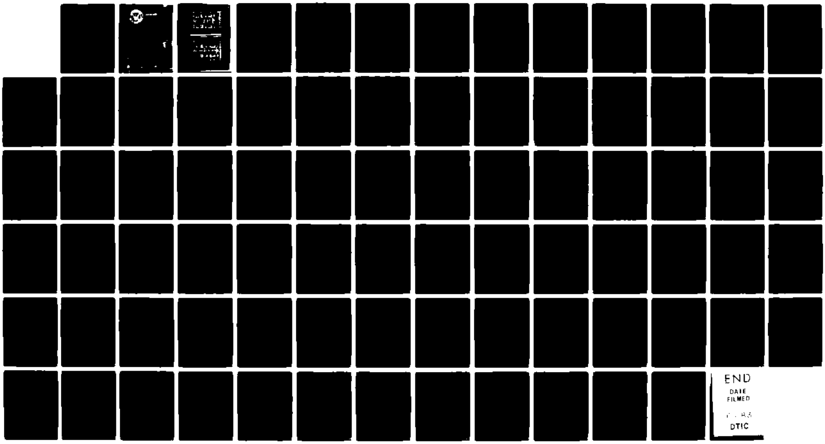

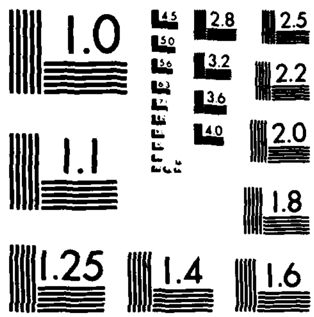

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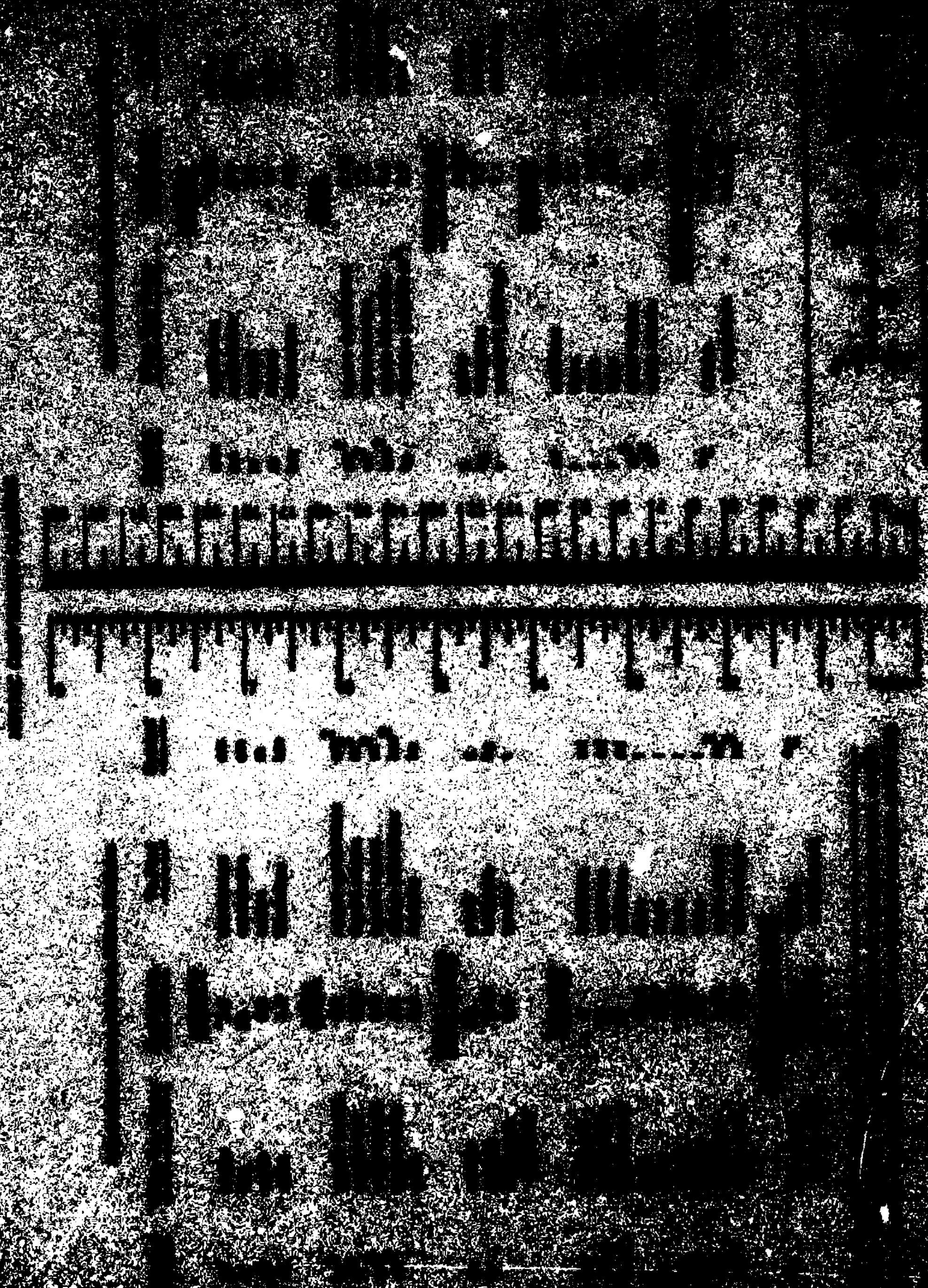
THE CONCEPT AND ECONOMICS OF RDF-3 UTILIZATION IN A NAVY SIZE PULVERIZED COAL BOILER

May 1983

An Investigation Conducted by
WASTE ENERGY TECHNOLOGY CORPORATION
Bedford, Massachusetts

N62583-82-MT-189



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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report addresses the economics of co-firing refuse derived fuel (RDF) in a pulverized coal boiler. The report specifies the type of RDF required, the type and cost of processing equipment to produce the RDF, the cost and type of modifications to the coal boiler, and the expected O&M costs for the modified boiler. Life cycle economic analyses based on various

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RDF feed rates are used to determine the suitability of RDF use in a pulverized coal boiler.

FOREWARD

This report is the first in a series of three reports on the co-combustion of Refuse Derived Fuel (RDF) in Navy sized steam boilers. Three types of boilers: pulverized coal, stoker coal, and oil-fired, were analyzed to determine the feasibility of RDF use. Information was provided in the following areas:

- Type of RDF required
- Processing plant needed to produce the RDF
- RDF production costs
- Required boiler modifications and costs
- Potential fuel and landfill savings
- Feasibility or breakeven point of RDF-coal use versus 100% evaluation
- Navy boilers with the potential to be converted to RDF use

The information in these reports is given in a generic form. It is intended to serve as guidance to activities considering procuring RDF for use in new or existing boiler facilities. Before applying the results to an activity, specific information will be required. The requirements include data on the following:

- Existing and projected fossil fuel costs
- Steam demand - peaks and average
- Types and conditions of existing boilers
- Local air pollution control requirements
- Quantity and properties of waste generated

The technical and economic evaluation of RDF use at a specific site will change depending on the above data. Therefore, cost information in this report should be used as an indication of current costs.

NCEL is also working in other areas of solid waste research, including design guidance for heat recovery incinerators, survey methods for solid waste characterization, other forms of waste as a fuel (mass buring and densified - RDF), and reliability analysis of HRI technology.

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SECTION 1.0

EXECUTIVE SUMMARY

This report presents the concept and economics of using RDF-3 in a Navy sized (150 mBtu per hour) pulverized coal boiler. RDF-3 is defined as a fuel derived from municipal solid waste which has been processed to remove metal, glass and other inorganics and shredded to a nominal particle size less than 2 inches. The purpose of the report is to identify the optimum processing scheme and the life cycle costs for co-combusting RDF-3 with coal at naval shore facilities. Evaluations have been included for utilzation of RDF-3 at substitution rates of 10% and 20% on a heating value basis.

Reference data has been gathered from many of the fully operational facilities that co-fire RDF with coal in suspension boilers. The experience gained at other facilities has been used as a guide in the development of the concepts and cost evaluations presented herein.

The system has been subdivided into five distinct subsystems:

- Processing subsystem
- Transportation subsystem
- Storage subsystem
- Delivery subsystem
- Combustion subsystem

It has been assumed that a private contractor will own and operate the processing and transportation subsystems for the production of conforming RDF-3 and delivery to the storage silo at the Navy site. The Navy will own and operate the remaining subsystems.

Based on a 20% RDF substitution rate, the processing subsystem will process 130 TPD of typical municipal solid waste, 5 days per week on a single shift basis. A pre-trommel will screen out the fine inert materials from the waste, so that a shear shredder can reduce the particle size for subsequent separations without embedding the inerts into the combustible components. After shredding, the waste is separated by a high velocity air stream to remove the lighter combustible fraction from the heavier glass and metal materials. This light fraction is de-entrained from the air and magnetically separated to remove any ferrous contaminants. The light fraction (RDF-3) is then conveyed from the processing subsystem to the storage silo using a rubber belted mechanical conveyor. A flexible molded side wall conveyor with cleats is employed to elevate the RDF-3 to the top of the silo.

The Atlas silo, a conical shaped structure, will provide storage for 3 days production of RDF-3 to allow the boiler to operate 24 hours per day, 7 days per week. The silo discharge is variable speed so that constant substitution rates can be maintained for boiler loads between 50% and 100% Maximum Continuous Rating (MCR).

A positive displacement pneumatic transport system delivers the RDF-3 from the storage silo to the boiler. Two transport lines are used to introduce the RDF-3 into opposite corners of the boiler.

The combustion subsystem consists of a suspension fired boiler which normally combusts coal. Modifications to the boiler, required to reliably co-fire RDF-3, include the addition of a dump grate, the installation of overfire and underfire air headers, and increase in the capacity of the ID fan. No changes are anticipated for the electrostatic precipitator, water treatment system or the ash handling system.

The construction costs based on January 1983 dollars for the five subsystems, presented in Figure 1-1, include engineering, construction management, procurement of land, site development, building erection, and equipment procurement and installation. A contingency has been included in the construction cost for each subsystem to account for unknown elements and potential problems.

The annual O&M costs for each of the subsystems are summarized in Figure 1-2. The O&M costs include labor, materials, utilities, residue disposal and other indirect expenditures required for facility operation.

Because of the split ownership and operational objectives of the private contractor and the Navy, two different financing methods for projecting capital costs and performing life cycle cost analysis were utilized. The life cycle cost analysis presented herein, indicate that at a 20% RDF substitution rate, the tipping fee required to offset those costs associated with the contractor owned and operated facilities (i.e. processing and transport subsystems), is $65.85 per ton. This tipping fee was calculated based on projected RDF-3 fuel sales to the Navy of $195,000 in year one, or $8.86 per ton of RDF. The Navy requires that over the life of the project (25 years), their return on investment is a minimum 10 percent, and that they incur no additional costs to combust RDF than they would if they continued to combust coal only.

These analyses also indicate that the tipping fee can be reduced to $49.00 per ton, provided that during the structuring of the project financing, a stabilization fund is created to derate the tipping fee during the initial years of the project. Capital to pay back the stabilization fund is generated during the later years of the project through "anticipated" revenues which more than offset the projected expenses to own and operate the facility. However, even at the derated tipping fee of $49.00

per ton, it is unlikely that a community would elect to pay such a fee for the disposal of solid waste, irrespective of the fact that the proposed facility may offer a long-term solution to their solid waste disposal problem.

Life cycle cost analysis for a 10% RDF substitution rate were performed and are presented herein. These analyses indicate for this small size boiler plant that over the life of the project, the projected fuel savings to the Navy are not sufficient to cover those costs associated with the ownership and operation of the facilities (i.e. storage, delivery and combustion subsystems) even if they could obtain the RDF at zero cost.

The utilization of RDF-3 in a pulverized coal boiler, as used by the Navy at its shore facilities, is a technically sound and environmentally desirable concept for waste disposal. However, utilization of RDF-3 in the quantities specified by the Navy and at the substitution rates projected for combustion in a pulverized coal boiler does not appear to be cost-effective when compared against the off-set costs for combusting coal alone.

The proposed concept economics reported herein would become more attractive provided: a) fuel cost savings are computed on a basis of fuel oil replaced and/or b) larger quantities of RDF-3 could be combusted by employing additional, different, or larger combustion units. Since the scope of work under this contract was limited to evaluating only 10% and 20% substitution rates in a 150 mBtu per hour boiler, insufficient data is available to project the level at which the proposed system concept becomes economically viable.

FIGURE 1-1

CONSTRUCTION COSTS SUMMARY

Private Contractor	10% Substitution	20% Subsitution
o Processing Subsystem	$4,365,300	$5,717,500
o Transportation Subsystem	1,372,500	1,639,750
	-----------	-----------
Subtotal	5,737,800	7,357,250
Navy		
o Storage Subsystem	1,539,600	1,990,300
o Delivery Subsystem	248,600	269,600
o Combustion Subsystem	241,200	250,700
	-----------	-----------
Subtotal	2,029,400	2,510,600
Total Construction Costs	$7,767,200	$9,867,850

FIGURE 1-2

ANNUAL O&M COSTS SUMMARY

Private Contractor	10% Substitution	20% Substitution
o Processing Subsystem	$606,000	$803,090
o Transportation Subsystem	27,300	37,400
Subtotal	633,300	840,490
Navy		
o Storage Subsystem	52,900	66,950
o Delivery Subsystem	69,100	76,200
o Combustion Subsystem	23,100	41,000
Subtotal	145,100	184,150
Total Annual O&M Costs	$778,400	$1,024,640

SECTION 2.0

INTRODUCTION

This report presents a concept for the utilization of RDF-3 in a pulverized coal boiler, as used by the Navy at its shore facilities. Economic evaluations are included, assuming the Navy will purchase the RDF-3 from a private contractor who owns and operates a solid waste processing facility. The RDF-3 will be co-fired with coal in an existing suspension fired boiler. It has been assumed that modifications to the combustion equipment will be required in order to utilize the RDF-3 as a fuel supplement. The considerable experience that has been gained with co-firing RDF and coal at major operatonal boiler facilities has been compiled as a basis for determining the boiler modifications which will be required.

In compliance with the scope of work, the project is presented using the following distinct elements:

- Processing subsystem
- Transportation subsystem
- Storage subsystem
- Delivery subsystem
- Combustion subsystem

The system concept for the overall project, discussed in section 3.0, is based on the requirements contained in the scope of work. Reference data from fully operational recovery facilities such as St. Louis, MO; Ames, IO; Monroe County, NY; and Milwaukee, WI have been used as a guide in the development of the mass balances and projected performance levels of the equipment components and subsystems.

Detailed construction cost estimates for each of the subsystems are presented in Section 4.0, along with a description of the work to be performed. Section 5.0 identifies the annual O&M costs for each subsystem, including labor, materials, utilities and residue disposal.

Life-cycle economics for the project, addressed in Section 6.0, have been prepared following standard engineering practice for estimating the long-term costs and benefits of the project. Different sets of evaluation criteria have been employed to account for the difference in financing methods between the private contractor and the Navy facilities. Section 7.0 identifies potential methods for making the proposed concept more economically attractive and provides comparitive technical, operational and financial information.

Information has been provided for both 10 and 20% RDF-3 substitution rates for coal, on a heating value basis.

SECTION 3.0

SYSTEM DESCRIPTION

3.1 GENERAL

Technology in the field of RDF production and handling has advanced at a rapid pace during the past few years as more facilities have begun operations. These advancements have been reflected in the newer facilities which are presently under design and construction. WETCO has conducted the engineering studies and investigations necessary to properly assess the state-of-the-art of RDF production and handling. The findings from these evaluations were used as the basis of projecting the performance levels of the subsystems presented herein.

This section details the subsystems utilized for producing, transporting, storing, feeding and combusting RDF-3 at a typical naval shore facility in a pulverized coal boiler, as outlined in the scope of work.

The processing facility will be located off the Navy site but within one-quarter mile of the storage facility. The processing facility will be privately owned and operated, and it will be the responsibility of the contractor to produce conforming RDF-3 and deliver it to the storage silo.

The system descriptions and sizing throughout this report are based on a 20 percent substitution rate of RDF-3 for coal in the boiler. A brief discussion is included at the end of each section which presents the impact of utilizing a 10 percent substitution rate.

The RDF-3 specifications provided by the Navy as the basis of design are as follows:

Heating value	7500 Btu/lb (dry)
Moisture content	20 %
Ash content	10 %
Particle size	95 % less than 2 inches
Density	5 lbs/cu. ft.

The RDF-3 product will consist primarily of paper, corrugated, plastics, textiles and other light organic materials which have been removed from the waste stream.

It has been assumed that the processing facility will operate five days per week, one shift per day and the boiler system will be operational 7 days per week, 24 hours per day. Therefore, the silo has been sized to provide storage for 3 days' combustion of RDF-3.

The storage silo will be located within 200 feet of the boiler and the retrieval mechanism from the silo will be required to deliver two separate feed streams to the boiler, so that opposite corners are fed.

The energy generated will be utilized by the Navy and will not require further transmission or generation beyond the boiler discharge steam line, which currently exists.

A listing of the equipment to be provided in each subsystem is presented in Figure 3-1. Typical suppliers for the equipment are included along with the unit power requirements.

FIGURE 3-1: EQUIPMENT LIST

EQUIPMENT	POTENTIAL VENDOR	MODEL NO.	APPROX. DIMENSIONS [1]	ESTIMATED POWER REQ'D.	DESIGN [2] CAPACITY
Trommel Screen	The Heil Co. Triple-S Humphreys	—	9'dia. x 40' L (3/4 to 1-1/2" dia. holes)	60 HP	20.0 TPH
Shear Shredder	IMCO [3] Saturn	5096	157"x70"x60" (LxWxH) Feed throat 50" x 96"	400 HP	15.2 TPH
Air Separator	Mac Equipment [3] Rader Systems				20,000 CFM
- Separator		—	5'x 3'x 10' (LxWxH)	10 HP	
- Cyclone		H85	85" dia.	15 HP	
- Baghouse		96AVW192	20'x6.5'x16.5'(LxWxH)	200 HP	
- Fan		HS70	—		
Magnetic Separator	Stearns [3] Dings	4248	42" dia. x 48" L	5 HP	
Secondary Shredder	Heil [3]	72F	14'x14'x12' (LxWxH) Feed Throat 72" dia.	500 HP	15.0 TPH
Dust Collector	Mac Equipment [3] Dustex IMCO	96MWP116	107" dia. x 26.5' H	125 HP	15,000 CFM
Storage Silo	Altas [3]	13TP	62'dia. x 62' H	75 HP	250 TONS
Boiler Feed [4]	Rader Systems [3] Mac Equipment				1.25 TPH (each)
- Blower Assembly		—	14'x 11'x 15' (LxWxH)	150 HP	
- Airlock Feeder		25x30	25" dia. x 30" L	10 HP	

[1] Dimensions used in facility layout(s).
[2] Nominal design capacity.
[3] Vendor used as basis for equipment selection and equipment dimensions.
[4] Two systems each.

3.2 PROCESSING SUBSYSTEM

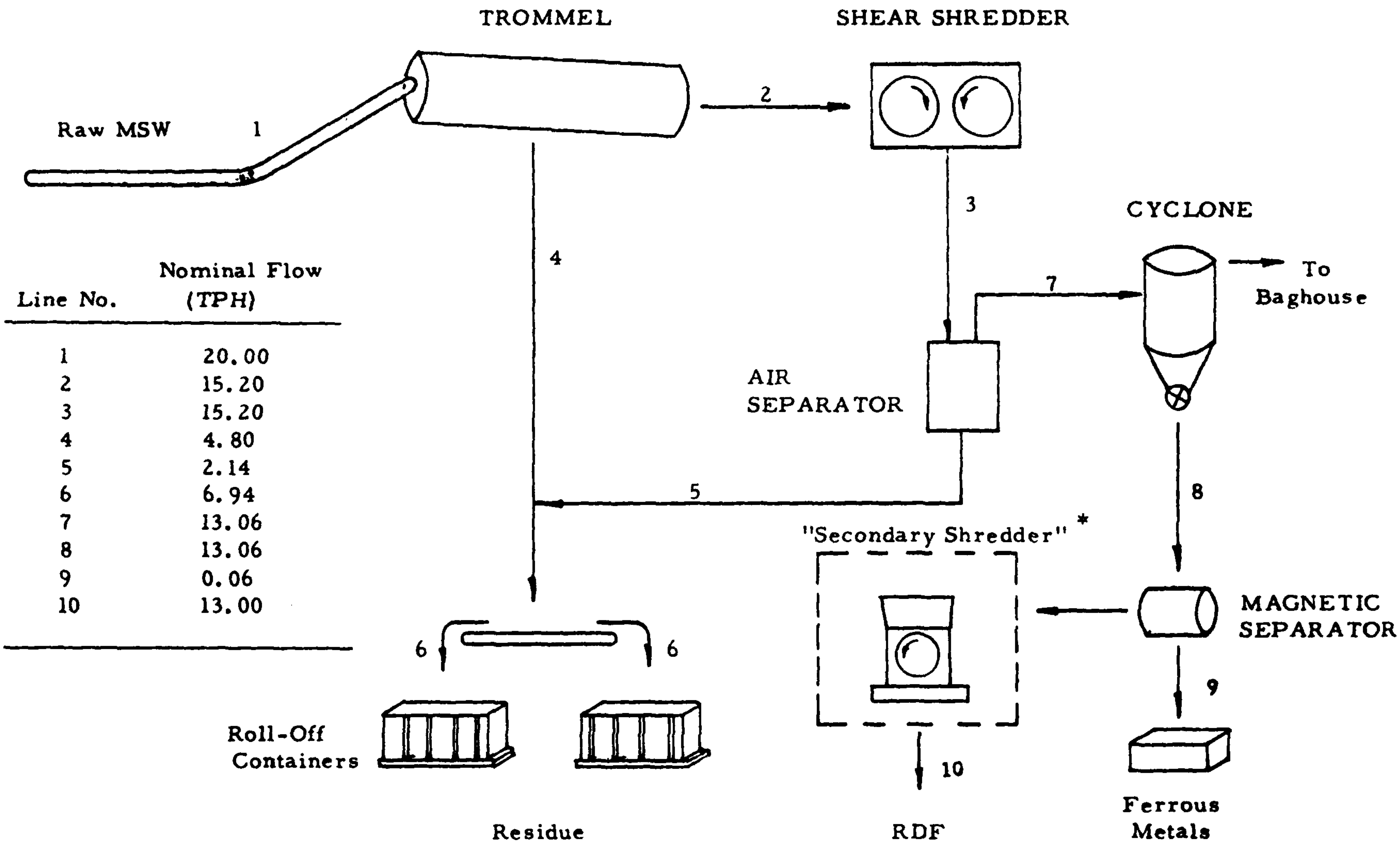
The proposed process system is shown diagrammatically in Figure 3-2. The system will process typical municipal solid waste (MSW) and has a capacity of 130 TPD (20 TPH). Based on a recovery rate of 65 percent, the system is anticipated to yield 84 TPD of RDF-3. The remaining residue will not be further processed and will require disposal at a certified landfill site.

Reference data gathered from many of the operational RDF processing facilities were compiled as a basis of design. These data are summarized in Figure 3-3.

A description of the various elements which comprise the processing subsystem is as follows:

Site- A minimum of 4 acres will be required for the processing subsystem to allow adequate access for delivery of MSW and collection/removal of residues. The site will be located adjacent to the Navy facililty so that transport of the RDF-3 will be less than one-quarter mile to the storage silo. A typical facility layout plan is shown on Figure 3-4.

Facility- The facility will be constructed using a pre-engineered, metal sided building with steel framed structures. The building will be divided into two main rooms by a partition wall. One room will enclose the tipping floor where the MSW is first unloaded and stored. The second room will house the equipment and conveyors necessary to process the waste into RDF-3. A minimum of 11,000 square feet of building space will be required to house the equipment and provide storage for incoming MSW.



Line No.	Nominal Flow (TPH)
1	20.00
2	15.20
3	15.20
4	4.80
5	2.14
6	6.94
7	13.06
8	13.06
9	0.06
10	13.00

* The secondary shredder is shown as an optional processing step, due to the undefined sizing capability of the shear shredder.

Figure 3-2: RDF-3 Process System Flow Diagram (20% Substitution)

FIGURE 3-3

PROCESS SUBSYSTEM - REFERENCE DATA

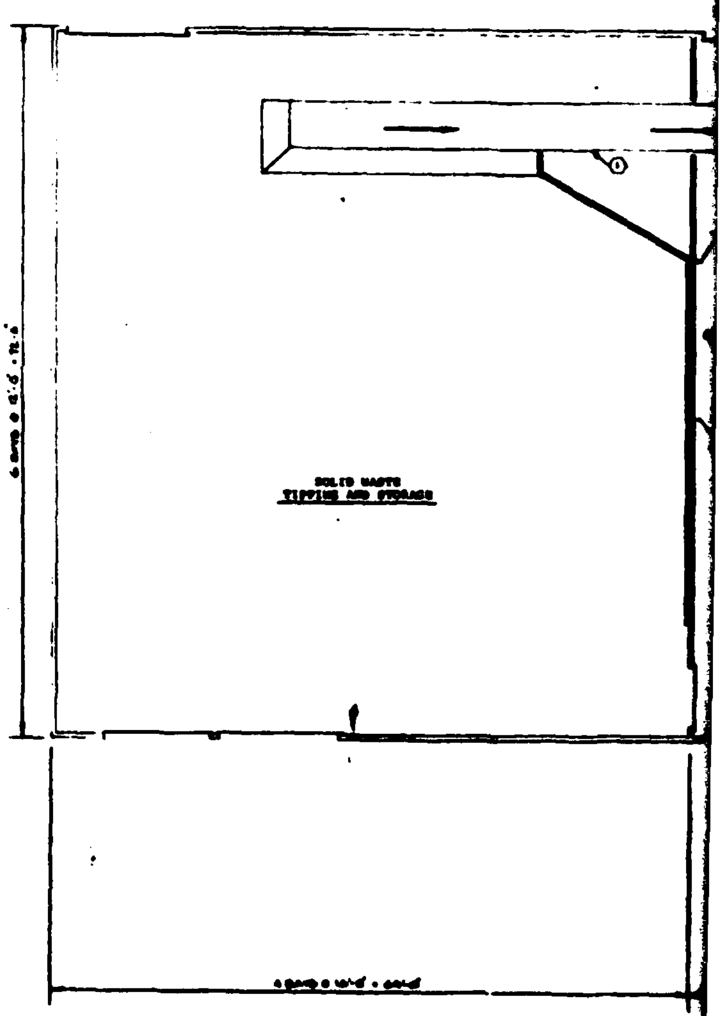
Reference Plant Location	System Description for RDF Removal	RDF Recovery (% of Infeed)	RDF Quality			
			Density (Kg/m^3)[3]	Ash (%)	Moist. (%)	HHV (Kj/kg)[2]
St. Louis Missouri	Shred, air classify	80.6	120 (7.5)	20.9	25.3	11,167 (4,801)
Ames Iowa	Shred, magnetic sep., screen, shred, air classify	67.8	42 (2.6)	9.6	18.4	14,209 (6,109)
Monroe County New York	Shred, air classify, screen, shred, magnetic sep.,	40.0[1]	80 (5.0)	19.7	27.0	11,769 (5,060)
Madison Wisconsin	Flail mill, magnetic sep., screen, shred, air classify	56.3	ND	15.1	24.2	ND
Milwaukee Wisconsin	Shred, air classify, magnetic sep., screen	54.4	135 (8.5)	19.3	29.2	11,711 (5,035)

1) The skim classifier and the secondary air classifiers were not operated during this period.
2) The values shown in parenthesis are Btu/#.
3) The values shown in parenthesis are pounds/cubic feet

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible][1]
1	[illegible]	5'-0"	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	5'-0"	[illegible]	0.0	7.0	7.0	
3	[illegible]	6'-0"	[illegible]	[illegible]	17.0	4.0	[illegible]
4	[illegible]	4'-0"	[illegible]	[illegible]	9.0	3.5	
5	[illegible]	5'-0"	[illegible]	0.0	5.5	2.0	O.C.
6	[illegible]	5'-0"	[illegible]	[illegible]	[illegible]	2.5	[illegible] P.C.
7	[illegible]	5'-0"	[illegible]	0.0	[illegible]	[illegible]	[illegible]
8	[illegible]	6'-0"	[illegible]	13.0	10.0	2.5	
9	[illegible]	6'-0"	[illegible]	[illegible]	7.5	2.5	
10	[illegible]	6'-0"	[illegible]	[illegible]	[illegible]	2.5	[illegible]

(1) [illegible] O.C. = [illegible] P.C. = [illegible]



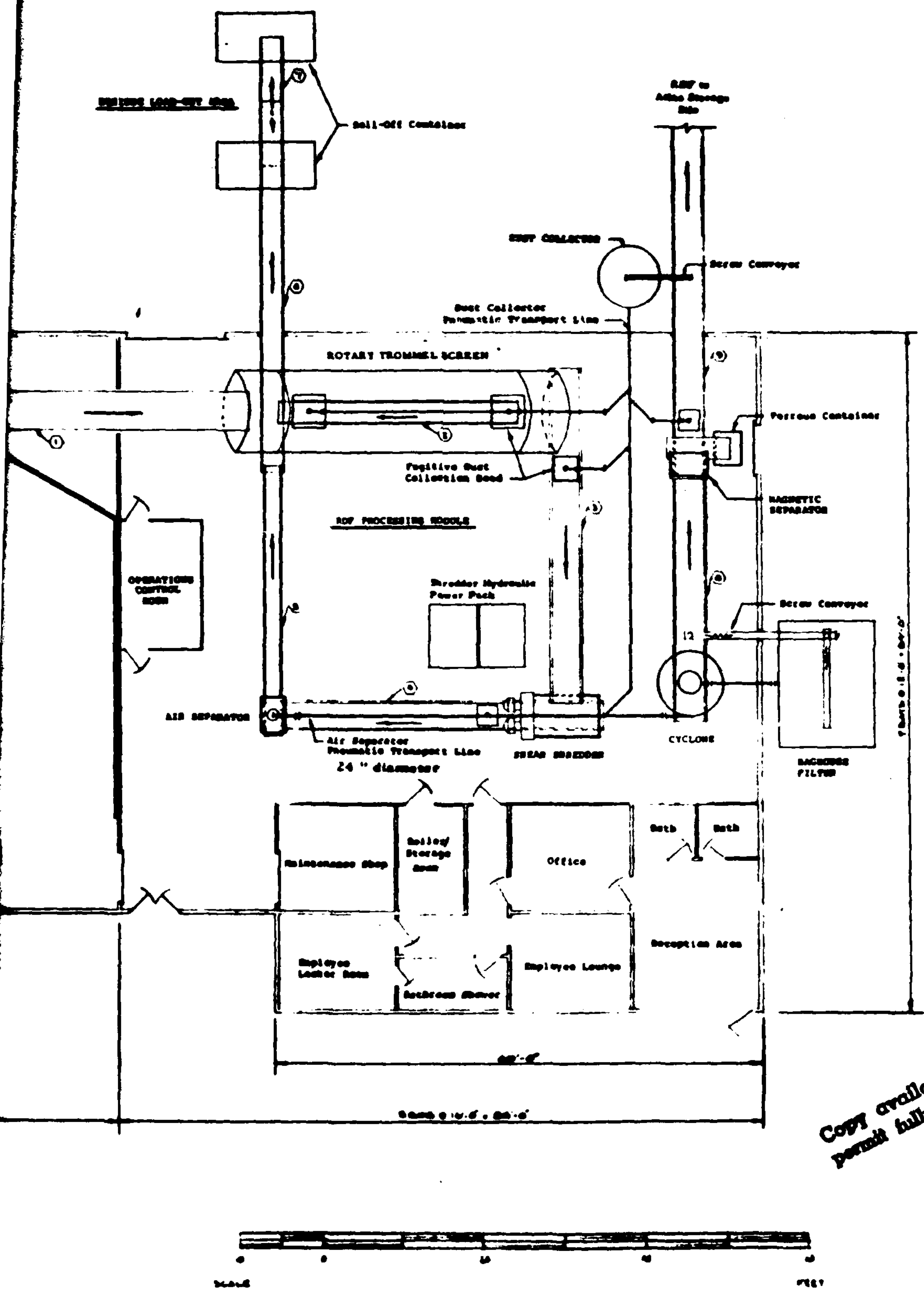


Figure 3-4

PRELIMINARY FACILITY LAYOUT
RDF-1 PROCESSING SYSTEM

WASTE ENERGY TECHNOLOGY CORPORATION

The facility will be heated and will be protected by a water deluge, fire protection system. Platforms and walkways will be included to allow maintenance of the equipment. Controls and instrumentation will be housed in a separate enclosure to prevent damage from dust. A separate dust collection system will be provided with pick-up hoods at each material transfer point throughout the system.

The tipping floor will be sized to provide storage for 200 tons of MSW. This will allow for one and one-half days' accumulation of waste to permit the system to operate on an uninterrupted basis. A front end loader will be employed to introduce MSW to the system.

<u>Pre-trommel</u>- The trommel will break open the majority of bags without the requirement for flail milling prior to screening. A 9-foot diameter trommel will remove the fine inerts and grit from the MSW prior to shredding. Experience at Hempstead, NY; Monroe County, NY; and Toronto, Canada, summarized in Figure 3-5, has verified that a substantial quantity of the fines which would otherwise be removed with the RDF during air classification can be separated out by pre-trommeling. This prevents the fines from becoming embedded in the combustible materials during shredding and allows a lower ash RDF to be recovered by air separation.

The quantity of material separated out as an undersize fraction can be controlled to a great extent by the proper selection of hole sizes for the trommel. The anticipated range of hole sizes is 3/4 to 1-1/2 inches diameter. The final determination should be made based on the actual size distribution of the MSW to be processed. Based on the data available, it appears that a screening efficiency between 50 and 70% can be anticipated.

FIGURE 3-5

PRE-TROMMEL - REFERENCE DATA

Reference Plant Location	Trommel			Performance Data	
	Diameter (Feet)	Length (Feet)	Openings (Inches)	Feedrate (TPH)	Undersize (% of infeed)
Hempstead New York	7.0	24.0	1-1/8	---	28.0
Monroe County New York	9.0	32.0	3/4	20.0	23.5
Toronto Canada	6.0	24.0	3/4	---	11.0

The trommel will be enclosed to prevent discharge of dust during operations. A dust hood will be provided, connected to the facility dust control system, to remove airborne dust that would otherwise pose problems related to personnel health and safety.

Primary shredder- A slow speed, shear type shredder will be utilized to reduce the particle size of the pre-trommel oversize fraction. The shear shredder reportedly does not pulverize the glass or cause the fines to become embedded in the combustible materials. The larger pieces of glass will not be picked up during air classification, which should result in a high quality, low ash RDF-3.

The shear shredder will be designed to process the most difficult-to-shred items that are anticipated in the waste stream. The shear shredder is advertised to offer the following benefits over other shredders:

- lower capital costs (including installation)
- lower maintenance costs
- reduced power consumption
- less potential for explosions

Little data could be located on the shear shredder to substantiate how it will perform on size reduction of MSW. The testing program being conducted by WETCO on the shear shredder in Charleston, SC will not be initiated until early October and therefore size distribution data for the shredder was not available for inclusion in this report.

For purposes of this report, it has been assumed that the shear shredder will reduce the pre-trommel oversize fraction to a particle size of 95% less than 2 inches. This represents the largest reported material size which has been effectively fired in a suspension-type boiler.

If it is determined the shear shredder cannot perform as advertised, other more conventional types of shredders can be utilized to shred the waste. Both horizontal shaft and vertical shaft shredders/hammermills have been shown to perform satisfactorily in size reduction of MSW to the particle sizes required for the proposed system. Selection of either type of conventional shredder will likely result in a significant increase in the overall capital and O&M costs for the project. Conventional shredders occupy greater floor space. Their high speed of rotation and greater height and weight will require increased size of the foundations, building and feed conveyor length. A high horsepower motor will be required to power the shredder.

Air separator- Air separation is required to further reduce the content of glass, metals and heavy organics in the RDF-3 which would cause damage to the airlocks, plugging of pneumatic lines, excess abrasion on wear surfaces and slagging in the boiler.

A vertical chamber air separation system, complete with blower, cyclone, dust collector and airlocks will remove the lighter combustible materials from the heavier components (glass, metals, and heavy organics) after primary shredding in the shear shredder. The light fraction will be transported pneumatically from the air separator and will be deentrained by a cyclone. A fabric type dust collector will filter the dust from the air before discharge to the atmosphere. The dust and light fraction will both be delivered to a belt conveyor for delivery to the storage silo at the Navy facility.

The heavy materials from the air separator will be combined with the residues from the pre-trommel for discard.

If the size distribution from the shear shredder is significantly larger than projected, a different type of air separation system can be employed. Either a rotary drum or concentric tube air classifer should be considered for processing the larger particle sizes. These units are larger in size and will result in increased capital costs for the project due to the increased floor space requirement and increased purchase price. O&M costs should not be greatly impacted.

Magnetic separator- A drum type magnetic separator placed above the light fraction conveyor belt will remove the magnetic metals (small amounts of cans, lids, and wire) from the flow stream which would otherwise create problems in the pneumatic transport system. After removal of the metals, the light fraction (RDF-3) will be transported to the storage silo at the Navy facility.

The ferrous metals that are removed will be collected and disposed of at a certified landfill. Due to contamination by textiles, string and other combustible materials, the ferrous metals removed from the combustible fraction will not be marketable.

Conveyors- The conveyors which will be required by the processing subsystem are itemized in Figure 3-6. Rubber belted, troughing conveyors are used throughout the facility, with the exception of the infeed to the trommel. Similar conveyors have been successfully employed at many of the major resource recovery facilities and have undergone numerous improvements in design and operations to increase their reliability.

Dust collection system- Low velocity pick-up hoods will be provided to prevent fugitive dust emissions at each material transfer point in the processing subsystem. The pick-up air will be filtered using a fabric type dust collector.

Uncertainties- Due to the inability to define the discharge particle size which will result from the shear shredder, it is difficult to assess whether additional processing will be required to prepare an RDF-3 product that conforms with the specifications dictated by the boiler. As discussed above, the waste size characteristics from the shredder may affect the selection of the air separation system. Additionally, secondary shredding may be necessary to reduce the RDF-3 to a particle size which can be accommodated by the boiler and its pneumatic feed system.

Rationale for the processing susbsystem selection- The proposed processing subsystem employs separation/processing concepts which have been successfully demonstrated at full-scale. The concepts, in the sequence selected, offer the most simple and cost-effective approach that was identified for producing a low ash RDF-3 product. The processing subsystem will employ equipment which is reported to be the most reliable and least expensive to operate of the alternatives available to perform each required separation/processing function. All of the equipment proposed, with the exception of the shear shredder, have been fully demonstrated. Although the shear shredder has not been adequately tested, shredding of MSW is a widely used process. Numerous conventional shredders are available to accomplish the size

FIGURE 3-6
CONVEYOR SCHEDULE

No.	Description	Width	Length	Incline Angle	Head El.	Tail El.	Remarks[1]
1	Trommel Infeed	5'-0"	25'-0"	0.0	(-)4.0	(-)4.0	Steel Belt, Horizontal Section
			38'-6"	35.0	18.0	(-)4.0	Steel Belt, Incline Section
2	Trommel Undersize	3'-0"	28'-6"	0.0	7.0	7.0	
3	Shredder Infeed	4'-0"	42'-0"	18.0	17.0	4.0	Cleated
4	Air Sep. Infeed	4'-0"	38'-6"	10.0	9.0	2.5	
5	Air Sep. Heavies	2'-6"	32'-0"	6.0	5.5	2.0	N.C.
6	Residue #1	3'-0"	46'-6"	20.0	18.0	2.5	"Chevron" Belt, P.C.
7	Residue #2	3'-0"	16'-0"	0.0	14.0	14.0	Reversible
8	RDF #1	4'-0"	30'-0"	15.0	10.0	2.5	
9	RDF #2	4'-0"	1240'-0"	~0.0	7.5	2.5	
10	RDF #3	4'-0"	112'-0"	45.0	68.0	2.5	Flexible Wall, Not Shown

[1] All rubber belt conveyors: 200fpm, 35° idlers, fully skirted and covered unless otherwise noted; N.C.= No Covers; P.C.= Partially Covered.

reduction function should the shear shredder not perform satisfactorily.

Impact on the processing subsystem for a 10% substitution rate- The quantity of RDF-3 required for operating at a 10% substitution rate is reduced from 84 tons per day to only 42 tons per day. The hourly capacity of the processing subsystem is reduced to 65 tons per day and many of the equipment sizes can be reduced. The size of the building can be reduced to approximately 8800 square feet.

3.3 TRANSPORTATION SUBSYSTEM

The RDF-3 from the processing subsystem will be transported approximately one-quarter mile to the storage silo located on the Navy site. The transport conveyor will be a four-foot wide troughed belt conveyor, enclosed to prevent spillage of RDF-3. The conveyor will run close to the ground to prevent the need for expensive support structures and walkways. It has been assumed that no roadways or other obstructions are present between the processing and storage subsystems. Due the anticipated infrequency of fires, no provisions have been incorporated for fire protection along the conveyor.

Once the troughed belt conveyor is near the storage silo, it transfers the RDF-3 onto a flexible molded side wall conveyor for delivery to the top of the silo. This conveyor has a cover belt to allow the material to be conveyed up the steep incline without spillage. Cleats on the belt, combined with the molded side walls, form compartments to carry the material without slippage.

Although there is no current operating experience with long distance conveying of RDF by mechanical conveyors, most of the facilities do convey RDF for short distances. From our evaluations, there is no reason that RDF can not be reliably conveyed for the one-quarter mile distance using a rubber belt conveyor.

Proper conveyor design and skirtboard installation will be essential for reliable operation without material spillage.

None of the operational facilities employ mechanical conveyors for long distance transport of RDF. They use either pneumatic transport, as in Ames for their 475 feet distance, or trailer transport, as in Monroe County for their 8 mile distance. A summary of the transportation information for the reference plants is presented in Table 3-7.

A pneumatic transport system is used at both Ames and Monroe County (RG&E) for long distance conveyance of RDF. The system at Monroe County conveys a nominal 3/4 inch RDF a distance of 1700 feet from the receiving facility at RG&E to the storage silo. Although the system at Ames has been plagued with operational and maintenance problems, Monroe County which is a more recently installed system reports a virtually trouble-free operation.

The pneumatic transport system is reported to operate with considerably less material spillage and maintenance requirements than for mechanical conveyance. However, the pneumatic system consumes more power than a mechanical system due to the requirement for large horsepower blowers to convey the material. The overall cost to operate the pneumatic system is likely to be higher than for the mechanical system.

A pneumatic transport system for conveying RDF-3 from the processing subsystem to the storage subsystem would consist of a positive displacement blower, silencers and filters, cyclone, airlock, and dust collector. The transport system would convey the material using high-pressure air to positively move the RDF-3 through the ducting.

FIGURE 3-7

TRANSPORTATION SUBSYSTEM -REFERENCE DATA

Reference Plant Location	System Description - Delivery to Boiler Site	Distance	System Description - Delivery to Storage
St. Louis Missouri	From cyclone to silo via mechanical conveyor. Removed from silo by augers onto mechanical conveyors to compactor. Trailers to boiler facility.	19 Miles	Trailers from process facility discharge RDF into receiving bin using built-in hydraulic rams.
Ames Iowa	From cyclone directly to silo at boiler site via pneumatic transport system.	475 Feet	Cyclone deentrains RDF from pneumatic system
Monroe County New York	From magnetic separator to compactor module via mechanical conveyors. Compacted into trailers for delivery to boiler site.	8 Miles	Trailers discharge RDF into receiving bin using hydraulic rams. Metering bin delivers RDF into pneumatic system for transport to silo.
Milwaukee Wisconsin	From screens onto mechanical conveyors for delivery to compactors. Compacted into trailers for delivery to boiler site.	20 Miles	Trailers discharge RDF into receiving bin using hydraulic rams. Metering bin delivers RDF into pneumatic system for transport to silo.

Rationale for the transportation subsystem selection- Various qualities, densities and sizes of RDF have been successfully conveyed at existing recovery facilities using mechanical conveyors provided by a variety of suppliers. Although none of the facilities have conveyed RDF for distances approaching 1/4 miles as proposed herein, considerable experience does exist with conveying other materials for distances of many miles. The vast experience with conveying RDF coupled with the past history of long distance conveyance of other materials, provide assurance that RDF can be reliably conveyed from the processing subsystem to the storage silo using a mechanical conveyor.

Impact on the transportation subsystem for a 10% substitution rate- Due to the reduced hourly throughput rate for RDF-3 production at the 10% substitution rate, the conveyors can be reduced from 4-foot to 3-foot wide. The horsepower requirements for the smaller conveyors will be significantly reduced which will lower the construction and O&M costs.

3.4 STORAGE SUBSYSTEM

The Atlas silo proposed herein is reported to be the most reliable method of storing, splitting, retrieving and metering RDF. It is employed in numerous facilities and has a proven record of success for RDF-3. It offers the ability to store large quantities of low density RDF and allows discharging the material into multiple feed streams to the boiler. The principal disadvantage of the Atlas silo is its inability to operate on a first-in/first-out basis. This deficiency necessitates the requirement to completely empty the silo at two-week intervals to prevent bridging due to mass-agglomeration of the material.

Most of the other alternatives for storage are rectangular in shape and present a problem in evenly distributing material within the bin to optimize its storage capacity. Alternative bins typically utilize screw augers for retrieval of the material. It has been demonstrated in numerous instances that augers cannot reliably handle RDF because of the wrapping of textiles and wire, and splitting into multiple discharge streams is difficult. Figure 3-8 provides a summary of the information collected pertaining to the storage of RDF from various recovery facilities.

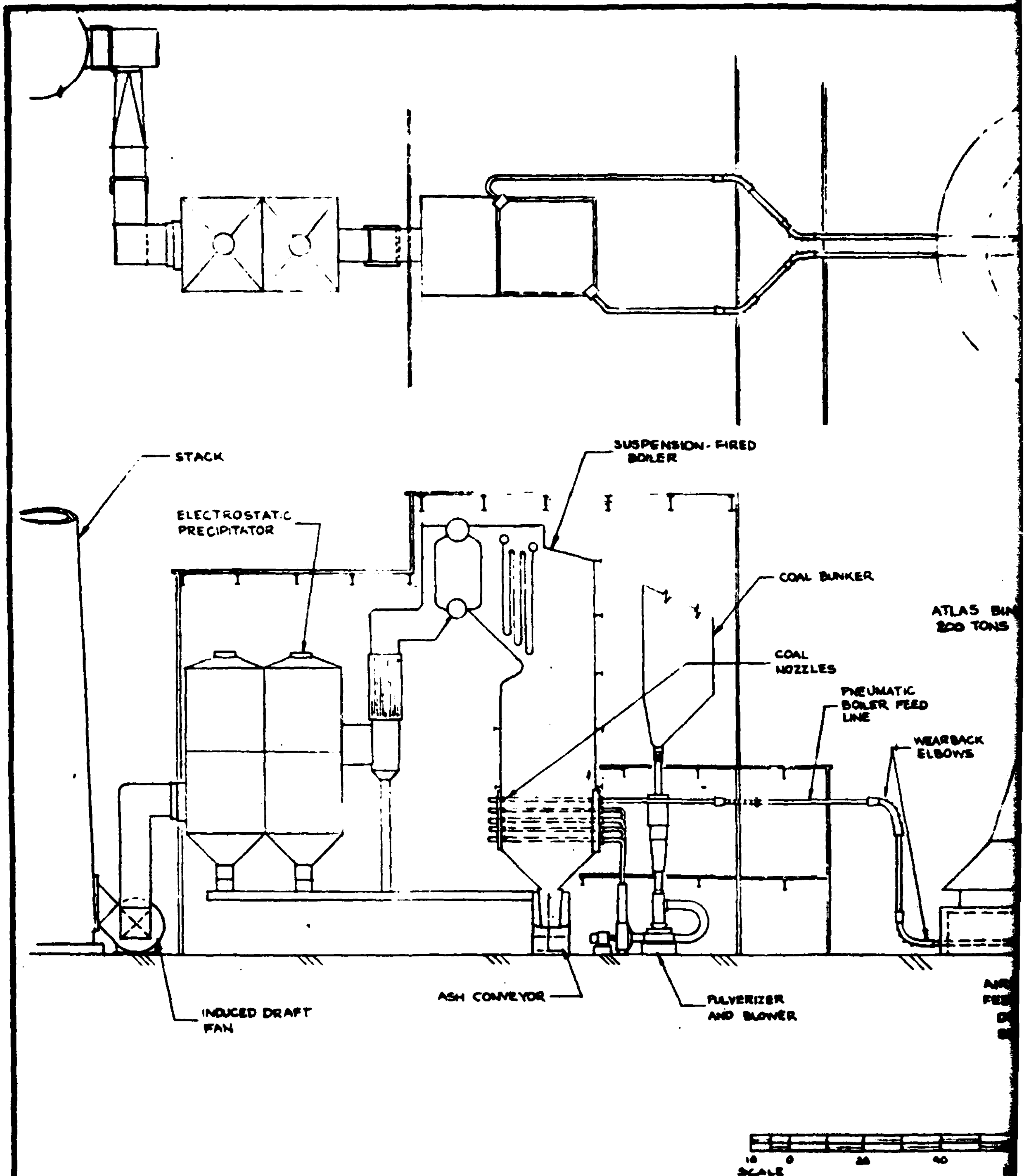
FIGURE 3-8

STORAGE SUBSYSTEM - REFERENCE DATA

Reference Plant Location	Type Storage	Storage Capacity	Discharge Mechanism		
			Type	No. Disch.	Disch. Rate
St. Louis Missouri	Miller-Hoft. Live bottom, rectangular	150 Tons	Augers	1	50 TPH
Ames Iowa	Atlas.	500 Tons	Sweep bucket and drag conveyor	4	14 TPH Each
Monroe County NewYork	a. Trailers	17 Tons Each	Hyd. Rams	---	---
	b. Atlas	450 Tons	Sweep bucket and drag conveyor	8	6 TPH Each
Milwaukee Wisconsin	Atlas	900 Tons	Sweep bucket and drag conveyor	4	15 TPH Each

The Atlas silo, as shown on the facility drawing in Figure 3-9, is a conical steel structure approximately 62 feet in diameter at the base, 20 feet in diameter at the top and 62 feet tall. The RDF-3 transport conveyor which delivers the material from the processing subsystem discharges the RDF-3 into the opening at the top of the silo. The material falls into the silo, forming a cone-shaped pile. The silo is mounted atop a circular concrete foundation, within which are separate rooms to house the retrieval and boiler feed equipment. The retrieval mechanism utilizes strings of buckets which rake along the bottom of the silo to sweep material into drag conveyors installed in trenches in the concrete floor above the foundation. The strings of buckets are pulled by a large rotating ring mounted along the outer edge of the silo. The two drag conveyors, located below the floor with grating above them at floor level, extend radially to the center of the silo from the exterior. The drag conveyors and rotating ring are both variable speed. Sensors monitor the material level conveyed by the drag conveyors. If the loading of the drag conveyors begins to decrease, the speed of the rotating ring increases to deliver more material. The speed of the drag conveyors can be varied from the boiler control room to provide the desired feedrates to the boiler. The discharge rate from the silo can be modulated so that substitution rates of 10 or 20 percent can be maintained for steaming rates between 50 percent and 100 percent of the boilers Maximum Continuous Rating (MCR). Each drag conveyor will deliver material to a rotary airlock which feeds a pneumatic transport line to the boiler.

The silo is equipped with a water spray fire protection system with sensors at various locations around the walls. Maintaining a negative pressure inside the Atlas silo (for dust control) using the pneumatic feed system was investigated. It was determined that the blowers used for the transport system require filtered air for efficient, reliable operation and as a result could not be used for drawing dust-laden air from the silo.


STACK
ELECTROSTATIC PRECIPITATOR
SUSPENSION-FIRED BOILER
COAL BUNKER
ATLAS
200 TONS
COAL NOZZLES
PNEUMATIC BOILER FEED LINE
WEARBACK ELBOWS
INDUCED DRAFT FAN
ASH CONVEYOR
PULVERIZER AND BLOWER
10 0 20 40
SCALE

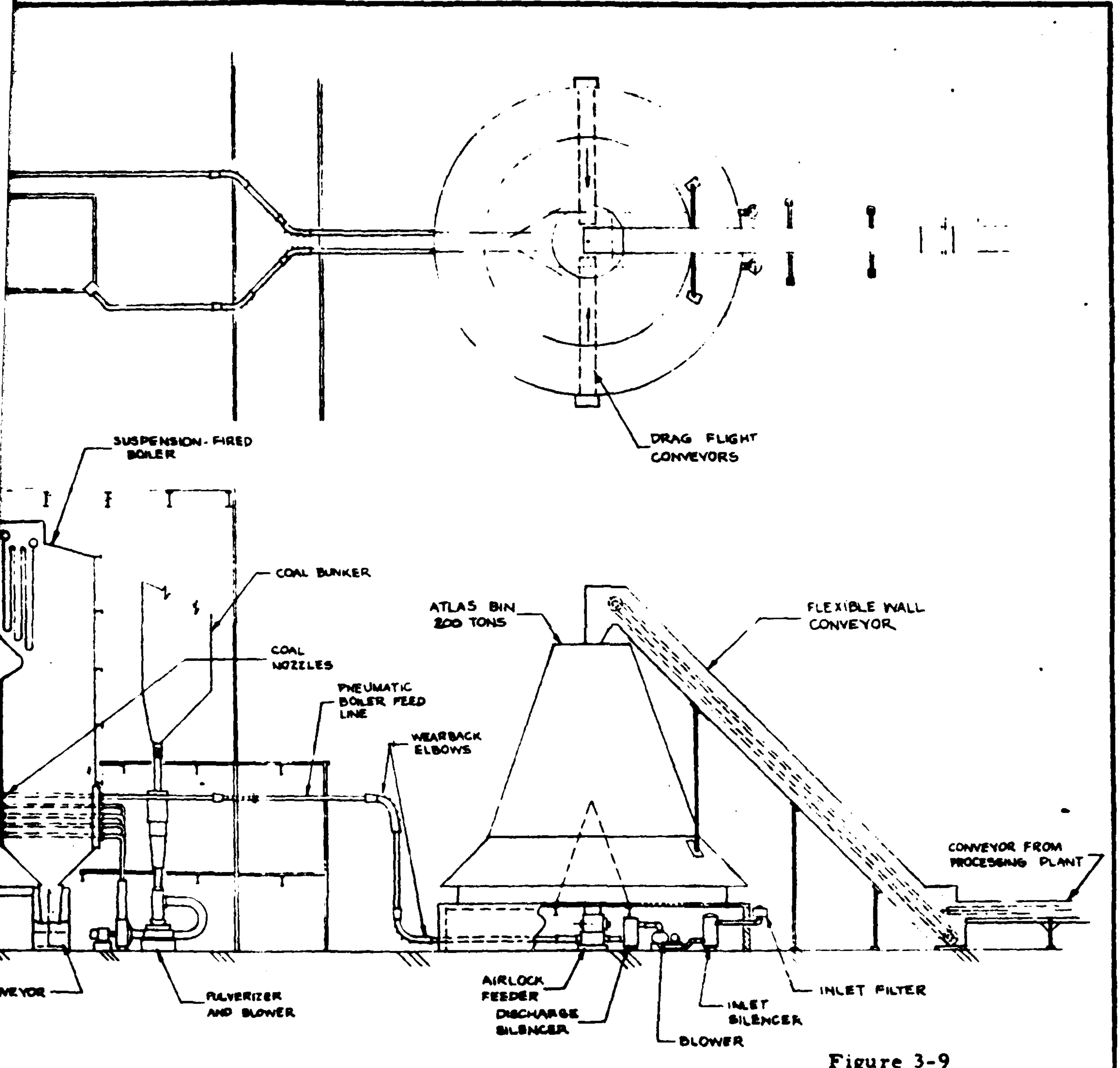


Figure 3-9

PRELIMINARY FACILITY LAYOUT
RDF-3 STORAGE/BOILER METERING-FEED SYSTEM

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Rationale for the storage subsystem selection- The Atlas silo has been selected for RDF-3 storage because of its proven record of success at other facilities. The Atlas system offers reliable storage of low density materials, it has experienced minimal problems with material bridging, it provides the capability to split the discharge into multiple streams, it allows metering of the discharge streams into the boiler, and it requires minimal maintenance.

Impact on the storage subsystem for a 10% substitution rate- The storage requirements for RDF-3 is reduced from 200 tons to 100 tons for operations at a 10% substitution rate. This reduces the size of the Atlas silo to 54 feet in diameter at the base, 20 feet in diameter at the top and 55 feet tall.

3.5 DELIVERY SUBSYSTEM

The delivery subsystem consists of two pneumatic transport lines which feed material from the Atlas silo retrieval mechanism into oposite corners of the boiler. The pneumatic transport air for each feed line is supplied by an electric motor-driven Roots-type positive displacement blower. The blower set includes inlet and discharge silencers and an inlet filter located outside the foundation wall. Clean air is essential for reliable blower operation. Each transport system will introduce RDF-3 into a corner of the boiler. Each pneumatic transport line will be designed to convey up to 5 TPH to ensure that 20% substitution (on a heating value basis) can be maintained for the anticipated variations in RDF-3 characteristics.

A disadvantage of using pneumatic transport of RDF is the introduction of cold air into the boiler. This has a slight effect on the temperature control in the boiler and also disturbs the boiler operation which is partly controlled through adjustments to the overfire and underfire air. Other difficulties which have been reported with pneumatic transport into the boiler are:

- Abrasion of ducting
- Blockages due to small diameter of ducting
- Airlock failure due to inclusion of metals in RDF-3
- High power consumption of blowers

The more recent facilities such as Milwaukee and Monroe County have reported relatively trouble-free operation of the pneumatic transport system for introducing RDF to the boilers. The problems with abrasion, blockages and airlock failures noted in the earlier systems appear to have been minimized through design changes and improvement of RDF quality as newer facilities were constructed.

Suspension-fired boilers, by definition, are closed waterwalled chambers designed specifically for combustion of pulverized coal which is pneumatically fed and forms a fireball within the furnace. The only fuel penetrations, apart from ignition oil burners, are the pulverized coal nozzles. For this reason, pneumatic feeding is the only practical means of introducing RDF into boilers of this type.

Rationale for delivery subsystem selection- Pneumatic transport of RDF into suspension-fired boilers is the only demonstrated method of feeding. Experience at existing facilities which co-fire RDF with coal, has shown these pneumatic systems operate reliably with minimal problems.

Impact on the delivery subsystem for a 10% substitution rate- The pneumatic transport lines can be decreased from 8-inch diameter to 6-inch diameter due to the reduced throughput requirements and need for less conveying air for the 10% substitution rate. Using smaller transport lines allows a decrease in the blower size used and will reduce the overall operations cost due to the reduction in power consumption.

3.6 COMBUSTION SUBSYSTEM

The suspension fired boiler specified by the Navy, located at a naval shore facility, currently combusts pulverized coal. The boiler is rated for 150 million Btu's per hour and is tangentially fed via coal nozzles layered on each corner of the boiler. Coal, delivered to the boiler pneumatically after being crushed in a ball mill, is conveyed using heated air.

The ash remaining after combustion falls into a water quench pit where it is periodically removed by sluicing the pit. The ash is pumped to a water treatment system where it is settled, partially dewatered and delivered to a landfill in closed containers. Water from the treatment system, after primary settling of the ash, is pumped to a lagoon for additional settling prior to entering the sewer system.

An electrostatic precipitator removes the particulates from the flue gases prior to discharge to the atmosphere. Fly ash removed from the precipitators is stored in closed containers for subsequent landfill disposal.

Numerous problems and anticipated problems have been reported in the literature over the past decade pertaining to the combustion of RDF and other forms of MSW. The problems reported at a given facility are frequently unique to the particular facility and are largely a result of the specific features of the boiler(s) utilized. The following discussions describe the types of problems which exist or have existed at facilities that co-fire RDF with coal in suspension-fired boilers.

- Increased ash loading- Co-firing RDF-3, which typically contains a higher ash content than coal, has been shown to create numerous problems related to combustion and ash handling. The presence of large items (wood, plastic, textiles) which do not fully combust in suspension increases not only the quantity of ash to be handled but also the difficulty of handling. Floatables such as wood and plastic cause bridging and plugging problems in the ash pit and water treatment equipment. Dump grates have been employed successfully to reduce the problems with unburned materials. The higher ash content generally indicates a high content of glass which causes slagging on the walls of the furnace and slag formation on the tubes which restricts the flow of hot gases. Clinker formation has also resulted from the higher glass content and caused blockages in the ash pit. The presence of wire and metals has caused the formation of "nests" which block the ash pit and plug the ash handling equipment.

- Decreased boiler load rating- For some facilities, due to the additional air requirements when RDF is co-fired with coal, the ratings while operating at maximum loads have been below the ratings experienced with combusting coal alone. Many of the facilities have reported they have inadequate ID fan capacity to operate near the full load rating of the boiler. Monroe County reports the load rating is reduced by approximately 5% when firing at a substitution rate of 15%. This decrease in rating should not be confused with efficiency loss of combustion, which has been shown to be minimal (generally less than 2%). As a result of the reduced load rating, many of the facilities limit the utilization of RDF when they are required to fire at their maximum load capability.

  The requirement to increase the ID fan capacity is different for each system. Generally, an increase of 5% to 15% of the fan capacity would be required. In many instances, the peripihereal/support equipment will be unable to accept the increased airflows which would result.

- o Normal temperature patterns disturbed- Exit gas temperatures reportedly increase due to the change in heat balance of the boiler which results when firing RDF. It is projected that the introduction of cold transport air reduces the temperature of the fire ball. Additionally, slag formation tends to reduce heat absorption in the fire box. This coupled with higher excess air, frequently affects the fire ball position and creates problems with controlling the proper temperature and air distribution in the furnace.

- o Incandesent and flaming particles in the upper region- Many particles continue to burn or flame in the upper regions of the furnace. These burning particles, frequently called "sparklers", are believed to be an indication of poor distribution of air and combustion temperatures inside the furnace. The presence of these "sparklers" also indicate that a higher than normal particulate loading is present at the precipitators.

- o Wastage of exposed surfaces- Severe wastage of boiler surfaces has been reported at some facilities. Ames had to install air jets near the grates to reduce wastage at the furnace section just above the grate area. The additional air is intended to provide an oxidizing atmosphere. Other facilities have been operational for many years without any signs of wastage in similar locations. It is felt that the proper distribution of air and temperatures thoughout the system is a critical element in the cause of observed wastage, corrosion and erosion.

- Corrosion potential due to chlorides- Much has been documented on the potential of corrosion which can result from the increased quantity of chlorides reported in RDF. Currently little data has been gathered which shows that corrosion is in fact a problem. Corrosion potential is subject to numerous conditions, including the presence of chlorides, water, reactive temperatures and corrosive surfaces.

- Increased air emissions- Most facilities that co-fire RDF and coal have reported an increase in the discharge of particulates. This does not always create problems with meeting the emission requirements. Along with the increase in particulates, the HCl concentration is usually somewhat higher. These are accompanied by decreases in SO_x and NO_x. The precipitators employed in many instances are undersized and cannot accomodate the increased air flows and the increased particulate loadings experienced with firing RDF.

- Loss of boiler efficiency- The loss of boiler efficiency has been reported to be minimal. The efficiency loss measured at Ames was 1.23% for firing at a 20% substitution rate at full load. Monroe County has projected a loss of efficiency of 1.46% for firing at a 20% substitution rate at full load. The efficiency does drop off as the boiler load is decreased, but is not a significant decrease until the boiler load approaches 50% of its MCR rating.

The anticipated modifications which will be required to the existing Navy boiler for co-firing RDF-3 with coal at substitution rates up to 20% are discussed below. These recommendations are based on the information obtained from the various operational facilities, summarized in Figure 3-10, which have previously or are currently co-firing RDF with pulverized coal in suspension fired boilers.

Feed ports/nozzles- Two entry ports will be required at opposite corners of the furnace, at the uppermost air compartment, for introduction of RDF-3. The pneumatic feed system will deliver the RDF-3 through nozzles similar to standard coal nozzles into the boiler above the top coal nozzle. The RDF-3 nozzles will include manual tilt linkages to permit the trajectory of the material to be adjusted manually.

Dump grates- Dump grates will be installed to allow additional time for material not completely combusted while falling in suspension to finish burning. Improved combustion of the larger items should reduce the amount of floatables in the ash pit and should reduce the quantity of difficult-to-handle materials that typically create handling problems. The grates will be programmed to allow dumping at pre-determined intervals, with provision for manual initiation of the dumping cycle at any time.

Increased overfire and underfire air- To minimize wastage of exposed surfaces, additional overfire and underfire air will be provided by installing a supply blower and air headers with multiple jets into the furnace above and below the dump grate. Each jet will be equipped with a valve for adjustment of the air volume.

Increased ID fan capacity- If practical, the induced draft fan will be modified to provide an increase in capacity. The additional capacity is necessary to accomodate the increased air flow resulting from adding the transport air and introducing larger volumes of overfire and underfire air. It is assumed the peripherel equipment associated with the ID fan can withstand the increased flows without additional modifications.

FIGURE 3-10

COMBUSTION SUBSYSTEM - REFERENCE DATA

Reference Plant Location	St. Louis Missouri	Ames Iowa	Rochester New York	Milwaukee Wisconsin
Type Boiler	Suspension	Suspension	Suspension	Suspension
Size Boiler	125 Mw	a) 35 Mw b) 60 Mw	a) 48 Mw b) 62 Mw c) 75 Mw	310 Mw
No. of Boilers	2	a) 1 b) 1	a) 1 b) 2 c) 1	2
APC Equipment	ESP	ESP	ESP	ESP
Entries/Boiler	4	4	2	4[1]
Feed Location	Between coal burners	Below coal nozzles	Above coal nozzles	Above coal nozzles
Modifications Implemented	Feed ports	Feed ports Dump grate Overfire air Curtain around throat	Feed ports Dump grates Primary settling equip. Underfire air	Feed ports
Problems Reported	Increased ash Metals in RDF	Tube failure near grates Slagging Dropout of unburned items Metals in RDF Increased particulates	Increased ash Decreased load rating Grate expansion	Slagging Floatables in ash pit Inadequate ID fan capacity Increased particulates

1) Both boilers can be fed at 2 corners or either boiler can be fed from 4 corners.

Screen ahead of water treatment system- A screen should be installed to remove any items (wood, wire "nests", plastic, clinkers) which might cause damage to the water treatment equipment or cause blockages to pumps, grinders or settling equipment. The screen should be located so that it can accept material as it is sluiced from the ash pit. The oversized material removed from the screen should be removed from the system for discard.

Ash handling and water treatment system- Most facilities have been designed to operate under the variations in the quantity and composition of ash which result from combusting varying types and grades of coal. It is assumed for the purposes of this report that adequate capacity is available for processing the added load which results from the higher ash content of the RDF-3, which could be double the loading for firing coal alone. The experience at Monroe County and Ames has shown that the equipment for both ash removal and water treatment can generally process the increased quantity of ash which results from co-firing RDF and coal, although the sluicing frequency for the ash is increased.

Additional emission control- Some of the existing facilities do not have adequate capacity in their precipitators to accept the increased particulate loadings which result from combusting RDF. Ames was forced to install a mechanical collector to reduce the loading going to their precipitators. Most well-designed systems do include some excess capacity to compensate for fluctuations which even exist with combusting various types of coal. It is assumed for the purposes of this report that the Navy facility has been well-designed and does include adequate excess capacity to accept the increased air volumes (up to 10%) and particulate loadings (up to 25%) which will result from co-firing RDF-3 with coal.

Rationale for the combustion subsystem modifications- Modifications made to the successfully operating facilities that co-fire RDF and coal have been reviewed and the problems experienced have been evaluated. Based on this information and the particular design features of the combustion equipment to be utilized, the proposed modifications were developed.

Impact to the combustion subsystem for a 10% substitution rate- The reduced feedrate to the boiler, as a result of using a 10% substitution rate, will place less of a burden on most of the combustion subsystem components, including the ash handling system, water treatment equipment, precipitator and ID fan. Less ash and fly ash will be generated and the load rating of the boiler will be less affected. The potential for slagging and corrosion at the 10% substitution rate of RDF-3should be less than for a 20% substitution rate.

SECTION 4.0

CONSTRUCTION COSTS

4.1 GENERAL

This section presents a detailed evaluation of the construction requirements for each of the five proposed subsystems. The construction costs reported herein exclude the costs related to financing, such as legal fees, bonding and underwriter costs, net interest during construction, debt reserve funds, and similar expenditures.

The construction costs for each subsystem include a uniform percentage projection for engineering, construction management, construction contractor fees (overhead and profit) and project contingency. These costs are anticipated to be comparable for the facilities whether owned by the private contractor or the Navy.

4.2 PROCESSING SUBSYSTEM

The construction costs for the processing subsystem for a 20% substitution rate of RDF-3 are presented in Figure 4-1. The contractor will be required to purchase a 4 acre site for the construction of the facility. The costs presented herein include the land cost, site development, building erection, equipment procurement and installation, and indirect costs, such as engineering, construction management, contractor fees and contingency. The total cost for constructing the processing subsystem, for a 20% substitution rate is estimated to be $5,171,500. The construction cost estimate for a 10% substitution rate is $4,365,300.

FIGURE 4-1

PROCESSING SUBSYSTEM: CONSTRUCTION COST
(January 1983 Dollars)

DESCRIPTION			ESTIMATED COST
1.0	Land Cost (4 Acres)		$100,000
2.0	Site Work		
	2.1 Earthwork	$ 40,000	
	2.2 Utilities	85,000	
	2.3 Fire Protection	45,000	
	2.4 Fuel Oil System	40,000	
	2.5 Paving & Surfacing	59,400	
	2.6 Site Improvements	32,500	
	2.7 Landscaping	5,500	
	2.8 Power Trans./Dist.	155,000	
	2.9 Yard Lighting	14,600	
	2.10 Misc.	6,000	
		Subtotal	483,000
3.0	Building/Structural		
	3.1 Found. & Floor Slab	$115,000	
	3.2 Pre-Fab Bldg.	235,200	
	3.3 Int. Constr.	31,500	
	3.4 Plumbing	20,200	
	3.5 Fire Protection	24,300	
	3.6 Heat & Vent.	28,300	
	3.7 Electrical	25,900	
		Subtotal	480,400
4.0	Process Equipment		
	4.1 Trommel Screen	380,000	
	4.2 Shear Shredder	310,000	
	4.3 Air Separator	210,000	
	4.4 Magnetic Separator	29,200	
	4.5 Dust Collection	145,800	
	4.6 Scale System	47,700	
	4.7 Steel Belt Convr.	103,500	
	4.8 Rubber Belt Convr.	130,000	
	4.9 Electrical Equip.	121,000	
	4.10 Installation	457,700	
		Subtotal	1,934,900
5.0	Capital Expenditures		
	5.1 Mobile Equip.	$140,000	
	5.2 Office Furnishings	29,000	
	5.3 Maintenance Shop	30,000	
	5.4 Spare Parts	117,000	
	5.5 Communications Equip.	3,800	
	5.5 Consummables	7,300	
		Subtotal	327,100
		TOTAL	$3,325,400
6.0	Contractor Overhead & Profit (@21%)		698,350
8.0	Engineering & Constr. Mgmt. (@15%)		544,200
9.0	Contingency (@15%)		603,550
		GRAND TOTAL	$5,171,500

The following incremental construction cost estimates are provided as options, in the event it is determined the shear shredder cannot satisfy its required performance requirements.

Larger Air Separation System - If the shear shredder delivers a discharge particle size that is significantly larger than nominal 2 inches, the vertical chamber air separator should be replaced with either a rotary drum or concentric tube classifier. The increase in construction costs (including building, installation, etc.) for the rotary drum air classifier is approximately $560,000. The costs for the concentric tube classifier would be slightly less than for the rotary drum.

Secondary Shredder - If the RDF-3 from the processing subsystem is significantly larger than nominal 2 inches, a secondary shredder will be required for size reduction. The incremental construction costs for adding a secondary shredder to the processing susbystem is approximately $885,000.

Conventional Hammermill - The shear shredder can be replaced with a conventional hammermill, if it is shown not to perform satisfactorily. Conventional hammermills, although larger and more costly to install and operate than a shear shredder, have been demonstrated at full scale in numerous facilities. The increased construction costs for replacing the shear shredder with a hammermill is estimated to be $555,000.

4.3 TRANSPORTATION SUBSYSTEM

The construction costs for the transportation subsystem are given in Figure 4-2. No land costs or building erection are required since this subystem consists of two mechanical conveyors located out-of-doors to deliver RDF-3 from the processing subsystem to the storage silo. A horizontal belt conveyor is provided to traverse a distance of approximately 1/4 mile and de-

FIGURE 4-2

TRANSPORTATION SUBSYSTEM: CONSTRUCTION COST
(January 1983 Dollars)

DESCRIPTION		ESTIMATED COST
1.0	Troughed Belt Convr.	$ 727,500
2.0	Molded Sidewall Convr.	182,500
3.0	Elec. Equipment	15,000
4.0	Installation	181,500
5.0	Spare Parts	18,000
	SUBTOTAL	$1,124,500
Contractor Overhead & Profit (@21%)		236,150
Engineering & Constr. Mgmt.		75,000
Contingency (@15%)		204,100
	TOTAL	$1,639,750

liver the material onto a flexible molded wall conveyor which elevates the RDF-3 to the top of the silo. It has been assumed that no obstructions or roadways exist. The horizontal conveyor will be located near the ground so that no walkways or platforms are required.

Minimal site development will be required and no facilities have been included with the transportation subsystem. The total projected construction cost for the transportation susbsystem for a 20% substitution rate is $1,639,750. The construction cost for a 10% substitution rate is $1,372,500.

4.4 STORAGE SUSBSYSTEM

The construction costs for the storage subsystem, to be owned by the Navy, does not include land cost but does provide for site development, equipment procurement and erection, and indirect costs. Although a building is not required to enclose the storage silo, "rooms" will be furnished as part of the silo foundation to house a portion of the delivery subsystem. The total estimated construction cost for the storage subsystem for a 20% substitution rate, given in Figure 4-3, is $1,990,300. The estimated construction cost for a 10% substitution rate is $1,539,600.

4.5 DELIVERY SUBSYSTEM

The construction costs for the delivery subsystem include equipment procurement and installation, equipment foundations, and an allowance for indirect costs. A minimal amount of site development work will be required for installing the transport pipelines. The projected construction cost for the delivery subsystem for a 20% substitution rate, shown in Figure 4-4, is $269,600. The projected construction cost for a 10% substitution rate is $248,600.

FIGURE 4-3

STORAGE SUBSYSTEM: ESTIMATED CONSTRUCTION COST
(January 1983 Dollars)

DESCRIPTION			ESTIMATED COST
1.0	Land Cost		---
2.0	Site Work		
2.1	Earthwork	$ 5,600	
2.2	Utilities	7,800	
2.3	Fire Protection	12,900	
2.4	Paving & Surfacing	11,200	
2.5	Site Improvements	4,200	
2.6	Landscaping	1,500	
2.7	Power Trans./Dist.	27,500	
2.8	Yard Lighting	7,500	
2.9	Misc.	3,500	
		Subtotal	81,700
3.0	Building/Structural		
3.1	Found. & Floor Slab	$165,500	
3.2	Misc. Steel	2,300	
3.3	Plumbing	3,200	
3.4	Fire Protection	8,500	
3.5	Heat & Vent.	5,200	
3.6	Electrical	8,300	
		Subtotal	193,000
4.0	Process Equipment		
4.1	Atlas Storage Silo (incl. ring drive & buckets)	745,000	
4.2	Drag Conveyors	25,000	
4.3	Electrical Equip.	12,500	
4.4	Installation	172,600	
		Subtotal	955,100
5.0	Capital Expenditures		
5.1	Spare Parts	38,000	
5.2	Communications Equip.	2,100	
		Subtotal	40,100
		TOTAL	$1,269,900
6.0	Contractor Overhead & Profit (@21%)		266,700
7.0	Engineering & Constr. Mgmt. (@15%)		223,200
9.0	Contingency (@15%)		230,500
		GRAND TOTAL	$1,990,300

FIGURE 4-4

DELIVERY SUBSYSTEM: CONSTRUCTION COST
(January 1983 Dollars)

DESCRIPTION		ESTIMATED COST
1.0	Airlock Feeders	$ 11,200
2.0	Blower & Air Piping	40,500
3.0	Transport Pipeline	47,500
4.0	Electrical Equipment	15,000
5.0	Installation	47,900
6.0	Spare Parts	10,500
	SUBTOTAL	$ 172,600
Contractor Overhead & Profit (@21%)		36,250
Engineering & Constr. Mgmt. (@15%)		29,400
Contingency (@15%)		31,350
	TOTAL	$ 269,600

4.6 COMBUSTION SUBSYSTEM

The combustion equipment to be utilized, an existing suspension-fired boiler which currently combusts pulverized coal, will require some modifications to the boiler to prepare it for co-firing RDF-3. The construction costs presented in Figure 4-5 include all the anticipated modifications required for introduction and combustion of RDF-3 in the boiler. The major elements of the construction cost for modifying the boiler are the installation of a dump grate, the addition of over-fire and under-fire air, and increase in the ID fan capacity. The total cost for the proposed modifications for a 20% substitution rate is estimated to be $250,700. For a 10% substitution rate, it is estimated to be $241,200.

FIGURE 4-5

COMBUSTION SUBSYSTEM MODIFICATIONS: CONSTRUCTION COST
(January 1983 Dollars)

DESCRIPTION	
1.0 Fuel Nozzles	$ 9,800
2.0 Dump Grate	
2.1 Hardware (incl. Hyd. Oper.)	29,500
2.1 Installation	44,000
2.3 Controls & Wiring	8,400
3.0 Underfire Air (incl. fan, ductwork, etc.)	22,750
4.0 ID Fan	6,500
5.0 Ash Screens	7,500
6.0 Spare Parts	5,000
SUBTOTAL	$133,450
Contractor Overhead & Profit (@15%)	28,000
Engineering & Constr. Mgmt.	65,000
Contingency (@15%)	24,250
	$250,700

FIGURE 4-4

DELIVERY SUBSYSTEM: CONSTRUCTION COST
(January 1983 Dollars)

DESCRIPTION	ESTIMATED COST
1.0 Airlock Feeders	$ 11,200
2.0 Blower & Air Piping	40,500
3.0 Transport Pipeline	47,500
4.0 Electrical Equipment	15,000
5.0 Installation	47,900
6.0 Spare Parts	10,500
SUBTOTAL	$ 172,600
Contractor Overhead & Profit (@21%)	36,250
Engineering & Constr. Mgmt. (@15%)	29,400
Contingency (@15%)	31,350
TOTAL	$ 269,600

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SECTION 5.0

O&M COSTS

5.1 GENERAL

This section details the annual operations and maintenance costs for each of the five proposed subsystems. The processing and transportation subsystems will be operated by a private contractor who has a contract with the Navy to produce conforming RDF-3 for delivery to the storage silo at their facility. The Navy will operate the storage, delivery and combustion subsystems.

The O&M costs include the required labor, materials, utilities and residue disposal costs for reliable operation and maintenance of the subsystems.

5.2 *PROCESSING SUBSYSTEM*

As shown in Figure 5-1, the processing subsystem will require a staff of 10 personnel to operate and maintain the facility. Additionally, they will operate and maintain the transportation equipment which delivers RDF-3 to the storage silo.

The annual O&M costs presented in Figure 5-2 for the processing subsystem are projected at $803,090 for a 20% substitution rate of RDF-3. For a 10% substitution rate, the annual O&M costs are $606,000.

The following incremental annual O&M costs are provided for the system options, as previously discussed for the processing subsystem:

Figure 5-1

PROCESSING SUBSYSTEM: ANNUAL LABOR COSTS
(January 1983 Dollars)

DESCRIPTION	NO. OF POSITIONS	HOURLY RATE	LABOR COST
<u>Administrative</u>			
Facility Manager	1	--	$27,000
Secretary	1	--	10,000
<u>Process</u>			
Shift Foreman	1	9.00	18,720
Weigh Clerk	1	5.50	11,440
Loader Oper.	1	7.50	15,600
Equipment Oper.	2	6.75	28,080
Gen. Helper	1	5.00	10,400
<u>Maintenance</u>			
Welder/Mechanic	1	8.75	18,200
Maint./Mechanic	1	6.75	14,040
		LABOR TOTAL	$153,480
Overhead (@ 75%)			115,110
			$268,590

Figure 5-2

PROCESSING SUBSYSTEM: ANNUAL O&M COSTS
(January 1983 Dollars)

DESCRIPTION	O&M COSTS		
<u>Building Occupancy</u>			
Security Service	25,000		
Clothing & Uniform	5,000		
Tool Allowance	2,000		
Telephone	3,500		
Insect & Pest Control	2,000		
Training & Education	1,000		
Build. Maint. & Repair	12,000		
Residue/Ferrous Disposal	131,500		
Laboratory Analysis	5,500		
Insurance[1]	18,700		
Taxes[2]	37,400		
		Subtotal	$243,600
<u>Consumables</u>			
Office Supplies	3,000		
Janitorial Supplies	2,000		
Medical Supplies	500		
Postage	1,000		
Printed Supplies & Forms	2,500		
		Subtotal	9,000
<u>Utilities</u>			
Water & Sewer	2,000		
Electricity & Gas	90,100		
		Subtotal	92,100
<u>Equipment</u>			
Fuel	10,500		
Maintenance			
- Mobile Equip.	12,000		
- Process Equip.	57,500		
Equipment Rental	5,000		
		Subtotal	85,000
<u>Labor</u>			268,590
		TOTAL	$698,290
Contingency and Management Fee (@15%)			104,800
		GRAND TOTAL	$803,090

[1] One-Half (1/2) percent of facility cost.
[2] One percent of facility cost

- Larger air separation system N/A
- Secondary shredder $93,450
- Conventional hammermill $20,150

5.3 TRANSPORTATION SUBSYSTEM

The personnel assigned to the processing subsystem will operate and maintain the transportation subsystem. Due to the minimal amount of time required for the transportation equipment, the labor cost has been allocated to the processing subsystem.

The annual O&M cost for the transport subsystem, shown in Figure 5-3, is $37,400 for a 20% substitution rate of RDF-3. For a 10% substitution rate, the projected annual O&M cost is $27,300.

5.4 STORAGE SUBSYSTEM

Labor requirements for the storage subsystem are minimal and therefore an increase in staffing is not anticipated. An allowance has been included to cover the labor costs on an overtime basis using existing personnel at the boiler facility.

The annual O&M costs for the storage subsystem, detailed in Figure 5-4, are estimated at $66,950 for a 20% substitution rate and $52,900 for a 10% substitution rate.

5.5 DELIVERY SUBSYSTEM

The delivery subsystem will require little operator attention. The maintenance requirements for the equipment are minimal. A labor cost allowance has been included to cover overtime for the existing boiler plant personnel since the needs do not warrant an increase in the staffing level.

Figure 5-3

TRANSPORTATION SUBSYSTEM: ANNUAL O&M COSTS
(January 1983 Dollars)

DESCRIPTION		ESTIMATED COST
1.0 Insurance[1]		$ 6,700
2.0 Taxes[2]		13,400
3.0 Electricity		4,900
4.0 Maintenance[3]		7,500
	TOTAL	$ 32,500
Contingency & Mgmt. Fee (@15%)		4,900
	GRAND TOTAL	$ 37,400

[1] One-half percent of equipment cost.
[2] One percent of equipment cost
[3] Parts only, labor provided by process personnel

Figure 5-4

STORAGE SUBSYSTEM: ANNUAL O&M COSTS
(January 1983 Dollars)

DESCRIPTION		ESTIMATED COST
1.0 Tool Allowance		$ 250
2.0 Build. Maint. & Repair		12,500
3.0 Insurance[1]		7,700
4.0 Water & Sewer		300
5.0 Electricity		29,100
6.0 Maintenance		6,000
7.0 Labor Allowance[2]		5,000
	SUBTOTAL	$ 60,850
Contingency (@10%)		6,100
	GRAND TOTAL	$ 66,950

[1] One-half percent of facility cost.
[2] Allowance for anticipated overtime asociated with facility maintenance - labor provided by boiler plant personnel.

The projected annual O&M cost for the delivery subsystem operating at a 20% substitution rate of RDF-3, presented in Figure 5-5, is $76,200. For a 10% substitution rate, the projected annual O&M cost is $69,100. Approximately 75% of these costs are due to the high power consumption of the equipment, especially the positive displacement blowers.

5.6 COMBUSTION SUBSYSTEM

The incremental annual O&M cost for the combustion subsystem as compared to combusting coal alone is minimal. No additional labor requirements are necessitated and the annual cost for operating and maintaining the dump grates, overfire/underfire air supply and screen are projected at $41,000 for a 20% substitution rate of RDF-3, as shown in Figure 5-6. The projected annual O&M cost for a 10% substitution rate is $23,100.

Figure 5-5

DELIVERY SUBSYSTEM: ANNUAL O&M COSTS
(January 1983 Dollars)

DESCRIPTION		ESTIMATED COST
1.0 Insurance[1]		$ 1,050
2.0 Electricity		57,700
3.0 Maintenance		5,500
7.0 Labor Allowance[2]		5,000
	SUBTOTAL	$ 69,250
Contingency (@10%)		6,950
	GRAND TOTAL	$ 76,200

[1] One-half percent of equipment cost.
[2] Allowance for anticipated overtime asociated with facility maintenance - labor provided by boiler plant personnel.

Figure 5-6

COMBUSTION SUBSYSTEM: "INCREMENTAL" ANNUAL O&M COSTS
(January 1983 Dollars)

DESCRIPTION		ESTIMATED COST
1.0 Ash Disposal		$ 28,000
2.0 Water		1,000
3.0 Electricity		7,250
4.0 Maintenance[1]		2,000
	SUBTOTAL	$ 37,250
Contingency (@10%)		3,750
	GRAND TOTAL	$ 41,000

[1] Parts only, labor provided by boiler plant personnel

SECTION 6.0

ECONOMIC EVALUATION

6.1 GENERAL

This section presents a detailed economic evaluation of the system proposed for producing, transporting, storing, feeding and combusting RDF-3 in a typical pulverized coal boiler at a naval shore facility. RDF-3 will be produced at a processing facility located near the Navy site. The processing and transportation subsystems will be owned and operated by a private contractor who will be required to produce conforming RDF-3 and transport it to the storage silo located on the Navy site. The Navy will own and operate the storage, delivery and combustion subsystems. The combustion subsystem will consist of an existing suspension-fired boiler which will be modified to co-fire RDF-3 with pulverized coal.

Because of the split ownership and operational responsibilities of the private contractor and the Navy, it will be necessary to utilize different financing methods for projecting the costs for the various subsystems.

6.2 CAPITAL COSTS

The capital costs are presented in two distinct groupings. The first includes the processing and transportation subsystems which will be owned and operated by a private contractor. For the purpose of this evaluation, Industrial Development Revenue Bonds were selected as the method of financing. With this type of financing structure, capital costs for the proposed subsystems will include the cost of construction, start-up, and other project expenditures which will be capitalized over the period of the debt. These expenditures will include project development funds (i.e. consulting fees, legal fees, etc.), net interest during construction, debt service reserve funds, and other expenses associated with the issuance of the revenue bonds.

The second grouping of capital costs includes the storage, delivery and combustion subsystems which will be owned and operated by the Navy. It has been assumed the Navy will allocate capital development funds for the project and therefore no special financing costs or debt service reserve funds will be required.

Capital costs for the processing and transportation subsystems- The capital costs included for this portion of the project assume that a private contractor has total responsibility for design, construction, operation, financing and ownership of the proposed subsystems. The parameters used in the development of the annual debt service for this grouping of subsystems are as follows:

o Method of financing	Revenue bonds
o Term of debt	20 years
o Interest rate	15% per year
o Construction period	18 months
o Start-up period	6 months

Figure 6-1 contains a detailed breakdown of the elements which comprise the annual debt payment for a 20 percent (%) RDF-3 substitution rate. Based on the parameters presented above, the annual debt payment for the processing and transport subsystems is $1,580,400. Applying these parameters to the capital costs associated with processing and transporting RDF-3 at a 10% substitution rate, the annual debt payment is $1,027,000.

Figure 6-1

RDF-3 PROCESSING/TRANSPORT SUBSYSTEM: CAPITAL COSTS

(January 1983 Dollars)

DESCRIPTION	ESTIMATED COST
Construction Cost	
- Process	$ 4,023,750
- Transport	1,360,650
Engineering & Constr. Mgmt.	
- Process	544,200
- Transport	75,000
Construction Contingency	
- Process	603,550
- Transport	204,100
Start-Up[1]	
- Process	562,150
- Transport	26,200
TOTAL DIRECT CONSTRUCTION COST	$ 7,399,600
Project Development Cost[2]	740,000
Interest During Construction	1,485,300
Debt Service Reserve (1 year)	1,782,400
Issuance Cost (4% Bond Issue)	475,300
TOTAL BOND ISSUE	$11,882,600
ANNUAL DEBT SERVICE (less earnings on debt service reserve)	$ 1,580,400

[1] Seventy percent (70%) annual O&M costs (year one).

[2] Ten percent (10%) total construction cost.

Capital costs for the storage, delivery and combustion subsystems- The capital costs for this portion of the proposed project assumes the Navy will own and operate the facility, but that design and construction of the facility will be bid through a competitive process using private engineers and contractors to perform the work. The parameters used in the development of the capital amortization cost for the Navy-owned subsystems are as follows:

o Method of financing	Capital allocation
o Amortization period	25 years
o Interest rate	10% per year
o Construction period	18 months
o Start-up period	6 months

Figure 6-2 contains a detailed breakdown of the elements which comprise the annual amortization cost for a 20% RDF-3 substitution rate. Based on the parameters presented above, the annual amortization cost for the storage, delivery and combustion subsystems is $286,700. Applying these parameters to the capital costs associated with a 10% substitution rate, the annual amortization cost is $231,600.

6.3 LIFE CYCLE COST ANALYSIS

Prior to conducting life cycle cost analysis for the subsystems to be owned and operated by the private contractor (i.e. processing and transport subsystems), the projected energy revenues from the sale of RDF-3 to the Navy were first calculated. This enabled us to determine the tipping fee required to cover the balance of operation and maintenance costs and debt service payments associated with their operation.

Figure 6-2

RDF-3 STORAGE/DELIVERY/COMBUSTION SUBSYSTEM: CAPITAL COST

(January 1983 Dollars)

DESCRIPTION	ESTIMATED COST
Construction Cost	
- Storage	$ 1,536,600
- Delivery	208,850
- Combustion	161,450
Engineering & Constr. Mgmt.	
- Storage	223,200
- Delivery	29,400
- Combustion	65,000
Construction Contingency	
- Storage	230,500
- Delivery	31,350
- Combustion	24,250
Start-Up[1]	
- Storage	33,500
- Delivery	38,100
- Combustion	20,500
TOTAL DIRECT CONSTRUCTION COSTS	$ 2,602,300
ANNUAL AMORTIZATION COST	286,700

[1] Fifty percent (50%) annual O&M costs (year one).

__Life cycle cost for the storage, delivery and combustion subsystems:__ Discussions with personnel at the Naval Facilities Engineering Command, Port Hueneme, California, provided the criteria for establishing the expected cost the Navy would pay for RDF-3 to combust in their existing pulverized coal fired boiler(s). This criteria, simply stated, is that the Navy would not pay any more to combust RDF than it would pay if they continued to combust coal over the life of the project (25 years). A summary of the parameters used in the development of the life cycle cost analysis for the Navy storage, delivery and combustion subsystems, are as follows:

o Life of Project	25 years
o Return on Investment	10% per year
o O&M Cost (year one)	$184,150
o O&M Cost Escalator	8% per year
o Capital Amortization	$286,700
o Fuel Savings (year one)	$459,900
o Fuel Cost Escalator (coal)	8% per year

Figure 6-3 presents the life cycle cost analysis for the Navy owned and operated storage, delivery and combustion subsystems at a 20% RDF-3 substitution rate. First year operations and maintenance (O&M) costs were developed in Section 5.0. The first year fuel savings was calculated assuming the 1983 cost for coal displaced by the RDF-3 was $45 per ton and that the average heat content of the coal is 13,000 Btu per pound.

In order to determine the cost the Navy would pay for RDF-3, the net present value (NPV) for O&M costs, capital amortization and fuel savings over the life of the project had to be calculated. If the NPV of the fuel savings were sufficient to cover the NPV of the O&M costs and capital amortization combined, the Navy could purchase the RDF-3 at same cost. Assuming that the fuel savings NPV are greater, a computer program can be used to determine the amount the Navy could pay for the RDF-3 and the

Figure 6-3

LIFE CYCLE COST ANALYSIS: 20% SUBSTITUTION
NAVY RDF-3 STORAGE/DELIVERY/COMBUSTION SYSTEM FILE: PDF

CAPITAL AMORTIZATION
- Interest Rate: 10%
- Term: 25 years

OPERATIONS ESCALATOR: 1.08
FUEL SAVINGS ESCALATOR: 1.08
FUEL COSTS ESCALATOR: 1.04

YEAR	O&M COST	CAPITAL AMORT.	FUEL COSTS (PDF-3)	TOTAL ANNUAL COSTS	FUEL SAVINGS (COAL)	NET ANNUAL COST [1]	PRESENT VALUE (ACCUMULATED)
1983	184150	286700	195000	665850	459900	205950	187227.3
1984	198882	286700	202800	688382	496692	191690	345648.8
1985	214792.6	286700	210912	712404.6	536427.4	175977.2	477863.0
1986	231976.0	286700	219348.5	738024.4	579341.5	158682.9	586245.6
1987	250534.0	286700	228122.4	765356.5	625688.9	139667.6	672968.2
1988	270576.8	286700	237247.3	794524.1	675744.0	118780.1	740016.4
1989	292222.9	286700	246737.2	825660.1	729803.5	95856.61	789206.0
1990	315600.7	286700	256606.7	858907.4	788187.8	70719.65	822197.3
1991	340848.8	286700	266871.0	894419.8	851242.8	43176.96	840508.5
1992	368116.7	286700	277545.8	932362.5	919342.2	13020.28	845528.4
1993	397566.0	286700	288647.6	972913.7	992889.6	-19975.9	838527.0
1994	429371.3	286700	300193.5	1016265.	1072321.	-56055.9	820665.8
1995	463721.0	286700	312201.3	1062622.	1158106.	-95484.1	793007.5
1996	500818.7	286700	324689.3	1112208.	1250755.	-138547.	756523.7
1997	540884.2	286700	337676.9	1165261.	1350815.	-185554.	712103.5
1998	584154.9	286700	351184.0	1222039.	1452881.	-236842.	660559.9
1999	630887.3	286700	365231.3	1282819.	1575591.	-292772.	602636.4
2000	681359.3	286700	379840.6	1347899.	1701638.	-353739.	539013.3
2001	735867.0	286700	395034.2	1417601.	1837769.	-420168.	470312.5
2002	794736.4	286700	410835.6	[illegible]	[illegible]	[illegible]	[illegible]
2003	858315.3	286700	427269.0	1572284.	2143574.	-571290.	319903.9
2004	926980.5	286700	444359.8	1658040.	2315060.	-657020.	239191.7
2005	1001139.	286700	462134.2	1749973.	2500265.	-750292.	155400.5
2006	1081230.	286700	480619.5	1848550.	2700286.	-851737.	68927.39
2007	1167728.	286700	499844.3	1954273.	2916309.	-962036.	-19864.7
PRESENT VALUE	3387560.	2602387.	2450350.	8440298.	8460163.	-19864.7	

	2470215.
RDF-3 FUEL COST ESCALATOR	1.04
PDF-3 FUEL COST (1st YEAR)	195000

[1]: Annual Cost less Fuel Savings.

associated fuel cost escalator. The basis of the program is to determine an RDF-3 fuel cost, escalated at some rate over the life of the project, whose net present value (NPV) when combined with the NPV of the O&M costs and capital amortization does not exceed the NPV of the projected fuel savings.

Based on these criteria and the life cycle cost parameters identified, the Navy could pay $195,000 in 1983 for RDF-3, escalated at 4 percent per year. This is equivalent to a first year RDF-3 fuel cost of $8.86 per ton, or $0.74 per million Btu. It should be noted that this is not the *only* combination of values that would satisfy the Navy criteria. For example, some combination of a higher first year fuel cost and lower escalation rate, or vise versa, would provide an acceptable solution.

As indicated in Figure 6-3, the fuel savings realized in year one ($459,900), do not offset the cost to the Navy to own and operate the RDF-3 storage, delivery and combustion subsystems ($665,850). It is not until year 11 that the projected annual fuel savings exceed the costs associated with owning and operating these facilities. In affect the Navy is subsidizing the project during the initial years. The net savings realized in years 11 through 25 (fuel savings less annual costs), is used to retire the debt (navy subsidy), which at the end of year 10 is $845,528. Assuming a 10 % return on investment, the debt is fully retired in year 25 leaving a postive cash balance of $19,864.

<u>Life cycle costs for the processing and transport subsystems</u>: The cost for RDF-3 that the Navy is willing to pay, constitutes the energy revenues for the processing and transport subsystems owned and operated by private contractor. The other source of revenue which is available to the private contractor to offset the costs associated with owning and operating the subsystems are tipping fees. The tipping fee required to offset these costs are readily determined over the life of the project by applying the

appropriate life cycle cost parameters. These parameters are presented on the following page.

o Life of Project	25 years
o O&M Costs (year one)	$840,490
o O&M Escalator	8% per year
o Debt Service Payment	$1,580,400
o Energy Revenues	$195,000
o Energy Revenue Escalator (RDF-3)	4% per year

Figure 6-4 presents the life cycle cost analysis for the processing and transport subsystems owned and operated by the private contractor at a 20% RDF-3 substitution rate. The first year tipping fee required to offset the costs associated with owning and operating the subsystems is $65.85 per ton. In order to insure that the tipping fee revenues are sufficient to offset these costs in addition to the projected energy revenues, the tipping fee will require escalation at 4 percent per year.

A tipping fee of $65.85 per ton in 1983 dollars is not consistent with what a community would pay for disposal of solid waste even if the proposed facility offered a long term disposal alternative to the community. One way to derate the tipping fee so that it can be considered acceptable (approximately $15-20/ton), would be to establish a stabilization fund. This fund essentially subsidizes the project during the initial years until tipping fee and energy revenues are sufficient to offset the projected operations and maintenance and debt service costs. Assuming a 15 percent return on investment for capital used to establish the stabilization fund, and a tipping fee escalator of 8% per year, the first year tipping fee could be derated to $49.00 per ton. This tipping fee would still be considered excessive for the disposal of solid waste.

Figure 6-4

LIFE CYCLE COSTS ANALYSIS: 20% SUBSTITUTION
PDF-3 PROCESSING/TRANSPORT FACILITY FILE: PDF.1

ANNUAL DEBT SERVICE BASIS:
- INTEREST RATE: 15%
- TERM: 25 years
OPERATIONS ESCALATOR: 1.08
ENERGY SALES ESCALATOR: 1.04

YEAR		O&M COST	DEBT SERVICE	TOTAL ANNUAL COSTS	ENERGY REVENUES	TIP FEE REVENUES [1]	TIP FEE ($/TON) [2]
1983	1	840490	1580400	2420890	195000	2225890	65.85473
1984	2	907729.2	1580400	2488129.	202800	2285329.	67.61329
1985	3	980347.5	1580400	2560748.	210912	2349836.	69.52176
1986	4	1058775.	1580400	2639175.	219348.5	2419827.	71.59251
1987	5	1143477.	1580400	2723877.	228122.4	2495755.	73.83890
1988	6	1234956.	1580400	2815356.	237247.3	2578108.	76.27539
1989	7	1333752.	1580400	2914152.	246737.2	2667415.	78.91760
1990	8	1440452.	1580400	3020852.	256606.7	2764245.	81.78241
1991	9	1555688.	1580400	3136088.	266871.0	2869217.	84.88809
1992	10	1680143.	1580400	3260543.	277545.8	2982998.	88.25437
1993	11	1814555.	1580400	3394955.	288647.6	3106307.	91.90258
1994	12	1959719.	1580400	3540119.	300193.5	3239926.	95.85579
1995	13	2116497.	1580400	3696897.	312201.3	3384696.	100.1389
1996	14	2285817.	1580400	3866217.	324689.3	3541527.	104.7789
1997	15	2468682.	1580400	4049082.	337676.9	3711405.	109.8049
1998	16	2666176.	1580400	4246576.	351184.0	3895392.	115.2483
1999	17	2879471.	1580400	4459871.	365231.3	4094639.	121.1432
2000	18	3109828.	1580400	4690228.	379840.6	4310388.	127.5263
2001	19	3358614.	1580400	4939014.	395034.2	4543980.	134.4373
2002	20	3627304.	1580400	5207704.	410835.6	4796868.	141.9192

[1]: Total Annual Cost less Energy Revenues.
[2]: Tip Fee Revenues divided by 130 TPD, 260 day per year.

Figures 6-5 and 6-6 present the life-cycle cost analysis for the Navy and private contractor owned and operated facilities, respectively, for a 10% RDF-3 substitution rate. As indicated in Figure 6-5, the net present value (NPV) of the projected fuel savings at the Navy facilities are not sufficient to offset the cost associated with their ownership and operation over the life of the project. Therefore, the only way that the Navy would consider using RDF-3 for combustion in their existing pulverized coal fired boilers, would be if the private contractor were to pay the Navy to take the RDF-3 -- a situation which is not likely to occur. Assuming that the Navy were to accept the RDF from the private contractor at zero cost and essentially subsidize the program, the first year tipping fee at the processing and transport tacility would be $98.24 per ton (zero energy revenues). As previously indicated, this is substantially higher than what a community would be willing to pay for a long-term solid waste disposal alternative.

. Figure 6-5

LIFE CYCLE COST ANALYSIS: 10% SUBSTITUTION
NAVY RDF-3 STORAGE/DELIVERY/COMBUSTION SYSTEM FILE: RDF-A

CAPITAL AMORTIZATION
- Interest Rate: 10%
- Term: 25 years
OPERATIONS ESCALATOR: 1.08
FUEL SAVINGS ESCALATOR: 1.08
FUEL COSTS ESCALATOR: NA

YEAR		O&M COST	CAPITAL AMORT.	FUEL COST (RDF-3)	TOTAL ANNUAL COST	FUEL SAVINGS (COAL)	NET ANNUAL COST [1]	PRESENT VALUE (ACCUMULATED)
1983	1	145100	231600	0	376700	229950	146750	133409.1
1984	2	156708	231600	0	388308	248346	139962	249080.2
1985	3	169244.6	231600	0	400844.6	268213.7	132631.0	348727.8
1986	4	182784.2	231600	0	414384.2	289670.8	124713.4	433908.7
1987	5	197406.9	231600	0	429006.9	312844.4	116162.5	506036.5
1988	6	213199.5	231600	0	444799.5	337872.0	106927.5	566394.3
1989	7	230255.5	231600	0	461855.5	364901.8	96953.71	616146.9
1990	8	248675.9	231600	0	480275.9	394093.9	86182.01	656351.4
1991	9	268570.0	231600	0	500170.0	425621.4	74548.57	687967.3
1992	10	290055.6	231600	0	521655.6	459671.1	61984.46	711865.0
1993	11	313260.0	231600	0	544860.0	496444.8	48415.21	728834.2
1994	12	338320.8	231600	0	569920.8	536160.4	33760.43	739591.3
1995	13	365386.5	231600	0	596986.5	579053.2	17933.27	744786.0
1996	14	394617.4	231600	0	626217.4	625377.5	839.9268	745007.1
1997	15	426186.8	231600	0	657786.8	675407.7	-17620.9	740788.9
1998	16	460281.7	231600	0	691881.7	729440.3	-37558.5	732615.0
1999	17	497104.3	231600	0	728704.3	787795.5	-59091.2	720924.1
2000	18	536872.6	231600	0	768472.6	850819.2	-82346.5	706113.4
2001	19	579822.4	231600	0	811422.4	918884.7	-107462.	688542.4
2002	20	626208.2	231600	0	857808.2	992395.5	-134587.	668536.9
2003	21	676304.9	231600	0	907904.9	1071787.	-163882.	646391.4
2004	22	730409.3	231600	0	962009.3	1157530.	-195521.	622372.5
2005	23	788842.0	231600	0	1020442.	1250132.	-229690.	596721.1
2006	24	851949.4	231600	0	1083549.	1350143.	-266594.	569655.0
2007	25	920105.3	231600	0	1151705.	1458155.	-306449.	541370.9
PRESENT VALUE		2669210.	2102242.	0	4771452.	4230081.	541370.9	

[1]: Annual Cost less Fuel Savings

Figure 6-6

LIFE CYCLE COSTS ANALYSIS: 10% SUBSTITUTION
RDF-3 PROCESSING/TRANSPORT FACILITY FILE:RDF.1-A

ANNUAL DEBT SERVICE BASIS:
- INTEREST RATE: 15%
- TERM: 25 years

OPERATIONS ESCALATOR: 1.08
ENERGY SALES ESCALATOR: NA

YEAR	.	O&M COST	DEBT SERVICE	TOTAL ANNUAL COSTS	ENERGY REVENUES	TIP FEE REVENUES [1]	TIP FEE ($/TON) [2]
1983	1	633300	1027000	1660300	0	1660300	98.24260
1984	2	683964	1027000	1710964	0	1710964	50.62024
1985	3	738681.1	1027000	1765681.	0	1765681.	52.23909
1986	4	797775.6	1027000	1824776.	0	1824776.	53.98744
1987	5	861597.7	1027000	1888598.	0	1888598.	55.87567
1988	6	930525.5	1027000	1957525.	0	1957525.	57.91495
1989	7	1004968.	1027000	2031968.	0	2031968.	60.11738
1990	8	1085365.	1027000	2112365.	0	2112365.	62.49600
1991	9	1172194.	1027000	2199194.	0	2199194.	65.06491
1992	10	1265970.	1027000	2292970.	0	2292970.	67.83934
1993	11	1367247.	1027000	2394247.	0	2394247.	70.83572
1994	12	1476627.	1027000	2503627.	0	2503627.	74.07180
1995	13	1594757.	1027000	2621757.	0	2621757.	77.56678
1996	14	1722338.	1027000	2749338.	0	2749338.	81.34135
1997	15	1860125.	1027000	2887125.	0	2887125.	85.41789
1998	16	2008935.	1027000	3035935.	0	3035935.	89.82055
1999	17	2169649.	1027000	3196649.	0	3196649.	94.57543
2000	18	2343221.	1027000	3370221.	0	3370221.	99.71069
2001	19	2530679.	1027000	3557679.	0	3557679.	105.2568
2002	20	2733133.	1027000	3760133.	0	3760133.	111.2466

[1]: Total Annual Cost less Energy Revenues
[2]: Tip Fee Revenues divided by 65 TPD, 260 day per year.

SECTION 7.0

CONCLUSIONS

7.1 GENERAL

The utilization of RDF-3 in a pulverized coal boiler, as used by the Navy at its shore facilities, is a technically sound and environmentally desirable concept for waste disposal. However, utilization of RDF-3 in the quantities specified by the Navy and at the substitution rates projected for combustion in a pulverized coal boiler does not appear to be cost-effective when compared against the off-set costs for combusting coal alone.

Following are some potential methods for making the proposed concept more economically attractive:

Use of oil as the basis of cost off-set- Basing the annual fuel savings on the off-set costs for coal does not provide adequate economic advantage for utilizing RDF-3 as a supplemental fuel. If the realized energy savings can be computed as a function of fuel oil replaced, the economics for utilization of RDF-3 will be greatly enhanced.

Increased usage of RDF-3- Because of the relatively small quantities of RDF-3 being utilized, the cost per ton for processing and handling is excessive. If larger quantities of RDF-3 could be combusted (by employing additional, different or larger combustion units), the cost per ton for production will be reduced and the energy savings realized from combusting the higher quantities will be increased. The combination of reduced production costs and increased savings will greatly improve the economic viability of combusting RDF-3 with coal in the Navy's boilers.

7.2 10% VS 20% SUBSTITUTION RATES

Comparative technical and operational information for the proposed system is provided in Figure 7-1 for both 10% and 20% substitution rates. Capital and annual O & M projections for each sub-system is given in Figure 7-2.

The projected solid waste tipping fee in 1983, as presented in Section 6.0, decreases from $98.24 per ton for a 10% substitution rate to $65.85 per ton for a 20% substitution rate. Although both these projections are much higher than would be considered acceptable by any community, they indicate that a considerable reduction in the tipping fee results from the increased utilization of RDF-3. Since the scope of work under this contract was limited to evaluating only 10% and 20% substitution rates in a 150 mBtu per hour boiler, insufficient data is available to project the level at which the proposed system concept becomes economically viable.

Figure 7-1

COMPARISON OF 10% vs. 20% SUBSTITUTION RATES

SUBSYSTEM	20% SUBST.	10% SUBST.
PROCESS		
Capacity	130 TPD	65 TPD
RDF Generation Rate	84 TPD	42 TPD
Site Requirement	4 acres	3.5 acres
Building Size	11,000 ft^2	8,800 ft^2
Power Consumption	$1.2x10^6$kwh/yr	$0.8x10^6$kwh/yr
Personnel Requirements	10	8
TRANSPORT		
Capacity	84 TPD	42 TPD
Conveyor Width	4'-0"	3'-0"
Power Consumption	$75x10^3$kwh/yr	$58x10^3$kwh/yr
STORAGE		
Storage Capacity	200 Tons	100 Tons
Silo Size	62'dia.x62'H	54'dia.x55'H
Nominal Discharge Rate	2.5 TPH	1.25 TPH
Power Consumption	$0.4x10^6$kwh/yr	$0.3x10^6$kwh/yr
DELIVERY		
Nominal Feed Rate	2.5 TPH	1.25 TPH
Power Consumption	$0.9x10^6$kwh/yr	$0.7x10^6$kwh/yr
COMBUSTION		
Boiler Rating	150 mBtu/hr	150mBTU/hr
RDF Combustion Rate		
-Quantity	2.5 TPH	1.25 TPH
-Heating Value	30 mBtu/hr	15 mBtu/hr

Figure 7-2

COMPARISON OF 10% vs. 20% SUBSTITUTION RATES

Subsystem	Capital Costs		Annual O&M Costs	
	10%	20%	10%	20%
Process	$4,365,300	$5,171,500	$606,000	$803,090
Transport	1,372,500	1,639,750	27,300	37,400
Storage	1,539,600	1,990,300	52,900	66,950
Delivery	248,600	269,600	69,100	76,200
Combustion	241,200	250,700	23,100	41,000
TOTAL PROJECT	$7,767,200	$9,321,850	$778,400	$1,024,640

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