

COMPUTER PROGRAM FOR THE DESIGN AND COST
ESTIMATION OF HAZARDOUS WASTE
INCINERATION FACILITIES

By

JEFFREY DEAN MATHIS

Bachelor of Science

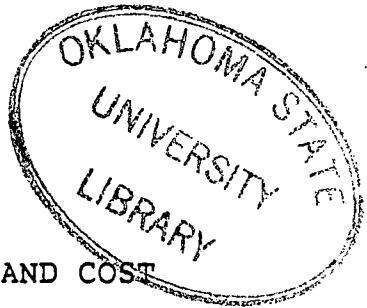
Oklahoma State University

Stillwater, Oklahoma

1986

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
December, 1986

Thesis
1986
M431c
Cop.2



COMPUTER PROGRAM FOR THE DESIGN AND COST

ESTIMATION OF HAZARDOUS WASTE

INCINERATION FACILITIES

Thesis Approved:

Robert A. Will

Thesis Adviser

Robert Robinson Jr.

Billy L. Hynes

Norman N. Durham

Dean of the Graduate College

1263896

PREFACE

The purpose of this study was to construct a computer program to design and cost estimate a hazardous waste incineration facility. This program also provides a method to economically analyze each facility. The combustors available for the design include; rotary kiln, fluidized bed, and liquid injection. Other process units were available to provide pollution control and other important facility requirements. These units include; afterburners, heat recovery boilers, quench chambers, venturi scrubbers, packed bed absorbers, and exhaust stacks. This program allows for a design up to a 10,000 lb/hr waste feed rate.

I am especially grateful to my thesis adviser, Dr. Robert A. Wills, for his valuable and friendly guidance, patience, and cooperation during this study. I am thankful to Dr. Billy L. Crynes and Dr. Robert L. Robinson for their cooperation as committee members. I am in appreciation of Hasan Qabazard and Carlos Ruiz for their professional and personnal assistance in completing this project. A special note of thanks is due all the office secretaries.

Financial support from the School of Chemical Engineering is greatly appreciated.

Finally, I wish to dedicate this achievement to my wife Marianne, and my parents Dean and Ebba who understood, inspired, and supported my work.

TABLE OF CONTENTS

Chapter	Page
I. INTRODUCTION	1
II. LITERATURE REVIEW	3
Incineration Design and Operation	
Literature	3
Incineration of Non-Hazardous Wastes	3
Incineration of Hazardous Wastes	5
Combustor Design and Operations	
Literature	6
Survey of Incinerator Industry	6
Combustors	6
Pollution Control	9
Pollution Control Regulations	9
Afterburners	10
Heat Recovery Boilers	10
Quench Chamber	11
Particulate and Caustic Scrubbing	12
Exhaust Stacks	14
Ductwork	15
Induction Fans	15
Literature on Other Facility Costs	16
Waste Storage	16
Sitetwork	17
III. BACKGROUND	18
Incineration Facility Design and Cost	18
Waste Incineration Practices	19
Process variables	19
Excess Air	19
Characteristics of Waste	19
Pretreatment	21
Fuel	21
Destruction Conditions	22
Pollution Control	26
Process Design	27

Chapter	Page	
	Primary Combustors Components and Accessories	27
	Combustors	30
	Afterburners	40
	Pollution Control System Design and Cost	40
	Heat Recovery Boilers	41
	Quench Chamber	43
	Venturi Scrubbers	44
	Packed Bed	49
	Exhaust Stack	55
	Miscellaneous Capital Cost Data	57
	Waste Storage	58
	Sitetwork and Foundations	62
	Instruments and Controls	62
	Operations Building and Offices	65
	Ductwork	65
	Certification and Engineering	67
	Structural Steel and Electrical Materials	68
IV. COMPUTER PROGRAM DESIGN AND COST ESTIMATION . . .	70	
	Incinerators	72
	Primary Combustors	72
	Afterburner Combustors	79
	Pollution Control	82
	Quench Chamber	84
	Heat Recovery	84
	Venturi Scrubber	87
	Induction Fan	94
	Packed Bed	97
	Exhaust Stack	104
	Ductwork	110
	Miscellaniuous Facility Costs	112
	Waste Storage Facility	112
	Other Facility Costs	115
	Indirect Costs	116
	Operating Costs	117
	Labor Costs	118
	Utilities Costs	119
	Waste Water Treatment	120
	Land Taxes	121
	Lime Caustic	121
	Steam Cost Recovery	121
	Start-up Costs	122
	Maintenence Costs	122
	Insurance Costs	122
	Operating Revenues	124
	Economic Analysis	124
V. DESCRIPTION OF COMPUTER PROGRAM	127	

Chapter	Page
Subroutine Description.	130
Synopsis of Individual Routines	130
Input and Output For Program.	162
VI. RESULTS OF THE COMPUTER PROGRAM.	164
Comparison of Program Results With Hand Calculations.	164
Waste Feed Characteristics	165
Product Gas Characteristics.	165
Primary and Afterburner Combustors . .	165
Pollution Control.	167
Results of Calculations.	169
Comparison of Computer Costs With Actual Facility Costs.	174
Capital Costs Obtained From Industry	176
Capital Costs Obtained From Literature	176
VII. FUTURE WORK.	178
Combustion Reaction Calculations.	178
Addition of Process Units	179
Combustors	179
Pollution Control.	180
Other Capital Cost Improvements	181
Economic Comparison Improvements.	182
Program Improvements.	182
VIII. CONCLUSIONS.	184
SELECTED BIBLIOGRAPHY	185
APPENDIXES.	191
APPENDIX A - CURVE FITTING CALCULATIONS.	192
APPENDIX B - COMPUTER PROGRAM LISTINGS FOR THE NON-LINEAR CURVE FITTING PROCEDURE.	210
APPENDIX C - SELECTED LIST OF VARIABLES USED IN PROGRAM <u>HWSTBRN</u>	215
APPENDIX D - COMPUTER PROGRAM <u>HWSTBRN</u> LISTING. .	227
APPENDIX E - OPERATING MANUAL.	328
APPENDIX F - EXAMPLES OF PROGRAM <u>HWSTBRN</u> OUTPUT.	354

LIST OF TABLES

Table	Page
I. Composition and Heating Value of Common Incinerator Fuels	22
II. Container Size Versus Chamber Size for the Rotary Kiln Incinerator	32
III. Scrubbing Efficiency Versus Number of Mass Transfer Units	51
IV. Height of Packing versus Scrubbing Height Efficiency	54
V. Storage Tank Materials of Construction Cost Factors.	60
VI. Cost of Incinerator Fuel Burner System	73
VII. Cost of 55-Gallon Drum Feed System	75
VIII. Cost Factors for Shell Materials	77
IX. Diameter of Fluidized Bed Incinerators based on the Moisture Evaporation Rate.	77
X. Diameter of Fluidized Bed Incinerators based on the Heat Release Rate.	78
XI. Materials of Construction Temperature Limitations of Quench Chamber	83
XII. Heat Recovery versus Pressure Drop for Heat Recovery Boilers	84
XIII. Materials of Construction Constants for Heat Recovery Boilers	86
XIV. Materials of Construction Cost Factors for Venturi Scrubbers	91

Table	Page
XV. Fan Costs for Induction Fans	95
XVI. Materials of Construction Cost Factors for Fans.	95
XVII. Constants based on packing type and size for the calculation of a liquid Mass Transfer Unit	102
XVIII. Constants based on packing type and size for the calculation of a gas Mass Transfer Unit	103
XIX. Packed bed absorber constants for the calculation of pressure drop.	106
XX. Cost of Exhaust Stacks	108
XXI. Cost of Straight Carbon Steel Ductwork	110
XXII. Properties and Cost of Firebrick for Ductwork.	112
XXIII. Cost of Waste Storage Facilities	114
XXIV. Cost Factors for Materials of Construction for Waste Storage Tanks.	113
XXV. Cost of Miscellaneous Capital Costs.	117
XXVI. Labor Costs.	118
XXVII. Labor Requirements	118
XXVIII. Waste Water Treatment Operating and Capital Costs	120
XXIX. Present Value Calculation.	125
XXX. Accelerated Cash Recovery System(ACRS) Depreciation Method	126
XXXI. Heat Capacity Values for Combustion Products.	137
XXXII. Computer output pertaining to incineration facility operations parameters.	148

Table	Page
XXXIII. Computer output representing the capital cost of the incineration facility	149
XXXIV. Computer program representing the design and cost of ductwork connecting the process units	150
XXXV. Computer program output pertaining to the incineration design and cost breakdown	152
XXXVI. Computer program output for the mass balance and inlet and outlet process conditions.	153
XXXVII. Characteristics of waste Sludges	166
XXXVIII. Hazardous waste incineration process equipment for Sludge #1	170
XXXIX. Hazardous waste incineration process equipment for sludge #2	171
XXXX. Comparision of capital cost estimated from the computer program with data published by Brunner.	177
XXXXI. Curve-fit constants for Waste feed burner system costs	194
XXXXII. Curve-fit constants for solid wastes feed system cost.	194
XXXXIII. Curve-fitting constants to cost support trays for the fluidized bed combustor	195
XXXXIV. Quantity factors to determine cost of fluidized bed support trays	196
XXXXV. Curve-fit constants to calculate fluidized bed combustor diameter.	197
XXXXVI. Curve-fit constants to calculate the pressure drop in a heat recovery boiler.	198
XXXXVII. Curve-fit constants to calculate the cut diameter for particulate removal in venturi scrubber.	198

Table	Page
XXXXVIII. Curve-fit constants to calculate the particulate removal efficiency in a venturi scrubber for specific pressure drops.	199
XXXXIX. Curve-fit constants to calculate the venturi scrubber wall thickness	200
L. Curve-fit constants to calculate the cost adjustment factor for venturi scrubber wall thickness	201
LI. Curve-fit constants to calculate the pressure adjustment factor for the induction fan	202
LII. Curve-fit constants to calculate the induction fan horsepower.	203
LIII. Curve-fit constants to calculate the induction fan rpms.	204
LIV. Curve-fit constants to calculate the cost of an induction fan motor.	205
LV. Curve-fit constants for the Lobo correlation to calculate the packed bed absorber diameter	206
LVI. Curve-fit constants to determine the packing factor for the packed bed absorber.	207
LVII. Curve-fit constants to calculate the cost of a packed bed absorber	207
LVIII. Curve-fit constants to calculate the cost of structural steel, metal building, instruments and electrical materials	208
LIX. Curve-fit constants to calculate the capital and operating costs for wastewater treatment facilities	209

LIST OF FIGURES

Figure	Page
1. Concentration of PCB combustion Products.	24
2. Figure of Rotary Kiln Incinerator	31
3. Figure of Fluidized Bed Incinerator	35
4. Figure of Liquid Injection Incinerator.	39
5. Figure of Fire-Tube Reboiler for Waste Heat Recovery.	42
6. Figure of Venturi Scrubber and Separator.	45
7. Commonly Observed Particulate Distribution.	47
8. Solubility Diagram to Determine Number of Mass Transfer Units	52
9. Lobo Correlation for Packed Bed Absorber Design.	56
10. Exhaust Stack Cost Data	59
11. Cost of Structural Steel Supports and Electrical Materials.	64
12. Cost of Structural Steel, Building, and Instruments and Controls.	69
13. Hazardous Waste Incineration Facility Process Flow Diagram.	71
14. Cost of Sieve and Valve Trays for The Fluidized Bed Incinerator	80
15. Cost of Valve Trays for the Fluidized Bed Incinerator	81
16. Particulate Removal Efficiency for Venturi Scrubber.	88
17. Cut Diameter versus Pressure Drop for Venturi Scrubber.	90

Figure	Page
18. Cost of Venturi Scrubbers	92
19. Pressure Connection Factors for Venturi Scrubbers	93
20. Pressure Correction Factors based on Atmospheric Pressure and Temperature.	96
21. Cost of Motor for Induction Fans.	98
22. Cost of Inlet and Outlet Dampers for Induction Fans.	99
23. Packing Factors for the Packed Bed Absorber . .	101
24. Equilibrium Curve for Scrubbing Hydrogen Chloride.	105
25. Cost of Packed Bed Absorber	107
26. Duct Elbow Costs.	111
27. Operation Cost to Reheat Incinerators	123
28. Subroutine Flowchart For Program HWSTBRN. . . .	129
29. Discounted Cash Flow Rate of Return Results for the Hand Design Using Waste Feed #1	172
30. Discounted Cash Flow Rate of Return Results for the Hand Design Using Waste Feed #2	173
31. Comparison of DCFRR Values for the Hand Calculations With the Computer Results. . . .	175

LIST OF VARIABLES

- a - Constant for packed bed absorption process.
- b - Constant for packed bed absorption process.
- c - Constant for packed bed absorption process.
- d - Heat capacity constant(See equation 42).
- e - Heat capacity constant(See equation 42).
- f - Heat capacity constant(See equation 42).
- g - Constant for packed bed absorption process.
- g₁ - Constant for materials of construction for heat recovery boiler.
- g₂ - Constant for materials of construction for heat recovery boiler.
- m - Slope of the vapor-liquid equilibrium curve(See figure 23).
- n - Constant for packed bed absorption process.
- t - Time(seconds).
- u_g - Gas viscosity(cps).
- u_l - Liquid viscosity(cps).
- z - Constant for packed bed absorption process.
- A - Area(square feet).
- A_c - Constant for Venturi scrubber removal efficiency.
- B_c - Constant for Venturi scrubber removal efficiency.
- C - Cost of heat recovery boiler(U.S. Dollars).
- C_b - Base cost for the Storage tank and heat recovery boiler(U.S. Dollars).
- C_C - Incineration facility capital cost(U.S. Dollars).

Ci - Inlet concentration(lb / cubic feet).
Co - Outlet concentration(lb/cubic feet).
Cst - Constant for calculation of induction fan horsepower.
Cp - Heat capacity(Btu/lb Fahrenheit).
D - Diameter of ductwork(inches).
Deg - Density of gas phase(lb/cubic feet).
Del - Density of liquid phase(lb/cubic feet).
Dg - Diffusivity of caustic in the gas phase(square feet/second).
Dl - Diffusivity of caustic in the liquid phase(square feet/second).
Dp - Diameter of particle(microns).
DTm - Log mean temperature difference(Fahrenheit).
EA - Excess air(Percent).
F - Packing factor.
FV - Future cost(U.S. Dollars).
Fd - Exchanger type cost factor.
Fm - Materials of construction cost factor for storage tanks and heat recovery boiler.
Fp - Design pressure cost facotr for the heat recovery boiler.
Gm - Mass velocity of the gas phase(lb/hour cubic feet).
H - Height of exhaust stack(feet).
Hg - Height of has transfer unit(Feet).
Hl - Height of liquid mass transfer unit(Feet).
Hog - Total height of one mass transfer unit(Feet).
HP - Power(Horsepower).
HR - Heat release rate(millions of Btu /hour).
Kp - Reaction equilibrium constant.
L - Length(feet).

Lm - Mass velocity of liquid phase(lb/hour square feet).

Nog - Number of mass transfer units required in the absorption process.

Pd - Penetration fraction of gas entrained particulates through the venturi scrubber.

PD - Pressure drop(inches H₂O).

PV - Present value cost(U.S. Dollars).

Pg - Gas density(lb/cubic feet).

P_l - Liquid density(lb/cubic feet).

Q - Heat transfer rate(Btu/hour).

Qf - Liquid flooding rate(cubic feet/minute square foot area).

Qr - Heat release rate(Btu/hour cubic feet).

T - Temperature(Fahrenheit).

RT - Rate of interest.

TCP - Theoretical combustion products rate(scf/Btu).

Te - Exit temperature from incinerator(Fahrenheit).

Tf - Temperature in incinerator(Fahrenheit).

U - Heat transfer coefficient(Btu/hour/ft²/Fahrenheit).

V - Volume(Gallons).

Vf - Gas flooding rate(cubic feet/minute square feet).

V_m - Volume rate(cubic feet/minute).

YR - Number of years that money is borrowed.

Y₁ - Inlet gas mole fraction.

Y₂ - Outlet gas mole fraction.

CHAPTER I

INTRODUCTION

One of the most important areas of the treatment of hazardous wastes is the ultimate disposal method. Land and ship based facilities are both technically feasible and economically viable at high feed rates. This program provides the process designer with a quick way to compare different incineration systems with the same waste feed rate.

The specific objectives of this project are:

- 1) Allow design and cost estimation for the available combustion systems.
- 2) Print a breakdown of the equipment, indirect, and operating expenses.
- 3) Provide a method to economically evaluate the facilities that have been designed and cost estimated.
- 4) Construct the computer program in a modular format to allow for additional incineration and pollution control process unit options.

The problem was solved by integrating information obtained from literature and visits to operating hazardous waste incineration facilities.

This report will outline a computer program for the design and cost estimation of hazardous waste incineration facilities. Design parameters and cost data obtained for this program are from literature or from visitation to

operating incineration facilities. The accuracy of this program is compared with capital and operating costs published for specific facilities.

CHAPTER II

LITERATURE REVIEW

Incineration Design and Operation Literature

There is much literature pertaining to the design and operation of non-hazardous waste incineration facilities. Unfortunately, there is little technical data for hazardous waste incineration facilities. This is due to the proprietary nature of the industry and the relative recentness of the technology. Much of the information that applies to hazardous waste incineration processes is obtained from incineration of sludges and solid wastes.

This literature review will cover the following topics. First, literature pertaining to general information on the incineration of hazardous wastes is presented. Second, literature on the design and operation of combustors and pollution equipment is discussed. Finally, literature pertaining to other components of the capital cost not covered above is presented.

Incineration of Non-Hazardous wastes

Many aspects of non-hazardous waste incineration practices are discussed by Brunner (1). He lays the groundwork for the design and operation for the incineration

of sewage sludges. This discussion includes the disposal alternatives, design parameters, operations, legislation, and capital costs of incineration facilities. This information is discussed more thoroughly in each section of this thesis.

A review of the state of art of incineration practices for the destruction of sewage sludges is presented by Balakrishnan et. al. (2). Balakrishnan discusses pretreatment options and operational characteristics of sewage sludge incineration systems. While pretreatment of hazardous wastes is limited, some of the discussed methods are applicable.

A more detailed evaluation of the sewage sludge incineration applied to fluidized bed and multiple hearth furnaces is presented by the Environmental Protection Agency (3). This publication discusses the incinerator and scrubbing performances of the units. Much of the data presented details the emission concentration of several pollutants.

Incineration of toxic wastes and other disposal methods is discussed in a publication by Powers (4). Powers book covers a much broader range of disposal methods. Applications and limitations of certain incineration processes are the major topics.

Incineration of Hazardous Wastes

Many sources for the design and operation of non-hazardous incinerators are available for more specific applications unimportant to hazardous waste incineration.

Application of incineration to hazardous waste was published by Bonner (5). He discusses many aspects of hazardous waste incineration design and operation. The book discusses many of the same subjects covered by Brunner on non-hazardous incineration. Important subjects covered are waste incineration practices; waste characterization, incineration and air pollution control design, and overall operation and monitoring of hazardous waste incineration processes.

A more complete discussion of the subject of hazardous waste incineration facilities is presented by The Electric Power Research Institute (EPRI). This publication provides an analysis of an incineration design parameters (for the rotary kiln, fluidized bed, and liquid injection incinerators) and cost analysis of PCB preprocessing, and permitting procedures. This is one of the few sources that discusses incineration technology applied to PCB combustion.

Combustor Design and Operation Literature

Survey of Industry

Frankel et. al. published data from a survey of the waste incineration industry (6). This data is based on information acquired from 119 different vendors of commercially available incineration systems. The purpose of this article was to determine the type of units in operation, their operating capacities, and the types of wastes incinerated. Incineration methods included are fluidized bed, multiple hearth, rotary kiln, liquid injection, and others. He presents data on the number of units in service, unit capacities, type of wastes incinerated, and design and operation conditions for the combustor.

Combustors

Fluidized Bed Combustors. Very little technical data is available on the design and cost estimation of fluidized bed incinerators. Fortunately, design parameters for fluidized beds can be calculated from data published in literature on operating facilities. Sizing characteristics and technical data for the bed diameter is presented by Brunner (1). Sewage sludge data is based on a water-based feed waste.

Huang discusses the operating characteristics of fluidized bed incinerators (7). In this, he covers the temperature distribution, residence time, height, operating

conditions and fluidizing characteristics. Diameter of a fluidized bed (based on heat release rate) and sizing procedures are presented in an article published by Sneyd (8). This information generally overlays data from the sources discussed above.

Literature available on procedures for the cost estimation of fluidized beds is unavailable. Fortunately, there has been cost data for specific operating facilities published in literature. One source of this cost data is by Brunner (1). This work includes the installed cost of fluidized bed incinerators with air preheaters.

A second source of cost data for a fluidized bed incinerator is published by Balakrishnan et. al. (2). This information was made available by Dorr-Oliver Incorporated; a well known consulting firm for the design of fluidized bed incinerators. Their costs include the installed incinerator not just the cost of the equipment.

A cost estimation method which can be applied to fluidized bed incinerators is presented by Vogel and Martin (9). While this method is specifically for rotary kiln and liquid injection units, it can also be applied to fluidized beds.

The design of a particular fluidized bed unit is discussed in a publication by Gottko (10), whereby technical information on dimensions, materials of construction, and steam generation is presented. Operating parameters such as bed and flyash removal are also discussed.

Rotary Kiln and Liquid Injection Combustors.

Information on the design and cost estimation of rotary kiln and liquid injection are available in literature. No doubt because these technologies have been used for years. Bonner describes the rotary kiln and liquid injection sub-systems along with incinerator applications (5).

A more complete discussion of the design and operation parameters of the rotary kiln and liquid injection incinerators is presented by Powers (4). Here, he presents data to calculate the dimensions of each incinerator type and the important factors that affect incineration operation. Powers also presents some approximations for the cost estimation of uninstalled commercially available incineration facilities. This cost data is based on the feed rate of the waste.

A more accurate method for the cost estimation of rotary kiln and liquid injection incinerators is presented by Vogel and Martin (9). This method estimates the cost of incinerator sub-systems including:

- 1) Waste feed system
- 2) Refractory
- 3) Shell
- 4) Ash removal

Cost factors are included for the assembly and installation of the incineration system. According to Vogel and Martin, this cost estimation method is accurate to ±20 percent.

Pollution Control

Information concerning the design and cost estimation of pollution control systems is well documented in the literature. This is due to the wide range of application of pollution control units and the importance of proper operation. Because of this, only publications pertaining to the incineration technology will be discussed. Presentation of the literature obtained will occur under each units topic. First, literature published dealing with emission legislation and emission standards will be discussed.

Pollution Control Regulations

A summary of important federal regulations that apply to generation storage, and disposal of hazardous waste is presented by Kahane et. al. (11). Kahane indicates that the important bodies of regulations are; the Resource Conservation and Recovery Act (RCRA), the Comprehensive Environmental Response and Liability Act, the Clean Water Act, Clean Air Act, and The Toxic Substances Control Act (TOSCA).

The actual regulations for processing hazardous wastes and the emissions standards for facilities is listed under Title 40 of the Federal Register (12). These regulations present base values for emission standards, destruction conditions, storage and operation procedures.

For incineration facilities, pollution control units selected are; afterburners, heat recovery boilers, quench chambers, venturi and packed bed scrubbers, induction fans and exhaust stacks. The literature on ductwork is also discussed under this section.

Afterburners

The design of afterburners is similar to that of liquid injection units. Therefore, literature on liquid injection units apply to afterburner units. Vogel and Martin have recommended some sizing parameters to design liquid injection incinerators (9). They also presented a cost estimation method.

Heat Recovery Boilers

Literature available on heat recovery units is limited to general design parameters and cost estimation.

Specification of heat recovery systems based on feed rate is presented by Lepeau (13). Lepeau limited the specification of heat recovery units to a payback period of 6 years. This was determined by an economic optimization for the specification of heat recovery from incineration.

Literature on design parameters and cost estimation is presented by Vatavuk and Neveril(48). The design is limited to the calculation of heat transfer area. The dimensions of the heat recovery boilers are not determined. Fortunately, these dimensions are not important to estimate the cost of the unit.

A second method to estimate the cost of heat recovery systems for the incineration industry is presented by Vogel and Martin (14). This cost estimation method is highly restricted. A more accurate cost estimation procedure is presented by Corripio et. al. (15). Vogel's method, which is curve-fit from data obtained in industry, estimates the cost of these units to \pm 20 percent.

A publication by Santoleri discusses the design parameters and operational considerations for heat recovery for the incineration of chlorinated hydrocarbons (16). Specifically, Santoreli recommends corrosion resistant materials, amount of heat to recover, and problems that may arise during operation. Information is available on estimation of the overall heat transfer coefficient for combustion gases(36).

An alternative heat recovery system, discussed by Sneyd (8), preheats air with the waste heat before incineration. Sneyd studied the effect of preheating air for fluidized bed combustors.

Quench Chamber

Quench chambers are implemented in many different industries. Therefore, there is much data available on this process. The literature available discusses the design parameters, operating requirements and problems common to quench chambers.

Vatavuk and Neveril present design and cost estimates for quench chambers (17). This method applies specifically to the incineration industry.

Particulate and Caustic Scrubbing

Scrubbers are pollution control systems important to many industries. Therefore, there is a large body of information in the literature covering the many aspects of scrubber design, operation and cost estimation. Only information important for this work will be discussed (caustic and particulates removal). Two kinds of scrubbers are normally specified for removal of particulates and caustics. These are the venturi and packed bed scrubber.¹²

Selection of scrubbers for particulate control is discussed by Seymor (18). Seymor describes the different types of scrubbers and test performance procedures. Equations to curve-fit particulate removal efficiency are available from this source.

Venturi Scrubbers. Design of venturi scrubbers is presented by Hesketh and Mohan (30). This method uses experimental data generated by the Environmental Protection Agency. Some important design parameters are also estimated. Cheremisoff also presents data for venturi scrubber designs. This is based on experimental cut-diameter data for venturi scrubbers. Recommended operating conditions are presented.

The cost of venturi scrubbers is also available in literature. Two design procedures for venturi scrubbers, that apply to incineration are discussed below.

The equipment and operating cost for a venturi scrubbers is estimated by Vogel and Neveril (14,19). Unfortunately, the design parameters are not adjustable. Cost is based on volume flowrate.

Estimation of the cost of a venturi scrubber is presented by Vatavuk (20). Material of construction, pressure drop, and gas volumetric flow rate are accounted for by Vatavuk. Also included is the cost estimation and dimensions of the vapor liquid separator after the venturi scrubber.

Recommended range of operating parameters is also presented. Accuracy of the cost data is estimated at ± 30 percent. Other procedures for design and cost of venturi scrubbers are available, but these methods are not for incineration operation or are not flexible design methods.

Packed Bed Scrubbers. The design of packed bed scrubbers is well documented in literature. Two design methods are discussed below.

The Air Pollution Control Association has published a method to design (and cost estimate) packed bed or tray bed absorbers (21). Column diameter was obtained using correlated data and the height was estimated by the mass transfer unit (MTU) method.

Another design method for packed bed scrubber is presented by Cheremisinoff (22). The procedure determines the diameter of the column from an empirical equation. Height is calculated by the mass transfer unit method.

A publication by Hanf and MacDonald presents information on scrubber applications and the height of packed bed scrubbers for a given removal efficiency (23). This data applies to highly soluble gases or absorption followed by chemical reaction. Also presented is data on water feed rates for the volume rate of fluegas.

Other sources for designing packed bed absorbers are available, but these are similar versions to the sources described above. Diffusion coefficients for caustics in gas and liquid phase are published by the Air Pollution Control Association (21).

The cost estimation of packed bed absorbers is available from a few sources in literature. The cost methods available are based on the volume rate of gas. Cost data was supplied by Hanf and MacDonald (23), the Air Pollution Control Association (21), and Peters and Timmerhaus (24).

Exhaust Stacks

The design and cost of exhaust stacks is available from many sources. Vatavuk and Neveril provide data to design and cost estimate exhaust stacks (14). Stack design using this method is limited to 200 feet, due to materials limitations, and does not include accessories. Vogel and

Martin also published cost data on exhaust stacks (25). The cost is based on a per foot basis and the accuracy of the method is estimated at ± 30 percent.

Ductwork

The design and cost of ductwork is available. A superior method to design and cost estimate ductwork and accessories is presented by Vatavuk and Neveril (26). Vatavuk provides recommended physical parameters for proper design of ductwork. Cost estimation method includes installation, bends, and materials of construction. Extra costs, such as firebrick for high temperature operation are not included.

Induction Fans

Information for the design of induction fans is provided in many sources in literature. Most design methods are not flexible. An exception to this was presented by Vatavuk and Neveril (27). This method allows specification of the number of fans, the pressure drop, motor rpm's. Fan selection is limited to radial or backward curved fan blades. The cost of induction fans and motors is also provided. This is the sum of the motor, fans, inlet and outlet dampers and extras costs.

Another method for compressor cost estimation is presented by Vogel and Martin (14). The only variable design parameter allowed is the fluegas flowrate. Pressure

difference and outlet temperature are specified. Cost factors are available to adjust for different pressure head and temperatures.

Literature on Other Facility Costs

Besides the equipment costs for incinerators, information on facility design are generally unavailable in the literature. Some design parameters and costs not available from the literature were obtained from visitations to incineration facility sites. Some sources from the literature pertaining to the design and cost of miscellaneous facility components are discussed below. Much of this data is from Lepeau (3) and Vogel and Martin (14,28).

Waste Storage

Hazardous waste is typically stored before incineration to insure an adequate feedstock. Vogel and Martin presented data to estimate the cost of storage tanks at 25,000, 10,000, and 5,000 gallons (9). This includes the accessory costs required for the storage of hazardous wastes. Also included is extra equipment that may be required for volatile wastes.

A more flexible method to estimate storage tank costs is presented by Corripio (15). The data presented was curve-fit from industrial costs. Costs include different materials of construction, lining and design pressure.

Sitework

Sitework and foundation costs can be significant due to the special design considerations. Unfortunately, data in the literature is unavailable for hazardous wastes. Lepeau does provide cost data for sitework and foundations (13). The variation in cost of sitework is discussed by Vatavuk and Neveril (29). He estimates, depending on the extent of work, that the costs may vary by up to 200 percent.

CHAPTER III

BACKGROUND

Incineration Facility Design and Cost

This background section is divided into seven parts. These are: incineration facility design practices, design and capital cost of incinerators and pollution control systems, miscellaneous facility components, operating costs, and facility capital costs. Information available was, with a few exceptions, limited to generalized process descriptions. Many important design parameters and cost information are not available. Much information was obtained from on-site visits to operating hazardous waste incineration facilities. This section provides an overview of the information on design of a hazardous waste incineration facility and the alternative data available for the cost estimation of the various process equipment.

Equipment specified for most hazardous incineration facilities are the same, but the actual design of the equipment may be very different. Specifications of the process units are dependent on the waste feed characteristics and the experience of the designer (31). Incineration is ideal for destruction of most chlorinated

wastes, reducing the chlorine content in the ash, and reducing the volume of waste that must be landfilled (16).

Waste Incineration Practices

Process Variables

A list of process variables for incineration considered are:

- 1) Amount of excess air
- 2) Characteristics of waste
- 3) Pretreatment of the waste
- 4) Type of Heating Fuel
- 5) Conditions for Destruction
- 6) Pollution Control

Each parameter will be discussed separately.

Excess Air

Literature sources recommend a range of 25 to 100 percent excess air (depending on the type of waste and type of incinerator selected) (1,32). Much data is available on excess air calculations. If waste feed contains significant amounts of nitrogen, incineration should take place under oxygen starved conditions (pyrolysis). Unfortunately, this risks incomplete combustion of the waste. This is recommended by Powers to prevent the formation of nitrous oxides from the nitrogen in the waste (4). Under starved air conditions, the nitrogen in the waste is converted to molecular nitrogen gas (N_2).

Characteristics of Waste

The characteristics of the waste feed is another important design parameter. Wastes vary widely in composition. Some wastes cannot be properly disposed of by incineration; for example wastes contaminated with heavy metals. A list of waste types, and their proper disposal methods is summarized by Brunner (1). The composition of some common sewage sludges was published by Balakrishnon et. al. (2). The properties of PCB's was published by Sebastian et. al. (33). Many equations are available to predict the heat value of the waste feeds. Two equations which predict the heat value of chlorinated and non-chlorinated hydrocarbon wastes are given below (32). Heat of combustion for waste feed can range from 4000 to 8,000 Btu/lb (2,16). The first equation predicts the lower waste heat value limit and the second equation predicts the upper heat value limit (as defined by Sterns et. al.) (32).

Low Value

$$(Btu/lb) = 14,100*(C) + 45,000*(H - O/8) - 760*(Cl) + 4,500 \quad (1)$$

High Value

$$(Btu/lb) = 14,100*(C) + 54,500*(H - O/8) - 150*(Cl) + 4,500 \quad (2)$$

The variables are expressed in weight fractions of each element (between 0 and 1) of the waste feed volatiles

components. Other equations, used for different types of wastes are available from many sources (2,4).

Pretreatment

Pretreatment is implemented in most waste incineration processes to improve the combustability of the feed. A comprehensive publication on this subject was published by Balakrishnon et. al. (2). Some common methods of waste pretreatment are degritting, blending, and thickening. Some of these methods are not applicable because nothing may be removed from a hazardous waste before incineration. Since nothing may be removed from a hazardous waste feed before incineration, pretreatment processes are limited. The costs of chemical pretreatment (to stabilize the waste) ranges from 15 to 30 U.S. Dollars (1970) per ton of waste according to Balakrishnon (2).

Fuel

Selection of fuel feed and fuel requirements are also discussed by Balakrishnon et. al. (2). Fuel requirements must include the following considerations:

- 1) Vaporize free water
- 2) Heat oxidation products to desired temperature.
- 3) Heat requirements for endothermic reaction of the ash products.
- 4) Heat losses due to radiation.

Selection of the fuel type depends on the cost and availability of the source. Two commonly available fuel sources for the incineration process are fuel oil #2 and natural gas. Combustion properties for both are listed in Table I (35).

TABLE I
COMPOSITION AND HEATING VALUE
OF COMMON INCINERATOR FUELS

Composition (Mole Percent)	Fuel Oil No. 1	Fuel Oil No. 2	Natural Gas
Carbon	86.4	87.3	74.4
Hydrogen	13.6	12.6	25.6
Oxygen	0.01	0.04	0.0
Nitrogen	0.003	0.006	0.0
Sulfur	0.09	0.22	0.0
Ash	<0.01	<0.01	<0.01
Heat of Combustion	137,000 (Btu/lb)	153,000 (Btu/lb)	1,020 (Btu/SCF)

Destruction Conditions

The destruction of these hydrocarbons is recommended to be 99.9999 % (6-nines) (35). The conditions for the destruction of the waste feed are another important design parameter. The temperature of the incineration process depends on the type of waste in question. For some

non-hazardous wastes, the combustor temperature is selected to eliminate the odor emissions (40). Chlorinated hydrocarbons begin to decompose at 500° C (54). The primary incinerator is specified to vaporize the waste feed if an afterburner is also specified. Unburned volatiles from the primary incinerator require the addition of afterburners (40). The concentration of contaminants for the destruction of hydrocarbons are listed in Figure 1 (32). Pressure in the incinerator is usually less than atmospheric (except for fluidized bed) (36).

For the combustion of chlorinated hydrocarbons, Santolari et. al. recommends the following design specifications (16). Chlorinated hydrocarbons require high air rates due to the slow combustion rates. Unfortunately, high air rates promote the formation of molecular chlorine. The amount of free chlorine formed at equilibrium is predicted by the equation below (31):

$$K_p = \frac{(HCl)^2 (O_2)^{0.5}}{(H_2O) (Cl_2)} \quad (3)$$

Here, the variables represent the relative concentrations of products and reactants. This indicates the effects of chlorine formation on the product gas concentration. Values of K_p are available from data published in the literature (5,32). Reduction of molecular chlorine can be accomplished by increasing the temperature of combustion, adding a light solvent, or injecting additional quantities of water to the

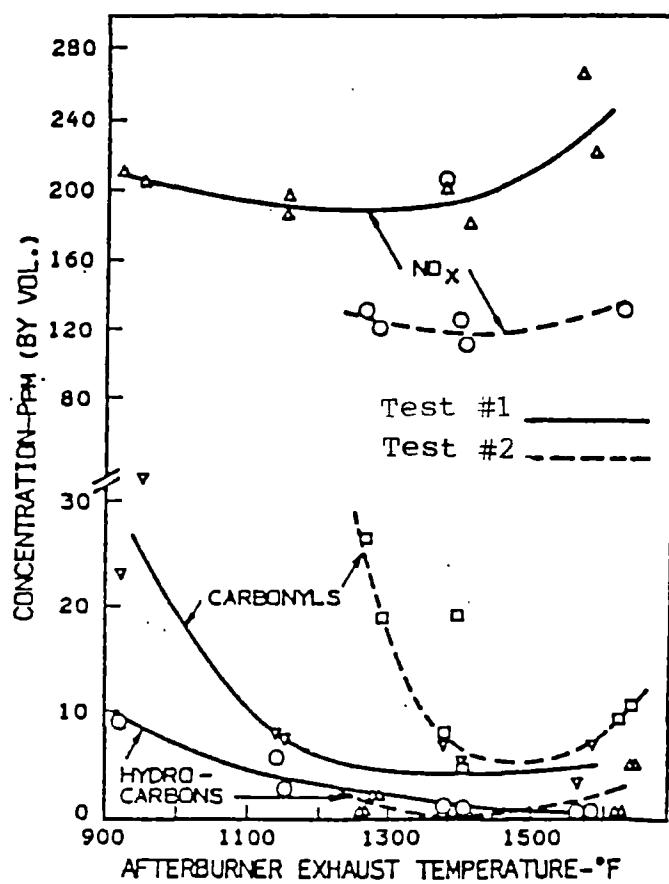


Figure 1. The effluent equilibrium concentration of incinerated hydrocarbons (53).

incinerator. If the waste feed exceeds 54 weight percent chlorine, an additional supply of hydrogen (in the form of a hydrocarbon or water) must be added because there is a lack of hydrogen for hydrogen chloride formation (32).

Selection of the conditions for destruction of the waste must be determined experimentally. Information published in the literature can provide guidelines, but each waste is very different. For the combustion of dioxins, the EPA recommends the following conditions (36):

- 1) For liquids with dioxin concentrations less than 357 ppm in a waste oil, the destruction efficiency of 99.9999 percent requires a primary temperature of 1,800° F and 2,200° F in the afterburner.
- 2) For solids with dioxin concentrations less than 1.01 ppm in a soil, the destruction efficiency of 99.9999 percent requires a primary incinerator temperature of 1,800° F and 2,200° F in the afterburner.

The retention time and heat release rate was not estimated from the source.

A different source suggested the same conditions for destruction of chlorinated hydrocarbons, but with an incinerator retention time of 2 s (11). For most hazardous waste feeds, 1,830° F is required in the afterburner. For chlorinated hydrocarbons, 2,200° F is recommended in the afterburner (11).

Pollution Control

Disposal of the incinerated refuse and exhaust scrubbing water is an important factor that must be considered in the design. Incinerator ash from hazardous waste may still be dangerous. Tests on ash from PCB wastes have indicated trace amounts of PCB's left in the ash (36).

Venturi quench chamber, and absorber waste waters are usually treated by ponding (37). This leaves a polluted, unuseable area. While this is acceptable for non-hazardous wastes, it is not feasible for hazardous wastes.

Particulates may also be separated from the water with a thickener and use of vacuum filtration (or centrifugation) (38). The removed particulates are usually disposed of with the bottom ash from the primary incinerator (37).

The selection and amount of pollution control equipment varies with different locations due to local pollution control regulations. One common requirement is to reduce the exhaust stack opacity to less than 20 % (18). Federal requirements for particulate matter and effluent chemical requirements are covered under Title 40 (12). A list of wastes and their classification is also available under Title 40 (12)

Test methods are available to determine the particulate and chemical emissions from the facility. Particulates emissions exhibit a large variety of particle distribution and chemical composition (37). Equipment used and

experimental methods for stack sampling is discussed in an article by Lindsey (37). Particulate control is dependent on venturi scrubber efficiency (37).

Process Design

From the design practices discussed in the previous section and the physical and chemical characteristics of the waste feed, a selection of equipment and design parameters can be made. This section discusses the information available on the incinerator, pollution control equipment (used in incineration technology), other facility capital costs, and the operating requirements.

Primary Combustors Components and Accessories

Many types of incinerators are available. Some incinerator technologies are not feasible for hazardous waste due to temperature limitations. Of the many types of incinerators, the following are accepted as hazardous incineration alternatives:

- 1) Liquid Injection
- 2) Multiple Hearth
- 3) Rotary Kiln
- 4) Fluidized Bed

These technologies have been proven as accepted methods of hazardous waste destruction (6). A computer program predicting the facility design and cost of a multiple hearth furnace has been published (39). Therefore, this type is

not covered in this paper. The basis for the program is different from this author's approach. Design and cost data used were obtained from total costs of hearth facility for different waste feeds. Design and cost of individual units was not conducted. The program is also not very flexible, but does attempt to account (stoichiometrically) for the endothermic reactions associated with the ash products.

Waste Feed System for Combustors. If the waste is pumpable, burners are implemented most often. Special burners are available for the waste feed systems with placement of the burners based on the waste heat content. If the waste feed has a low heat content, burners are placed counter-current to the waste feed. If high, the burners are placed co-current (40). If the waste is not pumpable, an alternate waste feed system, such as screw pump or a container method must be selected.

Fuel Burner System for Combustors. The fuel burner system is another important design parameter for the incinerator. The size of a fuel burner system is based on the number and capacity of the burners required (9). If the heat content of the waste feed is low (less than 4,000 Btu/lb), two or more fuel burners should be implemented.

Firebrick and Shell. Selection of firebrick and shell is based on the incineration product temperature, chemistry, and volume. The temperature of the incinerator specifies

the type of heat resistant firebrick used and the required thickness. Two types of refractory are available; castable and firebrick. Castable refractory is plastic and may be formed or sprayed on (9,40). More than one type of refractory may be used to line an incinerator (9). Firebrick lining and insulating firebrick is selected to protect the shell from a corrosive environment and high temperatures. Acid resistant firebrick is permeable to corrosive acids. Here, an insulating liner is required to protect the shell from corrosion. Firebrick linings cannot exceed 800 - 900° F. All firebrick are sensitive to temperature shock (4).

Firebrick refractory, high in aluminum oxide , breaks down with exposure to some salts in the ash (40). Manganese oxide firebrick should be used for refractory with high Sodium content (4). High alumina refractory is seldom used with waste high in alkalies or halides (11,16).

Other Combustor Design Considerations. Generally, incinerator design for hazardous waste incineration facility is as follows:

- 1) Minimize auxillary fuel requirements.
- 2) Operate with minimum excess air.
- 3) Produce minimum free chlorine.
- 4) High turbulence to provide efficient combustion.
- 5) Minimize combustion volume.
- 6) Minimize soot formation.

Soot formation can be reduced by not overloading the incineration system. Highly volatile, hard to burn

materials (such as rubber) can overload the system causing incomplete burning (41).

The discussion above included information applicable to all incineration systems. The following section discusses, separately, each option available for the different incinerators.

Combustors

Rotary Kiln Combustor. Rotary kiln incinerators are used mainly to vaporize volatiles in solid wastes (4,40), but the rotary kiln may incinerate liquids or solids. A picture of a rotary kiln is shown in Figure 2 (32). Kiln temperatures are usually based on the heat required to completely vaporize the volatiles within the solids retention time in the incinerator. Destruction of the volatiles takes place primarily in the afterburner (40). Solids retention time is recommended to range from 30 minutes to 1 hour (4). The time is based on the angle of inclination, rotary speed and length. The rotary speed of a rotary kiln is recommended to range from one to five revolutions per minute. For liquid feeds, kiln rotation is not required (4).

Solid waste can be fed by all methods discussed earlier. The feed rate is recommended to be 10 percent of the total volume of incinerator (4,40). If containers are fed, a single unit should not exceed 30 percent of the total volume (42). The volume of a rotary kiln can be sized based on the

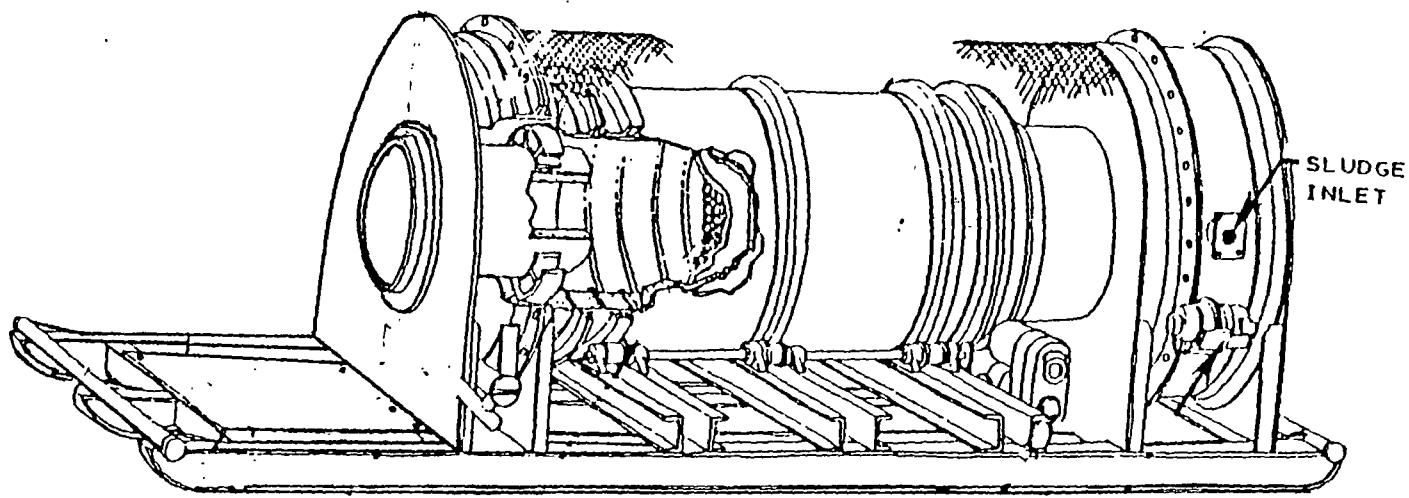


Figure 2. Diagram of an average rotary kiln incinerator for destruction of hazardous wastes (9).

retention time, heat release rate, or container size. If retention time is selected, the dimensions based on the volume rate of the exhaust gas and length to diameter ratio. The heat release rate for a rotary kiln ranges from 25,000 to 40,000 Btu/cubic feet (42). Values of heat release rate as low as 16,000 Btu/cubic feet of combustor volume have been found in literature (42,43). If containers are fed to the rotary kiln, the incinerator volume can be calculated from the relationship in Table II below (42):

TABLE II
CONTAINER SIZE VERSUS CHAMBER SIZE
FOR THE ROTARY KILN INCINERATOR

Container Size (gal)	Heat Release (million Btu/hr)
5	5
15	14
30	30
55	55

The volume of the combustion chamber is calculated based on 16,000 Btu/hour/cubic feet of emission gas (42).

As discussed earlier, temperatures in the kiln are dependent on the characteristics of the waste. Therefore, the temperature to volatize each waste should be determined experimentaly in an incinerator (40). Combustion

temperature in a kiln can reach 3,000° F (4,11), however the outside shell temperature will usually be around 500° F (4). Heat loss for a rotary kiln is reported to be 5 percent of the total heat released (42). Phillips reported heat losses of about 10 percent for a stainless steel shell (43). Heat loss from the ash is negligible (4). This simplifies the heat balance calculations. The dimension of a rotary kiln, in all cases, is based on the length to diameter ratio. For the rotary kiln, the recommended length to diameter ratio ranges from two to ten (4). Most kilns are designed with a ratio of three (11). The average design capacity for kilns is 1,600 lb/hr (6). The kiln is usually operated under a less than atmospheric pressure to prevent gas leaks (6). Air leaking into the system may cause problems, but efficient air seals will reduce the heat losses (43). Rings with wear pads are used most often. These seals reduce air leaks to 10 percent of the original value (4).

Factors that affect the rotary kiln capacity include (4):

- 1) Feed rate
- 2) Temperature
- 3) Excess air
- 4) Rotational speed
- 5) Moisture content
- 6) Preheat combustion air
- 7) Heat leaks
- 8) Instruments to optimize operation

For chlorinated hydrocarbons, materials range from inconel clad stainless steel shell (40) to a carbon steel shell (41).

The major problem with rotary kilns is due to the rotation of the walls. First, brick losses are higher in a kiln than other incineration technologies. Second, mechanical wear from ash may compound the brick loss problem. Third, the sleeve connecting the feed system to the shell may leak significant amounts of air.

Capital costs of rotary kiln incinerators can be estimated by different methods. Most methods available are highly uncertain. Powers estimates the uninstalled cost of rotary kiln to range from 30 to 60 U.S. Dollars (1976) / cubic feet (4). Installed costs are 200 percent of the free on board (fob) costs. Powers also estimates the cost of a municipal incinerator at 10,000 U.S. Dollars (1976) per daily ton of feed. Smaller industrial type kilns cost from 2,500 to 5,000 U.S. Dollars (1976) per daily ton of feed.

A superior method of cost estimation is provided by Vogel et. al. (9). The cost of the system is based on the cost of the incinerator sub-units. The cost of the shell and rotary drive is estimated at 175 U.S. Dollars (1976) per square foot of inside surface area (9). The cost of the drive system alone is based on \$ 100 / square foot of inside surface area. The larger cost includes the rotary drive system and carbon steel shell construction.

Fluidized Bed Combustor. Fluidized bed incinerator technology handles the same variety of wastes as the rotary kiln. Figure 3 shows a fluidized bed incinerator (1). The

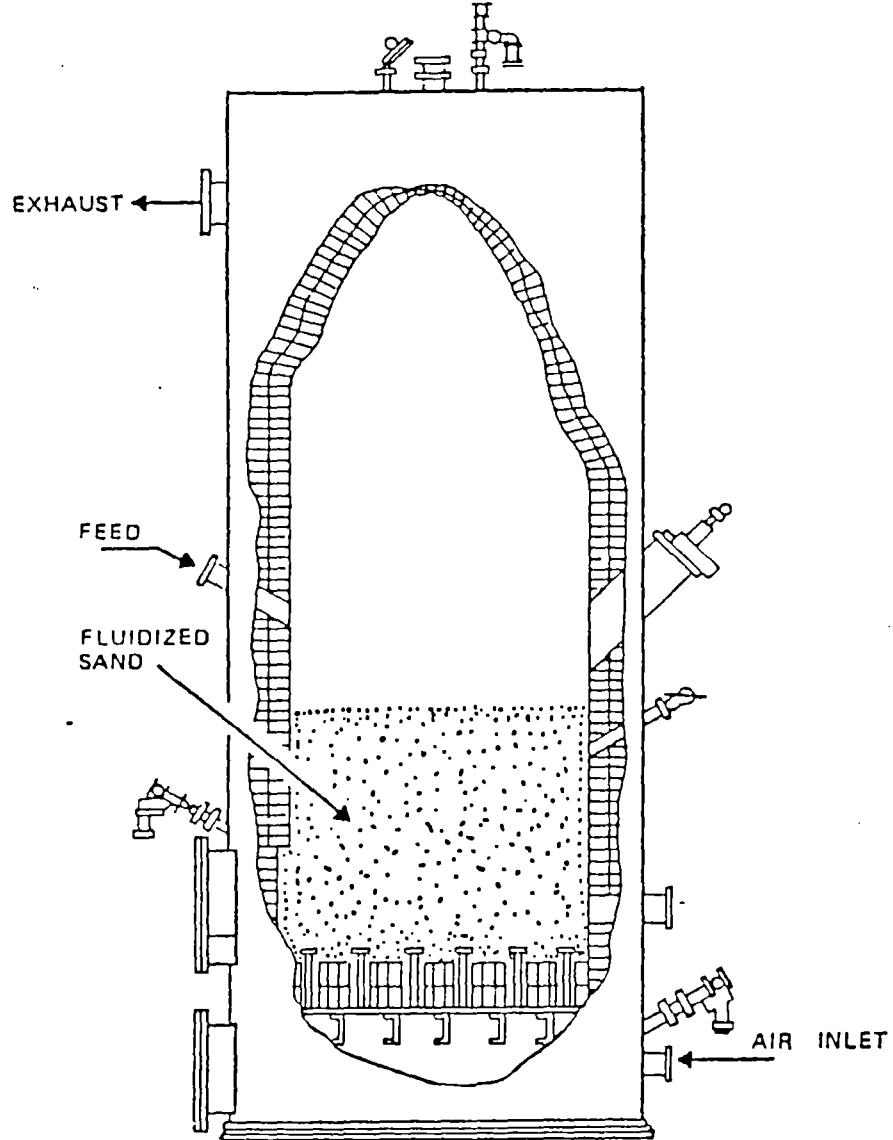


Figure 3. Example of one design
of a fluidized-bed
combustor (6).

factors affecting the combustor performance are listed below (7):

- 1) Diameter
- 2) Height
- 3) Fluidizing air
- 4) Distribution Characteristics
- 5) Method of bed feed
- 6) Location and type of injection mechanism
- 7) Physical and chemical characteristics of the waste
- 8) Operating bed height
- 9) Fluidizing conditions

Factors one to six are fixed parameters that cannot be changed easily. The last four parameters are operating parameters (56). Recommended operating procedures to insure proper incineration are:

- 1) Uniform temperature distribution
- 2) Stable bed fluidization
- 3) Adequate fluidized bed retention time.

The waste is fed from the top into the fluidized bed. The fluidizing media (usually silica sand) is fluidized by an upflow of air supplied from a blower at the bottom (8). The gas/solids mixing in the fluidized bed provides a high degree of turbulence to insure complete volatilization (2). Air is used as the fluidizing gas (8). This type of design allows construction of incinerators with much higher feed rates (designs up to 36,000 lb/hr have been found) (1). This is due to the much smaller length to diameter ratio used as compared to other incineration systems (10). This low ratio reduces the shell and firebrick costs. The length

to diameter ratio ranges from one to two, but complete design information is not available (7,10,43). Diameter of the fluidized bed is based on the superficial velocity (7). A correlation for fluidized bed diameter is not available (7,8), but is based on the amount of ash entrained in the emission gases (7). The height of the bed must be determined experimentally. Correlations for calculation of the height of a fluidized bed are not available. This is a design parameter unique to each waste.

Literature available on fluidized bed heights was found by studying specific examples. The height of the bed serves two purposes. First, the height allows the separation of ash entrained in the emission gases. This height is a function of the particle size, air density, and terminal velocity of ash particles (7). Second, the height provides a reasonable retention time for combustion (57). The efficiency of the fluidized bed allows excess air to be reduced to 20 to 25 % (8). The superficial velocity in the disengaging section of the fluidized bed range from 2.13 to 3.00 feet per second (7).

Conditions for destruction of wastes in fluidized beds are available from literature. An example of the destruction of a specific halogenated hydrocarbon was published by the Union Chemical Company (43). The primary incinerator (fluidized bed) temperature was 1,600 F. The afterburner temperature was 2,000 F. The residence time in the fluidized bed was two seconds. The shell and bed were

constructed of Hastelloy. Destruction efficiency was 99.9 to 99.9999 percent. Because of the lower temperature requirements, flyash and nitrous oxide formation is significantly reduced (2).

Capital cost data on a fluidized bed is almost non-existent in the literature. Cost data is limited to one incomplete source published by Brunner (1).

Liquid Injection Combustors. Liquid injection incinerators can destroy liquid hazardous wastes, but cannot handle solid wastes. The liquid feed is atomized in special waste burners, and this promotes efficient combustion. A diagram of a liquid injection incinerator is shown in Figure 4 (32). The primary design parameters for the liquid injection incinerator are based on the retention time and high turbulence. The average design capacity for a liquid injection incinerator is 1,600 lb/hr (6). Liquid injection incinerators are the most commonly used incinerators today (6). Operating pressure in the incinerator may be positive or negative (6). The length to diameter ratio of a liquid injection unit can range from two to ten (5). Combustion temperature is dependent upon the waste's characteristics. For some, easy to combust wastes, afterburners may not be required. These units can be placed horizontally or vertically (11). Tests published by Balakrishnan et. al. recommend the use of 90 percent alumina firebrick for temperatures between 2,500 to 2,800° F (2).

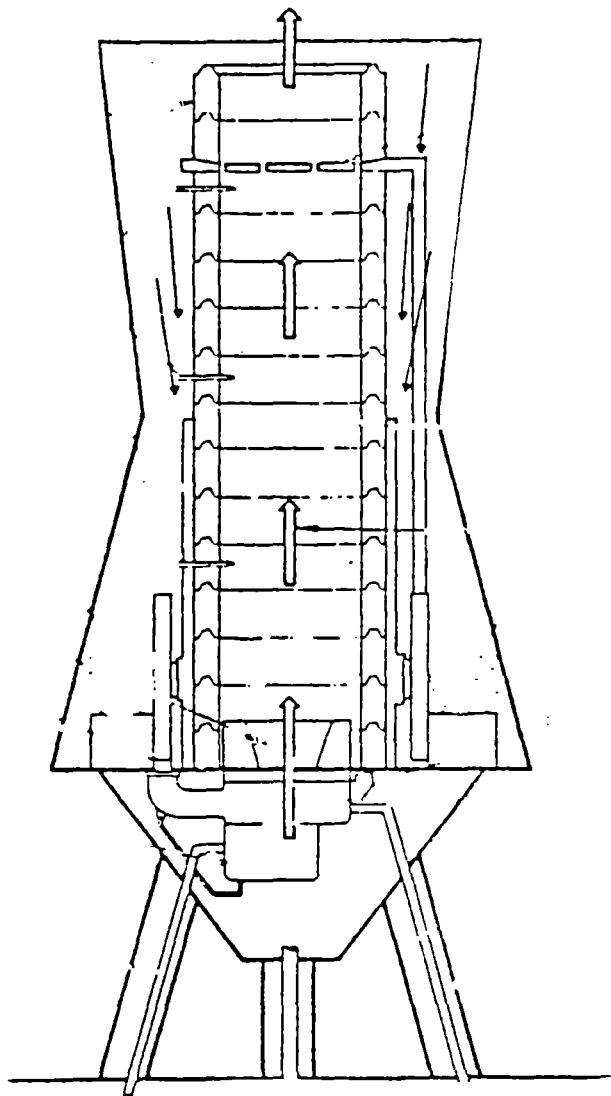


Figure 4. A vertical design of a liquid injection combustor. This type of incinerator may be horizontal or vertical (9).

The capital cost of the liquid injection incinerator is covered in the section on general incinerator design and costs. No ash removal system is required.

Afterburners

Afterburners are implemented after the primary combustor to insure the complete destruction of unburned volatiles released in the primary combustor (4). These units are designed and costed identically to the liquid injection incinerator unit. The pollution control system is specified after the incineration process to remove the chemicals and particulates in the gas stream.

Pollution Control System Design and Cost

This section covers the cost and design data for the pollution control systems. Due to the wide variety of industries requiring pollution control systems, an adequate amount of cost and design data has been published. Selection of the pollution process equipment was based on the equipment commonly used in the incineration industry (40,43). The units considered are:

- Heat Recovery unit
- Quench chamber
- Venturi Scrubber and Separator
- Induction Fan
- Packed Bed Absorber
- Exhaust Stack

Each unit will be discussed separately.

Heat Recovery Unit

Ninety percent of all incinerators are equipped with heat recovery (6). Figure 5 shows a fire-tube boiler for waste heat recovery (21). The design of water-tube or fire-tube boilers is complicated. Therefore, for cost estimation purposes, the design parameters for a heat recovery unit are limited to estimation of heat transfer area. The overall heat transfer coefficient for the boiler can range from two to eight Btu/hr/square foot (36). Implementation of a heat recovery system is limited to a payback period, as mentioned before, of 6.1 years (13). For most wastes, the feed rate must exceed 1,400 lb/hr (13).

Severe corrosion problems arise in the heat recovery boilers due to exposure to acid gases and molecular chlorine (Cl_2) (16). Carbon steel can be used if temperatures in the heat recovery unit are less than 500 °F and greater than the dew-point of the vapor (16). Proper operating parameters include (16):

- 1) Uniform gas temperature entering heat exchanger.
- 2) A high gas velocity to prevent ash build-up.
Recover 70-75 percent of total heat released.
- 3) A gas temperature leaving the boiler should be between 500 and 700 °F.

Implementation of heat recovery units significantly reduces the amount of water required in the quench chamber.

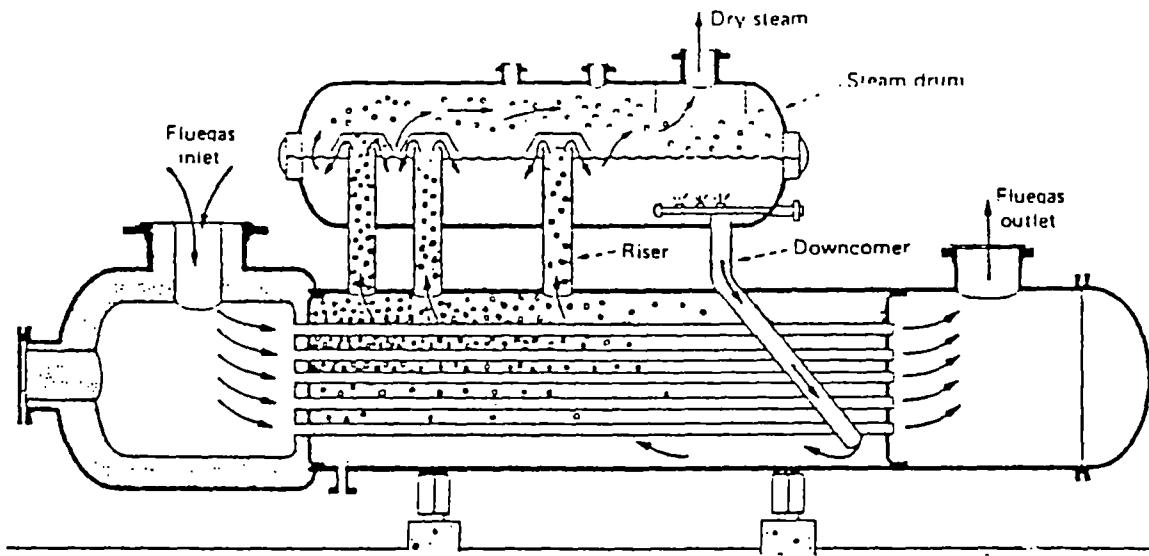


Figure 5. A fire-tube boiler for recovery of waste heat (73).

Quench Chamber

The quench chamber is a pollution control unit which cools the incinerator emissions. This unit is placed after the heat recovery system.

Two types of quench chambers are available depending on the amount of cooling. If the emission gases are cooled to saturation, a quencher should be used. If the outlet temperature is to be controlled, a spray chamber is specified. More controls are required on the spray chamber. The length to diameter ratio and superficial gas velocity and the design parameters affecting the construction of the quench chambers. The length to diameter should be large to promote water gas mixing. The superficial velocity should be low to increase the gas/liquid contacting time.

The materials of construction for a quench chamber are usually of corrosion resistant materials. This is due to the highly corrosive conditions within the quench chamber (17,43). Refractory is installed if temperatures in the chamber exceeds the limits of the shell material (See Table XI). Water requirements for the quench chamber depend on the amount of cooling in the chamber. Quench water requirements can be calculated from an energy balance or estimated by equation 4 below (44):

$$\frac{\text{gallon H}_2\text{O}}{1000 \text{ cubic feet}} = 2.4 * 10^{-3} * T \quad (4)$$

Here, T is the temperature in $^{\circ}\text{F}$.

Venturi Scrubber

Venturi scrubbers are sized to remove particulates from the incinerator gas emission stream. Venturi scrubbers are always accompanied with a gas liquid separator. An example of a venturi scrubber with separator is shown in Figure 6 (4). The parameters that must be identified to design and cost the venturi scrubber/separator system are (18):

Particle size distribution
Particle concentration
Physical properties of particles
Volumetric flow rate

Air pollution control regulations specify the maximum rate of emission, and concentration limit. Scrubbing efficiency is measured by equation 5 below (45):

$$\text{Efficiency (\%)} = \frac{\text{Solids Measured in Effluent}}{\text{Total Solids In}} \quad (5)$$

Parameters that control the collection efficiency in the venturi scrubber are (30):

Gas Velocity
Water Feed Rate
Time Involved in Collection
Pressure Drop

These parameters are directly related to the throat diameter and length (30). Methods are available to optimize the throat length, pressure drop, and particulate removal efficiency (30). The gas phase pressure drop and collection

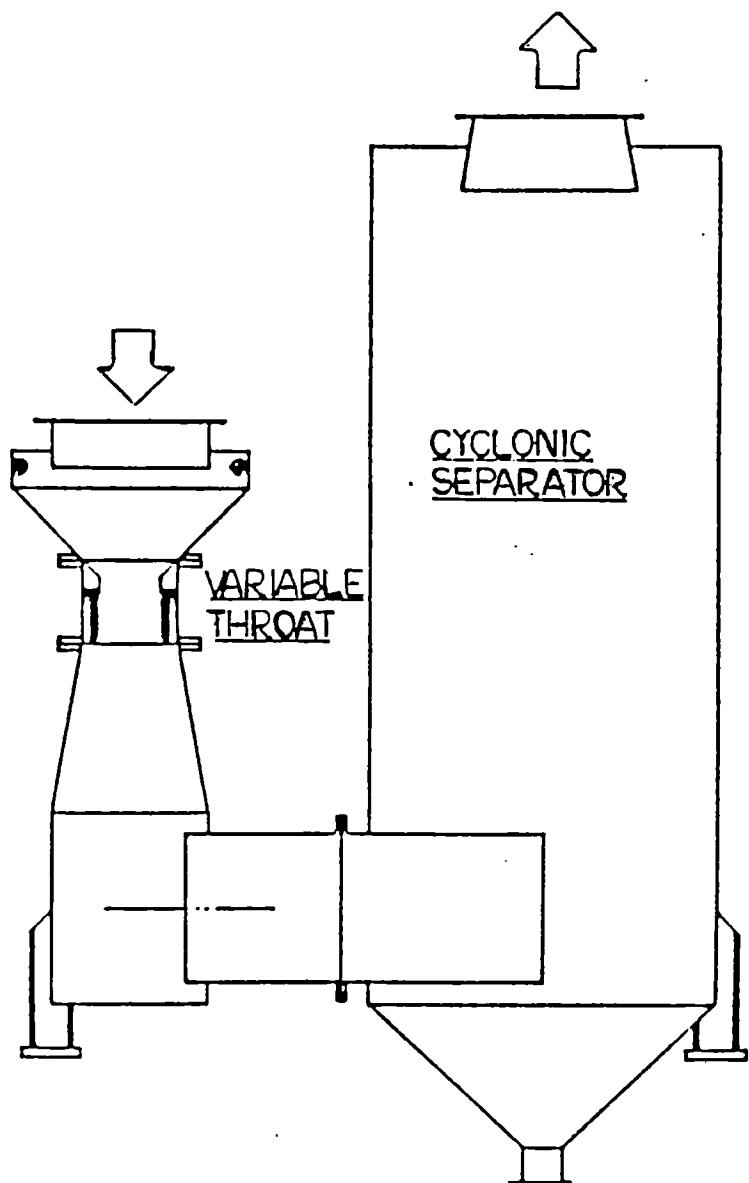


Figure 6. A venturi scrubber and separator for removal of particulates entrained in the gas emissions (52).

efficiency increase with the throat length (30). Generally, the length of the venturi throat should be 3 to 4 times the diameter of the venturi (22,30,46).

Design of a venturi scrubber is dependent on the particulate size distribution, specific gravity of the particulate, and collection curves, as a function of pressure drop. The particulate distribution must be determined experimentally for each waste. Figure 7 represents commonly observed particulate ranges (46).

The collection efficiency can be determined in many methods. The first design method, published by Vatavuk and Neveril, compares the pressure drop to the minimum particle size that is removed 100 percent. This relationship is represented by equation 6 (7,20):

$$P_d = 15.4 * D_p^{-1.39} \quad (6)$$

The pressure drop is expressed in inches of water and particle diameter is measured in microns. The variable P_d is the smallest particle size that is removed completely. The collection efficiency will vary with throat velocity and scrubber liquid flow rate (7). Accuracy of the Vatavuk's method is unknown.

The second method to estimate collection efficiency was published by Calvert (18). Calvert's method determines the cut diameter for a given venturi pressure drop.

Scrubbing water fed to the venturi is an important design parameter. The higher the water rate, the better the

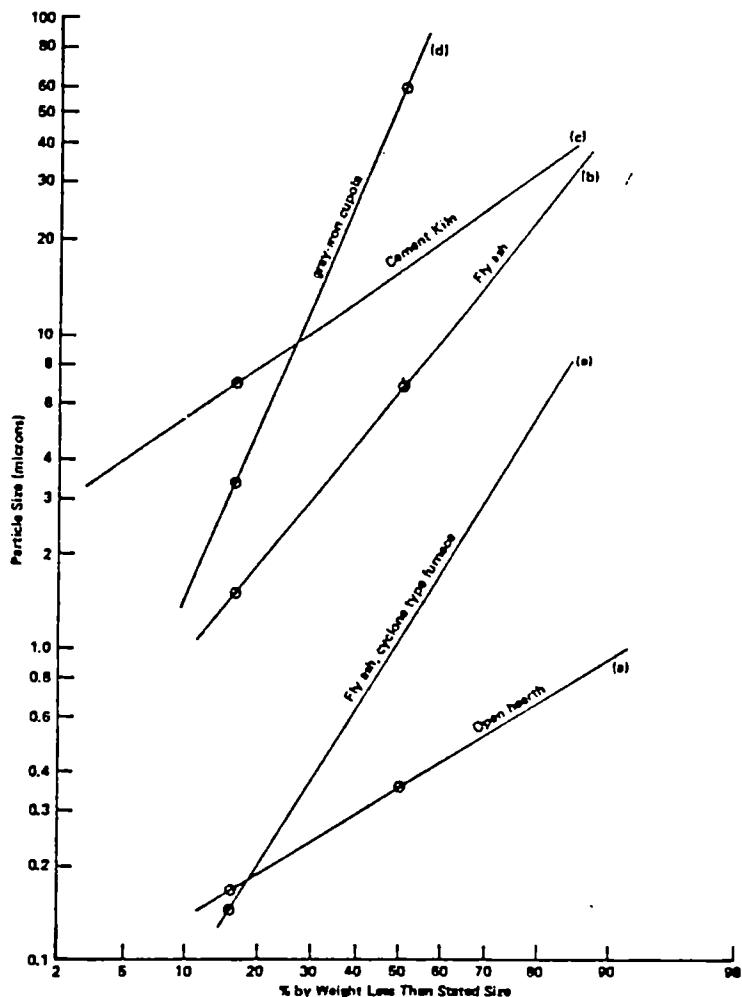


Figure 7. Example of the large range of particulate distributions that may occur from the combustion process (11).

collection efficiency (and greater pressure drop). Liquid rates in the venturi range from 7 to 10 gallons per 1000 cubic feet of gas (46). Liquid rates below 3 gallons per 1000 cubic feet of gas are too low for adequate particulate water contacting. Another source lists a much broader range of 5 to 20 gallons of water per 1000 cubic feet of gas (18). Liquid rates recommended for specific applications range from 8 gallon per 1000 cubic feed (22) to 28 gallon per 10000 cubic feet (30). Sosa et. al. suggest that water rates above 10 gallons per 1000 cubic feet do not improve scrubber performance (18). More information is available in the literature (22). Large liquid to gas ratios reduce the amount of scaling in the venturi scrubber (45).

The throat velocity in the venturi scrubbers is recommended to range from 200 to 400 feet per second (18). Air velocities below 100 feet per second do not produce enough turbulence for efficient particulate removal (22,46).

Venturi scrubbers are also effective in removing acid gases from the gas streams (46).

Water losses depend on the moisture content of the gas entering the scrubber. For high efficiency scrubbing, the gas stream is usually saturated with moisture (4). When humidified, the gas stream becomes corrosive.

Sulfite scaling occurs when the pH of the scrubbing water is not within certain limits. If limestone conditioning is used, the pH should always remain below six. If lime conditioning is used, the pH should remain below nine (45).

Bubbling oxygen in the scrubbing water holding tank can reduce scaling. Addition of magnesium sulfate will depress sulfite saturation levels (45). The scaling control methods discussed above are implemented in the holding tank (40).

The holding tank holds the scrubber water to be recycled. Addition of chemicals can decrease the saturation level of scrubber liquid forming solids (8). The retention time of this tank is five to 15 minutes to reduce saturation (37). To control solids concentration, a supply of seed crystals should be left in the tank. Solids should be no more than five to 15 percent suspended solids (45). Often, the holding tank is located at the bottom of the gas liquid separation chamber (43). Corrosion and scaling can be reduced by spraying the walls of the venturi with water (4).

Packed Bed Scrubber

Packed bed scrubbers are specified to reduce the concentration of caustics in the gas emissions. These units are effective due to the large surface area provided by the packing (21). Like the venturi scrubber, many design methods are available. Important design parameters for packed bed absorbers are (21):

- 1) Height of Packing
- 2) Absorption Characteristics of Caustics
- 3) Inlet/Outlet Caustic Concentration
- 4) Volumetric Flow Rate

All of the methods discussed below are based on these parameters.

Three types of packed absorbers are used in the pollution control industry. These are counter-current, co-current and cross-current (21). Only vertical counter-current absorbers will be discussed, because they are often selected for pollution control. Design recommendations found in the literature include (21):

- 1) Bed packing diameter should be no larger than 1/8 of the absorber diameter.
- 2) Redistributors placed every 10 - 15 feet apart.
- 3) Design for 40 - 70 percent flooding point.

The height of the packed bed can be determined by several methods.

The first method to be discussed is based on the calculation of a mass transfer unit. The height of one transfer unit depends on (21):

- 1) Packing Type
- 2) Relative gas and liquid flow rates
- 3) Concentration and solubility of contaminants

The total number of transfer units required to remove the contaminants may be determined by three methods.

First, the total number of transfer units may be determined from a solubility equilibrium diagram (See Figure 8). The total number is calculated between the operating and equilibrium curves. The total number of

transfer units may also be estimated using equation 7 below (22):

$$N_{eq} = \ln(Y_1/Y_2) \quad (7)$$

In this equation, Y_1 is the inlet gas mole fraction of caustic, and Y_2 is the final gas mole fraction of the caustic. Using this equation, Table III can be calculated to determine the number of transfer units versus scrubbing efficiency (22).

TABLE III
SCRUBBING EFFICIENCY VERSUS NUMBER
OF MASS TRANSFER UNITS

<u>N_{eq}</u>	<u>Scrubbing Efficiency (%)</u>
0.50	39.0
1.00	63.0
2.00	86.5
3.00	95.0
4.0	98.2
5.0	99.3
6.0	99.75

This method assumes a straight vapor/liquid equilibrium curve (See Figure 8). This is an acceptable assumption for the hydrogen chloride absorption.

The second method to calculate the bed height estimates the number of mass transfer units from practices common in

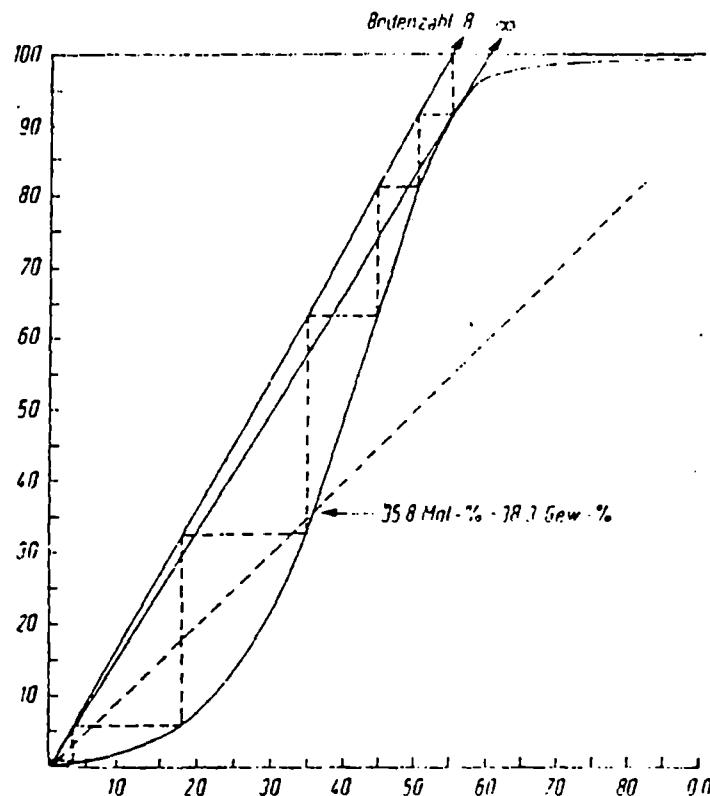


Figure 8. The equilibrium curve for the HCl/water system. The slope of the curve becomes very small as the hydrogen chloride in the liquid approaches zero (84).

the industry (22). For the pollution control industry, data has been published to predict the height of one transfer unit for the vapor/liquid systems with the following characteristics (22):

- 1) Highly soluble gases
- 2) Low soluble gases with reaction in liquid the liquid phase.

Data available for a specific scrubbing efficiency are listed in Table IV.

Absorption characteristics depend on the type of acid gas to be absorbed and the type of relative gas/liquid ratios. This method of bed height calculation presents the effect of the particular gas absorbed. The important physical properties are:

- 1) Viscosity
- 2) Density
- 3) Diffusivity

These properties (and their variation with temperature) can be calculated (22,34). The liquid flow rate recommended for packed bed absorbers ranges from 15 gallon per 1,000 cubic feet for water with caustic to 35 gallon per 1,000 cubic feet for water without caustic (22,40). For hydrogen chloride, the absorption process is effective without added caustic. Effective chlorine absorption requires addition of caustic (22). If hydrogen chloride is removed, Sodium Hypochlorite may form causing scaling problems (22). Caustic added to increase removal of the acid gas may be of

TABLE IV
HEIGHTS OF PACKING (FEET) TO OBTAIN LISTED EFFICIENCY^a

Packing efficiency	Packing size				
	1 in.	1-1/2 in.	2 in.	3 in.	3-1/2 in.
63.2	1	1.25	1.5	2.25	3
77.7	1.5	2	2.25	3.5	4.25
86.5	2	2.5	3	4.5	5.75
90	2.5	3.25	3.75	5.75	7
95	3	3.75	4.5	6.75	8.5
98	4	5	6	9	11.25
99	4.6	5.75	7	10.25	13
99.5	5.25	6.5	8	12	14.75
99.9	7	8.75	10.5	15.75	19.75
99.99	9.25	11.5	14	21	26

^a Restricted to specific applications on highly soluble gases or absorption followed by chemical reaction.

limestone or hydrated lime. To distribute the scrubbing water, solid cone spray nozzles are most often used (40). Unfortunately, these nozzles are prone to clogging if recycled water is used (15).

The diameter of the packed bed scrubber is usually calculated from experimental data. This is important to prevent flooding in the packed bed based on relative water/gas rates. The Lobo correlation (and many others) are used to estimate the diameter of the packed bed at the flooding point (79). The Lobo correlation can be used for many liquid and gas absorption processes (15). The design height can be determined by including a percent flooding factor. Figure 9 represents the data from the Lobo correlation. Equation 8 below also may be used to estimate the flooding point of the absorption process (22).

$$\left(\frac{28.6 \cdot V_f}{D_E l / D_E g} \right)^{1/2} \cdot \left(F \cdot u_l^{0.2} \right)^{1/3} + \left(Q_f / 7.48 l \cdot \left(F \cdot u_l^{0.2} \right) \right)^{1/2} = 18.91 \quad (8)$$

The variables for this equation are described in the list of variables. This equation must be solved by trial and error for the diameter of the bed.

Exhaust Stack

Exhaust stacks are specified to safely release gas emissions to the atmosphere. The design of an exhaust stack is based on the following parameters (26):

- 1) Wind loading
- 2) Seismic Zone
- 3) Soil bearing zone
- 4) Building code requirements

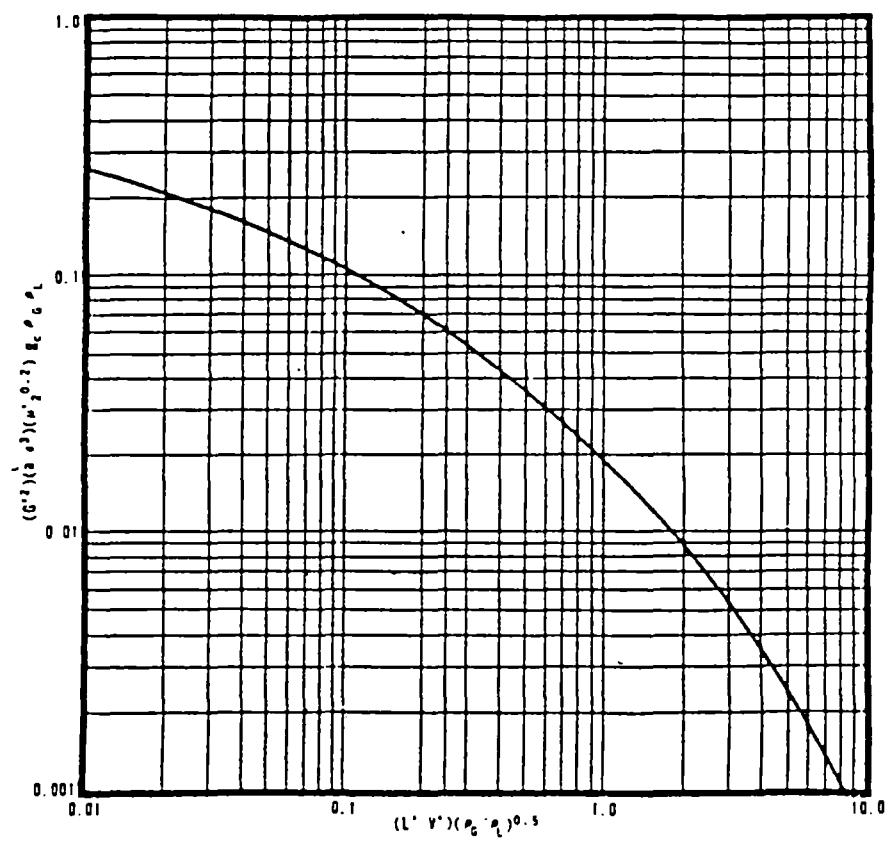


Figure 9. The Lobo correlation for the prediction of packed bed absorber flooding diameter (15).

The height of an exhaust stack is dependent on local regulations where the facility is located (9). The diameter of the stack is based on the expected wind velocity at the site. According to Vatavuk and Neveril, the gas velocity in the exhaust stack should be 1.5 times the expected wind velocity (26). The maximum exit velocity is limited to 9,000 feet per minute (26). Generally, the stack exit velocity should range from 600-3,000 feet per minute (42). The normal dimension of most exhaust stacks range from 15 inches to 9 feet in diameter and from 9 to 200 feet in height (42).

Many cost estimation methods are available in the literature. Major cost effects for the exhaust stacks are:

- 1) Diameter
- 2) Height
- 3) Material of Construction
- 4) Thickness
- 5) Lining materials

Materials of construction for the exhaust stack is usually carbon steel or plastic reinforced fiberglass (23,40). The thickness of the stack materials depends on practices common in industry. Lining is selected if emissions in the stack are reactive with the exhaust stack materials of construction.

One method of installed exhaust stack cost estimation is presented by Lepeau (13). Very little is known about the design parameters. The cost is based on the feed rate (of which 14 percent is non-volatile). The cost is for

installed stacks. The data from this source is represented in Figure 10 (13).

Miscellaneous Capital Cost Data

Along with the design and cost estimation of incinerators and pollution control systems, there are many other factors that must be included. Additional costs for a hazardous waste incineration facility include:

- 1) Waste Storage
- 2) Sitework and Foundations
- 3) Ductwork
- 4) Offices
- 5) Structural Steel
- 6) Certification
- 7) Electrical Materials
- 8) Engineering
- 9) Instruments and Controls
- 10) Waste water treatment system

Each of these cost parameters will be discussed separately.

Unlike the incinerator and pollution control systems, the costs above can be highly variable depending upon the location of the incineration facility site, placement of facility process equipment, selection of custom equipment and other design options that the designer desires to include.

Waste Storage

Storage facilities are required to accumulate enough waste to provide the incineration facility with a dependable, constant supply of feed. Current regulations

Installed Cost of Exhaust Stack

1982 U.S. Dollars

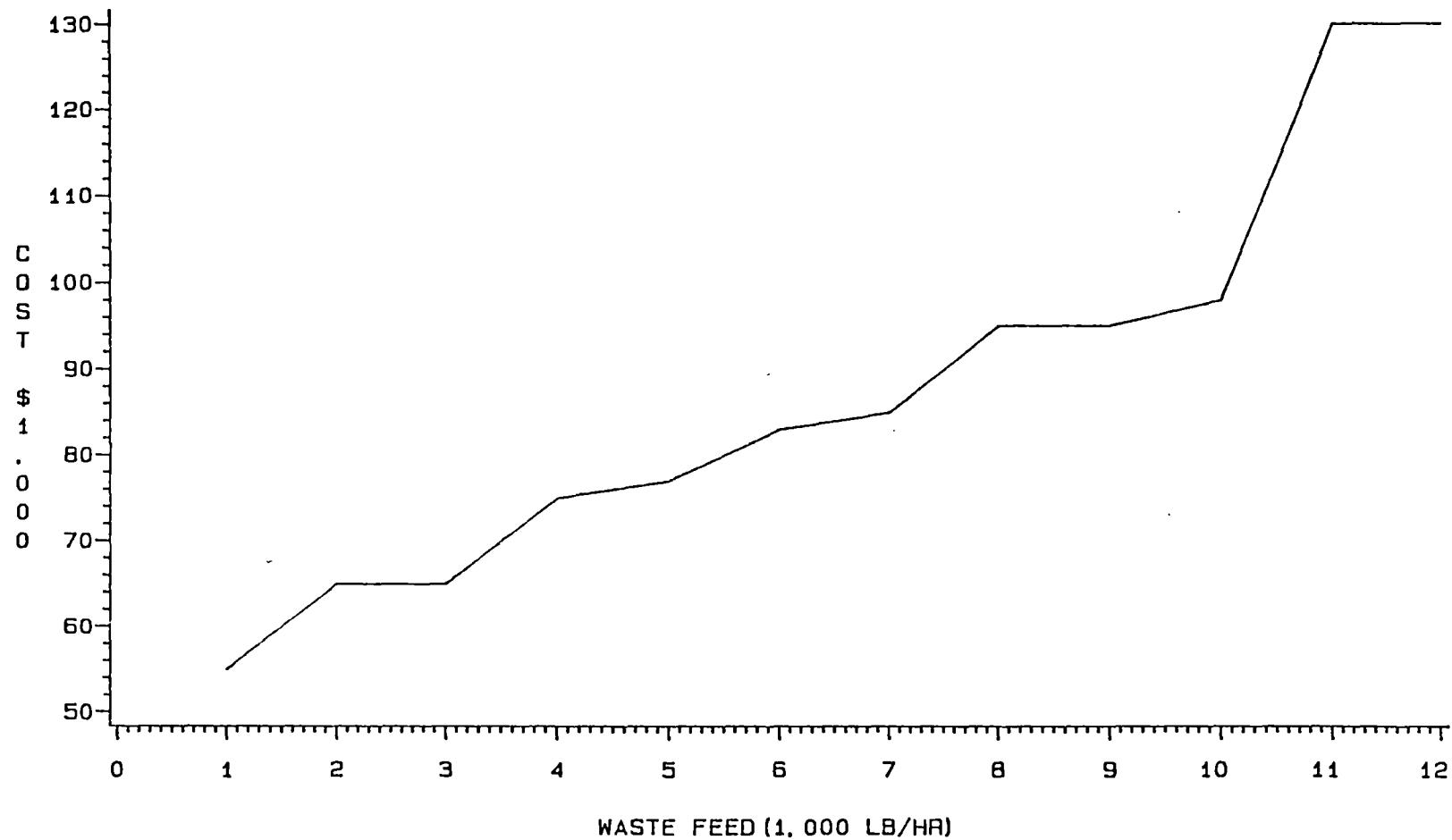


Figure 10. The cost of an installed exhaust stack (18).

limit the on-site storage capacity to a 48 hour supply (12). Of course, off-site storage facilities may also be constructed. Storage for hazardous wastes is generally limited to storage tanks or barrel barns. There are many methods to estimate the cost of storage tanks, but few to calculate the cost of a drum storage site. Each storage facility has special considerations that must be accounted for.

Two pertinent methods of cost estimation were found in literature for storage tanks. The first method was published by Corripio et. al. (15). Using this method, the cost of the tank is estimated in equation 9 (15).

$$C_t = C_b * F_m \quad (9)$$

Here, the variable F_m is a material of construction cost factor (Table V) and C_b is the base cost of the storage tank, as shown below:

TABLE V
STORAGE TANK MATERIALS OF CONSTRUCTION
COST FACTORS

<u>Materials of Construction</u>	<u>Cost Factor (F_m)</u>
Stainless Steel 316	2.7
Stainless Steel 304	2.4
Nickel	3.5
Inconel	3.8
Brick-and-Rubber-lined	2.75
Steel	
Brick-and-Rubber-lined	2.75
Steel	

Rubber lined Steel	1.9
Concrete	0.55

The material is specified by the user. The variable Cb is estimated for shop fabricated tanks from equation 10 and field erected units are estimated by equation 11 below (15):

$$Cb = \text{EXP} (2.331 + 1.3673 * (\ln(V) - 0.06309 * (\ln(V))^2.0)) \quad (10)$$

$$Cb = \text{EXP} (11.362 - 0.6104 * \ln(V) - 0.04536 * \ln(V)^2.0) \quad (11)$$

In this equation, the variable V is in gallons and the cost is calculated to January 1979. The error in the cost is estimated at 30 percent. Capacity of fabricated storage tanks range from 1,300 gallons to 21,000 gallons. For the field erected tanks, the volume (V) ranges from 21,000 to 11,000,000 gallons. These costs from equations 10 and 11 also include a 20 percent overcapacity factor (15). This cost does not include other accessories required for hazardous waste storage.

The second method of storage tank cost estimation was published by Vogel and Martin (9). While this method is less flexible (sizes tanks for 5,000, 10,000, and 25,000 gallons only) the estimation method is for storage of hazardous wastes and includes all of the accessories required. Other, special equipment can also be cost estimated from this source.

Sitework and Foundations

Cost estimation of sitework and foundations is highly variable. Costs for sitework may vary by 200 percent depending on the location (13,42). According to Vogel and Martin, the amount of land required is less than 10,000 square feet (without storage facility) (42).

Lepeau published cost data for sitework. This data is presented in Figure 11 (13). The cost is for non-hazardous waste incineration. From information published by Vatavuk and Neveril, Lepeau's values should be doubled for hazardous waste incineration processes (29).

A second method for sitework and foundation costs for hazardous waste incineration facilities was presented by Vogel and Martin (14). From this method, site preparation is estimated at 7 percent of the process equipment costs. Cost to bring utilities to the incineration site and for hook-up is estimated at 10 percent of the total equipment costs. Again, these costs may vary by 200 percent based on facility location (29).

Instruments and Controls

The cost of instruments for hazardous waste incineration facilities is highly variable depending upon many factors. Legal requirements specify what instruments should be used (6). Unfortunately, there is little uniformity in the industry about placement. Most cost estimation methods

estimate instruments with cost factors (used with the total equipment cost). Vogel and Martin recommended a cost factor of 20 percent of equipment cost for instruments and controls. This factor is for hazardous waste incineration facilities.

Lepeau published data for instrumentation and controls costs for non-hazardous waste incineration facilities. This cost data is presented in Figure 11 (13). Cost of instruments for hazardous waste incineration is much higher, but the extra equipment can be identified. Instruments and controls required for incineration process are (40,43):

- 1) Shielded thermocouples
- 2) Pressure monitoring taps
- 3) Flame detectors
- 4) Exhaust stack monitoring system
- 5) pH monitoring system

Most of the equipment is standard to all incineration facilities. The exhaust monitoring system between hazardous and non-hazardous incineration is the greatest difference.

Hazardous waste incineration facilities require a continuous stack monitoring system. This costs about 15,000 1985 U.S. Dollars (43) per each gas recording. Carbon monoxide and oxygen are generally monitored on a continuous basis. A gas chromatograph may also be selected to determine chemical emissions. These units cost about 64,000 U.S. Dollars (1983) and two units are usually specified (43). This includes equipment cost and installation.

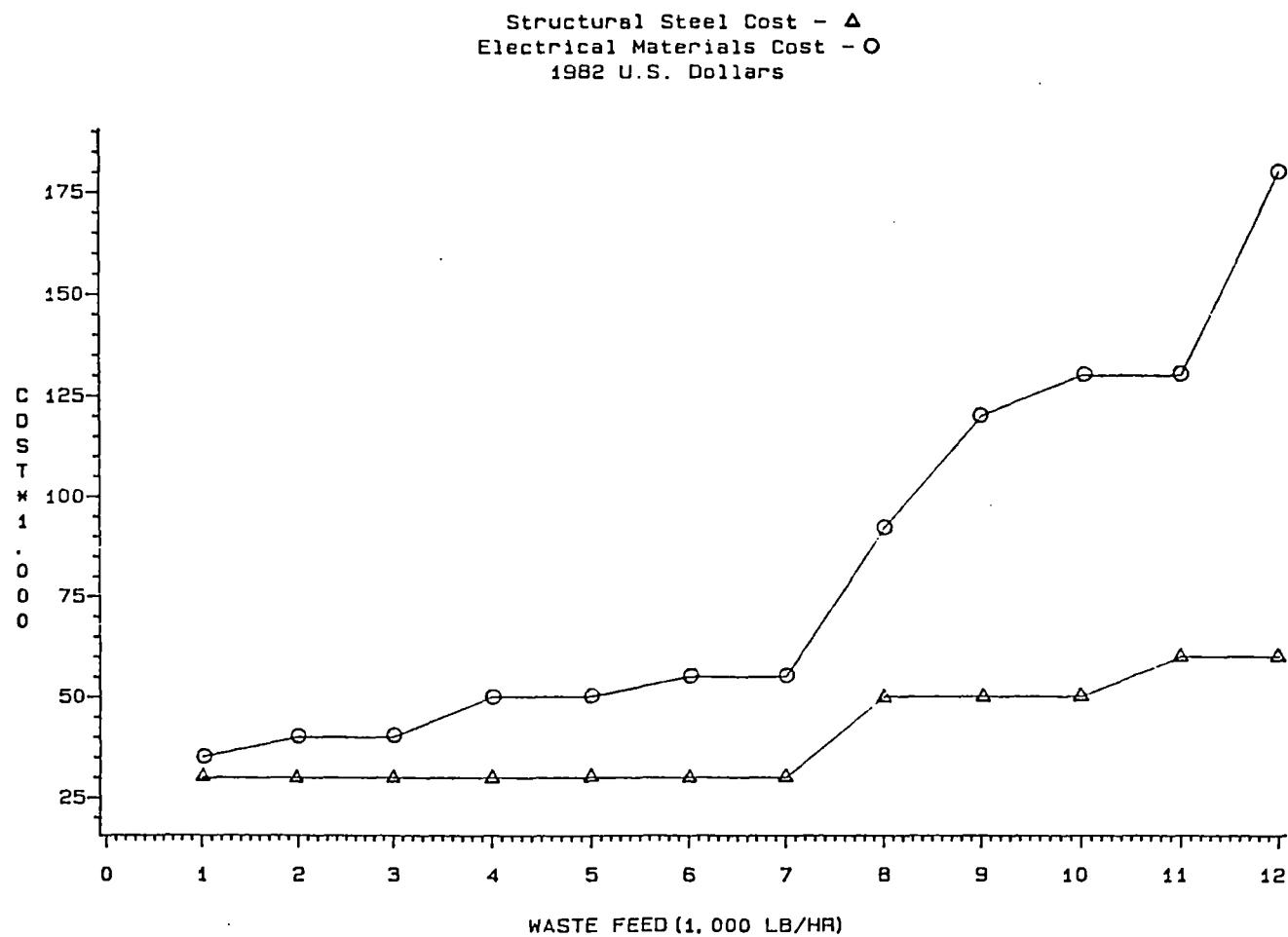


Figure 11. The cost of structural steel and electrical materials for non-hazardous waste incineration facilities (18).

Operations Building and Offices

The cost estimation of offices and operations building is highly variable depending on the designer and location. Building construction can range from simple weather enclosures with utilites, road, and fencing to a complex building with laboratories, heating, sanitation, offices and truck depot (29). Building costs associated with these facilities may vary by 200 percent (29). Lapeau has published cost estimates for a prefabricated steel building. This cost data is presented in Figure 11 (13). Other cost data for building costs is available, but the data was not useable (39).

Ductwork

Ductwork is specified for connecting the incineration and pollution control system process units. Much data is available in literature on this subject (14,24). Vogel and Margin published cost data for installed ductwork. Unfortunately, this cost data is not adequately described to be of any use. Vatavuk and Neveril presented a more detailed method for cost estimation of ductwork. Selection of ductwork is based on the following parameters:

- 1) Dust loading
- 2) Gas temperature
- 3) Corrosive nature of gas emissions
- 4) Number of bends and joints

The three basic types of ductwork are water-cooled, refractory lined, stainless steel and carbon steel. Carbon steel ductwork (without refractory) is specified for non-corrosive environments and gas temperatures below 1,150° F. With refractory lined carbon steel breeching, the wall temperature is limited to 800° F. Stainless steel ductwork (unlined) is limited to temperatures below 1,500° F. Wall temperature for refractory lined stainless steel ductwork should not exceed 1,200° F. Water-cooled ductwork is generally specified at temperatures above 1,500° F. Selection of water-cooled ductwork is unlikely for hazardous waste facilities due to the high cost. Therefore, this method will not be discussed further.

Calculations of the the diameter of ductwork is based on the dust loading. Gas velocities in ductwork can range from 2,000 feet per minute (for light dust loading) to 9,000 feet per minute (for heavy dust loading) (26).

Specification of the materials of construction for ductwork is also affected by the corrosive nature of the incinerated gas emissions. For destruction of chlorinated hydrocarbons, specification of unlined carbon steel ductwork is not recommended (43). Lined carbon steel ductwork has been shown to withstand chlorinated hydrocarbon incineration products (40). Specification of an inconel-clad-stainless steel is also an effective combination (43). Cost factors for inconel-clad- stainless steel is estimated at 3.3 times the cost of carbon steel ductwork (9).

Certification and Engineering

The cost of certification and engineering is different for each incineration design. Each facility has different problems based on local requirements and other unexpected factors. Certification for incineration of hazardous wastes is estimated at 10 percent of the capital cost by Vogel and Neveril (14). Certification costs were also obtained from Zinc (40). Three tests were usually required for certification. Each certification test costs around 22,000 (U.S. Dollars 1986) and lasts for 24 hours. Additionally, one test lasting 48 to 100 hours is also required and costs about 120,000 U.S. Dollars 1986. This includes all costs required to start-up and operate the incinerator for the required time to insure adequate destruction of a waste (40). The incinerator must be certified for each new waste that is burned(40).

The costs required to engineer an incineration facility is estimated at 4 to 7 percent of the design and an additional 4 to 7 percent for start-up and shakedown (1,14). An equation published by Unterburg et. al. estimates the engineering costs as:

$$\text{Cost} = 0.5 \times e^{[CC]^{0.846}} \quad (12)$$

The error in the equation is unknown, but it is recommended for capital costs ranging from 10,000 1969 U.S. Dollars to 5 million 1969 U.S. Dollars (1971) (39).

Structural Steel and Electrical Materials

Cost data for structural steel and electrical materials for hazardous waste incineration facilities were published by Lepeau (13). This data is for non-hazardous incineration facilities. The cost data from this source is presented in Figure 12 (13). Vogel and Martin presented factors for estimation of electrical materials at 20 percent of the total facility equipment cost (28).

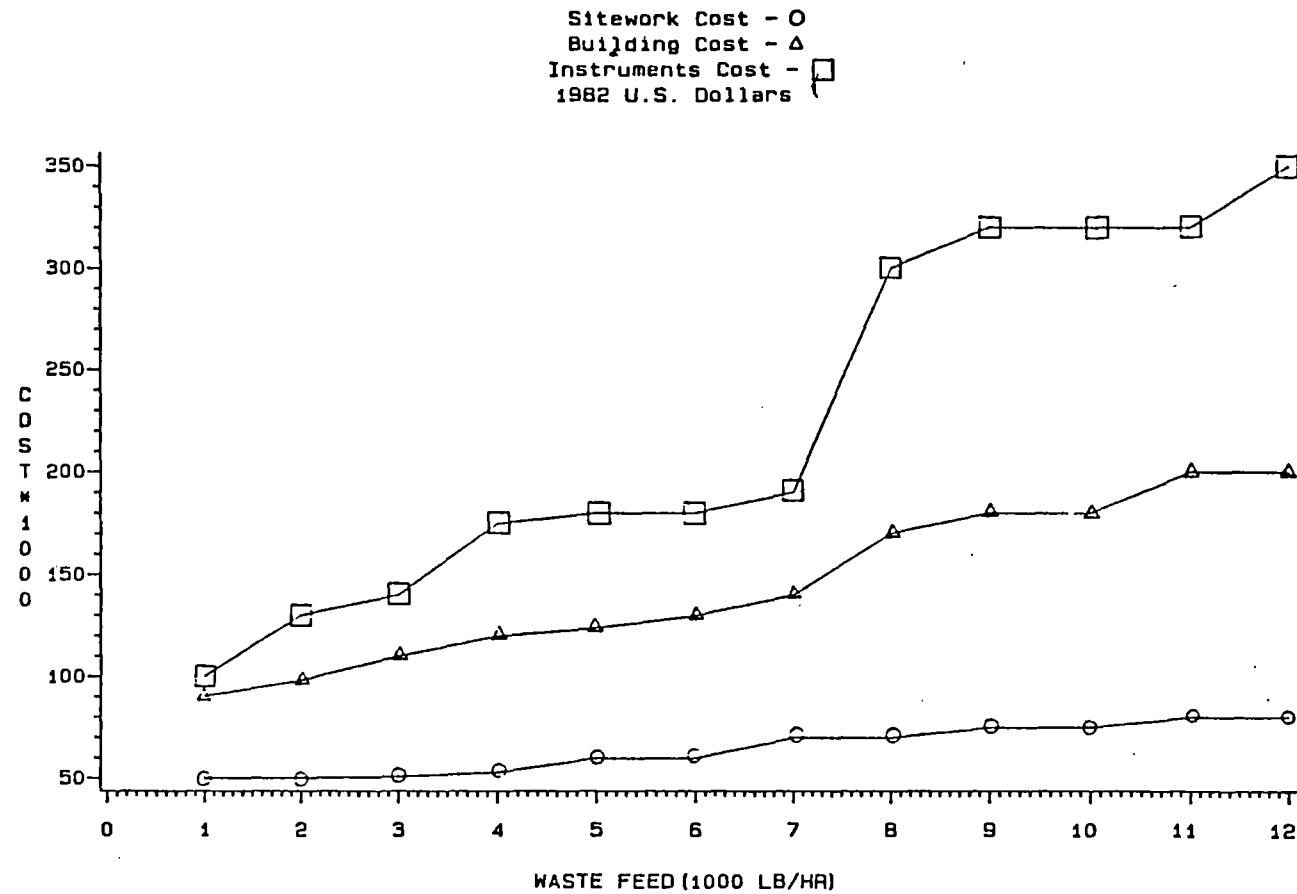


Figure 12. The cost of sitework, buildings, and instrument for non-hazardous waste incineration facilities (18).

CHAPTER IV

COMPUTER PROGRAM DESIGN AND COST ESTIMATION

Though spread widely in the literature, information has been published to adequately design and cost hazardous waste incineration facilities. A computer program is the ideal method in which to design and cost estimate a hazardous waste facility, based on the physical and chemical characteristics of the waste feed, as well as to meet the different standards that each area of the country requires. Any design must allow for a selection of a variety of individual pollution control units.

While the equipment used for incineration and pollution control is the same, the actual shape and cost are different from vendor to vendor. Figure 13 represents an example of a flow diagram for the incineration process. There are some methods to reduce the amount of materials required for the capital costs, but the final facility cost does not change significantly. Below is a description of the work included in the computer program HWSTBRN. The discussion is divided under each different process unit. Operating costs specific to each unit are also presented. Operating costs common to all units (such as maintenance) are discussed separately.

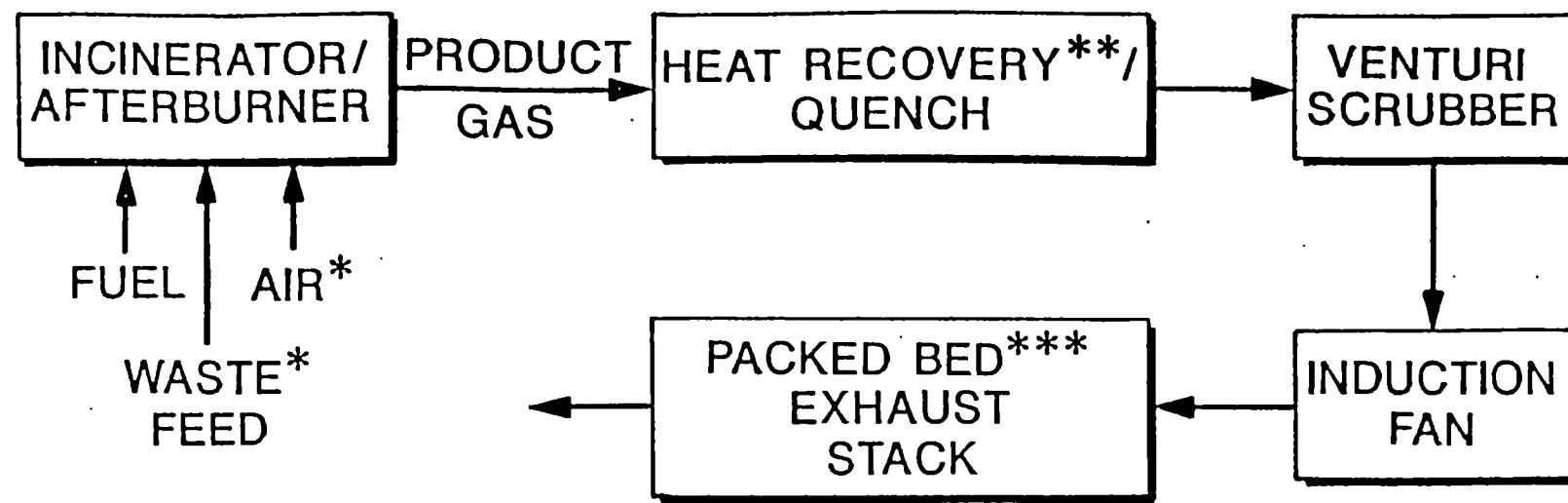


Figure 13. An example of a process flow diagram for a hazardous waste incineration facility.

Incinerators

Primary Combustor

The design and cost estimation of the primary incinerator is based on the heat release rate for solid wastes or retention time for liquid waste. These are both options that are selected by the user. The dimensions of the incinerator depend on the unit selected.

Retention Time. For PCB's, equation 13 can be used to estimate the retention time required to destroy PCBs to 99.9999 percent (6-9's) (32).

$$t = 3600 / (Q_r * TCP * (1+EA/100) * (T_f + T_e)/1040) \quad (13)$$

Definitions of the variables and their units are included on page viii. The retention time can also be specified by the user.

Fuel and Waste Burner System. To determine the amount of fuel required to reach the destruction temperature, combined mass and energy balances are solved. These balances are solved in a specific order (See page 140). These equations are solved by interval halving method for fuel. The balance of products from reactants is solved directly (for a given amount of fuel) by a simple stoichiometric balance for an ideal (100 %) combustion.

The design and cost of an incinerator is based on the following:

- 1) Fuel Burner System
- 2) Waste Feed System
- 3) Refractory and Shell
- 4) Ash Removal System
- 5) Special Equipment

These characteristics are common to all incineration systems. Special costs pertaining to individual types will be discussed under each section.

The cost of a fuel burner system is listed below in Table VI (9):

TABLE VI
COST OF INCINERATOR FUEL BURNER SYSTEM

<u>Burner Heat</u> <u>(Million Btu/hr)</u>	<u>Burner Cost</u> <u>(1981 Dollars)</u>
0.20 - 1.5	1,200 /burner
5.0	5,000 /burner
10.0	8,000 /burner

The equipment for the larger burner systems include:

- 1) Combustion Air Blower
- 2) Ductwork
- 3) Windbox
- 4) Valve Trains
- 5) Refractory Tile
- 6) Combustion Control System,
- 7) Flame Protection System

The method of waste feed depends on the type of waste and storage method. Three methods are available for waste feeding. This is selected by the user. The cost of a burner system was published by Vogel (9,18). The cost includes:

- 1) Air blower
- 2) Ductwork
- 3) Windbox
- 4) Valve trains
- 5) Refractory Tile
- 6) Combustion Control System
- 7) Flame Protection Devices

The cost of the waste burner system is represented by equation 14 (9).

$$1981 \text{ Cost} = 2727 * \text{HR} + 4545 \quad (14)$$

In this equation, the variable HR is the waste heat release rate in millions of Btu's. The cost of the waste burner system is referenced to January 1981 (9).

Other Waste Feed Systems. The second option for liquid waste feed is by containers. If the container capacity ranges from 5 to 30 gallons, hydraulic rams are usually specified. The cost of the rams (1981) is based on the total heat input (Btu/hr) (9). The cost of a ram system is listed in equation 15 (9).

$$1981 \text{ Cost} = 2727 * \text{HR} + 4545 \quad (15)$$

In this equation, the variable HR is the waste heat release rate in millions of Btu's. Feed systems for 55 gallon drums require special systems.

For 55 gallon drum feed systems, the cost is listed below in Table VII (9):

TABLE VII
COST OF 55-GALLON DRUM FEED SYSTEM

<u>U.S. Dollars(1981)</u>	<u>Heat Release(Btu/hr)</u>
175,000	60 - 70
300,000	> 90

To incinerate containerized waste, each container should be less than 10 percent of the total incineration volume (40). This system may be loaded manually or used with a cart system (9). A cart loading system includes:

- 1) 25 carts (2 - 3 cubic yards each)
- 2) Each cart handles 1,150 lb waste)

The cost of the cart loading system is 26,000 U.S. Dollars (1981) for a process with less than 40 million Btu/hr (9).

Another method to feed waste to an incinerator is a screw feed system. Information on this system is provided by Vogel (9). This cost includes (9):

- 1) 5 ft of screw conveyor
- 2) Trough
- 3) Feed Hopper
- 4) Drive Motor

Equipment cost is based on the screw length for a specific diameter (38). is listed in equations 16 and 17 (38).

$$(1978 \text{ Cost}) = 632.5 + 66 * L \quad 9 \text{ inch screw (16)}$$
$$(1978 \text{ Cost}) = 747.5 + 67.8 * L \quad 12 \text{ inch screw (17)}$$

These feed systems are often implemented in a fluidized bed combustor.

Firebrick and Shell. The cost of firebrick is also based on the waste characteristics. Data available are listed in Table XVI. Insulation firebrick is one inch for 2,000[°]F to four inches at 2,500[°]F. Refractory insulation ranges from four inches thick at 2,000[°]F to 12 inches at 2,500[°]F (28). Refractory thickness can also be estimated from thermal conductivity values of the refractories.

Shell cost data applies for a carbon steel shell Materials of construction are the same as the other incinerator types. This cost is estimated at 75 U.S. Dollars (1984)/square foot of surface area of shell (9). Cost factors that adjust the cost for different materials of construction and are listed in Table VIII (26).

TABLE VIII
COST FACTORS FOR SHELL MATERIALS

<u>Stainless Steel (316)</u>	-	2.7
<u>High Nickel Alloy</u>	-	3.5
<u>Monel</u>	-	3.3

These cost factors are applied to the cost of a carbon steel shell. Exact shell cost depends on the dimensions of the incinerator selected. These design parameters are discussed in each section.

Rotary Kiln Combustor. The dimensions of the rotary kiln are based on the retention time and length to diameter ratio. For the rotary kiln, the drive assembly cost is based on \$100/ square feet of surface area (9). Installation cost is 200 percent of the equipment cost (9).

Fluidized Bed Combustor. The diameter of the fluidized is based on information on common industry practice (See Table IX) (2).

TABLE IX
DIAMETER OF FLUIDIZED BED INCINERATORS BASED
ON THE MOISTURE EVAPORATION RATE

<u>Diameter(Feet)</u>	<u>Hot Air(lb/hour)</u>	<u>Cold Air(lb/hour)</u>
9	2,800	2,240
10	3,470	2,770

11	4,200	3,350
12	4,950	3,940
13	5,800	4,620
14	6,750	5,350
15	7,750	6,150
16	8,760	7,000
17	9,900	7,900
18	11,100	8,700
19	12,350	9,750
20	13,600	10,600
21	15,100	11,900
22	16,550	13,100
23	18,100	14,300
24	19,700	15,500
25	21,400	16,800

This is applicable if the water content of the waste is greater than 70 percent. If the water content is less than 70 percent, the diameter of the fluidized bed is calculated using the data in Table X (8).

TABLE X
DIAMETER OF FLUIDIZED BED INCINERATORS
BASED ON THE HEAT RELEASE RATE

Diameter(Feet)	Hot Air(Btu/hour)
10	9.6 million
14	18.9
18	31.3
22	46.7
25	60.3
28	75.7

The sizing method is selected by the user. The length to diameter ratio of a fluidized bed can range from 1 to 2. This is selected by the user based on ash characteristics (entrainment of particulates with the incinerated emissions). Cost of the shell, firebrick, and waste feed systems are the same as for the rotary kiln and liquid injection. Extra costs include the oversized air compressor and water cooled grid (made of carbon or stainless steel) to support the fluidizing media. Costs are not available for these grids, but can be estimated from valve or sieve trays used with tray absorption towers (47). These cost data are presented in Figure 14 and 15. Cost factors for shell materials are listed in Table VIII. Installation cost of the fluidized bed is estimated at 100 percent of equipment cost.

Liquid Injection Combustor. If the waste feed is pumpable, liquid injection incinerator may be selected. The dimensions of the unit are based on retention time and length to diameter ratio (between 2 and 10). The design and cost method is the same as the rotary kiln.

Afterburners

The design and cost estimation of afterburners is similar to the primary liquid injection incinerator. Length to diameter ratio and the retention time are specified by the user and is high to promote turbulence. The mass and energy

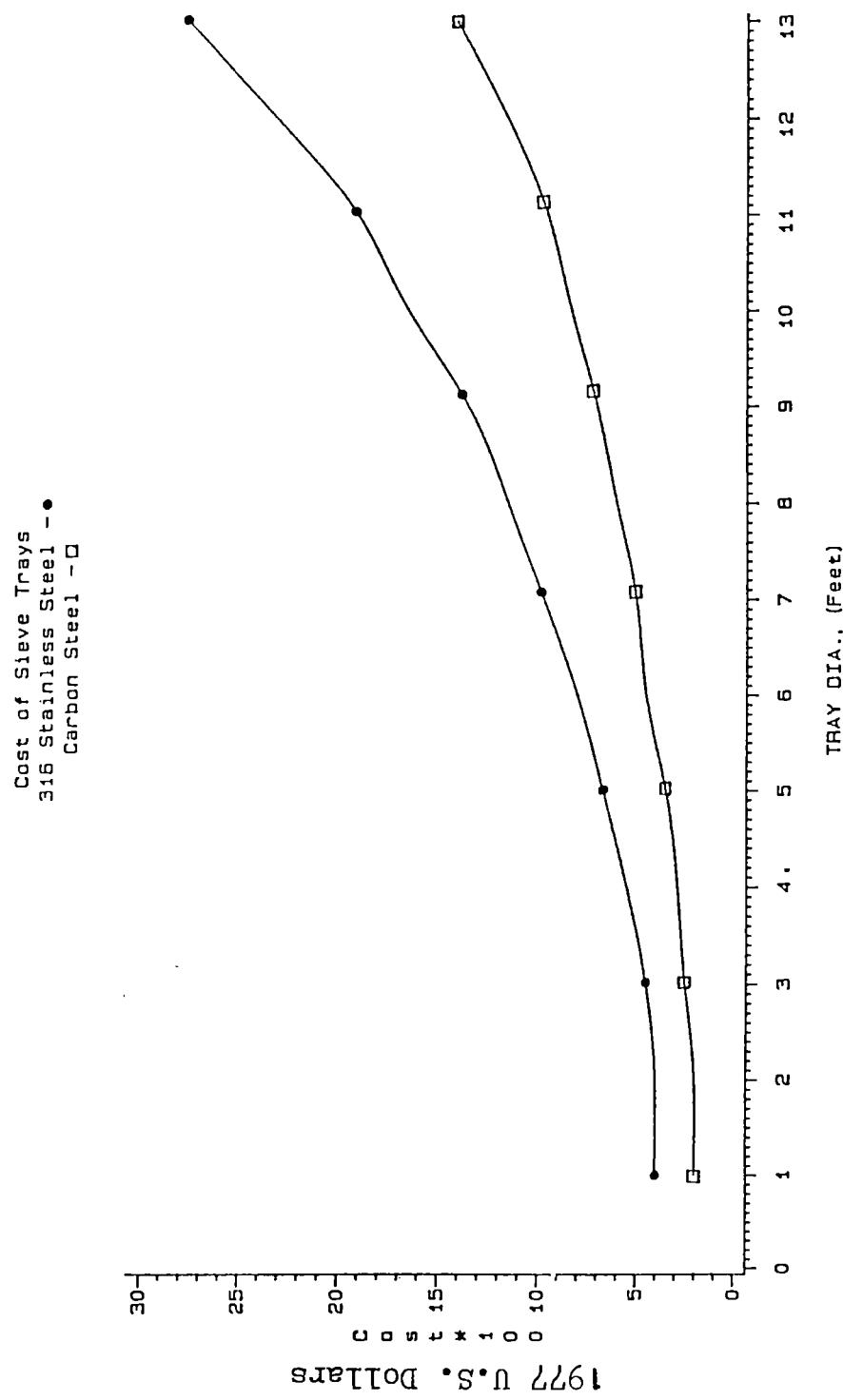


Figure 14. The cost of carbon steel and stainless steel sieve trays (18).

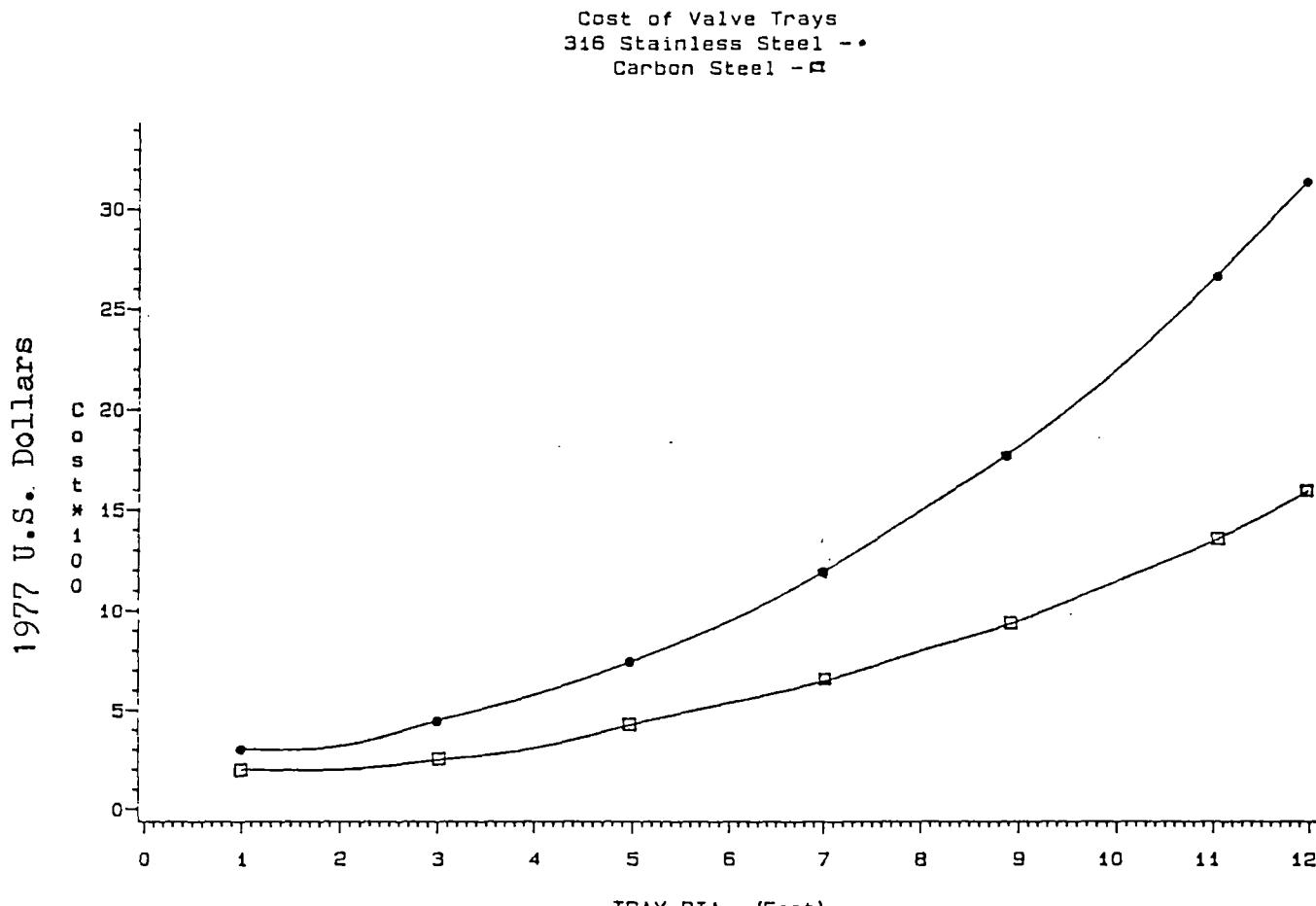


Figure 15. The cost of carbon steel and stainless steel valve trays (18).

balance based on added fuel is solved to determine fuel requirements to reach the afterburner temperature. The cost method for shell, firebrick, burners and installation is the same for the primary liquid injection incinerator. Materials of construction and installation are also the same as for the primary liquid injection incinerator.

Computer Design and Cost of
Pollution Control Systems

Quench Chamber

The quench chamber is designed to cool the gas to provide effective downstream pollution control processes and specify less expensive materials of construction. Two types of quench chambers are available for selection. A quencher is selected to cool the emissions to its saturation temperature. A spray chamber can be selected if a specific outlet temperature is required. The quench chamber is lined with firebrick if the gas temperature is greater than materials (specified by the user) can withstand (See Table VIII).

The length to diameter ratio of the venturi scrubber or spray chamber is set at three. The superficial velocity is the chamber is set at 10 feet per second (17). Cost of the quencher is represented by equation 18 and the cost of the spray chamber is represented by equation 19 below (17):

$$\begin{aligned} \text{Quencher} & - (1977 \text{ Cost}) = 0.22 * V_m + 8,000 & (18) \\ \text{Spray} & - (1977 \text{ Cost}) = 0.235 * V_m + 43,000 & (19) \end{aligned}$$

Here the variable V is in cubic feet per minute. These costs include the cost of the vessel, support rings, platform ladders, grating, spray system and controls. The cost does not include refractory, piping and installation (17). The costs of these accessories are the same as for the combustors. Materials of construction cost factors are listed in Table VIII. Selection of conditions for firebrick specifications depends on materials of construction listed in Table XI (26).

TABLE XI

MATERIALS OF CONSTRUCTION TEMPERATURE
LIMITATIONS OF QUENCH CHAMBERS

Temperature ($^{\circ}$ F)	Quench Materials
600	Carbon Steel
900	Stainless Steel
1,100	Inconel clad stainless steel

Heat exchangers can be placed before the quench chamber to reduce the water load required. Operating costs are based on pumping costs of water and utilities cost of water. The quench water rate is calculated from a heat balance.

Heat Recovery

Heat recovery units are used on larger projects to produce steam and reduce quench water load. Specific heat recovery equipment is based on the heat recovery rate and the payback period on the equipment. A 6.1 year payback period is considered the maximum (13). Twenty percent of the produced steam is considered lost during production and transportation.

The pressure drop in an incineration heat recovery process is dependent on the amount of heat recovered. The relationship is illustrated below in Table XII (46).

TABLE XII
HEAT RECOVERY VERSUS PRESSURE DROP
FOR HEAT RECOVERY BOILERS

Heat Recovery (%)	Pressure Drop (inches of H ₂ O)
0	2.0
3.0	6.0
5.0	8.0
7.0	10.0

Installed cost is approximately the same for both boiler types. One of the two costs method may be selected by the

user. The first method found was published by Corripio (15) and uses the cost estimation listed below:

$$C = C_b * F_d * F_p * F_m \quad (20)$$

C - Exchanger cost (1979)
 C_b - Base exchanger cost
 F_d - Pressure cost factor
 F_p - Exchanger type cost factor
 F_m - Materials of construction cost factor

The cost of the heat exchanger is based on the surface area required for heat exchangers. The base cost of the heat recovery boiler is estimated from equation 21.

$$C_b = \text{EXP} (8.551 - 0.30863 * \text{LN}(A) + 0.06811 * \text{LN}(A^2)) \quad (21)$$

For a kettle reboiler, the exchanger type cost factor are represented by equation 22.

$$F_d = 1.35 \quad (22)$$

The design pressure cost factor are estimated from equation 23:

$$F_p = 0.7771 + 0.04981 * \text{LN} (A) \quad (23)$$

Materials of construction cost adjustment factors is estimated from equation 24.

$$F_m = g_1 + g_2 * \text{LN} (A) \quad (24)$$

The constants g₁ and g₂ are listed in Table XIII and are based on the material selected.

TABLE XIII
MATERIALS OF CONSTRUCTION CONSTANTS
FOR HEAT RECOVERY BOILERS

Material	q1	q2
Stainless Steel 316	0.8608	0.23290
Stainless Steel 304	0.8193	0.15984
Stainless Steel 347	0.6116	0.22186
Nickel 200	1.5092	0.60859
Monel 400	1.2989	0.43377
Inconel 600	1.2040	0.50764
Incoloy 825	1.1854	0.49706
Titanium	1.5420	0.42913
Hastalloy	0.1549	1.51774

The variable A in the equations above is in units of square feet of heat exchanger area. The equation used to predict the area of the heat exchanger is:

$$A = Q / U * DT_m \quad (25)$$

The overall heat transfer coefficient for the boiler can range from 2 to 8 Btu/hour/square foot (36). Additional information is available on overall heat transfer coefficients for combustion gases (36).

The second method of heat recovery cost estimation is also included in the computer program (48). The installed cost of heat recovery boilers is estimated according to equation 26 (36):

$$C = (28,800 * A^{-0.440}) * \exp(0.0672 * (\ln A)^2) \quad (26)$$

This equation applies to heat exchange area from 200 to 50,000 square feet. This method assumes:

- 1) 35% Heat Recovery
- 2) Residence time 0.5 seconds
- 3) Cost includes exchangers and accessories

Accuracy of the data is estimated at ± 50 percent . Area of heat transfer is calculated from equation 25.

Venturi Scrubber

Venturi scrubbers are specified primarily to remove particulates from a gas stream. The fraction of particles removed in a gas stream is directly related to the pressure drop. Removal efficiency varies depending on the particulate size. Separation chambers are always specified with a venturi scrubber. For this computer program, the pressure drop can either be directly selected, or the pressure drop may be determined based on a particle size distribution selected by the user. Total pressure loss is 15 percent of the total pressure drop (18). If the particle distribution method is specified, removal efficiency is determined from data supplied by Cheremisinoff et. al. (22). The data is represented in Figure 16 for specific pressure drops (18). This data is curve-fit and included in the computer program (see Appendix A). The concentration of particulates emitted must be less than legal requirements. These requirements are already included in the program.

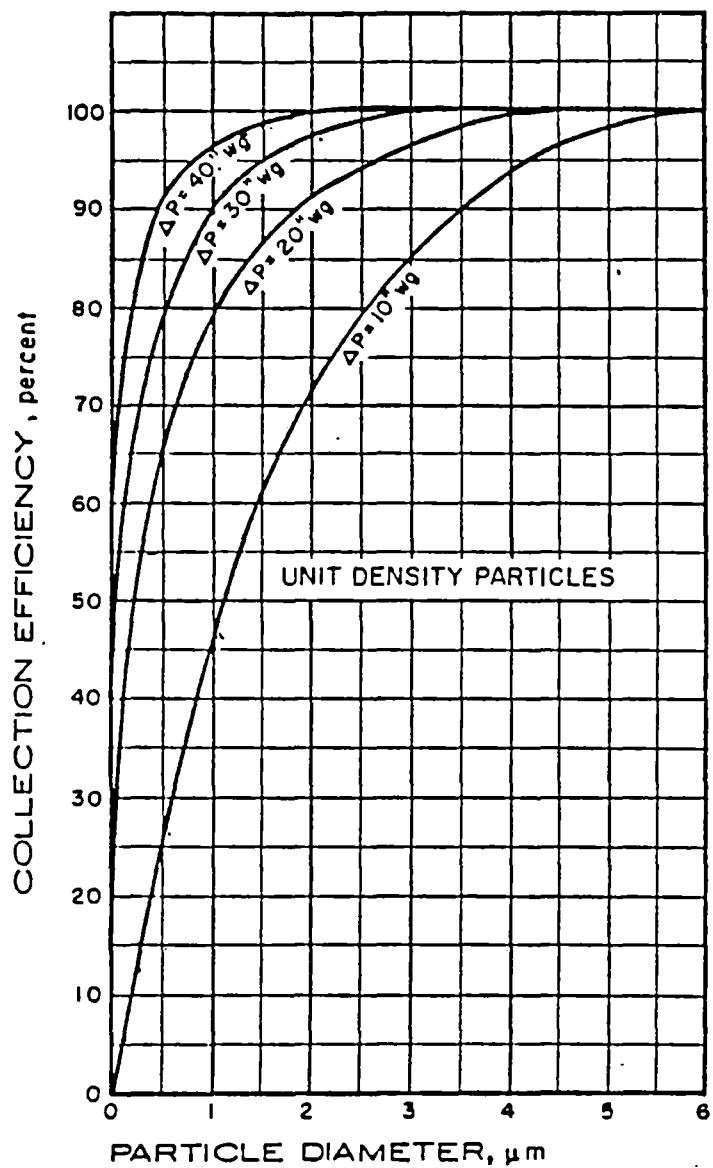


Figure 16. Experimental values for removal efficiency of particles at specific pressure drops (22).

A second method, included in the program, uses experimentally determined particulate collection efficiencies. Data found in literature limits the pressure drop of 10, 20, 40, and 60 inches of water. Given a particle distribution, inlet particulate concentration, and the scrubber pressure drop, the outlet concentration of the particulates is estimated. The fraction collected is the integral of the performance curves and the particle distribution. Stepwise integration is ideal for this method.

An alternative method to calculate the removal efficiency is presented below. The cut diameter for a given particle distribution is the particulate diameter at which the mass fraction removed is 50 percent. Venturi scrubbers collect particles by inertial compaction. This phenomena is described by equation 27 below (18):

$$Pt = \exp(-Ac * Dpa^Bc) = Co/Ci \quad (27)$$

Here, A and B are empirical constants. For venturi scrubber, the constant Ac is estimated at 2. The mass concentration of particles out is related to the cut diameter according to equation 27. Cut diameter for a pressure drop is given in Figure 17.

These values were experimentally determined. The method of solution is to determine the pressure drop (cut diameter) which reduces the outlet concentration to an acceptable levels.

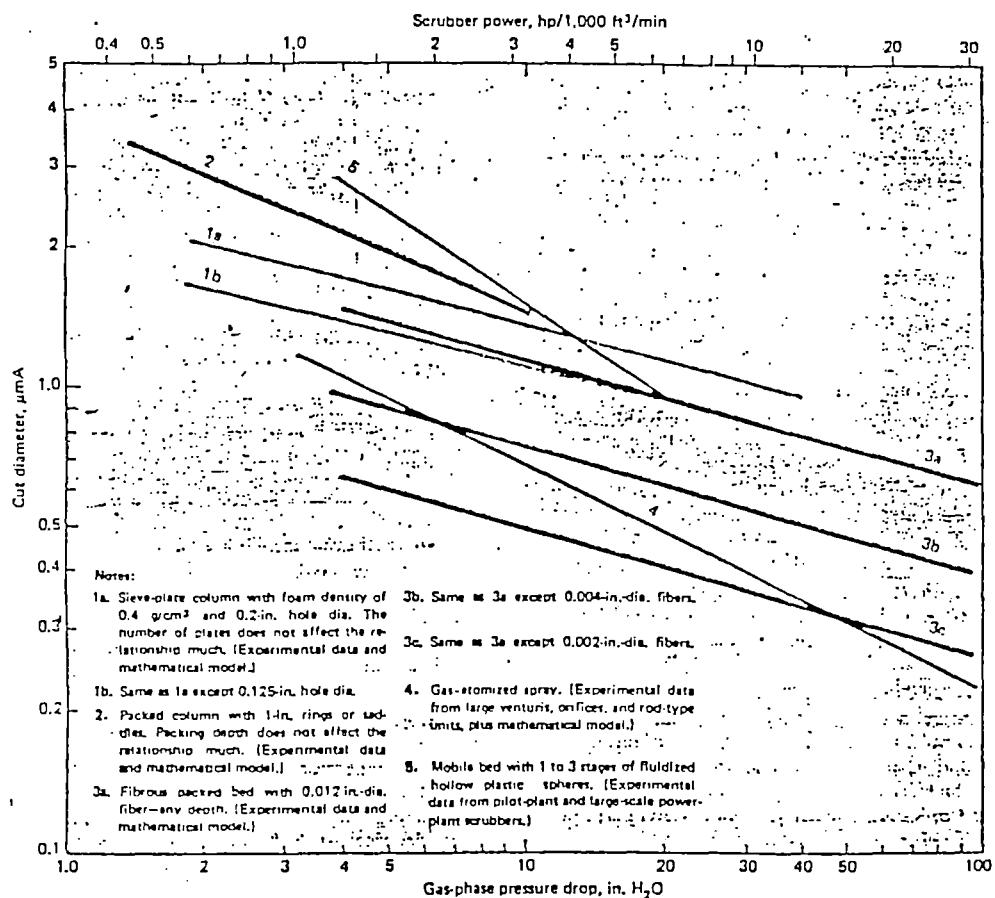


Figure 17. The cut diameter for removal of 50 percent of entrained particulates is plotted against venturi pressure drop (22).

If no particle distribution is provided, a pressure drop must be specified. This method bypasses all particulate removal calculations. The rate of water has a direct effect on particle collection efficiency. Water rates should range between three to ten gallons / million actual cubic feet of emission gas. This value is specified by the user.

Cost data for the venturi scrubber was published by Vatavuk and Neveril (20). The cost is based on the gas volume flow rate and total pressure drop in the venturi. Costs and pressure drop adjustment factors for venturi scrubber and separator are summarized in Figures 18 and 19. This cost data was compiled in 1977. This includes:

Venturi
Elbow
Separator
Pumps
Controls
1/8 inch carbon steel

Cost adjustments are also available for materials of construction. These values are listed in Table XIV (20), and are included in the computer program.

TABLE XIV
MATERIALS OF CONSTRUCTION COST FACTORS
FOR VENTURI SCRUBBERS

Stainless Steel 304	-	2.3
Stainless Steel 316	-	3.2

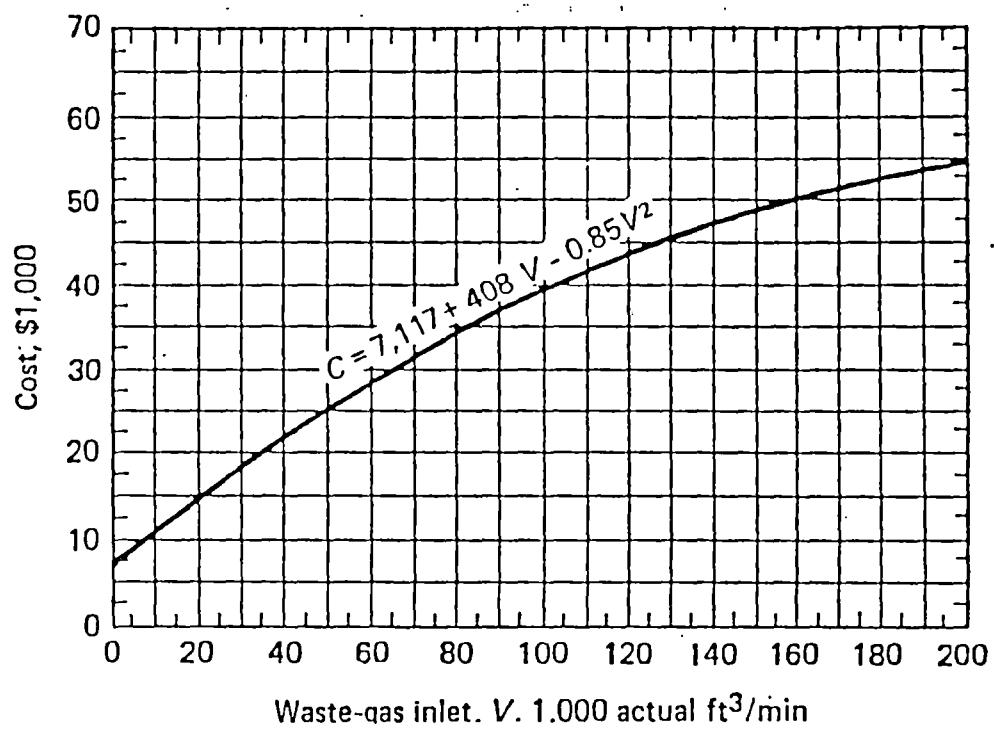


Figure 18. The cost of a venturi scrubber and separator (31).

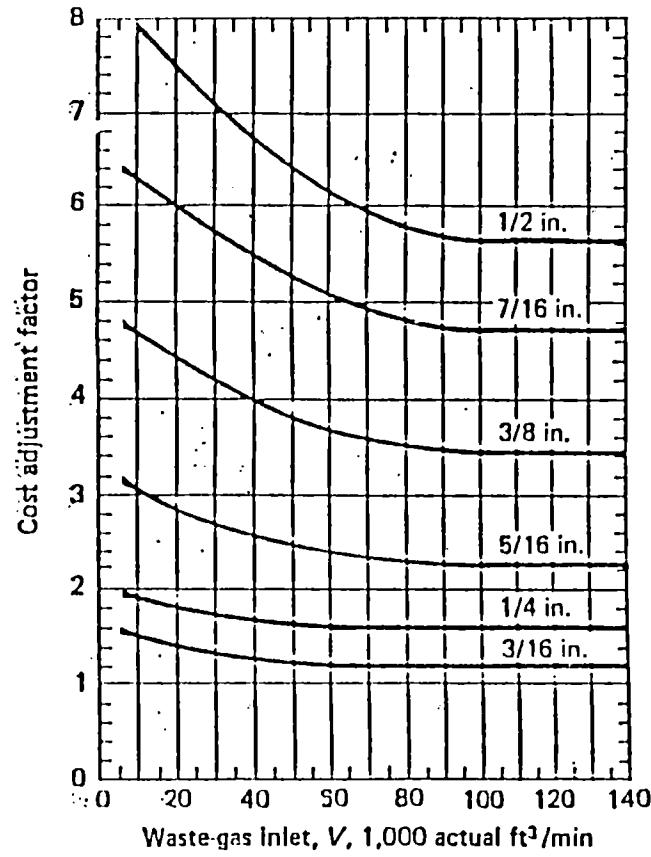
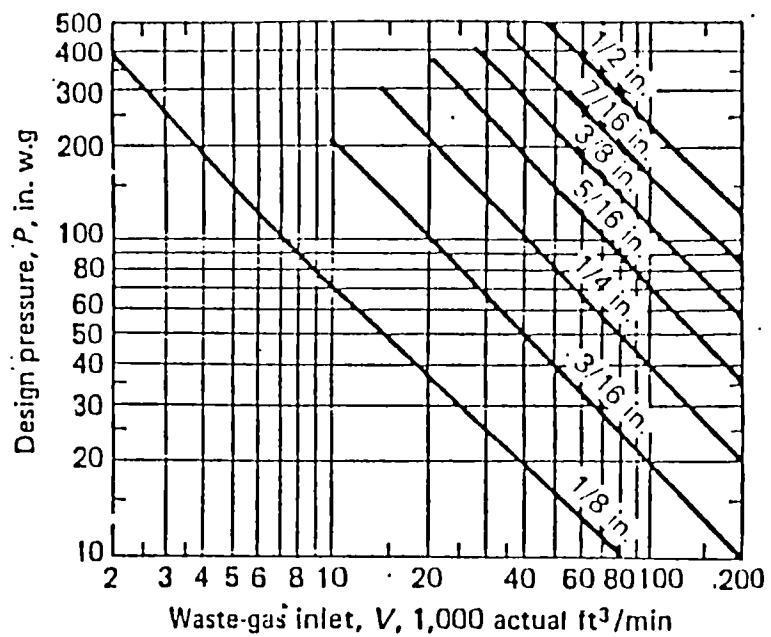


Figure 19. These figures are used together to determine the cost adjustment factor for venturi scrubbers. First, the pressure drop and waste gas feed rate are used to determine the required venturi shell thickness. Second, the cost adjustment factor is determined based on the shell thickness and the waste gas rate. This factor should be multiplied by the cost determined in Figure 17 (31).

If an automatic throat adjustment mechanism is installed, 6,350 (1981) U.S. Dollars is added to the venturi system cost. If a manual throat adjustment mechanism is specified, 3,450 (1981) U.S. Dollars is added to the cost of the system (20).

Separators are specified with the venturi scrubbers to allow vapor and liquid separation after the scrubbing process. Diameter and length of the separator is based on industrial practice and is described by equations 28 and 29.

$$\text{Height } H=8+0.25*Vm-0.00048*Vm^2 \quad (28)$$

$$\text{Diameter } D=5+0.11*Vm-0.00024*Vm^2 \quad (29)$$

This cost is included with the venturi scrubber equipment.

Operating costs for the venturi scrubber (and separator) are primarily the utility and pumping cost of water. Since the water is usually recycled after use, only 25 percent of the total water requirements is added. Start-up costs were estimated at 5 percent of equipment cost (29).

Induction Fan

Induction fans are used to transport the emission gases of the incineration process through the pollution control system. The induction fan should be specified after the particulate removal unit to reduce the fan blade wear. The total cost of an induction fan includes the cost of fans, motors, and inlet and outlet dampers. Design and cost method used were published by Vatavuk (27). Cost of the fan

is dependent on the air flowrate and fan pressure drop. For pressure discharges greater than 30 in water, multiple fans in series are specified. Fan operation conditions are corrected for temperature and pressure other than 70° F and 14.7 Psia (Figure 20). Fan costs are represented in Table XV, based on the impellor diameter (27).

TABLE XV
FAN COSTS FOR INDUCTION FANS

Diameter of Impellor (Inches)	Cost of Fan (U.S. Dollars 1977)
18	2,200
27	4,000
40	7,000
60	10,500
80	25,000
98	38,000

These costs are for class 4 (high performance) fans. Fan costs are adjusted for materials of construction based on factors listed in Table XVI (27).

TABLE XVI
MATERIALS OF CONSTRUCTION
COST FACTORS FOR FANS

Stainless Steel - 2.50

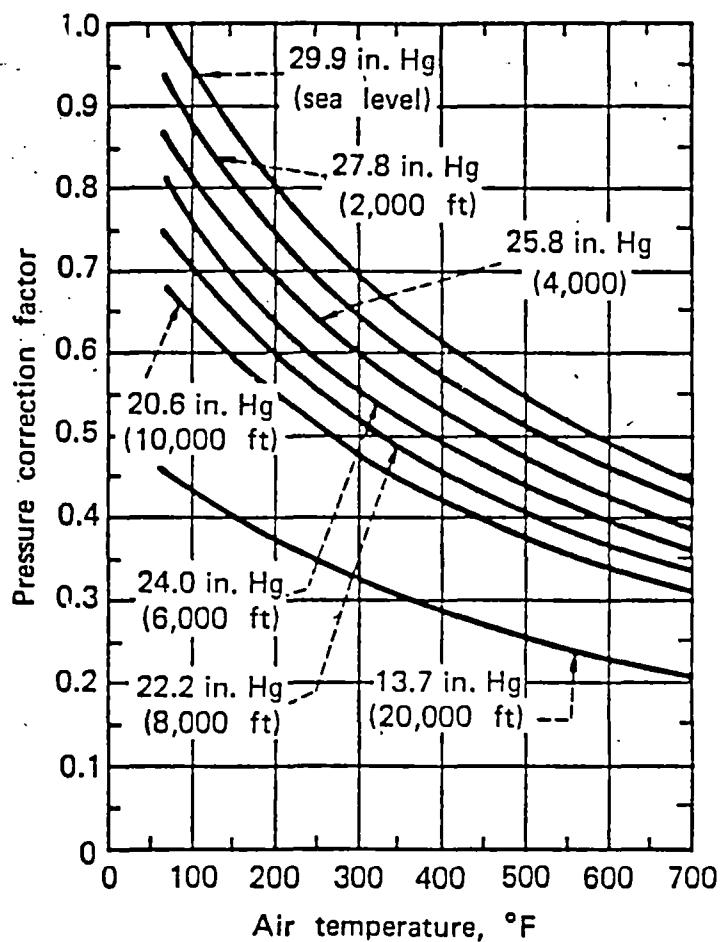


Figure 20. The actual design pressure head required for conditions different than 60 Fahrenheit and 14.696 Psia pressure (31).

Inconel-Clad-Stainless - 3.0
steel

If the fan service temperature is between 250 and 600 °F, a 3 percent charge is added to the total fan cost (27).

The design and cost of the motor is dependent on the power requirements, the fan's rpm, and the air flow rate. The cost of the electric motor is found by using Figures 20 and 21 (20). The cost is based to 1977. Cost of the inlet and outlet dampers is based on the volume rate of the gas and diameter of the impellor. Figure 22 summarizes this cost data. Cost data was compiled in December 1977 (27).

Operating costs specific to induction fans consist of electricity cost to operate the motor.

Packed Bed

Packed bed absorbers are implemented to reduce the concentration of water soluble caustics (usually HCl, SO₂, and NO₂). The packed bed design and cost method were presented by Cheremisinoff et. al. (22). The diameter of the packed bed is based on the liquid and vapor mass rates. The diameter is determined by two methods. The first method, using the Lobo correlation, can be used to directly solve for the diameter from experimental data. This correlation has been curve-fit for this program. The second method to calculate the diameter of a packed bed absorber

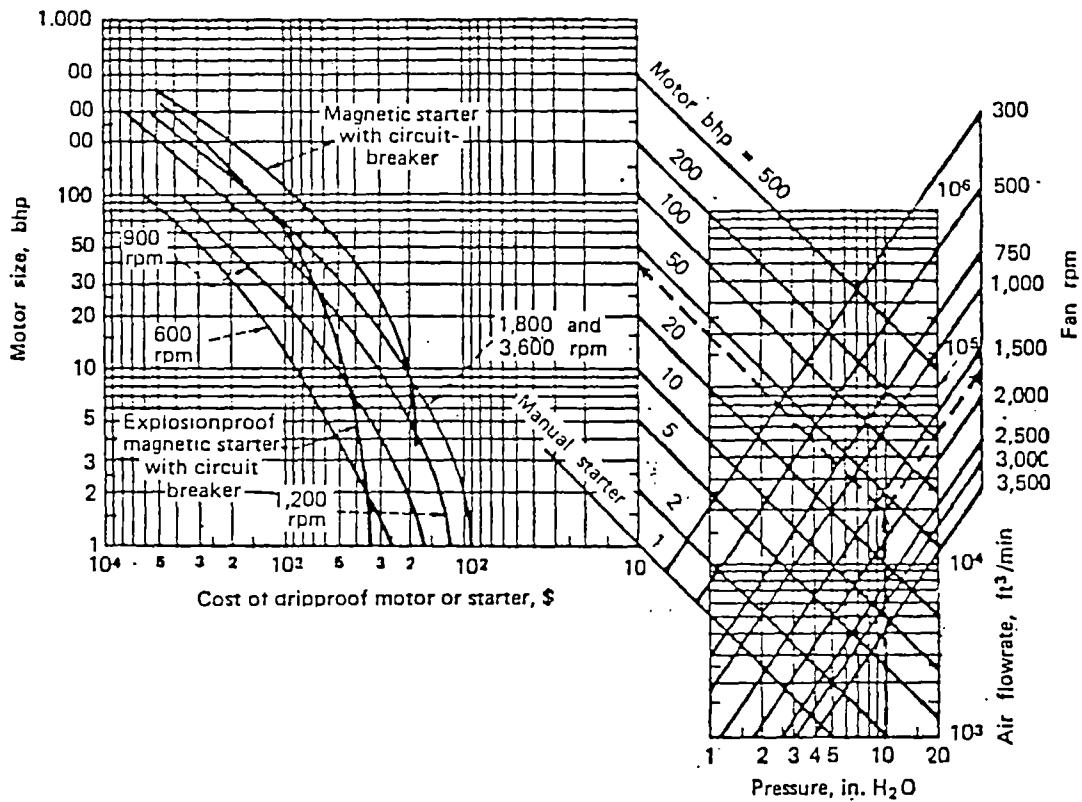


Figure 21. The cost of an electric motor based on the power requirements and motor rpm's (31).

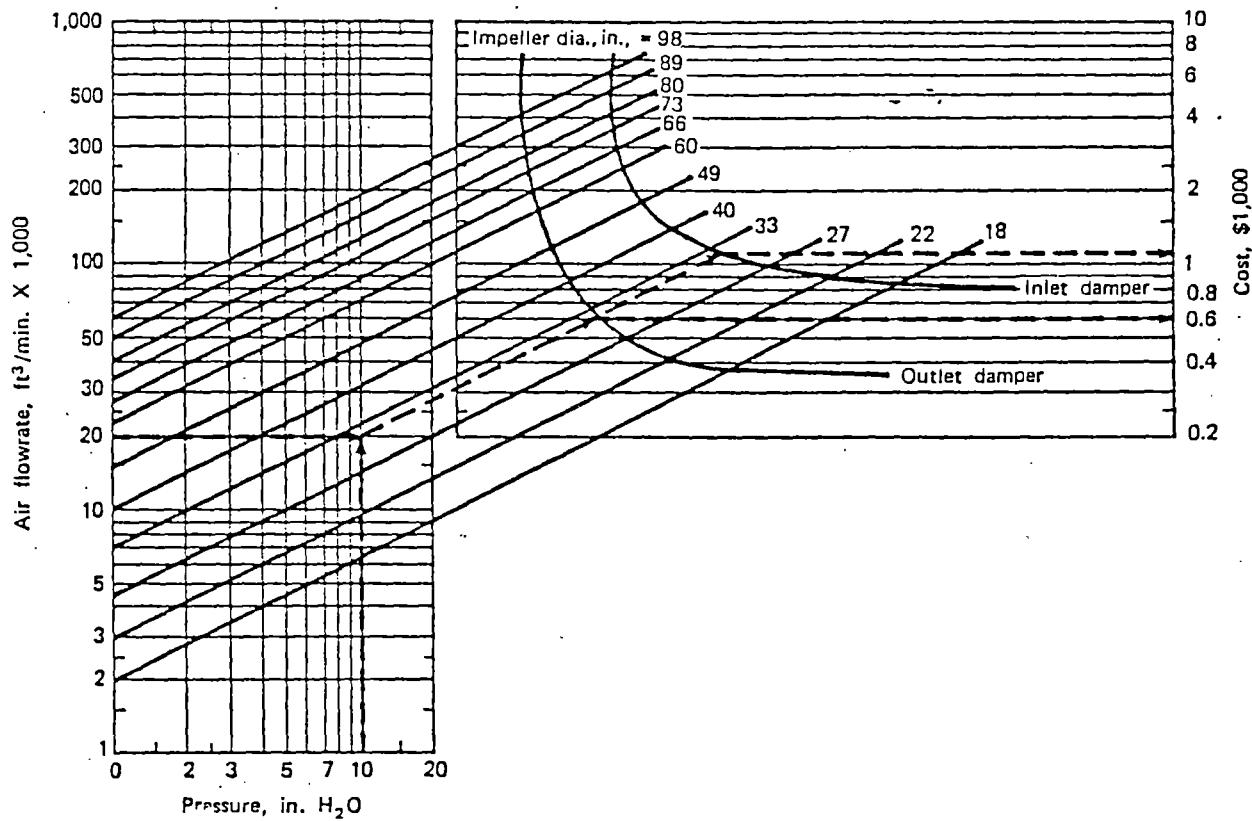


Figure 22. The cost of both the inlet and outlet dampers (81).

requires the solution of an empirical relationship (See equation 8). The diameter is solved by the interval halving method. One of the two methods must be selected by the user for this program.

Both methods require a correction factor dependent on the type of packing used. These factors are shown in Figure 23 (22). The packing factor is dependent on the packing type and size.

The height of the packed bed can be determined in two ways. First the user may directly select the height of the packed bed, eliminating all absorption calculations. Second, the mass transfer method may also be selected to determine the packed bed design height.

Using an alternate method, included in the program, the user must specify the total number of transfer units required to scrub the gas. The height of one transfer unit is based on the diffusion rate of the caustic in the gas and liquid phase. A method to calculate the height of a packed bed column was published by The Air Pollution Control Association (21). The height on one transfer unit is calculated from the equations 30 to 32 below (21):

$$H_{OG} = H_g + (m)(G_m/L_m)*H_l \quad (30)$$

$$H_g = a * G_m^b / L_m^q * (u_g / P_g / D_g)^{0.50} \quad (31)$$

$$H_l = z(L/u_l)^n * (u_l/P_l/D_l)^{0.50} \quad (32)$$

Here a, b, q, n, z are constants based on the packing size. These constants are given in Tables XVII and XVIII (21). The variables D_l and D_g are the diffusivity of the caustic in

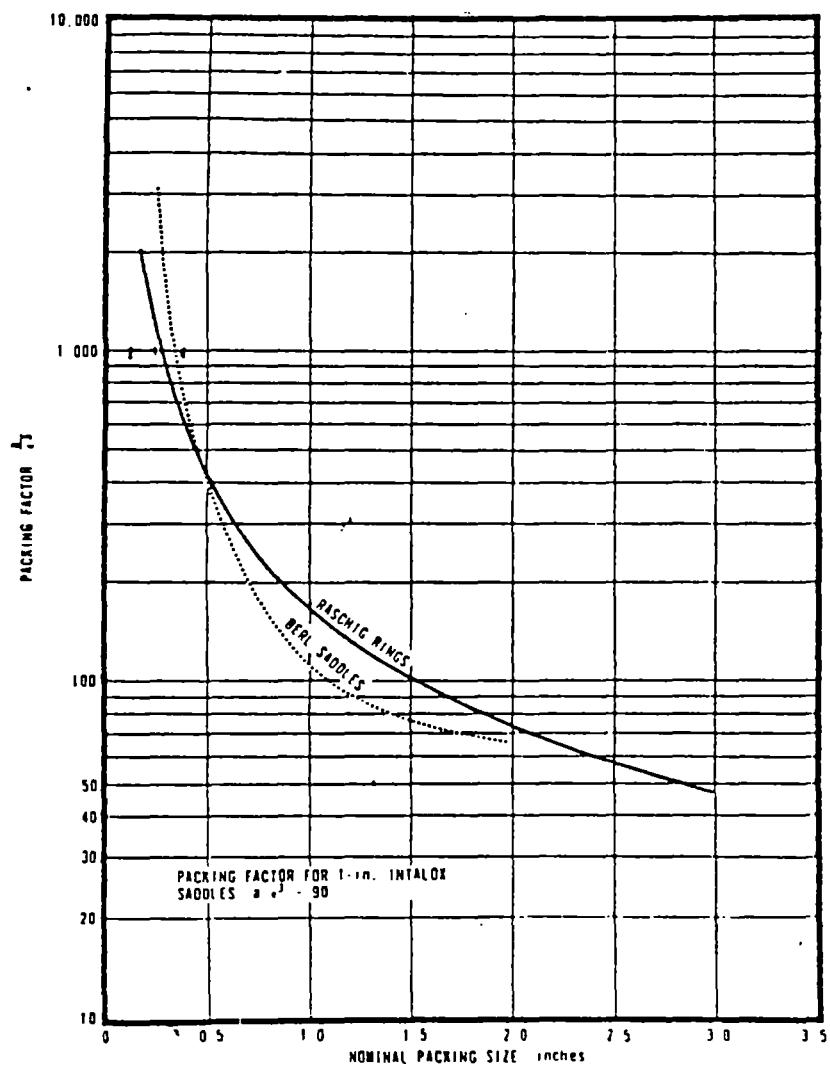


Figure 23. Packing factors for use with the Lobo correlation (73).

TABLE XVII
CONSTANTS FOR GAS MASS TRANSFER UNITS

Packing	a	b	g	Range of	
				Gas	Liquid
				(lb/hr/ft ²)	
Raschig Rings					
3/8 inch	2.32	0.45	0.47	200 - 500	500 - 1,500
1 inch	7.00	0.39	0.58	200 - 800	400 - 500
1 inch	6.41	0.32	0.51	200 - 600	500 - 4,500
1-1/2 inch	17.30	0.38	0.66	200 - 700	500 - 1,500
1-1/2 inch	2.58	0.38	0.40	200 - 700	1,500 - 4,500
2 inch	3.82	0.41	0.45	200 - 800	500 - 4,500
Berl Saddles					
1/2	32.40	0.30	0.74	200 - 700	500 - 1,500
1/2	0.81	0.30	0.24	200 - 700	1,500 - 4,500
1	1.97	0.36	0.40	200 - 800	400 - 4,500
1-1/2 inch	5.05	0.32	0.45	200 - 1500	400 - 4,500

TABLE XVIII
CONSTANTS FOR LIQUID MASS TRANSFER UNITS

Packing	Nominal size (inches)	z	n	Range of Liquid (lb/hr/ft ²)
Raschig Rings	1/2	0.0018	0.46	400 -15,000
	3/4	0.0036	0.35	400 -15,000
	1	0.0100	0.22	400 -15,000
	1-1/2	0.0111	0.22	400 -15,000
	2	0.0125	0.22	400 -15,000
Berl Saddles	1/2	0.0067	0.28	400 -15,000
	3/4	0.0058	0.28	400 -15,000
	1	0.0058	0.28	400 -15,000
	1-1/2	0.0062	0.28	400 -15,000

Constants available for packed bed absorber calculation of the liquid mass transfer unit. This data is used with equation 32(22).

the liquid and gas phases respectively. The variable m represents the slope of the equilibrium curve (See Figure 24)(49) The pressure drop in a packed bed absorber is determined, based on the type of packing, from equation 33.

$$\Delta P/Z = m * (10^{-8}) * (10(n*Lm/Pg)) * G_m / Pg \quad (33)$$

Data used in this equation are represented in Table XIX (21).

These values must be selected by the user. This allows selection of the caustic to be absorbed. For hydrogen chloride absorption, typical values for diffusion coefficients are listed below.

$$D(\text{liquid}) = 2.64 * 10^{-5} \text{ cm}^2/\text{sec.} \quad (34)$$

$$D(\text{gas}) = 0.360 * 10^{-2} \text{ cm}^2/\text{sec} \quad (35)$$

The effect of temperature has been estimated from correlations published in the literature (34,50).

The cost data for a packed bed absorber, included in the program, was published by the Air Pollution Control Association. This data is represented in Figure 25. The cost of the bed is for a one foot section and includes the cost of accessories.

Exhaust Stack

Exhaust stacks are pollution control used to release gas emissions safely to the atmosphere. The design of exhaust stack is based on the diameter and height. The diameter is

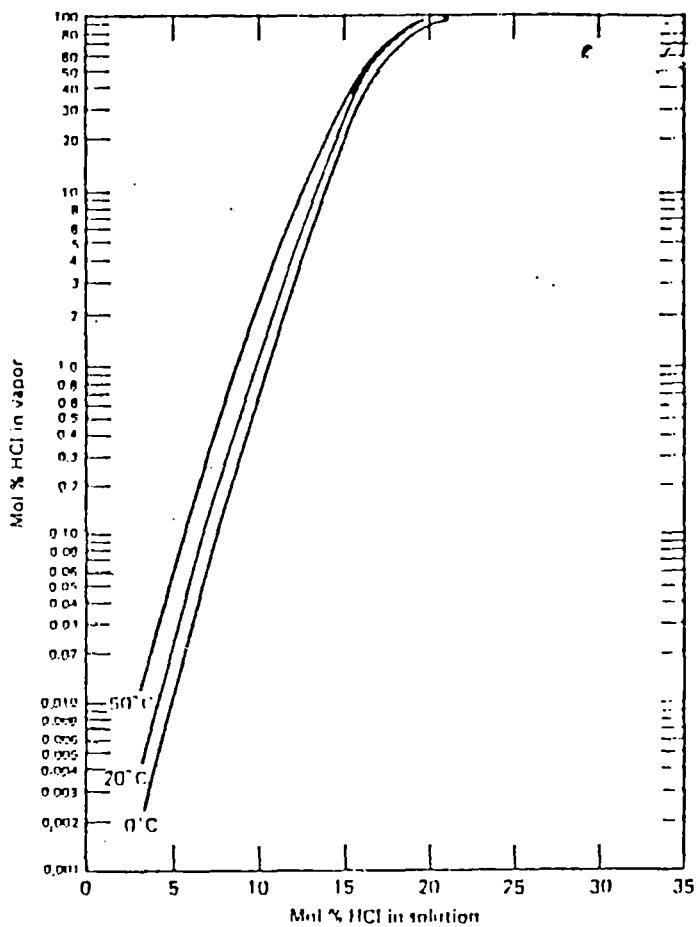


Figure 24. Vapor liquid equilibrium curve used to calculate the slope (m) for absorption calculations (85).

TABLE XIX
CONSTANTS FOR PRESSURE DROP CALCULATION

Packing	Nominal size (inches)	m	n	Range of Liquid (lb/hr/ft ²)	
Raschig Rings	1/2	139.00	0.00720	300	- 8,600
	3/4	32.90	0.00450	1800	-10,800
	1	32.10	0.00434	360	-27,000
	1-1/2	12.08	0.00398	720	-18,000
	2	11.13	0.00295	720	-21,000
Berl Saddles	1/2	60.40	0.00340	300	-14,100
	3/4	24.10	0.00295	360	-14,400
	1	16.01	0.00295	720	-78,800
	1-1/2	8.01	0.00225	720	-21,600
Intalox Saddles	1	12.44	0.00277	2520	-14,400
	1-1/2	5.66	0.00225	2520	-14,400

This table represents the constants used to calculate the pressure drop for a packed bed absorber. Constants presented in this table are applied to equation 33(22).

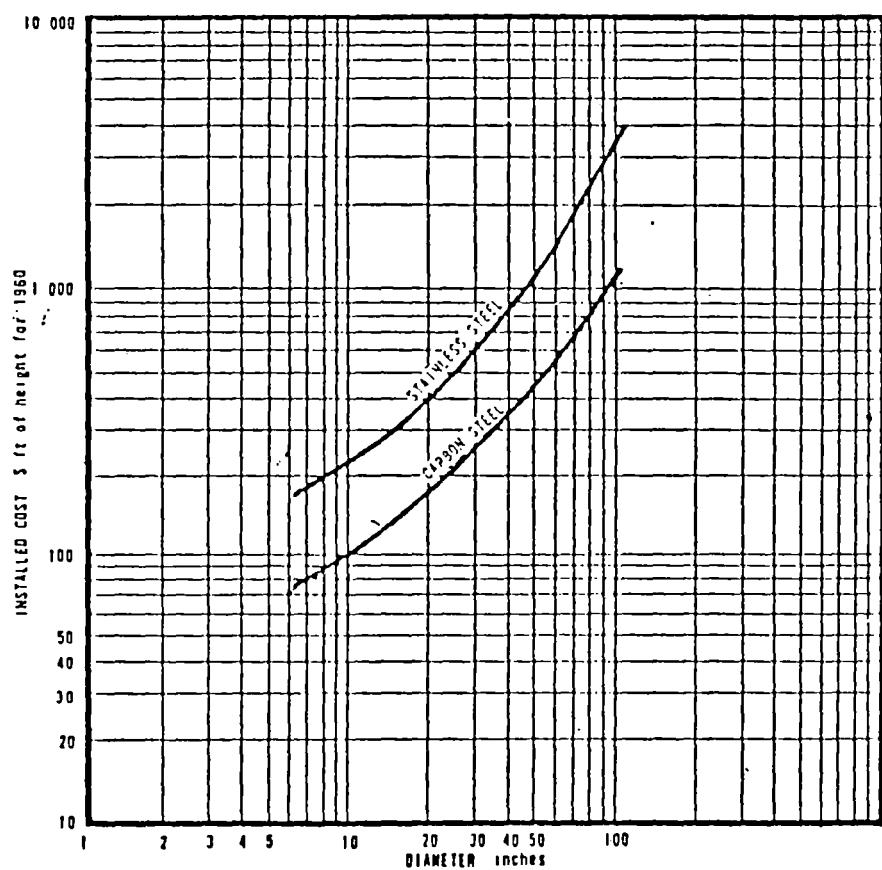


Figure 25. Cost of a packed bed absorber per foot (15).

directly related to the average wind velocity at the facility site. The stack velocity is 1.5 times the expected wind velocity (which is specified by the user). The maximum allowed stack velocity is 9,000 ft/minute (25). The height of the exhaust stack is selected by the user. If the diameter of the stack exceeds 60 inches, stack height must be between 100 and 200 feet.

Cost data to estimate exhaust stacks were obtained from information published by Vatavuk et. al. (25). Using this method, the uninstalled cost of the exhaust is calculated based on the height of the stack at a given diameter. The cost data is divided into many categories based on stack height, thickness, and diameter. The results of the data are presented below in equation form from Table XX (25).

TABLE XX
COST OF EXHAUST STACKS

<u>20-100 feet high stacks</u>	
<u>Diameter (inches)</u>	<u>Cost (Dec. 1977)</u>
60	1,265 + 87.4 * H
54	1,150 + 83.9 * H
48	1,035 + 79.3 * H
42	977 + 70.0 * H
36	862 + 65.5 * H
30	862 + 59.8 * H
24	862 + 49.4 * H

3/8-inch plate

Continued

<u>Diameter(inches)</u>	<u>Cost(Dec. 1977)</u>
60	2,070 + 104. * H
54	1,840 + 102. * H

5/16-inch plate

<u>Diameter(inches)</u>	<u>Cost(Dec. 1977)</u>
60	1,667 + 98.0 * H
54	1,495 + 95.0 * H
48	1,380 + 86.0 * H
42	1,092 + 80.0 * H

200-600 foot high stacks
1/4-inch plate

<u>Diameter(feet)</u>	<u>Cost(Dec. 1977)</u>
40	-946 + 9.23 * H
30	-1050 + 8.25 * H
20	-1325 + 8.63 * H

In this table, the variable H represents the stack height. The height of the exhaust stack is in feet. This cost method includes (26):

- 1) Flanges
- 2) 4 Cables (Stainless steel)
- 3) Clamps
- 4) Surface coating

These costs do not include installation and lining (refractory or plastic). Installation costs range from 30-100 percent of the equipment costs (17,18). The computer program included a cost factor of 50 percent. This factor is low for shop fabricated stacks and high for field erected exhaust stacks (14). This factor is selected by the user.

Ductwork

Ductwork must be specified to connect the incineration and pollution control process units. The design of the ductwork is for a heavy dust loading, or 9,000 feet / minute superficial velocity (26). The type of ductwork (Materials of construction), length, and number of bends must be selected by the user.

The cost of fabricated straight carbon steel ductwork is presented in Table XXI based on the ductwork wall thickness and diameter (26).

TABLE XXI
COST OF STRAIGHT CARBON STEEL DUCTWORK

Thickness (inches) (inches)	Cost (Dec 1977) (Dec 1977)	Diameter Range (inches)	
		High	Low
1/2	-3.86+3.01*D	85	10
3/8	-2.93+2.38*D	140	15
1/4	-2.05+1.77*D	155	30
3/16	-1.76+1.37*D	190	40
1/8	-1.46+1.09*D	200	50

The diameter of the ductwork (D) is in inches. The cost of duct elbows is shown in Figure 26 (26). The cost of refractory (if required) is listed below in Table XXII (26):

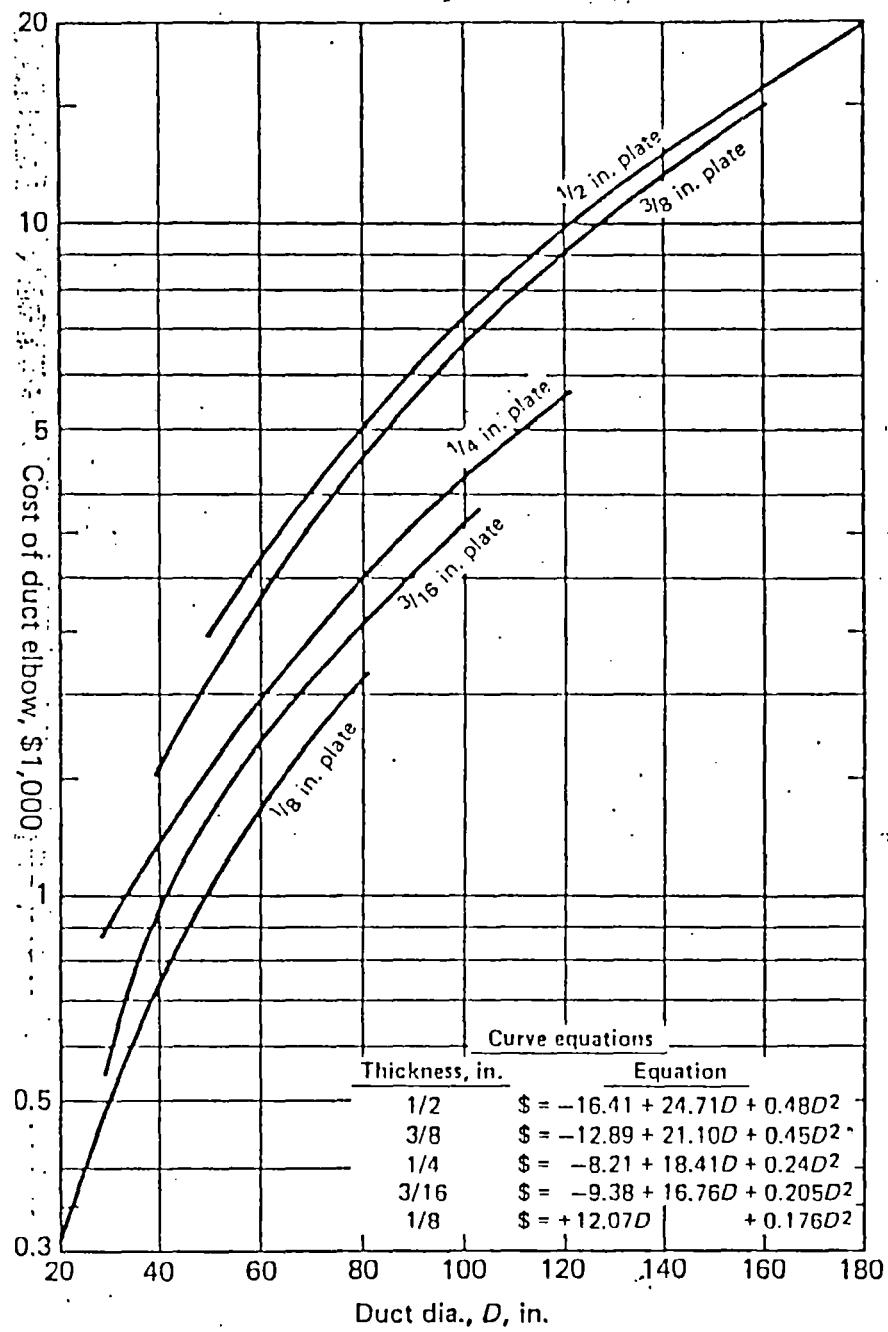


Figure 26. The cost of carbon steel ductwork elbows (29).

TABLE XXII
PROPERTIES AND COST OF FIREBRICK FOR DUCTWORK

TYPE OF REFRACTORY	THERMAL CONDUCTIVITY		PURCHASE	INSTALLED
	(Btu/hr/ft ² /F/in)		(\$/ft ³)	(\$/ft ³)
	1000 [°] F	2000 [°] F		
Firebrick	9.3	10.0	7	90
Insulation	1.9	2.1	6	30
Castable	5.1	5.7	25	75
Plastic	N.A.	N.A.	13	N.A.
Ceramic	N.A.	N.A.	N.A.	25

The temperature limitations of the refractory is 3,200 for the firebrick, 2,000[°]F for the insulation, 3,000[°]F for the castable, 3,000[°]F for the plastic, and 2,300 for the ceramic fibers (36).

Miscellaneous Facility Costs

Waste Storage Facility

Selection of size and number of tanks is left to the designer. The cost of storage tanks using this method includes (9):

- 1) Vessel (Carbon Steel)
- 2) Dimple jacketing
- 3) Agitator
- 4) Pumps (2 stainless steel)
- 5) Piping
- 6) Insulation
- 7) Grating
- 8) Diking

The cost of each storage unit is calculated in Table XXIII. Cost factors for the materials of construction apply to the vessel cost only and are (9):

TABLE XXIV
COST FACTORS FOR MATERIALS OF CONSTRUCTION
FOR WASTE STORAGE TANKS

2.7 - Stainless Steel 316
2.4 - Stainless Steel 304
1.7 - Rubber lining
5.8 - Glass lining

Other special equipment may also be included if required. This includes equipment to control volatiles and combustable wastes.

Equipment to control volatile emissions include nitrogen blanketing, condensors, or disposable carbon absorption filter units.

The cost of nitrogen blanketing is presented as operating expenses by Vogel and Martin (9). The nitrogen storage system is rented at an estimated annual rate of 2,500 U.S. Dollars for small units to 6,000 U.S. Dollars for large multiple tank storage facilities. The annual cost of nitrogen is estimated at 1,000 U.S. Dollars per 25,000 gallons storage tank. These costs are based to June 1981

TABLE XXIII
COST OF WASTE STORAGE FACILITY

Item	Tank Capacity, gallons		
	5,000	10,000	25,000
Vessel, Carbon Steel*	\$8,000	\$11,000	\$23,000
Dimple Jacketing	3,000	5,000	12,000
Agitator, Stainless Steel	6,000	8,000	9,000
Pumps(2), Stainless Steel	10,000	11,000	24,000
Piping	8,000	10,000	13,000
Insulation	3,000	5,000	13,000
Grating	1,000	2,000	5,000
Diking	5,000	7,000	13,000
Total	\$44,000	\$59,000	\$112,000

(9). If condensors are selected, by the user, the cost of the condenser is estimated at 4,000 U.S. Dollars for copper finned tubes to 10,000 U.S. Dollars for stainless steel tubes (June 1981) (36). These are one time capital costs.

Disposable carbon absorption units can also be selected. The cost for disposable filter systems is an annual operating cost. One filter can last 6 months and each unit costs about 600 U.S. Dollars (June 1981) (36).

An option to waste storage tanks is a barrel barn. Like the storage tank facilities, barrel barns must have special safety precautions to minimize waste leaks. Cost estimation methods for a barrel barn were published by Vogel and Martin (26). On-site storage capacity is limited, as for storage tanks, to a 48 hour supply of waste (12). The cost of a barrel storage facilities (for 55 gallon drums) is estimated at 40 U.S. Dollars (1981) per square foot of surface area. This cost includes fire-prevention and ventilation equipment (9). For the program, the storage requirements for drums are 75 drums per 100 square feet of surface area of warehouse space (26).

Other Facility Costs

Besides the cost of each incineration and pollution control units, there are other capital cost involved. These costs are:

Structural Steel Supports
Instruments and Controls
Electrical Materials
Sitework

Metal Building Spare Parts

Costs may vary greatly depending upon the location and waste feed characteristics.

Data for structural steel supports, electrical materials, sitework and buildings were obtained from Lepeau (13). For hazardous waste incineration facilities, the cost of controls and instruments is doubled over that of non-hazardous incineration facilities. An additional \$150,000 U.S. Dollars (1985) is added for special instruments. Spare parts inventory costs were set at 8 percent of the equipment costs. Figures 11 and 12 represent this data (13).

Indirect Costs

Indirect costs involved in the capital cost of incineration facilities are installation, first-time start-up costs, certification for hazardous waste, and miscellaneous engineering costs. These costs are estimated using cost factors published by Vogel (28). Installation costs include all installation not covered in the specific unit operation routines. Estimation factors are listed in Table XXV (28).

TABLE XXV
MISCELLANEOUS CAPITAL COSTS

1)	Installation	- 50% of equipment cost
2)	Start-up	- 10% of equipment cost
3)	Certification	- 10% of equipment cost + 170,000
4)	Engineering	- 7% of equipment cost
5)	Instrumentation	- 20% of equipment cost + 150,000

The extra certification costs include three short-term test trials and one 48 hours test burn required by the EPA for certification (40). Instrument costs include extra monitoring equipment required for hazardous waste operation.

Operating Costs

The operating costs of the incineration facility is calculated from the labor utilites, start-up , annual maintanance, insurance, and land taxes. The labor costs are calculated from data in the literature for labor requirement for hazardous waste incineration facilities. Labor costs include field labor, lab technicians, operators chief operators, lab supervisor, and payroll expenses. The labor time is calculated from data obtained from literature on common practice. This data is presented in Table XXVI (32).

TABLE XXVI

LABOR COSTS

Position	(\$/hr) Salary	(hr/day) Operation	Percent Time Required
Lab Technician	7.00	8.0	100
Chief Operator	8.00	24.0	50
Operator	7.00	24.0	100
Yard Workers	7.00	8.0	100
Secretaries	7.00	8.0	50

The number of each position required for the facility depends on the size. An estimation of these requirements is listed in Table XXVII (32).

TABLE XXVII
LABOR REQUIREMENTS

Position	1,000 lb/hr	10,000 lb/hr	> 10,000 lb/hr
Lab Technician	1	1	2
Chief Operator	0	1	1
Operator	1	2	4
Yard Workers	1	2	3
Secretaries	1	1	2

Other charges related to labor are estimated at twenty percent of total labor costs (32).

Other operating costs for the facility include:

- 1) Utilities Costs
- 2) Waste treatment and disposal
- 3) Land taxes
- 4) Lime caustic
- 5) Waste Heat Recovery
- 6) Start-up Costs
- 7) Maintenance
- 8) Insurance Costs
- 9) Revenue Generated

Utilities Costs

Fuel costs are the sum of the fuel requirements for the incinerator and afterburner. Water costs include the sum of quench, venturi scrubber, packed bed, and heat recovery boiler. Electricity costs include pumping requirements (for fuel and water) in the incinerator, afterburner, quench chamber, venturi scrubber, and packed bed absorber. Liquid pumping costs are estimated from equation 35 (19):

$$H_p = 0.36 * (\text{gallon}/\text{minute}) \quad (36)$$

This equation assumes a 30 psig spray pressure. Power calculations include a 50 percent loss factor. Fan compressor costs from air blowers and induction fans are estimated from equation 36 (41).

$$H_p = PD * V_m / 4,464 \quad (37)$$

In this equation, PD is the pressure drop in inches of water and V is the volumetric flowrate of the gas in actual cubic feet per minute.

Waste Treatment

Waste disposal costs are calculated for the amount of ash generated by the incineration facility. Disposal costs range from \$40/ton to \$400/ton to landfill the ash waste (51).

Capital cost data for a waste water treatment system were not available in the literature. Information published by Vatavuk and Neveril does estimate the total capital cost and operating cost based on the water feed rate. This data is presented in Table XXVIII (44) and is included in the program.

TABLE XXVIII
WASTE WATER TREATMENT OPERATING
AND CAPITAL COSTS

Waste Flow Rate (gallon/minute)	Installed Cost (\$1,000)	Operate Cost (U.S. \$ / Kilogallon)
1190	3,380	2.10
2290	4,450	1.50
5270	5,270	1.26

These costs are based to December 1982. The operating costs include (44):

- 1) Electricity
- 2) Water treatment chemicals
- 3) Capital Recovery
- 4) Miscellaneous charges

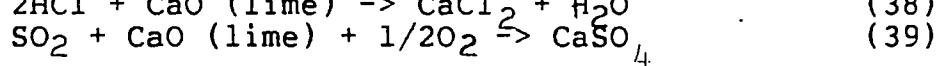
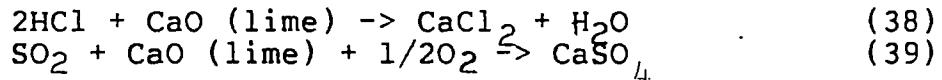
Labor is not included in these costs.

Land Taxes

Land taxes for the facility are estimated at 2 percent of the capital cost (29).

Lime Caustic

Lime or limestone added in the venturi and packed bed is calculated from the amount of caustic added. Caustic is used to neutralize the acid gases produced by the incineration process, and increase the vapor/liquid absorption properties in the venturi scrubber and packed bed absorber. Absorption reactions in the program include:



The cost of lime (CaO) is estimated at 40.0 U.S. Dollars (1980) / ton (29).

Steam Cost Recovery

The production of steam in the heat recovery boiler reduces the operation cost. Steam produced is calculated by the sensible heat loss of the incinerator emissions and the latent heat of vaporization of steam at 185 Psia. A 20 percent loss factor is included for heat losses. Steam recovery costs are calculated based on \$ 5.04 per 1000 lbs produced (41).

Start-up Costs

Start-up costs for yearly start-up is calculated for incinerator reheat time and start-up cost factors for each facility unit. Costs to reheat incinerator are estimated from Figure 27 (14). The cost to reheat the incinerator is based on the time from cold start and the heat released per cubic foot of volume from the fuel burner. Start-up time must be at least 2 weeks long per year (14). Additional start-up costs are estimated at 1 to 2 percent of the equipment cost (different for each piece of equipment).

Maintenence Costs

The yearly maintenance cost of the facility is estimated at three to six percent of fluidized bed and liquid injection equipment cost. For the rotary kiln, start-up cost is estimated at 8 percent of the brick costs (for replacement). Maintenance labor costs is 100 percent of the maintenance materials costs.

Insurance Costs

Insurance costs are estimated from cost factors discovered in literature (41). Insurance is estimated at 1 percent of the capital cost.

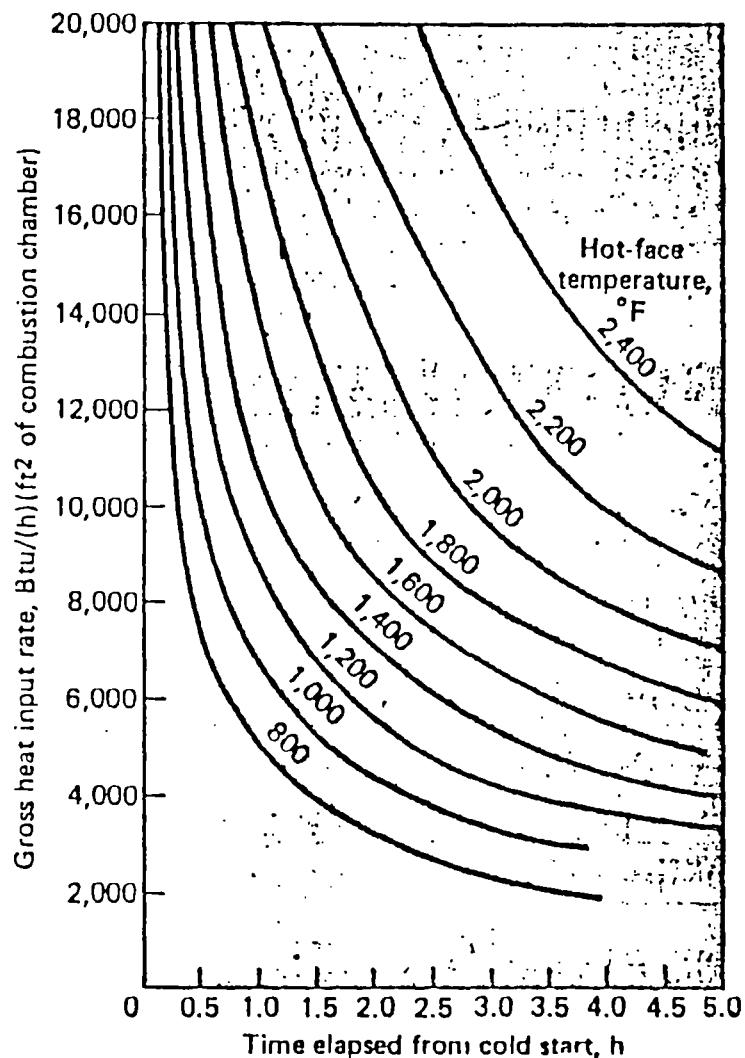


Figure 27. Heat input required to preheat incinerators (except fluidized beds) based on the surface area of the combustor (36).

Operating Revenues

Operating revenues is selected by the user on a dollars per ton basis. For this program, the default value for revenue is 400 U.S. dollars per ton of feed.

Summary of the individual operating costs are summed to estimate the total yearly costs. These costs are used for the economic analysis option.

Economic Analysis

Several methods are available to economically evaluate hazardous waste incineration facilities. The Present Value method and the Discount Cash Flow Rate of Return factor are calculated by this program (52). These methods may be selected or these procedures can be omitted by the user.

The present value adjusts all costs to the present. An example of this present value method is shown in Table XXIX. From this, a discount rate of return factor is calculated. This number represents the greatest interest rate at which money can be borrowed and still break even over the process life of the facility (See Table XXIX). For incineration facilities, the process life is estimated at 10 years. This method is presented by Gerald Smith (52). The costs involved are multiplied by the present value factor calculated from equation 39 (52).

$$PV = FV * EXP (YR * RT) \quad (40)$$

TABLE XXIX
PRESENT VALUE CALCULATIONS

YEAR	DISCOUNTED CASH FLOW RATE OF RETURN ANALYSIS OUTPUT (MILLIONS OF U. S. DOLLARS)										
	0	1	2	3	4	5	6	7	8	9	10
INCOME	0.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
OPERATE	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
DEPREC.	0.0	0.7	1.3	1.1	0.9	0.9	0.9	0.8	0.8	0.8	0.8
TAXABLES	0.0	7.8	7.2	7.4	7.6	7.6	7.6	7.7	7.7	7.7	7.7
TAXES	0.0	3.9	3.6	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.8
NET INC.	*****	3.9	3.6	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.8
DEPREC.	0.0	0.7	1.3	1.1	0.9	0.9	0.9	0.8	0.8	0.8	0.8
CAPITAL	-9.2	-	-	-	-	-	-	-	-	-	-
CASH FLW	-9.2	4.6	4.9	4.8	4.7	4.7	4.7	4.7	4.7	4.7	4.7

THE TOTAL CASH FLOW = 38.00 MILLION DOLLARS
DISCOUNTED CASH FLOW RATE OF RETURN = 30.6%

In this equation, PV is the present value, FV is the equivalent value, YR is the year in question, and RT is the interest rate at which the money is borrowed. The depreciation method selected is the Accelerated Cash Recovery System (ACRS) and was specified according to U.S. tax law (as of September 1986). These values can be easily modified if required. Table XXX represents the depreciation rate for a variety of facility lives (52).

TABLE XXX
ACCELERATED CASH RECOVERY SYSTEM
(ACRS) DEPRECIATION METHOD

3 Years	5 Years	10 Years	15 Years
25 %	15 %	8 %	5 %
38	22	14	10
37	21	12	9
-	21	10	8
-	21	10	7
-	-	10	6
-	-	9	6
-	-	9	6
-	-	9	6
-	-	9	6
-	-	-	6
-	-	-	6
-	-	-	6
-	-	-	6

The tax rate is specified by the user (usually at 50 percent).

CHAPTER V

DESCRIPTION OF COMPUTER PROGRAM

The computer program HWSTBRN is a modular package containing over 51 routines. The program is written in Fortran 77 and was run on a IBM 3085 computer system. The program was fully conceived by the author. No other packaged routines were incorporated. Design and cost of the incineration facility obtained varied from the open literature to information obtained from research facilities and commercial vendors (Phillips Petroleum and The John Zinc Company).

An important objective in the design of this program was to provide a flexible package in which different process units could be added without difficulty. The package is written in a modular form. Each unit can be specified independently and the the program can be easily altered.

The software package consists of 2 modules. These modules control the input, the design and cost estimation and the output created from the analysis. The input module allows creating new data sets or recalls old data sets. The input module allows inspection of all data, and making any alterations that are required. Physical and certain cost data are also available for inspection and alterations.

This method prevents the problem of creating data sets manually, reducing the chance of errors.

The main module of the software package, designs and cost estimates the facility based on the design specifications selected in the input module. A subroutine flowchart for the main program is listed in Figure 28. The user is allowed to specify up to nine units in series. The only restriction controlled by the program is the temperature limitation for downstream pollution control equipment. The flexibility provides a large number of alternatives in the design of the hazardous waste incineration facility. Unfortunately, this method allows the specification in any order without regard for proper design consideration.

Design of each unit operation is determined by a controlling subroutine. Each unit available has one such routine. This controlling routine calls other support routines that break the design and cost procedures down into a series of small steps. This method of programming is common with large software packages used today.

Selection of the support routines available is controlled by logical variables which are turned on and off, depending on the physical conditions for each unit or selection by the user. All options available are engaged in the controlling subroutines; except for selection of materials of construction, which is selected in the main routine.

The third section of the software package controls the output supplied on the design and cost estimation results.

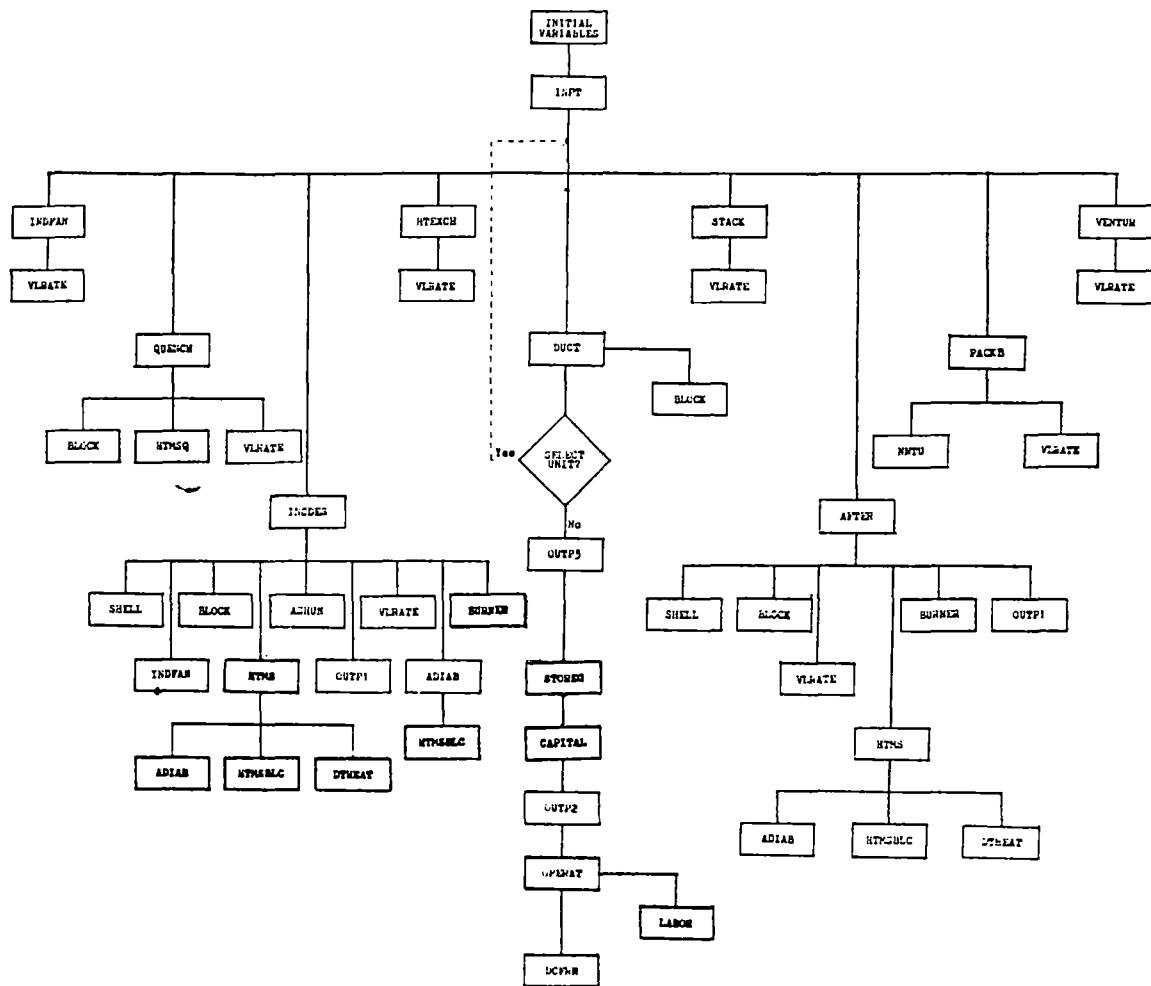


Figure 28. Subroutine flowchart for the main program HWSTBRN.

Many levels of output are available, depending on what the user specifies. The level of output is selected by the user in the input section of the program. See the output section for additional information.

Subroutine Description

Below is a description of each routine provided as an option for program HWSTBRN. The information indicates the type of subroutine, options available, routines that call the subroutine, routines called by the subroutine, and a description of the type of calculations completed. For the program two types of routines are recognized. Controlling subroutines are called to control the design and cost of each unit operation available. Controlling routines are selected by the user. Support routines are called by the controlling routines to perform operations used more than once.

Synopsis of Individual routines

The main program controls selection of the unit operations specified by the user. Design parameters common to each unit (i.e. materials of construction) are specified in the main routine. Each unit is selected in the order specified by the user. Each routine and the unit it represents is listed below.

INCDES	-	Primary Incinerator
AFTER	-	Afterburner
QUENCH	-	Quench Chamber
HTEXCH	-	Heat Recovery System

VENTUR	-	Venturi Scrubber/Separator
INDFAN	-	Induction fan Assembly
PCKBD	-	Packed Bed Absorber
STACK	-	Exhaust Stack
ADIAB	-	Adiabatic combustion

After each controlling routine, ductwork is designed and costed to connect the next unit. The length and number of elbows is selected by the user after each unit. After all the specific units are analyzed, subroutines CAPTAL calculates all miscellaneous capital costs. Operating costs are calculated from subroutine OPER. A series of output routines are then called depending on the requirements of the user.

Subroutine Adiab

The subroutine ADIAB is implemented from the controlling subroutine INCDES if the user specifies adiabatic combustion of the waste feed; or from subroutine HTMS if the total heat released by the waste feed exceeds the combustion temperature specified by the user without the addition of any excess fuel. Subroutine ADIAB calls subroutine HTMSBL and DTHEAT to solve the adiabatic combustion problem. Solution to the adiabatic process is solved by directly determining the mass balance and a trial and error solution of the energy balance to determine the temperature. Interval halving is the method used to determine the exit temperature of the emission gases.

Subroutine After

Subroutine AFTER is a controlling routine implemented to design and cost estimate a liquid injection afterburner. This subroutine is called only by the main program and is one of the unit options that the user can specify.

The design of the afterburner is based on the desired exit temperature, retention time, and length to diameter ratio. Fuel and air added to increase the temperature to the required exit temperature. The amount of fuel (and air) is determined from subroutine HTMS (see subroutines INCDES AND HTMS) from the specified outlet temperature selected by the user. The design volume is determined from the volume rate (calculated in subroutine VL RATE) and the retention time specified by the user. The diameter and length are calculated from the length to diameter ratio specified by the user.

The capital cost of the afterburner is calculated from its components. The cost of refractory and insulation firebrick is calculated from subroutine BLOCK, the cost of the shell is calculated in subroutine SHELL. Fuel burner costs were calculated from subroutine BURNER. Contingency costs are not included unless specified by the user. Installation cost of the afterburner is 50 percent of equipment costs and is calculated in subroutine CAPTAL. Operating costs are based on the following: Maintenance costs are 9 percent of the equipment costs. Operating costs

for the afterburner includes only the cost to pump the fuel into the chamber and cost of the fuel. All other operating costs are negligible.

Options available with the afterburner are the materials of construction. The shell can be constructed of carbon steel, stainless steel, or Inconel-clad-stainless steel. This option is selected by the user.

Subroutine Ashun

The subroutine AHSUN is called by INCDES and is implemented to determine the cost of an ash handling system. The cost of the ash control system is based on the heat release rate of the waste feed. Two types of ash handling systems are available depending on the size of the incinerator. Incinerators with a heat release greater than 15 million Btu/hour require automatic ash control systems.

Subroutine Block

The subroutine BLOCK is called by INCDES, QUENCH, and DUCT. This subroutine determines the thickness and amount of refractory and insulation firebrick for the incinerators, afterburners, quench chambers and ductwork.

The thickness of the refractory is determined by two methods. The first method is used if heat loss through the shell is specified by the user. The thickness is based on the thermal conductivity of the firebrick. If no heat loss is specified, the thickness is based on data from the

literature. The thickness, using this method is based on the hot-face temperature. These values are based on practice common in the industry.

The cost estimation of the refractory and insulation firebrick is listed in Table VIII. The cost is based on the hot-face temperature of the firebrick, the corrosive nature of the emissions, and the thickness of the refractory. If the weight fraction of chlorine is greater than 0.5%, corrosive resistant materials are selected. Selection of firebrick material also sets the cost. Installation of the bricks is 100% of the materials cost. Shipping is estimated at 30% of the brick materials costs. Yearly maintenance, excluding materials, is 15 % of the total materials cost for the rotary kiln, ten percent for fluidized bed, and five percent for the liquid injection incinerator. Costs are updated using the Chemical Engineering Plant cost Index factors for fabricated materials.

Subroutine Burner

Subroutine BURNER is used to determine the number, heat release rate and cost of both the waste feed burners and fuel burners. Subroutine BURNER is called by subroutine INCDES and AFTER.

Waste feed burners are sized and costed based on the heat released rate of the waste feed and the water content. If the heat value of the waste feed is less than 4,000 Btu/lb, or if the water content is greater than twenty percent, at

least two fuel burners must be used. Burners of three different sizes are available (see literature review) depending on the heat released by the fuel. If the total heat load requires more than eight fuel burners, a warning message is printed indicating a need to inspect the number of burners selected. Burner costs are calculated anyway.

Waste feed burner systems are based on the total heat released rate from the waste feed. Costs of both burner systems were obtained from data supplied by Vogel (See literature review) (9).

Subroutine Captal

Subroutine CAPTAL is a controlling routine that is called by the main routine. This routine calculates information on miscellaneous parts of the capital cost. This routine determines the cost of a metal building for instruments and operations room, the sitework required to prepare the land for the facility, cost of structural steel used to support the incineration and pollution control units, cost of electrical materials, and other indirect capital costs. Cost data for all but indirect costs are calculated by equations listed by equation 44. Indirect costs include installation costs not included in each specific unit operation, the first-time start-up costs, cost of spare parts inventory, cost of certification and engineering costs to design the facility.

Options available with this routine are selection of start-up and sitework cost factors. These values are specified by the user.

Subroutine Dtheat

Subroutine DTHEAT is called by subroutines HTMS, ADIAB, QUENCH, HTEXCH, and others. This routine determines the amount of heat required for a given temperature difference. The equations used are:

$$Q = Cp \Delta T \quad (41)$$

where

$$Cp = c + fT + eT^2 + dT^3 \quad (42)$$

The constants c,d,e, and f where obtained for the product gases (See Table XXXI) (54).

Along with the emission gas, the ash products heat requirements and a 10 percent heat loss factor is also included in the heat calculations.

Subroutine Duct

Subroutine DUCT is a support routine called by the main program. This subroutine designs and cost estimates ductwork and breeching connecting the incineration and pollution control units. Depending on the materials of construction, firebrick insulation and refractory may be selected. This material is designed and cost estimated in

TABLE XXXI
HEAT CAPACITY VALUES FOR
COMBUSTION PRODUCTS

Compound	a	b*10 ²	c*10 ⁵	d*10 ⁹
Water	33.46	0.6880	0.7604	-3.593
Hydrogen Chloride	29.10	-0.1340	0.9710	-4.333
Carbon Dioxide	36.10	4.2330	-2.8870	7.464
Carbon Monoxide	28.90	0.4110	0.3550	-2.220
Nitrogen	29.00	0.2200	0.5720	-2.870
Oxygen	29.00	1.1580	-0.6076	1.311
Nitrous Oxide	29.50	8.1900	-0.2950	3.650
Nitrogen Dioxide	36.10	3.9700	-2.8800	7.780
Chlorine	33.60	1.3700	-1.6100	6.470
Sulfur Dioxide	38.90	3.9000	-3.1000	8.610
Hydrogen Sulfate	139.00	15.6000	-	
Fluorine	29.00	-	-	
Hydrogen Fluoride	72.4	-	-	

subroutine BLOCK. Different materials of construction can be selected for each unit. This allows the use of less expensive materials at low temperatures.

The diameter of the ductwork is based on the velocity of the gas (to prevent particulate settling in the ductwork). Since heavy particulate loading is very probable, a velocity of 9,000 feet per minute is selected. The length and number of elbows depends on the placement of each unit and is specified by the user.

The cost of ductwork is based on the diameter, materials of construction and the number of elbows. The cost (per foot length) of ductwork is listed in Table XXI based on ductwork wall thickness and diameter. If the diameter of the ductwork exceeds the information on cost, the gas velocity is increased 20 percent, then the design and cost analysis is repeated. If the diameter needs to be increased, the gas velocity is decreased by 20 percent.

Subroutine Eng

Subroutine ENG is a support routine called by many routines. This subroutine converts physical and design data from metric units to english units. The converted units are:

Energy - Btu
Length - Ft
Temperature - F
Mass - pounds(lb)
Pressure - PSIA

Units are converted from the metric units listed in subroutine METRC. This routine is used for the output routines and some design routines.

Subroutine Htexch

Subroutine HTEXCH is a controlling routine implemented to cost estimate the heat recovery unit for pollution control systems. The design of a two phase heat exchanger is complicated and was not conducted.

The cost estimation of the heat recovery unit can be calculated by two methods. The first method requires an estimation of the overall heat transfer coefficient. This value is used to calculate the area of the heat transfer for the steam generation process. The calculated area of heat exchange is used to estimate the cost of the heat recovery boiler. The second cost estimation method is based on the gas flow rate and an exit temperature of 500° F. Cost is estimated for installed units.

Material of construction and the cost method are options available to the user. Both of the options are selected by the user. Cost data is updated from Chemical Engineering Plant Cost Index updating cost factors for equipment costs. The operating cost is essentially the steam produced from the boiling process. The amount of steam produced is calculated from the enthalpy change between the inlet and outlet streams and include a 20 percent loss factor.

Subroutine HTMS

Subroutine HTMS is called from subroutine INCDES if the outlet temperature of the incineration is specified. The subroutine is designed to solve a simultaneous mass and energy balance. These balances are based on the required exit temperature from the incinerator (selected by the user) and the amount of fuel required to reach this temperature. If, on the first loop of the balance, no fuel is required, the heat released by the waste feed exceeds the amount of heat required to reach the exit temperature. Control is then transferred to subroutine ADIAB. Interval halving is used to converge to the amount of fuel required to reach the desired incineration temperature.

The subroutine HTMSBL is called from the subroutine ADIAB and HTMS. This routine serves two purposes. First, the amount of air required to achieve 100 percent combustion is determined and increased to meet the excess air required by the user. Second, the incineration products are balanced based on the waste feed. The equations are balanced in the following order:

- 1- All Carbon is converted to Carbon dioxide.
- 2- All sulfur is converted to Sulfur dioxide.
- 3- All Nitrogen is converted to Nitrogen gas.
- 4- All chlorine is converted to Hydrogen chloride until all hydrogen is consumed.
All remaining chlorine is converted to molecular chlorine (Cl_2).
- 5- All fluorine is converted to Hydrogen fluoride until all hydrogen consumed.
All remaining fluorine converted to molecular fluorine (F_2).
- 6- All remaining hydrogen converted to water.

7- All remaining oxygen converted to molecular oxygen (O_2).

Since the destruction conditions must be set by the user, there is no guarantee that the stack gases will reach 100 % combustion efficiency.

The results of this subroutine are stored in the variable MLPRTD. Additional space has been allotted for production of other product chemicals. This is left to future work. An error message is printed if the error in the mass balance is greater than 1 percent.

Subroutine Htmsq

Subroutine HTMSQ is a support routine called by subroutine QUENCH. This routine calculates the amount of water required to cool the gas stream in the Quench chamber. The amount of heat required is calculated from subroutine DTHEAT. The amount of water required to cool the stream is then determined (using the interval halving method). Antoine's equation is used to determine the maximum amount of water that can be evaporated. Therefore, heat removed by evaporation from water cannot exceed the saturation limit. If further cooling is required, the specific heat of water is used.

No capital costs are considered in this routine, but the operating costs for the water, and the pumping costs are calculated. All water that is not vaporized is removed and recirculated. Water that is vaporized is added to the gas stream.

Subroutine Incdes

The subroutine INCDES is the controlling routine that designs and cost estimates the primary incinerator for the facility. The design procedures (and their routines) are as follows. For an adiabatic combustion (no fuel added), control is moved to subroutine ADIAB. The mass balance is solved directly and the energy balance (routine DTHEAT) is solved by trial and error for the outlet temperature. If the outlet temperature is specified, the mass and energy balance are solved simultaneously (in routine HTMS) for the added fuel and outlet temperature. If no extra fuel is added in routine HTMS, control of the energy balance is moved to subroutine ADIAB for an adiabatic combustion solution to the problem. With either method, control to subroutine INCDES is returned with the waste feed converted to product gas (in subroutine HTMSBL) at the combustion temperature.

The design of the primary incinerator is based on the retention time (liquid injection or rotary kiln), total heat released from the combustion (rotary kiln) or design parameters available in literature (fluidized bed). The length and diameter relationship is determined by the length to diameter ratio supplied by the user (in all cases).

Once the dimensions are calculated, the firebrick insulation and refractory are selected, designed and costed in subroutine BLOCK. The cost of the incinerator shell is

calculated in subroutine SHELL and is based on material of construction. If the ash production rate is greater than 1 percent, then an ash bin is costed from subroutine ASHUN.

Subroutine INCDES has available the following options:

- 1) Incinerator type:
 - fluidized bed
 - Rotary Kiln
 - Liquid Injection
 - Rectangular
- 2) Waste Feed Mechanism:
 - Waste Burners(liquid waste only)
 - Cart feed system
 - Barrel Loader
 - Rams Loader
- 3) Ash Removal System
 - Included
 - Excluded
- 4) Combustion Calculation
 - Specific Exit Temperature
 - Adiabatic Combustion

These options are selected by the user and/or the program based on the conditions of incineration.

Special design considerations are included depending on the type of incinerator selected. For fluidized bed, these characteristics are:

- 1) Diameter of unit determined from common industry practice Table IX and X.
- 2) Cost of fluidizing air support trays(2 required) based on sieve or valve tray construction sized from the diameter of the fluidized bed.
- 3) Installation cost is 100 percent of equipment cost.
- 4) Maintenance cost is 7 percent of equipment cost.
- 5) Cost of air blower for fluidizing air to 5 Psig.

Design and cost calculated from subroutine INDFAN.

For the rotary kiln, the special design considerations are:

- 1) Diameter based on retention time or heat release rate for incinerator volume.
- 2) Cost of rotary drive unit.
- 3) Installation cost of 200 percent of equipment cost.
- 4) Maintenance cost is 20 percent of equipment cost.

For the liquid injection unit, the special cost considerations are:

- 1) Installation cost based on 50 percent of equipment cost
- 2) Maintenance cost is 9 percent of equipment cost.

The operation cost (excluding maintenance) includes only the electricity costs to compress the air (for fluidized bed only) and to operate the rotary drive mechanism. All other operating costs are negligible or are approximated in subroutine OPER. Feeds are not included unless specified by the user (as a percentage of the equipment costs).

Subroutine Indfan

Subroutine INDFAN is a controlling routine called in the main program. This routine is a unit operation selected by the user. The routine designs and cost estimates the cost of an induction fan system. The routine implements subroutine VL RATE to calculate the volume rate of gas. The design of the induction fan system is dependent on the gas rate and the pressure head. The pressure head of the fan is

selected by the user. This value is usually equal to the venturi pressure drop.

The cost of the system includes the motor cost, fan cost and inlet and outlet dampers cost. Motor cost is calculated from Equation 49. The fan cost method is discussed in on page 95 and the cost data is listed in Figures 20 and 21.

Options available to the user are the material of construction for the fan and dampers and the total pressure head. Selection of most paramaters is made by the program.

Subroutine Inpt

Subroutine INPT is called by the main program to read data from an external data file. These files can be created manually, or as an interactive input program provided. Physical data and utilities costs are read from routine BLOCK DATA. All design operation parameters and economic input are read from the external file created by the user. If specified by the user, all data read will be printed to insure accuracy of input variables.

Subroutine Labor

Subroutine LABOR is a support routine called by the subroutine OPERAT. This routine is an option selected by the user. The routine calculates the labor costs associated with operating a hazardous waste facility. Personnel accounted for are:

- 1) Chief Operator
- 2) Laboratory Supervisor

- 3) Operators
- 4) Lab Technicians
- 5) Secretaries
- 6) Yard Workers

The number of each, and hours per day worked is summarized in Table XXVI. Payroll supply charges are estimated at 20 percent of Labor costs Plant and laboratories supervisors is estimated at 20 percent of labor costs apiece. Other payroll related expense is estimated at 30 percent of labor costs. A summary of the costs can be printed in a table if specified by the user.

Subroutine Nntu

Subroutine NNTU is a support routine called by subroutine PCKBD. This routine is called as an option (selected by the user) as a method to determine the height of the absorption packing required to remove the desired chemical (21).

The method in this routine is the Mass Transfer Unit method. The height of one transfer unit is solved with equations 30 to 32. Constants used in the equations are dependent of the packing type, size and size as well as the physical characteristics of the caustic being scrubber. The height of one transfer is multiplied by the number of transfer units required (specified by the user). The total height of packing is then returned to subroutine PCKBD.

Subroutine Outp1

Subroutine OUTP1 is a print routine called by the main program. This routine prints out the data pertaining to facility operation. An example of this output is listed in Table XXXII.

Subroutine Outp2

Subroutine OUPT2 is a print routine called by the main program. It is an option selected by the user. This routine prints a table representing the capital cost for the hazardous waste incineration facility. Capital costs are updated to the year specified by the user. An example of this output is listed in Table XXXIII.

Subroutine Outp3

Subroutine OUTP3 is a print routine called by the main program. This routine is an option selected by the user. A table is produced representing the design and cost parameters determined by subroutine DUCT. The routine is called after all ductwork has been determined. An example of this table is listed in Table XXXIV.

Subroutine Outp6

Subroutine OUTP6 is a print routine called by subroutine INCDES. This routine prints the incineration design parameters, the calculated dimension, and the cost

TABLE XXXII

**COMPUTER OUTPUT PERTAINING TO INCINERATION
FACILITY OPERATIONS PARAMETERS**

INCINERATOR DESIGN AND COST FOR
ROTARY KILN

****INPUT STREAM CHARACTERISTICS****

COMBUSTED GAS EXIT RATE	189708.69 LB/HR
ASH FEED RATE	0.00 LB/HR
VOLATILES FEED RATE	9000.00 LB/HR
FREE WATER IN SLUDGE FEED	0.00 LB/HR
FUEL FEED RATE	3252.70 LB/HR
AIR FEED RATE (AT 50.00% EXCESS)	177514.50 LB/HR

PROCESS DESIGN VARIABLES

PERCENT EXCESS AIR IS	50.00 PERCENT
PERCENT EXCESS FUEL IS	0.00 PERCENT
INCINERATOR TEMPERATURE	2000.00 DEG. FAHRENHEIT
AMBIENT TEMPERATURE	80.00 DEG. FAHRENHEIT.
DAILY USE	24.00 HOURS/DAY.
LENGTH OF PROCESS RUN	289.00 DAYS/YEAR.
SHUTDOWN LENGTH	76.00 DAYS/YEAR.
RETENTION TIME	2.00 SECONDS
LENGTH TO DIAMETER RATIO ESTIMATE	5.00

TABLE XXXIII
COMPUTER OUTPUT PERTAINING TO CAPITAL COST
OF THE INCINERATION FACILITY

TOTAL CAPITAL COST	
COMBUSTION CHAMBERS:	1976 \$
PRIMARY COMBUSTOR	989407.19
SECONDARY COMBUSTOR	1006837.00
ENERGY RECOVERY BOILER	149723.69
AIR POLLUTION CONTROL SYSTEM	
QUENCH CHAMBER	45399.73
VENTURI SCRUBBER AND SEPARATOR	91359.50
PACKED BED SCRUBBER	4691.82
INDUCTION FAN	179274.37
EXHAUST STACK(0 FEET HIGH)	0.00
WASTE WATER TREATMENT FACILITY	173989.2
STORAGE TANK FACILITY	608000.00
TOTAL DUCTWORK	113383.56
METAL BUILDING	143025.25
SITWORK AND FOUNDATIONS	247.82
STRUCTURAL STEEL	35935.28
ELECTRICAL MATERIAL	118699.69
INSTRUMENTS AND CONTROLS	113578.75
TOTAL-----	3773546.00
 TOTAL INSTALLATION COST	 2459029.00
START-UP (10 % OF EQUIPMENT COST)	377354.69
SPARE PARTS (8 % OF EQUIPMENT COST)	301883.56
CERTIFICATION (10 % OF EQUIPMENT COST)	377354.69
ENGINEERING (7 % OF EQUIPMENT COST)	264148.19
INSTRUMENTATION (20 % OF EQUIPMENT COST)	882709.12
CONTINGENCY FEE (20 % OF EQUIPMENT COST)	754709.12
TOTAL INDIRECT COSTS	5417186.00
 ***** TOTAL CAPITAL COST=	 9190732.00

TABLE XXXIV
COMPUTER OUTPUT PERTAINING TO THE DESIGN
AND COST OF DUCTWORK

COST OF DUCTWORK					
		DUCTWORK COST	FIREBRICK COST	DAMPERS COST	TOTAL COST
1 TO 2		11628.8	16310.2	8143.1	36082.0
2 TO 3		21746.4	21935.2	9030.3	52711.8
3 TO 4		1448.8	0.0	4061.2	5509.9
4 TO 5		1152.9	0.0	4080.4	5233.2
5 TO 6		2841.8	0.0	4081.5	6923.3
6 TO 7		2841.9	0.0	4081.5	6923.4
7 TO 8		0.0	0.0	0.0	0.0

DUCTWORK DESIGN OUTPUT					
UNITS	OUTER DIAMETER	BRICK DIAMETER	MATERIALS OF CONSTRUCTION	DUCT LENGTH	NUMBER OF ELBOWS
1 TO 2	75.6	0.00	IC	10.00	1.
2 TO 3	81.8	0.00	IC	10.00	2.
3 TO 4	38.8	0.00	IC	10.00	0.
4 TO 5	39.0	0.00	CS	10.00	1.
5 TO 6	39.0	0.00	CS	15.00	3.
6 TO 7	39.0	0.00	CS	15.00	3.
7 TO 8	0.0	0.00	CS	0.00	0.

breakdown. Table XXXV represents an example of this routine. This routine is an option selected by the user.

Subroutine Outp7

Subroutine OUTP7 is a print routine called by the main program. This routine is selected by the user. If called, a table of the mass balance and inlet and outlet conditions is printed. Table XXXVI is an example of the output.

Subroutine Operat

Subroutine OPERAT is a controlling routine called by the main program. The routine is selected by the user. All operation costs involved in operating the hazardous waste facility are summarized in this routine. Costs calculated in this routine are:

- 1) Utilities
- 2) Labor
- 3) Land Taxes
- 4) Insurance
- 5) Depreciation
- 6) Steam Production
- 7) Start-up Costs

Labor costs are calculated in subroutine LABOR. Utilities are determined by summing the amount used by each unit. Insurance, start-up, and taxes are calculated from the cost factors below:

Taxes	-	2% of Capital Cost
Insurance	-	0.6% of Capital Cost
Start-up	-	10% of Capital Cost

TABLE XXXV
COMPUTER OUTPUT PERTAINING TO INCINERATION
DESIGN AND COST BREAKDOWN

INCINERATOR DIAMETER (FT) =	12.8267
INCINERATOR LENGTH (FT) =	58.4393
MATERIALS OF CONSTRUCTION FOR THE INCINERATOR	
REFRACTORY SELECTED = 90%-ALUMINA FIREBRICK	THICKNESS = 1.5 INCHES
INSULATION SELECTED = INSULATING FIREBRICK	THICKNESS = 5.3 INCHES
INCINERATOR SURFACE AREA (FT ²)	6269.8516
INCINERATOR VOLUME (FT ³)	6269.8789
INCINERATOR BURNER DATA	
NUMBER OF FUEL BURNERS =	5
WASTE FEED BURNER HEAT LOAD =	0.810E+08 BTU/HR
OPTIONS IN EFFECT	
A 10 PERCENT HEAT LOSS (OF TOTAL HEAT RELEASED) IS INCLUDED IN THE HEAT/MASS BALANCE	
WASTE FEED IS A LIQUID. WASTE BURNERS ARE SELECTED	
INCONEL WAS SELECTED TO CONTRACT THE SHELL	

INCINERATOR COST BREAKDOWN

TOTAL BRICK COST \$	197151.25
TOTAL SHELL COST \$	409029.87
COST OF BURNER SYSTEM \$	70604.44
COST OF ASH SYSTEM \$	0.00
COST OF DRIVE SYSTEM \$	165264.56
COST OF SKIRTING \$	10000.00
EXTRA COSTS \$	137357.06
<hr/>	
TOTAL INCINERATOR COST	989407.19

TABLE XXXVI
COMPUTER OUTPUT FOR THE MASS BALANCE AND PROCESS CONDITIONS

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T = 2000.00 FAHRENHEIT	OUTPUT STREAM T = 2200.00 FAHRENHEIT
P = 14.68 PSIA	P = 14.64 PSIA

	LB/HR	LB/HR
FUEL	1008.65	0.00
AIR	0.00	0.00
H ₂ O	2331.53	2448.61
HCl	1849.08	1849.08
CO ₂	31818.07	38462.77
CO	0.00	0.00
N ₂	136107.81	136107.81
O ₂	14602.17	11848.75
NO	0.00	0.00
NO ₂	0.00	0.00
Cl ₂	0.00	0.00
SO ₂	0.00	0.00
H ₂ SO ₄	0.00	0.00
F ₂	0.00	0.00
HF	0.00	0.00
P ₂ O ₆	0.00	0.00
NE	0.00	0.00

Subroutine Pckbd

Subroutine PCKBD is a controlling routine implemented to design and cost estimate a packed bed absorber. This subroutine is called by the main program and is a unit operation selected by the user.

The subroutine is divided into two main parts, the design and the installed cost. For the design, the user selects the packing type and the size (See Table XVII - XIX). The user has the option of specifying a minimum height to insure adequate scrubbing, or selected as a constant, by-passing the physical absorption calculations altogether. If the user specifies Mass Transfer Method to determine bed height, diffusion coefficients of the caustic in gas and water must be specified. Additional design information such as absorption efficiency, percent flooding and the number of absorption transfer units must be specified by the user. The diameter of the column is calculated in subroutine absorption height is calculated in subroutine NNTU and is based on equations 30 to 32. Constants used in these equations are listed in Table XVII to XVIII.

The cost of an installed packed bed is calculated from data available in literature. Costs were updated by Chemical Engineering Plant Cost Index factor for fabricated equipment.

Several options are available to design the packed bed absorber. These options are listed below:

- 1) Packing Type:

Raschig Rings
Berl Saddles
4) Packing Sizes
 1/2 inch
 3/4 inch
 1 inch
 1.5 inch
 2 inch
1) Material of Construction:
 Fibergalss Reinforced Plastic
 Carbon Steel
 Stainless Steel
 Inconel Clad Stainless Steel

The cost and physical absorption properties for each packing is different for each packing type and size.

Subroutine Quench

Subroutine QUENCH is a controlling routine implemented to design and cost estimate a quench chamber. This subroutine is called only by the main program and is selected by the user as one of the unit operations.

The dimensions of the quench chamber are based on the volume rate of the emission gases at the average temperature. The velocity of the emission gas is set at 10 ft/s and the length to diameter ratio of three. These parameters are set to fit the cost data (equation 18 and 19) for the carbon steel shell. Two types of quench chambers can be implemented. A quencher is selected if the gas temperature is to be cooled to its saturation temperature. A spray chamber is selected if the outlet stream of the quencher is specified.

Cost of the quench chamber is based on carbon steel construction (38). Depending on the material of construction firebrick may be required to line the quench chamber. The temperature allowed is listed in Table XI. Subroutine BLOCK is called if the temperature exceeds the limitations above. Installation costs for the quench chamber is 67 percent of the equipment costs. Cost update method is based on Chemical Engineering Plant Cost Index factor for fabricated equipment.

Options available with the quench chamber are the materials of construction and type of quench chamber selected. These are both selected by the user.

Subroutine Shell

Subroutine SHELL is a support routine called by subroutines INCDES and AFTER. This routine cost estimates the shell for all incinerators and afterburners, and rotary drive mechanism for the rotary kiln incinerator. Cost of the shell is based on the surface area of the incinerator design which itself is based on the diameter of the incinerator plus the thickness of the refractory and insulating firebrick. Thickness of the metal shell is 2 inches for all designs. The cost updating method is based on the Chemical Engineering Plant Cost Index factors for fabricated equipment.

Options available with shell cost is the materials of construction. Cost factors are available for carbon steel, 316 stainless steel, or Inconel-clad-stainless steel.

Subroutine Stack

Subroutine STACK is a controlling routine that is specified by the user. This routine designs and estimates the cost of exhaust stacks used in the pollution control industry. The dimensions of the exhaust stack used to cost estimate the stack. The height of the exhaust stack is selected by the user. The diameter is based on the expected wind velocity (selected by the user). Due to the limitations in cost data, stacks with a diameter greater than 60 inches in diameter must be between 100 and 200 feet high. Short stacks, between 0 and 100 feet high can be constructed of plastic reinforced fiberglass, carbon steel, or stainless steel. Large stacks are constructed of carbon steel.

Options available for the exhaust stack are limited to the material of construction. This must be selected by the user.

Subroutine Storage

Subroutine Storage is a controlling routine that is selected by the user as a unit operation. This routine designs and cost estimates the waste storage facility for on site storage of liquids (storage tanks) or solids (barrel barn). The size of the storage facility is based on the incinerator feed rate, the number of days of waste to be stored. Design includes a 20 percent overdesign. Tank

sizes, and the cost to outfit each tank is listed in Table XXII.

Options available with this routine are:

- 1) Selection of total storage volume.
- 2) Materials of construction
- 3) Type of storage (barrel or storage tanks)

Additional equipment may be selected by the routine depending on the waste characteristics.

Subroutine Ventur

Subroutine VENTUR is a controlling routine implemented to design and cost estimate a venturi scrubber. This subroutine is called by the main program and is a unit option selected by the user.

The design of the venturi scrubber is based on the pressure drop required to remove particulate matter entrained in the gas stream. The pressure drop calculation are initiated at 20 inches water and increased by 10 in H₂O until the emission limit (input by the user) is met. This method is used because venturi particulate removal efficiency data is only known for specific pressure drops. Data determined from actual use.

The capital cost of venturi scrubber and separators is based on the gas flow rate and pressure drop.

Subroutine Vlrate

Subroutine VL RATE is called by many routines. This routine calculates the total volumetric rate, mass rate, and mole rate. The calculations can be in metric or english units depending on the program requirements.

Function Lists

A number of functions were developed with this routine to represent certain cost and design data.

Function Fanfxn

Function FANFXN is called by subroutine INDFAN to determine the cost of electric motors used to operate the induction fans. The cost of the motor is dependent on the fan rpm's and the total horsepower required to operate the fans at the desired pressure. Appendix A contains the cost data. This data was obtained from a method published by Vatavuk (27).

Function Fx1

Function FX1 is called by subroutine PCKBD and determines the diameter of the packed bed based on the Lobo correlation. The diameter can be determined from data in Figure 9.

Function Fx3

Function FX3 is called by subroutine PCKBD and is used to determine the cost of a packed bed absorber. The cost of the absorber is dependent on the diameter of the bed. This data was published by The Air Pollution Control Association.

Function Fx4

Function FX4 is called by subroutine INDFAN and is used to determine the power requirements of the induction fan system. This data was correlated from information published by Vatavuk (27). See Appendix A for more information.

Function Fxpack

Function FXPACK is called by subroutine PCKBD and determines the packing factor for Beryl saddles and Raschig rings. The value of the packing factor depends on the type of packing selected and the size of the packing. This data was curve-fit from information published by The Air Pollution Control Association. See Appendix A for more information.

Function Loadr

Function LOADR is called to estimate the cost of a containerized or drum fee system. Cost of the system is based on the feed rate of waste. For more information see Appendix A.

Function Pakdia

Function PAKDIA is one method of determining the diameter of a packed bed absorption column (22). The relationship used is listed in equations 16 and 17. The equation is solved by trial and error using the interval halving method for the diameter. Information required for the function is the liquid viscosity, the liquid and gas density, the packing factor, and the mass flow rate of the liquid and the gas.

Function Pressr

Function PRESSR is called by many unit operations and subroutine DUCT. This function estimates the pressure drop of the system using the pressure drop equation listed below (34).

$$DP = -f * Pg * L * VEL^2 / 2 * Gc * C \quad (43)$$

In this equation, f is the friction factor (estimated at 0.0045), C is the hydraulic radius, Gc is the gravity constant, and VEL is the gas velocity.

Function Scrfed

Function SCRFED is called to estimate the cost of a screw feed system for the incinerator. The feed should be a solid to specify. The cost of the screw feed system is based on the waste feed rate. Cost data used is listed in equations 16 and 17.

Function Traycs

Function TRAYCS is called to estimate the cost of the support trays used for the fluidized bed incinerator. Either valve of sieve trays may be specified. Trays may be constructed of carbon steel or stainless steel. The cost of the trays is based on the diameter. For further information see Appendix A.

Function Wtpprt

Function WTPPRT is the method used to determine the particulate removal efficiency of the venturi scrubber. This function calculates the removal efficiency for a given particle size for a given pressure drop. For more information, see Appendix A.

Input and Output For Program

Design and physical data used to cost and design a hazardous waste incineration is read from external data files by subroutine INPT. An additional interactive program is available to build data files for Program HWSTBRN.

This program allows selection of equipment to completely design and cost estimate a hazardous waste incineration facility, the incineration system only, pollution control subsystems, or single units. The input routine asks for data in the following order.

- 1) Waste feed rate and characteristics.
- 2) Ambient facility conditions
- 3) Selection of Unit and all the design

- parameters required for the particular unit.
- 4) Operating parameters
 - 5) Economic parameters
 - 6) Output level.

For further information, see Appendix C.

Design of hazardous waste incineration facility requires the coordination of the many options that must be available to the user. The output routine in this program, prints output on several levels, depending on the requirements of the user. The user has the option of selecting the following levels of output:

- 1) Economic Cost Analysis
- 2) Capital and operating cost tables
- 3) Design and cost parameters for each unit.
- 4) All print statements in program.

Example of print levels 1 to 3 are listed in Appendix E. The input variables are printed to insure accurate data files.

CHAPTER VI

RESULTS OF THE COMPUTER PROGRAM

The results of the output of computer program HWSTBRN are presented below. These results are analyzed in two ways. First, the results of the computer program will be compared with the results of hand calculations using the same design and cost methods. Second, the accuracy of the capital cost method used will be compared with capital cost data provided from sources in the literature and visitation to an operating hazardous waste incineration facility.

Comparison of Program Results With Hand Calculations

Before construction of computer program HTSTBRN, a series of hand calculations were conducted to determine the feasibility of the program and to provide some results to compare program output. The results of these calculations were presented at the American Institute of Chemical Engineers 1986 Spring Convention. These calculations allowed for the economic comparison of different types of hazardous waste incineration facilities (55). These facilities were compared according to the Discounted Cash Flow Rate of Return Method. A description of the facility and the design parameters are presented below.

Waste Feed Characteristics

The land based facilities are compared for two different types of waste sludge with three different waste feed rates. The two sludges are a water based sludge with a low concentration of polychloride biphenyls (PCBs) (waste feed #1) and an oil based waste of essentially pure PCBs (waste feed #2). For the three feeds, each of the systems is designed for a small feed rate, 500 pounds of waste feed per hour, and two large feed rates, 10,000 and 20,000 pounds of waste feed per hour. Characteristics of the waste feed must be known for the proper choice of the incinerator alternatives and for the proper design and selection of materials. The elemental and the overall compositions of the two model waste feeds are given in Table XXXVII. Physical properties of the oil-based waste feed are available from the literature (3,4). Heating value of the waste (5) was predicted by Equation 2.

Product Gas Characteristics

Composition of the product gas must be determined to specify pollution control devices. For all processes, 100 percent combustion was assumed.

Primary and Afterburner Combustors

The conditions for incineration for all systems were chosen to be at a temperature of 1,800 F for two seconds

TABLE XXXVII
CHARACTERISTICS OF WASTE SLUDGES

	COMPOSITION SLUDGE #1 (Weight Percent)	COMPOSITION SLUDGE #2 (Weight Percent)
<u>OVERALL COMPOSITION</u>		
Total Volatiles	60.00	100.00
Free Moisture	20.00	--
Ash	20.00	--
<u>VOLATILES</u>		
C	29.83	57.00
H	3.99	3.00
O	25.69	7.60
S	0.12	--
N	0.37	--
C ₁	--	32.40
HEAT OF COMBUSTION (BTU/LB Volatiles)	6000.0	9500.0
VISCOSITY	> 500 SSU	< 500 SSU
<u>ASH COMPOSITION</u>		
SiO ₂	30.0	--
Al ₂ O ₃	12.0	--
Fe ₂ O ₃	13.0	--
MgO	2.0	--
CaO	34.0	--
P ₂ O ₅	7.0	--

retention time in the primary incinerator and 2,000° F for two seconds in the afterburner to comply with legal restrictions (7). For the fluidized bed, a pressure of five psig is desired to insure proper fluidization (8). Relative dimensions for each system were obtained from the literature as common practice in industry (9). For the water based feed, the waste is unpumpable, therefore liquid injection combustors were considered unsuitable.

Dimensions of the combustors were based on the retention time and the length to diameter ratio. For the liquid injection primary and afterburner combustors, the length to diameter ratio was set at five. For the fluidized bed combustor, the length to diameter was set at two; and the rotary kiln was set at three. For all combustors, the material of construction was inconel-clad-stainless steel.

Pollution Control

Figure 13 indicates all of the equipment for all facilities used and the placement of each unit. Selection and placement of each process unit was based on practices common in the incineration industry.

Heat Recovery. Heat recovery units were used to cool the gases from 2,000 to 500° F to produce 150 psig steam. Heat recovery was used for all units except waste #1 at low feed rates (10,11). Additional cooling was supplied by a quench chamber to cool the emission gases to 180° F. The

shell material chosen for the quench chamber was Inconel-625 (13).

Venturi Scrubber. The venturi was designed to remove particulates in the stack gas to 0.08 grains per actual cubic feet of exhaust gas. Inconel was also selected for the materials of construction. The pressure drop was specified to be 40 inches of water to remove the particulates.

Packed Bed Absorber. Packed bed absorbers are specified to remove the hydrogen chloride produced in the combustion process. The material of construction was specified to be plastic reinforced fiberglass (approximately the same as carbon steel in cost). Packed bed scrubbing was not required for the water based sludge due to the low hydrogen chloride content.

Induction Fan. Induction fans were used to move the emission gases through the pollution control system. Placement of fan varies depending on the combustion system in question. For the rotary kiln and liquid injection system, the fan is located after the venturi. For the fluidized bed combustor, the fan is placed before the combustor to provide the air for the fluidization process. A pressure difference of 40 inches of water was specified as the pressure head for the downstream fans. A pressure head of 5 psig was specified for the fluidized bed fan. Because

of the corrosive environment in the downstream fans, they were constructed of Inconel-625 (13). All of other fans were constructed of carbon steel.

Exhaust Stack. Exhaust stacks were selected to be 50 feet tall for the small waste feed and 100 feet tall for the larger systems. Material of construction for all exhaust stacks was carbon steel.

Results of Hand Calculations

From the design parameters specified above, capital cost calculations were carried by hand and computer program to estimate the complete hazardous waste facility. Equipment selected for each system is summarized in Tables XXXVIII and XXXIX. These costs are based to 1985. The facilities were compared, according the DCFRR method and the results are shown in Figures 29 and 30. While these are the results of the hand calculations, they are close to the values of the computer program.

Examination of the results in Figure 29 and 30 suggest the following. First, all systems are economically cost competitive at large waste feed rates. This is due to the fact that the cost of the combustor is not significant compared to the other facility costs. At smaller waste feed rates, the liquid injection combustors are more cost effective than fluidized bed or rotary kiln combustors. Unfortunately, liquid injection combustors are not as

TABLE XXXVIII
HAZARDOUS WASTE INCINERATION PROCESS EQUIPMENT
SLUDGE #1

SYSTEM	LB/HR	HEAT RECOVERY	QUENCH CHAMBER	VENTURI SCRUBBER	INDUCTION FAN	PACKED BED	EXHAUST STACK
Rotary Kiln	500		X	X	X		X
	10,000	X	X	X	X		X
	20,000	X	X	X	X		X
Fluidized Bed	500						
	10,000	X	X	X	X		X
	20,000	X	X	X	X		X
Liquid Injection	500						
	10,000						THIS SYSTEM IS NOT APPROPRIATE FOR AN UNPUMPABLE SLUDGE
	20,000						
Plasma Arc Pyrolysis	500						
	10,000						THIS SYSTEM IS NOT APPROPRIATE FOR AN UNPUMPABLE SLUDGE
	20,000						

TABLE XXXIX
HAZARDOUS WASTE INCINERATION PROCESS EQUIPMENT
SLUDGE #2

SYSTEM	LB/HR	HEAT RECOVERY	QUENCH CHAMBER	VENTURI SCRUBBER	INDUCTION FAN	PACKED BED	EXHAUST STACK
Rotary Kiln	500	X	X	X	X	X	X
	10,000	X	X	X	X	X	X
	20,000	X	X	X	X	X	X
Fluidized Bed	500	X	X	X	X	X	X
	10,000	X	X	X	X	X	X
	20,000	X	X	X	X	X	X
Liquid Injection	500	X	X	X	X	X	X
	10,000	X	X	X	X	X	X
	20,000	X	X	X	X	X	X
Plasma Arc Pyrolysis	500	X	X	X	X	X	X
	10,000	X	X	X	X	X	X
	20,000	X	X	X	X	X	X

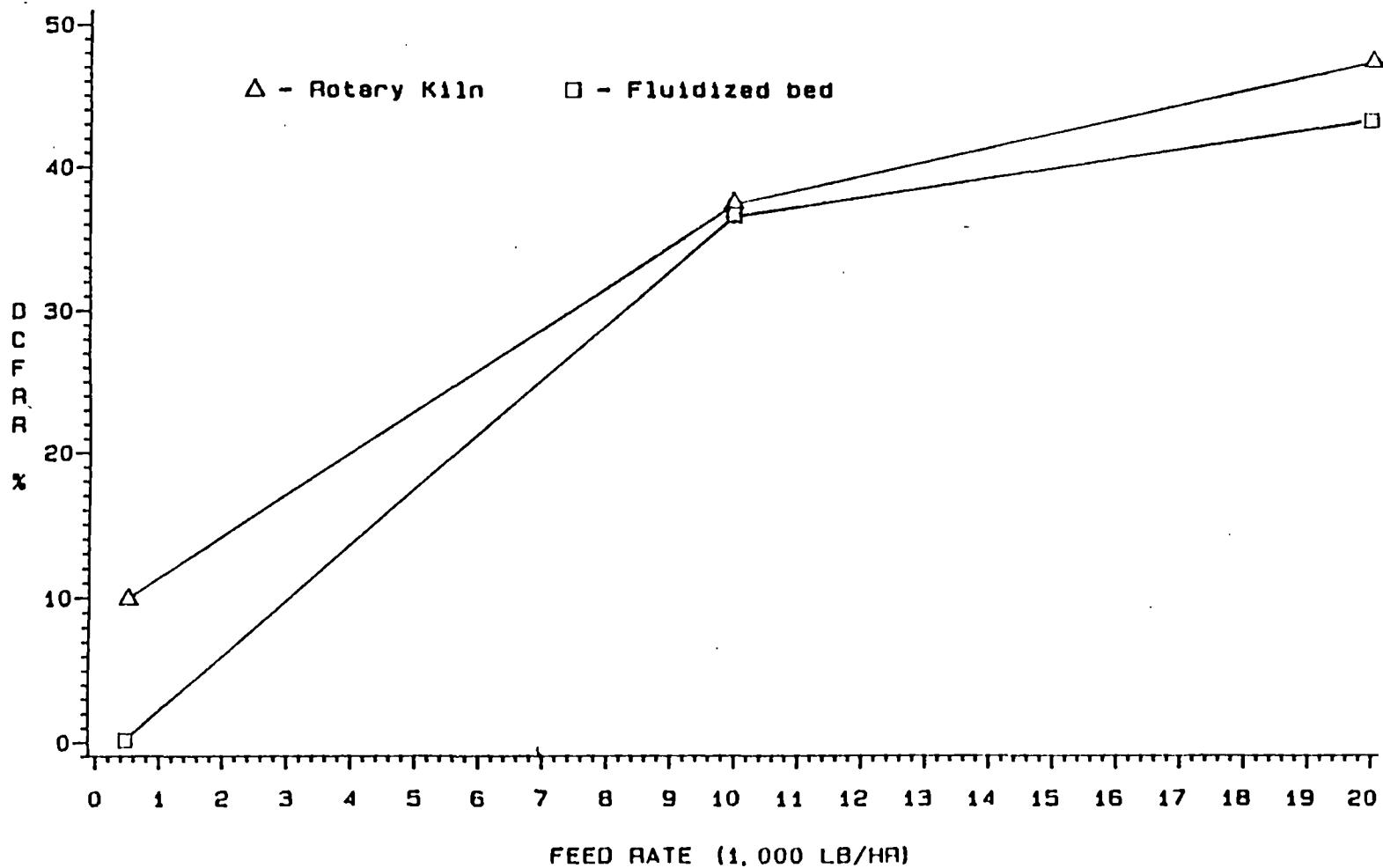


Figure 29. Discounted cash flow rate of return results for the hand design using waste feed #1.

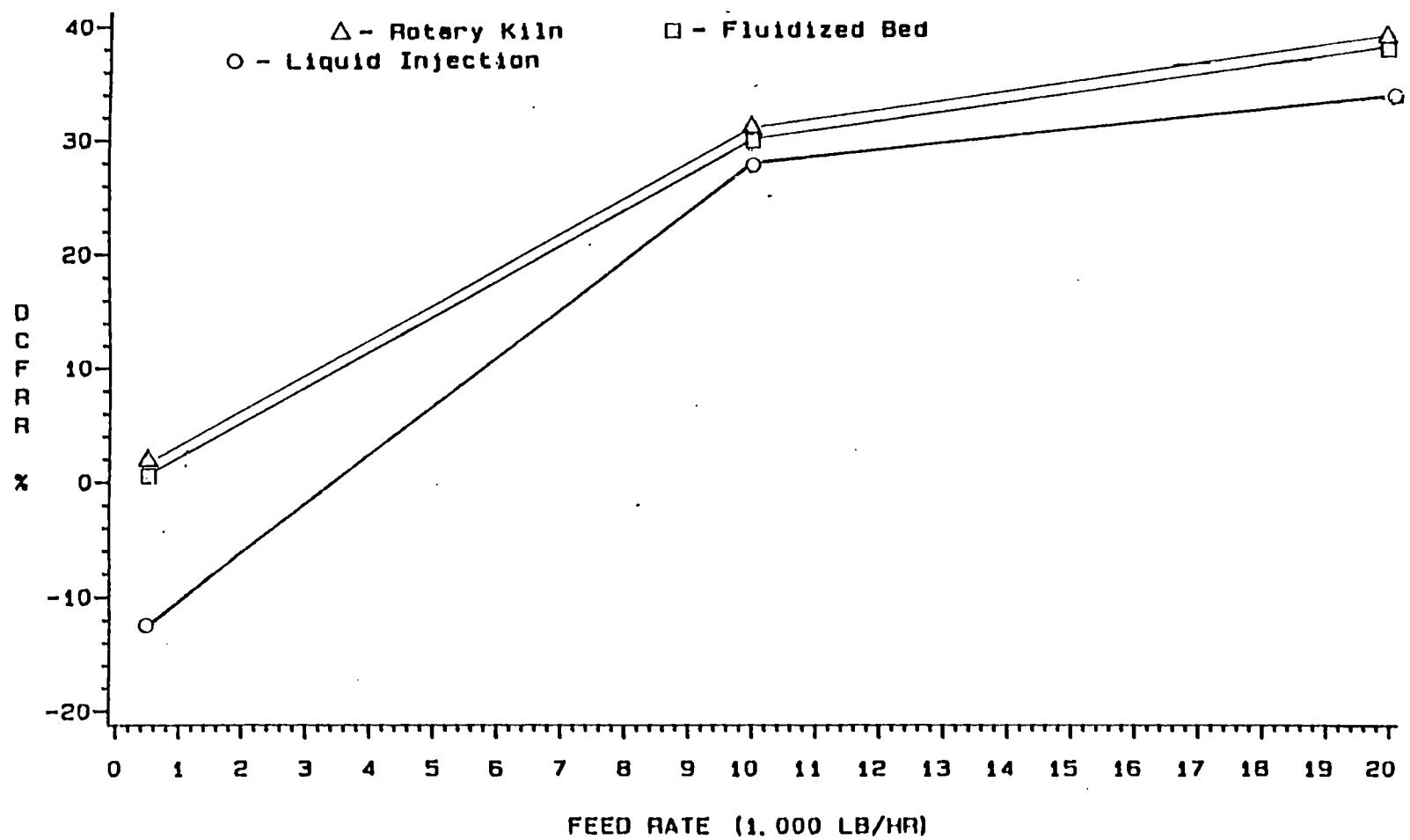


Figure 30. Discounted cash flow rate of return results for the hand design using waste feed #2.

flexible in the types of waste that are combusted. Although, not shown here, fluidized bed become more cost effective for wastes with high ash content at low feed rates. Third, the results indicate that with a 400 U.S. Dollars per ton charge to incinerate the wastes, at large feed rates, the facilities can be profitable.

Comparison of Hand Calculations and Computer Program Results. Figure 31 shows the comparison of the DCFRR determined by hand calculation and the results determined by the program. Comparison of the fluidized bed and liquid injection combustors yields the same results discussed above for the rotary kiln. The results apply for a rotary kiln combustor with waste #2 as the feed. Both results are approximately the same. The difference in the DCFRR at low feed rates is due to differences in process design and cost estimation procedures between the hand calculations and the program.

Comparison of Computer Costs With Actual Facility Costs

Very few capital costs were discovered in literature. The examples that were present, are not adequately described for comparison with the computer program. Cost estimates for comparison were also obtained from visitation to operating hazardous waste incineration facilities. The comparison of these results are presented below.

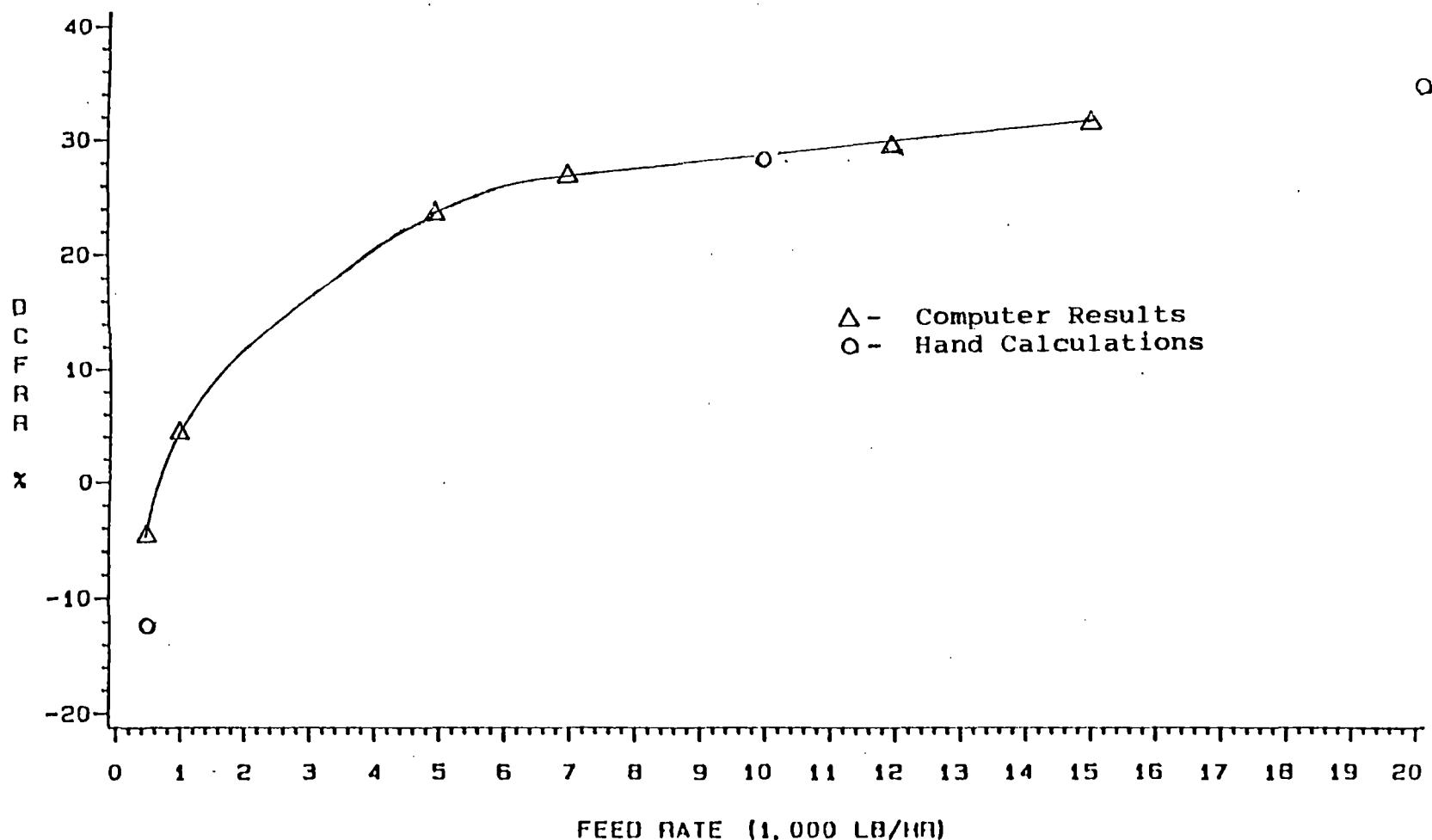


Figure 31. Comparison of the DCFRR values for the hand calculations with that of the computer results.

Capital Costs Obtained From Industry

A rotary kiln incinerator, for the combustion of chlorinated solvents, was constructed by Phillips Petroleum at the Phillips Research Center in Bartlesville Oklahoma. The cost of the facility equipment and installation was estimated at 2.7 to 3.0 million U.S Dollars (1981) (40). The computer program's cost estimation is 2.94 million U.S. Dollars (1981).

Capital Costs Obtained From Literature

A source that estimates the cost of a rotary kiln incinerator was published in literature by the Eastman Kodak Company (53). The capital cost of this facility was estimated at 11.3 million U.S. Dollars (1976). The computer program estimated, for the same facility, a capital cost of 9.20 million U.S. Dollars (1976).

Other sources were available in literature. Unfortunately, these sources did not adequately describe their design parameters and waste feed characteristics.

One source provides cost data for a fluidized bed incinerator and air preheater unit. This data was published by Brunner (1). The cost of these systems and computer program cost estimated is listed in Table XXXX and is based on the waste feed rate.

TABLE XXXX

COMPARISION OF CAPITAL COST ESTIMATED
FROM THE COMPUTER PROGRAM WITH DATA
PUBLISHED BY BRUNNER

Feed Rate(lb/hour)	Brunner	Program
200	180,000	188,100
400	300,000	318,000
1,000	550,000	865,000
2,000	850,000	1,466,000
2,900	1,150,000	2,500,000

These cost are calculated to 1980 (1). The difference in Brunners costs compared to those generated by the computer are due more to the heat recovery unit and not the cost of a fluidized bed combustor.

Comparison of the capital cost estimated by the computer program with that of the data available from different sources indicate that the program accurately estimates the cost of hazardous waste incineration facilities. In all cases, the greatest error in the cost was over 100 percent (See Table XXXX). The average error for all comparisons is 20 percent. While this indicates a reasonable amount of accuracy, more sources with adequate descriptions of the process conditions and waste characteristics must be found. Since sources in the literature have been exhausted, these costs must come from incineration facilities. Presently, from the capital cost data available, the accuracy of program HWSTBRN is limited to waste feed rates less than 10,000 lb per hour.

CHAPTER VII

FUTURE WORK

Further development is needed on this program.

Presently, this program provides adequate combustion and pollution control options to accomplish the required design considerations. Unfortunately, little has been done beyond this. Additional work that is recommended includes; combustion reaction calculations, additional process units, include portable as well as permanent facility sitework costs, increase user friendliness of the program, provide more flexibility in the economic analysis, more accurate cost estimates for some direct and indirect capital costs, and more data is needed to compare actual capital costs with that of the computer program. Improvements in these areas would greatly improve the quality of the program results and improve the user's ability to use the program

Combustion Reaction Calculations

One design method that can be improved is the calculation of the products of the combustion reaction. Presently, a simple stoichiometric balance is applied for a definite number of product gases. More waste feed elements and a larger variety of combustion product gases should be

included. There are also other methods available to calculate the product gas composition using advanced mathematical procedures.

Addition of Process Units

There are many combustors and pollution control options that are not available with this program. More hazardous waste combustors should be made available to expand the programs ability to handle special wastes and provide a greater range for economic comparisons. Additional pollution control process units should be included to provide more flexibility in particulate and caustic removal systems and to allow combining two units into one (such as packed bed absorbers and exhaust stacks).

Combustors

Additional destruction units that are recommended include; multiple hearth combustors and pyrolysis units. Multiple hearth should be included because it has proved to be effective in combustion of hazardous wastes with high solids (non-combustibles) content. Cost data is available on these units (See Literature Review section). Pyrolysis systems need to be included because this is an expanding field of hazardous waste destruction. An example of a pyrolysis system that has adequate cost data available is the plasma arc pyrolysis. Unfortunately, inclusion of pyrolysis presents special problems. Foremost of these

problems is calculation of the equilibrium destruction concentration. Complex computer programs are available. Unfortunately, the results of these programs (to my knowledge) are less than adequate for design purposes.

I also recommend inclusion of special combustion systems. Many of these systems, such as vertically fired updraft combustors, are variations of basic combustors which include (or do not require) special combustion or downstream process equipment.

Improvements on the capital cost estimation of the fluidized bed combustor should also be considered. Presently, this combustor cost estimation is questionable due to the use of bubble-cap trays to substitute for the fluidizing support trays.

Pollution Control

Additional pollution control units that should be included with the program are centered around particulate and caustic gas removal. The process units involved are venturi scrubbers and packed bed absorbers. The physical removal mechanisms (particulate entrainment and caustic gas chemical absorption) are the same in most cases regardless of the type of removal system in question. Therefore, in most cases, addition of these options would only require cost data.

Particulate Scrubbers. Presently, the computer program only allows specification of standard type venturi scrubbers. Other high energy scrubbers are available and used by many incineration facilities. These types should be included to improve the economic comparison aspect of the program with specific incineration facilities.

Besides high energy wet scrubbers, there are methods available to remove particulates from a gas stream without addition of water or large system pressure losses. The most prominent and economical of these is the electrostatic precipitators. These units are often specified. Therefore, design and cost data is probably available in literature.

Caustic Gas Scrubbers. Other pollution control options that should be included in the program are used to control caustic gas emissions. While counter-current vertical absorbers are used most often, plate absorption columns and horizontal co-current and counter-current absorbers may have practical applications. Plate type absorbers can be used if high absorption rates are desired. Horizontal units would have applications on skid-mounted and portable incineration facilities.

Other Capital Cost Improvements

Besides the addition of specific process units, other improvements can be made on the capital costs. Foremost of these is the sitework, direct, and indirect capital costs.

The cost of sitework, as mentioned before is highly variable depending on the type of waste, location of facility, and other sitework specifics. Options, such as portable combustion facilities and ship-based facilities are feasible for inclusion in the program.

Indirect facility capital costs are estimated by cost factors. As the accuracy of the cost estimation package is employed, a more logical approach will be required.

Economic Comparison Improvements

Future work for economic evaluation and comparison of facilities can be improved by several methods. Presently, only one simple method is used. An alternative method would be to calculate the revenue requirements to achieve a specific rate of return based on facility capital cost and process life. This would determine the cost per ton to incinerate a particular waste. Additionally, the time required to build the facility and time value of money should also be provided as an economic alternative.

Program Improvements

The most important area of future work is to improve the user friendliness of the computer package. Included are; change the program for interactive operation, allow design parameter changes without having to recompile the main program, increase amount of output relating to incorrect or unwise design parameters that are specified by the user.

Since the program is operated on a IBM 3085, only part of the computer package is interactive (the part that builds the input data file for the main program). Presently, changing the program is not feasible. But, with a different host computer, this would be a wise change. It would allow implementation of design changes to compare several processes and from warning messages issued by the main program. Once the main program becomes interactive, the other changes discussed above could be implemented.

Once the design and cost of a facility has been determined, the user should be allowed to respecify a single (or multiple) design parameter and recalculate the new cost. This would significantly improve the cost to operate the program and would require the addition of a small amount of computer code.

More improvement is also required on warning messages issued by the program. Presently, only critical design and cost problems cause the printing of a warning message. The additional messages would alert the user if the design or cost data for a individual unit is above or below the recommended range from the data source.

CHAPTER VIII

CONCLUSIONS

From the information presented in the previous chapters, the following conclusions can be drawn. First, there is adequate information available in literature to design and cost estimate hazardous waste incineration facilities. This is based primarily upon information on non-hazardous incineration and pollution control equipment. Second, the information available has been organized into a computer program. This includes allowing the selection of a large variety of combustor and pollution control options. Third, the results of this program are reasonably accurate compared to results available for specific operating facilities. Data available in literature limits the maximum waste feed rate to 10,000 lb/hr. This program should significantly add to information pertaining to the cost and economics of hazardous waste incineration facilities.

BIBLIOGRAPHY

1. Brunner, Calvin, Design of Sewage Sludge Incineration Systems, Park Ridge, New Jersey: Noyes Data Corporation, 1980.
2. Balakrishnan, S. and R.W. Okey, State of the Art Review on Sludge Incineration Practice, Federal Water Quality Administration, FWQA Contract 14-12-499, project no. 17070, Washington, D.C.: U.S. Government Printing Office, 1970.
3. Sewage Sludge Incineration, EPA-R2-72-040, Washington, D.C.: U.S. Government Printing Office, 1979.
4. Powers, Phillip, How to Dispose of Toxic Substances and Industrial Wastes, Park Ridge, New Jersey: Noyes Data Corporation, 1976.
5. Bonner, T., and B. Desai, Hazardous Waste Incineration Engineering, Park Ridge, New Jersey, Noyes Data Corporation, 1981.
6. Frankel, I. and N. Sanders, "Survey of the Incinerator Manufacturing Industry", Chemical Engineering, Vol. 90, (March, 1983), pp. 44-55.
7. Huang, Wen, "Factors Affecting the Performance of a Co-disposal Atmospheric Fluidized-Bed Combustor", 1982 National Waste Processing Conference, New York: The American Society of Mechanical Engineers, 1982, pp. 133-137.
8. Sneyd, Robert, "Energy Recovery from Fluidized-Bed Combustion", Chemical Engineering Progress, Vol. 91 (January, 1984), pp. 161-172.
9. Vogel, Gregory, and Edward J. Martin, "Estimating Costs of Equipment and Accessories", Chemical Engineering, Vol. 90 (October, 1983), pp. 75-78.

10. Gottko, Richard, "Emissions Control With Fluidized-Bed, Steam-Generating System", Chemical Engineering Progress Vol. 91 (January, 1984), pp. 148-160.
11. Kahane, Stephen and Suzanne Phinny, The Tightening Environmental Regulatory Climate for Hazardous Waste Management- Current Mandates and Future Directions for Industrial Compliance, New York: Jacobs Engineering Group, 1986.
12. Code of Federal Regulations, Title 40, Washington, D.C.: U.S. Government Printing Office, 1984.
13. Lepeau, Mateo, "Evaluating Heat Recovery from Burning Refuse", Chemical Engineering, Vol. 90 (March, 1983), pp. 81-84.
14. Vogel, Gregory, and Edward J. Martin, "Estimating Capital Costs of Facility Components", Chemical Engineering, Vol. 90 (November, 1983), pp. 87-90.
15. Corripiro, Armando B., "Estimate Costs of Heat Exchangers and Storage Tanks via Correlations", Chemical Engineering, Vol. 88 (January, 1982), pp. 125-127.
16. Santoleri, Joseph, "Optimum Energy and By-Product Recovery in Chlorinated Hydrocarbon Disposal Systems", 1982 National Waste Processing Conference, New York: The American Society of Mechanical Engineers, 1982, pp. 121-132.
17. Vatavuk, William, and Robert B. Neveril, "Part V: Estimating the Size and Cost of Gas Conditioners", Chemical Engineering Vol. 87 (January, 1980), pp. 127-132.
18. Seymour, Calvert, "How to Choose a Particulate Scrubber", Chemical Engineering, Vol. 84 (August, 1977), pp. 54-68.
19. Vogel, Gregory, and Edward J. Martin, "Estimating Operating Costs", Chemical Engineering, Vol. 91 (January, 1984), pp. 97-100.

20. Vatavuk, William, and Robert B. Neveril, "Part X: Estimating Size and Costs of Venturi Scrubbers", Chemical Engineering Vol. 87 (November, 1980), pp. 92-98.
21. Modern Pollution Control Technology, Volume I, New York: Research and Education Association, 1978.
22. Cheremisinoff, Paul, and Richard A. Young, eds, Air Pollution Control and Design Handbook Parts 1 and 2, New York: Marcel and Dekkar Inc., 1977.
23. Hanf, E.W. and J.W. MacDonald, "Economic Evaluation of Wet Scrubbers", Chemical Engineering Progress, Vol. 71 (March, 1975), pp. 48-52.
24. Perters, Max and Klaus Timmerhaus, Plant Design and Economics for Chemical Engineers, 3rd eds, New York: McGraw-Hill Book Company, 1980.
25. Vatavuk, William, and Robert B. Neveril, "Part VIII: Estimating Costs of Exhaust Stacks", Chemical Engineering Vol. 87 (October, 1980), pp. 129-130.
26. Vatavuk, William and Robert B. Neveril, "Part IV: Estimating the Size and Cost of Ductwork", Chemical Engineering Vol. 87 (December, 1980), pp. 71-73.
27. Vatavuk, William, and Robert B. Neveril, "Part VII: Estimating Costs of Fans and Accessories", Chemical Engineering Vol. 88 (May, 1981), pp. 171-175.
28. Vogel, Gregory, and Edward J. Martin, "Example of Incinerator Cost Estimation", Chemical Engineering, Vol. 91 (February, 1984), pp. 121-122.
29. Vatavuk, William, and Robert Neveril, "Part II: Factors for Estimating Capital and Operating Costs", Chemical Engineering, Vol. 87 (November, 1980), pp. 157-162.
30. Hesketh, Howard, and Mohan Krishna, "Specifying Venturi Scrubber Throat Length for Effective Particle Capture at Minimum Pressure Loss Penalty", Journal of

the Air Pollution Control Association", Vol. 33
(September, 1983), pp. 854-857.

31. Stearns, Conrad, and Schmidt Consulting Engineers, Disposal of Polychlorinated Biphenyls (PCBs) and PCB-Contaminated Materials, Volume I, FP-1207 Research Project 1263-1, Long Beach, California, 1979.
32. Sebastian, F.P., and G.F. Kroneberger, "Latest Developments on Polychlorinated Biphenyls Decomposition in BSP Multiple Hearth Furnaces", Industrial Process Design for Pollution Control, Volume 5, New York: American Institute of Chemical Engineers, 1974.
34. Perry, Robert, and Cecil Chilton, eds., Chemical Engineers Handbook, New York: McGraw-Hill Book Co., 1973.
35. "Chementator", Chemical Engineering, Vol. 88 (May, 1982), p. 18.
36. Vatavuk, William and Robert B. Neveril, "Part XII: Estimating the Size and Costs of Incinerators", Chemical Engineering Vol. 89 (March, 1982), pp. 153-160.
37. Kashdan, Edward and Ranade Madhav, "Design Guidelines for an Optimum Scrubber System", Environmental International Vol. 6 (1981), pp. 11-20.
38. Vatavuk, William, and Robert B. Neveril, "Part VI: Estimating Costs of Dust-Removal and Water-handling Equipment", Chemical Engineering Vol. 88 (May, 1981), pp. 223-228.
39. Uterberg, Walter, and Robert Sherwood, Computerized Design and Cost Estimation for Multiple-Hearth Sludge Incinerators, Federal Water Quality Administration, FWQA Contract 14-12-547, project no. 17070, Washington, D.C.: U.S. Government Printing Office, 1971.
40. Houser, Clarence, Hazardous Waste Incineration Project Leader, Phillips Petroleum, Bartlesville, Oklahoma, Interviewed on March 11, 1985.

41. Campbell, Jake, Combustion Engineering, and Scott Reed, Technical Engineer, John Zinc Inc., Tulsa, Oklahoma, Interviewed on March 29, 1986.
42. Vogel, Gregory, and Edward J. Martin, "Equipment Sizes and Integrated-Facility Costs", Chemical Engineering. Vol. 91, (September, 1983), pp. 143-146.
43. Contract Documents: Destruction of Hazardous Wastes Using Plasma Arc Technology, Niagara Falls, New York, Albany New York: New York State Department of Environmental Conservation, 1983.
44. Vatavuk, William and Robert B. Neveril, "Part XVII: Particle Emissions Control", Chemical Engineering Vol. 91 (April, 1984), pp. 91-99.
45. Lindsey, William, "Obtian Accurate Samples to Determine Scrubber Efficiency", Chemical Engineering, Vol. 93 (January, 1984), p. 103.
46. Sosa, F.J., and P.L. Fajardo, Particulate Air Pollution: Problems and Solutions, Boca Raton, Florida: CRC Press Inc., 1980.
47. Hall, Richard and Jay Matley, "Current Costs of Process Equipment", Chemical Engineering, Vol. 89 (April, 1982), pp. 120-129.
48. Vatavuk, William, and Robert Neveril, "Part I: Parameters for Sizing Systems", Chemical Engineering, Vol. 87 (October, 1980), pp. 165-168.
49. Miconnet, P, and P. Guigon, "Hydrogen Chloride Absorption in a Turbulent Contact Scrubber", The Chemical Engineering Journal, Vol. 22 (1981), pp. 143-149.
50. Hines, Anthony L, and Robert N. Maddox, Mass Transfer Fundamental and Applications, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1985.
51. Piasecke, Bruce, and Gary Davis, "A Grand Tour of Europe's Hazardous-Waste Facilities", Technology Review Vol. 92 (July, 1985), pp. 20-29.

52. Smith, Gerald, Engineering Economy: Analysis of Capital Expenditures, 2nd eds, Ames Iowa: Iowa State University Press, 1973.
53. Bastian, R.E. and W.R. Seeman, "The Design and Operation of a Chemical Waste Incinerator for the Eastman Kodak Company", 1982 National Waste Processing Conference, New York: The American Society of Mechanical Engineers, 1982, pp. 557-566.
54. Felder, Richard M., and Ronald W. Rousseau, Elemental Principles of Chemical Processes, New York: John Wiley & Sons, 1978.
55. Wills, Robert A. and Jeffrey D. Mathis, "Economic Considerations for Comparison of Hazardous Waste Incineration Facilities", American Institute of Chemical Engineers 1986 Spring Convention, Article presented in April, 1986.

APPENDIXES

APPENDIX A

CURVE FITTING CALCULATIONS

All of the design and cost data for the computer program, was curve-fit using the simplex method(55). Non-linear and linear curve-fit methods are used depending on the form of the data. The simplex method was used to optimize the curve-fit on non-linear equations. A computer program based on this method is listed in Appendix B.

A simple sum of least square method is used to curve-fit linear equations. The computer program to optimize the linear equation is presented in Appendix B. The data and the curve-fit equation are discussed separately under each unit. The maximum fractional error for all the curve-fitting procedures did not exceed 0.10 (10 percent error) and in most cases was less than 0.01 (1 percent).

Waste Feed Burners

The equation for the cost of a waste burner system was curve-fit from data in literature. Equation 44 was used to curve-fit this data.

$$Y = a * X + b \quad (44)$$

The constants for this data are listed in Table XXXXI.

TABLE XXXI
CURVE-FIT CONSTANTS FOR WASTE FEED
BURNER SYSTEM COSTS

a	b
<u>5.0E-4</u>	<u>26,000</u>

The cost is based on the heat release rate of the waste feed. The equation was curve-fit using the linear curve-fit program in Appendix B.

Incinerator Waste Feed System

The cost of a waste feed system to feed containers (other than 55-gallon barrels) was obtained from literature (9). The data was curve-fit to equation 44. The cost of a ram feed system is based on the waste feed rate (lb/hour). The constants for this curve-fit are listed in Table XXXII.

TABLE XXXII
CURVE-FIT CONSTANTS FOR SOLIDS WASTES FEED SYSTEM

a	b
<u>2727</u>	<u>4545.</u>

This equation was fit using the linear curve-fitting program in Appendix B. Appendix B.

Cost of Sieve and Valve Trays

Based on Fluidized Bed

Diameter

The data used to curve-fit the equation is listed in Figure 11. The general equation used is listed in equation 45.

$$Y = a + b * X + c * X^2 + d * X^3 \quad (45)$$

This equation was curve-fit using a linear curve-fitting program(See Appendix B. The results are represented in Table XXXXIII.

TABLE XXXXIII

CURVE-FIT CONSTANTS TO COST SUPPORT TRAYS
FOR THE FLUIDIZED BED COMBUSTOR

Carbon Steel Construction

Type	a	b	c	d
Sieve Tray	2.00	0.157	0.111	0.00
Valve Tray	2.91	-0.185	0.212	0.00

316 Stainless Steel Construction

Type	a	b	c	d
Sieve Tray	2.81	-0.462	0.103	0.00
Valve Tray	1.28	-0.589	0.066	0.0075

These equations are applied in Function TRAYCS.

Cost factors, depending on the quantity of trays required, is listed in Table XXXXIV.

TABLE XXXXIV

QUANTITY FACTORS TO DETERMINE COST
OF FLUIDIZED BED SUPPORT TRAYS

Quantity	Cost Factors
1	3.00
2	2.80
3	2.65
4	2.50
5	2.30

For the computer program, this value is one. Two trays are required, but they are different sizes.

Fluidized Bed Diameter

A linear equation was used to fit both sets of data to calculate the fluidized bed diameter(See Table IX and X). The data was fit to equation 44. The value of the constants ae listed in Table XXXXV.

TABLE XXXV
CURVE-FIT CONSTANTS TO CALCULATE FLUIDIZED
BED SUPPORT TRAYS

Data	a	b
TABLE IX(Cold Air Feed)	0.001	7.83
TABLE IX (Hot Air Feed)	0.001	7.89
TABLE X(Hot Air Feed)	0.267	8.69

The constants calculated from Table X are based on the evaporation rate of the water in the waste feed. The constants calculated from Table X are based on the heat release rate in the incinerator(millions of Btu/hour). These equations are applied in Subroutine INCDES.

Heat Recovery Boiler Pressure

Drop

The pressure drop through the heat recovery boiler is estimated from Table XII. This data was curve-fit to equation 44. The constants for this equation are listed below in Table XXXVI.

TABLE XXXVI
CURVE-FIT CONSTANTS TO CALCULATE THE PRESSURE
DROP IN A HEAT RECOVERY BOILER

<u>a</u>	<u>b</u>
0.872	-1.920

The independent variable in this equation is the percent of heat recovered. The pressure drop is calculated in inches of water. This equation is used in subroutine HTEXCH.

Particulate Cut Diameter

versus Venturi Scrubber

Pressure Drop

Calculation of particulate removal efficiency using the cut-diameter method was curve-fit using the data in Figure 16. The data was curve fit to equation 47. The constants for this equation are listed in Table XXXVII.

TABLE XXXVII
CURVE-FIT CONSTANTS TO CALCULATE THE CUT-DIAMETER FOR
PARTICULATE REMOVAL IN VENTURI SCRUBBERS

<u>a</u>	<u>b</u>
-0.519	0.856

The independent variable in this equation is the gas phase pressure drop(inches of H₂O). The cut diameter is in microns. This equation is used in subroutine VENTUR.
bototm

Particulate Removal Efficiency
versus the Particle Size for a
Specific Pressure Drop

The set of curves represented by Figure 12 are curve fit using the general equation:

$$Y = a \exp(b*x^c) + d \quad (46)$$

The equation was curve-fit using the non-linear curve-fitting program SIMP listed in Appendix B. The constants(a,b,c, and, d) depend on the pressure drop and are represented in Table XXXXVIII.

TABLE XXXXVIII

CURVE-FIT CONSTANTS TO CALCULATE THE CUT DIAMETER FOR PARTICULATE REMOVAL IN VENTURI SCRUBBERS

Pressure Drop (Inches H ₂ O)	a	b	c	d
10	9.437	1.864	0.178	-12.43
20	17.856	1.455	0.126	0.9600
30	48.714	1.324	0.054	-95.25
40	20.473	1.730	0.041	-20.30
60	25.735	1.329	0.029	1.339
80	25.695	1.340	0.018	1.836

These equations are used in Function WTPPRT.

Venturi Scrubber Wall

Thickness

The thickness of the venturi scrubber wall was curve-fit from data in Figure 17. This data is fit using equation 47.

$$Y = a * \log (X) + b \quad (47)$$

A linear curve-fit method was used to determine the constants of equation 43. These constants are represented in Table XXXIX. The equation are based on the venturi pressure drop for a given wall thickness.

TABLE XXXIX

CURVE-FIT CONSTANTS TO CALCULATE THE VENTURI SCRUBBER WALL THICKNESS

Wall Thickness(inches)	a	b
1/8	-0.956	9.509
3/16	-0.991	9.294
1/4	-1.00	8.888
5/16	-1.046	8.535
3/8	-1.00	7.601
7/16	-1.00	6.685
1/2	-0.930	9.796

The dependent variable(x-value) is the venturi scrubber pressure drop. The equations are used in Function THICK.

Venturi Scrubber Cost

Adjustment Factor

The cost adjustment factors data for venturi scrubber is represented in Figure 17. This data is curve-fit using equation 47. The linear curve-fit routine was used to fit the data(See Appendix B). The constants are represented in Table L.

TABLE L

CURVE-FIT CONSTANTS TO CALCULATE THE COST ADJUSTMENT FACTOR FOR VENTURI SCRUBBER WALL THICKNESS

Wall Thickness(inches)	a	b
1/8	0.0	1.0
3/16	-7.0E-3	1.57
1/4	-6.25E-3	1.96
5/16	-0.0121	3.22
3/8	-0.0175	4.83
7/16	-0.021	6.46
1/2	-0.003	8.30

These equations are based on the gas volume rate for a given metal th thickness. The dependent variable(x-value) in this equation is the gas volume rate for a given metal wall thickness. These equations are used in subroutine VENTUR.

Pressure Adjustment Factors
for Height and Temperature

Factors to correct the pressure head of the induction fans(due to elevation) is represented in Figure 19. The non-linear curve-fitting program(Appendix B) was used to determine the constants in equation 48.

$$Y = a * \tan (x b + c) + d \quad (48)$$

These constants are presented in Table LI depending on the elevation above sea level.

TABLE LI
 CURVE-FIT CONSTANTS TO CALCULATE THE
 PRESSURE ADJUSTMENT FACTOR FOR THE
 INDUCTION FAN

Height(Feet)	a	b	c	d
0.0	4.883	-1.03	0.258	0.467
2000	1.220	-1.72	0.137	-0.138
4000	1.956	-1.228	0.118	-0.361
8000	1.708	0.101	-2.775	-1.062
20000	2.419	-0.931	0.052	-1.272

The dependent variable (x-value) in these equations are the temperature. The equations are used in subroutine INDFAN.

Induction Fan Horsepower and
RPMs Calculation

The set of curves represented by Figure 20 are curve-fit using the general equation 47. The equation was curve-fit using a linear curve fit program listed in Appendix B. The constants a and b are calculated depending on the horsepower(for the energy calculation). These constants are represented in Table LII.

TABLE LII
 CURVE-FIT CONSTANTS TO CALCULATE THE
 INDUCTION FAN HORSEPOWER

HP	a	b
5.0	-0.999	8.5172
2.0	-1.000	9.2100
5.0	-1.060	10.13
10.0	-1.000	10.82
20.0	-1.000	11.51
50.0	-1.080	12.43
100.0	-1.000	13.12
200.0	-1.000	13.82
500.0	-1.080	14.88

Constants curve-fit for to calculate the rpms is listed below in Table LIII.

TABLE LIII
CURVE-FIT CONSTANTS TO CALCULATE THE
INDUCTION FAN HORSEPOWER

RPM	a	b
300	1.416	10.043
500	1.441	8.99
750	1.476	8.01
1000	1.441	7.60
1500	1.731	5.97
2000	1.571	5.84
2500	1.441	5.59
3000	1.244	5.54
3500	1.450	4.899

The power and rpms for the fan system was determined by the following method. First, a pressure head for a single fan is guessed(beginning at 20 inches of H_2O). The pressure is inserted as the independent variable in the equations to determine the volumetric flow rate for a given amount of power(HP). If the calculated volume rate is less than the actual volume rate, the program moves to the next highest horsepower equation(See Table LIV). This procedure is repeated until the calculated volume rate is greater than the actual volume rate. If the program moves through the entire set of equations, the pressure drop is decreased and the procedure is repeated until the problem is solved. The calculation of the rpms is the same as for the horsepower procedure.

Cost of Induction Fan Motor

The relationship between motor rotation and brake horsepower determines the cost of the motor in question. Data curve-fit was obtained from Figure 20. The general equation for this data is listed in equation 49.

$$Y = c + a * X + b * X^2 \quad (49)$$

One equation must be curve-fit for every motor rotation speed. Motor costs were available only for specific rotation speeds. The constants from equation 49 applied to the data in Figure 20 is listed in Table LIV.

TABLE LIV

CURVE-FIT CONSTANTS TO CALCULATE THE COST OF AN INDUCTION FAN MOTOR

RPMs	a	b	c
600	0.088	0.0965	4.337
900	0.185	0.159	5.924
1200	0.225	0.093	4.721
<u>1800 - 3600</u>	<u>0.125</u>	<u>0.103</u>	<u>4.546</u>

These equations are applied in Subroutine INDFAN. Calculation of horse-power and fan rpm's is based on pressure drop per fan versus the air volumetric flowrate

Lobo Correlation for Packed
Bed Absorbers

Data used to calculate the diameter of a packed bed absorber are represented in Figure 9. Due to the difficulties, the data was curve fit in three parts. The value of these constants are listed in Table LV.

TABLE LV

CURVE-FIT CONSTANTS FOR THE LOBO CORRELATION
TO CALCULATE THE PACKED BED ABSORBER
DIAMETER

X-axis Range	a	b	c
0.01 - 0.10	-3.981	22.91	0.2827
0.10 - 1.00	-0.219	0.131	0.112
1.00 - 8.00	-7.4E-3	5.94E-4	0.0236

This data was curve-fit using the linear curve-fit program in Appendix B. Variables for the X and Y axis are listed in Figure 9.

Packing Factor for Packed Bed
Absorbers

Packing factors used to calculate the diameter of a packed bed absorber are represented in Figure 22. Two equations were required; one for Berl saddles, and one for

Raschig rings. Data was curve-fit using equation (45). The constants for this data is listed in Table LVI.

TABLE LVI

CURVE-FITCONSTANTS TO DETERMINE THE PACKING FACTOR FOR THE PACKED BED ABSORBER

Packing Type	a	b	c	d
Berl Saddles	9558	-37200	50500	-28383
Raschig Rings	3714	-17151	34400	-34100

Packed Bed Absorber Cost

The cost of a packed bed absorber is represented in Figure 24. Two equations are curve-fit; one for carbon steel materials, and the other for 316 stainless steel materials of construction. These curves are represented by equation 45. The constants for the data (from Figure 24) is represented in Table LVII.

TABLE LVII

CURVE-FIT CONSTANTS TO CALCULATE THE COST OF A PACKED BED ABSORBER

Construction	a	b	c	d
Carbon Steel	24.29	7.71	-4.e-4	3.e-4
Stainless Steel	28.91	22.03	-0.166	0.003

This data is used in Subroutine PCKBD.

Structural Steel, Metal Building,
Instruments and Electrical
Materials Cost

The cost of structural steel, metal building instruments and electrical materials is curve-fit to equation 44. These costs are represented in Figures 11 and 12. The values of the constants from this equation are listed in Table LVIII.

TABLE LVIII

CURVE-FIT CONSTANTS TO CALCULATE THE COST OF STRUCTURAL
STEEL, METAL BUILDING, INSTRUMENTS AND
ELECTRICAL MATERIALS

	a	b
Structural Steel	3.146	19.54
Metal Building	10.696	73.54
Instruments and		
Controls	3.211	43.60
Electrical		
Materials	12.280	1.616

This data is used in Subroutine CAPTAL.

Capital and Operating Costs for a
Wastewater Treatment Facility

Calculation of the capital and operating costs for the treatment of waste water effluent is represented in Table XXVI. These costs were curve-fit to equation 44. The constants calculated are represented in Table LIX.

TABLE LIX
CURVE-FIT CONSTANTS TO CALCULATE THE CAPTIAL
AND OPERATING COSTS FOR WASTEWATER
TREATMENT FACILITIES

	a	b
Capital Cost	1.221	-11.0
Operating Cost	-1.8E-4	2.15

The independent variable for these equations are gallons of waste water per minute. For the capital cost, the cost is in thousands of U.S. Dollars. The operating cost is in U.S. Dollars per thousand gallons of waste water feed. The capital cost equation is used in subroutine CAPTAL, and the operating cost equation is used in subroutine OPER.

APPENDIX B

COMPUTER PROGRAM LISTING FOR THE LINEAR AND NON
LINEAR CURVE FITTING PROCEDURE

```

COMMON/FRST/ L(20),H(20),CENTER(20),ERROR(20),TSIMP(20),XVAR(20), 0000001C
1 MAXERR(20),MEAN(20),STEP(20),DATA(20,2),P(20),Q(20) 0000002C
COMMON/SEC/M,NITER,MXITER,NVPP,N,NP,ALFA,BETA,GAMMA,ROOT2,IDEBUG 00000030
COMMON/LOGIC/ DONE
      DIMENSION SIMP(20,20),NEXT(20,20) 00000050
      LOGICAL DONE 00000060
      REAL L,MEAN,MAXERR,NEXT 00000070
      IDEBUG=0 00000080
      M=3 00000090
      NVPP=2 00000100
      N=M+1 00000110
      NP=200 00000120
      ALFA =1.0 00000130
      BETA=0.5 00000140
      GAMMA=2.0 00000150
      LW=5 00000160
      PAGE=12 00000170
      ROOT2=1.414214 00000180
      CALL ENTER(SIMP) 00000190
      CALL SOR(SIMP,1) 00000200
      DO 39 I=1,M 00000210
        P(I)=STEP(I)*(N**C.50+M-1.)/(M*ROOT2) 00000220
        Q(I)=STEP(I)*(N**O.50-1.0)/(M*ROOT2) 00000230
      39 CONTINUE 00000240
      DO 40 I=2,N 00000250
        DO 41 J=1,M 00000260
          SIMP(I,J)=SIMP(1,J)+Q(J) 00000270
      41 CONTINUE 00000280
      SIMP(I,I-1) = SIMP(1,I-1) + P(I-1) 00000290
      CALL SOR(SIMP,I) 00000300
      40 CONTINUE 00000310
      DO 42 I=1,N 00000320
        L(I)=1 00000330
        H(I)=1 00000340
      42 CONTINUE 00000350
      CALL FIRST(SIMP) 00000360
      NITER=C 00000370
      100 CONTINUE 00000380
      DONE = .TRUE. 00000390
      NITER=NITER+1 00000400
      DO 43 I=1,N 00000410
        CENTER(I)=O.O 00000420
      43 CONTINUE 00000430
      DO 44 I=1,N 00000440
        IF(I.NE.H(N)) THEN 00000450
          DO 46 J=1,M 00000460
            CENTER(J)=CENTER(J)+SIMP(I,J) 00000470
        46 CONTINUE 00000480
        ENDIF 00000490
      44 CONTINUE 00000500
      DO 60 I=1,N 00000510
        CENTER(I)=CENTER(I)/M 00000520
        NEXT(1,I)=(1.0+ALFA)*CENTER(I)-ALFA*SIMP(H(N),I) 00000530
      60 CONTINUE 00000540
      CALL SOR(NEXT,1) 00000550
      IF(NEXT(1,N).LE.SIMP(L(N),N))THEN 00000560
        CALL NV(NEXT,SIMP) 00000570
        DO 47 I=1,M 00000580
          NEXT(1,I)=GAMMA*SIMP(H(N),I)+(1.0-GAMMA)*CENTER(I) 00000590
      47 CONTINUE 00000600
      CALL SOR(NEXT,1) 00000610
      IF(NEXT(1,N).LE.SIMP(L(N),N)) CALL NV(NEXT,SIMP) 00000620
    ELSE
      IF(NEXT(1,N).LE.SIMP(H(N),N) ) THEN 00000630
        CALL NV(NEXT,SIMP) 00000640
      ELSE
        DO 49 I=1,M 00000650
          NEXT(1,I)=BETA*SIMP(H(N),I)+(1.0-BETA)*CENTER(I) 00000660
      49 CONTINUE 00000670
      CALL SOR(NEXT,1) 00000680
      IF(NEXT(1,N).LE.SIMP(H(N),N)) THEN 00000690
        CALL NV(NEXT,SIMP) 00000700
      ELSE
        DO 50 I=1,M 00000710
          NEXT(1,I)=ALFA*SIMP(H(N),I)+(1.0-ALFA)*CENTER(I) 00000720
      50 CONTINUE
    ENDIF
  ENDIF
END

```

```

      ELSE                                00000730
        DO 50 I=1,N                         00000740
          DO 51 J=1,M                         00000750
            SIMP(I,J)=(SIMP(I,J)+SIMP(L(N),J))*BETA 00000760
51        CONTINUE                           00000770
        CALL SOR(SIMP,I)                     00000780
50        CONTINUE                           00000790
        ENDIF                               00000800
        ENDIF                               00000810
      ENDIF                                00000820
      CALL ORDER(SIMP)                      00000830
      DO 52 J=1,N                         00000840
        ERROR(J)=ABS((SIMP(H(J),J)-SIMP(L(J),J))/SIMP(H(J),J)) 00000850
        IF(IDEBUG.EQ.1) WRITE(6,505) ERROR(J),MAXERR(J) 00000860
505 FORMAT(5X,'ERROR CALCULATED= ',E14.4,'MAXERR=',E14.4) 00000870
        IF(DONE) THEN                       00000880
          IF(ERROR(J).GT.MAXERR(J)) THEN    00000890
            DONE=.FALSE.                   00000900
          ENDIF                            00000910
        ENDIF                            00000920
52 CONTINUE                           00000930
      IF(.NOT.(DONE.OR.NITER.GE.MXITER)) GOTO 100 00000940
      DO 53 I=1,N                         00000950
        MEAN(I)=O.O                        00000960
        DO 54 J=1,N                         00000970
          MEAN(I)=MEAN(I)+SIMP(J,I)        00000980
54 CONTINUE                           00000990
        MEAN(I)=MEAN(I)/N                  00001000
53 CONTINUE                           00001010
      CALL REPORT(SIMP)                   00001020
      STOP                                00001030
      END                                 00001040
      SUBROUTINE ENTER(SIMP)              00001050
      COMMON//FRST/ L(20),H(20),CENTER(20),ERROR(20),TSIMP(20),XVAR(20), 00001060
1 MAXERR(20),MEAN(20),STEP(20),DATA(20,2),P(20),Q(20) 00001070
      COMMON//SEC/M,NITER,MXITER,NVPP,N,NP,ALFA,BETA,GAMMA,ROOT2,IDEBUG 00001080
      COMMON//LOGIC/ DONE                00001090
        DIMENSION SIMP(20,20),NEXT(20,20) 00001100
        LOGICAL DONE                      00001110
        REAL L,MEAN,MAXERR,NEXT           00001120
        WRITE(6,10)                      00001130
10 FORMAT(5X,'INPUT DATA')             00001140
        READ(4,11) MXITER                 00001150
11 FORMAT(1X,I3)                      00001160
        DO 20,I=1,M                      00001170
          READ(4,21) SIMP(I,I)            00001180
21 FORMAT(1X,F7.2)                    00001190
22 FORMAT(1X,E7.2)                    00001200
24 FORMAT(1X,I3)                      00001210
23 FORMAT(1X,5(F9.3))                00001220
20 CONTINUE                           00001230
        DO 30 I=1,M                      00001240
          READ(4,21) STEP(I)              00001250
30 CONTINUE                           00001260
        DO 40 I=1,N                      00001270
          READ(4,22) MAXERR(I)            00001280
40 CONTINUE                           00001290
        NP=0                                00001300
        READ(4,24) NP                      00001310
        DO 31 II=1,NP                     00001320
          READ(4,23) DATA(II,1),DATA(II,2) 00001330
C         DATA(II,1) = LOG(DATA(II,1))   00001340
C         DATA(II,2) = LOG(DATA(II,2))   00001350
31 CONTINUE                           00001360
        WRITE(6,100) MXITER                00001370
100 FORMAT(5X,'MAXIMUM ITERATIONS= ',I5) 00001380
        WRITE(6,101) (SIMP(I,I),I=1,M)    00001390
101 FORMAT(5X,'STARTING COEFFICIENTS:',5(E15.5)) 00001400
        WRITE(6,102) (STEP(I),I=1,M)      00001410
102 FORMAT(5X,'STARTING STEPS:',5(E15.5)) 00001420
        WRITE(6,103) (MAXERR(I),I=1,N)    00001430
103 FORMAT(5X,'MAXIMUM ERROR:',5(E15.5)) 00001440

```

```

        WRITE(6,106)                               00001450
106 FORMAT(5X,'POINT #           X-VALUE      Y-VALUE') 00001460
104 FORMAT(5X,I3,2E15.5)                      00001470
      DO 105 I=1,NP
         WRITE(6,104) I,(DATA(I,II),II=1,NVPP) 00001480
105 CONTINUE
      RETURN
      END
      SUBROUTINE SOR(X,II)                      00001490
      COMMON/FRST/ L(20),H(20),CENTER(20),ERROR(20),TSIMP(20),XVAR(20),
1 MAXERR(20),MEAN(20),STEP(20),DATA(20,2),P(20),Q(20) 00001500
      COMMON/SEC/M,NITER,MXITER,NVPP,N,NP,ALFA,BETA,GAMMA,ROOT2,IDEBUG 00001510
      COMMON/LOGIC/ DONE
         DIMENSION X(20,20)                      00001520
         LOGICAL DONE                           00001530
         REAL L,MEAN,MAXERR,NEXT                00001540
      DO 12 I=1,NP
         XVAR(I)=DATA(I,1)                      00001550
         IF (IDEBUG.EQ.1) WRITE(6,500) I,XVAR(I) 00001560
500 FORMAT(5X,'#= ',I3,'X-VALUE= ',F9.2)       00001570
12 CONTINUE
      DO 11 I=1,M
         TSIMP(I)=X(II,I)                      00001580
         IF (IDEBUG.EQ.1) WRITE(6,501) I,TSIMP(I) 00001590
501 FORMAT(5X,'#= ',I3,'COEFF = ',F9.2)       00001600
11 CONTINUE
      X(II,N)=0.0                            00001610
      DO 10 I=1,NP
         X(II,N) = X(II,N) + (ABS(F(TSIMP,XVAR(I))- DATA(I,2)))**2.0 00001620
10 CONTINUE
      RETURN
      END
      SUBROUTINE FIRST(SIMP)                   00001630
      COMMON/FRST/ L(20),H(20),CENTER(20),ERROR(20),TSIMP(20),XVAR(20),
1 MAXERR(20),MEAN(20),STEP(20),DATA(20,2),P(20),Q(20) 00001640
      COMMON/SEC/M,NITER,MXITER,NVPP,N,NP,ALFA,BETA,GAMMA,ROOT2,IDEBUG 00001650
      COMMON/LOGIC/ DONE
         DIMENSION SIMP(20,20),NEXT(20,20)    00001660
         LOGICAL DONE                           00001670
         REAL L,MEAN,MAXERR,NEXT                00001680
      DO 10 J=1,N
         WRITE(6,20) J,(SIMP(J,I),I=1,N)      00001690
20 FORMAT(5X,'SIMP(''.I2,'')= ',5(E15.5))     00001700
10 CONTINUE
      RETURN
      END
      SUBROUTINE NV(NEXT,SIMP)                 00001710
      COMMON/FRST/ L(20),H(20),CENTER(20),ERROR(20),TSIMP(20),XVAR(20),
1 MAXERR(20),MEAN(20),STEP(20),DATA(20,2),P(20),Q(20) 00001720
      COMMON/SEC/M,NITER,MXITER,NVPP,N,NP,ALFA,BETA,GAMMA,ROOT2,IDEBUG 00001730
      COMMON/LOGIC/ DONE
         DIMENSION SIMP(20,20),NEXT(20,20)    00001740
         LOGICAL DONE                           00001750
         REAL L,MEAN,MAXERR,NEXT                00001760
         IF(IDEBUG.EQ.1) WRITE(6,10) NITER
10 FORMAT(5X,'-----',I4)                    00001770
      DO 20 I=1,N
         SIMP(H(N),I)=NEXT(1,I)              00001780
20 CONTINUE
      RETURN
      END
      SUBROUTINE ORDER(SIMP)                  00001790
      COMMON/FRST/ L(20),H(20),CENTER(20),ERROR(20),TSIMP(20),XVAR(20),
1 MAXERR(20),MEAN(20),STEP(20),DATA(20,2),P(20),Q(20) 00001800
      COMMON/SEC/M,NITER,MXITER,NVPP,N,NP,ALFA,BETA,GAMMA,ROOT2,IDEBUG 00001810
      COMMON/LOGIC/ DONE
         DIMENSION SIMP(20,20),NEXT(20,20)    00001820
         LOGICAL DONE                           00001830
         REAL L,MEAN,MAXERR,NEXT                00001840
      DO 10 J=1,N
         DO 20 I=1,N
            IF(SIMP(I,J).LT.SIMP(L(J),J)) L(J)=I 00001850
20 CONTINUE
10 CONTINUE
      RETURN
      END

```

```

      IF(SIMP(I,J).GT.SIMP(H(J),J)) H(J)=I
20    CONTINUE
10  CONTINUE
RETURN
END
SUBROUTINE REPORT(SIMP)
COMMON//FRST/ L(20),H(20),CENTER(20),ERROR(20),TSIMP(20),XVAR(20),
1 MAXERR(20),MEAN(20),STEP(20),DATA(20,2),P(20),Q(20)
COMMON//SEC/M,NITER,MXITER,NVPP,N,NP,ALFA,BETA,GAMMA,ROOT2,IDEBUG
COMMON//LOGIC/ DONE
DIMENSION SIMP(20,20),NEXT(20,20)
LOGICAL DONE
REAL L,MEAN,MAXERR,NEXT
WRITE(6,10) NITER
10 FORMAT(5X,'PRIGRAM EXITED AFTER ',I5,' ITERATIONS')
WRITE(6,11)
11 FORMAT(5X,'THE FINAL SIMPLEX IS')
DO 100 J=1,N
  WRITE(6,12) (SIMP(J,I),I=1,N)
12 FORMAT(2X,(7F9.3))
100 CONTINUE
WRITE(6,13)
13 FORMAT(5X,'THE MEAN IS;')
  WRITE(6,14) (MEAN(I),I=1,N)
14 FORMAT(5X,7(F9.5))
  WRITE(6,110)
110 FORMAT(5X,'THE ESTIMATED FRACTIONAL ERROR IS;')
  WRITE(6,15) (ERROR(I),I=1,N)
15 FORMAT(2X,(7E12.4))
  WRITE(6,120)
120 FORMAT(5X,'#          X           Y           Y**"           DY')
SIGMA=0.0
DO 51 I=1,NP
  XVAR(I)= DATA(I,1)
51 CONTINUE
DO 50 I=1,NP
  Y=F(MEAN,XVAR(I))
  DY=DATA(I,2)-Y
  SIGMA=SIGMA+(ABS(DY))**2.0
  WRITE(6,130) I,DATA(I,1),DATA(I,2),Y,DY
130 FORMAT(3X,I3.5(E12.5))
50 CONTINUE
SIGMA=(SIGMA/NP)**0.50
WRITE(6,140) SIGMA
140 FORMAT(5X,'THE STANDARD DEVIATION IS=',F15.4)
SIGMA=SIGMA/(NP-M)**0.50
WRITE(6,150) SIGMA
150 FORMAT(5X,'THE FRACTIONAL ESTIMATED ERROR OF THE '/5X,
1 ' IS= ',E15.4)
STOP
END
FUNCTION F(X,D)
DIMENSION X(20)
F=X(1)*D+X(2)*D**2.+X(3)
IF(IDEBUG.EQ.1) WRITE(6,10) F,X(1),X(2),X(3),X(4),D
10 FORMAT(5X,'FUNCTION = ',E15.5/5X,'A= ',F9.2,'B= ',F9.2/
1 5X,'X-VALUE= ',F9.2)
RETURN
END

```

APPENDIX C

SELECTED LIST OF VARIABLES USED IN PROGRAM HWSTBRN

AFTINC	- Total capital cost of afterburner (U.S Dollars).
AREA	- Cross sectional area of each process unit(if calculated).
AOP	- Input variable. Present value cost adjustment factor.
ASH	- Ash flow rate of waste feed(lb/hr). ASH=MASSSL=VOLIT=FREH2O
ASHCST	- ATotal cost of ash handling subunit used with incinerators that produce ash(U.S. Dollars).
BAL	- Logical variable. Indicates if feed needs to be balanced stoichiometrically.
BARREL	- Logical variable. If true, a barrel storage facility is costed.
BCOST	- This array contains the cost of insulation and refractory firebrick(U.S. Dollars per square feet per inch).
BNMFR	- This array contains the name of the refractory selected for the process unit in question.
BNMIN	- This array contains the name of the insulation selected for the process unit in question.
BRIKNM	- This array contains the name of all firebrick options available for selection.
BRKTOT	- Total cost of firebrick required for the routine acce accessing subroutine BLOCK.
CONST	- Constants used for the packed bed absorber design calculations(absorption and pressure loss).
CONTEN	- Input variable. Percent contingency fee based on the total capital cost.
CP	- Heat capacity of product gas (joules/gmole/Celcius).

CS	- Logical variable. If true, carbon steel capital material of construction is selected.
CSTCNT	- Cost of instruments and controls(U.S. Dollars).
CSTCRT	- Cost of certification for hazardous waste destruction (U.S. Dollars).
CSTEM	- Cost of electrical materials(U.S. Dollars).
CSTELC	- Cost of electricity(\$/Kilowatt hour).
CSTENG	- Engineering costs required to design and construct the incineration facility(U.S/ Dollars).
CSTFAN	- Total cost of the induction fan(U.S. Dollars).
CSTFUL	- Cost of fuel oil #2(\$/lb).
CSTHTR	- Total cost of the heat recovery boiler(U.S. Dollars).
CSTIIN	- Installation cost of all equipment without special installation requirements (10 percent of total capital cost)(U.S. Dollars).
CSTINS	- Total capital cost of primary incinerator(U.S. Dollars).
CSTINT	- Total capital cost required to install and test all instruments used to monitor the incineration process(US. Dollars).
CSTMIB	- Total cost of metal on-site building(U.S. Dollars).
CSTPAK	- Total cost of the packed bed scrubber installed(U.S. D Dollars).
CSTPK	- This array contains the packing cost for the packing materials options.
CSTQUE	- Total cost of the quench chamber(U.S. Dollars).
CSTSIT	- Total cost of sitework and preparation(U.S. Dollars).
CSTSPPR	- Cost of spare parts required for facility(U.S. Dollars).
CSTSTC	- Total cost of structural steel required for incineration facility(U.S. Dollars).

CSTSTK	- Total cost(including installation) of exhaust stack(U.S. Dollars).
CSTSTR	- First time start-up costs. 8 percent of total capital costs(U.S. Dollars).
CSTVEN	- Total cost of the venturi scrubber and the liquid/gas separating chamber(U.S. Dollars).
DAY	- Number of hours per day in operation(hours).
DCBRIK	- Total cost of insulation and/or refractory brick used for the ductwork(U.S. Dollars). This includes installation.
DCDIA	- Inside diameter of ductwork between each unit(feet).
DCMATL	- Material of construction for ductwork between each unit.
DCS	- Logical variable. If true, ductwork is constructed of carbon steel.
DCTBCS	- Cost of the firebrick used to line the ductwork (U.S. Dollars).
DCTFLG	- Logical variable. If true, firebrick design calculations are determined for ductwork.
DCTTST	- Total ductwork equipment cost for the incineration system.
DCTCST	- Cost of ductwork for each unit required to connect the process units(U.S. Dollars).
DCTLEN	- Length of ductwork between each process unit(feet)
DCTVEL	- Velocity of gas flowing through the ductwork(feet/minute).
DELTAH	- Amount of heat required to heat or cool the product gas from T1 to T2(Joules/hour).
DEPREC	- Amount of depreciation for the total hazardous waste facility(U.S. Dollars). Used only for straight line depreciation method.
DESVOL	- Volume of process unit if calculated(cubic feet).
DFHCLL	- Diffusion coefficient of caustic in liquid phase(square feet per hour).

DFHCLG	- Diffusion coefficient of caustic in gas phase(square feet /hour).
DIA	- Diameter of process unit if calculated(feet).
DIABRK	- Diameter of unit including the thickness of firebricks used(feet).
DIC	- Logical variable. If true, material of construction of ductwork in inconel clas stainless steel.
DP	- Absolute pressure in each process unit(Psia).
DRV CST	- Cost of rotary kiln drive unit to rotate the drum(U.S. Do Dollars). Calculated only if rotary kiln is designed.
DSDIA	- Ductwork shell thickness(inches).
DSPCST	- Cost of dispoal(U.S. Dollars/hour).
DSS	- Logical variable. If true, stainless steel material is used for the ductwork.
EFFABS	- Effective absorption factor. Range of 0 to 1.0. FOr ideal absorption process value = 1.0.
ELBNUM	- Number of elbows between each process unit.
ENGL	- Logical variable. If true, the variables are converted to english units of measurements.
EQVCAP	- Total equivalent capital cost spread out over the process life of facility(U.S. Dollars).
EQVFIN	- Finance charges for borrowing money(U.S. Dollars /year).
EQVOPR	- Operating costs for future worth calculations(U.S. Dollars).
EQVPFT	- Profit from facility for future worth calculations(U.S. Dollars).
EQVREV	- Total revenues generated from receiving waste(U.S. Dollars).
EXCESS	- Excess air feed to each process unit(percent).
EXTRA	- Extra costs based on the total facility costs(U.S. Dollars). See variable CONTEN.
FACCEB	- Input variable. Updating cost factor for building cost and construction.

FACCEE	- Input variable. Updating cost factor for machinery and equipment.
FACCEF	- Input variable. Updating cost factor for fabricated equipment.
FACCES	- Input variable. Updating cost factor for structural steel and supports.
FACMCS	- Class of fan being designed(always equal to 4 for high performance fans).
FEED	- Mass rate of each product in the gas phase(lb/hour).
FG	- Logical variable. If true, fiberglass is used to line the venturi scrubbers.
FINCRG	- Input variable. Interest rate for borrowing mon money(percent). Used only for future worth calculations.
FLGPAS	- Logical variable. If true, ductwork is designed. IF false, ductwork is not designed.
FLTOT	- Total fuel required for the entire facility(lb/hour).
FLUID	- Logical variable. IF true, fluidized bed incinerator is designed.
FREH2O	- Free water in waste feed. FREH2O=MASSSL*WTPH2O
FUELNM	- Names of the options on the type of fuel used to provide extra heat for incinerator to reach the required temperature.
FULC	- Fuel cost(U.S. Dollars/million Btu).
HEIGHT	- Total height of packed bed absorption column(feet).
HTCNT	- Heat of combustion of the fuel feed(Btu/lb).
HTCOMB	- Heat of combustion of volatiles(Btu/hour).
HPTOT	- Total horse-power required to operate all electric equipment at the facility(horse-power).
HSTVAP	- Heat of vaporization of water at 1 atm(Btu/lb).
HTLS	- Logical variable. If true, an additional heat loss of 10 percent is added to the heat valance.

IC - Logical variable. If true, inconel-clad stainless steel is specified.

IDEBUG - Debug variable

0 - No debug printouts
 5 - Prints final answer for each unit.
 25 - Prints important intermediate calculations.
 50 - Prints all debug messages.

III - Number of unit presently being analyzed by the program.

INCDIA - Diameter of unit in question(feet).

INCLEN - Length of process unit in question(feet).

IYEAR - Variable indicating date for basis of cost estimation(year).

JPIK - Selection of packing type(and associated constants for the packed bed design subroutine).

LCOST - Logical variable. If true, cost calculations are printed.

LIQI - Logical variable. If true, liquid injection incinerators is designed.

LQD - Logical variable. IF true, the waste feed is a pumpable liquid and waste feed burners are specified).

MASSAR - Input variable. Total mass rate of air feed(lb/hr).

MASSFL - Input variable. Total mass rate of fuel feed(lb/hr).

MASSSL - Input variable. Total mass rate of waste feed(lb/hour).

MATL - Input variable. Type of material selected for each process unit. Options to place in variable are:

CS - Carbon Steel
 IC - Inconel-clad stainless steel
 CP - Fiberglass reinforced carbon steel

METRIC - Logical variable. If true, the metric system is used for calculations.

MLPRDT - Mole rate of each product gas(lbmole/hour).

MSAIR	- Total amount of air added to each process unit(lb/hour).
MSFUEL	- Total amount of fuel added to each unit(lb/hour).
MSSLUD	- Total mass rate of sludge feed for each element for each unit(lb/hour).
MSTOT	- Total amount of vapor for each element for each unit(lb/hour).
MTLDCT	- Input variable. Specifies materials of construction for ductwork(See MATL).
MTLBRK	- Firebrick material used to line ductwork.
NRES	- Input variable. The relative resistance of brick-type against corrosion.
NSET	- Data. Indicates the relative corrosion resistance of available materials of construction.
NTU	- Input variable. Number of absorption transfer units required in the absorption column.
NUMBRN	- Total number of burners in the fuel burner system.
NUNT	- Input variable. Number of units for incineration an dpollution control.
PAKH2O	- The mass rate of H2O feed to the packed bed absorber(lb/hour).
PCKSIZ	- The size of the packing selected for the design of the absorption column(inches).
PINC	- System pressure entering the unit in question(Psia).
PRDMW	- Data. Molecular weight of each product speci(AMU).
PSIZE	- The selection of absorption column packing sizes(inches).
RECT	- Logical variable. If true, a rectangular incinerator is designed.
REFINS	- Thickness of refractory in the brick calculation subroutines(inches).

RETIM	- The retention time allowed for each unit(if specified by the user or calculated by the program)(seconds).
REVLB	- Input variable. The profit generated per pound of waste feed(U.S. Dollars/lb waste feed).
RHO	- Density of gas(lb/cubic feet).
RHOL	- Density of liquid(lb/cubic feet).
RLD	- Input variable. The length to diamter ratio of each unit(specified by the user or calculated by the program).
ROTARY	- Logical variable. If true, a rotary kiln incinerator is designed.
RTINST	- Input variable. Rate of interest to borrow money for future worth calculations(percent).
PAKRAG	- Data. The range of liquid and vapor mass velocities for constants used to design the packed bed absorber(lb/hour/square feet). See variable CONST.
PAYEXP	- Labor related expenses(U.S. Dollars/year).
PCKCHS	- Data. The name of the packing selected for the packed bed absorber.
PCKNAM	- Data. Name of packing available for the design of the packed bed absorber.
SCRW	- Logical variable. If true, the waste is fed to the incinerator with a screw feed sub-unit.
SECC	- Total secretaries salary(U.S. Dollars/year).
SEMI	- Logical variables. If true, semi-automatic ash removal system is specified.
SHLCST	- Cost of incinerator shell(U.S. Dollars).
SLD	- Logical variable. If true, the waste feed incinerated is a solid.
SLPABS	- Input variable. The slope of the equilibrium curve for the absorption. process.
SS	- Logical variable. If true, the material of construction is of stainless steel.
STMCST	- Amount of steam recovered in the heat recovery unit(U.S. Dollars).

STMREC - Amount of steam recovered in the heat recovery unit(lb/hour).

SUNIT - Name of unit options available.

SUNIT(1) - Incinerator(INC)
 SUNIT(2) - Quench Chamber(QUE)
 SUNIT(3) - Heat Recovery Boiler(HTE)
 SUNIT(4) - Venturi Scrubber(VEN)
 SUNIT(5) - Induction Fan(FAN)
 SUNIT(6) - Packed Bed Absorber(PCK)
 SUNIT(7) - Tray Absorber(TRA)
 SUNIT(8) - Afterburner(AFT)
 SUNIT(9) - Exhaust Stack(STK)
 SUNIT(10)- Adiabatic Temperature(ADB)

SUPC - Supervisors salary(\$/year).

SUPP - Supervisors total salary(\$/year).

T1 - Inlet temperature to unit under consideration (degrees fahrenheit).

T2 - Outlet temperature to unit under consideration (degree fahrenheit).

TA - Input variable. Ambient temperature(Fahrenheit).

TBRNTT - Total cost of burner system (fuel and waste feed) (U.S. Dollars).

TEKC - Technicians salary(U.S. Dollars / hour).

THCKIN - Total thickness of the insulation firebrick(inches).

TKOND - Thermal conductivity of firebrick used to line incinerator(Btu/hour/square foot/Fahrenheit/inch).

TLIM - Data. Limiting temperature of use(Fahrenheit)

TOTCAP - Total capital cost of all units and sub-units(U.S. Dollars).

TOTDP - Total pressure drop across the incinerator and pollution control systmeem.

TOTELC - Total amount of electricity cost for the facility(U.S. Dollars/year).

TOTH2O - Total amount of water used by the incineration facility(lb/year).

TOTLAB	- Total labor costs for the incineration facility(U.S. Dollars /year).
TOTTOT	- Total equipment and indirect capital costs required to build an incineration facility(U.S. Dollars /year).
TTCAUS	- Total amount of caustic used in the absorption and the venturi scrubber(lb/hour).
TTL	- The mass rate of gas in each unit(lb/hour).
TTMP	- Input variable. Stores the temperature in each unit specified by the user(Fahrenheit).
UNIT	- Input variable. Name of units being considered. See SUNIT.
VENAUT	- Logical variable. If true, automatic venturi throat adjustment is selected. If false, a manuel venturi throat adjustment is selected.
VISCG	- Viscosity of gas.
VISCL	- Viscosity of liquid(lb/hour/foot).
VOLIT	- Volitiles flow rate of waste feed. VOLIT= MASSSL*WTVOL.
VOLTIL	- Logical variable. If true, the waste feed is considered to have volatile components.
VOLRAT	- Volumetric flow rate of gas in each unit(cubic feet/ hour).
WATRAT	- Water rate in the packed bed absorber(lb/hour).
WSTNME	- Input variable. Identity name of waste being incinerated.
WTRCST	- Cost of water(\$/lb).
WTRTOT	- Total water required for the facility(lb/hour).
XXAIR	- Elemental composition of air(weight percent).
XXFUEL	- Elemental composition of fuel(weight percent).
XXSLUD	- Elemental composition of the waste feed(weight percent).
YEAR	- Number of days per year in operation(days).
YRNUM	- Estimated facility life(years). Used for economic analysis.

- Z - Total height of the packed bed absorption column(feet).
- ZFLHT - Input variable. Heat of combustion of sludge feed(lb volatiles/hour).
- ZINSUR - The amount of insurance for the waste incineration facility(U.S. Dollars / year).
- ZLOSS - Heat loss from incinerator(Btu/hour). Used if logical variable HTLS is true.
- ZSLHT - Data. Heat of combustion of fuel(Btu/lb).
- ZTOT - Cost of all labor except management(U.S. Dollars / year).

APPENDIX D

LISTING OF THE COMPUTER PROGRAMS INPUT
HWSTBRN, THEIR CONTROLLING PROGRAMS AND DATA SET CP

PROGRAM INCIN

```
00000010SET &DOT =
00000020ATTRIB ROSE LRECL(80) BLKSIZE(7440) RECFM(F B) DSORG(PS)
00000030START:WRITE IS THIS A NEW PROBLEM (Y OR N) ?
00000040READ &NAME
00000050IF &NAME = Y THEN GOTO NEW
00000060OLD:WRITE ENTER DATASET NAME TO BE RETRIEVED FROM TAPE:
00000070READ &NAME
00000080ALLOC DS(&NAME) FILE(FT14FO01) OLD USING(ROSE) CAT SPACE(100,100) TRACKS
00000100NEW:WRITE ENTER THE NEW DATA SET TO BE CREATED ON TAPE:
00000110READ &NAME
00000120ALLOC DS(&NAME) FILE(FT12FO01) NEW USING(ROSE) CAT SPACE(100,100) TRACKS
00000130NEXT:WRITE ALLOCATE ANOTHER DATASET (Y OR N) :
00000140READ &NEXT
00000150IF &NEXT = Y THEN GOTO START
00000151ALLOC DS(CP.DATA) FILE(FT04FO01) OLD USING(ROSE) CAT SPACE(100,100) TRACKS
00000160CALL INPUT1
00000170FREEALL
```

PROGRAM KILN

DATA SET CP

PHYSICAL PROPERTIES DATA FOR INCINERATOR DESIGN

FIRST DATA SET...

HEAT CAPACITY DATA WITH UNITS J/GMOLE DEG. CEL.

FORMAT OF CP=A+BT+CT**2+DT**3

--A--	--B--	--C--	--D--	-TLOW-	-THIGH-	--MW-
0.3346E+02	0.6880E-02	0.7604E-05-0	0.3593E-08	0.0000E+00	0.1500E+04	18.01601
0.2913E+02-0	0.1341E-02	0.9715E-05-0	0.4335E-08	0.0000E+00	0.1200E+04	36.45000
0.3611E+02	0.4233E-01-0	0.2887E-04	0.7464E-08	0.0000E+00	0.1500E+04	44.00999
0.2895E+02	0.4110E-02	0.3548E-05-0	0.2220E-08	0.0000E+00	0.1500E+04	28.00999
0.2900E+02	0.2199E-02	0.5723E-05-0	0.2871E-08	0.0000E+00	0.1500E+04	28.02000
0.1100E+03	0.0000E+00	0.0000E+00	0.0000E+00	0.2500E+02	0.2500E+02	31.99200
0.2950E+02	0.8188E-02-0	0.2950E-05	0.3652E-09	0.0000E+00	0.3500E+04	30.00999
0.3607E+02	0.3970E-01-0	0.2880E-04	0.7870E-08	0.0000E+00	0.1200E+04	46.00999
0.3360E+02	0.1367E-01-0	0.1607E-04	0.6473E-08	0.0000E+00	0.1200E+04	70.91000
0.3891E+02	0.3904E-01-0	0.3104E-04	0.8606E-08	0.0000E+00	0.1500E+04	64.07001
0.1391E+03	0.1559E+00	0.0000E+00	0.0000E+00	0.1000E+02	0.4500E+02	98.08000
0.2900E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.3500E+04	36.89000
0.7240E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.1000E+04	19.00841
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	100.00000
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	20.18300
40-50%-ALUMINA FIREBRICK	2000.0000	4.000000	0	001.61000		
60-70%-ALUMINA FIREBRICK	2500.0000	3.000000	0	002.41000		
90%-ALUMINA FIREBRICK	4000.0000	2.000000	1	010.25000		
INSULATING FIREBRICK	2000.0000	2.000000	0	001.25000		
INSULATING FIREBRICK	2230.0000	2.000000	0	001.30000		
INSULATING FIREBRICK	2600.0000	2.000000	1	001.90000		
CASTABLE	2200.0000	2.000000	0	001.20000		
CASTABLE	2600.0000	2.000000	0	001.70000		

NAME, HEAT DATA AND COST OF FUELS.

NAME, MEAT DATA AND COST OF FUELS.				
SPECIES	\$/GAL	BTU/GAL	\$/BTU	BTU/LB
NO. 2 FUEL OIL	1.251370000.00	0.9120E+06	0.1840E+05	

DESIGN AND COST DATA FOR PACKED BED.

DATA ACQUIRED FROM MODERN POLLUTION CONTROL TECHNOLOGY VOL 1

STAFF OF RESEARCH AND EDUCATION ASSOCIATION

628.5 B432M V. 1 AT OSU LIBRARY.

RASCHIG RINGS	0.5	11.70	2.32	0.45	0.47	2	5	5	15	0.00182	0.46	139.00	0.00720
RASCHIG RINGS	1.0	6.50	7.00	0.39	0.58	2	8	4	5	0.00357	0.35	32.90	0.0045
RASCHIG RINGS	1.5	5.05	17.30	0.38	0.66	2	7	5	15	0.0111	0.22	12.08	0.00400
RASCHIG RINGS	2.0	4.85	3.82	0.41	0.45	2	8	5	45	0.0125	0.22	11.13	0.00295
BERL SADDLES	0.5	24.80	32.40	0.30	0.74	2	7	5	15	0.00666	0.28	60.40	0.00340
BERL SADDLES	1.0	9.90	1.97	0.36	0.40	2	8	4	45	0.00588	0.28	16.01	0.00295
BERL SADDLES	1.5	7.50	5.05	0.32	0.45	210	4	45	0.00625	0.28	8.01	0.00225	
STM \$/LB	WTR \$/LB	DISP \$/LB	FUEL \$/LB	ELC \$/KWH	\$/TON	LIME							
0.00504000	0.00025000	0.00500000	0.17600000	0.043200000	33.500000								
40.656000													

PROGRAM INPUT

C\$JOB	,NOLIST	00000010
	REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD	00000020
1	,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS	00000030
	LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL	00000040
1	.IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP,	00000050
2	SSB,SCRW,VENAUT,FG,PRI,SLD,LQD,PLASMA,BRN,ADIA	00000060
3	,KRB,FXH,UTB,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS	00000070
2	, HT1,HT2,HT3,VALVE,SIEVE,CMBST,HM1,HM2,ECLOG	00000080
	LOGICAL INCIP,AFTINC	00000090
	LOGICAL FEDPT,QUNCH,HTEIN,VININ,ININ,PCIN,STKIN	00000100
	CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*20	00000110
1	,BNMFR*4,BNMIN*4,SUNIT*3,PCKNM*4,MTLDCT*3,MTLBRK*3,DCMATL*2	00000120
	CHARACTER MATLC*2,SCRNME*20,FLNAM*15	00000130
	CHARACTER ELEMNT*10	00000140
	DIMENSION MATLC(4),ELEMNT(9)	00000150
	COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL,	00000160
1	MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP	00000170
2	,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAB,ZLFD2(9,9)	00000180
	COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL	00000190
1	,VISCG,EFFABS,TDCOST,CONST(7,8),SLPABS,PAKRAZ(7,4),Z,CSTINS,TBRNTT00000200	00000210
	COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC	00000220
1	,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS	00000230
2	,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST	00000240
3	,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN	00000250
	COMMON/COST/ SHLCST,DRVCST,BRKTOT,ASHCST,STM CST,DCTCST(9)	00000260
1	,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,EXFUEL(9).FEDRG2	00000270
	COMMON/INPUT/ CP(6,15),PRDMW(15).HEIGHT,WTRCST,DSPCST,CSTEBC	00000280
1	,AOP,WTPVOL,WTPH20,WATRAT,NTU,AQQ,CSTSTO,SCHMDT,PRCFLD	00000290
	COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK	00000300
1	,PREXTI,DPTOT,PREEXT,ELEVAT,TOTDP,QSET,QTEMP,HCLRM	00000310
2	,CSTIIN,CSTSTR,CSTS PR,CSTCRT,CSTENG,DCDIA(9),CSTINT	00000320
3	,DSDIA(9),DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,	00000330
4	,TOTECL,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR,	00000340
5	TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,	00000350
6	VENWAT,DIAPT(100),WTPR(100),FINCRG,REFINS,THCKIN,EQVFIN	00000360
	COMMON/UPDATE/ FACSUM,FACCES,FACMSC,FACCEE,FACCEF,FACCEB	00000370
1	,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS	00000380
	COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP	00000390
	COMMON/DCT/ ELBNU M(9),DCTLEN(9),DCTVEL(9),DIA(9)	00000400
	COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NPRTS,NUMBRN	00000410
	COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11)	00000420
1	,PCKCHS(4),PCKNM(7,4),DCMATL(9),MTLDCT,MTLBRK,SCRNME(6)	00000430
2	,WSTNME(6),BNMFR(6),BNMIN(6),FLNAM	00000440
	COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL	00000450
1	,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC	00000460
2	,SLD,SCRW,VENAUT,PLASMA,BRN,ADIA,PRI,FG,LQD	00000470
3	,KRB,FXH,UTB,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS	00000480
2	, HT1,HT2,HT3,VALVE,SIEVE,CMBST,HM1,HM2,ECLOG	00000490
C	FEDRG2= 1.142E-5	00000500
	MATLC(1)='CS'	00000510
	MATLC(2)='SS'	00000520
	MATLC(3)='IC'	00000530
	QSAT=0.0	00000540
	QTEMP=0.0	00000550
	SIEVE=.FALSE.	00000560
	VALVE=.TRUE.	00000570
	DO 123 I=1,9	00000580
	EXFUEL(I)=0.0	00000590
123	CONTINUE	00000600
	XSUM=0.0	00000610
	SUNIT(1)='INC'	00000620
	SUNIT(2)='QUE'	00000630
	SUNIT(3)='HTE'	00000640
	SUNIT(4)='VEN'	00000650
	SUNIT(5)='IND'	00000660
	SUNIT(6)='PCK'	00000670
	SUNIT(7)='TRA'	00000680
	SUNIT(8)='AFT'	00000690
	SUNIT(9)='STK'	00000700
	SUNIT(10)='ADI'	00000710
	SUNIT(11)=' '	00000720

```

ELEMNT(1)='HYDROGEN'          00000730
ELEMNT(2)='CARBON'            00000740
ELEMNT(3)='OXYGEN'             00000750
ELEMNT(4)='NITROGEN'           00000760
ELEMNT(5)='CHLORINE'           00000770
ELEMNT(6)='SULPHUR'            00000780
ELEMNT(7)='FLUORINE'           00000790
ELEMNT(8)='PHOSPHOR'           00000800
ELEMNT(9)='NEON'                00000810
PLASMA=.FALSE.                  00000820
ROTARY=.FALSE.                  00000830
FLUID=.FALSE.                   00000840
LIQI=.FALSE.                     00000850
METRIC=.FALSE.                   00000860
ENGL=.FALSE.                      00000870
ADIA=.FALSE.                      00000880
LCOST=.FALSE.                      00000890
BARREL=.FALSE.                      00000900
SCRW=.FALSE.                      00000910
BRN=.FALSE.                      00000920
CALL DEFALT                      00000930
665 WRITE(6,664)                  00000940
664 FORMAT(10X,'SELECT ONE OF THE FOLLOWING OPTIONS'/
1 15X,'1 - CREATE A NEW FILE'/
2 15X,'2 - ALTER AN EXISTING FILE')
READ*, ITEMP
IF(ITEMP.GT.2.OR.ITEMP.LT.1) GOTO 665
IF(ITEMP.EQ.1) GOTO 200
CALL INPT(NREAC,NPRD)
GOTO 230
200 WRITE(6,80)
80 FORMAT(5X,'SELECT METRIC(ENTER 1) OR ENGLISH(ENTER 2) SYSTEM'/
1 5X,'OF MEASUREMENTS')
METRIC=.FALSE.
ENGL=.FALSE.
READ*, TEMPER
IF(TEMPER.EQ.1) METRIC=.TRUE.
IF(TEMPER.EQ.2) ENGL=.TRUE.
IF(TEMPER.LT.1.0.OR.TEMPER.GT.2.0) WRITE(6,131)
131 FORMAT(5X,'*** SELECT THE NUMBER 1 OR 2 ***')
IF(TEMPER.LT.1.0.RT.TEMPER.GT.2) GOTO 200
WRITE(6,90)
WRITE(6,500)
90 FORMAT(7X,'WASTE FEED CHARACTERISTICS AND PROPERTIES///')
500 FORMAT(5X,'INPUT WASTE FEED IDENTIFICATION NAME')
READ*, WSTNM(1)
3033 XSUM=0.0
WRITE(6,3036)
3036 FORMAT(10X,'FOR THE WASTE FEED')
DO 3020 I=1,8
    WRITE(6,3021) ELEMNT(I)
3021 FORMAT(10X,'INPUT WEIGHT PERCENT OF ',A10,', IN WASTE FEED')
READ*, XXSLUD(I)
XSUM=XSUM+XXSLUD(I)
IF(XSUM.LE. 1.0 ) GOTO 3020
    WRITE(6,3022)
3022 FORMAT(10X,'TOTAL WEIGHT FRACTION ABOVE 1.0. '/10X,'REDO FROM',
1 ' START')
    GOTO 3033
3020 CONTINUE
IF(XSUM.GT.0.98) GOTO 7038
    WRITE(6,3037)
3037 FORMAT(10X,'TOTAL WEIGHT PERCENT OF WASTE FEED IS BELOW 98%'/
1 10X,'WILL NORMALIZE')
XXSM=0.0
DO 7039 L=1,8
    XXSM=XXSM+XXSLUD(L)
7039 CONTINUE
DO 7040 L=1,8
    XXSLUD(L)=XXSLUD(L)/XXSM
7040 CONTINUE
372 WRITE(6,371)

```

```

371 FORMAT(10X,'SELECT ONE OF THE FOLLOWING OPTIONS'/          00001450
  1 10X,'1 - SPECIFY THE HEATING VALUE OF THE WASTE'/        00001460
  2 10X,'2 - CALCULATE THE HEAT VALUE OF A CHLORINATED HYDROCARBON' 00001470
  3 , '(LOW VALUE)''                                         00001480
  4 10X,'3 - CALCULATE THE HEAT VALUE OF A CHLORINATED HYDROCARBON' 00001490
  5 , '(HIGH VALUE)')                                         00001500
    READ*, ITEMP                                            00001510
    IF(ITEMP.GT.3.OR.ITEMP.LT.1) GOTO 372                  00001520
    HT1=.FALSE.                                              00001521
    HT2=.FALSE.                                              00001522
    HT3=.FALSE.                                              00001523
    IF(ITEMP.EQ.1) HT1=.TRUE.                                00001530
    IF(ITEMP.EQ.2) HT2=.TRUE.                                00001540
    IF(ITEMP.EQ.3) HT3=.TRUE.                                00001550
    IF(HT1) GOTO 7038                                      00001551
    IF(HT2) ZSLHT=14100* XXSLUD(2)+ 45000*(XXSLUD(3)-XXSLUD(1)/8) 00001552
    1 760*XXSLUD(5)+4500                                         00001553
    IF(HT2) ZSLHT=14100* XXSLUD(2)+ 54500*(XXSLUD(3)-XXSLUD(1)/8) 00001554
    1 150*XXSLUD(5)+4500                                         00001564
7038 IF(ENGL)WRITE(6,93)                                     00001565
  IF(METRIC) WRITE(6,94)                                     00001570
  93 FORMAT(5X,'INPUT THE HEAT OF COMBUSTION OF THE WASTE SLUDGE' 00001580
  1 , '(BTU/HR)')                                           00001590
  94 FORMAT(5X,'INPUT THE HEAT OF COMBUSTION OF THE WASTE SLUDGE' 00001600
  1 , '(KJ/KG)')                                           00001610
    READ*, ZSLHT                                            00001620
3035 WRITE(6,100)                                           00001630
100 FORMAT(5X,'FOR THE SLUDGE FEED INPUT THE WEIGHT FRACTION OF', 00001640
  1' VOLITLES')                                           00001650
  READ*, WTPVOL                                           00001660
  WRITE(6,120)                                           00001670
120 FORMAT( 5X,'INPUT THE WEIGHT FRACTION OF FREE H2O IN THE SLUDGE', 00001680
  1' FEED.')                                              00001690
  READ*, WTPH20                                           00001700
  WTTOT=WTPVOL+WTPH20                                     00001710
  IF(WTTOT.GT.1.05) WRITE(6,3034)                         00001720
3034 FORMAT(10X,'THE SUM OF THE OVERALL COMPOSITION IS GREATER THAN', 00001730
  1 ' ONE. PLEASE RESPECIFY.')                           00001740
  IF(WTTOT.GT.1.0) GOTO 3035                            00001750
2000 FORMAT(6A5)                                           00001760
870 WRITE(6,871)                                           00001770
871 FORMAT(10X,'SELECT ONE OF THE FOLLOWING'/          00001780
  1 15X, '1 - WASTE IS NON-VOLATILE'/'                 00001790
  2 15X, '2 - WASTE IS VOLATILE'/'                     00001800
  3 15X, '3 - WASTE IS VOLATILE AND COMBUSTABLE')     00001810
    READ*, ITEMP                                            00001820
    IF(ITEMP.GT.3.OR.ITEMP.LT.1) GOTO 870                00001830
    VOLTIL=.FALSE.                                         00001840
    CMBST=.FALSE.                                         00001850
    IF(ITEMP.EQ.2) VOLTIL=.TRUE.                          00001860
    IF(ITEMP.EQ.3) VOLTIL=.TRUE.                          00001870
    IF(ITEMP.EQ.3) CMBST=.TRUE.                          00001880
    IF(METRIC) WRITE(6,71)                               00001890
    IF(ENGL)WRITE(6,70)                                 00001900
71 FORMAT(5X,'ENTER PRESSURE OF INLET AIR(ATM)')       00001910
70 FORMAT(5X,'ENTER PRESSURE OF INLET AIR(PSIA)')      00001920
  READ*, PINC                                             00001930
  IF(METRIC)WRITE(6,76)                                 00001940
  IF(ENGL)WRITE(6,75)                                 00001950
75 FORMAT(5X,'ENTER AMBIENT TEMPERATURE(DEGREES FAHENHEIT) ') 00001960
76 FORMAT(5X,'ENTER AMBIENT TEMPERATURE(DEGREES CELCIUS)') 00001970
  READ*, TA                                               00001980
  WRITE(6,350)                                           00001990
350 FORMAT(5X,'ENTER THE ELEVATION OF THE FACILITY(ABOVE SEA LEVEL)'/ 00002000
  1 5X,'IN FEET')                                         00002010
  READ*, ELEVAT                                           00002020
  IF(ENGL)WRITE(6,91)                                 00002030
91 FORMAT(5X,'INPUT THE FEED RATE OF THE WASTE STREAM(LB/HR)') 00002040
  IF(METRIC)WRITE(6,92)                               00002050
92 FORMAT(5X,'INPUT THE FEED RATE OF THE WASTE STREAM(KG/HR)') 00002060
  READ*, MASSSL                                           00002070
145 WRITE(6,140)                                         00002080

```

```

140 FORMAT(5X,'ENTER 1 FOR FACILITY DESIGN ONLY. ENTER 2 IF'/
15X,'DESIGN AND COST ANALYSIS IS DESIRED')
READ*, TEMPER
IF(TEMPER.EQ.1) LCOST=.FALSE.
IF(TEMPER.EQ.2) LCOST=.TRUE.
IF(TEMPER.LT.1.0R.TEMPER.GT.2) WRITE(6,141)
141 FORMAT(5X,'A VALUE BETWEEN 1 AND 2 MUST BE SELECTED')
IF(TEMPER.LT.1.0R.TEMPER.GT.2) GOTO 145
WRITE(6,146)
146 FORMAT(5X,'HOW MANY UNITS ARE TO BE DESIGNED')
READ*, NUNIT
IF(FEDPT) GOTO 230
I=0
4016 I=I+1
IF(AFTINC.OR.INCIP.OR.QUNCH.OR.HTEIN.OR.VININ.OR.ININ.OR.PCIN.OR.
1 STKIN) I=JU
IF(I.GT.NUNIT) GOTO 21
IF(INCIP) GOTO 220
IF(AFTINC) GOTO 210
IF(QUNCH) GOTO 223
IF(HTEIN) GOTO 222
IF(VININ) GOTO 224
IF(ININ) GOTO 225
IF(PCIN) GOTO 226
IF(STKIN) GOTO 227
WRITE(6,147)
147 FORMAT(15X,'1 - INCINERATOR',15X,'2 - AFTERBURNER'/
1      15X,'3 - HEAT RECOVERY UNIT',8X,'4 - QUENCH'/
2      15X,'5 - VENTURI SCRUBBER',10X,'6 - INDUCTION FAN'/
3      15X,'7 - PACKED BED ABSORBER',7X,'8 - EXHAUST STACK ')
155 WRITE(6,150)I
150 FORMAT(5X,'SELECT UNIT NUMBER ',I2)
READ*, NUMUN
IF(NUMUN.LT.1.0R.NUMUN.GT.8) WRITE(6,156)
156 FORMAT(5X,'UNIT NUMBER NOT WITHIN RANGE. RESPECIFY')
IF(NUMUN.LT.1.0R.NUMUN.GT.8) GOTO 155
IF(NUMUN.EQ.3) GOTO 559
103 WRITE(6,101)
101 FORMAT(10X,'SELECT TYPE OF MATERIAL TO CONSTRUCT UNIT',
1      ':/15X,'1 - INCONEL CLAD'/15X,'2 - STAINLESS STEEL 316'/
2      15X,'3 - CARBON STEEL')
READ*, TEMPER
IF(TEMPER.GT.4.0.R.TEMPER.LT.1) WRITE(6,99)
99 FORMAT(10X,'CHOICE MUST BE BETWEEN 1 AND 4. RESPECIFY')
IF(TEMPER.EQ.1.) MATL(I)='IC'
IF(TEMPER.EQ.2.) MATL(I)='SS'
IF(TEMPER.EQ.3.) MATL(I)='CS'
IF(TEMPER.GT.3.0.R.TEMPER.LT.1.0) WRITE(6,102)
102 FORMAT(10X,'MATERIAL SELECTION OUT OF RANGE. RESPECIFY')
IF(TEMPER.GT.3.0.R.TEMPER.LT.1.) GOTO 103
559 IF(NUMUN.EQ.1) GOTO 220
IF(NUMUN.EQ.2) GOTO 210
IF(NUMUN.EQ.3) GOTO 222
IF(NUMUN.EQ.4) GOTO 223
IF(NUMUN.EQ.5) GOTO 224
IF(NUMUN.EQ.6) GOTO 225
IF(NUMUN.EQ.7) GOTO 226
IF(NUMUN.EQ.8) GOTO 227
GOTO 155
180 WRITE(6,181)
181 FORMAT(10X,'TRAYBED ABSORPTION COLUMN DESIGN PROCEDURE NOT ',
1 'COMPLETE')
GOTO 20
220 WRITE(6,161)
ROTARY=.FALSE.
FLUID=.FALSE.
LIQI=.FALSE.
PLASMA=.FALSE.
ADIA=.FALSE.
IF(INCIP) GOTO 8002
UNIT(I)='INC'
161 FORMAT(10X,'****INPUT DESIGN PARAMETERS FOR INCINERATOR****'//)

```

```

8002 WRITE(6,162)          00002810
162 FORMAT(5X,'INPUT THE TYPE INCINERATOR TO BE DESIGNED') 00002820
166 WRITE(6,163)          00002830
163 FORMAT(15X,'1 - ROTARY KILN',10X,'2 - LIQUID INJECTION'/
115X,'3 - FLUIDIZED BED',8X,'4 - PLASMA ARC PYROLYSIS') 00002840
    READ*, TEMPER          00002850
    IF(TEMPER.EQ.1) ROTARY=.TRUE.          00002860
    IF(TEMPER.EQ.2) LIQI=.TRUE.          00002870
    IF(TEMPER.EQ.3) FLUID=.TRUE.          00002880
    IF(TEMPER.EQ.4) PLASMA=.TRUE.          00002890
        IF(TEMPER.GT.4.0.OR.TEMPER.LT.1.0) WRITE(6,164)          00002900
164 FORMAT(5X,'*** NUMBER NOT IN RANGE. RESPECIFY ***') 00002910
    IF(TEMPER.GT.4.0.OR.TEMPER.LT.1.)GOTO 166          00002920
874 WRITE(6,875)          00002930
875 FORMAT(10X,'SELECT ONE OF THE FOLLOWING'/
1 15X,'1 - WASTE IS A SOLID'/
2 15X,'2 - WASTE IS A PUMPABLE LIQUID') 00002940
    READ*, ITEMP          00002950
    IF(ITEMP.GT.2.0R.ITEMP.LT.1) GOTO 874          00002960
    SLD=.FALSE.          00002970
    LQD=.FALSE.          00002980
        IF(ITEMP.EQ.1) SLD=.TRUE.          00002990
        IF(ITEMP.EQ.2) LQD=.TRUE.          00003000
503 WRITE(6,501)          00003010
501 FORMAT(10X,'WASTE FEED MECHANISM'/15X,'1 - WASTE FEED BURNERS'/
1 15X,'2 - BARREL FEED'/15X,'3 - SCREW FEED') 00003020
    READ*, ITEMP          00003030
    IF(ITEMP.LT.1.0R.ITEMP.GT.3) WRITE(6,502)          00003040
502 FORMAT(10X,'SELECTION OUT RANGE, RESPECIFY') 00003050
    IF(ITEMP.LT.1.0R.ITEMP.GT.3) GOTO 503          00003060
    BRN=.FALSE.          00003070
    BARREL=.FALSE.          00003080
    SCRWF=.FALSE.          00003090
        IF(ITEMP.EQ.1) BRN=.TRUE.          00003100
        IF(ITEMP.EQ.2) BARREL=.TRUE.          00003110
        IF(ITEMP.EQ.3) SCRWF=.TRUE.          00003120
167 WRITE(6,96)          00003130
96 FORMAT(10X,'SELECT 1 OF THE 2 OPTIONS'/15X,'1 - SET OUTLET TEMP'/
1 'ERATURE'/15X,'2 - ADIABATIC COMBUSTION') 00003140
    READ*, TEMPER          00003150
        IF(TEMPER.GT.4.0.OR.TEMPER.LT.1.0) WRITE(6,164)          00003160
        IF(TEMPER.GT.4.0.OR.TEMPER.LT.1.)GOTO 167          00003170
    IF(TEMPER.EQ.2) ADIA=.TRUE.          00003180
    IF(.NOT.ADIA.AND.ENGL) WRITE(6,97)          00003190
97 FORMAT(10X,'INPUT EXIT TEMPERATURE IN DEGREES FAHRENHEIT') 00003200
    IF(.NOT.ADIA.AND.METRIC) WRITE(6,98)          00003210
98 FORMAT(10X,'INPUT TEMPERATURE IN DEGREES CELCIUS') 00003220
    IF(.NOT.ADIA)READ*, TTMP(I)          00003230
551 WRITE(6,550)          00003240
550 FORMAT(25X,'SPECIFY ONE OF THE FOLLOWING'/
1 10X,'1 - INCLUDE A 10 PERCENT HEAT LOSS'/
2 10X,'2 - NO HEAT LOSSES INCLUDED') 00003250
    READ*, ITEMP          00003260
    IF(ITEMP.GT.2.0R.ITEMP.LT.1) GOTO 551          00003270
    IF(ITEMP.EQ.1) HTLS=.TRUE.          00003280
    IF(ITEMP.EQ.2) HTLS=.FALSE.          00003290
    WRITE(6,115)          00003300
115 FORMAT(10X,'INPUT THE EXCESS AIR REQUIRED(FRACTION BETWEEN 0'/
1 ' AND 1)')          00003310
    READ*, EXCESS(I)          00003320
    WRITE(6,877)          00003330
877 FORMAT(10X,'INPUT THE EXCESS FUEL REQUIRED(FRACTION BETWEEN 0'/
1 ' AND 1)')          00003340
    READ*, EXFUEL(I)          00003350
    WRITE(6,113)          00003360
113 FORMAT(10X,'INPUT ESTIMATE OF THE RATIO OF LENGTH TO DIAMETER'/
110X,'RATIO(A VALUE BETWEEN 2 AND 9 IS GENERALLY SELECTED)') 00003370
    READ*, RLD(I)          00003380
    WRITE(6,114)          00003390
114 FORMAT(10X,'INPUT RETENTION TIME OF INCINERATOR (SECONDS)') 00003400
    READ*, RETIM(I)          00003410
    WRITE(6,380)          00003420

```

```

380 FORMAT(5X,'EXTRA COSTS FOR INCINERATOR(PERCENT OF EQUIPMENT COST') 00003530
  READ*, PREXTI 00003540
  IF(PREXTI.GT.2.0) PREXTI=PREXTI/100.0 00003550
  IF(INCIP) GOTO 4032 00003560
  CALL STAND(I) 00003570
  GOTO 20 00003580
210 WRITE(6,261) 00003590
  IF(AFTINC) GOTO 8001 00003600
  UNIT(I)='AFT' 00003610
261 FORMAT(10X,'INPUT DESIGN PARAMETERS FOR AFTERBURNER///') 00003620
8001 IF(METRIC) WRITE(6,98) 00003630
  IF(ENGL) WRITE(6,97) 00003640
  READ*, TTMP(I) 00003650
  WRITE(6,114) 00003660
  READ*, RETIM(I) 00003670
  WRITE(6,113) 00003680
  READ*, RLD(I) 00003690
  WRITE(6,115) 00003700
  READ*, EXCESS(I) 00003710
  WRITE(6,380) 00003720
  READ*, PREXT 00003730
  IF(AFTINC) GOTO 4015 00003740
  CALL STAND (I) 00003750
  GOTO 20 00003760
222 WRITE(6,361) 00003770
  FXH=.FALSE. 00003780
  KRB=.FALSE. 00003790
  UTB=.FALSE. 00003800
  S316=.FALSE. 00003810
  S304=.FALSE. 00003820
  S347=.FALSE. 00003830
  NI200=.FALSE. 00003840
  MD400=.FALSE. 00003850
  IN600=.FALSE. 00003860
  IN825=.FALSE. 00003870
  TI=.FALSE. 00003880
  HS=.FALSE. 00003890
  UNIT(I)='HTE' 00003900
361 FORMAT(10X,'INPUT DESIGN PARAMETERS FOR HEAT RECOVERY UNIT///') 00003910
  IF(ENGL)WRITE(6,97) 00003920
  IF(METRIC) WRITE(6,98) 00003930
  READ*, TTMP(I) 00003940
126 WRITE(6,125) 00003950
125 FORMAT(10X,'SPECIFY THE COST ESTIMATION METHOD FOR THE HEAT', 00003960
  1 ' RECOVERY BOILERS//'
  2 15X,'1 - GENERALIZED COST ESTIMATION METHOD'/
  3 15X,'2 - COST METHOD FOR BOILERS FOR THE INCINERATION INDUSTRY') 00003970
  READ*, ITEMP 00004000
  IF(ITEMP.GT.2.OR.ITEMP.LT.1) GOTO 126 00004010
  IF(ITEMP.EQ.1) HM2=.TRUE. 00004020
  IF(ITEMP.EQ.2) HM1=.TRUE. 00004030
8003 WRITE(6,194) 00004040
194 FORMAT(25X,'TYPE OF HEAT RECOVERY SYSTEM//'
  1 10X,'1 - FIXED HEAD      2 - KETTLE REBOILER  /'
  1 10X,'          3 - U-TUBE') 00004060
  READ*,ITEMP 00004070
  IF(ITEMP.GT.3.OR.ITEMP.LT.1) WRITE(6,195) 00004080
195 FORMAT(10X,'SELECTION IF OUT OF RANGE. RESPECIFY')
  IF(ITEMP.GT.3.OR.ITEMP.LT.1) GOTO 8003 00004100
  IF(ITEMP.EQ.1) FXH=.TRUE. 00004110
  IF(ITEMP.EQ.2) KRB=.TRUE. 00004120
  IF(ITEMP.EQ.3) UTB=.TRUE. 00004130
  765 WRITE(6,673) 00004140
  673 FORMAT(25X,'MATERIALS OF CONSTRUCTION//'
  1 10X,'1 - STAINLESS STEEL 316      2 - STAINLESS STEEL 304/'
  2 10X,'3 - STAINLESS STEEL 347      4 - NICKEL 200/'
  3 10X,'5 - MONEL 400          6 - INCONEL 600/'
  4 10X,'7 - INCONEL 825          8 - TITANIUM/'
  5 10X,'          9 - HASTELLOY           ')
  READ*,ITEMP 00004160
  IF(ITEMP.GT.9.OR.ITEMP.LT.1) WRITE(6,764) 00004170
764 FORMAT(10X,'NUMBER IS OUT OF RANGE. RESPECIFY') 00004180

```

```

IF(IITEMP.GT.9.OR.IITEMP.LT.1) GOTO 765          00004250
IF(IITEMP.EQ.1) S316=.TRUE.                      00004260
IF(IITEMP.EQ.2) S304=.TRUE.                      00004270
IF(IITEMP.EQ.3) S347=.TRUE.                      00004280
IF(IITEMP.EQ.4) NI200=.TRUE.                     00004290
IF(IITEMP.EQ.5) MO400=.TRUE.                     00004300
IF(IITEMP.EQ.6) IN600=.TRUE.                     00004310
IF(IITEMP.EQ.7) IN825=.TRUE.                     00004320
IF(IITEMP.EQ.8) TI=.TRUE.                        00004330
IF(IITEMP.EQ.8) HS=.TRUE.                        00004340
WRITE(6,8004)                                     00004350
B004 FORMAT(10X,'INPUT THE OVERALL HEAT TRANSFER COEFFICIENT'/10X,      00004360
1 '(SHOULD RANGE FROM 1 TO 3 BTU/HR/FT2 FAHRENHEIT)')                  00004370
READ*,HTC                                         00004380
IF(HTEIN) GOTO 174                                00004390
CALL STAND(I)                                     00004400
GOTO 20                                           00004410
223 WRITE(6,461)                                    00004420
  QTEMP=0.0                                       00004430
  QSAT=0.0                                       00004440
  UNIT(I)='QUE'                                    00004450
461 FORMAT(10X,'INPUT DESIGN PARAMETERS FOR QUENCH UNIT'///)           00004460
  WRITE(6,370)                                     00004470
370 FORMAT(5X,'SELECT ONE OF THESE OPTIONS'//      00004480
1 10X,'1 - SPECIFY OUTLET TEMPERATURE'          00004490
2 10X,'2 - SATURATED GAS OUTLET')               00004500
  READ*,ICONV                                      00004510
  IF(ICONV.EQ.1) QTEMP=1                           00004520
  IF(ICONV.EQ.2) QSAT=1                           00004530
  IF(ENGL)WRITE(6,97)                            00004540
  IF(METRIC) WRITE(6,98)                          00004550
  READ*,TTMP(I)                                    00004560
  IF(QUNCH) GOTO 171                             00004570
  CALL STAND(I)                                   00004580
  GOTO 20                                         00004590
224 WRITE(6,561)                                    00004600
  DO 251 IJ=1,100                                 00004610
    DIAPT(IJ)=0.0                                 00004620
    WTPRT(IJ)=0.0                                 00004630
251 CONTINUE                                       00004640
  NRTS=0                                         00004650
  PRI=.FALSE.                                     00004660
  UNIT(I)='VEN'                                    00004670
561 FORMAT(10X,'INPUT DESIGN PARAMETERS FOR VENTURI SCRUBBER'///)        00004680
  IF(ENGL)WRITE(6,97)                            00004690
  IF(METRIC) WRITE(6,98)                          00004700
  READ*,TTMP(I)                                    00004710
563 WRITE(6,562)                                    00004720
562 FORMAT(10X,'VENTURI THROAT CONTROL MECHANISM'/15X,'1 - AUTOMATIC'   00004730
1 /15X,'2 - MANUAL')                           00004740
  READ*,IITEMP                                     00004750
  IF(IITEMP.EQ.1) VENAUT=.TRUE.                   00004760
  IF(IITEMP.EQ.2) VENAUT=.FALSE.                  00004770
  IF(IITEMP.LT.1.OR.IITEMP.GT.2) GOTO 563       00004780
  WRITE(6,353)                                     00004790
353 FORMAT(5X,'WATER RATE IN VENTURI SCRUBBER(LB H2O/1000 FT3 GAS)') 00004800
  READ*, VENWAT                                    00004810
355 WRITE(6,354)                                    00004820
354 FORMAT(5X,'SELECT ON OF THE FOLLOWING'//      00004830
1 10X,'1 - PARTICULATE REMOVAL EFFICIENCY FROM EXPERIMENTAL DATA'     00004840
2 10X,'2 - DIRECT SPECIFICATION OF VENTURI PRESSURE DROP')            00004850
  READ*, INUM                                      00004860
  IF(INUM.GT.2.OR.INUM.LT.1) WRITE(6,141)         00004870
  IF(INUM.GT.2.OR.INUM.LT.1) GOTO 355             00004880
  IF(INUM.EQ.1) PRI=.TRUE.                        00004890
  IF(INUM.EQ.2) PRI=.FALSE.                       00004900
  IF(PRI) GOTO 356                               00004910
  WRITE(6,357)                                     00004920
357 FORMAT(5X,'SPECIFIY OVERALL REMOVAL EFFICIENCY(LB/ACF)')            00004930
  READ*, FEDRG2                                    00004940
  IF(INUM.EQ.2) WRITE(6,358)                      00004950
358 FORMAT(5X,'SPECIFY VENTURI SCRUBBER TOTAL PRESSURE DROP(IN H2O)')   00004960

```

```

        IF(INUM.EQ.2) READ*, DPTOT          00004970
        GOTO 366                          00004980
356 WRITE(6,196)                      00004990
196 FORMAT(5X,'INPUT PARTICULATE DISTRIBUTION'//)
1 10X,'SPECIFY NUMBER OF DATA POINTS') 00005000
    READ*, NPRTS                      00005020
    WRITE(6,362)                      00005030
362 FORMAT(10X,'SPECIFY THE PARTICULATE DIAMETER AND WEIGHT PERCENT')
    DO 363 IJ=1,NPRTS                00005040
        READ*, DIAPT(IJ),WTPRT(IJ)    00005050
363 CONTINUE                         00005070
366 WRITE(6,364)                      00005080
364 FORMAT(5X,'SELECT THE FOLLOWING OPTION'/10X,'1 - FIBERGLASS LINED' 00005090
1 .' THROAT'/10X,'2 - UNLINED THROAT')
    READ*, ITEMP                      00005100
    IF(ITEMP.LT.1.OR.ITEMP.GT.2) GOTO 366 00005110
    IF(ITEMP.EQ.1) FG=.TRUE.           00005120
    IF(ITEMP.NE.1) FG=.FALSE.         00005130
    IF(VININ) GOTO 177               00005140
    CALL STAND(I)                   00005150
    GOTO 20                           00005160
225 WRITE(6,197)                      00005170
    UNIT(I)='IND'                   00005180
197 FORMAT(10X,'INPUT DESIGN PARAMETERS FOR THE INDUCTION FAN'///) 00005200
    WRITE(6,351)                      00005210
351 FORMAT(5X,'ENTER THE PRESSURE HEAD FOR THE TOTAL COMPRESSION'
1 5X,' PROCESS')
    READ*, TOTDP                     00005220
    IF(ENGL)WRITE(6,97)              00005230
    IF(METRIC) WRITE(6,98)           00005240
    READ*, TTMP(I)                  00005250
    FANCLS=4.0                       00005260
    IF(ININ) GOTO 640               00005270
    CALL STAND(I)                   00005280
    GOTO 20                           00005290
226 WRITE(6,761)                      00005300
    IF(ENGL)WRITE(6,97)              00005310
    IF(METRIC) WRITE(6,98)           00005320
    READ*, TTMP(I)                  00005330
    UNIT(I)='PCK'                   00005340
    WRITE(6,762)                      00005350
762 FORMAT(10X,'INPUT MAJOR CAUSTIC TO BE SCRUBBED BY THE ABSORPTION',00005360
1 ' COLUMN')
    READ*, SCRNAME(1)               00005370
    WRITE(6,381)                      00005380
381 FORMAT(5X,'CAUSTIC REMOVAL EFFICIENCY(PERCNET)')                 00005390
    READ*, HCLRM                     00005400
2003 FORMAT(6A5)                    00005410
    WRITE(6,763)                      00005420
763 FORMAT(10X,'INPUT THE RELATIVE WATER FEED RATE TO THE PACKED BED',00005430
2 ' SCRUBBER'/15X,'VALUE MUST BE BETWEEN 15 - 30 GALLON H2O PER', 00005440
3 ' 1000 FT^3 OF GAS FLOW')
    READ*, PAKH20                     00005450
761 FORMAT(10X,'INPUT DESIGN PARAMETERS FOR THE PACKED BED'///) 00005460
766 WRITE(6,198)                      00005470
198 FORMAT(10X,'INPUT PACKING TYPE'/15X,'1 - BERL SADDLES'/15X,
1 '2 - RASCHIG RINGS')
    READ*, TEMPER                    00005480
    IF(TEMPER.GT.2.0.OR.TEMPER.LT.1.0) WRITE(6,199) 00005490
199 FORMAT(10X,'SELECTION OUT OF RANGE RESPCLFY')
    IF(TEMPER.GT.2.0.OR.TEMPER.LT.1.0) GOTO 766 00005500
    IF(TEMPER.EQ.1) PCKCHS(1)='BERL' 00005510
    IF(TEMPER.EQ.1) PCKCHS(2)=' SAD' 00005520
    IF(TEMPER.EQ.1) PCKCHS(3)='DLES' 00005530
    IF(TEMPER.EQ.1) PCKCHS(4)=' '
    IF(TEMPER.EQ.2) PCKCHS(1)='RASC' 00005540
    IF(TEMPER.EQ.2) PCKCHS(2)='HIG ' 00005550
    IF(TEMPER.EQ.2) PCKCHS(3)='RING' 00005560
    IF(TEMPER.EQ.2) PCKCHS(4)='S '
769 WRITE(6,767)                      00005570
767 FORMAT(10X,'INPUT THE SIZE OF THE PACKING USED'/15X,
1 '1 - 0.5 INCH PACKING      2 - 1.0 INCH PACKING ',/15X, 00005580
                                         00005590
                                         00005600
                                         00005610
                                         00005620
                                         00005630
                                         00005640
                                         00005650
                                         00005660
                                         00005670
                                         00005680

```

2 '3 - 1.5 INCH PACKING	4 - 2.0 INCH PACKING ')	00005690
READ*, ITEMPR		00005700
IF(ITEMPR.GT.4.0.R.ITEMPR.LT.1.0) WRITE(6,768)		00005710
768 FORMAT(10X,'SELECTION OUT OF RANGE, RESPECIFY.')		00005720
IF(ITEMPR.GT.4.0.R.ITEMPR.LT.1.0) GOTO 769		00005730
IF(ITEMPR.EQ.1) PCKSIZ=0.5		00005740
IF(ITEMPR.EQ.2) PCKSIZ=1.0		00005750
IF(ITEMPR.EQ.3) PCKSIZ=1.5		00005760
IF(ITEMPR.EQ.4) PCKSIZ=2.0		00005770
WRITE(6,770)		00005780
770 FORMAT(10X,'INPUT THE EFFECTIVE ABSORPTION FACTOR(BETWEEN 1'		00005790
1 , ' AND 2).')		00005800
READ*, EFFABS.		00005810
WRITE(6,771)		00005820
771 FORMAT(10X,'INPUT THE PERCENT FLOODING IN THE PACKED BED'/		00005830
1 '(BETWEEN 0 AND 100)')		00005840
READ*, PRCFLD		00005850
WRITE(6,772)		00005860
772 FORMAT(10X,'INPUT THE NUMBER OF ABSORPTION TRANSFER UNITS',		00005870
1 '(OBTAINED FROM EQUILIBRIUM DIAGRAM)')		00005880
READ*, NTU		00005890
WRITE(6,774)		00005900
774 FORMAT(10X,'INPUT THE SLOPE OF THE EQUILIBRIUM CURVE')		00005910
READ*, SLPABS		00005920
WRITE(6,775)		00005930
775 FORMAT(10X,'INPUT THE DIFFUSION COEFFICIENT FOR THE CAUSTIC IN',		00005940
1 ' THE GAS PHASE')		00005950
READ*, DFHCLG		00005960
WRITE(6,776)		00005970
776 FORMAT(10X,'INPUT THE DIFFUSION COEFFICIENT FOR THE CAUSTIC IN',		00005980
1 ' THE LIQUID PHASE')		00005990
READ*, DFHCLL		00006000
WRITE(6,773)		00006010
773 FORMAT(10X,'INPUT THE SCHMIDT NUMBER FOR THE ABSORPTION PROCESS',		00006020
1 '(INPUT 1.0 IF NOT KNOWN)')		00006030
READ*, SCHMDT		00006040
CALL STAND(I)		00006050
IF(PCIN) GOTO 643		00006060
GOTO 20		00006070
227 WRITE(6,861)		00006080
UNIT(I)='STK'		00006090
IF(ENGL)WRITE(6,97)		00006100
IF(METRIC) WRITE(6,98)		00006110
READ*, TTMP(I)		00006120
861 FORMAT(10X,'INPUT DESIGN PARAMETERS FOR THE EXHAUST STACK///')		00006130
WRITE(6,8050)		00006140
8050 FORMAT(10X,'INPUT HEIGHT OF EXHAUST STACK')		00006150
READ*, HEIGHT		00006160
IF(STKIN) GOTO 646		00006170
GOTO 20		00006180
20 CONTINUE		00006190
GOTO 4016		00006200
21 CONTINUE		00006210
WRITE(6,1000)		00006220
1000 FORMAT(10X,'THE FOLLOWING INPUT REQUIREMENTS PERTAIN TO THE ',		00006230
1 'ECONOMIC ANALYSIS OF THE FACILITY///')		00006240
WRITE(6,660)		00006250
660 FORMAT(10X,'YEAR TO DATE THE CAPITAL COST OF THE FACILITY')		00006260
READ*, IYEAR		00006270
WRITE(6,552)		00006280
552 FORMAT(10X,'HOW MANY HOURS PER DAY IS THE INCINERATOR '		00006290
1 , 'OPERATING?')		00006300
READ*, DAY		00006310
WRITE(6,553)		00006320
553 FORMAT(10X,'HOW MANY DAYS PER YEAR IS THE INCINERATOR IN ',		00006330
1 'OPERATION?')		00006340
READ*, YEAR		00006350
WRITE(6,655)		00006360
655 FORMAT(10X,'REVENUE GENERATED FOR WASTE INCINERATION(\$/TON)')		00006370
READ*, REVLB		00006380
WRITE(6,656)		00006390
656 FORMAT(10X,'LENGTH OF PROCESS LIFE(YEARS)')		00006400

```

        READ*, YRNUM                         00006410
657  WRITE(6,654)                         00006420
654 FORMAT(10X,'SELECT ONE OF THE FOLLOWING OPTIONS'/
1 15X,'1 - INPUT AVERAGE COST INDEX FOR EQUIPMENT COST'/
2 15X,'2 - INPUT SPECIFIC COST INDEX FACTORS FROM CHEMICAL'/
3 19X,'ENGINEERING EQUIPMENT COST FACTORS')
        READ*, ITEMP                         00006430
        IF(ITEMP.GT.2.OR.ITEMP.LT.1) GOTO 657  00006440
        IF(ITEMP.EQ.2) GOTO 658               00006450
        WRITE(6,659) IYEAR                   00006460
659 FORMAT(10X,'INPUT AVERAGE EQUIPMENT COST UPDATE FACTOR FOR THE'/
1 13X,'YEAR ',I4)                      00006470
        READ*, FACSUM                         00006480
        FACCES=FACSUM                        00006490
        FACMSC=FACSUM                        00006500
        FACCEE=FACSUM                        00006510
        FACCEF=FACSUM                        00006520
        FACCEB=FACSUM                        00006530
        GOTO 248                            00006540
658  WRITE(6,1010)                         00006550
1010 FORMAT(10X,'INPUT COST UPDATE FACTOR FOR'/
1 , ' EQUIPMENT MACHINERY AND SUPPORTS')
        READ*, FACCES                         00006560
        WRITE(6,1003)                         00006570
1003 FORMAT(10X,'INPUT COST UPDATE FACTOR FOR'/
1 , 'FOR ELECTRICAL EQUIPMENT')
        READ*, FACCEE                         00006580
        WRITE(6,1004)                         00006590
1004 FORMAT(10X,'INPUT THE COST UPDATE FACTOR FOR'/
1 , 'FABRICATED EQUIPMENT')
        READ*, FACCEF                         00006600
        WRITE(6,1005)                         00006610
1005 FORMAT(10X,'INPUT THE COST UPDATE FACTOR FOR'/
1 , 'STRUCTURAL SUPPORTS AND MISC.')
        READ*, FACMSC                         00006620
        WRITE(6,1006)                         00006630
1006 FORMAT(10X,'INPUT THE COST UPDATE FACTOR FOR'/
1 , 'BUILDING COSTS')
        READ*, FACCEB                         00006640
        WRITE(6,1015)                         00006650
1015 FORMAT(10X,'INPUT THE COST FACTOR FOR'/
1 , ' PIPES, VALVES & FITTINGS')
        READ*, FACPVF                         00006660
        WRITE(6,1016)                         00006670
1016 FORMAT(10X,'INPUT THE COST FACTOR FOR'/
1 , ' PUMPS AND COMPRESSORS')
        READ*, PACPC                          00006680
        WRITE(6,1017)                         00006690
1017 FORMAT(10X,'INPUT THE COTS FACTOR FOR'/
1 , 'PROCESS INSTRUMENTS')
        READ*, FACPI                          00006700
        WRITE(6,1018)                         00006710
1018 FORMAT(10X,'INPUT THE COST FACTOR FOR'/
1 , ' ENGINEERING & SUPERVISION')
        READ*, FACENG                         00006720
        WRITE(6,1019)                         00006730
1019 FORMAT(10X,'INPUT THE COST FACTOR FOR'/
1 , ' CONSTRUCTION LABOR')
        READ*, FACLAB                         00006740
        WRITE(6,1020)                         00006750
1020 FORMAT(10X,'INPUT THE COST FACTOR FOR'/
1 , ' PROCESS MACHINERY')
        READ*, FACPRS                         00006760
248  CONTINUE                           00006770
        WRITE(6,554)                         00006780
554  FORMAT(10X,'SPECIFY THE PERCENTAGE OF EQUIPMENT COST FOR THE'/
1  'CONTINGENCY COSTS.')
        READ*, CONTEN                         00006790
230  CONTINUE                           00006800
        IF(ECLOG) GOTO 1217                 00006810
C
C

```

```

C     CHECK INPUT BEFORE PRINTING TO OUTPUT FILE.          00007130
C
C
C     FEDPT=.FALSE.
C     WRITE(6,182) WSTNME(1)                                00007140
182 FORMAT(25X,'INPUT DATA FOR'/22X,A20)                 00007150
C     WRITE(6,183)                                00007160
C     00007170
183 FORMAT(10X,'GENERAL PHYSICAL PROPERTIES OF WASTE FEED') 00007180
C     WRITE(6,184) MASSL,WTPVOL,WTPH20,ZSLHT               00007190
C     00007200
184 FORMAT(15X,'WASTE FEED RATE=      ',F9.2,' LB/HR')   00007210
1     15X,'WEIGHT PERCENT VOLATILES=    ',F9.6,/        00007220
2     15X,'WEIGHT PERCENT H2O=           ',F9.6/        00007230
3     15X,'HEAT CONTENT OF WASTE=       ',F9.0)        00007240
C     IF(LQD) WRITE(6,930)                                00007250
C     IF(SLD) WRITE(6,931)                                00007260
930 FORMAT(10X,'WASTE FEED IS A LIQUID')                00007270
931 FORMAT(10X,'WASTE FEED IS A SOLID')                  00007280
C     IF(CMBST) WRITE(6,185)                                00007290
C     IF(VOLTIL) WRITE(6,186)                                00007300
185 FORMAT(15X,'WASTE FEED IS COMBUSTABLE')              00007310
186 FORMAT(15X,'WASTE FEED HAS SIGNIFICANT QUATITIES'/
1     18X,'OF VOLATILES')                                00007320
C     WRITE(6,187) (XXSLUD(IJK),IJK=1,9),(XXFUEL(IJK),IJK=1,9),
1     (XXAIR(IJK), IJK=1,9)                            00007330
C     00007340
187 FORMAT(25X,'COMPOSITON OF WASTE FEED, FUEL'/
1     25X,' AND AIR(WEIGHT PERCENT'      '//)          00007350
2     5X,' STREAM   H   C   O   N   CL   S   F   P   NE  // 00007360
3     5X,' WASTE FEED',9(2X,F5.3)/                   00007370
4     5X,' FUEL   ',9(2X,F5.3)/                   00007380
5     5X,' AIR    ',9(2X,F5.3))                   00007390
C     WRITE(6,188) ELEVAT,TA,PINC,FEDRG2                00007400
188 FORMAT(10X,'AMBIENT CONDITIONS'/15X,
1     'FACILITY CONDITONS=      ',F6.0,' FEET'        00007410
2     15X,'TEMPERATURE=         ',F6.0,' FAHRENHEIT'  00007420
3     15X,'PRESSURE=            ',F6.0,' PSIA'        00007430
4     15X,'PARTICULATE EMISSION LIMIT= ',E15.5,'LB/ACF') 00007440
C     IF(BRN) WRITE(6,932)                                00007450
C     IF(SCRW) WRITE(6,933)                                00007460
C     IF(BARREL) WRITE(6,934)                               00007470
C     IF(.NOT.BARREL) WRITE(6,935)                           00007480
932 FORMAT(10X,'BURNERS ARE USED FOR THE WASTE FEED SYSTEM') 00007490
933 FORMAT(10X,'A SCREW AND CART SYSTEM IS USED FOR WASTE FEED') 00007500
934 FORMAT(10X,'A BARREL BARN IS SPECIFIED TO STORE THE WASTE FEED') 00007510
935 FORMAT(10X,'STORAGE TANKS ARE USED TO STORE WASTE')    00007520
170 WRITE(6,4013)                                         00007530
C     READ*, ITEMP                                         00007540
C     IF(ITEMP.GT.2.0.R.ITEMP.LT.1) GOTO 170             00007550
C     IF(ITEMP.EQ.1) GOTO 189                            00007560
C     FEDPT=.TRUE.
C     GOTO 200                                         00007570
189 JJ=0                                         00007580
5000 JJ=JJ+1                                         00007590
CS=.FALSE.                                         00007600
SS=.FALSE.                                         00007610
IC=.FALSE.                                         00007620
C     IF(MATL(JJ).EQ.MATLC(1)) CS=.TRUE.                00007630
C     IF(MATL(JJ).EQ.MATLC(2)) SS=.TRUE.                00007640
C     IF(MATL(JJ).EQ.MATLC(3)) IC=.TRUE.                00007650
C     WRITE(6,231) JJ,UNIT(JJ)                          00007660
231 FORMAT(I3,2X,A5)                                00007670
C     IF(SUNIT(8).EQ.UNIT(JJ)) GOTO 4015             00007680
C     IF(SUNIT(2).EQ.UNIT(JJ)) GOTO 171              00007690
C     IF(SUNIT(1).EQ.UNIT(JJ)) GOTO 4032             00007700
C     IF(SUNIT(4).EQ.UNIT(JJ)) GOTO 177              00007710
C     IF(SUNIT(5).EQ.UNIT(JJ)) GOTO 640              00007720
C     IF(SUNIT(6).EQ.UNIT(JJ)) GOTO 643              00007730
C     IF(SUNIT(3).EQ.UNIT(JJ)) GOTO 174              00007740
C     IF(SUNIT(9).EQ.UNIT(JJ)) GOTO 646              00007750
C     GOTO 5001                                         00007760
4032 WRITE(6,4000)
INCIP=.FALSE.
4000 FORMAT(10X,'INCINERATOR INPUT DATA')           00007770
C     00007780
C     00007790
C     00007800
C     00007810
C     00007820
C     00007830
C     00007840

```

IF(ROTARY) WRITE(6,4001)	00007850
IF(FLUID) WRITE(6,4002)	00007860
IF(LIQ1) WRITE(6,4003)	00007870
IF(PLASMA) WRITE(6,4004)	00007880
4001 FORMAT(25X,'ROTARY KILN INCINERATOR')	00007890
4002 FORMAT(25X,'FLUIDIZED BED INCINERATOR')	00007900
4003 FORMAT(25X,'LIQUID INJECTION INCINERATOR')	00007910
4004 FORMAT(25X,'PLASMA ARC PYROLYSIS PROCESS')	00007920
IF(ADIA) WRITE(6,4005)	00007930
IF(.NOT.ADIA) WRITE(6,4006) TTMP(JJ)	00007940
4005 FORMAT(10X,'ADIABATIC COMBUSTION PROCESS')	00007950
4006 FORMAT(10X,'OUTLET TEMPERATURE FROM INCINERATOR= ',F6.1)	00007960
WRITE(6,4007) RETIM(JJ)	00007970
4007 FORMAT(10X,'RETENTION TIME OF THE COMBUSTED GAS(SECONDS)= ',F6.1)	00007980
WRITE(6,4008) EXCESS(JJ)	00007990
4008 FORMAT(10X,'EXCESS AIR FOR COMBUSTION PROCESS= ',F6.1,'PERCENT')	00008000
WRITE(6,936) EXFUEL(JJ)	00008010
936 FORMAT(10X,'EXCESS FUEL FOR COMBUSTION PROCESS= ',F6.1,'PERCENT')	00008020
WRITE(6,4009) RLD(JJ)	00008030
4009 FORMAT(10X,'LENGTH TO DIAMETER RATIO= ',F6.1)	00008040
IF(IC) WRITE(6,4010)	00008050
4010 FORMAT(10X,'MATERIAL OF CONSTRUCTION IS INCONEL')	00008060
IF(SS) WRITE(6,4011)	00008070
4011 FORMAT(10X,'MATERIAL OF CONSTRUCTION IS STAINLESS STEEL')	00008080
IF(CS) WRITE(6,4012)	00008090
4012 FORMAT(10X,'MATERIAL OF CONSTRUCTION IS CARBON STEEL')	00008100
WRITE(6,937) PREXTI	00008110
937 FORMAT(10X,'EXTRA COSTS INCLUDED WITH INCINERATOR= ',F6.3,	00008120
1 ' PERCENT OF EQUIPMENT COST')	00008130
IF(FLUID.AND.VALVE) WRITE(6,938)	00008140
IF(FLUID.AND.SIEVE) WRITE(6,939)	00008150
938 FORMAT(10X,'VALVES TRAYS USED TO COST ESTIMATE FLUIDIZED BED ',	00008160
1 'SUPPORT TRAYS')	00008170
939 FORMAT(10X,'SIEVE TRAYS USED TO COST EXTIMATE FLUIDIZED BED ',	00008180
1 'SUPPORT TRAYS')	00008190
4014 WRITE(6,4013)	00008200
4013 FORMAT(10X,'IF THE DATA HAS BEEN ENTERED CORRECTLY, ENTER 1;'	00008210
1 /10X, 'IF CHANGES ARE NEEDED ENTER 2')	00008220
READ*, TEMPER	00008230
IF(TEMPER.GT.2.OR.TEMPER.LT.1) GOTO 4014	00008240
IF(TEMPER.EQ.1) GOTO 5001	00008250
INCIP=.TRUE.	00008260
GOTO 4016	00008270
4015 WRITE(6,4017)	00008280
AFTINC=.FALSE.	00008290
4017 FORMAT(25X,'AFTERBURNER INPUT DATA')	00008300
IF(METRIC) WRITE(6,4018) TTMP(JJ)	00008310
IF(ENGL) WRITE(6,4019) TTMP(JJ)	00008320
4018 FORMAT(10X,'OUTLET TEMPERATURE= ',F6.1,' CELCIUS')	00008330
4019 FORMAT(10X,'OUTLET TEMPERATURE= ',F6.1,'FAHRENHEIT')	00008340
WRITE(6,4020) RETIM(JJ)	00008350
4020 FORMAT(10X,'RETENTION TIME OF AFTERBURNER= ',F6.1,' SECONDS')	00008360
WRITE(6,4021) EXCESS(JJ)	00008370
WRITE(6,4022) EXFUEL(JJ)	00008380
WRITE(6,4023) RLD(JJ)	00008390
WRITE(6,878) PREXT	00008400
878 FORMAT(10X,'CONTINGENCY COST FACTOR= ',F6.3)	00008410
4021 FORMAT(10X,'EXCESS AIR= ',F5.1,'PERCENT')	00008420
4022 FORMAT(10X,'EXCESS FUEL= ',F5.1,' PERCENT')	00008430
4023 FORMAT(10X,'LENGTH TO DIAMETER RATIO= ',F5.1)	00008440
IF(IC) WRITE(6,4024)	00008450
IF(SS) WRITE(6,4025)	00008460
IF(CS) WRITE(6,4026)	00008470
4024 FORMAT(10X,'AFTERBURNER MATERIALS IN INCONEL CLAD')	00008480
4025 FORMAT(10X,'AFTERBURNER MATERIALS IS STAINLESS STEEL')	00008490
4026 FORMAT(10X,'AFTERBURNER MATERIALS IS CARBON STEEL')	00008500
4030 WRITE(6,4013)	00008510
READ*, ITEMP	00008520
IF(ITEMP.GT.2.OR.ITEMP.LT.1) GOTO 4030	00008530
IF(ITEMP.EQ.1) GOTO 4031	00008540
AFTINC=.TRUE.	00008550
GOTO 4016	00008560

```

171 WRITE(6,172) 00008570
  QUNCH=.FALSE.
172 FORMAT(25X,'QUENCH CHAMBER INPUT DATA') 00008580
  IF(CS) WRITE(6,4012) 00008590
  IF(SS) WRITE(6,4011) 00008600
  IF(IC) WRITE(6,4010) 00008610
    IF(QSAT.EQ.1.0) WRITE(6,940) 00008620
      IF(QTEMP.EQ.1.0) WRITE(6,941) TTMP(JJ) 00008630
940 FORMAT(10X,'EMISSION GASES COOLED TO SATURATION') 00008640
941 FORMAT(10X,'GASS COOLED TO EXIT TEMPERATURE= ',F9.2,' FAHRENHEIT') 00008660
173 WRITE(6,4013) 00008670
  READ*, ITEMP 00008680
  IF(ITEMP.GT.2.0R.ITEMP.LT.1) GOTO 173 00008690
  IF(ITEMP.EQ.1) GOTO 5001 00008700
    QUNCH=.TRUE.
    GOTO 4016 00008720
174 WRITE(6,175) 00008730
175 FORMAT(25X,'INPUT DATA FOR HEAT RECOVERY BOILER') 00008740
  IF(CS) WRITE(6,4012) 00008750
  IF(SS) WRITE(6,4011) 00008760
  IF(IC) WRITE(6,4010) 00008770
  HTEIN=.FALSE.
  IF(FXH) WRITE(6,942) 00008780
  IF(KRB) WRITE(6,943) 00008790
  IF(UTB) WRITE(6,944) 00008800
942 FORMAT(10X,'HEAT ROCOVERY BOILER IS A FIXED-HEAD EXCHANGER') 00008810
943 FORMAT(10X,'HEAT ROCOVERY BOILER IS A KETTLE EXCHANGER') 00008820
944 FORMAT(10X,'HEAT ROCOVERY BOILER IS A U-TUBE EXCHANGER') 00008830
  WRITE(6,945) TTMP(JJ) 00008840
945 FORMAT(10X,'OUTLET TEMPERATURE FROM REBOILER IS=',F9.2, 00008850
  1 ' FAHRENHEIT') 00008860
  IF(S316) WRITE(6,946) 00008870
  IF(S304) WRITE(6,947) 00008880
  IF(S347) WRITE(6,948) 00008890
  IF(NI200) WRITE(6,949) 00008900
  IF(MO400) WRITE(6,950) 00008910
  IF(IN600) WRITE(6,951) 00008920
  IF(IN825) WRITE(6,952) 00008930
  IF(TI) WRITE(6,953) 00008940
  IF(HS) WRITE(6,954) 00008950
946 FORMAT(10X,'HEAT EXCHANGER CONSTRUCTED OF STAINLESS STEEL 316') 00008960
947 FORMAT(10X,'HEAT EXCHANGER CONSTRUCTED OF STAINLESS STEEL 304') 00008970
948 FORMAT(10X,'HEAT EXCHANGER CONSTRUCTED OF STAINLESS STEEL 347') 00008980
949 FORMAT(10X,'HEAT EXCHANGER CONSTRUCTED OF NICKEL 200') 00008990
950 FORMAT(10X,'HEAT EXCHANGER CONSTRUCTED OF MOLYEBDENUM 300') 00009000
951 FORMAT(10X,'HEAT EXCHANGER CONSTRUCTED OF INCONEL 600') 00009010
952 FORMAT(10X,'HEAT EXCHANGER CONSTRUCTED OF INCONEL 825') 00009020
953 FORMAT(10X,'HEAT EXCHANGER CONSTRUCTED OF TITANIUM') 00009030
954 FORMAT(10X,'HEAT EXHANGER CONSTRUCTED OF HASTELLOY') 00009040
  WRITE(6,955) HTC 00009050
955 FORMAT(10X,'HEAT TRANSFER COEFFICIENT= ',F9.3,' BTU/FT^2/HR', 00009060
  1 '/FAHRENHEIT') 00009070
176 WRITE(6,4013) 00009080
  READ*, ITEMP 00009090
  IF(ITEMP.GT.2.0R.ITEMP.LT.1) GOTO 176 00009100
  IF(ITEMP.EQ.1) GOTO 5001 00009110
    HTEIN=.TRUE.
    GOTO 4016 00009120
177 WRITE(6,178) 00009130
  VININ=.FALSE. 00009140
178 FORMAT(25X,'INPUT DATA FOR VENTURI SCRUBBER ') 00009150
  IF(CS) WRITE(6,4012) 00009160
  IF(SS) WRITE(6,4011) 00009170
  IF(IC) WRITE(6,4010) 00009180
  WRITE(6,956) VENWAT 00009190
956 FORMAT(10X,'WATER RATE IN THE VENTURI SCRUBBER= ',F9.2,' LB H2O/' 00009200
  1 , ' 1000 ACF OF GAS') 00009210
  IF(FG) WRITE(6,957) 00009220
957 FORMAT(10X,'FIBERGLASS IS USED TO LINE THE SCRUBBER THROAT') 00009230
  IF(VENAUT) WRITE(6,958) 00009240
  IF(.NOT.VENAUT) WRITE(6,959) 00009250
958 FORMAT(10X,'AUTOMATIC PRESSURE DROP THROAT ADJUSTMENT IS SPECIFIED') 00009260
                                         00009270
                                         00009280

```

```

      1')
959 FORMAT(10X,'MANUAL PRESSURE DROP THROAT ADJUSTMENT IS SPECIFIED') 00009290
      IF(PRI) WRITE(6,960) 00009300
      IF(.NOT.PRI) WRITE(6,961) DPTOT 00009310
960 FORMAT(10X,'PRESSURE DROP IS CALCULATED FROM EXPERIMENTAL DATA') 00009320
961 FORMAT(10X,'PRESSURE DROP IS SPECIFIED DIRECTLY=',F9.2, 00009330
      1 'INCHES OF H2O') 00009340
      IF(.NOT.PRI) GOTO 962 00009350
      WRITE(6,963) 00009360
963 FORMAT(15X,'PARTICLE DIAMETER           WEIGHT'/ 00009370
      1      15X,' (MICRONS) (PERCENT)') 00009380
      DO 964 IL=1,NPRTS 00009390
         WRITE(6,965) DIAPT(IL),WTPRT(IL) 00009400
965 FORMAT(18X,F10.2,14X,F9.6) 00009410
964 CONTINUE 00009420
962 CONTINUE 00009430
192 WRITE(6,4013) 00009440
      READ*,ITEMP 00009450
      IF(ITEMP.GT.2.0R.ITEMP.LT.1) GOTO 192 00009460
      IF(ITEMP.EQ.1) GOTO 5001 00009470
         VININ=.TRUE. 00009480
         GOTO 4016 00009490
640 WRITE(6,641) 00009500
         ININ=.FALSE. 00009510
641 FORMAT(25X,'INPUT DATA FOR INDUCTION FANS') 00009520
      IF(CS) WRITE(6,4012) 00009530
      IF(SS) WRITE(6,4011) 00009540
      IF(IC) WRITE(6,4010) 00009550
      WRITE(6,966) TOTDP 00009560
966 FORMAT(10X,'TOTAL PRESSURE HEAD THROUGH INDUCTION FAN=',F9.2, 00009570
      1 'INCHES H2O') 00009580
192 WRITE(6,4013) 00009590
      READ*,ITEMP 00009600
      IF(ITEMP.GT.2.0R.ITEMP.LT.1) GOTO 642 00009610
      IF(ITEMP.EQ.1) GOTO 5001 00009620
         ININ=.TRUE. 00009630
         GOTO 4016 00009640
643 WRITE(6,644) 00009650
644 FORMAT(25X,'INPUT DATA FOR PACKED BED ABSORBER') 00009660
      IF(CS) WRITE(6,4012) 00009670
      IF(SS) WRITE(6,4011) 00009680
      IF(IC) WRITE(6,4010) 00009690
      WRITE(6,970) SCRNAME(1) 00009700
      WRITE(6,971) HCLRM 00009710
      WRITE(6,972) PAKH20 00009720
      WRITE(6,973) (PCKCHS(IJK),IJK=1,4) 00009730
      WRITE(6,974) PCKSIZ 00009740
970 FORMAT(10X,'CAUSTIC TO BE SCRUBBED IS ',A15) 00009750
971 FORMAT(10X,'OVERALL REMOVAL EFFICIENCY= ',F12.8) 00009760
972 FORMAT(10X,'ABSORPTION WATER FEED RATE= ',F9.2,'GALLONS H2O//', 00009770
      1 ' 1000 FT^3 OF GAS') 00009780
973 FORMAT(10X,'TYPE OF PACKING USED IS ',A4) 00009790
974 FORMAT(10X,'SIZE OF PACKING IS= ',F6.1,' INCHES') 00009800
      WRITE(6,975) EFFABS,PRCFLD,NTU,SLPABS 00009810
975 FORMAT(10X,'ABSORPTION PARAMETERS/' 00009820
      1      15X,'ABSORPTION EFFICIENCY=      ',F9.2,' OF IDEAL' / 00009830
      1      15X,'PERCENT FLOODING=          ',F9.2,' PERCENT' / 00009840
      2      15X,'NUMBER OF TRANSFER UNITS=   ',I4/ 00009850
      3      15X,'SLOPE OF EQUILIBRIUM CURVE=  ',F6.1/ 00009860
      4)
      WRITE(6,976) DFHCLG,DFHCLL 00009870
976 FORMAT(15X,'DIFFUSION COEFFICIENT OF CAUSTIC IN GAS= ',F9.2, 00009880
      1 ' FT^2/SECOND' / 00009890
      2      15X,'DIFFUSION COEFFICIENT OF CAUSTIC IN LIQUID= ',F9.2, 00009900
      3 ' FT^2/SECOND' ) 00009910
645 WRITE(6,4013) 00009920
      PCIN=.FALSE. 00009930
      READ*,ITEMP 00009940
      IF(ITEMP.GT.2.0R.ITEMP.LT.1) GOTO 645 00009950
      IF(ITEMP.EQ.1) GOTO 5001 00009960
         PCIN=.TRUE. 00009970
         GOTO 4016 00009980
977 FORMAT(10X,'ABSORPTION COEFFICIENT OF CAUSTIC IN GAS= ',F9.2, 00009990
      1 ' FT^2/SECOND' / 00009990
      2      15X,'ABSORPTION COEFFICIENT OF CAUSTIC IN LIQUID= ',F9.2, 00010000
      3 ' FT^2/SECOND' )

```

```

646 WRITE(6,647)                                     00010010
  STKIN=.FALSE.                                     00010020
647 FORMAT(25X,'INPUT DATA FOR EXHAUST STACK DESIGN') 00010030
  IF(CS) WRITE(6,4012)                             00010040
  IF(SS) WRITE(6,4011)                             00010050
  IF(IC) WRITE(6,4010)                             00010060
  WRITE(6,977) HEIGHT                            00010070
977 FORMAT(10X,'HEIGHT OF THE EXHAUST STACK= ',F9.2,' FEET') 00010080
648 WRITE(6,4013)                                     00010090
  READ*,ITEMP                                      00010100
  IF(ITEMP.GT.2.0R.ITEMP.LT.1) GOTO 648          00010110
  IF(ITEMP.EQ.1) GOTO 5001                         00010120
    STKIN=.TRUE.                                    00010130
    GOTO 4016                                       00010140
4031 CONTINUE                                         00010150
5001 CONTINUE                                         00010160
  IF(JJ.LE.NUNIT) GOTO 5000                      00010170
650 WRITE(6,649)                                     00010180
649 FORMAT(25X,'INPUT DATA FOR DUCTWORK DESIGN'/
  1 10X,' UNIT MATERIALS LENGTH(FEET) # OF ELBOWS') 00010190
  DO 233 J=1,NUNIT                                00010200
    IJ=J+1                                         00010210
    WRITE(6,651) J,IJ,DCMATL(J),DCTLEN(J),ELBNUM(J) 00010220
651 FORMAT(10X,I2,' TO ',I2,5X,A5,2X,F9.2,2X,F9.2) 00010230
233 CONTINUE                                         00010240
652 WRITE(6,4013)                                     00010250
  READ*,ITEMP                                      00010260
  IF(ITEMP.GT.2.0R.ITEMP.LT.1) GOTO 652          00010270
  IF(ITEMP.EQ.1) GOTO 653                         00010280
  DO 234 J=I,NUNIT                                00010290
    CALL STAND(J)                                  00010300
234 CONTINUE                                         00010310
653 CONTINUE                                         00010320
1217 WRITE(6,1210) IYEAR,DAY,YEAR,REVLB,YRNUM       00010330
  WRITE(6,1211) FACCES,FACMSC,FACCEE,FACCEF,FACCEB,FACPVF,FACPC,
  1  FACPI                                         00010340
1210 FORMAT(25X,'ECONOMIC DATA FOR THE INCINERATION FACILITY'/
  1 25X,' FOR THE YEAR ',I4/                     00010350
  2 10X,'DAILY OPERATION= ',F5.1/                 00010360
  3 10X,'YEARLY OPERATION= ',F5.1/                00010370
  4 10X,'COST FOR INCINERATION= ',F6.1/           00010380
  5 10X,'TOTAL PROCESS LIFE= ',F5.1/)            00010390
1211 FORMAT(25X,'COST FACTORS FROM CHEMICAL PROCESS INDUSTRY'/
  1 25X,' FOR ',I4/                           00010400
  2 10X,'COST FACTOR FOR EQUIPMENT, MACHINERY, AND SUPPORTS= ',F5.1/ 00010410
  3 10X,'COST FACTOR FOR STRUCTURAL SUPPORTS AND MISCELLANIOUS= ',F5.1/ 00010420
  4 10X,'COST FACTOR FOR ELECTRICAL EQUIPMENT= ',F5.1/           00010430
  5 10X,'COST FACTOR FOR FABRICATED EQUIPMENT= ',F5.1/           00010440
  6 10X,'COST FACTOR FOR BUILDING= ',F5.1/          00010450
  7 10X,'COST FACTOR FOR PIPES, VALVES, AND FITTINGS= ',F5.1/        00010460
  8 10X,'COST FACTOR FOR PUMPS AND COMPRESSORS= ',F5.1/          00010470
  9 10X,'COST FACTOR FOR PROCESS INSTRUMENTS= ',F5.1/          00010480
  9 10X,'COST FACTOR FOR ENGINEERING AND SUPERVISION= ',F5.1/        00010490
  A 10X,'COST FACTOR FOR CONSTRUCTION LABOR= ',F5.1/          00010500
  B 10X,'COST FACTOR FOR PROCESS MACHINERY= ',F5.1/          00010510
  C 10X,'COST FACTOR FOR FACILITIES= ',F5.1/          00010520
1234 FORMAT(
  A 10X,'COST FACTOR FOR ENGINEERING AND SUPERVISION= ',F5.1/ 00010530
  B 10X,'COST FACTOR FOR CONSTRUCTION LABOR= ',F5.1/          00010540
  C 10X,'COST FACTOR FOR PROCESS MACHINERY= ',F5.1/          00010550
  C 10X,'COST FACTOR FOR FACILITIES= ',F5.1/          00010560
1215 WRITE(6,4013)                                     00010570
  READ*,ITEMP                                      00010580
  ECLOG=.FALSE.                                    00010590
  IF(ITEMP.GT.2.0R.ITEMP.LT.1) GOTO 1215          00010600
  WRITE(6,4013)                                     00010610
  READ*,ITEMP                                      00010620
  ECLOG=.FALSE.                                    00010630
  IF(ITEMP.GT.2.0R.ITEMP.LT.1) GOTO 1215          00010640
  WRITE(6,4013)                                     00010650
  READ*,ITEMP                                      00010660
  ECLOG=.FALSE.                                    00010670
  IF(ITEMP.GT.2.0R.ITEMP.LT.1) GOTO 1215          00010680
  WRITE(6,4013)                                     00010690
  READ*,ITEMP                                      00010700
  ECLOG=.FALSE.                                    00010710
  IF(ITEMP.GT.2.0R.ITEMP.LT.1) GOTO 1215          00010720

```

```

IF(ITEMP.EQ.2) ECLOG=.TRUE.          00010730
IF(ITEMP.EQ.2) GOTO 21             00010740
CCONT=CONTEN*100.0                 00010750
WRITE(6,127) CCONT                00010760
127 FORMAT(10X,'CONTINGENCY COST FACTOR      =',F6.2,' PERCENT') 00010770
CALL WRIT                          00010780
STOP                             00010790
END                               00010800
SUBROUTINE STAND(II)              00010810
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00010820
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00010830
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL 00010840
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00010850
2 SSB,SCRW,VENAUT,FG,PRI,SLD,LQD,PLASMA,BRN,ADIA 00010860
3 ,KRB,FXH,UTB,S316,S304,S347,NI200,MO400,IN600,IN825,TI,HS 00010870
2 , HT1,HT2,HT3,VALVE,SIEVE,CMBST,HM1,MM2,ECLOG 00010880
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*20 00010890
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00010900
CHARACTER MATLC*2,SCRNME*20,FLNAM*15 00010910
DIMENSION MATLC(4)                00010920
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00010930
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00010940
2 VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAB,ZLFD2(9,9) 00010950
COMMON/PCKBED/ PSIZE(7),PCKSZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00010960
1 ,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT 00010970
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00010980
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIN(9),FANCLS 00010990
2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00011000
3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00011010
COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STM CST,DCTCST(9) 00011020
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,EXFUEL(9),FEDRG2 00011030
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECLC 00011040
1 ,AOP,WTPVOL,WTPH20,WTRAT,NTU,AQG,CSTSTO,SCHMDT,PRCFLD 00011050
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00011060
1 ,PREXTI,DPTOT,PREXT,ELEVAT,TOTDP,QSET,QTEMP,HCLRM 00011070
2 ,CSTIIN,CSTSTR,CSTSPr,CSTCRT,CSTENG,DCDIA(9),CSTINT 00011080
3 ,DSDIA(9),DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN, 00011090
4 ,TOTECL,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00011100
5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00011110
6 ,VENWAT,DIAPT(100),WTPRT(100),FINCRG,REFINS,THCKIN,EQFVIN 00011120
COMMON/UPDATE/ FACSUM,FACCES,FACMSC,FACCEE,FACCEB 00011130
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00011140
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00011150
COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00011160
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NPRTS,NUMBRN 00011170
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00011180
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK,SCRNME(6) 00011190
2 ,WSTNME(6),BNMFR(6),BNMIN(6),FLNAM 00011200
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL 00011210
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC 00011220
2 ,SLD,SCRW,VENAUT,PLASMA,BRN,ADIA,PRI,FG,LQD 00011230
3 ,KRB,FXH,UTB,S316,S304,S347,NI200,MO400,IN600,IN825,TI,HS 00011240
2 , HT1,HT2,HT3,VALVE,SIEVE,CMBST,HM1,MM2,ECLOG 00011250
00011260
C
III=III+1                         00011270
WRITE(6,103) III,III                00011280
103 FORMAT(10X,'FOR DUCTWORK BETWEEN UNITS',I2,' AND ',I2) 00011290
IF(ENGL) WRITE(6,104)                00011300
IF(METRIC) WRITE(6,107)              00011310
104 FORMAT(10X,'INPUT THE LENGTH OF THE DUCTWORK ', 00011320
1 '(FEET)')                         00011330
107 FORMAT(10X,'INPUT THE LENGTH OF THE DUCTWORK FROM UNIT'. 00011340
1 ' TO THE NEXT UNIT(M)')           00011350
READ*, DCTLEN(II)                   00011360
WRITE(6,105)                         00011370
105 FORMAT(10X,'INPUT THE NUMBER OF BENDS IN THE DUCTWORK') 00011380
READ*, ELBNUM(II)                   00011390
112 WRITE(6,106)                     00011400
106 FORMAT(10X,'INPUT THE MATERIAL USED FOR DUCTWORK'/15X,'1 - IC'/
1 15X,'2 - SS'/15X,'3 - CS'/15X,'4 - WATER COOLED') 00011410
READ*, TEMPER                        00011430
IF(TEMPER.EQ.1) DCMATL(II)='IC'     00011440

```

```

IF(TEMPER.EQ.2) DCMATL(II)='SS'
IF(TEMPER.EQ.3) DCMATL(II)='CS'
IF(TEMPER.EQ.4) DCMATL(II)='WC'
IF(TEMPER.GT.4.0.OR.TEMPER.LT.1.0) WRITE(6,111)
111 FORMAT(10X,'SELECTION OUT OF RANGE. RESPECIFY')
IF(TEMPER.GT.4.0.OR.TEMPER.LT.1.0) GOTO 112
RETURN
END
SUBROUTINE DEFALT
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD
1 ,XXFUEL,XXAIR,MASSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL
1 .IC,SSG,VOLTL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP,
2 SSB,SCRW,VENAUT,FG,PRI,SLD,LQD,PLASMA,BRN,ADIA
3 ,KRB,FXH,UTB,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS
2 . HT1,HT2,HT3,VALVE,SIEVE,CMBST,HM1,HM2,ECLOG
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*20
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNM*4,MTLDCT*3,MTLBKR*3,DCMATL*2
CHARACTER MATLC*2,SCRNME*20,FLNAM*15
DIMENSION MATLC(4)
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSL,MASSFL,
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP
2 ,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9)
COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL
1 ,VISCG,EFFABS,TOCOST,CONST(7.8),SLPABS,PAKRAZ(7,4),Z,CSTINS,TBRNTT00011690
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9).HTC
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS
2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST
3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN
COMMON/COST/ SHLCST,DRVRCST,BRKTD,ASHCST,STMCS,TCTCST(9)
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,EXFUEL(9),FEDRG2
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL
1 ,ADP,WTPVOL,WTPH20,WATRAT,NTU,ADQ,CSTSTD,SCHMDT,PRCFLD
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK
1 ,PREXTI,DPTOT,PREXT,ELEVAT,TOTDP,QSET,QTEMP,HCLRM
2 ,CSTIIN,CSTSTR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT
3 ,DSDIA(9),DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,
4 TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR,
5 TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,
6 VENWAT,DIAPT(100),WTPRT(100),FINCRG,REFINS,THCKIN,EQFVIN
COMMON/UPDATE/ FACSUM,FACCES,FACMSC,FACCEE,FACCEF,FACCEB
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP
COMMON/DCT/ ELBNU(9),DCTLEN(9),DCTVEL(9),DIA(9)
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,UPIK,IYEAR,NPRTS,NUMBRN
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11)
1 ,PCKCHS(4),PCKNM(7,4),DCMATL(9),MTLDCT,MTLBKR,SCRNME(6)
2 ,WSTNME(6),BNMFR(6),BNMIN(6),FLNAM
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL
1 ,IC,SSG,VOLTL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC
2 ,SLD,SCRW,VENAUT,PLASMA,BRN,ADIA,PRI,FG,LQD
3 ,KRB,FXH,UTB,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS
2 . HT1,HT2,HT3,VALVE,SIEVE,CMBST,HM1,HM2,ECLOG

50 WRITE(6,100)
100 FORMAT(10X,'SELECT TYPE OF AUXILLARY HEAT '/15X,'1 - NATURAL GAS'/00012000
1 15X,'2 - FUEL OIL #2')
READ*,INTER
IF(INTER.NE.1) GOTO 20
FLNAM='NATURAL GAS'
ZFLHT=1020*16.044*10.73 -(459.96+60.0)/14.696
GOTO 40
20 IF(INTER.NE.2) GOTO 30
FLNAM='FUEL OIL#2'
ZFLHT=13970.0
GOTO 40
30 WRITE(6,300)
300 FORMAT(10X,'SELECTION OUT OF RANGE. RESPECIFY')
GOTO 50
40 CONTINUE
TEKC=7.0
SECC=7.0

```

```

SUPC=8.0
DO 10 I=1,8
  XXAIR(I)=0.0
  XXFUEL(I)=0.0
10 CONTINUE
  XXFUEL(1)=0.0130
  XXFUEL(2)=0.9870
  XXAIR(3)=0.2332
  XXAIR(4)=0.7672
  FACMSC=796.7
  FACCEE=347.6
  FACCEF=337.9
  FACCEB=302.4
  FACCES=345.6
  TEKC=7.00
  SECC=7.00
  SUPC=8.00
  DAY=24.0
  YEAR=260.0
  RETURN
END
SUBROUTINE WRIT
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP,
2 ,SSB,SCRW,VENAUT,FG,PRI,SLD,LQD,PLASMA,BRN,ADIA
3 ,KRB,FXH,UTB,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS
2 ,HT1,HT2,HT3,VALVE,SIEVE,CMBST,HM1,HM2,ECLOG
  CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*20
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2
  CHARACTER MATLC*2,SCRNME*20,FLNAM*15
DIMENSION MATLC(4)
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL,
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP
2 ,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAB,ZLFD2(9,9)
COMMON/PCKBED/ PSIZE(7),PCKSZ,I,CSTPK(7),PAKH20,RHOL,RHO,VISCL
1 ,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00012540
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS
2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST
3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN
COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STM CST,DCTCST(9)
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,EXFUEL(9),FEDRG2
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECLC
1 ,AOP,WTPVOL,WTPH20,WATRAT,NTU,AQ,CSTSTD,SCHMDT,PRCFLD
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK
1 ,PREXTI,DPTOT,PREXT,ELEVAT,TOTDP,QSET,QTEMP,HCLRM
2 ,CSTIIN,CSTSTR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT
3 ,DSDIA(9),DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,
4 ,TOTECL,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR,
5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,
6 ,VENWAT,DIAPT(100),WTPRT(100),FINCRG,REFINS,THCKIN,EQFVIN
COMMON/UPDATE/ FACSUM,FACCES,FACMSC,FACCEE,FACCEF,FACCEB
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP
COMMON/DCT/ ELENUM(9),DCTLEN(9),DCTVEL(9),DIA(9)
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NPRTS,NUMBRN
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11)
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK,SCRNME(6)
2 ,WSTNME(6),BNMFR(6),BNMIN(6),FLNAM
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC
2 ,SLD,SCRW,VENAUT,PLASMA,BRN,ADIA,PRI,FG,LQD
3 ,KRB,FXH,UTB,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS
2 ,HT1,HT2,HT3,VALVE,SIEVE,CMBST,HM1,HM2,ECLOG
C   OPEN(UNIT=12,FILE='ANS',STATUS='NEW')
  WRITE(12,205) DAY,YEAR
205 FORMAT(1X,F4.1,1X,F5.1)
  WRITE(12,71) WSTNME(1)
71 FORMAT(1X,A20)
  WRITE(12,70)(XXSLUD(I),I=1,9)

```

WRITE(12,70)(XXFUEL(I),I=1,9)	00012890
WRITE(12,70)(XXAIR(I),I=1,9)	00012900
70 FORMAT(1X,F6.4,2X,F6.4,2X,F6.4,2X,F6.4,2X,F6.4,2X,F6.4,2X,F6.4 1,2X,F6.4,2X,F6.4)	00012910
WRITE(12,20) MASSSL,ZSLHT	00012920
WRITE(12,207) FLNAM,ZFLHT	00012930
207 FORMAT(1X,A15,F7.1)	00012940
20 FORMAT(1X,2F11.4)	00012950
WRITE(12,76) BRN,SCRW,BARREL,RECT,SLD,LQD,CMBST	00012960
76 FORMAT(1X,L1)	00012970
WRITE(12,73) WTPH20,WTPVOL	00012980
WRITE(12,30) METRIC,ENGL,LCOST	00012990
73 FORMAT(1X,F9.7)	00013000
WRITE(12,90) NUNIT	00013010
90 FORMAT(1X,I2)	00013020
TTMP(NUNIT+1)=TA	00013030
WRITE(12,110) TTMP(NUNIT+1),PINC,ELEVAT,FEDRG2	00013040
110 FORMAT(1X,F10.2)	00013050
WRITE(12,100) (UNIT(I).MATL(I),TTMP(I) 1,DCTLEN(I),ELBNUM(I),DCMATL(I),I=1,NUNIT)	00013060
DO 130 I=1,NUNIT	00013070
100 FORMAT(1X,A3,1X,A2,F10.2,F10.5,F4.1,1X,A2)	00013080
IF(UNIT(I).EQ.SUNIT(1)) GOTO 700	00013090
IF(UNIT(I).EQ.SUNIT(2)) GOTO 713	00013100
IF(UNIT(I).EQ.SUNIT(3)) GOTO 710	00013110
IF(UNIT(I).EQ.SUNIT(4)) GOTO 712	00013120
IF(UNIT(I).EQ.SUNIT(5)) GOTO 711	00013130
IF(UNIT(I).EQ.SUNIT(6)) GOTO 707	00013140
IF(UNIT(I).EQ.SUNIT(7)) GOTO 130	00013150
IF(UNIT(I).EQ.SUNIT(8)) GOTO 708	00013160
IF(UNIT(I).EQ.SUNIT(9)) GOTO 709	00013170
GOTO 130	00013180
700 WRITE(12,30) ROTARY,FLUID,LIQI,HTLS	00013190
30 FORMAT(1X,L1)	00013200
WRITE(12,40) RETIM(I),RLD(I),EXCESS(I),EXFUEL(I)	00013210
WRITE(12,73) PREXTI	00013220
WRITE(12,76) ADIA,SIEVE,VALVE	00013230
GOTO 130	00013240
711 WRITE(12,110) TOTDP	00013250
GOTO 130	00013260
712 WRITE(12,110) VENWAT,DPTOT	00013270
WRITE(12,76) PRI	00013280
IF(.NOT.PRI) GOTO 241	00013290
WRITE(12,31) NPRTS	00013300
31 FORMAT(1X,I3)	00013310
DO 32 IJ=1,NPRTS	00013320
WRITE(12,33) DIAPT(IJ),WTPRT(IJ)	00013330
32 CONTINUE	00013340
241 WRITE(12,222) FEDRG2	00013350
222 FORMAT(1X,E15.5)	00013360
WRITE(12,76) VENAUT,FG	00013370
GOTO 130	00013380
713 WRITE(12,221) QSAT,QTEMP	00013390
221 FORMAT(1X,2F3.1)	00013400
33 FORMAT(1X,F9.5)	00013410
GOTO 130	00013420
707 WRITE(12,720) (PCKCHS(JJ),JJ=1,4),PCKSZ,EFFABS,NTU,SCHMDT,PRCFLD	00013430
WRITE(12,208) WATRAT,SLPABS,HCLRM	00013440
208 FORMAT(1X,F6.3,F6.2,F8.4)	00013450
WRITE(12,209) SCRNAME(1)	00013460
209 FORMAT(1X,A20)	00013470
WRITE(12,211) DFHCLL,DFHCLG	00013480
211 FORMAT(1X,F10.2)	00013490
40 FORMAT(1X,F10.2)	00013500
720 FORMAT(1X,4A4,F6.2,F10.8,I3,F6.3,F6.2)	00013510
GOTO 130	00013520
708 WRITE(12,134) RLD(I)	00013530
WRITE(12,134) RETIM(I)	00013540
134 FORMAT(1X,F10.5)	00013550
WRITE(12,223) PREXT	00013560
223 FORMAT(1X,F9.7)	00013570
GOTO 130	00013580
	00013590
	00013600

```

709 WRITE(12,212) HEIGHT          00013610
212 FORMAT(1X,F5.1)              00013620
      WRITE(12,76) VOLTIL         00013630
      GOTO 130                  00013640
710 WRITE(12,76) FXH,KRB,UTB,HM1,HM2   00013650
      WRITE(12,76) S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS 00013660
      WRITE(12,110) HTC          00013670
130 CONTINUE                      00013680
      WRITE(12,200) FACMSC,FACCEE,FACCEF,FACCES, 00013690
1  FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS,IYEAR 00013700
200 FORMAT(2X,11F6.1,15)           00013710
      WRITE(12,210) YRNUM,RTINST,REVLB,CONTEN 00013720
210 FORMAT(1X,F4.1,F4.1,F8.3,F8.3) 00013730
C   CLOSE(12)                     00013740
      RETURN                         00013750
      END                            00013760
      SUBROUTINE INPT(NREAC,NPRD)    00013770
      REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00013780
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00013790
      LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL 00013800
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00013810
2 ,SSB,SCRW,VENAUT,FG,PRI,SLD,LQD,PLASMA,BRN,ADIA 00013820
3 ,KRB,FXH,UTB,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS 00013830
2 ,HT1,HT2,HT3,VALVE,SIEVE,CMBST,HM1,HM2,ECLOG 00013840
      LOGICAL INCIP,AFTINC        00013850
      LOGICAL FEDPT,QUNCH,HTEIN,VININ,ININ,PCIN,STKIN 00013860
      CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*20 00013870
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00013880
CHARACTER MATLC*2,SCRNME*20,FLNAM*15 00013890
CHARACTER ELEMNT*10 00013900
DIMENSION MATLC(4),ELEMNT(9) 00013910
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00013920
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00013930
2 ,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAA,ZLFD2(9,9) 00013940
COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00013950
1 ,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT 00013960
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9).HTC 00013970
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00013980
2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00013990
3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00014000
COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STM CST,DCTCST(9) 00014010
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,EXFUEL(9),FEDRG2 00014020
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECLC 00014030
1 ,ADP,WTPVOL,WTPH20,WATRAT,NTU,ADQ,CSTSTO,SCHMDT,PRCFLD 00014040
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00014050
1 ,PREXTI,DPTOT,PREXT,ELEVAT,TOTDP,QSET,QTEMP,HCLRM 00014060
2 ,CSTIIN,CSTSTR,CSTSPR,CSTCRT,CSTENG,DCDIA(9).CSTINT 00014070
3 ,DSDIA(9),DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN, 00014080
4 ,TOTECLC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00014090
5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00014100
6 ,VENWAT,DIAPT(100),WTPRT(100),FINCRG,REFINS,THICKIN,EQVFIN 00014110
COMMON/UPDATE/ FACSUM,FACCES,FACMSC,FACCEE,FACCEF,FACCEB 00014120
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00014130
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00014140
COMMON/DCT/ ELBNU(9),DCTLEN(9),DCTVEL(9),DIA(9) 00014150
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NPRTS,NUMBRN 00014160
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00014170
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK,SCRNME(6) 00014180
2 ,WSTNME(6),BNMFR(6),BNMIN(6),FLNAM 00014190
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL 00014200
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC 00014210
2 ,SLD,SCRW,VENAUT,PLASMA,BRN,ADIA,PRI,FG,LQD 00014220
3 ,KRB,FXH,UTB,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS 00014230
2 ,HT1,HT2,HT3,VALVE,SIEVE,CMBST,HM1,HM2,ECLOG 00014240
C 00014250
C WATER RATE BETWEEN 15 AND 35 GAL/FT GAS FLOW 00014260
      BRN=.FALSE. 00014270
      ELEVAT=20000.0 00014280
      VENWAT= 0.003 00014290
      QSAT=0.0 00014300
      QTEMP=1.0 00014310
      PRI=.FALSE. 00014320

```

NPRTS=0.0	00014330
FEDRG2=1.142E-05	00014340
C LB/ACF	00014350
PREXT=0.10	00014360
PREXTI = 0.10	00014370
C PERCENT EXTRA COST	00014380
ADIA=.FALSE.	00014390
PLASMA=.FALSE.	00014400
SIEVE=.FALSE.	00014410
VALVE=.TRUE.	00014420
WATRAT=15.	00014430
VOLTIL=.FALSE.	00014440
VENAUT=.FALSE.	00014450
FG=.FALSE.	00014460
FANCLS=4.0	00014470
IF(IDEBUG.GT.25) WRITE(6,79)	00014480
79 FORMAT(10X, '***** 1SUMMARY OF INPUT DATA *****')	00014490
RTINST=0.10	00014500
TOTDP=60.0	00014510
YRNUM=10.0	00014520
REVLB=400.0/2000.0	00014530
FINCRG=12.0	00014540
AOP=0.24	00014550
AOQ=3.725	00014560
WSTNME(1)='TEST '	00014570
WSTNME(2)='SLUDG'	00014580
WSTNME(3)='E NUM'	00014590
WSTNME(4)='BER 1'	00014600
WSTNME(5)=''	00014610
WSTNME(6)=''	00014620
CONTEN=20.0	00014630
SLD=. FALSE.	00014640
LQD=. TRUE.	00014650
HEIGHT=100.0	00014660
FACMSC=796.7	00014670
FACCEE=347.6	00014680
FACCEF=337.9	00014690
FACCEB=302.4	00014700
FACCES=345.6	00014710
TEKC=7.00	00014720
SECC=7.00	00014730
SUPC=8.00	00014740
DAY=24.0	00014750
YEAR=300.0	00014760
IF(IDEBUG.GT.25) WRITE(6,500)	00014770
500 FORMAT(10X, 'SUBROUTINE INPT')	00014780
IJKLM=1	00014790
IF(IJKLM.EQ.1) GOTO 1200	00014800
READ(4,12)	00014810
READ(4,10) (CP(1,J),CP(2,J),CP(3,J),CP(4,J),CP(5,J),CP(6,J),	00014820
1 PRDMW(J),J=1,NPRD)	00014830
11 FORMAT(1X,6E11.4)	00014840
12 FORMAT(////)	00014850
10 FORMAT(1X,6E11.4,F10.5)	00014860
DO 60 J=1,8	00014870
READ(4,50)(BRIKNM(I,J),I=1,6), TLIM(J),TKOND(J),NRES(J),BCOST(J)	00014880
50 FORMAT(1X,6(A4),2X,F9.4,2X,F8.4,2X,I1,2X,F9.4)	00014890
IF(IDEBUG.GT.10)WRITE(6,50)(BRIKNM(I,J),I=1,6), TLIM(J),TKOND(J)	00014900
1 ,NRES(J),BCOST(J)	00014910
60 CONTINUE	00014920
READ(4,81)	00014930
81 FORMAT(///)	00014940
DO 140 J=1,1	00014950
READ(4,74) (FUELNM(I,J),I=1,5),PRICE,HTCNT,FULC,ZFLHT	00014960
74 FORMAT(1X,5A3,F7.2,F10.2,2E11.4)	00014970
140 CONTINUE	00014980
READ(4,215)	00014990
215 FORMAT(////)	00015000
DO 220 J=1,7	00015010
READ(4,210) (PCKNAM(J,JJ),JJ=1,4),PSIZE(J),CSTPK(J)	00015020
1 ,(CONST(J,JJ),JJ=1,3),(PAKRAG(J,JJ),JJ=1,4),(CONST(J,JJ),JJ=4,7)	00015030
IF(IDEBUG.LT.10) GOTO 220	00015040

```

      IF(IDEBUG.GT.5)WRITE(6,210) (PCKNAM(J,JJ),JJ=1,4),PSIZE(J),CSTPOOO15050
      1K(J),(CONST(J,JJ),JJ=1,3),(PAKRAG(J,JJ),JJ=1,4),(CONST(J,JJ),JJ=4 00015060
      2,7) 00015070
210 FORMAT(1X,4A4,F4.1,2F6.2,2F5.2,3F2.0,F3.0,F8.5,F5.2,F7.2,F8.5) 00015080
220 CONTINUE 00015090
      READ(4,75) STMCST,WTRCST,DSPCST,CSTFUL,CSTECL,CSTLME 00015100
75 FORMAT(/1X,F11.6,F11.6,F11.6,F11.6,F11.6,F11.6) 00015110
      IF(IDEBUG.GT.25)WRITE(6,78) STMCST,WTRCST,DSPCST,CSTFUL,CSTECL 00015120
78 FORMAT(1OX,'COST OF RECOVERED STEAM = ',3X,F8.6,' $/LB'/' 00015130
1 10X,'COST OF WATER = ',14X,F8.6,' $/LB'/' 00015140
2 10X,'COST OF WASTE ASH AND WATER = ',F8.2,' $/LB TREATED'/' 00015150
3 10X,'COST OF FUEL = ',12X,F8.6,' $/LB'/' 00015160
4 10X,'COST OF ELECTRICITY = ',4X,F8.6,'$/KWH') 00015170
      READ(4,76) HSTVAP 00015180
1200 CONTINUE 00015190
      HSTVAP=HSTVAP*1000.0 00015200
76 FORMAT(1X,F10.5) 00015210
      READ(14,732) DAY,YEAR 00015220
732 FORMAT(1X,F4.1,1X,F5.1) 00015230
      READ(14,4000) WSTNME(1) 00015240
4000 FORMAT(1X,A20) 00015250
      READ(14,70)(XXSLUD(I),I=1,9) 00015260
      READ(14,70)(XXFUEL(I),I=1,9) 00015270
      READ(14,70)(XXAIR(I),I=1,9) 00015280
      READ(14,72) MASSSL,ZSLHT 00015290
      CLMS = MASSSL*XXSLUD(5) 00015300
      READ(14,734) FLNAM,ZFLHT 00015310
734 FORMAT(1X,A15,F7.1) 00015320
      READ(14,733) BRN,SCRW,BARREL,RECT,SLD,LQD,CMBST 00015330
733 FORMAT(1X,L1) 00015340
72 FORMAT(1X,2F11.4) 00015350
70 FORMAT(1X,F6.4,2X,F6.4,2X,F6.4,2X,F6.4,2X,F6.4,2X,F6.4 00015360
    1,2X,F6.4,2X,F6.4) 00015370
      IF (IDEBUG.GT.5) WRITE(6,55) 00015380
55 FORMAT('          BRICK TYPE      ,   TLIM      ,   THERM COND      , CL?,  C0500015390
1T')
      IF(IDEBUG.GT.5) WRITE(6,76) HSTVAP 00015410
      IF(IDEBUG.GT.5) WRITE(6,77) PRICE,HTCNT,FULC 00015420
1,ZFLHT 00015430
77 FORMAT(5X,'PRICE= ',E15.5,'HEAT CONTENT= ',E15.5, 'FUEL COST',
1'= ',E15.5/10X,'HEAT OF COMBUSTION= ',E15.5) 00015440
      IF(IDEBUG.GT.5)WRITE(6,456) ZFLHT 00015450
456 FORMAT(1OX,'HEAT OF COMBUSTION (IN INPUT UNITS)= ',E15.5) 00015460
      READ(14,73) WTPH20,WTPVOL 00015480
      READ(14,30) METRIC,ENGL,LCOST 00015490
73 FORMAT(1X,F9.7) 00015500
      FREH20=WTPH20*MASSSL 00015510
      VOLIT=WTPVOL*MASSSL 00015520
      ASH=MASSSL-FREH20-VOLIT 00015530
      READ(14,90) NUNIT 00015540
90 FORMAT(1X,I2) 00015550
      READ(14,110) TTMP(NUNIT+1),PINC,ELEVAT,FEDRG2 00015560
110 FORMAT(1X,F10.2) 00015570
      TA=TTMP(NUNIT+1) 00015580
      READ(14,100) (UNIT(I),MATL(I),TTMP(I) 00015590
1,DCTLEN(I),ELBNUM(I),DCMATL(I),I=1,NUNIT) 00015600
      DO 130 I=1,NUNIT 00015610
      IF(IDEBUG.GT.5) WRITE(6,100) UNIT(I),MATL(I),TTMP(I+1) 00015620
1,DCTLEN(I),ELBNUM(I),DCMATL(I) 00015630
100 FORMAT(1X,A3,1X,A2,F10.2,F4.1,1X,A2) 00015640
      IF(UNIT(I).EQ.SUNIT(1)) GOTO 700 00015650
      IF(UNIT(I).EQ.SUNIT(2)) GOTO 804 00015660
      IF(UNIT(I).EQ.SUNIT(3)) GOTO 801 00015670
      IF(UNIT(I).EQ.SUNIT(4)) GOTO 803 00015680
      IF(UNIT(I).EQ.SUNIT(5)) GOTO 802 00015690
      IF(UNIT(I).EQ.SUNIT(6)) GOTO 707 00015700
      IF(UNIT(I).EQ.SUNIT(7)) GOTO 130 00015710
      IF(UNIT(I).EQ.SUNIT(8)) GOTO 708 00015720
      IF(UNIT(I).EQ.SUNIT(9)) GOTO 800 00015730
      GOTO 130 00015740
700 READ(14,30) ROTARY,FLUID,LIQI,HTLS 00015750
30 FORMAT(1X,L1) 00015760

```

```

READ(14,40) RETIM(I),RLD(I),EXCESS(I),EXFUEL(I)          00015770
READ(14,73) PREXTI                                      00015780
READ(14,30) ADIA,SIEVE,VALVE                           00015790
   GOTO 130
707 READ(14,720) (PCKCHS(JJ),JJ=1,4),PCKSZ,EFFABS,NTU,SCHMDT,PRCFLD 00015810
   READ(14,736) WATRAT,SLPABS,HCLRM                      00015820
736 FORMAT(1X,F6.3,F6.2,F8.4)                           00015830
   READ(14,737) SCRNM(E1)                                00015840
737 FORMAT(1X,A20)                                      00015850
   READ(14,911) DFHCLL,DFHCLG                           00015860
911 FORMAT(1X,F10.2)                                     00015870
730 FORMAT(1X,F10.2)                                     00015880
720 FORMAT(1X,4A4,F6.2,F10.7,I3,F6.3,F6.2)            00015890
   IF(IDEBUG.GE.25)
1 WRITE(6,43) (PCKCHS(JJ),JJ=1,4),PCKSZ,EFFABS,NTU,SCHMDT,PRCFLD 00015910
43 FORMAT(10X,'PACKING TYPE CHOSEN= ',4(A4),'PACKING SIZE(IN)= ', 00015920
   1 F9.2/10X,'EFFECTIVE ABSORTION = ',F9.0,'NTU= ',I5/        00015930
   2 10X,'SCHMIDT NUMBER= ',E15.5,'PERCENT OF FLOODING= ',F9.2) 00015940
   GOTO 130
708 READ(14,134) RLD(I)                                 00015960
   READ(14,134) RETIM(I)                                00015970
134 FORMAT(1X,F10.5)                                     00015980
   READ(14,73) PREXT                                     00015990
   GOTO 130
800 READ(14,1) HEIGHT                                 00016010
   1 FORMAT(1X,F5.1)                                     00016020
   READ(14,30) VOLTIL                                00016030
   GOTO 130
801 READ(14,30) FXH,KRB,UTB,HM1,HM2                00016050
   READ(14,30) S316,S304,S347,NI200,MO400,IN600,IN825,TI,HS 00016060
   READ(14,110) HTC                                    00016070
   GOTO 130
802 CONTINUE                                         00016090
   READ(14,110) TOTDP                                00016100
   GOTO 130
803 READ(14,110) VENWAT,DPTOT                     00016120
   READ(14,30) PRI                                    00016130
   IF(.NOT.PRI) GOTO 34                            00016140
   READ(14,31) NPRTS                               00016150
31 FORMAT(1X,I3)                                     00016160
   DO 32 IJ=1,NPRTS
      READ(14,33) DIAPI(IJ),WTPRT(IJ)               00016170
33 FORMAT(1X,2F9.5)                                     00016190
32 CONTINUE                                         00016200
34 READ(14,813) FEDRG2                            00016210
813 FORMAT(1X,E15.5)                                     00016220
   READ(14,30) VENAUT,FG                           00016230
   GOTO 130
804 READ(14,221) QSAT,QTEMP                         00016250
221 FORMAT(1X,2F3.1)                                00016260
   GOTO 130
130 CONTINUE                                         00016270
   READ(14,731) FACMSC,FACCEE,FACCEF,FACCEB,FACCES, 00016280
   1 FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS,IYEAR    00016290
731 FORMAT(2X,11F6.1,I5)                           00016310
   READ(14,742) YRNUM,RTINST,REVLB,CONTEN           00016320
742 FORMAT(1X,F4.1,F4.1,F8.3,F8.3)                00016330
   DO 200 II=1,NUNIT
      IF(EXCESS(II).GT.1.0) WRITE(6,71) II          00016340
71 FORMAT(2X,'WARNING! EXCESS AIR IS GREATER THAN 1 IN UNIT',F5.1) 00016360
200 CONTINUE                                         00016370
40 FORMAT(1X,F10.2)                                00016380
   IF(IDEBUG.GT.5) WRITE(6,30) ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HT 00016390
1LS
   IF(IDEBUG.GT.5) WRITE(6,41) PINC                 00016400
41 FORMAT(10X,'INLET PRESSURE TO INCINERATOR = ',F6.2,' PSIA') 00016420
   IF(IDEBUG.LT.10) GOTO 765                      00016430
   WRITE(6,150) (CP(1,J),CP(2,J),CP(3,J),CP(4,J),CP(5,J),CP(6,J), 00016440
   1 PRDMW(J),J=1,NPRD)                           00016450
150 FORMAT(1X,'SPEC.      A      ,      B      ,      C      ,      D      , 00016460
   A TLOW , THIGH , MW' //                      00016470
   1 3X,'H2O  ',4E11.3,4X,2F7.2,F9.4/3X,'HCl  ',4E11.3,4X,2F7.2,F9.4/ 00016480

```


PROGRAM HWSTBRN

```

REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD          00000010
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS  00000020
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCDST,HTLS,RECT,BAL,PRI 00000030
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00000040
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD  00000050
4,CUTVN,CMBST,TCH                                         00000060
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00000070
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00000080
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00000090
2 ,SCRNME*20                                         00000100
CHARACTER MATLC*2                                         00000110
DIMENSION MATLC(4)                                         00000120
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00000130
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00000140
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9) 00000150
COMMON/PCKBED/ PSIZE(7),PCKSZ,I,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00000160
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAZ(7,4),Z,CSTINS,TBRNTT00000170
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00000180
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIN(9),FANCLS 00000190
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00000200
3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00000210
COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STM CST,DCTCST(9) 00000220
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00000230
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTOT00000240
1,AOP,WATRAT,TOTDP,NTU,AOQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00000250
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLM E 00000260
3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00000270
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00000280
1 ,DCTTST,CSTM TB,CSTSIT,CSTSC,CSTEM,CSTCN T,PREXTI,SKRCST 00000290
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTS P R,CSTCRT,CSTENG,DCDIA(9),CSTINT00000300
3 ,DSDIA(9),CSTL0D,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN, 00000310
4 ,TOTECL,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR. 00000320
5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00000330
6 ,EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00000340
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB 00000350
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00000360
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00000370
COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00000380
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00000390
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00000400
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00000410
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00000420
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00000430
1 ,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00000440
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00000450
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00000460
00000470
C
C   INITIALIZE VARIABLES 00000480
C                                         00000490
IDEBUG=0                                         00000500
DO 1200 I=1,100 00000510
DIAPT(I)=O.O 00000520
WTPRT(I)=O.O 00000530
1200 CONTINUE 00000540
VISCG=O.O 00000550
VISCL=O.O 00000560
TOCOST=O.O 00000570
TOTCAP=O.O 00000580
SUNIT(1)='INC' 00000590
SUNIT(2)='QUE' 00000600
SUNIT(3)='HTE' 00000610
SUNIT(4)='VEN' 00000620
SUNIT(5)='IND' 00000630
SUNIT(6)='PCK' 00000640
SUNIT(7)='TRA' 00000650
SUNIT(8)='AFT' 00000660
SUNIT(9)='STK' 00000670
SUNIT(10)='ADI' 00000680
SUNIT(11)=' ' 00000690
MATLC(1)='IC' 00000700
MATLC(2)='SS' 00000710
MATLC(3)='CS' 00000720

```

```

MATLC(4)='WC'          00000730
FLTOT=0.0              00000740
CSTSTC=0.0              00000750
CSTEM=0.0               00000760
AFTINC=0.0              00000770
CSTMTC=0.0              00000780
CSTPAK=0.0              00000790
CSTHTR=0.0              00000800
CSTQUE=0.0              00000810
CSTFAN=0.0              00000820
CSTSTK=0.0              00000830
TOTLAB=0.0              00000840
TTMAIN=0.0              00000850
CSTSIT=0.0              00000860
CSTIIN=0.0              00000870
CSTSTR=0.0              00000880
CSTSPPR=0.0             00000890
CSTCRT=0.0              00000900
CSTENG=0.0              00000910
CSTINT=0.0              00000920
TOTECLC=0.0              00000930
TOTH2O=0.0              00000940
TTFUEL=0.0              00000950
TTWSTD=0.0              00000960
TTCAUS=0.0              00000970
TTOPR=0.0              00000980
CSTCNT=0.0              00000990
CSTVEN=0.0              00001000
DCTTST=0.0              00001010
IYEAR=1985              00001020
WTRTOT=0.0              00001030
TOTMAN=0.0              00001040
DO 60 III=1,9           00001050
DESVOL(III)=0.0          00001060
  MSTOT(III)=0.0          00001070
  DIA(III)=0.0            00001080
  AREA(III)=0.0           00001090
  VOLRAT(III)=0.0          00001100
  INCLEN(III)=0.0          00001110
  EXCESS(III)=0.0          00001120
  RLD(III)=0.0             00001130
  DO 11 I=1,9              00001140
    DCDIA(I)=0.0            00001150
    DSDIA(I)=0.0            00001160
    DCTBCS(I)=0.0            00001170
    TDCTCS(I)=0.0            00001180
    MSSLUD(I,III)=0.0          00001190
    MLPRT(I,III)=0.0          00001200
    MSFUEL(I,III)=0.0          00001210
    MSAIR(I,III)=0.0          00001220
    XXSLUD(I)=0.0             00001230
    XXFUEL(I)=0.0             00001240
    XXAIR(I)=0.0              00001250
    TKOND(I)=0.0              00001260
    TTMP(I)=0.0              00001270
    IF(I.GE.9) GOTO 11          00001280
    TLIM(I)=0.0              00001290
    BCOST(I)=0.0              00001300
    NRES(I)=0                  00001310
    DO 12 L=1,6                00001320
      BRIKNM(L,I)=             00001330
  12  CONTINUE              00001340
  11  CONTINUE              00001350
  60 CONTINUE              00001360
  IC=.FALSE.                00001370
  SSG=.FALSE.                00001380
  BARREL=.FALSE.              00001390
  VOLTIL=.FALSE.              00001400
  LOC=2                      00001410
  ROTARY=.FALSE.              00001420
  FLUID=.FALSE.              00001430
  LIQI=.FALSE.              00001440

```

```

METRIC=.FALSE.          00001450
ENGL=.FALSE.           00001460
LCOST=.FALSE.          00001470
PMPHP=0.0              00001480
HPTOT=0.0              00001490
DPTOT=0.0              00001500
BLWHP=0.0              00001510
DIABRK=0.0              00001520
MASSSL=0.0              00001530
MASSFL=0.0              00001540
ZFLHT=0.0              00001550
ZSLHT=0.0              00001560
PINC=0.0              00001570
PEXT=0.0              00001580
T1=0.0              00001590
T2=0.0              00001600
HTCOMB=0.0              00001610
BAL=.TRUE.           00001620
SEMI=.FALSE.          00001630
DO 13 JJJ=1,20        00001640
    UNIT(JJJ)='      '
    MATL(JJJ)='      '
    IF(JJJ.GE.16) GOTO 13
    PRDMW(JJJ)=0.0
    DO 14 JJJJ=1,6
        CP(JJJJ,JJ)=0.0
14    CONTINUE          00001710
13 CONTINUE            00001720
SHLCST=0.0              00001730
DRV CST=0.0             00001740
TBRNTT=0.0              00001750
BRKTOT=0.0              00001760
ASHCST=0.0              00001770
NUMIT=0                 00001780
HTLS=.FALSE.          00001790
RECT=.FALSE.          00001800
NREAC=9                 00001810
NPRD=15                 00001820
RETIM(III)=0.0          00001830
ZLOSS=0.0              00001840
C
C READ IN PHYSICAL DESIGN AND COST DATA
C
CALL INPT(NREAC,NPRD)          00001860
234 FORMAT(3E15.4)          00001880
MUNIT=NUNIT+1                00001890
C
C DEBUG OUTPUT TO CHECK INPUTDATA
C
DO 50 III=1,NUNIT          00001910
IC=.FALSE.                  00001920
SS=.FALSE.                  00001930
CS=.FALSE.                  00001940
DIC=.FALSE.                  00001950
DSS=.FALSE.                  00001960
DCS=.FALSE.                  00001970
DWC=.FALSE.                  00001980
IF(IDEBUG.GT.25)WRITE(6,110) UNIT(III)          00001990
110 FORMAT(10X,'UNIT IN QUESTION IS ',A10)      00002000
IF(MATL(III).EQ.MATLC(1)) IC=.TRUE.          00002010
IF(MATL(III).EQ.MATLC(2)) SS=.TRUE.          00002020
IF(MATL(III).EQ.MATLC(3)) CS=.TRUE.          00002030
IF(DCMATL(III).EQ.MATLC(1)) DIC=.TRUE.          00002040
IF(DCMATL(III).EQ.MATLC(2)) DSS=.TRUE.          00002050
IF(DCMATL(III).EQ.MATLC(3)) DCS=.TRUE.          00002060
IF(DCMATL(III).EQ.MATLC(4)) DWC=.TRUE.          00002070
T1=TTMP(III)                  00002080
T2=TTMP(III+1)                00002090
PINC=PEXT                  00002100
IF(UNIT(III).EQ.SUNIT(1)) CALL INCDES(NREAC,NPRD) 00002110
IF(UNIT(III).EQ.SUNIT(2)) CALL QUENCH(NREAC,NPRD) 00002120
IF(UNIT(III).EQ.SUNIT(3)) CALL HTEXCH(NREAC,NPRD) 00002130
                                         00002140
                                         00002150
                                         00002160

```

```

        IF(UNIT(III).EQ.SUNIT(4)) CALL VENTUR(NREAC,NPRD)          00002170
        IF(UNIT(III).EQ.SUNIT(5)) CALL INDFAN(NREAC,NPRD)          00002180
        IF(UNIT(III).EQ.SUNIT(6)) CALL PCKBD(NREAC,NPRD)          00002190
        IF(UNIT(III).EQ.SUNIT(7)) CALL TRABED(NREAC,NPRD)          00002200
        IF(UNIT(III).EQ.SUNIT(8)) CALL AFTER(NREAC,NPRD)           00002210
        IF(UNIT(III).EQ.SUNIT(9)) CALL STACK(NPRD)                 00002220
        IF(UNIT(III).EQ.SUNIT(10)) CALL ADIAB(NREAC,NPRD)          00002230
        IF(FLGPAS) CALL DUCT(NPRD)                                00002240
        CALL OUTP7(NPRD)                                         00002250
50      CONTINUE                                              00002260
        CALL OUTP3(NPRD)                                         00002270
        CALL STOREG(NREAC,NPRD)                                    00002280
        CALL CAPTAL                                             00002290
        CALL OUTP2(NPRD)                                         00002300
        CALL OPERAT                                             00002310
        CALL EQIV                                               00002320
        CALL DCFRR(TOTTOT,TTOPR,YRNUM,MASSSL,DAY,YEAR,REVLB)    00002330
        STOP                                                 00002340
        END                                                 00002350
        SUBROUTINE ADIAB(NREAC,NPRD)                           00002360
        REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD      00002370
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS  00002380
        LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00002390
1 .IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00002400
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD  00002410
4,CUTVN,CMBST,TCH                                         00002420
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00002430
        CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00002440
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00002450
2 ,SCRNME*20                                              00002460
        COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00002470
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00002480
2 ,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLF2(9,9) 00002490
        COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00002500
1 ,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00002510
        COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00002520
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00002530
2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00002540
3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00002550
        COMMON/COST/ SHLCST,DRVCS,BrkTot,ASHCST,STMCST,DCTCST(9) 00002560
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00002570
        COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTOT00002580
1 ,AOP,WATRAT,TOTDP,NTU,AOQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00002590
2 ,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00002600
3 ,QSAT,VENH2O,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00002610
        COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00002620
1 ,DCTTST,CSTMTC,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00002630
2 ,CSTIN,EXTRA1,CSTSTR,CSTSCR,CSTSPr,CSTCRT,CSTENG,DCDIA(9),CSTINT00002640
3 ,DSDIA(9),CSTL0D,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN, 00002650
4 ,TOTECL,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00002660
5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00002670
6 ,EQVCP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00002680
        COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB 00002690
1 .FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00002700
        COMMON/SALARY/ TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00002710
        COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00002720
        COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,UPIK,IYEAR,NUMBRN,NPRTS 00002730
        COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00002740
1 ,PCKCHS(4),PCKNM(7,4),DCMATL(9),MTLDCT,MTLBRK 00002750
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00002760
        COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00002770
1 .IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,FLGPAS00002780
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00002790
3 ,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00002800
        MASSFL=0.0 00002810
        IF(ENGL) CALL METRC(NREAC,NPRD) 00002820
200 CONTINUE 00002830
        DELTAH=0.0 00002840
        IF(IDEBUG.GT.25) WRITE(6,500) 00002850
500 FORMAT(10X,'SUBROUTINE ADIAB') 00002860
        DTTEMP=100.0 00002870
        FFF=0 00002880

```

```

      FF=1                                         00002890
      IF(IDEBUG.GT.25) WRITE(6,40) MASSSL,MASSFL,MASSAR 00002900
 40 FORMAT(2X,'MASSSL ',E15.5,2X,'MASSFL ',E15.5,2X,'MASSAR ',E15.5) 00002910
      DO 13 I=1,NREAC                           00002920
         MSSLUD(I,III)=VOLIT*XXSLUD(I)          00002930
 13 CONTINUE                                     00002940
      HTCOMB=VOLIT*ZSLHT                         00002950
      CALL HTMSBL(NREAC,NPRD)                     00002960
 11 IF(IDEBUG.GT.25) WRITE(6,500)                00002970
      CALL DTHEAT(NPRD)                          00002980
         IF(IDEBUG.GT.25) WRITE(6,998) DELTAH,HTCOMB 00002990
 998 FORMAT(4X,'HEAT FOR GAS= ',E15.5/4X,'HEAT OF COMBUSTION= ', 00003000
 1 E15.5)                                       00003010
         IF(ABS(DELTAH-HTCOMB).LT.(.001*DELTAH)) GOTO 19 00003020
         IF(DELTAH.GT.HTCOMB) GOTO 15             00003030
         T2=T2+DTTEMP                            00003040
         IF(FF.EQ.0) DTTEMP=DTTEMP/2.0            00003050
         IF(FFF.EQ.0) FFF=1                      00003060
         IF(FFF.EQ.1) GOTO 11                   00003070
         FF=0                                      00003080
         GOTO 11                                 00003090
 15 T2=T2-DTTEMP                                00003100
         IF(FF.EQ.0) DTTEMP=DTTEMP/2.0            00003110
         IF(FFF.EQ.0) FFF=-1                     00003120
         IF(FFF.EQ.-1) GOTO 11                  00003130
         FF=0                                      00003140
         GOTO 11                                 00003150
 19 IF(IDEBUG.GT.10)WRITE(6,50) T2               00003160
      TTMP(III+1)=T2                           00003170
 50 FORMAT(10X,'THE ABIABATIC TEMPERATURE OF THE COMBUSTION PROCESS=' 00003180
 1,F10.3,'DEGREES CELCIUS')                   00003190
         IF(METRIC) CALL ENG(NREAC,NPRD)          00003200
      RETURN                                     00003210
      END                                         00003220
      SUBROUTINE HTMS(NREAC,NPRD)                00003230
      REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00003240
 1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00003250
      LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00003260
 1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00003270
 2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00003280
 4,CUTVN,CMBST,TCH                           00003290
 3,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825,TI,HS,UTB,HM1,HM2 00003300
         CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00003310
 1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00003320
 2 ,SCRNME*20                                00003330
      LOGICAL FUEL                               00003340
      COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00003350
 1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00003360
 2,VOLIT,ASH,FREH2O,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9) 00003370
      COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00003380
 1 ,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00003390
      COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00003400
 1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00003410
 2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00003420
 3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00003430
      COMMON/COST/ SHLCST,DRV CST,BRKTOT.ASHCST,STMCST,DCTCST(9) 00003440
 1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00003450
      COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECLC,DPTOT00003460
 1 ,AOP,WATRAT,TOTDP,NTU,AQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00003470
 2 ,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00003480
 3 ,QSAT,VENH2O,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00003490
      COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00003500
 1 ,DCTTST,CSTMTE,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00003510
 2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPr,CSTCRT,CSTENG,DCDIA(9),CSTINT00003520
 3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTS(9),TOTLAB,TTMAIN, 00003530
 4 ,TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00003540
 5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00003550
 6 ,EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00003560
      COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB 00003570
 1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00003580
      COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00003590
      COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00003600

```

```

COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00003610
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00003620
1,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00003630
2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00003640
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00003650
1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00003660
2,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00003670
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00003680
    DELTAH=0.0 00003690
    MASSAR=0.0 00003700
    MASSFL=0.0 00003710
    FUEL=.TRUE. 00003720
    IF(IDEBUG.GT.25) WRITE(6,500) 00003730
500 FORMAT(10X,'SUBROUTINE HTMS') 00003740
    DTFUEL=2000.0*453.96 00003750
    FFF=0 00003760
    FF=1 00003770
    IF(IDEBUG.GT.50) WRITE(6,40) MASSSL,T2,MASSAR 00003780
40 FORMAT(2X,'MASSSL ',E15.5,2X,'T2 ',E15.5,2X,'MASSAR ',E15.5) 00003790
11 CONTINUE 00003800
    IF(MASSFL.LT.0.0) FUEL=.FALSE. 00003810
    IF(FUEL) GOTO 12 00003820
    CALL ADIAB(NREAC,NPRD) 00003830
    GOTO 60 00003840
12 DO 10 I=1,NREAC 00003850
    IF(IDEBUG.GT.50) WRITE(6,30) I,XXSLUD(I),XXFUEL(I),XXAIR(I) 00003860
30 FORMAT(2X,'COMP. ',I3,2X,'XXSLUD ',F6.4,2X,'XXFUEL ',F6.4, 00003870
    12X,'XXAIR ',F6.4) 00003880
    MSSLUD(I,III)=VOLIT*XXSLUD(I) 00003890
    MSFUEL(I,III)=MASSFL*XXFUEL(I) 00003900
10 CONTINUE 00003910
    HTCOMB=MASSFL*ZFLHT+VOLIT*ZSLHT 00003920
    CALL HTMSBL(NREAC,NPRD) 00003930
    CALL DTHEAT(NPRD) 00003940
    IF(IDEBUG.GT.25) WRITE(6,500) 00003950
    IF(IDEBUG.GT.25) WRITE(6,998) DELTAH,HTCOMB,MASSFL 00003960
998 FORMAT(4X,'HEAT FOR GAS= ',E15.5/4X,'HEAT OF COMBUSTION= ', 00003970
    1 E15.5/4X,'MASS RATE OF FUEL',5(E15.5 )) 00003980
    IF(ABS(DELTAH-HTCOMB).LT.(.001*DELTAH)) GOTO 19 00003990
    IF(DELTAH.LT.HTCOMB) GOTO 15 00004000
    MASSFL=MASSFL+DTFUEL 00004010
    IF(FF.EQ.0) DTFUEL=DTFUEL/2.0 00004020
    IF(FFF.EQ.0) FFF=1 00004030
    IF(FFF.EQ.1) GOTO 11 00004040
    FF=0 00004050
    GOTO 11 00004060
15 MASSFL=MASSFL-DTFUEL 00004070
    IF(FF.EQ.0) DTFUEL=DTFUEL/2.0 00004080
    IF(FFF.EQ.0) FFF=-1 00004090
    IF(FFF.EQ.-1) GOTO 11 00004100
    FF=0 00004110
    GOTO 11 00004120
19 IF(IDEBUG.GT.1)WRITE(6,999)MASSFL,MASSAR 00004130
999 FORMAT(4X,' FINAL MASS RATE OF FUEL= ',E15.5/2X,' FINAL AIR FLOW00004140
    1RATE(GRAMS/HR)= ',E15.3) 00004150
    MSTOT(III)=0.0 00004160
    DO 20 I=1,NREAC 00004170
        MSAIR(I,III)=MASSAR*XXAIR(I) 00004180
        MSTOT(III)=MSTOT(III)+MSSLUD(I,III)+MSFUEL(I,III)+MSAIR(I,III) 00004190
50 FORMAT(10X,'FOR UNIT ',I2,'MASS FLOW RATE =',E15.5,'G/HR') 00004200
20 CONTINUE 00004210
    IF(IDEBUG.GT.25)WRITE(6,50) III,MSTOT(III) 00004220
    FLTtot=FLTtot+MASSFL 00004230
60 RETURN 00004240
    END 00004250
    SUBROUTINE HTMSBL(NREAC,NPRD) 00004260
    REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00004270
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00004280
    LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00004290
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00004300
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00004310
4,CUTVN,CMBST,TCH 00004320

```

```

3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00004330
  CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00004340
  1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00004350
  2 .SCRNME*20 00004360
    REAL MLFEED(9),FD(9),MLFED(9) 00004370
C 00004380
C 00004390
C   THIS SUBROUTINE WILL CALCULATE A MASS/HEAT BALANCE FROM A GIVEN S00004400
C GIVEN SLUDGE,FUEL, AND AIR FLOWRATE PROVIDED. 00004410
C 00004420
C 00004430
C C23456789 00004440
  INTEGER BLORD(15) 00004450
  DIMENSION FDPAR(9,3),HEAT(15) 00004460
  COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00004470
  1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00004480
  2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELAH,ZLFD2(9,9) 00004490
  COMMON/PCKBED/ PSIZE(7),PCKSZI,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00004500
  1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00004510
  COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00004520
  1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00004530
  2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00004540
  3,INCLEN(9),MSTDOT(9),MLPRDT(15,9),PINC.PEXT,WTRTOT,FLTOT,TOTMAN 00004550
  COMMON/COST/ SHLCST,DRVCS,CRKTOT,ASHCST,STMCST,DCTCST(9) 00004560
  1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00004570
  COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTOT00004580
  1,ADP,WATRAT,TOTDP,NTU,ADQ,CSTSTD,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00004590
  2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00004600
  3,QSAT,VENH20,DAMPY(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00004610
  COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00004620
  1 ,DCTTST,CSTMTB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00004630
  2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT00004640
  3 ,DSDIA(9),CSTLDD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN. 00004650
  4 ,TOTEI,COTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00004660
  5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00004670
  6 ,EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00004680
  COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB 00004690
  1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00004700
  COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00004710
  COMMON/DCT/ EBLNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00004720
  COMMON/INT/IDEBUG,NRES(8),NUNIT(8),NSET,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00004730
  COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00004740
  1,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00004750
  2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00004760
  COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00004770
  1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00004780
  2,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00004790
  3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00004800
  DATA FD/1.00797,12.01115,15.9994,14.0067,35.453,32.064,18.9984 00004810
  1 ,30.9738,20.183/ 00004820
  IF(IDEBUG.GT.25) WRITE(6,500) 00004830
  500 FORMAT(10X,'SUBROUTINE HTMSBLC') 00004840
C 00004850
C   ALL REACTANT DIMENSIONS CATALOG 00004860
C   1-H, 2-C, 3-O, 4-N, 5-CL, 6-S, 7-F, 8-P, 9-NE 00004870
C 00004880
C 00004890
C   ALL PRD** DIM'S CATALOG 00004900
C   1-H2O, 2-HCl, 3-CO2, 4-CO, 5-N2, 6-O2, 7-NO 00004910
C   8-NO2, 9-Cl2, 10-SO2, 11-H2SO4,12-F2, 13-HF, 14-P2O6 00004920
C   15-NE 00004930
  IF(UNIT(III).EQ.SUNIT(8)) GOTO 62 00004940
  5 CONTINUE 00004950
  DO 40 I=1,NPRD 00004960
    MLPRDT(I,III)=0.0
    MSFUEL(I,III)=MASSFL*XXFUEL(I) 00004980
  40 CONTINUE 00004990
  DO 10 J= 1 , NREAC 00005000
    IF(UNIT(III).EQ.SUNIT(8)) MLFEED(J)=(ZLFD2(J,III-1) 00005010
    1 + MSFUEL(J,III))/FD(J) 00005020
    IF(UNIT(III).NE.SUNIT(1)) GOTO 63 00005030
    MLFEED(J)=(MSSLUD(J,III)+MSFUEL(J,III))/FD(J) 00005040

```

```

63 ZLFD2(J,III)=MLFEED(J) 00005050
510 FORMAT(2X,'TOTAL MOLE RATE OF ELEMENT ',I2,' = ',E15.5/ 00005060
 1 2X,'INLET FLOW OF SLUDGE G/HR= ',E15.5,' INLET AIR RATE G/HR= ', 00005070
 2 E15.5/2X,'INLET FUEL FLOW RATE G/HR= ',E15.5,'ELEMENT ATOMIC WEI 00005080
 3GHT= ',F9.4) 00005090
10 CONTINUE 00005100
  AMEET=(MLFEED(1)-MLFEED(5))/4.0/0.2099+MLFEED(2)/0.2099 00005110
1+MLFEED(6)/0.2099/2.0*6.0 00005120
  MASSAR=AMEET*29.0*(EXCESS(III)+1.0) 00005130
  DO 65 K=1,NREAC 00005140
    MSAIR(K,III)=MASSAR*XXAIR(K) 00005150
    MLFEED(K)=MLFEED(K)+MSAIR(K,III)/FD(K) 00005160
    IF(IDEBUG.GT.50) WRITE(6,510)K, MLFEED(K),MSSLUD(K,III),MSAIR(K,II 00005170
1I),MSFUEL(K,III),FD(K) 00005180
65 CONTINUE 00005190
  GOTO 70 00005200
62 CONTINUE 00005210
  IF(NSET.EQ.1) GOTO 81 00005220
    NSET=1 00005230
    MLFED(1)=MLPRDT(1,III-1)*2.0+MLPRDT(2,III-1)+MLPRDT(11,III-1)+ 00005240
    1  MLPRDT(13,III-1) 00005250
    MLFED(2)=MLPRDT(3,III-1)+MLPRDT(4,III-1) 00005260
    MLFED(3)=MLPRDT(1,III-1)+MLPRDT(3,III-1)*2.+MLPRDT(4,III-1)+ 00005270
    1 MLPRDT(6,III-1)*2.+MLPRDT(7,III-1)+MLPRDT(8,III-1)*2.+ 00005280
    2 MLPRDT(10,III-1)*2.+MLPRDT(11,III-1)*4.+MLPRDT(14,III-1) 00005290
    MLFED(4)=MLPRDT(5,III-1)*2.+MLPRDT(7,III-1)+MLPRDT(8,III-1)*2. 00005300
    MLFED(5)=MLPRDT(2,III-1)+MLPRDT(9,III-1) 00005310
    MLFED(6)=MLPRDT(10,III-1)+MLPRDT(11,III-1) 00005320
    MLFED(7)=MLPRDT(12,III-1)*2.+MLPRDT(13,III-1) 00005330
    MLFED(8)=MLPRDT(14,III-1)*2. 00005340
81 DO 80 I=1,NREAC 00005350
  MLFEED(I)=MLFED(I)+MASSFL*XXFUEL(I)/FD(I) 00005360
80 CONTINUE 00005370
  DATA BLORD/3,10,4,5,2,7,1,8,9,12,11,13,14,15,6/ 00005380
70  DO 30 I=1,NPRD 00005390
  IF(BLORD(I).EQ.4.OR.BLORD(I).EQ.7.OR.BLORD(I).EQ.8.OR.BLORD(I) 00005400
  1 .EQ.9.OR.BLORD(I).EQ.11.OR.BLORD(I).EQ.12. 00005410
  2 OR.BLORD(I).EQ.13.OR.BLORD(I).EQ.14.OR.BLORD(I).EQ.15) GOTO 30 00005420
    IF(BLORD(I).EQ.3) GOTO 22 00005430
    IF(BLORD(I).EQ.5) GOTO 23 00005440
    IF(BLORD(I).EQ.2) GOTO 24 00005450
    IF(BLORD(I).EQ.1) GOTO 25 00005460
    IF(BLORD(I).EQ.6) GOTO 26 00005470
    IF(BLORD(I).EQ.10) GOTO 27 00005480
    GOTO 20 00005490
22 CONTINUE 00005500
C 00005510
C  BALANCE FOR CARBON DIOXIDE (100 % CONVERSION) 00005520
C 00005530
  MLPRDT(3,III)=MLFEED(2)/1.0 00005540
  MLFEED(3)=MLFEED(3)-MLPRDT(3,III)*2.0 00005550
  MLFEED(2)=MLFEED(2)-MLPRDT(3,III)*1.0 00005560
  GOTO 20 00005570
C 00005580
C  BALANCE FOR SULFUR DIOXIDE (100 % CONVERSION) 00005590
C 00005600
  27 MLPRDT(10,III)=MLFEED(6)/1.0 00005610
  MLFEED(3)=MLFEED(3)-MLPRDT(10,III)*2.0 00005620
  MLFEED(6)=MLFEED(6)-MLPRDT(10,III)*1.0 00005630
  GOTO 20 00005640
C 00005650
C  MASS BALANCE FOR HYDROGEN CHLORIDE 00005660
C 00005670
  24 MLPRDT(2,III)=MLFEED(5)*1.0 00005680
  MLFEED(1)=MLFEED(1)-MLPRDT(2,III)*1.0 00005690
  MLFEED(5)=MLFEED(5)-MLPRDT(2,III) 00005700
  GOTO 20 00005710
C 00005720
C  MASS BALANCE FOR NITROGEN GAS 00005730
C 00005740
  23 MLPRDT(5,III)=MLFEED(4)/2.0 00005750
  MLFEED(4)=MLFEED(4)-MLPRDT(5,III)*2.0 00005760

```

```

      GOTO 20                               00005770
C
C      MASS BALANCE FOR WATER             00005780
C
 25  MLPRDT(1,III)=MLFEED(1)/2.0        00005790
    MLFEED(1)=MLFEED(1)-MLPRDT(1,III)*2.0   00005800
    MLFEED(3)=MLFEED(3)-MLPRDT(1,III)*1.0   00005810
    IF(III.EQ.1)MLPRDT(1,III)=MLPRDT(1,III)+FREH2O/18.01 00005820
    GOTO 20                               00005830
C
C      MASS BALANCE FOR OXYGEN           00005840
C
 26  MLPRDT(6,III)=MLFEED(3)/2.0        00005850
    MLFEED(3)=MLFEED(3)-MLPRDT(6,III)*2.0   00005860
C
 20  CONTINUE                            00005870
    FEED(BLORD(I))=MLPRDT(BLORD(I),III)*PRDMW(BLORD(I)) 00005880
    IF(IDEBUG.GT.50) WRITE(6,60) BLORD(I)
    IF(IDEBUG.NE.25) GOTO 66
    WRITE(6,61) FEED(BLORD(I)),MLPRDT(BLORD(I),III),PRDMW(BLORD(I))
 61  FORMAT(10X,'FEED RATE= ',E15.5,'MOLE RATE',E15.5,'MOLE WEIGHT', 00005910
    1E15.5)
 66  CONTINUE                            00005920
 60  FORMAT(10X,'BALANCING SPECI',I3)     00005930
 30  CONTINUE                            00005940
    ZLOSS=0.0                           00005950
C
  DO 85 I=1,NREAC
    IF(MLFEED(I).LT.0.0) WRITE(6,95) I,MLFEED(I)
 95  FORMAT(5X,'REACTANT',I3,' WAS LESS THAN ZERO',F10.3,
 1 'CHECK BALANCE OF EQUATION')
 85  CONTINUE                            00005960
    RETURN                               00005970
    END                                  00005980
    SUBROUTINE DTHEAT(NPRD)
    REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD
 1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS
    LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI
 1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP,
 2 ,SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD
 4,CUTVN,CMBST,TCH
 3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2
    CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5
 1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2
 2 ,SCRNME*20
    DIMENSION HEAT(15)
    COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL,
 1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP
 2 ,VOLIT,ASH,FREH2O,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9)
    COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH2O,RHOL,RHO,VISCL
 1 ,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00006270
    COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC
 1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS
 2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST
 3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN
    COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STMCST,DCTCST(9)
 1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9)
    COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPT00006340
 1 ,AOP,WATRAT,TOTDP,NTU,AQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100)
 2 ,QTEMP,WASCAP,H20M,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME
 3 ,QSAT,VENH2O,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH2O,VAPNO
    COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK
 1 ,DCTTST,CSTM TB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST
 2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTS PR,CSTCRT,CSTENG,DCDIA(9),CSTINT00006400
 3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,
 4 ,TOTELC,TOTH2O,TTFUEL,TTWSTD,TTCAUS,TTOPR,
 5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,
 6 ,EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK
    COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB
 1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS
    COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP
    COMMON/DCT/ ELBNU M(9),DCTLEN(9),DCTVEL(9),DIA(9)

```

```

COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00006490
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00006500
1,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00006510
2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00006520
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00006530
1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00006540
2,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00006550
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00006560
DETAH=0.0 00006570
IF(IDEBUG.GT.25) WRITE(6,110) T1,T2 00006580
110 FORMAT(2X,'INLET TEMP DEG C=',F9.3,'OUTLET TEMP= ',F9.3) 00006590
DO 100 I=1,NPRD 00006600
    HEAT(I)=0.0 00006610
    HEAT(I)=CP(1,I)*(T2-T1)+CP(2,I)/2.*(T2**2.-T1**2.) 00006620
1 +CP(3,I)/3.*(T2**3.-T1**3.)+CP(4,I)/4.*(T2**4.-T1**4.) 00006630
    HEAT(I)=HEAT(I)*MLPRDT(I,III) 00006640
    DELTAH=HEAT(I)+DETAH 00006650
    IF(IDEBUG.GT.50) WRITE(6,51) I,HEAT(I),MLPRDT(I,III) 00006660
51 FORMAT(2X,'FOR SPECI',I2,'DELTA ENTH(J/HR)',E15.5,'MOLE RATE OF' 00006670
1 PRODUCT',E15.5) 00006680
100 CONTINUE 00006690
C   HEAT TO VAPORIZ FREE WATER INSLUDGE 00006700
    PRTH20=HSTVAP*FREH20/18.00 00006710
    IF(III.EQ.1)DETAH=DETAH+PRTH20 00006720
    IF(IDEBUG.GT.25.AND.UNIT(III).EQ.SUNIT(III)) WRITE(6,230) PRTH20 00006730
1,FREH20 00006740
230 FORMAT(10X,'HEAT OF VAPORIZATION OF WATER=',E15.5/10X,'INLET FLOW' 00006750
1,' RATE= ',E15.5) 00006760
    ZLOSS=DETAH*0.10 00006770
    HTASH=0.26*ASH/78.0*(T2-T1) 00006780
    IF(HTLS) DELTAH=DETAH+ZLOSS 00006790
    IF(III.EQ.1) DELTAH=DETAH+HTASH 00006800
    RETURN 00006810
    END 00006820
    SUBROUTINE VLRATE(TVOL,PVOL,NPRD) 00006830
    REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00006840
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00006850
    LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00006860
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,AUTODP, 00006870
2 ,SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00006880
4,CUTVN,CMBST,TCH 00006890
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00006900
    CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00006910
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00006920
2 ,SCRNME*20 00006930
1 ,TOTML 00006940
    COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00006950
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00006960
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DETAH,ZLFD2(9,9) 00006970
    COMMON/PCKBED/ PSIZE(7),PCKSZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00006980
1 ,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00006990
    COMMON/DES/RLD(9),DES VOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00007000
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00007010
2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00007020
3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00007030
    COMMON/COST/ SHLCST,DRV CST, BRKTOT, ASHCST, STM CST, DCTCST(9) 00007040
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00007050
    COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPT00007060
1 ,AOP,WATRAT,TOTDP,NTU,AOQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00007070
2 ,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLM 00007080
3 ,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00007090
    COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00007100
1 ,DCTTST,CSTMTB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00007110
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPr,CSTCRT,CSTENG,DCDIA(9),CSTINT00007120
3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN, 00007130
4 ,TOTECL,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00007140
5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00007150
6 ,EQVCAP,FINCRCG,REFINS,THCKIN,EQVFIN,DCBRIK 00007160
    COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEB,FACCEB 00007170
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00007180
    COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00007190
    COMMON/DCT/ ELBNUm(9),DCTLEN(9),DCTVEL(9),DIA(9) 00007200

```

```

COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00007210
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00007220
1,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00007230
2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00007240
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00007250
1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00007260
2,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00007270
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00007280
IF(IDEBUG.GT.25) WRITE(6,500) 00007290
500 FORMAT(10X,'SUBROUTINE VLRATE') 00007300
    RG=10.73 00007310
    TK=459.96 00007320
    TTL(III)=0.0 00007330
    MSTOT(III)=0.0 00007340
    DO 10 I=1,NPRD 00007350
        TTL(III)=TTL(III)+MLPRDT(I,III) 00007360
        MSTOT(III)=MSTOT(III)+MLPRDT(I,III)*PRDMW(I) 00007370
10 CONTINUE 00007380
    VOLRAT(III)=TTL(III)*RG*(TVOL+TK)/PVOL 00007390
    IF(IDEBUG.GT.10)WRITE(6,20) VOLRAT(III),TTL(III),MSTOT(III) 00007400
20 FORMAT(10X,'VOLUME RATE= ',E15.5,'FT^3/HR. MOLE RATE ',E15.5, 00007410
'LBMOLE/HR MASS RATE= ',E15.5,' LB/HR') 00007420
100 RETURN 00007430
END 00007440
SUBROUTINE INPT(NREAC,NPRD) 00007450
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00007460
1,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00007470
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00007480
1,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,AUTODP, 00007490
2,SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00007500
4,CUTVN,CMBST,TCH 00007510
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM2 00007520
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00007530
1, ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00007540
2, ,SCRNME*20 00007550
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00007560
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00007570
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAAH,ZLFD2(9,9) 00007580
COMMON/PCKBED/ PSIZE(7),PKCSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00007590
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00007600
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00007610
1,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00007620
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00007630
3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00007640
COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STM CST,DCTCST(9) 00007650
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00007660
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTEBC,DPTCT00007670
1,AOP,WATRAT,TOTDP,NTU,AOQ,CSTSTD,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00007680
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00007690
3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00007700
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00007710
1,DCTTST,CSTMTC,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00007720
2,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT00007730
3,DSDIA(9),CSTLDD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN, 00007740
4, TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00007750
5, TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00007760
6, EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00007770
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB 00007780
1, FACPV,FACPC,FACPI,FACENG,FACLAB,FACPRS 00007790
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00007800
COMMON/DCT/ EBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00007810
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00007820
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00007830
1,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00007840
2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00007850
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00007860
1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00007870
2,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00007880
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00007890
C   TCH IS A LOGICAL VAR TO SPECIFY REFRACTORY THICK CALCULATED FROM . 00007900
C   INDUSTRIAL PRACTICE. 00007910
C   TCH=.TRUE. 00007920

```

```

CUTVN=.FALSE.
C WATER RATE BETWEEN 15 AND 35 GAL/FT GAS FLOW          00007930
      WRITE(6,79)                                         00007940
      79 FORMAT(10X,'***** SUMMARY OF INPUT DATA FILE *****') 00007950
      IF(IDEBUG.GT.25) WRITE(6,500)                         00007970
      500 FORMAT(10X,'SUBROUTINE INPT')
      READ(4,12)
      READ(4,10) (CP(1,J),CP(2,J),CP(3,J),CP(4,J),CP(5,J),CP(6,J),
      1 PRDMW(J),J=1,NPRD)                                00008000
      11 FORMAT(1X,6E11.4)                                 00008010
      12 FORMAT(////)
      10 FORMAT(1X,6E11.4,F10.5)                           00008020
      DO 60 J=1,8
      READ(4,50)(BRIKNM(I,J),I=1,6), TLIM(J),TKOND(J),NRES(J),BCOST(J) 00008030
      50 FORMAT(1X,6(A4),2X,F9.4,2X,F8.4,2X,I1,2X,F9.4) 00008040
      IF(IDEBUG.GT.10)WRITE(6,50)(BRIKNM(I,J),I=1,6), TLIM(J),TKOND(J)
      1 ,NRES(J),BCOST(J)                                00008050
      60 CONTINUE                                         00008100
      READ(4,81)                                         00008110
      81 FORMAT(///)
      DO 140 J=1,1
      READ(4,74) (FUELNM(I,J),I=1,5),PRICE,HTCNT,FULC,ZFLHT 00008120
      74 FORMAT(1X,5A3,F7.2,F10.2,2E11.4)                00008130
      140 CONTINUE                                         00008160
      READ(4,215)                                         00008170
      215 FORMAT(////)
      DO 220 J=1,7
      READ(4,210) (PCKNM(J,JJ),JJ=1,4),PSIZE(J),CSTPK(J) 00008190
      1 ,(CONST(J,JJ),JJ=1,3),(PAKRAG(J,JJ),JJ=1,4),(CONST(J,JJ),JJ=4,7) 00008210
      IF(IDEBUG.LT.10) GOTO 220
      IF(IDEBUG.GT.5)WRITE(6,210) (PCKNM(J,JJ),JJ=1,4),PSIZE(J),CSTP00008230
      1K(J),(CONST(J,JJ),JJ=1,3),(PAKRAG(J,JJ),JJ=1,4),(CONST(J,JJ),JJ=4
      2,7)                                              00008240
      2,7)                                              00008250
      210 FORMAT(1X,4A4,F4.1,2F6.2,2F5.2,3F2.0,F3.0,F8.5,F5.2,F7.2,F8.5) 00008260
      220 CONTINUE                                         00008270
      READ(4,75) STM CST,WTRCST,DSPCST,CSTFUL,CSTECL,CSTLME 00008280
      75 FORMAT(/1X,F11.6,F11.6,F11.6,F11.6,F11.6)        00008290
      IF(IDEBUG.GT.25)WRITE(6,78) STM CST,WTRCST,DSPCST,CSTFUL,CSTECL 00008300
      78 FORMAT(10X,'COST OF RECOVERED STEAM = ',3X,F8.6,'$/LB'
      1 10X,'COST OF WATER = ',14X,F8.6,'$/LB'/
      2 10X,'COST OF WASTE ASH AND WATER = ',F8.2,'$/LB TREATED'/
      3 10X,'COST OF FUEL = ',12X,F8.6,'$/LB'/
      4 10X,'COST OF ELECTRICITY = ',4X,F8.6,'$/KWH')    00008310
      READ(4,76) HSTVAP
      HSTVAP=HSTVAP*1000.0                               00008320
      76 FORMAT(1X,F10.5)                                00008330
      READ(15,732) DAY,YEAR                            00008340
      WRITE(6,732) DAY,YEAR                            00008400
      732 FORMAT(1X,F4.1,1X,F5.1)                        00008410
      READ(15,4000) WSTNME(1)                          00008420
      WRITE(6,4000) WSTNME(1)                          00008430
      4000 FORMAT(1X,A20)                                00008440
      READ(15,70)(XXSLUD(I),I=1,9)                     00008450
      WRITE(6,70)(XXSLUD(I),I=1,9)                     00008460
      READ(15,70)(XXFUEL(I),I=1,9)                     00008470
      WRITE(6,70)(XXFUEL(I),I=1,9)                     00008480
      READ(15,70)(XXAIR(I),I=1,9)                      00008490
      WRITE(6,70)(XXAIR(I),I=1,9)                      00008500
      READ(15,72) MASSSL,ZSLHT                         00008510
      WRITE(6,72) MASSSL,ZSLHT                         00008520
      CLMS = MASSSL*XXSLUD(5)                          00008530
      READ(15,734) FLNAM,ZFLHT                         00008540
      WRITE(6,734) FLNAM,ZFLHT                         00008550
      734 FORMAT(1X,A15,F7.1)                           00008560
      READ(15,733) BRN,SCRW,BARREL,RECT,SLD,LQD,CMBST 00008570
      WRITE(6,733) BRN,SCRW,BARREL,RECT,SLD,LQD,CMBST 00008580
      733 FORMAT(1X,L1)                                00008590
      72 FORMAT(1X,2F11.4)                            00008600
      70 FORMAT(1X,F6.4,2X,F6.4,2X,F6.4,2X,F6.4,2X,F6.4
      1,2X,F6.4,2X,F6.4)                            00008610
      IF (IDEBUG.GT.5) WRITE(6,55)                      00008620
      55 FORMAT('           BRICK TYPE      ,   TLIM     , THERM COND . CL? , COS00008640

```

```

1T')                                         00008650
  IF(IDEBUG.GT.5) WRITE(6,76) HSTVAP          00008660
  IF(IDEBUG.GT.5) WRITE(6,77) PRICE,HTCNT,FULC 00008670
  1,ZFLHT                                     00008680
  77 FORMAT(5X,'PRICE= ',E15.5,'HEAT CONTENT= ',E15.5,'FUEL COST',
  1'= ',E15.5/10X,'HEAT OF COMBUSTION= ',E15.5) 00008690
  IF(IDEBUG.GT.5)WRITE(6,456) ZFLHT          00008710
  456 FORMAT(10X,'HEAT OF COMBUSTION (IN INPUT UNITS)= ',E15.5) 00008720
  READ(15,73) WTPH20,WTPVOL                 00008730
  WRITE(6,73) WTPH20,WTPVOL                 00008740
  READ(15,30) METRIC,ENGL,LCOST            00008750
  WRITE(6,30) METRIC,ENGL,LCOST            00008760
  73 FORMAT(1X,F9.7)                         00008770
  FREH20=WTPH20*MASSSL                     00008780
  VOLIT=WTPVOL*MASSSL                     00008790
  ASH=MASSSL-FREH20-VOLIT                  00008800
  READ(15,90) NUNIT                         00008810
  WRITE(6,90) NUNIT                         00008820
  90 FORMAT(1X,I2)                          00008830
  READ(15,110) TTMP(NUNIT+1),PINC,ELEVAT,FEDRG2 00008840
  WRITE(6,110) TTMP(NUNIT+1),PINC,ELEVAT,FEDRG2 00008850
  110 FORMAT(1X,F10.2)
  TA=TTMP(NUNIT+1)
  TTMP(1)=TA
  READ(15,100) (UNIT(I),MATL(I),TTMP(I+1),
  1,DCTLEN(I),ELBNUM(I),DCMATL(I),I=1,NUNIT) 00008860
  WRITE(6,100) (UNIT(I),MATL(I),TTMP(I+1),
  1,DCTLEN(I),ELBNUM(I).DCMATL(I),I=1,NUNIT) 00008870
  DO 130 I=1,NUNIT
  IF(IDEBUG.GT.5) WRITE(6,100) UNIT(I),MATL(I),TTMP(I+1)
  1,DCTLEN(I),ELBNUM(I),DCMATL(I)           00008880
  100 FORMAT(1X,A3,1X,A2,F10.2,F10.5,F4.1,1X,A2)
  IF(UNIT(I).EQ.SUNIT(1)) GOTO 700          00008890
  IF(UNIT(I).EQ.SUNIT(2)) GOTO 804          00008900
  IF(UNIT(I).EQ.SUNIT(3)) GOTO 801          00008910
  IF(UNIT(I).EQ.SUNIT(4)) GOTO 803          00008920
  IF(UNIT(I).EQ.SUNIT(5)) GOTO 802          00008930
  IF(UNIT(I).EQ.SUNIT(6)) GOTO 707          00008940
  IF(UNIT(I).EQ.SUNIT(7)) GOTO 130          00008950
  IF(UNIT(I).EQ.SUNIT(8)) GOTO 708          00008960
  IF(UNIT(I).EQ.SUNIT(9)) GOTO 800          00008970
  GOTO 130
  700 READ(15,30) ROTARY,FLUID,LIQI,HTLS    00008980
  WRITE(6,30) ROTARY,FLUID,LIQI,HTLS        00008990
  30 FORMAT(1X,L1)
  READ(15,40) RETIM(I),RLD(I),EXCESS(I),EXFUEL(I) 00009000
  WRITE(6,40) RETIM(I),RLD(I),EXCESS(I),EXFUEL(I) 00009010
  READ(15,73) PREXTI                        00009020
  WRITE(6,73) PREXTI                        00009030
  READ(15,30) ADIA,SIEVE,VALVE             00009040
  WRITE(6,30) ADIA,SIEVE,VALVE             00009050
  GOTO 130
  707 READ(15,720) (PCKCHS(JJ),JJ=1,4),PCKSZ,EFFABS,NTU,SCHMDT,PRCFLD 00009170
  WRITE(6,720) (PCKCHS(JJ),JJ=1,4),PCKSZ,EFFABS,NTU,SCHMDT,PRCFLD 00009180
  READ(15,736) WATRAT,SLPABS,HCLRM         00009190
  WRITE(6,736) WATRAT,SLPABS,HCLRM         00009200
  736 FORMAT(1X,F6.3,F6.2,F8.4)            00009210
  READ(15,737) SCRNM(E1)                  00009220
  WRITE(6,737) SCRNM(E1)                  00009230
  737 FORMAT(1X,A20)
  READ(15,911) DFHCLL,DFHCLG              00009240
  WRITE(6,911) DFHCLL,DFHCLG              00009250
  911 FORMAT(1X,F10.2)                    00009260
  730 FORMAT(1X,F10.2)                    00009270
  720 FORMAT(1X,4A4,F6.2,F10.8,I3,F6.3,F6.2)
  IF(IDEBUG.GE.25)
  1 WRITE(6,43) (PCKCHS(JJ),JJ=1,4),PCKSZ,EFFABS,NTU,SCHMDT,PRCFLD 00009280
  1 F9.2/10X,'EFFECTIVE ABSOPTION = ',F9.0,'NTU= ',I5/
  2 10X,'SCHMIDT NUMBER= ',E15.5,'PERCENT OF FLOODING= ',F9.2) 00009290
  GOTO 130
  708 READ(15,134) RLD(I)                  00009300

```

```

      WRITE(6,134) RLD(I)                      00009370
      READ(15,134) RETIM(I)                    00009380
      WRITE(6,134) RETIM(I)                    00009390
134  FORMAT(1X,F10.5)                      00009400
      READ(15,73) PREXT                      00009410
      WRITE(6,73) PREXT                      00009420
      GOTO 130                                00009430
800  READ(15,1) HEIGHT                     00009440
      WRITE(6,1) HEIGHT                     00009450
1  FORMAT(1X,F5.1)                        00009460
      READ(15,30) VOLTIL                     00009470
      WRITE(6,30) VOLTIL                     00009480
      GOTO 130                                00009490
801  READ(15,30) FXH,KRB,UTB,HM1,HM2     00009500
      WRITE(6,30) FXH,KRB,UTB,HM1,HM2     00009510
      READ(15,30) S316,S304,S347,NI200,MD400,IN600,IN825, TI,HS 00009520
      WRITE(6,30) S316,S304,S347,NI200,MD400,IN600,IN825, TI,HS 00009530
      READ(15,110) HTC                       00009540
      WRITE(6,110) HTC                       00009550
      GOTO 130                                00009560
802  CONTINUE
      READ(15,110) TOTDP                     00009570
      WRITE(6,110) TOTDP                     00009580
      GOTO 130                                00009590
      00009600
803  READ(15,110) VENWAT,DPTOT          00009610
      WRITE(6,110) VENWAT,DPTOT          00009620
      READ(15,30) PRI                         00009630
      WRITE(6,30) PRI                         00009640
      IF(.NOT.(PRI.AND.CUTVN)) GOTO 34      00009650
      READ(15,31) NPRTS                      00009660
      WRITE(6,31) NPRTS                      00009670
31   FORMAT(1X,I3)
      DO 32 IJ=1,NPRS
          READ(15,33) DIAAPT(IJ),WTPRT(IJ)
          WRITE(6,33) DIAAPT(IJ),WTPRT(IJ)
      00009680
      00009690
      00009700
      00009710
33   FORMAT(1X,2F9.5)
32   CONTINUE
34   READ(15,813) FEDRG2                 00009730
      WRITE(6,813) FEDRG2                 00009740
      00009750
813  FORMAT(1X,E15.5)
      READ(15,30) VENAUT,FG                00009760
      WRITE(6,30) VENAUT,FG                00009770
      GOTO 130                                00009780
      00009790
804  READ(15,221) QSAT,QTEMP            00009800
      WRITE(6,221) QSAT,QTEMP            00009810
      00009820
221  FORMAT(1X,2F3.1)
      GOTO 130                                00009830
      00009840
130  CONTINUE
      READ(15,731) FACMSC,FACCEE,FACCEF,FACCEB,FACCES,
1  FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS,IYEAR        00009850
      WRITE(6,731) FACMSC,FACCEE,FACCEF,FACCEB,FACCES,
1  FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS,IYEAR        00009860
      00009870
      00009880
731  FORMAT(2X,11F6.1,15)
      READ(15,742) YRNUM,RTINST,REVLB,CONTEN
      WRITE(6,742) YRNUM,RTINST,REVLB,CONTEN
      00009890
      00009900
      00009910
742  FORMAT(1X,F4.1,F4.1,F8.3,F8.3)
      DO 200 II=1,NUNIT
          IF(EXCESS(II).GT.1.0) WRITE(6,71) II
      00009920
      00009930
      00009940
71   FORMAT(2X,'WARNING! EXCESS AIR IS GREATER THAN 1 IN UNIT',F5.1)
      00009950
200  CONTINUE
40   FORMAT(1X,F10.2)
      IF(IDEBUG.GT.5) WRITE(6,30) ROTARY,FLUID,LIQI,METRIC,ENGL,L COST,HT00009980
      1LS
      IF(IDEBUG.GT.5) WRITE(6,41) PINC
      00010000
41   FORMAT(1OX,'INLET PRESSURE TO INCINERATOR = ',F6.2,' PSIA')
      IF(IDEBUG.LT.10) GOTO 765
      00010020
      WRITE(6,150) (CP(1,J),CP(2,J),CP(3,J),CP(4,J),CP(5,J),CP(6,J),
1  PRDMW(J),J=1,NPRD)
      00010030
      00010040
150  FORMAT(1X,'SPEC.          A      ,      B      ,      C      ,      D      , 00010050
      A TLLOW , THIGH , MW'                  // 00010060
      1 3X,'H2O  ',4E11.3,4X,2F7.2,F9.4/3X,'HCL  ',4E11.3,4X,2F7.2,F9.4/ 00010070
      2 3X,'CO2  ',4E11.3,4X,2F7.2,F9.4/3X,'CO  ',4E11.3,4X,2F7.2,F9.4/ 00010080

```

```

3 3X,'N2   ',4E11.3,4X,2F7.2,F9.4/3X,'02   ',4E11.3,4X,2F7.2,F9.4/ 00010090
4 3X,'NO   ',4E11.3,4X,2F7.2,F9.4/3X,'N02  ',4E11.3,4X,2F7.2,F9.4/ 00010100
5 3X,'CL2  ',4E11.3,4X,2F7.2,F9.4/3X,'S02  ',4E11.3,4X,2F7.2,F9.4/ 00010110
6 3X,'H2S04',4E11.3,4X,2F7.2,F9.4/3X,'F2   ',4E11.3,4X,2F7.2,F9.4/ 00010120
7 3X,'HF   ',4E11.3,4X,2F7.2,F9.4/3X,'P206  ',4E11.3,4X,2F7.2,F9.4/ 00010130
8 3X,'NE   ',4E11.3,4X,2F7.2,F9.4)          00010140
765 CONTINUE
IF(IDEBUG.GT.5)WRITE(6,38) (XXSLUD(I),XXFUEL(I),XXAIR(I),I=1,9) 00010160
38 FORMAT(////25X,'MASS FRACTION OF FEED STREAMS'//13X,'SPECIES S00010170
1LUDGE      FUEL      AIR'/15X,' H   ',2X,F7.5,5X,F7.5,5X,F7.5/00010180
1 15X,' C   ',2X,F7.5,5X,F7.5,5X,F7.5/ 00010190
1 15X,' O   ',2X,F7.5,5X,F7.5,5X,F7.5/ 00010200
1 15X,' N   ',2X,F7.5,5X,F7.5,5X,F7.5/ 00010210
1 15X,' CL  ',2X,F7.5,5X,F7.5,5X,F7.5/ 00010220
1 15X,' S   ',2X,F7.5,5X,F7.5,5X,F7.5/ 00010230
1 15X,' F   ',2X,F7.5,5X,F7.5,5X,F7.5/ 00010240
1 15X,' P   ',2X,F7.5,5X,F7.5,5X,F7.5/ 00010250
1 15X,' NE  ',2X,F7.5,5X,F7.5,5X,F7.5/) 00010260
PEXT=PINC
IF(IDEBUG.GE.25) WRITE(6,82) 00010280
82 FORMAT(10X,'*****') 00010290
RETURN 00010300
END 00010310
SUBROUTINE BLOCK(NREAC,NPRD) 00010320
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00010330
1 .XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00010340
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00010350
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP. 00010360
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00010370
4,CUTVN,CMBST,TCH 00010380
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00010390
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00010400
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00010410
2 .SCRNME*20 00010420
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00010430
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00010440
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9) 00010450
COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00010460
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7.4),Z,CSTINS,TBRNTT00010470
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00010480
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00010490
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00010500
3,INCLEN(9),MSTOT(9),MLPRDT(15.9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00010510
COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STM CST,DCTCST(9) 00010520
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00010530
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTD00010540
1,AOP,WATRAT,TOTDP,NTU,AQ,CSTSTD,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00010550
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00010560
3,QSAT,VENH2O,DAMPL(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00010570
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00010580
1 .DCTTST,CSTM TB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00010590
2 .CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT00010600
3 .DSDIA(9),CSTLDD,DCTBCS(9),TDCTS(9),TOTLAB,TTMAIN, 00010610
4 TOTELC.TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00010620
5 TOTTOT,DEPREC,EQVFPT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00010630
6 EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00010640
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB 00010650
1 .FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00010660
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00010670
COMMON/DCT/ ELMNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00010680
COMMON/INT/ IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00010690
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00010700
1,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00010710
2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00010720
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00010730
1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00010740
2,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00010750
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00010760
BRKTOT=0.0 00010770
IF(IDEBUG.GT.25) WRITE(6,500) 00010780
500 FORMAT(10X,'SUBROUTINE BLOCK') 00010790
DDSVOL=DESVOL(III) 00010800

```

```

TD2=TTMP(III+1)          00010810
TD1=TTMP(III)            00010820
9 CONTINUE                00010830
C23456789                00010840
REFINS=1.0+(4.0-1.0)/(3000.-1800.)*(TD2-1800) 00010850
THCKIN=4.0+(12.0-4.0)/(3000.-1800.)*(TD2-1800.) 00010860
IF(TD2.GT.3000.) THCKIN=12.0 00010870
IF(TD2.LT.1800.) THCKIN=4.0 00010880
IF(TD2.LT.1800.)REFINS=1.0 00010890
IF(TD2.GT.3000.)REFINS=4.0 00010900
ARINS=3.1416*(DIA(III)+REFINS*2./12.+THCKIN*2./12.)*INCLEN(III) 00010910
ARREF=3.1416*(DIA(III)+THCKIN*2./12.)*INCLEN(III) 00010920
DIA(III)=DIA(III)+REFINS*2./12.+2.*THCKIN/12. 00010930
DIABRK=DIA(III) 00010940
SHELVL=DIABRK**2.*3.1416/4.0*INCLEN(III) 00010950
DTLGM=(TD2-TD1)/LOG(TD2/TD1) 00010960
NCOR=0 00010970
NCHOSE=0 00010980
MCHOSE=0 00010990
C 00011000
C CHOOSE REFRactory MATERIAL 00011010
C 00011020
C 00011030
IF(XXSLUD(5).GT.0.005) NCOR=1 00011040
DO 10 I=1,3 00011050
  IF(NCOR.GT.NRES(I)) GOTO 10 00011060
  IF(TD2.GT.TLIM(I)) GOTO 10 00011070
  RBCOST=BCOST(I) 00011080
  DO 300.II=1,6 00011090
    BNMFRII=BRIKNM(II,I) 00011100
300 CONTINUE 00011110
  NCHOSE=I 00011120
  GOTO 15 00011130
10 CONTINUE 00011140
  RBCOST=BCOST(3) 00011150
  DO 304 IJ=1,6 00011160
    BNMFRIJ=BRIKNM(IJ,6) 00011170
304 CONTINUE 00011180
15 DO 20 I=4,8 00011190
  IF(NCOR.GT.NRES(I)) GOTO 20 00011200
  IF(TD2.GT.TLIM(I)) GOTO 20 00011210
  ZIBCOS=BCOST(I) 00011220
  DO 301.II=1,6 00011230
    BNMIN(II)=BRIKNM(II,I) 00011240
301 CONTINUE 00011250
  MCHOSE=I 00011260
  GOTO 25 00011270
20 CONTINUE 00011280
  ZIBCOS=BCOST(8) 00011290
  DO 303 IJ=1,6 00011300
    BNMIN(IJ)=BRIKNM(IJ,6) 00011310
303 CONTINUE 00011320
25 CONTINUE 00011330
  IF(.NOT.HTLS) GOTO 30 00011340
  IF(TCH) GOTO 30 00011350
  THCKIN=(-(TD2-TA)/ZLOSS+REFINS/TKOND(NCHOSE)/ARINS)*TKOND(MCHOSE)*00011360
1 ARREF 00011370
  IF(DCTFLG) DSDIA(III)=DIA(III)*12.0+(THCKIN+REFINS)*2.0 00011380
  IF(THCKIN.LT.0.125) THCKIN=3.0 00011390
30 IF(IDEBUG.GT.25)WRITE(6,110) RBCOST,ZIBCOS,DIABRK,INCLEN(III) 00011400
1 .TKOND(NCHOSE),ZLOSS 00011410
110 FORMAT(2X,'COST OF REFRactory INSULATION ($/FT**2IN)= ',F9.2/ 00011420
1 2X,'COST OF INSULATION ($/FT**2)= ',F9.2/10X,'DIAMETER OF UNIT ', 00011430
2'WITH BRICK COVERING(FT)= ',F9.2, 00011440
3' LENGTH OF INCINERATOR(FT)= ',F12.2, 00011450
4 /1X,'THERMAL CONDUCTIVITY= ',F10.2,E15.5) 00011460
  BRKCOS=(RBCOST*THCKIN*ARREF+ZIBCOS*REFINS*ARINS) 00011470
1 *FACMSC/318.7 00011480
  BRKINS=BRKCOS*1.0 00011490
  BRKSHP=BRKCOS*0.30 00011500
  IF(.NOT.DCTFLG) BRKTOT=BRKCOS+BRKINS+BRKSHP 00011510
  IF(DCTFLG) DCBRIK=BRKCOS+BRKINS+BRKSHP 00011520

```

```

IF(FLUID.AND.(.NOT.DCTFLG)) BRKMAN=BRKTOT*0.150          00011530
IF(LIQI.AND.(.NOT.DCTFLG)) BRKMAN=BRKTOT*0.050          00011540
IF(FLUID.AND.DCTFLG) BRKMAN=DCBRIK*0.150                00011550
IF(LIQI.AND.DCTFLG) BRKMAN=DCBRIK*0.050                00011560
IF(ROTARY) BRKMAN=BRKTOT*0.10                            00011570
IF(IDEBUG.LE.25) GOTO 40                                 00011580
      WRITE(6,100) ARINS,TD2,REFINS,THCKIN,(BNMIN(I))
1,
1I=1,6)
1,   (BNMFR(I),I=1,6),SHELVL,BRKCOS,BRKINS,BRKSHP        00011600
100  FORMAT(30X,'DATA USED IN SUBROUTINE BLOCK'//           00011610
     1/5X,' SURFACE AREA(III)(FT**3)',F9.2/5X,              00011620
     1' TEMPERATURE(F)= ',                                00011630
     2F9.2/5X,' INSULATING THICKNESS(IN.)= ',F7.2,' REFRactory THICKNE 00011640
     3SS(IN.)=',F7.2/                                         00011650
     5 5X,' INSULATION USED= ',6(A4),' REFRactory USED'.6(A4 00011660
     4)/10X,' SHELL VOLUME (FT**3)= ',F9.2/20X,' COST OF BRICKS AND', 00011670
     5 ' INSULATION'//10X,' BRICK COST = ',10X,F12.2/          00011680
     610X,' INSTALLATION COSTS = ',2X,F12.2/               00011690
     710X,' SHIPPING COSTS = ',6X,F12.2/                  00011700
     8 10X, '-----')                                     00011710
     IF(.NOT.DCTFLG) WRITE(6,641) BRKTOT                   00011720
     IF(DCTFLG) WRITE(6,641) DCBRIK                      00011730
641 FORMAT(
1 10X,'TOTAL BRICK COST= ',5X,F12.2)                   00011740
40 RETURN                                                 00011750
END
SUBROUTINE INCDES(NREAC,NPRD)                             00011760
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD       00011770
1 .XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00011780
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00011790
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00011800
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00011810
4,CUTVN,CMBST,TCH
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00011820
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00011830
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00011840
2 ,SCRNME*20
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00011850
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00011860
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9) 00011870
COMMON/PCKBED/ PSIZE(7),PCKSZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00011880
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4).Z.CSTINS,TBRNTT00011890
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00011900
1 .BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00011910
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00011920
3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00011930
COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STMCST,DCTCST(9) 00011940
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00011950
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTD00011960
1,AOP,WATRAT,TOTDP,NTU,AQQ,CSTSTD,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00011970
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00011980
3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00011990
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00012000
1 ,DCTTST,CSTM TB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00012010
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTS PR,CSTCRT,CSTENG,DCDIA(9),CSTINT00012020
3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN, 00012030
4 TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00012040
5 TOTTOT,DEPREC,EQVPFT,REVBL,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00012050
6 EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00012060
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB 00012070
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00012080
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00012090
COMMON/DCT/ EBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00012100
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,UPIK,IYEAR,NUMBRN,NPRTS 00012110
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00012120
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00012130
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00012140
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00012210
1 ,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00012220
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00012230
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00012240

```

```

HPBLWR=0.0          00012250
DRVHP=0.0          00012260
CSTSCR=0.0          00012270
CSTLOD=0.0          00012280
SKRCST=0.0          00012290
IF(IDEBUG.GT.25) WRITE(6,500)          00012300
500 FORMAT(10X,'SUBROUTINE INCDES')      00012310
IF(ENGL) CALL METRC(NREAC,NPRD)        00012320
CALL HTMS(NREAC,NPRD)                  00012330
IF(METRIC) CALL ENG(NREAC,NPRD)        00012340
PVOL=PINC           00012350
TVOL=T2              00012360
CALL VLRATE(TVOL,PVOL,NPRD)          00012370
RHO=MSTOT(III)/VOLRAT(III)          00012380
DESVOL(III)=VOLRAT(III)*RETIM(III)/3600.0 00012390
IF(IDEBUG.GT.1)WRITE(6,600) RETIM(III),VOLRAT(III),DESVOL(III) 00012400
600 FORMAT(10X,'RETENTION TIME= ',F7.4,' VOLUME RATE=',F12.2 00012410
1.' DESIGN VOLUME=',F12.2)          00012420
IF(ROTARY) AREA(III)=5.76*DESVOL(III)**0.67 00012430
IF(LIQI) AREA(III)=5.76*DESVOL(III)**0.67 00012440
HTCOMB=(MASSFL*ZFLHT+VOLIT*ZSLHT)/1.E6 00012450
DIA(III)=5.2385+0.54878*HTCOMB-5.284E-3*HTCOMB**2.+ 00012460
1.2.655E-5*HTCOMB**3.          00012470
IF(.NOT.FLUID)DIA(III)=(DESVOL(III)*4.0/3.1416/RLD(III))**(.1./3 00012480
1.)          00012490
INCLEN(III)=DIA(III)*RLD(III)          00012500
AREA(III)=3.141596*DIA(III)**2./4.0*INCLEN(III) 00012510
IF(.NOT.FLUID) INCLEN(III)=DESVOL(III)/3.14159/DIA(III)**2.0*4.0 00012520
IF(RECT) AREA(III)=0.30*DESVOL(III)+149.0 00012530
IF(IDEBUG.LT.25) GOTO 782            00012540
WRITE(6,300) DESVOL(III),DIA(III),INCLEN(III),AREA(III),VOLRAT( 00012550
1III)
300 FORMAT(2X,'DESIGN VOLUME (FT**3)= ',E15.5/2X,'INCINERATOR DIAMETER 00012570
1 R (FT)= ',E15.5,'INCINERATOR LENGTH (FT)= ',E15.5/2X,          00012580
2 ' SURFACE AREA(III) OF INCINERATOR (FT**2)= ',E15.5/2X,'GAS FLOW' 00012590
3, ' RATE (FT**3/HR)= ',E15.5)          00012600
782 IF(UNIT(III).EQ.SUNIT(8)) LIQI=.TRUE. 00012610
    CALL BLOCK(NREAC,NPRD)          00012620
    CALL SHELL(NREAC,NPRD)          00012630
    CALL BURNER(NREAC,NPRD)         00012640
    DIABED=DIA(III)               00012650
MTL=1              00012660
IF(SS) MTL=2          00012670
IF(IC) MTL=2          00012680
XASH=ASH/MASSSL       00012690
IF(FLUID) TRACST=TRAYCS(SIEVE,VALVE,DIABED,MTL)*FACCEF/329.1 00012700
ASHGAS=ASH*PERUPT       00012710
IF(XASH.GT.0.02) CALL ASHUN          00012720
CSTLOD=0.0          00012730
IF(SLD) CSTLOD=LOADR(HTCOMB/1E6,BARREL)*FACCES/308.4' 00012740
IF(SLD.AND.SCRW) CSTSCR=SCRFED(HTCOMB/1.E6)*FACCES/308.4 00012750
SKRCST=10000.0          00012760
EXTRA1 = 0.0          00012770
IF(ASH.GT.1.0) CALL ASHUN          00012780
IF(ROTARY) SKRCST=10000.0          00012790
EXTRA1=(BRKTOT+CSTSCR+CSTLOD+SHLCST+TBRNTT+ASHCST+SKRCST)*PREXTI 00012800
CSTINC=BRKTOT+SHLCST+TBRNTT+ASHCST+CSTSCR+CSTLOD+EXTRA1+SKRCST 00012810
    IF(ROTARY) CSTINC=CSTINC+DRV CST          00012820
    IF(ROTARY) CSTINS=2.0*CSTINC          00012830
    IF(FLUID) CSTINS=CSTINC*1.0          00012840
    IF(LIQI) CSTINS=CSTINC*0.5          00012850
GAL=MASSFL/60.0/47.0          00012860
IF(ROTARY) CSTMAN=CSTINC*0.20          00012870
IF(LIQI) CSTMAN=CSTINC*0.09          00012880
IF(FLUID) CSTMAN=CSTINC*0.07          00012890
TOTMAN=TOTMAN+CSTMAN          00012900
IF(ROTARY) DRVHP=0.22*MASSSL/500.0 00012910
FLPMHP=0.036*GAL          00012920
IF(FLUID) HPBLWR=PINC/14.696*33.9*12.0/60.0/4464.0=MASSAR 00012930
IF(.NOT.FLUID) GOTO 200          00012940
    TOTDP=5.0*33.9*12.0/14.696          00012950
    VLHOLD=VOLRAT(III)          00012960

```

```

VOLRAT(III)=MASSAR*10.73*(TA+460.)/29.0/PINC          00012970
    CALL INDFAN(NREAC,NPRD)                            00012980
    VOLRAT(III)=VLHOLD                                00012990
200 CONTINUE
    PEXT= PEXT- PRESSR(MSTOT(III),RHO,DIA(III),INCLEN(III)) 00013000
    TOTELC=TOTELC+(DRVHP/0.80*0.746+0.746*HPBLWR/0.80)*DAY*YEAR 00013010
    TOTELC=FLOPMHP*0.746/0.80+TOTELC                      00013020
    HPTOT=HPTOT+(DRVHP+HPBLWR)/0.80                      00013030
1 * DAY*0.746                                         00013040
    CSTIIN=CSTIIN+CSTINS                                00013050
    CALL OUTP1(NPRD)                                    00013060
    CALL OUTP6(NPRD)                                    00013070
    IF(NUNIT.NE.III) FLGPAS=.TRUE.                      00013080
100 RETURN
    END
    SUBROUTINE AFTER(NREAC,NPRD)
    REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD      00013100
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00013110
    LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00013120
1 ,IC,SSG,VOLIT,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00013130
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00013140
4,CUTVN,CMBST,TCH                                         00013150
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,INB25,TI,HS,UTB,HM1,HM2 00013160
    CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00013170
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00013180
2 .SCRNME*20
    COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00013190
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00013200
2 ,VOLIT,ASH,FREH2O,HTCNT,FULC,FEED(15),TA,DELTAB,ZLFD2(9.9) 00013210
    COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00013220
1 ,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00013230
    COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00013240
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00013250
2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00013260
3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00013270
    COMMON/COST/ SHLCST,DRV CST,BRKTO T,ASHCST,STM CST,DCTCST(9) 00013280
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00013290
    COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DS PCST,CSTE L,DP TO00013300
1 ,AOP,WATRAT,TOTDP,NTU,AQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00013310
2 ,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00013320
3 ,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00013330
    COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00013340
1 ,DCTTST,CSTM TB,CSTSIT,CSTSTC,CSTE M,CSTCNT,PREXT,PREXTI,SKRCST 00013350
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT00013360
3 ,DSDIA(9),CSTLDD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN, 00013370
4 ,TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00013380
5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00013390
6 ,EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00013400
    COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB 00013410
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00013420
    COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00013430
    COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00013440
    COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00013450
    COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00013460
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00013470
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00013480
    COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00013490
1 ,IC,TCH,SSG,VOLIT,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00013500
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00013510
3 ,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,INB25,TI,HS,UTB,HM1,HM2 00013520
    AASH=ASH                                         00013530
    SHLCST=0.0                                         00013540
    BRKTOT=0.0                                         00013550
    ASHCST=0.0                                         00013560
    VVOLIT=VOLIT                                       00013570
    FFREE=FREH20                                       00013580
    ASH=0.0                                           00013590
    VOLIT=0.0                                         00013600
    FREH20=0.0                                         00013610
    DO 30 I=1,NPRD
        MLPRDT(I,III)=MLPRDT(I,III-1)                00013620
30 CONTINUE

```

```

PVOL=PINC          00013690
TVOL=T2           00013700
CALL VLRATE(TVOL,PVOL,NPRD) 00013710
IF(T1.GT.T2) GOTO 80 00013720
IF(IDEBUG.GT.25)WRITE(6,90) T1,T2 00013730
90 FORMAT(5X,'INLET TEMP IN AFTER =',F7.2,'CELCIUS. OUTLET TEMP= ', 00013740
1F7.2,'CELCIUS')
IF(IDEBUG.GT.25) WRITE(6,500) 00013750
500 FORMAT(10X,'SUBROUTINE AFTER') 00013770
IF(LIQI) AFT=1. 00013780
IF(ROTARY) AFT=2. 00013790
IF(FLUID) AFT=3. 00013800
NSET =0          00013810
IF(.NOT.LIQI) LIQI=.TRUE. 00013820
FLUID=.FALSE.    00013830
ROTARY=.FALSE.   00013840
BAL=.TRUE.       00013850
IF(ENGL) CALL METRC(NREAC,NPRD) 00013860
VVOLIT=VOLIT    00013870
VOLIT=0.0        00013880
VMSAIR=MASSAR  00013890
MASSAR=0.0       00013900
CALL HTMS(NREAC,NPRD) 00013910
ISST=0          00013920
IF(ISST.EQ.1) STOP 00013930
IF(METRIC) CALL ENG(NREAC,NPRD) 00013940
PVOL=PINC        00013950
TVOL=T2           00013960
CALL VLRATE(TVOL,PVOL,NPRD) 00013970
RHO=MSTOT(III)/VOLRAT(III) 00013980
DESVOL(III)=VOLRAT(III)*RETIM(III)/3600.0 00013990
IF(IDEBUG.LT.25) GOTO 60 00014000
WRITE(6,600) RETIM(III),VOLRAT(III),DESVOL(III) 00014010
600 FORMAT(10X,'RETENTION TIME= ',F7.4,'VOLUME RATE=',E15.5 00014020
1,'DESIGN VOLUME=',E15.5)
60 AREA(III)=5.76*DESVOL(III)**0.67 00014030
DIA(III)=(DESVOL(III)*4.0/3.1416/RLD(III))**(.1./3.) 00014040
INCLEN(III)=DIA(III)*RLD(III) 00014050
IF(IDEBUG.NE.1) GOTO 70 00014060
WRITE(6,300) DESVOL(III),DIA(III),INCLEN(III),AREA(III),VOLRAT( 00014070
1III)
700 FORMAT(2X,'DESIGN VOLUME (FT**3)= ',E15.5/2X,'INCINERATOR DIAMETER 00014100
1 R (FT)= ',E15.5,'INCINERATOR LENGTH (FT)= ',E15.5/2X, 00014110
2,'SURFACE AREA(III) OF INCINERATOR (FT**2)= ',E15.5/2X,'GAS FLOW' 00014120
3,' RATE (FT**3/HR)= ',E15.5) 00014130
70 IF(UNIT(III).EQ.SUNIT(8)) LIQI=.TRUE.
    CALL BLOCK(NREAC,NPRD) 00014140
    CALL SHELL(NREAC,NPRD) 00014150
    CALL BURNER(NREAC,NPRD) 00014160
    EXTRA2 = (BRKTOT+SHLCST+TBRNTT)*PREXT 00014170
    AFTINC=BRKTOT+SHLCST+TBRNTT 00014180
    AFTINC=AFTINC+(EXTRA2) 00014190
    FULCST=MASSFL*ZFLHT*FULC 00014200
    GAL=MASSFL/60.0*ZFLHT/HTCNT 00014210
    CSTMAN=AFTINC*0.09 00014220
    TOTMAN=TOTMAN+CSTMAN 00014230
    FLPMPHP=0.036*GAL 00014240
    TOTELC=TOTELC+(FLPMHP*DAY*YEAR*0.746/0.80) 00014250
    CSTIIN=CSTIIN+AFTINC*.30 00014260
    CALL OUTP1(NPRD) 00014270
    CALL OUTP6(NPRD) 00014280
    LIQI=.FALSE. 00014290
    IF(AFT.EQ.1) LIQI=.TRUE. 00014300
    IF(AFT.EQ.2) ROTARY=.TRUE. 00014310
    IF(AFT.EQ.3) FLUID=.TRUE. 00014320
    IF(NUNIT.NE.III) FLGPAS=.TRUE. 00014330
    GOTO 100 00014340
80 WRITE(6,400)T1,T2 00014350
    FLGPAS=.FALSE. 00014360
400 FORMAT(10X,'THE INLET TEMPERATURE OF THE INCINERATOR ',F7.2, 00014370
1,'OUTLET TEMPERATURE IS ',F7.2,' DEGREES FAHRENHEIT') 00014380
100 ASH=AASH 00014390
                                         00014400

```

```

VOLIT=VVOLIT                                00014410
FREH20=FFREE                                 00014420
    PEXT= PEXT- PRESSR(MSTOT(III),RHO,DIA(III),INCLEN(III)) 00014430
RETURN                                         00014440
END                                            00014450
SUBROUTINE BURNER                           00014460
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00014470
1 .XXFUEL.XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00014480
LOGICAL ROTARY,FLUID.LIQI.METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00014490
1 .IC,SSG,VOLTIL,BARREL,SEMI.DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00014500
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00014510
4,CUTVN.CMBST,TCH                           00014520
3,KRB,FXH,S316,S304,S347,NI200,MO400,ING600,IN825,TI,HS,UTB,HM1,HM2 00014530
    CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00014540
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00014550
2 ,SCRNME*20                                00014560
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00014570
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00014580
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9) 00014590
COMMON/PCKBED/ PSIZE(7).PCKSZ,CSTPK(7).PAKH20,RHOL,RHO,VISCL 00014600
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00014610
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00014620
1 .BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00014630
2,HTCOMB,AREA(9),VOLRAT(9),REPCT,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00014640
3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00014650
COMMON/COST/ SHLCST,DRV CST, BRKTOT, ASHCST, STMCST, DCTCST(9) 00014660
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00014670
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTEBC,DPT0T00014680
1,AOP,WATRAT,TOTDP,NTU,AQO,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00014690
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00014700
3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBA5,EXTRA2,DIFH20,VAPNO 00014710
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00014720
1 .DCTTST.CSTM TB,CSTSIT,CSTSC,CSTM,CSTCNT,PREXT,PREXTI,SKRCST 00014730
2 .CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT00014740
3 .DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN, 00014750
4 TOTELC.TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00014760
5 TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00014770
6 EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00014780
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB 00014790
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00014800
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00014810
COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00014820
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00014830
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00014840
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00014850
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00014860
COMMON/LOGIC/ROTARY,FLUID.LIQI.METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00014870
1 .IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,FLGPAS00014880
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00014890
3,KRB,FXH,S316,S304,S347,NI200,MO400,ING600,IN825,TI,HS,UTB,HM1,HM2 00014900
    TBRNTT=0.0                                00014910
    BRNSCT=0.0                                00014920
    BRNCST=0.0                                00014930
    IF(ZSLHT.LT.4000.) GOTO 10 00014940
NUM=0                                         00014950
ZNUM=0.                                         00014960
C ONLY ONE FUEL BURNER REQUIRED 00014970
    IF(IDEBUG.GT.25) WRITE(6,35) ZFLHT,MASSFL,HTFLCB 00014980
35 FORMAT(2X,'HEAT CONTENT OF FUEL(BTU/LB)= ',E15.2,'MASS RATE OF FUE00014990
    1L (LB/HR)= ',E15.2/2X,'HEAT OUTPUT FROM FUEL(BTU/HR) = ',E15.2) 00015000
C                                         00015010
    HTFLCB=ZFLHT*MASSFL 00015020
    IF(HTFLCB.GT.1.5E6) GOTO 20 00015030
C FOR SMALL BURNERS ($1,200. DOLLARS EACH FOR 1.5E6 MAX BTU/HR HT RATE 00015040
ZNUM=HTFLCB/1.2E6 00015050
NUM=ZNUM 00015060
    IF(ZNUM.GT.NUM) NUM=NUM+1 00015070
    ZNUM=NUM 00015080
    BRNCST=ZNUM*1200.00 00015090
    GOTO 40 00015100
20 IF(HTFLCB.GT.5.0E6) GOTO 30 00015110
    ZNUM=HTFLCB/4.0E6 00015120

```

```

NUM=ZNUM                                     00015130
  IF(ZNUM.GT.NUM) NUM=NUM+1                  00015140
  ZNUM=NUM                                     00015150
  BRNCST=ZNUM*5000.0                          00015160
  GOTO 40                                     00015170
30 ZNUM=HTFLCB/10.0E6                         00015180
  NUM=ZNUM                                     00015190
  IF(ZNUM.GT.NUM) NUM=NUM+1                  00015200
  ZNUM=NUM                                     00015210
  BRNCST=ZNUM*10000.                           00015220
  IF(NUM.GT.8) WRITE(6,34) NUM                00015230
34 FORMAT(2X,'HEAT LOAD IS TOO LARGE FOR BURNER SYSTEMS'/I5,' BURNERS' 00015240
  1RS ARE REQUIRED')
  GOTO 40                                     00015250
10 CONTINUE                                    00015260
C TWO FUEL BURNERS REQUIRED                  00015270
C
  HTFLCB=ZFLHT*MASSFL/2.                      00015280
  IF(HTFLCB.GT.1.5E6) GOTO 21                 00015290
C FOR SMALL BURNERS ($1,200. DOLLARS EACH FOR 1.5E6 MAX BTU/HR HT RATE 00015320
  ZNUM=HTFLCB/1.2E6*2                         00015330
  NUM=ZNUM                                     00015340
  IF(ZNUM.GT.NUM) NUM=NUM+1                  00015350
  ZNUM=NUM                                     00015360
  BRNCST=ZNUM*1200.00                         00015370
  GOTO 40                                     00015380
21 IF(HTFLCB.GT.5.0E6) GOTO 32               00015390
  ZNUM=HTFLCB/4.0E6*2.                         00015400
  NUM=ZNUM                                     00015410
  IF(ZNUM.GT.NUM) NUM=NUM+1                  00015420
  ZNUM=NUM                                     00015430
  BRNCST=ZNUM*5000.0                          00015440
  GOTO 40                                     00015450
32 ZNUM=HTFLCB/10.0E6*2.                      00015460
  NUM=ZNUM                                     00015470
  IF(ZNUM.GT.NUM) NUM=NUM+1                  00015480
  IF(NUM.GT.8) WRITE(6,31) NUM                00015490
31 FORMAT('HEAT LOAD IS TOO LARGE FOR BURNER SYSTEMS'/I5,' BURNERS' 00015500
  1 ARE REQUIRED')
  40 CONTINUE                                    00015510
C
  IF(.NOT.BRN) GOTO 60                         00015520
  IF(III.NE.1) GOTO 60                         00015530
C WASTE FUEL BURNER SELECTION                00015540
C
  HTWSCB=ZSLHT*MASSSL                         00015550
  IF(HTWSCB.LT.2.30E7) GOTO 50                 00015560
  BRNSCT=HTWSCB*3.248E-4+30029.6             00015570
  GOTO 60                                     00015580
50 BRNSCT=HTWSCB*5E-4+26000.                   00015590
60 CONTINUE                                    00015600
  TBRNTT=(BRNSCT+BRNCST)/344.9*FACPVF        00015610
  IF(IDEBUG.LT.25) GOTO 70
    WRITE(6,100) ZSLHT,HTWSCB,BRNSCT,ZFLHT,HTFLCB,BRNCST,NUM      00015620
100 FORMAT(10X,'DATA USED IN SUBROUTINE BURNER'//10X,'SLUDGE ',     00015630
  1'BURNER CALCULATIONS'// 1X,'SLUDGE HEAT OF COMBUSTION(BTU/LB)=', 00015640
  2E15.3,'TOTAL SLUDGE HEAT LOAD(BTU/HR)= ',E15.3//1X,'COST OF ',   00015650
  3'SLUDGE BURNER SYSTEM (JUNE 1981 DOLLARS)= ',E15.2//10X,       00015660
  4'FUEL BURNER CALCULATIONS'// 1X,'FUEL HEAT OF COMBUSTION (BTU/LB)=',00015670
  5,E15.2,'TOTAL HEAT LOAD (BTU/HR)= ',E15.3//1X,'COST OF FUEL BURNER'00015680
  6,' SYSTEM (JUNE 1981 DOLLARS)= ',E15.2,'NUMBER OF NOZZLES USED FOR'00015690
  7','FUEL COMBUSITON= ',I2)                    00015700
70 CONTINUE                                    00015710
  NUMBRN=NUM                                     00015720
  RETURN                                         00015730
  END                                            00015740
  SUBROUTINE QUENCH(NREAC,NPRD)                 00015750
  REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD      00015760
  1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00015770
  LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00015780
  1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP,00015790
  2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00015800

```

```

4,CUTVN,CMBST,TCH          00015850
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00015860
  CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5      00015870
  1,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2    00015880
  2,SCRNME*20                00015890
  COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL,      00015900
  1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP     00015910
  2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9)       00015920
  COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL      00015930
  1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00015940
  COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC   00015950
  1,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS    00015960
  2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST  00015970
  3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN   00015980
  COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STMCST,DCTCST(9)        00015990
  1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9)         00016000
  COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTEBC,DPTD00016010
  1,AOP,WATRAT,TOTDP,NTU,AQ,CSTSTD,ASHGAS,PERUPT,FEDRG2,DIAPT(100)  00016020
  2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME               00016030
  3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DFH20,VAPNO      00016040
  COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK    00016050
  1,DCTTST,CSTMTB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST   00016060
  2,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT00016070
  3,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,             00016080
  4,TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR,                      00016090
  5,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,   00016100
  6,EQVCP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK                     00016110
  COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB               00016120
  1,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS                   00016130
  COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP        00016140
  COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9)              00016150
  COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,UPIK,IYEAR,NUMBRN,NPRTS  00016160
  COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00016170
  1,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK               00016180
  2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)                      00016190
  COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00016200
  1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00016210
  2,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00016220
  3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00016230
  DO 10 I=1,NPRD          00016240
    MLPRDT(I,III)=MLPRDT(I,III-1)                                00016250
10 CONTINUE                00016260
  MASSFL=0.0                00016270
  AASH=ASH                  00016280
  VVOLIT=VOLIT              00016290
  FFREE=FREH20              00016300
  ASH=0.0                   00016310
  VOLIT=0.0                 00016320
  FREH20=0.0                 00016330
  IF(ENGL) CALL METRC(NREAC,NPRD)                               00016340
  CALL HTMSQ(NREAC,NPRD)                                         00016350
  FREH20=0.0                 00016360
  IF(METRIC) CALL ENG(NREAC,NPRD)                               00016370
  TVOL=T1                  00016380
  PVOL=PINC                00016390
  CALL VL RATE(TVOL,PVOL,NPRD)                                00016400
  FACLEN = 3.0           00016410
  VEL=10.0                 00016420
  C FEET / SECOND          00016430
    RHO=MSTOT(III)/VOLRAT(III)                                00016440
    ARRA=MSTOT(III)/RHO/VEL/3600.0                            00016450
    DIA(III)= (ARRA/3.1416*4.0)**(0.5)                         00016460
    INCLEN(III)= DIA(III)*FACLEN                           00016470
    DESVOL(III)= 3.1416*DIA(III)**2.0/4.0*INCLEN(III)        00016480
    IF(QTEMP.EQ.1.0) CSTQUE=0.235*VOLRAT(III)/60.0 + 43000.0 00016490
    IF(IDEBUG.EQ.100) WRITE(6,900) QTEMP,VOLRAT(III),CSTQUE 00016500
900 FORMAT(10X,'QTEMP=',F4.1,'VOLUME RATE(FT^3/HR)= ',E15.5) 00016510
  1 10X,'COST OF QUENCH CHAMBER= ',E15.5)                    00016520
    IF(QSAT.EQ.1.0) CSTQUE=0.220*VOLRAT(III)/60.0 + 8000.0 00016530
    IF(T1.GT.600.0.AND.CS) CALL BLOCK(NREAC,NPRD)            00016540
    IF(T1.GT.900.0.AND.SS) CALL BLOCK(NREAC,NPRD)            00016550
    IF(T1.GT.1100.0.AND.IC) CALL BLOCK(NREAC,NPRD)           00016560

```

```

ASH=AASH                                00016570
VOLIT=VVOLIT                            00016580
FREH2O=FFREE                            00016590
CSTQUE=CSTQUE/308.4*FACCES              00016600
CSTIIN=CSTIIN+CSTQUE*0.67                00016610
PEXT= PEXT- PRESSR(MSTOT(III),RHO,DIA(III),INCLEN(III)) 00016620
WRITE(6,400)                             00016630
400 FORMAT('1',25X,'QUENCH CHAMBER DESIGN SPECIFICATIONS///') 00016640
WRITE(6,401) T2,DIA(III),INCLEN(III),H2OM,VAPNO 00016650
401 FORMAT(10X,'QUENCH TEMPERATURE = ',F6.1,' FAHRENHEIT'/
1 10X,'QUENCH DIAMETER = ',2X,F7.1,' FEET'/
2 10X,'QUENCH LENGTH = ',2X,F7.1,' FEET'/
3 10X,'WATER RATE = ',2X,E10.3,' LB/HR'/
4 10X,'WATER OUT = ',2X,E10.3,' LB/HR'/
1 10X,'OPTIONS IN EFFECT'/
IF(IC) WRITE(6,300)                      00016720
300 FORMAT(15X,'INCONEL WAS SELECTED AS THE MATERIAL OF CONSTRUCTION') 00016730
IF(SS) WRITE(6,301)                      00016740
IF(CS) WRITE(6,302)                      00016750
301 FORMAT(15X,'STAINLESS STEEL WAS SELECTED AS THE MATERIAL OF '.
1 'CONSTRUCTION.')                      00016760
1 IF(T2.GT.600.0.AND.CS) WRITE(6,304) (BNMIN(I),I=1,6),THCKIN,(BNMF00016780
1 (I),I=1,6),REFINS                   00016790
1 IF(T2.GT.900.0.AND.SS) WRITE(6,304) (BNMIN(I),I=1,6),THCKIN,(BNMF00016800
1 (I),I=1,6),REFINS                   00016810
1 IF(T2.GT.1100.0.AND.IC) WRITE(6,304) (BNMIN(I),I=1,6),THCKIN,(BNMF00016820
1 R(I),I=1,6),REFINS                   00016830
304 FORMAT(15X,'REFRACTORY SELECTED FOR QUENCH = ',6(A4),' THICKNESS ' 00016840
1 , '=' ,F3.1/15X,'INSULATION SELECTED FOR QUENCH = ',6(A4).      00016850
2 ' THICKNESS = ',F3.1)                 00016860
302 FORMAT(15X,'CARBON STEEL WAS SELECTED AS THE MATERIAL OF '.
1 'CONSTRUCTION')                      00016870
1 IF(QTEMP.EQ.1) WRITE(6,402)             00016880
402 FORMAT(15X,'QUENCH CHAMBER DESIGNED FOR SPECIFIC OUTLET'.
1 ' TEMPERATURE')                      00016900
1 IF(QSAT.EQ.1) WRITE(6,403)             00016910
403 FORMAT(15X,'QUENCH CHAMBER DESIGNED TO COOL GAS TO SATURATED'.
1 ' TEMPERATURE')                      00016930
1 IF(NUNIT.NE.III) FLGPAS=.TRUE.        00016940
TOTMAN=TOTMAN+CSTQUE*0.10                00016960
TOTELC=TOTELC+0.746*DAY*YEAR*0.036*H2OM/62.4/35.45*264.35 00016970
RETURN                                     00016980
END                                         00016990
SUBROUTINE HTEXCH(NREAC,NPRD)            00017000
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00017010
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00017020
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00017030
1 .IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DS5,DCS,DWC,AUTODP. 00017040
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00017050
4,CUTVN,CMBST,TCH                         00017060
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00017070
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00017080
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00017090
2 ,SCRNME*20                               00017100
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL. 00017110
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00017120
2 ,VOLIT,ASH,FREH2O,HTCNT,FULC,FEED(15),TA,DELTAH,ZLF2(9.9) 00017130
COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00017140
1 ,VISCG,EFFABS,TOCOST,CONST(7.8),SLPABS,PAKRAG(7.4),Z,CSTINS,TBRNTT00017150
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00017160
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00017170
2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00017180
3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00017190
COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STM CST,DCTCST(9) 00017200
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00017210
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPECST,CSTEBC,DPTOT00017220
1 ,AOP,WATRAT,TOTDP,NTU,ADQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00017230
2 ,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME           00017240
3 ,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00017250
COMMON/OUTPUT/ AFTING,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00017260
1 ,DCTTST,CSTMTB,CSTSIT,CSTSTC,CSTM,CSTCNT,PREXTI,SKRCST 00017270
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT00017280

```

```

3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,          00017290
4 TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR,                      00017300
5 TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,   00017310
6 EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK                  00017320
    COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB           00017330
1. FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS                 00017340
    COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP      00017350
    COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9)            00017360
    COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,UPIK,IYEAR,NUMBRN,NPRTS 00017370
    COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00017380
1,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK             00017390
2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)                      00017400
    COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRIOOO17410
1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00017420
2,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00017430
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00017440
    PSTM=185.0
    DO 20 I=1,NPRD
        MLPRTD(I,III)=MLPRTD(I,III-1)
20 CONTINUE
    IF(ENGL) CALL METRC(NREAC,NPRD)                           00017450
    CALL DTHEAT(NPRD)                                         00017460
    IF(METRIC) CALL ENG(NREAC,NPRD)                           00017470
C     BOILER STEAM CHARACTERISTICS
C         P=150 PSIA                                         00017530
C         T=366.0 FAHRENHEIT                                00017540
C         DH(VAP)= 857.4 BTU/LB                            00017550
C
C STMRT= -DELTAH/857.41                                     00017560
C STMREC=STMCAST*STMRT*0.80                                 00017570
C TVOL=60.0                                                 00017580
C PVOL=14.696                                              00017590
C CALL VLRATE(TVOL,PVOL,NPRD)                             00017600
C IF(HM2) GOTO 30                                         00017610
C AR=ABS(DELTAH/HTC/(T2-T1))                            00017620
33 CONTINUE
    CSTMTR=(28800.*AR**(-0.440))*EXP(0.0672*LOG(AR)**2.0) 00017630
    IF(AR.LT.200.0.AND.AR.GT.50000.0) WRITE(6,303) AR       00017640
303 FORMAT(10X,'**ERROR- AREA MUST RANGE BETWEEN 200 AND 50000
1 SQUARE FEET FOR CALCULATION ACCURACY.'/10X,'AREA USED IS',F9.1, 00017650
2 'FT**2')
    IF(IDEBUG.GT.1) WRITE(6,10) STMRT,STMREC,CSTMTR        00017660
10 FORMAT(10X,'RATE OF STEAM FORMATION (GRAMS/HR)',E15.5/10X, 00017710
1'REVENUE FROM RECOVERED STEAM ($/HR WITH 80% EFFICIENCY)',F7.2, 00017720
2/10X,'HEAT EXCHANGER COST(U.S. DOLLARS)',F12.2)        00017730
    IF(METRIC) CALL ENG(NREAC,NPRD)                         00017740
    IF(IC) CSTMTR=CSTMTR*3.0                               00017750
    IF(T2.GT.800.0) CSTMTR=CSTMTR*1.2                     00017760
    CSTMTR=CSTMTR/308.4*FACCES                           00017770
    IF(NUNIT.NE.III) FLGPAS=.TRUE. .
        PEXT=PINC-0.872*(ABS(DELTAH/HTCOMB)*100.0)-1.920 00017780
        IF(PEXT.GT.PINC) PEXT=PINC - 2.0/12.0/33.9*14.696 00017790
        WRITE(6,400)                                         00017810
400 FORMAT(30X,'HEAT RECOVERY SYSTEM DESIGN')
        WRITE(6,402) STMRT,STMREC                          00017820
402 FORMAT(10X,'CHARACTERISTICS OF STEAM PRODUCED'
1 15X,'PRESSURE OF STEAM FORMED=          185. PSIA '/ 00017830
2 15X,'QUANTITY OF STEAM PRODUCED = ',9X,F12.0,' LB/HR' / 00017840
3 15X,'COST RECOVERED FROM STEAM PRODUCTION = ',F12.2,' U.S. ', 00017850
4 ' DOLLARS/HR'/10X,'MATERIALS OF CONSTRUCTION')
    IF(IC) WRITE(6,500)                                     00017860
500 FORMAT(15X,'MATERIAL OF CONSTRUCTION IS INCONEL')      00017870
    IF(T2.GT.800.0) WRITE(6,501)                         00017880
501 FORMAT(15X,'DESIGN IS FOR HIGH TEMPERATURE PERFORMANCE')
    GOTO 31
30 AR=ABS(DELTAH/HTC/(T2-T1))                           00017890
    CB=EXP(8.551 - 0.30863 * LOG(AR) + 0.06811 * LOG(AR)**2.0) 00017900
    IF(FXH) FD=EXP(-1.1156 + 0.0906 * LOG(AR))           00017910
    IF(KRB) FD=1.35                                         00017920
    IF(UTB) FD=EXP(-0.9816 + 0.0830 * LOG(AR))           00017930
    IF(PSTM.GE.100.0.AND.PSTM.LE.300.0) FP=0.7771+0.04981*LOG(AR) 00017940
    IF(PSTM.GT.300.0.AND.PSTM.LE.600.0) FP=1.0305+0.07140*LOG(AR) 00017950

```

```

IF(PSTM.GT.600.0.AND.PSTM.LE.900.0) FP=1.1400+0.12088*LOG(AR)      00018010
IF(PSTM.GE.100.0.OR.PSTM.LE.900.0) GOTO 34                           00018020
IF(PSTM.LT.100.0) WRITE(6,301) PSTM                                 00018030
301 FORMAT(10X,'PRESSURE OF HEAT EXCHANGER IS TOO SMALL FOR ESTIMATION') 00018040
   1 AT ',F10.3,'PSIA. METHOD 1 IS USED'                                00018050
   IF(PSTM.GT.900.0) WRITE(6,302) PSTM                                 00018060
302 FORMAT(10X,'PRESSURE OF HEAT EXCHANGER IS TOO LARGE FOR ESTIMATION') 00018070
   1 AT ',F10.3,'PSIA. METHOD 1 IS USED'                                00018080
   34 IF(AR.LT.150.0.AND.AR.GT.12000.0) WRITE(6,304) AR                  00018090
304 FORMAT(10X,'AREA OF HEAT TRANSFER(,F7.1,' FT*2) IS OUT OF RANGE' 00018100
   1/10X,'METHOD 1 IS USED')                                         00018110
   IF(AR.LT.150.0.AND.AR.GT.12000.0) GOTO 33                         00018120
   IF(.NOT.S316) GOTO 600                                           00018130
      G1=0.8608                                         00018140
      G2=0.23296                                         00018150
600 IF(.NOT.S304) GOTO 601                                         00018160
      G1=0.8193                                         00018170
      G2=0.15984                                         00018180
601 IF(.NOT.S347) GOTO 602                                         00018190
      G1=0.6116                                         00018200
      G2=0.22186                                         00018210
602 IF(.NOT.NI200) GOTO 603                                         00018220
      G1=1.5092                                         00018230
      G2=0.60859                                         00018240
603 IF(.NOT.MD400) GOTO 604                                         00018250
      G1=1.2989                                         00018260
      G2=0.43377                                         00018270
604 IF(.NOT.IN600) GOTO 605                                         00018280
      G1=1.2040                                         00018290
      G2=0.50764                                         00018300
605 IF(.NOT.IN825) GOTO 606                                         00018310
      G1=1.1854                                         00018320
      G2=0.49706                                         00018330
606 IF(.NOT.TI) GOTO 607                                         00018340
      G1=1.5420                                         00018350
      G2=0.42913                                         00018360
607 IF(.NOT.HS) GOTO 608                                         00018370
      G1=0.1549                                         00018380
      G2=1.51774                                         00018390
608 CONTINUE                                         00018400
   FM=G1+G2*(LOG(AR))                                         00018410
   CSTHTR=(CB*FD*FP*FM)*FACCES/332.3                         00018420
   CSTIIN=CSTIIN+CSTHTR*1.00                                     00018430
   WTRTOT=WTRTOT+STMRT                                         00018440
   TOTMAN=TOTMAN+CSTHTR*0.10                                     00018450
31 RETURN                                         00018460
END                                         00018470
SUBROUTINE VENTUR(NREAC,NPRD)                                         00018480
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD                00018490
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS        00018500
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI    00018510
1 .IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00018520
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD  00018530
4,CUTVN,CMBST,TCH                                         00018540
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00018550
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNM*5       00018560
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2  00018570
2 ,SCRNME*20                                         00018580
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL,    00018590
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP  00018600
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9)    00018610
COMMON/PCKBED/ PSIZE(7),PCKSZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL     00018620
1 ,VISCG,EFFABS,TOCOST,CONST(7.8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT 00018630
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC  00018640
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00018650
2 ,HTCOMB,AREA(9),VOLRAT(9),REPCT,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00018660
3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00018670
COMMON/COST/ SHLCST,DRV CST,BRKTO T,ASHCST,STMCST,DCTCST(9)      00018680
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9)       00018690
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTO 00018700
1 ,AOP,WATRAT,TOTDP,NTU,AQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00018710
2 ,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLM               00018720

```

```

3.QSAT, VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO      00018730
  COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK      00018740
  1 ,DCTTST,CSTMTC,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST      00018750
  2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPP,CSTCRT,CSTENG,DCDIA(9),CSTINT00018760
  3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,                00018770
  4 ,TOTECL,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR,                         00018780
  5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,       00018790
  6 ,EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK                      00018800
  COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB                  00018810
  1 ,FACPVF,FACPFC,FACPI,FACENG,FACLAB,FACPRS                      00018820
  COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP               00018830
  COMMON/DCT/ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9)                     00018840
  COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS      00018850
  COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11)     00018860
  1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK                   00018870
  2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)                           00018880
  COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00018890
  1 ,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00018900
  2 ,SLD,SCRW,VEAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN    00018910
  3 ,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI.HS.UTB,HM1,HM2  00018920
  C
  ICONV=0                                         00018930
  PSTPAT=0.0                                      00018940
  FFF=0                                         00018950
  FF=1                                         00018960
  DO 30 I=1,NPRD                                 00018970
    MLPRT(I,III)=MLPRT(I,III-1)                 00018980
  30 CONTINUE                                     00018990
    CALL VL RATE(T2,PINC,NPRD)                  00019000
    IF(.NOT.(PRI.AND.CUTVN)) GOTO 60           00019010
  VENDP=20.0                                      00019020
  20 VENREM=0.0                                    00019030
  VENBEF=0.0                                      00019040
  DO 10 I=1,NPRTS                                00019050
    VEN1=ASHGAS*WTPRT(I)                        00019060
    VEN2=(1.0-WTPRT(DIAPT(I),VENDP))          00019070
    VEN3=VEN2*VEN1                               00019080
    VENREM=VENREM+VEN3                          00019090
    VENBEF=VENBEF+VEN1                          00019100
    IF(IDEBUG.GE.25) WRITE(6,29) VENDP          00019110
  29 FORMAT(20X,'PRESSURE DROP = ',F10.4)        00019120
  10 CONTINUE                                     00019130
    PREPAT=ASHGAS/VOLRAT(III)                  00019140
    PSTPAT=VENREM/VOLRAT(III)                  00019150
    IF(PSTPAT.GT.FEDRG2) VENDP=VENDP+10.0      00019160
    IF(VENDP.GT.100) GOTO 61                   00019170
    IF(PSTPAT.GT.FEDRG2) GOTO 20               00019180
    DPTOT=VENDP                                 00019190
    IF(METRIC) CALL ENG(NREAC,NPRD)            00019200
    DO 200 I=1,NPRD                            00019210
      MLPRT(I,III)=MLPRT(I,III-1)              00019220
  200 CONTINUE                                     00019230
    60 VOLUME=VOLRAT(III)/60.0/1000.0          00019240
    IF(.NOT.CUTVN) GOTO 61                     00019250
    VENDP=20.0                                    00019260
  420 VENREM=0.0                                  00019270
  VENBEF=0.0                                      00019280
  CTDI=LOG(VENDP) * (-0.519) +(-.856)         00019290
  CTDI=EXP(CTDI)                                00019300
  A=2.00                                         00019310
  C=0.50/EXP(A*CTDI**2.0)                      00019320
  DO 410 I=1,NPRTS                            00019330
    PT=C*EXP(2.0*DIAPT(I))                    00019340
    VENBEF=ASHGAS*WTPRT(I)+VENBEF             00019350
    VENREM=ASHGAS*WTPRT(I)*PT+VENREM          00019360
    IF(IDEBUG.EQ.25) WRITE(6,29) VENDP          00019370
  410 CONTINUE                                     00019380
    PREPAT=ASHGAS/VOLRAT(III)                  00019390
    PSTPAT=VENREM/VOLRAT(III)                  00019400
    IF(PSTPAT.GT.FEDRG2) VENDP=VENDP+1.0      00019410
    IF(VENDP.GT.100) GOTO 61                   00019420
    IF(PSTPAT.GT.FEDRG2) GOTO 420             00019430
  
```

```

      DPTOT=VENDP          00019450
  61 CONTINUE          00019460
 300 FORMAT(10X,'VOLUME RATE (FT^3/MIN/1000)= ',10X,E15.5/10X,    00019470
   1 'VOLUME RATE (FT^3/HR) = ',10X,E15.5/10X,'VENTURI COST= ',    00019480
   2 10X,F12.0,'1979 DOLLARS')
   CSTVEN=7117.0+408.*VOLUME-0.85*VOLUME**2.          00019500
   IF(IDEBUG.GE.25) WRITE(6,300) VOLUME,VOLRAT(III),CSTVEN    00019510
   BCONST=LOG(VOLUME) - 1.0*LOG(ABS(PINC/14.695*33.9*12.0    00019520
   1 - 33.9*12.0))          00019530
   IF(BCONST.GT.5.0) THCK=1./8.          00019540
   IF(BCONST.GT.3.0.AND.BCONST.LT.5.00) THCK=3.0/16.        00019550
   IF(BCONST.GT.2.9.AND.BCONST.LT.3.00) THCK=1./4.        00019560
   IF(BCONST.GT.2.48.AND.BCONST.LT.2.9) THCK=3./8.        00019570
   IF(BCONST.GT.2.3.AND.BCONST.LT.2.48) THCK=7./16.        00019580
   IF(BCONST.LT.2.3) THCK=1./2.          00019590
   IF(THCK.LT.0.25.AND.VOLUME.GT.100000.) VENFAC=5.8    00019600
   VVV=VOLRAT(III)/60.0/1000.0          00019610
   DO 600 IL=1,7          00019620
     ICONT= THICK(DPTOT,VVV,IL)          00019630
     IF(ICONT.LT.1) GOTO 600          00019640
     IF(IL.EQ.1) VNCST=1.0          00019650
     IF(IL.EQ.2) VNCST=-7.00E-3*VVV+1.57        00019660
     IF(IL.EQ.3) VNCST=-6.25E-3*VVV+1.9625        00019670
     IF(IL.EQ.4) VNCST=-0.0121*VVV+3.221        00019680
     IF(IL.EQ.5) VNCST=-0.0175*VVV+4.8255        00019690
     IF(IL.EQ.6) VNCST=-0.021*VVV+6.457        00019700
     IF(IL.EQ.7) VNCST=-0.003*VVV+8.3        00019710
     IF(IL.EQ.7.AND.VVV.GT.90.0) VNCST=5.6        00019720
     IF(IL.EQ.7.AND.VVV.GT.90.0) VNCST=5.6        00019730
     IF(IL.EQ.6.AND.VVV.GT.100.0) VNCST=4.75        00019740
     IF(IL.EQ.5.AND.VVV.GT.100.0) VNCST=3.4        00019750
     IF(IL.EQ.4.AND.VVV.GT.90.0) VNCST=2.2        00019760
     IF(IL.EQ.3.AND.VVV.GT.60.0) VNCST=1.6        00019770
     IF(IL.EQ.2.AND.VVV.GT.60.0) VNCST=1.2        00019780
     GOTO 601          00019790
 600 CONTINUE          00019800
 601 CSTVEN=CSTVEN*VNCST          00019810
   IF(IC) CSTVEN=CSTVEN*3.5          00019820
   IF(SS) CSTVEN=CSTVEN*3.2          00019830
   IF(VENAUT) CSTVEN=CSTVEN+6350.0        00019840
   IF(.NOT.VENAUT) CSTVEN=CSTVEN+3450.0        00019850
   IF(FG) CSTVEN=CSTVEN*1.15          00019860
   INCLEN(III)=8.0+0.250*VOLUME-0.00048*VOLUME**2.        00019870
   DIA(III)=5.0+0.11*VOLUME-0.00024*VOLUME**2.        00019880
   IF(NUNIT.NE.III) FLGPAS=.TRUE.        00019890
   VENH20=VENWAT*VOLRAT(III)/1000.0        00019900
 C LBH20/HR          00019910
   CSTIIN=CSTIIN+CSTVEN*.40          00019920
   CSTVEN=CSTVEN/308.4*FACCES        00019930
   WTRTOT=WTRTOT+VENH20*0.25        00019940
   TOTMAN=TOTMAN+CSTVEN*0.10        00019950
   GAL=VENH20/62.4/35.45*264.17        00019960
   WTRHP=0.036*GAL          00019970
   CSEL=WTRHP/0.80*0.746        00019980
   TOTELC=TOTELC+CSEL          00019990
   WRITE(6,501)          00020000
 501 FORMAT('1',30X,'VENTURI SCRUBBER DESIGN OUTPUT')        00020010
   WRITE(6,500) DPTOT,VENH20,THCK,FEDRG2,PSTPAT        00020020
 500 FORMAT(15X,'TOTAL PRESSURE DROP=      ,F10.0,' INCHES H2O')/ 00020030
   1 15X,'WATER FEED RATE=      ,E15.5,      'LB/HR'/ 00020040
   2 15X,'VENTURI SHELL THICKNESS=      ,F10.2,' INCHES'/ 00020050
   3 15X,'FEDERAL PARTICULATE LEVELS=      ,E15.5,'LB/ACF'/ 00020060
   4 15X,'CALCULATED EMISSION LEVELS=      ,E15.5,'LB/ACF') 00020070
   WRITE(6,320) INCLEN(III),DIA(III)        00020080
 320 FORMAT(15X,'LENGTH OF VENTURI SEPARATOR(FT)= ',F9.0,/ 00020090
   1 15X,'DIAMETER OF VENTURI SEPARATOR(FT)= ',F9.0)        00020100
   WRITE(6,503)          00020110
 503 FORMAT(15X,'OPTIONS SELECTED')        00020120
   IF(PRI) WRITE(6,504)        00020130
 504 FORMAT(20X,'PRESSURE DROP CALCULATED '/20X,'FROM EXPERIMENTAL DATA') 00020140
   1')          00020150
   IF(.NOT.PRI) WRITE(6,505)        00020160

```

```

505 FORMAT(20X,'PRESSURE DROP DIRECTLY SPECIFIED')
      IF(VENAUT) WRITE(6,506)                                00020170
506 FORMAT(20X,'AUTOMATIC THROAT CONTROL SPECIFIED')
      IF(.NOT.VENAUT) WRITE(6,507)                            00020180
507 FORMAT(20X,'MANUAL THROAT CONTROL SPECIFIED')
      IF(FG) WRITE(6,508)                                    00020190
508 FORMAT(20X,'THROAT LINED WITH FIBERGLASS')
      IF(IC) WRITE(6,509)                                    00020200
509 FORMAT(20X,'VENTURI CONSTRUCTED OF INCONEL')
      IF(SS) WRITE(6,510)                                    00020210
510 FORMAT(20X,'VENTURI SCRUBBER CONSTRUCTED OF STAINLESS STEEL')
      IF(CS) WRITE(6,511)                                    00020220
511 FORMAT(20X,'VENTURI SCRUBBER CONSTRUCTED OF CARBON STEEL')
      RETURN                                                 00020230
      END                                                   00020240
      SUBROUTINE INDFAN(NREAC,NPRD)
      REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD
      1 .XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS
      LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI
      1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP.
      2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD
      4,CUTVN,CMBST,TCH
      3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2
      LOGICAL ELC
      CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5
      1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2
      2 ,SCRNME*20
      COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL,
      1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP
      2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9)
      COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL
      1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT
      COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC
      1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS
      2,HTCOMB,AREA(9).VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST
      3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN
      COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STM CST,DCTCST(9)
      1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9)
      COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTOT
      1,AOP,WATRAT,TOTDP,NTU,ADQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100)
      2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME
      3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO
      COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK
      1 ,DCTTST,CSTM TB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST
      2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTS PR,CSTCRT,CSTENG,DCDIA(9),CSTINT
      3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,
      4 ,TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR,
      5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV.
      6 ,EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK
      COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB
      1 ,FACPVF,FACP C,FACPI,FACENG,FACLAB,FACP RS
      COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP
      COMMON/DCT/ ELBNU M(9),DCTLEN(9),DCTVEL(9),DIA(9)
      COMMON/INT/IDEBUG,NRES(8).NUNIT.III.NSET,UPIK,IYEAR,NUMBRN,NPRTS
      COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11)
      1,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK
      2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)
      COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI
      1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS
      2,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN
      3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2
      IF(METRIC) CALL ENG(NREAC,NPRD)
      ELC=.FALSE.
      DO 400 I=1,NPRD
        MLPRDT(I,III)=MLPRDT(I,III-1)
      400 CONTINUE
      PEXT=PIN C+TOTDP/12.0/33.9*14.696
      T2=(T1+459.6)*(PEXT/PINC)**((1.4-1.0)/1.4)-459.6
      TVOL=T2
      PVOL=PIN C
      IF(UNIT(III).NE.SUNIT(1)) CALL VL RATE(TVOL,PVOL,NPRD)
      BCRPM=-1.45E-3

```

```

CCRPM= 0.50          00020890
DPSTG= 20.0          00020900
NMSTM=1              00020910
VOLFAN=VOLRAT(III)/60.0 00020920
VOLFN=VOLFAN        00020930
30 CONTINUE          00020940
DO 63 I=1,9          00020950
  LGC=RPM(DPSTG,I,VOLFN) 00020960
  IF(LGC.LT.1) GOTO 65 00020970
    IF(I.EQ.9) RPMEST=300.0 00020980
    IF(I.EQ.8) RPMEST=500.0 00020990
    IF(I.EQ.7) RPMEST=750.0 00021000
    IF(I.EQ.6) RPMEST=1000.0 00021010
    IF(I.EQ.5) RPMEST=1500.0 00021020
    IF(I.EQ.4) RPMEST=2000.0 00021030
    IF(I.EQ.3) RPMEST=2500.0 00021040
    IF(I.EQ.2) RPMEST=3000.0 00021050
    IF(I.EQ.1) RPMEST=3500.0 00021060
  GOTO 64              00021070
65 CONTINUE          00021080
63 CONTINUE          00021090
  IF(RPMEST.GT.3600.0) DPSTG=DPSTG-1.0 00021100
  IF(RPMEST.LT.300.) GOTO 40 00021110
  WRITE(6,66)          00021120
66 FORMAT(10X,'**ERROR - AFTER 10 ITERATIONS, RPM'S WAS ',1
  'NOT SOLVED.')      00021130
  ELC=.TRUE.           00021140
64 CONTINUE          00021150
  IF(IDEBUG.GE.25) WRITE(6,603) VOLFAN,DPSTG,C1,RPMEST 00021160
603 FORMAT(10X,'VOLUME RATE OF FAN (FT**3/MIN/1000)= ',F10.2/
  110X,'PRESSURE CHANGE PER FAN STAGE (IN H2O)= ',F10.2/
  210X,'C1 CONSTANT=',F12.2/ 00021180
  310X,'ESTIMATE OF RPMS',F12.2) 00021190
  GOTO 50              00021200
40 NMSTM=NMSTM+1.0    00021220
  VOLFN=VOLFAN/NMSTM 00021230
  GOTO 30              00021240
50 NUMFAN=TOTDP/DPSTG 00021250
  IF(DPSTG.GT.2.5) GOTO 51 00021260
  FANCLS=1.0           00021270
  GOTO 56              00021280
51 IF(DPSTG.GT.4.25) GOTO 52 00021290
  FANCLS=2.0           00021300
  GOTO 56              00021310
52 IF(DPSTG.GT.6.75) GOTO 53 00021320
  FANCLS=3.0           00021330
  GOTO 56              00021340
53 FANCLS=4.0          00021350
56 CONTINUE          00021360
  IF(IDEBUG.GT.25) WRITE(6,350) RPMEST,C1,DPSTG,VOLFAN,NUMFAN 00021370
350 FORMAT(10X,'RPM ESTIMATE= ',F9.2,3X,'CONST 1= ',E15.5, 00021380
  1' PRESSURE DROP PER STAGE= ',E15.5,'IN H2O' 00021390
  2/ 10X,'VOLUME RATE PER FAN TRAIN',E15.5,' FT*3/HR' 00021400
  3, 'NUMBER OF FANS=',I3) 00021410
  IF(NUMFAN.GT.ABS(NUMFAN)) NUMFAN=NUMFAN+1 00021420
C   CALCULATE HORSEPOWER FOR INDUCTION 00021430
DO 60 ISTRM=1,10      00021440
  VOLFN=VOLRAT(III)/60.0 00021450
  VOLFN=VOLFAN/ISTRM 00021460
  NMSTM=ISTRM          00021470
  LGC=0                00021480
  DO 61 I=1,9          00021490
    LGC=FX4(DPSTG,I,VOLFN) 00021500
    IF(LGC.LT.1) GOTO 61 00021510
      IF(I.EQ.1) HPFAN=1.0 00021520
      IF(I.EQ.2) HPFAN=2.0 00021530
      IF(I.EQ.3) HPFAN=5.0 00021540
      IF(I.EQ.4) HPFAN=10.0 00021550
      IF(I.EQ.5) HPFAN=20.0 00021560
      IF(I.EQ.6) HPFAN=50.0 00021570
      IF(I.EQ.7) HPFAN=100.0 00021580
      IF(I.EQ.8) HPFAN=200.0 00021590

```

```

        IF(I.EQ.9) HPFAN=500.0          00021610
        GOTO 32                         00021620
61 CONTINUE                               00021630
60 CONTINUE                               00021640
        WRITE(6,62)                      00021650
62 FORMAT(10X,'**ERROR - AFTER 10 ITERATIONS HORSEPOWER WAS',
     1 ' NOT SOLVED')
32 CONTINUE                               00021660
        THPFAN=HPFAN*NSTM               00021670
        IF(HPFAN.GT.500.0) WRITE(6,100) HPFAN      00021680
100 FORMAT(10X,'HORSE POWER IS TOO LARGE AT ',F13.3,'HORSE POWER') 00021690
     GOTO 80                           00021700
70 CONTINUE                               00021710
        THPFAN=HPFAN*NSTM               00021720
        IF(HPFAN.GT.50.0) WRITE(6,110) HPFAN      00021730
110 FORMAT(10X,'HORSEPOWER IS TOO LARGE TOO BE USED BY THIS EQUATION') 00021740
C   SELECT MOTOR SIZE                  00021750
     80 IF(RPMEST.LT.4000.0) GOTO 310          00021760
        WRITE(6,200) RPMEST              00021770
200 FORMAT(10X,'RPM IS TOO HIGH AT ',E15.5) 00021780
310 IF(RPMEST.LT.2400.0) GOTO 320          00021790
     RPMEST=3600.0                      00021800
     GOTO 380                           00021810
320 IF(RPMEST.LT.1400.0) GOTO 330          00021820
     RPMEST=1800.0                      00021830
     GOTO 380                           00021840
330 IF(RPMEST.LT.1000.) GOTO 335          00021850
     RPMEST=900.0                      00021860
     GOTO 380                           00021870
335 IF(RPMEST.LT.400.) WRITE(6,340) RPMEST 00021880
340 FORMAT(10X,'RPM'S ARE TOO LOW AT ',F9.2,'SET TO 600 RPM'S) 00021890
380 CSTMOT=FANFXN(HPFAN,RPMEST)           00021900
     IF(IDEBUG.GE.25) WRITE(6,355) C2,HPFAN,RPMEST,CSTMOT 00021910
355 FORMAT(10X,'CONST 2= ',E15.5,'FAN HORSEPOWER= ',E15.5,'HP'/ 00021920
     110X,'RPM ESTIMATE= ',E15.5,' COST OF MOTOR= ',E15.5,'US DOLLARS') 00021930
     VOLFAN=VOLFAN/1000.0                 00021940
     C3=LOG(VOLFAN)-0.5012*LOG(DPSTG)       00021950
     IF(C3.LT.0.0) C3=0.0                  00021960
     DIAIMP=9.765 + 13.42*C3 - 3.490 * C3**2. + 1.34 * C3**3. 00021970
     IF(DIAIMP.GT.18.0) GOTO 205          00021980
     IF(FANCLS.EQ.1) CSTUF= 800.0          00021990
     IF(FANCLS.EQ.2) CSTUF= 1000.0          00022000
     IF(FANCLS.EQ.3) CSTUF= 1900.0          00022010
     IF(FANCLS.EQ.4) CSTUF= 2200.0          00022020
     DPRCST=(.39+.86)*1000.0             00022030
     GOTO 250                           00022040
205 IF(DIAIMP.GT.27.0) GOTO 210          00022050
     IF(FANCLS.EQ.1) CSTUF= 1500.0          00022060
     IF(FANCLS.EQ.2) CSTUF= 2000.0          00022070
     IF(FANCLS.EQ.3) CSTUF= 3500.0          00022080
     IF(FANCLS.EQ.4) CSTUF= 4000.0          00022090
     DPRCST=(0.5+1.)*1000.0             00022100
     GOTO 250                           00022110
210 IF(DIAIMP.GT.40.0) GOTO 220          00022120
     IF(FANCLS.EQ.1) CSTUF= 2800.0          00022130
     IF(FANCLS.EQ.2) CSTUF= 3700.0          00022140
     IF(FANCLS.EQ.3) CSTUF= 5800.0          00022150
     IF(FANCLS.EQ.4) CSTUF= 7000.0          00022160
     DPRCST=(0.87+1.5)*1000.0            00022170
     GOTO 250                           00022180
220 IF(DIAIMP.GT.60.0) GOTO 230          00022190
     IF(FANCLS.EQ.1) CSTUF= 6000.0          00022200
     IF(FANCLS.EQ.2) CSTUF= 6000.0          00022210
     IF(FANCLS.EQ.3) CSTUF=10200.0         00022220
     IF(FANCLS.EQ.4) CSTUF=10500.0         00022230
     DPRCST=(1.7+2.5)*1000.0            00022240
     GOTO 250                           00022250
230 IF(DIAIMP.GT.80.0) GOTO 240          00022260
     IF(FANCLS.EQ.1) CSTUF=10000.0         00022270
     IF(FANCLS.EQ.2) CSTUF=10400.0         00022280
     IF(FANCLS.EQ.3) CSTUF=20000.0         00022290
     IF(FANCLS.EQ.4) CSTUF=25000.0         00022300

```

```

      DPRCST=(1.8+4.1)*1000.0          00022330
      GOTO 250                         00022340
240 IF(DIAIMP.GT.98.0) GOTO 250      00022350
      IF(FANCLS.EQ.1) CSTUF=16000.0    00022360
      IF(FANCLS.EQ.2) CSTUF=20100.0    00022370
      IF(FANCLS.EQ.3) CSTUF=30000.0    00022380
      IF(FANCLS.EQ.4) CSTUF=38000.0    00022390
      DPRCST=(4.0+7.5)*1000.0        00022400
250 IF(T2.GT.250.0.AND.T2.LT.600.0) CSTUF=CSTUF*1.03 00022410
      IF(T2.GT.600.0) WRITE(6,358)    00022420
358 FORMAT(10X,'TEMPERATURE IS TOO HIGH FOR FANS')
      IF(SS) CSTUF=CSTUF*2.50        00022430
      IF(IC) CSTUF=CSTUF*3.0         00022440
      IF(IDEBUG.GE.25) WRITE(6,357)   DIAIMP,C3,CSTUF,NUMFAN 00022450
357 FORMAT(10X,'DIAMETER OF IMPELLOR(IN)= ',F9.2,' CONST 3= ',E15.5 00022470
1/10X,'COST OF EACH FAN= ',F10.2,'US DOLLARS. THERE ARE',I2,'FANS' 00022480
2)
      CSTFAN=CSTFAN/226.70*FACCES*NSTM*NMFAN               00022490
      CSTMOT=CSTMOT/226.70*FACCES                         00022500
      DPRCST=DPRCST/226.70*FACPVF                         00022510
      CSTFAN= CSTUF*NMFAN*NSTM+(DPRCST+CSTMOT)*NSTM       00022520
      IF(NUNIT.NE.III) FLGPAS=.TRUE.                      00022530
      CSTINS=CSTINS+CSTFAN*0.50                          00022540
      WRITE(6,500)                                         00022550
500 FORMAT('1',30X,'INDUCED DRAFT FAN DESIGN//')        00022560
      WRITE(6,501) TOTDP                           00022570
501 FORMAT(10X,'TOTAL PRESSURE DROP(INCLUDING ADJUSTMENT FOR ', 00022580
1'ELEVATION) = ',F7.2,' IN H2O')
      WRITE(6,800) ELEVAT                         00022590
800 FORMAT(10X,'ELEVATION OF FACILITY=           ',F7.0,' FEET') 00022600
      WRITE(6,502) DPSTG                           00022610
502 FORMAT(10X,'PRESSURE DROP PER STAGE = ',F7.2,' IN H2O') 00022620
      WRITE(6,503) VOLFAN                         00022630
503 FORMAT(10X,'VOLUME RATE PER PARALLEL FEED = ',F7.2,'FT**3/MIN', 00022640
1'1000')
      WRITE(6,504) NUMFAN                         00022650
504 FORMAT(10X,'NUMBER OF FANS PER STAGE = ',I3)        00022660
      WRITE(6,505) RPMEST                         00022670
505 FORMAT(10X,'MOTOR RPM'S = ',F9.2)                 00022680
      WRITE(6,506) THPFAN                         00022690
      WRITE(6,512) NSTM                           00022700
512 FORMAT(10X,'NUMBER OF INLET STREAMS=',I3)        00022710
506 FORMAT(10X,'TOTAL HORSEPOWER REQUIRED TO COMPRESS GAS = ',F10.2, 00022720
1' HP')
      WRITE(6,507) DIAIMP                         00022730
507 FORMAT(10X,'DIAMETER OF IMPELLOR = ',F7.0,' INCHES ')
      WRITE(6,611)                               00022740
611 FORMAT(10X,'OPTIONS SELECTED')
      IF(IC) WRITE(6,508)                         00022750
508 FORMAT(15X,'MATERIAL OF CONSTRUCTION FOR FANS IS INCONEL ')
      IF(SS) WRITE(6,509)                         00022760
509 FORMAT(15X,'MATERIAL OF CONSTRUCTION OF THE FANS IS STAINLESS'.
1 ' STEEL')
      IF(CS) WRITE(6,600)                         00022770
600 FORMAT(15X,'MATERIAL OF CONSTRUCTION OF THE FANS IS CARBON',
1 ' STEEL')
      WRITE(6,804)                               00022780
804 FORMAT(15X,'CLASS 4 FANS ARE SPECIFIED(HIGH PERFORMANCE)') 00022790
      CSTUFF=CSTUF*NMFAN*NSTM                     00022800
      IF(IDEBUG.GE.25) WRITE(6,806) CSTUFF,DPRCST,CSTMOT,CSTFAN 00022810
806 FORMAT(//29X,'COST OF INDUCTION FANS'
1 15X,'COST OF FANS=      ',F10.0,' U.S. DOLLARS'
2 15X,'COST OF DAMPERS=   ',F10.0,' U.S. DOLLARS'
3 15X,'COST OF MOTORS=   ',F10.0,' U.S. DOLLARS'
4 15X,'-----'
5 15X,'TOTAL INDUCTION FAN COST= ',F8.0,' U.S. DOLLARS')
      CSTIIN=CSTIIN+CSTFAN*0.50                    00022820
      TOTELC=TOTELC+(THPFAN/0.80*0.746+0.746*0.0/0.80)*DAY*YEAR 00022830
      TOTMAN=TOTMAN+CSTFAN*0.10                   00022840
      RETURN
      END
      SUBROUTINE PCKBD(NREAC,NPRD)                00022850

```

```

REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP,
2 ,SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD
4,CUTVN,CMBST,TCH
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2
LOGICAL FLAG
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2
2 ,SCRNME*20
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL,
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9)
COMMON/PCKBED/ PSIZE(7),PKCSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00023200
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC
1 ,BCOST(8),TLIM(8).ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST
3,INCLEN(9),MSTOT(9),MLPRDT(15.9).PINC,PEXT,WTRTOT,FLTOT,TOTMAN
COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STM CST,DCTCST(9)
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9)
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTELC,DPT00023270
1,AOP,WATRAT,TOTDP,NTU,AOQ,CSTSTD,ASHGAS,PERUPT,FEDRG2,DIAPT(100)
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME
3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK
1 ,DCTTST,CSTM TB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST
2 ,CSTIIN,EXTRA1,CSTSTR,CSTCSR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT00023330
3 ,DSDIA(9),CSTL0D,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,
4 ,TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR,
5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,
6 ,EQVCP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK
COMMON/UPDATE/ FACES,FACMSC,FACCEE,FACCEF,FACCEB
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP
COMMON/DCT/ ELBNU(9),DCTLEN(9),DCTVEL(9),DIA(9)
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBERN,NPRTS
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11)
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00023460
1 ,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00023470
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2
JPIK=0
IDEBUG=26
DO 30 I=1,NPRD
    MLPRDT(I,III)=MLPRDT(I,III-1)
30 CONTINUE
NPSTM=1
GC= 32.174
COSTP=0.0
    DO 10 I=1,7
        IF(PCKCHS(1).NE.PCKNAM(I,1)) GOTO 10
            IF(PSIZE(I).GT.PKCSIZ) COSTP=CSTPK(I)
                JPIK=I
                IF(COSTP.GT.0.01) GOTO 20
10 CONTINUE
20 CONTINUE
COSTP=CSTPK(2)
IF(JPIK.LE.4) FLAG=.TRUE.
PAKFAC = FXPACK(PKCSIZ,FLAG)
IF(METRIC) CALL ENG(NREAC,NPRD)
DO 200 I=1,NPRD
    MLPRDT(I,III)=MLPRDT(I,III-1)
200 CONTINUE
CALL VL RATE(60.0,PINC,NPRD)
GSMS=MSTOT(III)
PAKH20=VOLRAT(III)*35.45*62.4/264.35*WATRAT/1000.0
RHO= MSTOT(III)/VOLRAT(III)

```

```

RHOL= 62.4 00023770
FLOLIQ=(PAKH20/MSTOT(III))*(RHO/RHOL)**0.5 00023780
VISCL=0.1167*(RHOL*0.1603)**(0.5) *10.**0.552*(1.-(T2+460.)) 00023790
1/1165.3))/((T2+459.0)/1165.3) 00023800
TPFXN=1.058*((T2+460.)/1165.5)**0.645-0.261/((1.9*(T2+460.)/1165.3)) 00023810
1)**(0.9*2.3*LOG(1.9*(T2+460.)/1165.3)) 00023820
VISCG=33.3*(18.011*647.5)**0.5/56.0**0.667*TPFXN 00023830
VISCG=VISCG*1E-4*2.42 00023840
700 DIAMTR=PAKDIA(VISCL,RHOL,RHO,PAKFAC,GSMS,PAKH20)/EFFABS*100.0 00023850
DIAMTR=DIAMTR*12.0 00023860
IF(DIAMTR.GT.100.0) GOTO 500 00023870
IF(DIAMTR.LT.6.0) DIAMTR=6.0 00023880
GOTO 505 00023890
500 WRITE(6,600) DIAMTR 00023900
600 FORMAT(10X,'THE DIAMETER OF THE PACKED BED IS TOO LARGE', 00023910
1 'FOR COST CALCULATIONS'/10X,'DIAMETER(IN)= ',F10.0, 00023920
2 'NUMBER OF INLET STREAMS INCREASED BY ONE') 00023930
NPSTM=NPSTM+1 00023940
GSMS=GSMS/NPSTM 00023950
PAKH20=VOLRAT(III)/NPSTM*35.45*62.4/264.35*WATRAT/1000.0 00023960
GOTO 700 00023970
505 AREA(III)=3.1416*(DIAMTR/12.0)**2.0/4.0 00023980
GMASS=MSTOT(III)/AREA(III) 00023990
IF(IDEBUG.GE.25) 00024000
1 WRITE(6,234) GMASS,RHO,RHOL,PAKFAC,VISCL,EFFABS,DIAMTR 00024010
234 FORMAT(10X,'GMASS= ',E15.5,'RHO= ',E15.5/ 00024020
1 'RHOL= ',E15.5,'PAKFAC= ',E15.5,'VISCL= ',E15.5/ 00024030
2 'EFFABS= ',E15.5,'DIAMTR= ',E15.5) 00024040
CALL NNTU 00024050
IF(Z.LT.10.0) Z=10.0 00024060
IF(Z.GT.100.0) Z=100.0 00024070
PVV=(DIAMTR/12.0)**2.0*3.14/4.00*Z 00024080
CPAK=0.0 00024090
CPAK=CDSTP*PVV*FACCES/100.0 00024100
CINSTL=FX3(DIAMTR)*FACCES/100.0 00024110
WRITE(6,710) CINSTL,CPAK,CSTPAK 00024111
710 FORMAT(10X,'COST OF ABSORBER COLUMN = ',F12.2/ 00024112
1 10X,'COST OF ABORBER PACKING = ',F12.2/ 00024113
2 10X,'TOTAL ABSORBER COST = ',F12.2) 00024114
DIAMTR=DIAMTR/12.0 00024120
CSTPAK=(CINSTL*Z+CPAK)*NPSTM 00024130
DP(III)=CONST(JPIK,6)*1.0E-08*10.**((CONST(JPIK,8)*PAKH20/AREA(III)) 00024140
1/RHOL)*(GMASS*3600.0)**2.0/RHO*NTU 00024150
IF(NUNIT.NE.III) FLGPAS=.TRUE. 00024160
IF(METRIC) CALL ENG(NREAC,NPRD) 00024170
WTRTOT=WTRTOT+PAKH20*0.25 00024180
CSTIIN=CSTIIN+CSTPAK*0.50 00024190
CLMM=1.04*CLMS 00024200
WRITE(6,800) DIAMTR,Z,CSTPAK,PAKH20,AREA(III),NTU,CLMM 00024210
800 FORMAT('1',30X,'PACKED BED DESIGN PARAMETERS'/15X,'DIAMETER', 00024220
1 'OF COLUMN(FT)= ',F10.2,' TOTAL HEIGHT OF COLUMN(FT)= ', 00024230
2 F10.2 00024240
3 /15X,'CALCULATED COST OF COLUMN= ',F10.2,' U.S. DOLLARS' 00024250
4 15X,'CALCULATED FEED RATE= ',F10.2/ 00024260
5 15X,'AREA OF BED= ',F10.2,'FT**2' 00024270
6 15X,'NUMBER OF MASS TRANSFER UNITS= ',I9/ 00024280
7 15X,'AMOUNT OF LIME ADDED= ',F10.2,'LB/HR') 00024290
WRITE(6,678) 00024300
678 FORMAT(15X,'OPTIONS SELECTED') 00024310
WRITE(6,610) (PCKCHS(I),I=1,4),PCKSIZ 00024320
610 FORMAT(20X,'PACKING SELECTED IS ',4A4/20X,'PACKING SIZE IS ', 00024330
1 F4.1,' INCHES') 00024340
IF(IC) WRITE(6,570) 00024350
570 FORMAT(10X,'PACKED COLUMN IS CONSTRUCTED OF INCONEL') 00024360
IF(CS) WRITE(6,571) 00024370
571 FORMAT(10X,'PACKED COLUMN IS CONSTRUCTED OF CARBON STEEL') 00024380
MLPRDT(2,III)=MLPRDT(2,III)*(1.0-HCLRM/100.00) 00024390
CSTBAS=CSTLME/2000.0*CLMS*1.04 00024400
TOTMAN=TOTMAN+CSTPAK*0.05 00024410
WHP=0.036*PAKH20/62.4/35.45*264.17 00024420
TOTELC=TOTELC+0.746*WHP*DAY*YEAR 00024430
IDEBUG=0 00024440

```

```

RETURN                               00024450
END                                 00024460
SUBROUTINE NNTU                      00024470
  REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD      00024480
  1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00024490
  LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00024500
  1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP. 00024510
  2 ,SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00024520
  4,CUTVN,CMBST,TCH                         00024530
  3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00024540
  CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00024550
  1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00024560
  2 ,SCRNME*20                                00024570
  COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00024580
  1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00024590
  2 VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9) 00024600
  COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00024610
  1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT 00024620
  COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00024630
  1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00024640
  2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00024650
  3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PING,PEXT,WTRTOT,FLTOT,TOTMAN 00024660
  COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STM CST,DCTCST(9) 00024670
  1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00024680
  COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTO 00024690
  1,AOP,WATRAT,TOTDP,NTU,A00,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00024700
  2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00024710
  3,QSAT,VENH20,DAMPY(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00024720
  COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00024730
  1 ,DCTTST,CSTMTB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00024740
  2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT 00024750
  3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN. 00024760
  4 ,TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR. 00024770
  5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV. 00024780
  6 ,EQVCP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00024790
  COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEB 00024800
  1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00024810
  COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00024820
  COMMON/DCT/ EBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00024830
  COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00024840
  COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00024850
  1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00024860
  2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00024870
  COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00024880
  1 ,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS 00024890
  2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00024900
  3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00024910
  IF(IDEBUG.GE.25) WRITE(6,10) VISCL,VISCG,T2,MSTOT(III),AREA(III) 00024920
  10 FORMAT(10X,'LIQUID VISCOSITY( CP)= ',E15.5,' GAS VISCOSITY(LB',00024930
  1 '/FT/HR)= ',E15.5/10X,' TEMPERATURE ( F)= ',F9.2/10X,' MASS FLOW RATE 00024940
  2(LB/HR)= ',E15.5,' AREA(FT**2)= ',E15.5) 00024950
C   00024960
C   CHANGE VISCOSITY TO LB/HR/FT**2 00024970
  VISCL=VISCL*2.4191 00024980
  ACONST=VISCL/EXP(0.522/293.3) 00024990
  VISCOR=ACONST*EXP((0.522/((T2-32.0)/1.8+273.96))/VISCL) 00025000
  BCONST=VISCG/((T2+460.)**1.5/((T2+460.)*1.47*(672))) 00025010
  CORVIS=BCONST*((T2+460.)**1.5/((T2+460.)*1.47*672))/VISCG 00025020
  VELMSG=MSTOT(III)/AREA(III) 00025030
  VELMSL=PAKH20/AREA(III) 00025040
  HG=CONST(JPIK,1)*VELMSG**CONST(JPIK,2)/VELMSL**CONST(JPIK,3) 00025050
C   EQUATION 2-23MASS TRANSFER BY HINES 00025060
  HG=HG*(VISCL/RHOL/DFHCLL*VISCOR/((T2+460.0)/528.0)) 00025070
  SCMIDL=(VISCL/RHOL/DFHCLL*VISCOR/((T2+460.0)/528.0)) 00025080
  HL=CONST(JPIK,4)*(PAKH20/AREA(III)/VISCL)**CONST(JPIK,5)*SCMIDL 00025090
  1 **0.50 00025100
  HOG=HG+SLPABS*(TTL(III)/(PAKH20/18.011))*HL 00025110
  Z=HOG*NTU 00025120
  IF(IDEBUG.GE.25) WRITE(6,20) Z,HOG,NTU,HG,HL,SCMIDL,PAKH20,VELMSG,00025130
  1 VELMSL 00025140
  20 FORMAT(10X,'TOTAL HEIGHT OF BED(FT)= ',E15.5,' HEIGHT OF ',00025150
  1 'ONE TRANSFER UNIT(FT)= ',E15.5,' NUMBER OF TRANSFER' 00025160

```

```

1, ' UNITS= ', I5/                                00025170
110X,'HG= ',E15.5,'HL= ',E15.5,'SCHMIDT NUMBER= ',E15.5/    00025180
2 10X,'WATER RATE(LB/HR)= ',E15.5,'MASS VELOCITY GAS= ',E15.5,   00025190
3 'MASS VELOCITY LIQUID= ',E15.5)                00025200
IF(IDEBUG.GE.25)                                     00025210
1 WRITE(6,234) SLPABS,(CONST(JPIK,I),I=1,4),VISCOR,DFHCLL, DFHCLG 00025220
234 FORMAT(10X,'SLOPE OF EQUILIBRIUM CURVE= ',E15.5/          00025230
1 10X,'CONSTANTS OF EQUATIONS'/                  00025240
2 4(10X,E15.5/),10X,'VISCOR= ',E15.5,'DIFFUSION COEFFICIENTS', 00025250
3 ' FOR LIQUID AND GAS= ',2E15.5)                00025260
      RETURN                                         00025270
      END                                           00025280
      SUBROUTINE TRABED(NREAC,NPRD)                 00025290
      REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00025300
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00025310
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00025320
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00025330
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00025340
4,CUTVN,CMBST,TCH                                00025350
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825, TI,HS,UTB,HM1, HM2 00025360
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00025370
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00025380
2 ,SCRNME*20                                         00025390
      WRITE(6,10)                                     00025400
10 FORMAT(2X,'THIS SUBROUTINE (TRABED) IS NOT WORKING') 00025410
      RETURN                                         00025420
      END                                           00025430
      SUBROUTINE DUCT(NPRD)                          00025440
      REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00025450
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00025460
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00025470
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00025480
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00025490
4,CUTVN,CMBST,TCH                                00025500
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825, TI,HS,UTB,HM1, HM2 00025510
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00025520
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00025530
2 ,SCRNME*20                                         00025540
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00025550
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00025560
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9) 00025570
COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00025580
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNT 00025590
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00025600
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00025610
2,HTCOMB,AREA(9),VOLRAT(9),REP CST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00025620
3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00025630
COMMON/COST/ SHLCST,DRV CST, BRKTOT,ASHCST,STM CST,DCTCST(9) 00025640
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00025650
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTE LC,DPTO 00025660
1,AOP,WATRAT,TOTDP,NTU,AQ, C STSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00025670
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00025680
3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00025690
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00025700
1 ,DCTTST,CSTM TB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00025710
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTS PR,CSTCRT,CSTENG,DCDIA(9),CSTINT 00025720
3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN, 00025730
4 ,TOTE L,C TOH20,TT FUEL,TT WSTD,TT CAUS,TT OPR, 00025740
5 ,TOT TOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00025750
6 ,EQVCA P,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00025760
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB 00025770
1 ,FACP VF,FACP C,FACP I,FACENG,FAC LAB,FACP RS 00025780
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00025790
COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00025800
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPR TS 00025810
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00025820
1,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00025830
2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00025840
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00025850
1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS 00025860
2,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00025870
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825, TI,HS,UTB,HM1, HM2 00025880

```

```

IF(METRIC) CALL ENG(NREAC,NPRD) 00025890
IF(IDEBUG.GT.5.AND.DIC) WRITE(6,16) III 00025900
IF(IDEBUG.GT.5.AND.DSS) WRITE(6,12)III 00025910
IF(IDEBUG.GT.5.AND.DCS) WRITE(6,13) III 00025920
IF(IDEBUG.GT.5.AND.DWC) WRITE(6,14) III 00025930
16 FORMAT(10X,'FOR UNIT',I2,'DUCTWORK IS MADE OF INCONEL') 00025940
12 FORMAT(10X,'FOR UNIT',I2,'DUCTWORK IS MADE OF STAINLESS STEEL') 00025950
13 FORMAT(10X,'FOR UNIT',I2,'DUCTWORK IS MADE OF CARBON STEEL') 00025960
14 FORMAT(10X,'FOR UNIT',I2,'DUCTWORK IS WATER COOLED') 00025970
DCTCST(III)=0.0 00025980
DCTFLG=.TRUE. 00025990
DCBRIK=0.0 00026000
DCTVEL(III)=9000.0*60.0 00026010
CALL VL RATE(TTMP(III+1),PINC,NPRD) 00026020
RHO=MSTOT(III)/VOLRAT(III) 00026030
IF(IDEBUG.GT.1)WRITE(6,70)RHO,MSTOT(III),VOLRAT(III),T2,PINC 00026040
70 FORMAT(5X,'DENSITY OF GAS = ',E15.5,'LB/FT**3','TOTAL MASS RATE', 00026050
1' IN = ',E15.5,'LB/HR'/10X,'VOLUME RATE OF THE GAS',E15.5,'FT**3'. 00026060
2'/HR','T2= ',F9.2,'PINC= ',F9.2) 00026070
15 DCDIA(III)=(MSTOT(III)/RHO/DCTVEL(III)/3.1416*4.0)**0.5*12.0 00026080
IF(IDEBUG.GT.1) WRITE(6,11) DCDIA(III),DCTVEL(III) 00026090
11 FORMAT(10X,'ESTIMATED DUCT DIAMETER(INCHES)',F10.4,'GAS VELOCITY(F00026100
1T/HR',F14.4) 00026110
IF(DCDIA(III).GT.170.0) GOTO 51 00026120
IF(DCDIA(III).LT.20) GOTO 52 00026130
IF(.NOT.DCS) GOTO 10 00026140
IF(T2.LT.1100) GOTO 41 00026150
ZHOLD=INCLEN(III) 00026160
INCLEN(III)=DCTLEN(III) 00026170
DHOLD=DIA(III) 00026180
ZHOLD=INCLEN(III) 00026190
DIA(III)=DCDIA(III)/12.0 00026200
INCLEN(III)=DCTLEN(III) 00026210
CALL BLOCK(NREAC,NPRD) 00026220
INCLEN(III)=ZHOLD 00026230
DCDIA(III)=DIA(III)*12.0 00026240
DIA(III)=DHOLD 00026250
41 CONTINUE 00026260
IF(DCDIA(III).GT.80) GOTO 20 00026270
DCTCST(III)=(-1.46+1.09*DCDIA(III))*DCTLEN(III) 00026280
DCTCST(III)=DCTCST(III)+(12.07*DCDIA(III)+0.176*DCDIA(III)**2.0) 00026290
1*ELBNUM(III) 00026300
GOTO 100 00026310
20 IF(DCDIA(III).GT.130.) GOTO 21 00026320
DCTCST(III)=(-1.76+1.37*DCDIA(III))*DCTLEN(III) 00026330
DCTCST(III)=DCTCST(III)+(-9.83*DCDIA(III)+0.205*DCDIA(III)**2.0 00026340
1+16.76*DCDIA(III)) 00026350
1*ELBNUM(III) 00026360
GOTO 100 00026370
21 IF(DCDIA(III).GT.140) GOTO 22 00026380
DCTCST(III)=(-2.05+1.77*DCDIA(III))-DCTLEN(III) 00026390
DCTCST(III)=DCTCST(III)+(-8.21*DCDIA(III)+0.240*DCDIA(III)**2.0 00026400
1+18.41*DCDIA(III)) 00026410
1*ELBNUM(III) 00026420
GOTO 100 00026430
22 IF(DCDIA(III).GT.150) GOTO 23 00026440
DCTCST(III)=(-2.93+2.38*DCDIA(III))*DCTLEN(III) 00026450
DCTCST(III)=DCTCST(III)+(-12.89*DCDIA(III)+0.450*DCDIA(III)**2.0 00026460
1+21.1*DCDIA(III)) 00026470
1*ELBNUM(III) 00026480
GOTO 100 00026490
23 IF(DCDIA(III).GT.170) GOTO 24 00026500
DCTCST(III)=(-3.86+3.01*DCDIA(III))-DCTLEN(III) 00026510
DCTCST(III)=DCTCST(III)+(-16.41*DCDIA(III)+0.480*DCDIA(III)**2.0 00026520
1+24.71*DCDIA(III)) 00026530
1*ELBNUM(III) 00026540
GOTO 100 00026550
24 DCTVEL(III)=DCTVEL(III)*1.20 00026560
IF(IDEBUG.GT.1)WRITE(6,101) DCTVEL(III) 00026570
101 FORMAT(10X,'DUCT DIAMETER TOO LARGE. ADJUSTED GAS VELOCITY T 00026580
10',5X,F10.3,3X,'FEET/MINUTES') 00026590
GOTO 15 00026600

```

```

10 IF(DWC) GOTO 50                                00026610
    IF(T2.LT.1300.AND.DSS) GOTO 42                00026620
    IF(T2.LT.1400.AND.DIC) GOTO 42                00026630
    ZHOLD=INCLEN(III)
    INCLEN(III)=DCTLEN(III)
    DHOLD=DIA(III)
    ZHOLD=INCLEN(III)
    DIA(III)=DCDIA(III)/12.0                      00026640
    INCLEN(III)=DCTLEN(III)
    CALL BLOCK(NREAC,NPRD)
    INCLEN(III)=ZHOLD
    DCDIA(III)=DIA(III)*12.0                      00026650
    DIA(III)=DHOLD
    42 CONTINUE
    IF(DCDIA(III).GT.75.) GOTO 31                00026660
        DCTCST(III)=(-4.22+3.83*DCDIA(III))*DCTLEN(III) 00026670
        DCTCST(III)=DCTCST(III)+(19.04*DCDIA(III)+0.703*DCDIA(III)**2.0) 00026680
        1*ELBNUM(III)
        GOTO 100
    31 IF(DCDIA(III).GT.130.) GOTO 32            00026690
        DCTCST(III)=(-21.73+5.75*DCDIA(III))*DCTLEN(III) 00026700
        DCTCST(III)=DCTCST(III)+(17.6*DCDIA(III)+1.05*DCDIA(III)**2.0 00026710
        1+124)
        1*ELBNUM(III)
        GOTO 100
    32 IF(DCDIA(III).GT.150) GOTO 33            00026720
        DCTCST(III)=(-26.84+7.54*DCDIA(III))*DCTLEN(III) 00026730
        DCTCST(III)=DCTCST(III)+(19.3*DCDIA(III)+1.46*DCDIA(III)**2.0 00026740
        1+134.0)
        1*ELBNUM(III)
        GOTO 100
    33 IF(DCDIA(III).GT.160) GOTO 34            00026750
        DCTCST(III)=(-42.17+10.86*DCDIA(III))*DCTLEN(III) 00026760
        DCTCST(III)=DCTCST(III)+(23.7*DCDIA(III)+2.10*DCDIA(III)**2.0 00026770
        1+199.0)
        1*ELBNUM(III)
        GOTO 100
    34 DCTVEL(III)=DCTVEL(III)*1.20            00026780
    WRITE(6,110) DCTVEL(III)
110 FORMAT(10X,'DIAMETER MUST BE INCREASED BY INCREASE THE VELOCITY' 00026790
    1TO ',5X,F10.2,X,'FEET/MINUTE')
    GOTO 15
    50 DCTCST(III)=51.84+4.45*DCDIA(III)          00026800
    DCTCST(III)=DCTCST(III)+(-12.89+21.10*DCDIA(III)+0.45*DCDIA(III))*00026810
    1*ELBNUM(III)
    GOTO 100
    51 DCTVEL(III)=DCTVEL(III)*1.20            00026820
    GOTO 15
    52 DCTVEL(III)=DCTVEL(III)/1.20            00026830
    GOTO 15
100 AUTODP=.TRUE.
    DMPCST=554.85+96.54*DCDIA(III)-0.394*DCDIA(III)**2.            00026840
    1+5.81E-3*DCDIA(III)**3.
    DAMPT(III)=DMPCST*FACPVF/228.0                  00026850
    DCIBC(III)=DCBRIK/228*FACPVF
    DCTFLG=.FALSE.
    DCTCST(III)=DCTCST(III)/228.0*FACPVF          00026860
    CSTINS=CSTINS+DCTCST(III)*0.12
    PEXT=PEXT-PRESSR(MSTOT(III),RHO,DCDIA(III),DCTLEN(III))      00026870
    FLGPAS=.FALSE.
    TDCTCS(III)=DAMPT(III)+DCTCST(III)+DCIBC(III)          00026880
    TOTMAN=TOTMAN+DCTCST(III)*0.05
    DCTTST=DCTTST+TDCTCS(III)
    RETURN
    END
    SUBROUTINE HTMSQ(NREAC,NPRD)
    REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD
    1 ,XXFUEL,XXAIR,MASSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS
    LOGICAL ROTARY,FLUID,LIQ1,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI
    1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP,
    2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD
    4,CUTVN,CMBST,TCH

```

```

3,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825, TI,HS,UTB, HM1, HM2
CHARACTER BRIKNM=4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2
2 ,SCRNME*20
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL,
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9)
COMMON/PCKBED/ PSIZE(7),PCKSZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00027410
COMMON/DES/RLD(9),DES VOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST
3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN
COMMON/COST/ SHLCST,DRV CST,BRK TOT,ASHCST,STM CST,DCTCST(9)
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9)
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DS PCST,CSTE LC,DPTO T00027480
1,AOP,WATRAT,TOTDP,NTU,AQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100)
2,QTEMP,WASCAP,H20M,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME
3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK
1 ,DCTTST,CSTM TB,CSTSIT,CSTSTC,CSTM,CSTCNT,PREXT,PREXTI,SKRCST
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTS PR,CSTCRT,CSTENG,DCDIA(9),CSTINT00027540
3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,
4 ,TOTE LC,TOTH20,TT FUEL,TT WSTD,TT CAUS,TT OPR,
5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,
6 ,EQVCAP,FINCRG,REFINS,THCKIN,EQVF IN,DCBRIK
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB
1 ,FACP VF,FACPC,FACPI,FACENG,FACLAB,FACPRS
COMMON/SALAR Y/TEKC,SUPC,SECC,DAY, YEAR,ZTOT,SUPP,PAYEXP
COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9)
COMMON/INT/ IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPR TS
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11)
1,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK
2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRIO 00027670
1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DCI,DS S,DCS,DWC,FLGPAS00027680
2,SLD,SCRW, VENAUT,FG, BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN
3,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825, TI,HS,UTB, HM1, HM2
ANTOINE'S CONSTANTS FOR WATER
PRESSURE IN TERMS OF MMHG(CHANGED TO ATM)

ICONV=0
SATH20=0.0
FREH20=0.0
AA=7.96681
AB=1668.21
AT=228.0
PVH20=10.0**((AA-AB/(AT+T2))/760.0
IF(IDEBUG.GE.25)WRITE(6,200) PVH20,T2,PINC
200 FORMAT(10X,'VAPOR PRESSURE OF WATER IS ',F9.2,' ATM AT A TEMPERATU00027820
1RE OF ',F9.2,' CELCIUS. '/10X,'TOTAL PRESSURE= ',F9.2)
DELT AH=0.0
H2O=0.0
TTVOL=T2*1.8+32.0
PVOL= PINC*14.696
CALL VL RATE(TTVOL,PVOL,NPRD)
IF(METRIC) VOLRAT(III)=VOLRAT(III)/35.453
VOLTEM=VOLRAT(III)
RC2=8.206E-05
CALL DTHEAT(NPRD)
DELT AH=-DELT AH
IF(IDEBUG.GE.25) WRITE(6,401) DELTAH
401 FORMAT(10X,'AMOUNT OF HEAT REQUIRED TO COOL GAS',E15.5,'JOULES/HR')
1)
DTH20=2000.0*453.96
FFF=0
FF=1
HTLIQ=75.4*(T2-TA)
HEAT=0.0
HEAT1=0.0
HEAT1=CP(1,1)*(T2-T1)+CP(2,1)/2.-(T2**2.-T1**2.)
1 +CP(3,1)/3.-(T2**3.-T1**3.)+CP(4,1)/4.* (T2**4.-T1**4.)

```

```

      HEAT=CP(1,1)*(T2-TA)+CP(2,1)/2.*(T2**2.-TA**2.)          00028050
1    +CP(3,1)/3.*(T2**3.-TA**3.)+CP(4,1)/4.*(T2**4.-TA**4.)  00028060
      IF(IDEBUG.GT.1) WRITE(6,20) HEAT,T2,TA,CP(1,1)            00028070
11  CONTINUE
      ICONV=ICONV+1
      IF(ICONV.GE.100) WRITE(6,402)                                00028080
402 FORMAT(15X,'VENTURI SAT NOT RESOLVED')
      IF(ICONV.GE.100) GOTO 19
      ICONV=ICONV+1
      PRT20=(MLPRDT(1,III)+H20)*RC2*(T2+273.15)/VOLTEM        00028140
20  FORMAT(10X,'HEAT TO RAISE H2O FROM TA TO T1= ',E15.5,'OUTLET TEMP' 00028150
     1,F9.2,' AMBIENT TEMPERATURE(CELC)',F9.2/'HEAT CAPACITY OF H2O ', 00028160
     2E15.5)
      VAPNO=0.0
      DIFH20=H20
      IF(PRT20.LT.PVH20) GOTO 50
      SATH20=(PVH20)*VOLTEM/RC2/(T2+273.15)                      00028200
      DIFH20= SATH20 - MLPRDT(1,III)                                00028220
      VAPNO= H20 - DIFH20                                         00028230
50  CONTINUE
      COLDH=H20*HTLIQ+DIFH20*HSTVAP
      IF(IDEBUG.GE.25)                                             00028240
1   WRITE(6,400) COLDH,H20,MLPRDT(1,III),SATH20,DIFH20,VAPNO  00028250
400 FORMAT(10X,'HEAT FROM H2O TO COOL GAS= ',E15.5,' JOULES/HR' / 00028260
     1           10X,'TOTAL AMOUNT OF WATER ADDED= ',E13.5,' GMOLES/HR' / 00028270
     2           10X,'H2O IN WASTE GAS= ',E13.5,'GMOLES/HR' / 00028280
     2           10X,'MAXIMUM AMOUNT OF H2O= ',E15.5,' GMOLES/HR' / 00028290
     3           10X,'H2O VAPORIZED= ',E15.5,' GMOLES/HR' / 00028300
     4           10X,'H2O NOT VAPORIZED= ',E15.5,' GMOLES/HR' )  00028310
      IF(ICONV.GT.100) WRITE(6,403)                                00028320
403 FORMAT(10X,'QUENCH WATER CONVERGENCE CALCULATION HAS NOT CONVERGED 00028330
1')
      IF(ICONV.GT.700.0) STOP                                     00028340
      IF(IDEBUG.GT.1)WRITE(6,300)DIFH20,COLDH,PRT20               00028350
300 FORMAT(10X,'H2O ABOVE SATURATION(GMOLES/HR)',E15.5,      00028360
     1'TOTAL HEAT TRANSFERRED ',E15.5/10X,'TOTAL PARTIAL PRESSURE OF H20 00028370
     2',E15.5)
      IF(IDEBUG.GT.1) WRITE(6,120) H20,DIFH20,HSTVAP,HEAT1       00028380
120 FORMAT(10X,'ESTIMATED H2O(GMOLES/HR) ',E15.5,' H2O NOT VAPORIZED ' 00028390
     1,E15.5// HEAT OF VAPORIZATION JOULES/GM ',E15.5,' HEAT USED 00028400
     2TO RAISE H2O FROM T1 TO T2 ',E15.5)
      IF(ABS(DELTAH-COLDH).LT.(.001*DELTAH)) GOTO 19          00028410
      IF(DELTAH.LT.COLDH) GOTO 15
      H2O=H20+DTH20
      IF(FF.EQ.0) DTH20=DTH20/2.0
      IF(FFF.EQ.0) FFF=-1
      IF(FFF.EQ.1) GOTO 11
      FF=0
      GOTO 11
15  H2O = H20 -DTH20
      IF(FF.EQ.0) DTH20=DTH20/2.0
      IF(FFF.EQ.0) FFF=-1
      IF(FFF.EQ.-1) GOTO 11
      FF=0
      GOTO 11
19  IF(IDEBUG.GT.1)WRITE(6,999)H20
999 FORMAT(4X,' FINAL MOLE RATE OF QUENCH WATER= ',E15.5)    00028550
      FREH20=FFRH20
      MLPRDT(1,III)= MLPRDT(1,III)+H20                         00028560
      FEED(1)= FEED(1)+DIFH20*18.011                           00028570
      H2OM=H20*18.011
      WTRTOT=WTRTOT + (H2OM-VAPNO*18.011)/453.96              00028580
      IF(IDEBUG.GT.1) WRITE(6,150) H20,MLPRDT(1,III),MLPRDT(1,III-1) 00028590
150 FORMAT(10X,'AFTER',E15.5,'WATER',E15.5,'H2O MOLE AFTER', 00028600
     1E15.5,'H2O MOLE BEFORE')
      VAPNO=VAPNO*18.011
      RETURN
      END
      SUBROUTINE SHELL(NREAC,NPRD)
      REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD        00028610
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS    00028620
      LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00028630

```

```

1 .IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00028770
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00028780
4,CUTVN,CMBST,TCH 00028790
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,INB25,TI,HS,UTB,HM1,HM2 00028800
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00028810
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4.MTLDC*3,MTLBRK*3,DCMATL*2 00028820
2 ,SCRNME*20 00028830
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00028840
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00028850
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9) 00028860
COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00028870
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00028880
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00028890
1 .BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00028900
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00028910
3,INCLEN(9),MSTOT(9),MLPRDT(15,9).PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00028920
COMMON/COST/ SHLCST,DRV CST,BRKTO T,ASHCST,STM CST,DCTCST(9) 00028930
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00028940
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTE LC,DPTD00028950
1,AOP,WATRAT,TOTDP,NTU,AQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00028960
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00028970
3,OSAT,VENH20,DAMP T(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00028980
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00028990
1 .DCTTST,CSTMTB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00029000
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTS PR,CSTCRT,CSTENG,DCDIA(9),CSTINT00029010
3 ,DSDIA(9),CSTLOD,DCTBCS(9).TDCTCS(9),TOTLAB,TTMAIN, 00029020
4 TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00029030
5 TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00029040
6 EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00029050
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB 00029060
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00029070
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00029080
COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00029090
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00029100
COMMON/ALPHA/MATL(20),ERIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00029110
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDC,MTLBRK 00029120
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00029130
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00029140
1 .IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00029150
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00029160
3 ,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,INB25,TI,HS,UTB,HM1,HM2 00029170
C THIS SUBROUTINE PROVIDES THE COST FOR A CYLINDRICAL 00029180
C SHAPED INCINERATOR 00029190
C ROTARY DRIVE IS ALSO CALCULATED FOR THE ROTARY KILN. 00029200
THKSL=2./12. 00029210
SHLCST=0.0 00029220
C 00029230
C23456789 00029240
SHLARA=(DIA(III)+THKSL)*3.1416*INCLEN(III) 00029250
1 + 3.1416*(DIA(III)**2.0 / 4.0 *1.5) 00029260
IF(ROTARY) DRV CST=100.*SHLARA 00029270
SHLCST= 75.*SHLARA 00029280
C 00029290
C COST FACTORS FOR DIFFERENT MATERIALS 00029300
C INCONEL= 3.3 00029310
C STAINLESS STEEL 316= 2.7 00029320
C MONEL= 3.3 00029330
C NICKEL= 3.5 00029340
C 00029350
IF(IC) SHLCST=SHLCST*3.3 00029360
IF(SS) SHLCST=SHLCST*2.7 00029370
IF(IDEBUG.GT.1) GOTO 10 00029380
IF(IDEBUG.GT.1)WRITE(6,20) SHLARA,DIABRK,THKSL,SHLCST 00029390
20 FORMAT(2X,'SURFACE AREA(III) OF INCINERATOR(FT**2)= ',E15.3,'DIAME00029400
1TER (FT)= ',E15.3/2X,'THICKNESS OF SHELL(IN)= ',F9.2, 00029410
2 'COST OF SHELL ($)= ',E15.2) 00029420
10 SHLCST=SHLCST/305.9*FACCEF 00029430
DRV CST=DRV CST/305.9*FACCEF 00029440
RETURN 00029450
END 00029460
SUBROUTINE STOREG(NREAC,NPRD) 00029470
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00029480

```

```

1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS      00029490
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI      00029500
1 .IC,SSG,VOLTL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00029510
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD  00029520
4,CUTVN,CMBST,TCH
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1, 00029540
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5      00029550
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2  00029560
2 .SCRNME*20
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00029580
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00029590
2.VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAB,ZLFD2(9,9)   00029600
COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL  00029610
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7.4),Z,CSTINS,TBRNTT 00029620
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC  00029630
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00029640
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00029650
3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00029660
COMMON/COST/ SHLCST,DRVVCST,BRKTOT,ASHCST,STM CST,DCTCST(9)    00029670
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9)       00029680
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTO 00029690
1,AOP,WATRAT,TOTDP,NTU,AQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00029700
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME            00029710
3,QSAT,VENH20,DAMPT(10).DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO  00029720
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK  00029730
1 ,DCTTST,CSTMTB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00029740
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT 00029750
3 ,DSDIA(9),CSTLOD,DCTBCS(9),DCTCTS(9),TOTLAB,TTMAIN.          00029760
4 TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR,                      00029770
5 TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,  00029780
6 EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK                  00029790
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB             00029800
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS                 00029810
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP        00029820
COMMON/DCT/ ELBNU(9),DCTLEN(9),DCTVEL(9),DIA(9)              00029830
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00029840
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00029850
1 ,PCKCHS(4),PCKNAM(7.4),DCMATL(9),MTLDCT,MTLBRK            00029860
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)                     00029870
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00029880
1 ,IC,TCH,SSG,VOLTL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS 00029890
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00029900
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1, 00029910
HM2 INTEGER BNUM                                              00029920
C
C      CSTNIT=0.0                                              00029930
C      CSTN2=0.0                                              00029940
C      CSTCON=0.0                                             00029950
C      BNUM=0.                                                 00029960
C      MNUM=0.                                                 00029970
C      LNUM=0.                                                 00029980
C      ARACST=0.0                                             00029990
C      CSTSTO=0.0                                            00030000
C      STRCST=0.0                                            00030010
C          FLAG=0                                              00030020
C          SDENS=47.1                                         00030030
C          CSTFAC=1.0                                         00030040
C          IF(IC) CSTFAC=3.3                                 00030050
C          IF(SSB) CSTFAC=2.7                                 00030060
C          VOL=(MASSSL/SDENS*24.*3.0*7.48)*1.20           00030080
C          TOTVOL=VOL                                         00030090
C          IF(BARREL) GOTO 60                                00030100
C          IF(FLAG.GT.0) GOTO 20                            00030110
C
C      COST THE 3 POSSIBLE WASTE STORAGE CONTAINERS.          00030120
C
C      SMLTAN=8000.*CSTFAC+3000.+6000.+10000.+8000.+3000.+1000.+5000. 00030150
C      MEDTAN= 10000*CSTFAC+5000.+8000.+11000.+10000.+5000.+2000.+7000. 00030160
C      BIGTAN=23000*CSTFAC+12000.+9000.+24000.+13000.+13000.+5000.+13000. 00030170
C      FLAG=0                                              00030180
20 DO 50 I=1,100                                           00030190
      IF(VOL.LE.1000.) GOTO 51                           00030200

```

```

IF(VOL.GT.25000.) GOTO 30                                00030210
IF(VOL.GT.10000.) GOTO 40                                00030220
STRCST=STRCST+SMLTAN                                     00030230
VOL=VOL-5000.                                            00030240
LNUM=LNUM+1                                              00030250
GOTO 50                                                 00030260
40 STRCST=STRCST+MEDTAN                                 00030270
VOL=VOL-10000.                                           00030280
MNUM=MNUM+1                                              00030290
GOTO 50                                                 00030300
30 STRCST=STRCST+BIGTAN                                 00030310
VOL=VOL-25000.                                           00030320
BNUM=BNUM+1                                              00030330
50 CONTINUE                                              00030340
51 CONTINUE                                              00030350
CSTSTD=STRCST                                         00030360
IF(.NOT.VOLTIL) GOTO 101                               00030370
IF(VOLTIL.AND.(.NOT.CMBST)) GOTO 102                 00030380
TOTNUM=MNUM+BNUM+LNUM                                    00030390
CSTNIT=TOTNUM*2500./305.9*FACCES                      00030400
CSTN2=TOTVOL*1000./310.1*FACMSC/2500.                  00030410
102 CSTCON=10000.*305.9/FACCEF                         00030420
CSTSTD=(CSTSTD+CSTNIT+CSTN2+CSTCON)/305.9*FACCEF      00030430
101 WRITE(6,300) BNUM, MNUM, LNUM, STRCST, CSTNIT, CSTN2, CSTCON 00030440
300 FORMAT('1',25X,'LIQUID WASTE STORAGE FACILITY'//)
1 15X,'NUMBER OF 25,000 GALLON TANKS = ',I3/          00030450
2 15X,'NUMBER OF 10,000 GALLON TANKS = ',I3/          00030460
3 15X,'NUMBER OF 1,000 GALLON TANKS = ',I3/          00030470
4 15X,'TOTAL STORAGE TANK COST= ',F9.0,' U.S. DOLLARS'/' 00030480
5 15X,'CSTNIT= ',F9.0,' U.S. DOLLARS'/' 00030490
6 15X,'NITROGEN BLANKET SYSTEM= ',F9.0,' U.S. DOLLARS'/' 00030500
7 15X,'CONDENSOR COST= ',F9.0,' U.S. DOLLARS'/' 00030510
GOTO 100                                              00030520
00030530
C
C. CALCULATION OF BARREL STORAGE FACILITIES
C
60 BRLNUM=VOL/55.*24.*3.                                00030540
BRLARA=BRLNUM/75.                                         00030550
ARACST=40.0*BRLARA                                       00030560
ARACST=ARACST*FACCEB/257.2                            00030570
WRITE(6,200) BRLNUM,BRLARA,ARACST                      00030580
200 FORMAT('1',25X,'COST PARAMETERS FOR BARREL STORAGE FACILITY'/
1 15X,'NUMBER OF BARRELS FOR ',I2,' DAYS OF STORAGE= ',F9.2/ 00030590
2 15X,'AREA OF STORAGE FACILITY = ',F9.2,' FT^2' 00030600
3 15X,'COST OF BARREL STORAGE FACILITY(INSTALLED)= ',F9.2, 00030610
4 'U.S. DOLLARS'/' 00030620
100 TOTMAN=TOTMAN+ARACST*0.05+CSTSTD*0.05             00030630
RETURN                                                 00030640
END                                                   00030650
SUBROUTINE ASHUN                                         00030660
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00030670
1 ,XXFUEL,XXAIR,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00030680
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00030690
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00030700
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00030710
4,CUTVN,CMBST,TCH                                         00030720
3,KRB,FXH,S316,S304,S347,NI200,M0400,IN600,IN825, 00030730
TI,HS,UTB,HM1,HM2 CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00030740
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00030750
2 .SCRNME*20 COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSFL, 00030760
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00030770
2,VOLIT,ASH,FREH20,HTCMNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9) 00030780
COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00030790
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT 00030800
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00030810
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00030820
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00030830
3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00030840
COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STM CST,DCTCST(9) 00030850
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00030860
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTO 00030870

```

```

1,AOP,WATRAT,TOTDP,NTU,AQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00030930
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00030940
3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00030950
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00030960
1 .DCTTST,CSTMTC,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00030970
2 .CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPP,CSTCRT,CSTENG,DCDIA(9),CSTINT00030980
3 .DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN, 00030990
4 TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00031000
5 TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00031010
6 EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00031020
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB 00031030
1 .FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00031040
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00031050
COMMON/DCT/ ELBNU(9),DCTLEN(9),DCTVEL(9),DIA(9) 00031060
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00031070
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00031080
1 .PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00031090
2 .WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00031100
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00031110
1 .IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00031120
2 .SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00031130
3 .KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00031140
SEMI=.FALSE. 00031150
ASHCST=0.0 00031160
IF(HTCOMB.GT.20.OE6) GOTO 60 00031170
IF(.NOT.SEMI) GOTO 60 00031180
ASHCST=15000.0 00031190
GOTO 50 00031200
60 IF(HTCOMB.GT.15E6) GOTO 20 00031210
ASHCST=7000.0 00031220
GOTO 50 00031230
20 IF(HTCOMB.GT.75.E6) GOTO 30 00031240
ASHCST=10000.0 00031250
GOTO 50 00031260
30 ASHCST=22000.0 00031270
50 ASHCST=ASHCST*FACCES/308.4 00031280
IF(IDEBUG.GT.1) WRITE(6,70) ASHCST 00031290
70 FORMAT(2X,'COST OF ASH HANDLING SYSTEM($)= ',E15.5) 00031300
ASHCST=ASHCST/308.4*FACCEE 00031310
RETURN 00031320
END 00031330
SUBROUTINE OUTP1(NPRD) 00031340
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00031350
1 .XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00031360
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00031370
1 .IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00031380
2 .SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00031390
4 .CUTVN,CMBST,TCH 00031400
3 .KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00031410
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00031420
1 .BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00031430
2 .SCRNME*20 00031440
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00031450
1 .MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00031460
2 .VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAB,ZLFD2(9,9) 00031470
COMMON/PCKBED/ PSIZE(7),PCKSZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00031480
1 .VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRA(7,4),Z,CSTINS,TBRNTT00031490
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9).DP(9),TTL(9),HTC 00031500
1 .BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00031510
2 .HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00031520
3 .INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00031530
COMMON/COST/ SHLCST,DRVCST,BRKTOT,ASHCST,STM CST,DCTCST(9) 00031540
1 .CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00031550
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTOT00031560
1 .AOP,WATRAT,TOTDP,NTU,AQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00031570
2 .QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00031580
3 .QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00031590
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00031600
1 .DCTTST,CSTMTC,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00031610
2 .CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPP,CSTCRT,CSTENG,DCDIA(9),CSTINT00031620
3 .DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN, 00031630
4 TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00031640

```

```

      5 TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,      00031650
      6 EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK      00031660
      COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB      00031670
      1, FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS      00031680
      COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP      00031690
      COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9)      00031700
      COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00031710
      COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00031720
      1,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK      00031730
      2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)      00031740
      COMMON/LOGIC/ROTARY,FLUID,LIQI.METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00031750
      1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS 00031760
      2,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00031770
      3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00031780
      PREFD=O.O      00031790
      IF(UNIT(III).NE.SUNIT(1)) PREFD=MSTOT(III-1)      00031800
      EEXCES=EXCESS(III)*100.0      00031810
      EEXFUL=O.O      00031820
      RYEYEAR=365.0-YEAR      00031830
      RYEYEAR= 365.0-YEAR      00031840
      WRITE(6,10)      00031850
      10 FORMAT('1',25X,'INCINERATOR DESIGN AND COST FOR')      00031860
      IF(III.EQ.2) WRITE(6,16)      00031870
      IF(UNIT(III).EQ.SUNIT(8)) GOTO 17      00031880
      IF(ROTARY) WRITE(6,12)      00031890
      IF(LIQI) WRITE(6,13)      00031900
      IF(FLUID) WRITE(6,14)      00031910
      12 FORMAT(34X,'ROTARY KILN')      00031920
      13 FORMAT(34X,'LIQUID INJECTION')      00031930
      14 FORMAT(34X,'FLUIDIZED BED')      00031940
      16 FORMAT(27X,'LIQUID INJECTION AFTERBURNER')      00031950
      53 FORMAT(//)      00031960
      17 WRITE(6,53)      00031970
      WRITE(6,20)      00031980
      20 FORMAT(25X,'*****INPUT STREAM CHARACTERISTICS*****')      00031990
      WRITE(6,21) MSTOT(III),ASH,VOLIT,FREH20,MASSFL,EEXCES,MASSAR      00032000
      21 FORMAT(15X,'COMBUSTED GAS EXIT RATE',16X,F11.2,' LB/HR '/15X,'ASH 00032010
      1FEED RATE ',26X,F10.2,' LB/HR'/15X,'VOLITILES FEED RATE',21X,F10.200032020
      2,' LB/HR'/15X,'FREE WATER IN SLUDGE FEED',15X,F10.2,' LB/HR'/15X 00032030
      3,'FUEL FEED RATE ',21X,F15.2,' LB/HR'/15X,'AIR FEED RATE (AT ',F6.200032040
      4,'% EXCESS)',2X,F15.2,' LB/HR')      00032050
      IF(UNIT(III).NE.SUNIT(1)) WRITE(6,23) PREFD      00032060
      23 FORMAT(15X,'GAS FEED FROM PREVIOUS UNIT',12X,F10.2,' LB/HR ')      00032070
      WRITE(6,40) EEXCES,EEXFUL,T2,TA,DAY,RYEAR,RETIM(III),RLD(III) 00032080
      40 FORMAT(//29X,'PROCESS DESIGN VARIABLES//15X,'PERCENT EXCESS AIR 00032090
      1IS ',
      1 19X,F5.2,' PERCENT',/15X,'PERCENT EXCESS FUEL IS ',18X,F5.2,      00032100
      1 ' PERCENT.'      00032120
      2 /15X,'INCINERATOR TEMPERATURE ',15X,F7.2,' DEG. FAHRENHEIT'      00032130
      3/15X,'AMBIENT TEMPERATURE ',15X,F7.2,' DEG. FAHRENHEIT.'      00032140
      4/15X,'DAILY USE ',15X,F7.2,' HOURS/DAY.'      00032150
      5/15X,'LENGTH OF PROCESS RUN ',15X,F7.2,' DAYS/YEAR.'      00032160
      6/15X,'SHUTDOWN LENGTH ',15X,F7.2,' DAYS/YEAR.'      00032170
      7/15X,'RETENTION TIME ',15X,F7.2,' SECONDS '      00032180
      8/15X,'LENGTH TO DIAMETER RATIO ESTIMATE',6X,F7.2)      00032190
      RETURN      00032200
      END      00032210
      SUBROUTINE OUTP7(NPRD)      00032220
      REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD      00032230
      1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS      00032240
      DIMENSION FEED(15)      00032250
      LOGICAL ROTARY,FLUID,LIQI.METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00032260
      1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,AUTCDP, 00032270
      2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00032280
      4,CUTVN,CMBST,TCH      00032290
      3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00032300
      CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00032310
      1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00032320
      2 ,SCRNME*20      00032330
      CHARACTER MATLC*2      00032340
      DIMENSION MATLC(4)      00032350
      COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00032360

```

```

1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP      00032370
2 VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9)        00032380
COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL       00032390
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00032400
COMMON/DES/RLD(9),DESVOL(9).TKOND(9),EXCESS(9),DP(9),TTL(9).HTC     00032410
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS    00032420
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST  00032430
3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN    00032440
COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STMCST,DCTCST(9)          00032450
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9)           00032460
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTEBC,DPTDT00032470
1,AOP,WATRAT,TOTDP,NTU,ADQ,CSTSTD,ASHGAS,PERUPT,FEDRG2,DIAPT(100)   00032480
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME                 00032490
3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO       00032500
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK       00032510
1 .DCTTST,CSTMTB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST     00032520
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPP,CSTCRT,CSTENG,DCDIA(9),CSTINT00032530
3 .DSDIA(9),CSTLDD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,              00032540
4 TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR,                         00032550
5 TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,      00032560
6 EQVCP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK                         00032570
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB                   00032580
1, FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS                        00032590
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP               00032600
COMMON/DCT/ ELBNU(9),DCTLEN(9),DCTVEL(9),DIA(9)                      00032610
COMMON/INT/IDEBUG,NRES(8),NUNIT.III,NSET,JPIK,IYEAR,NUMBRN,NPRTS    00032620
COMMON/ALPHA/MATL(20),BRIKNM(6,8);FUELNM(4,5),UNIT(20),SUNIT(11)   00032630
1,PCKCHS(4),PCKNM(7,4),DCMATL(9),MTLDCT,MTLBRK                     00032640
2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)                           00032650
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00032660
1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00032670
2,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN  00032680
3,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825,TI,HS,UTB,HM1,HM2 00032690
DO 165 I= 1,NPRD
      FEDD(I)=O.O
165 CONTINUE
      IF(III.EQ.1) GOTO 166
      DO 150 I=1,NPRD
          FEDD(I)=MLPRDT(I,III-1)*PRDMW(I)
150 CONTINUE
166 CONTINUE
      56 FORMAT('1'//)
      WRITE(6,56)
      WRITE(6,140) T1,T2,PINC,PEXT
140 FORMAT(25X,'PROCESS STREAM CONDITIONS AND COMPOSITION'//5X,
1'INPUT STREAM T= ',F7.2,' FAHRENHEIT',7X,'OUTPUT STREAM T= ',
2F7.2,' FAHENHEIT'/18X,'P= ',F7.2,' PSIA',27X,'P= ',F7.2,' PSIA'// 00032820
322X,'LB/HR',31X,'LB/HR'/22X,'----',31X,'----')
      IF(UNIT(III).EQ.SUNIT(1).OR.UNIT(III).EQ.SUNIT(8)) 00032830
1 WRITE(6,110)MASSFL
110 FORMAT(5X,' FUEL ',5X,F10.2,32X,'0.00')
      IF(UNIT(III).EQ.SUNIT(1).OR.UNIT(III).EQ.SUNIT(8)) 00032880
1 WRITE(6,120)MASSAR
120 FORMAT(5X,' AIR ',5X,F10.2,32X,'0.00')
      IF(UNIT(III).EQ.SUNIT(1))
1 WRITE(6,130) MASSSL
130 FORMAT(5X,' WASTE ',5X,F10.2,32X,'0.00')
      IF(UNIT(III).EQ.SUNIT(1))
1 WRITE(6,135) ASH
135 FORMAT(5X,' ASH ',10X,'0.00',26X,F10.2)
      WRITE(6,50) (FEDD(II),FEED(II),II=1,15)
50 FORMAT(
2 5X,' H2O ',5X,F10.2,26X,F10.2/ 00032990
B 5X,' HCl ',5X,F10.2,26X,F10.2/ 00033000
2 5X,' CO2 ',5X,F10.2,26X,F10.2/ 00033010
C 5X,' CO ',5X,F10.2,26X,F10.2/ 00033020
3 5X,' N2 ',5X,F10.2,26X,F10.2/ 00033030
D 5X,' O2 ',5X,F10.2,26X,F10.2/ 00033040
4 5X,' NO ',5X,F10.2,26X,F10.2/ 00033050
E 5X,' NO2 ',5X,F10.2,26X,F10.2/ 00033060
5 5X,' CL2 ',5X,F10.2,26X,F10.2/ 00033070
F 5X,' SO2 ',5X,F10.2,26X,F10.2/ 00033080

```

```

6 5X,' H2SO4 ',5X,F10.2,26X,F10.2/          00033090
7 5X,' F2   ',5X,F10.2,26X,F10.2/          00033100
8 5X,' HF   ',5X,F10.2,26X,F10.2/          00033110
9 5X,' P2O6 ',5X,F10.2,26X,F10.2/          00033120
A 5X,' NE   ',5X,F10.2,26X,F10.2/)          00033130
      WRITE(6,300)                                00033140
300 FORMAT('1')
      RETURN                                     00033150
      END                                         00033170
      SUBROUTINE OUTP6(NPRD)                      00033180
      REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS
      LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI
1 .IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP,
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD
4,CUTVN,CMBST,TCH
3,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825, TI,HS,UTB,HM1,HM2
      CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2
2 ,SCRNME*20
      CHARACTER MATLC=2                           00033240
      DIMENSION MATLC(4)                         00033300
      COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL,
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP
2 ,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9)
      COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL
1 ,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00033350
      COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS
2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST
3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN
      COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STMCST,DCTCST(9)
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9)
      COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTD00033420
1 ,AOP,WATRAT,TOTDP,NTU,AOQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100)
2 ,QTEMP,WASCAP,H2DM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME
3 ,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO
      COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK
1 ,DCTTST,CSTM TB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT00033480
3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,
4 ,TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR,
5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVDPR,EQVREV,
6 ,EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK
      COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS
      COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP
      COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9)
      COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS
      COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11)
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)
      COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00033610
1 .IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00033620
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN
3 ,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825, TI,HS,UTB,HM1,HM2
      IF(CONTEN.GT.1.0) EXTRA= TOTCAP*(100.+CONTEN)/100.0
      HTWAST=MASSSL*ZSLHT
      WRITE(6,60) DIA(III),INCLEN(III),(BNMFR(I),I=1,6),REFINS
1 ,(BNMIN(I),I=1,6),THCKIN,AREA(III),DESVOL(III),NUMBRN
60 FORMAT("//25X,'INCINERATOR PROCESS DESIGN SPECIFICATIONS'//)
110X,'INCINERATOR DIAMETER (FT)= ',13X,F10.4/          00033700
210X,'INCINERATOR LENGTH (FT)= ',15X,F10.4/          00033710
310X,'MATERIALS OF CONSTRUCTION FOR THE INCINERATOR'/15X,'REFRACTORY00033720
3 SELECTED = ',6(A4),9X,'THICKNESS = ',F5.1,' INCHES'/
3 15X,'INSULATION SELECTED = ',6(A4),9X,'THICKNESS = ',F5.1
3 , ' INCHES '/
310X,'INCINERATOR SURFACE AREA (FT**2)',8X,F10.4/          00033760
410X,'INCINERATOR VOLUME           (FT**3)',6X,F10.4/          00033770
510X,'INCINERATOR BURNER DATA'/15X,'NUMBER OF FUEL BURNERS',
6 ' = ',I3 )                                              00033780
      IF(LQD.AND.UNIT(III).EQ.SUNIT(1)) WRITE(6,117) HTWAST
00033790
00033800

```

```

117 FORMAT(15X,'WASTE FEED BURNER HEAT LOAD = ',E10.3,' BTU/HR')      00033810
    WRITE(6,110)                                         00033820
110 FORMAT(10X,'OPTIONS IN EFFECT')                                00033830
    IF(HTLS) WRITE(6,111)                                         00033840
111 FORMAT(10X,'A 10 PERCENT HEAT LOSS (OF TOTAL HEAT RELEASED)',     00033850
    1 ' IS INCLUDED IN THE HEAT/MASS BALANCE CALCULATIONS')          00033860
    IF(SLD.AND.III.EQ.1) WRITE(6,112)                                         00033870
112 FORMAT(10X,'FEED IS A SOLID. AN ASH REMOVAL SYSTEM AND A',       00033880
    1 ' BULK FEED SYSTEM ARE SELECTED')          00033890
    IF(LQD.AND.III.EQ.1) WRITE(6,113)                                         00033900
    IF(SLD.AND.III.EQ.1) WRITE(6,114)                                         00033910
114 FORMAT(15X,'WASTE FEED IS A SOLID. RAM LOADER USED')           00033920
113 FORMAT(15X,'WASTE FEED IS A LIQUID. WASTE BURNERS ARE SELECTED') 00033930
    IF(IC) WRITE(6,711)                                         00033940
711 FORMAT(15X,'INCONEL WAS SELECTED TO CONTRACT THE SHELL')        00033950
    IF(SS) WRITE(6,712)                                         00033960
    IF(CS) WRITE(6,713)                                         00033970
712 FORMAT(15X,'STAINLESS STEEL WAS SELECTED TO CONTRACT THE SHELL') 00033980
713 FORMAT(15X,'CARBON STEEL WAS SELECTED TO CONTRACT THE SHELL')    00033990
    WRITE(6,70) BRKTOT,SHLCST,TBRNTT                                         00034000
70 FORMAT(//25X,'INCINERATOR COST BREAKDOWN'//)                   00034010
    110X,'TOTAL BRICK COST $',10X,F9.2/                                00034020
    210X,'TOTAL SHELL COST $',8X,F11.2/                               00034030
    A10X,'COST OF BURNER SYSTEM $',3X,F11.2)                           00034040
    IF(III.NE.1) GOTO 200                                         00034050
    IF(SLD.AND.BARREL) WRITE(6,116) CSTLOD                         00034060
116 FORMAT(10X,'55-GAL BARREL WASTE LOADER $',8X,F11.2)            00034070
300 FORMAT(10X,'RAM WASTE LOADER $',8X,F11.2)                      00034080
    IF(SLD.AND.(.NOT.BARREL)) WRITE(6,300) CSTLOD                  00034090
    IF(SLD.AND.SCRW) WRITE(6,118) CSTSCR                         00034100
118 FORMAT(10X,'SCREW FEEDER TO RAM $',5X,F11.2)                  00034110
    IF(.NOT.LIQI) WRITE(6,80) ASHCST                         00034120
    IF(ROTARY) WRITE(6,85) DRVCST                         00034130
80 FORMAT(10X,'COST OF ASH SYSTEM $',8X,F9.2)                     00034140
85 FORMAT(10X,'COST OF DRIVE SYSTEM $',6X,F9.2)                  00034150
    IF(ROTARY) WRITE(6,90) SKRCST                         00034160
90 FORMAT(10X,'COST OF SKIRTING $',10X,F9.2)                     00034170
200 IF(III.EQ.1) WRITE(6,95) EXTRA1                         00034180
    IF(III.EQ.2) WRITE(6,95) EXTRA2                         00034190
95 FORMAT(10X,'EXTRA COSTS $',15X,F9.2/10X,'-----'----- 00034200
    1-----')                                         00034210
    IF(UNIT(III).EQ.SUNIT(1)) WRITE(6,100) CSTINC             00034220
100 FORMAT(10X,'TOTAL INCINERATOR COST ',F13.2)                 00034230
    IF(UNIT(III).EQ.SUNIT(8)) WRITE(6,100) AFTINC             00034240
    RETURN                                         00034250
    END                                           00034260
    SUBROUTINE OUTP2(NPRD)
    REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD          00034280
    1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00034290
    LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00034300
    1 .IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP. 00034310
    2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00034320
    4,CUTVN,CMBST,TCH                                         00034330
    3,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825,TI,HS,UTB,HM1,HM2 00034340
    CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00034350
    1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00034360
    2 ,SCRNME*20                                         00034370
    COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00034380
    1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00034390
    2 ,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9) 00034400
    COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00034410
    1 ,VISCG,EFFABS,TDCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT 00034420
    COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00034430
    1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00034440
    2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00034450
    3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00034460
    COMMON/COST/ SHLCST,DRVCST,BRKTOT,ASHCST,STMCST,DCTCST(9) 00034470
    1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00034480
    COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTO 00034490
    1 ,AOP,WATRAT,TOTDP,NTU,AQZ,CSTSTD,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00034500
    2 ,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME          00034510
    3 ,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00034520

```

```

COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK      00034530
1 ,DCTTST,CSTMTC,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST      00034540
2 .CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPP,CSTCRT,CSTENG,DCDIA(9),CSTINT00034550
3 .DSDIA(9),CSTLDD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,                00034560
4 TOTELC,TOTH2D,TTFUEL,TTWSTD,TTCAUS,TTOPR,                           00034570
5 TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,        00034580
6 EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK                         00034590
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB                     00034600
1 .FACPVF,FACPFC,FACPI,FACENG,FACLAB,FACPRS                         00034610
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP                 00034620
COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9)                      00034630
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS       00034640
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11)       00034650
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK                      00034660
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)                            00034670
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00034680
1 ,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00034690
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN   00034700
3 ,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825,TI,HS,UTB,HM1,HM2  00034710
CALL CAPITAL                                         00034720
CONFEET=CONTEN*TOTCAP                                00034730
IF(CSTPAK.GT.10000000.) CSTPAK=0.0                  00034740
TOTIND= CSTIIN+CSTSTR+CSTSPP+CSTCRT+CSTENG+CSTINT+CONFEET          00034750
TOTTOT= TOTCAP+TOTIND                                00034760
WRITE(6,10)                                           00034770
10 FORMAT('1',32X,'TOTAL CAPITAL COST'/21X,'-----')            00034780
WRITE(6,20) IYEAR,CSTINC,AFTINC                      00034790
WRITE(6,30) CSTHTR                                    00034800
WRITE(6,40) CSTQUE,CSTVEN,CSTPAK                      00034810
WRITE(6,50) CSTFAN                                    00034820
NHEIGH=HEIGHT                                       00034830
WRITE(6,60) NHEIGH,CSTSTK                           00034840
WRITE(6,81) WASCAP                                 00034850
WRITE(6,61) CSTSTO                                00034860
WRITE(6,70) DCTTST                                00034870
WRITE(6,80) CSTMTC                                00034880
WRITE(6,90) CSTSIT                                00034890
WRITE(6,100) CSTSTC                               00034900
WRITE(6,110) CSTEM                                 00034910
WRITE(6,120) CSTCNT                               00034920
WRITE(6,130) TOTCAP                                00034930
WRITE(6,150) CSTIIN,CSTSTR,CSTSPP,CSTCRT,CSTENG,CSTINT,CONFEET,    00034940
1 TOTIND                                           00034950
WRITE(6,160) TOTTOT                                00034960
20 FORMAT(10X,'COMBUSTION CHAMBERS:',30X,I4,' $'/59X,'-----'/    00034970
115X,'PRIMARY COMBUSTOR',24X,F12.2/15X,'SECONDARY COMBUSTOR',22X   00034980
A,F12.2)                                            00034990
30 FORMAT(10X,'ENERGY RECOVERY BOILER',24X,F12.2)                00035000
40 FORMAT(10X,'AIR POLLUTION CONTROL SYSTEM'/15X,'QUENCH CHAMBER ', 00035010
126X,F12.2/15X,'VENTURI SCRUBBER AND SEPARATOR',11X,F12.2/      00035020
215X,'PACKED BED SCRUBBER',22X,F12.2)                          00035030
50 FORMAT(10X,'INDUCTION FAN',33X,F12.2)                         00035040
60 FORMAT(10X,'EXHAUST STACK',13,' FEET HIGH)',18X,F12.2)          00035050
81 FORMAT(10X,'WASTE WATER TREATMENT FACILITY',15X,F12.1)         00035060
61 FORMAT(10X,'STORAGE TANK FACILITY',25X,F12.2)                 00035070
70 FORMAT(10X,'TOTAL DUCTWORK',32X,F12.2)                         00035080
80 FORMAT(10X,'METAL BUILDING',32X,F12.2)                         00035090
90 FORMAT(10X,'SITEWORK AND FOUNDATIONS',22X,F12.2)               00035100
100 FORMAT(10X,'STRUCTURAL STEEL',31X,F12.2)                        00035110
110 FORMAT(10X,'ELECTRICAL MATERIAL',27X,F12.2)                    00035120
120 FORMAT(10X,'INSTRUMENTS AND CONTROLS',22X,F12.2/55X,'-----'  00035130
A-) )                                              00035140
130 FORMAT(20X,'TOTAL----',26X,F12.2//)                           00035150
150 FORMAT(10X,'TOTAL INSTALLATION COST',23X,F12.2/                00035160
1 10X,'START-UP (10 % OF EQUIPMENT COST)',13X,F12.2/              00035170
2 10X,'SPARE PARTS (8 % OF EQUIPMENT COST)',11X,F12.2/             00035180
3 10X,'CERTIFICATION (10 % OF EQUIPMENT COST)',8X,F12.2/            00035190
4 10X,'ENGINEERING (7 % OF EQUIPMENT COST)',11X,F12.2/              00035200
5 10X,'INSTRUMENTATION (20 % OF EQUIPMENT COST)',6X,F12.2/           00035210
7 10X,'CONTINGENCY FEE (20 % OF EQUIPMENT COST)',6X,F12.2/           00035220
6 55X,'-----'/10X,'TOTAL INDIRECT COSTS',26X,F12.2)00035230
160 FORMAT(//10X,'***** TOTAL CAPITAL COST= ',20X,F12.2///)        00035240

```

```

RETURN                                         00035250
END                                           00035260
SUBROUTINE OUTP3(NPRD)                         00035270
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00035280
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00035290
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00035300
1 .IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00035310
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00035320
4,CUTVN,CMBST,TCH 00035330
3,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825, TI,HS,UTB,HM1, HM2 00035340
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00035350
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00035360
2 ,SCRNME*20 00035370
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00035380
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00035390
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAA,ZLFD2(9,9) 00035400
COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00035410
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00035420
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00035430
1 .BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00035440
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNRM,RTINST 00035450
3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00035460
COMMON/COST/ SHLCST,DRV CST,BRKTO,TASHCST,STMCST,DCTCST(9) 00035470
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00035480
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTOT00035490
1,AOP,WATRAT,TOTDP,NTU,AQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00035500
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00035510
3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00035520
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00035530
1 .DCTTST,CSTM TB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00035540
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTS PR,CSTCRT,CSTENG,DCDIA(9),CSTINT00035550
3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN, 00035560
4 ,TOTECL,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00035570
5 ,TOTTOT,DEPREC,EQVPREC,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00035580
6 ,EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00035590
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCE,FACCEB 00035600
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00035610
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00035620
COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00035630
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00035640
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00035650
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00035660
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00035670
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00035680
1 ,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00035690
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00035700
3 ,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825, TI,HS,UTB,HM1, HM2 00035710
      WRITE(6,200) 00035720
200 FORMAT(20X,'DUCTWORK DESIGN OUTPUT'//)
   1 4X,'          OUTER BRICK MATERIALS OF DUCT      NUM' 00035730
   2 ,BER OF/' 00035740
   3 4X,'UNITS DIAMETER DIAMETER CONSTRUCTION LENGTH     ELBOWS') 00035750
DO 10 I=1,NUNIT 00035770
MUNIT=I+1 00035780
WRITE(6,100) I,MUNIT,DCDIA(I),DSDIA(I),DCMATL(I),DCTLEN(I) 00035790
1 ,ELBNUM(I) 00035800
100 FORMAT(2X,I2,' TO',I2,3X,F5.1,2X,F9.2,5X,A4,6X,F6.2,9X,F3.0) 00035810
10 CONTINUE 00035820
WRITE(6,310) 00035830
310 FORMAT(//32X,'COST OF DUCTWORK'//)
   1 17X,'DUCTWORK FIREBRICK DAMPERS      TOTAL  /' 00035850
   2 5X,' COST      COST      COST      COST    '00035860
   3 ,COST' 00035870
   3 //) 00035880
MUNIT=0.0 00035890
DO 20 I=1,NUNIT 00035900
MUNIT=I+1 00035910
WRITE(6,300) I,MUNIT,DCTCST(I),DCIBC(I),DAMPT(I),TDCTCS(I) 00035920
300 FORMAT(5X,I2,' TO ',I2,3X,F7.1,8X,F7.1,9X,F7.1,9X,F7.1) 00035930
20 CONTINUE 00035940
      RETURN 00035950
END 00035960

```

```

SUBROUTINE OUTP4(NPRD)                               00035970
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00035980
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00035990
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00036000
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00036010
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00036020
4,CUTVN,CMBST,TCH 00036030
3,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825, TI,HS,UTB, HM1, HM2 00036040
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00036050
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00036060
2 ,SCRNME*20 00036070
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00036080
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00036090
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAB,ZLFD2(9,9) 00036100
COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00036110
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00036120
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00036130
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00036140
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00036150
3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00036160
COMMON/COST/ SHLCST,DRVCST,BRKTOT,ASHCST,STMCST,DCTCST(9) 00036170
1,CSTFUL,DFHCOLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUF(9) 00036180
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECLC,DPTD00036190
1,AOP,WATRAT,TOTDP,NTU,AQ,CSTSTD,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00036200
2,QTEMP,WASCAP,H2DM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00036210
3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00036220
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00036230
1 ,DCTTST,CSTMTC,CSTSIT,CSTSC,CSTEM,CSTCN,PREXT,PREXTI,SKRCST 00036240
2 ,CSTIN,EXTRA1,CSTSTR,CSTSCR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT00036250
3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN, 00036260
4 ,TOTECLC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00036270
5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00036280
6 ,EQVCPA,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00036290
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB 00036300
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00036310
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00036320
COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00036330
COMMON/INT/IDEBUG,NRES(8),NUNIT,III.NSET,JPIK,IYEAR,NUMBRN,NPRTS 00036340
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00036350
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK 00036360
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6) 00036370
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00036380
1 ,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00036390
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00036400
3 ,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825, TI,HS,UTB, HM1, HM2 00036410
WRITE(6,20) TOTLAB,TTMAIN,TOTECLC,TOTH20,TTFUEL,TTWSTD,TTCAUS 00036420
WRITE(6,130) TTOPR 00036430
20 FORMAT(10X,'LABOR',30X,F12.2/10X,'MAINTENENCE',30X,F12.2/ 00036440
110X,'UTILITIES'/ 00036450
215X,'ELECTRICITY',30X,F12.2/15X,'WATER',36X,F12.2/ 00036460
315X,'FUEL',30X,F12.2/15X,'SOLID WASTE DISPOSAL',30X,F12.2/ 00036470
415X,'CAUSTIC LIME',30X,F12.2) 00036480
130 FORMAT(10X,'***TOTAL - ',30X,F12.2) 00036490
RETURN 00036500
END 00036510
SUBROUTINE OUTPS(NPRD) 00036520
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00036530
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00036540
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00036550
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00036560
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00036570
4,CUTVN,CMBST,TCH 00036580
3,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825, TI,HS,UTB, HM1, HM2 00036590
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00036600
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00036610
2 ,SCRNME*20 00036620
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00036630
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00036640
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAB,ZLFD2(9,9) 00036650
COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00036660
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00036670
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00036680

```

```

1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS      00036690
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00036700
3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN    00036710
COMMON/COST/ SHLCST,DRV CST,BRK TOT,ASHCST,STM CST,DCTCST(9)        00036720
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9)           00036730
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTR CST,DSPCST,CSTE LC,DPTO T00036740
1,AOP,WATRAT,TOTDP,NTU,ADQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00036750
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME                00036760
3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO       00036770
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK      00036780
1 ,DCTTST,CSTMTB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXTI,SKRCST        00036790
2 ,CSTIN,EXTRA1,CSTSTR,CSTSCR,CSTS PR,CSTCRT,CSTENG,DCDIA(9),CSTINT00036800
3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,               00036810
4 TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR,                         00036820
5 TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,     00036830
6 EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK                      00036840
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB                  00036850
1 .FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS                      00036860
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP            00036870
COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9)                 00036880
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS   00036890
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00036900
1 ,PCKCHS(4),PCKNM(7,4),DCMATL(9),MTLDCT,MTLBRK                  00036910
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)                         00036920
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00036930
1 ,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00036940
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00036950
3 ,KRB,FXH,S316,S304,S347,NI200,MD0400,IN600,IN825, TI,HS,UTB,HM1,HM2 00036960
ANSWER =EQVREV-EQVOPR-EQVCAP                                     00036970
TOT= TTOPR+DEPREC+TAX+ZINSUR                                    00036980
WRITE(6,10) TOTTOT,TTOPR,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT 00036990
WRITE(6,20) EQVOPR,EQVREV,EQVCAP,EQVFIN                        00037000
WRITE(6,30) ANSWER                                            00037010
10 FORMAT(10X,'CAPITAL COST',20X,F12.2/10X,'-----'//          00037020
1 10X,'OPERATING COST',20X,F12.2/10X,'DEPRICINATION COST',15X, 00037030
2 F12.2/10X,'TAXES(2% OF CAPITAL COTS)',20X,F12.2/              00037040
3 10X,'INSURANCE(.6% OF CAPTIAL COST)',20X,F12.2//             00037050
4 15X,'TOTAL COST-',20X,F12.2)                                 00037060
20 FORMAT(10X,'ANNUALIZED OPERATING COST',20X,F12.2/             00037070
1 10X,'ANNUALIZED REVENUES',20X,F12.2/ 10X,'ANNUALIZED EQUIPMENT', 00037080
2 ' COST',20X,F12.2/10X,'FINANCE CHARGES',20X,F12.2)           00037090
30 FORMAT(10X,'ANNUAL EQUIVALENT',20X,F12.2/10X,'REVENUES GENERATED') 00037100
RETURN                                                       00037110
END                                                       00037120
SUBROUTINE LABOR                                         00037130
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD            00037140
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS      00037150
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00037160
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00037170
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00037180
4 ,CUTVN,CMBST,TCH                                         00037190
3 ,KRB,FXH,S316,S304,S347,NI200,MD0400,IN600,IN825, TI,HS,UTB,HM1,HM2 00037200
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00037210
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00037220
2 ,SCRNME*20                                              00037230
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00037240
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00037250
2 ,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9) 00037260
COMMON/PCKBED/ PSIZE(7),PKCSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00037270
1 ,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00037280
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9).DP(9),TTL(9),HTC 00037290
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00037300
2 ,HTCCMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00037310
3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00037320
COMMON/COST/ SHLCST,DRV CST,BRK TOT,ASHCST,STM CST,DCTCST(9) 00037330
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9)        00037340
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTR CST,DSPCST,CSTE LC,DPTO T00037350
1 ,AOP,WATRAT,TOTDP,NTU,ADQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00037360
2 ,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME            00037370
3 ,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00037380
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00037390
1 ,DCTTST,CSTMTB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXTI,SKRCST        00037400

```

```

2 .CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPr,CSTCRT,CSTENG,DCDIA(9),CSTINT00037410
3 .DSDIA(9),CSTL0D,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,          00037420
4  TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR,          00037430
5  TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,  00037440
6  EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK          00037450
COMMON/UPDATE/  FACCES,FACMSC,FACCEE,FACCEF,FACCEB          00037460
1.  FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS          00037470
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00037480
COMMON/DCT/  ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9)      00037490
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00037500
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5).UNIT(20),SUNIT(11) 00037510
1,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK        00037520
2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)                00037530
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00037540
1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00037550
2,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00037560
3,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825,TI,HS,UTB,HM1,HM2 00037570
PSUPS=0.0                                              00037580
TEKC=7.00                                             00037590
SECC=7.00                                             00037600
SUPC=8.00                                             00037610
PCHEMS=0.0                                            00037620
ZTOT=0.0                                              00037630
YARDS=0.0                                              00037640
IF(MASSSL.GT.1000.0) GOTO 10                         00037650
C   SALARY    BASE SALARY # REQUIRED OPER(HR/DAY) PERCENT BENIFIT00037660
C   $           $/HR      WHEN OPER. *(DAY/YR) TIME NEEDED FACTOR00037670
  LTEKS= TEKC*   1.0*     8.0*YEAR*  1.00*   1.20  00037680
  COPERS= SUPC*   0.0*     DAY*YEAR*  0.50*   1.19  00037690
  OPERS= TEKC*   1.0*     DAY*YEAR*  1.00*   1.20  00037700
  YARDS= TEKC*   1.0*     8.00*YEAR* 1.00*   1.44  00037710
  SECS = SECC*   1.0*     8.0*YEAR*  0.50*   1.44  00037720
  ZTOT=LTEKS+COPERS+OPERS+YARDS+SECS               00037730
  PSUPS=ZTOT*0.20                                     00037740
  NTEK=1.0                                           00037750
  NOPER=1.0                                         00037760
  NYARD=1.0                                         00037770
  NSEC=1.0                                           00037780
  GOTO 50                                           00037790
10 IF(MASSSL.GT.10000.) GOTO 20                      00037800
  LTEKS= TEKC*   1.0*     8.0*YEAR*  1.00*   1.20  00037810
  COPERS= SUPC*   1.0*     365.*DAY * 0.50*   1.19  00037820
  OPERS= TEKC*   2.0*     365.0*DAY * 1.00*   1.20  00037830
  YARDS= TEKC*   2.0*     8.0*YEAR*  1.00*   1.44  00037840
  SECS = SECC*   1.5*     8.0*YEAR*  0.50*   1.44  00037850
  ZTOT= LTEKS+COPERS+OPERS+YARDS+SECS              00037860
  PSUPS=ZTOT*0.20                                     00037870
  NTEK=1.0                                           00037880
  NOPER=2.0                                         00037890
  NYARD=2.0                                         00037900
  NSEC=1.5                                           00037910
  PCHEMS=ZTOT*0.20                                    00037920
  GOTO 50                                           00037930
20 CONTINUE                                         00037940
  LTEKS= TEKC*   2.0*     8.0*YEAR*  1.00*   1.20  00037950
  COPERS= SUPC*   1.0*     365.*DAY * 0.50*   1.19  00037960
  OPERS= TEKC*   4.0*     365.0*DAY * 1.00*   1.20  00037970
  YARDS= TEKC*   3.0*     8.0*YEAR*  1.00*   1.44  00037980
  SECS = SECC*   2.0*     8.0*YEAR*  0.50*   1.44  00037990
  ZTOT= LTEKS+COPERS+OPERS+YARDS+SECS              00038000
  PSUPS=ZTOT*0.20                                     00038010
  NTEK=2                                              00038020
  NOPER=4                                            00038030
  NYARD=3                                            00038040
  NSEC=2                                              00038050
  PCHEMS=ZTOT*0.20                                    00038060
50 CONTINUE                                         00038070
  LTEKS=LTEKS*268.50/268.5                           00038080
  COPERS=COPERS*268.50/268.5                        00038090
  YARDS=YARDS*268.50/268.5                          00038100
  SECS=SECS*268.50/268.5                           00038110
  OPERS=OPERS*268.50/268.5                         00038120

```

```

PCHEMS=PCHEMS*268.50/268.5          00038130
ZTOT=ZTOT*268.50/268.5            00038140
SUPP= ZTOT*0.20*268.50/268.5       00038150
PAYEXP=ZTOT*0.30*268.50/268.5      00038160
IF(IDEBUG.GT.1) WRITE(6,100) TEKC,SUPC,SECC,MASSSL,DAY,YEAR 00038170
TOTLAB=ZTOT+PCHEMS+SUPP+PAYEXP    00038180
100 FORMAT(5X,'OPERATING LABOR DEBUG OUTPUT FOR INPUT DATA'/8X, 00038190
1'BASE TECHNICIAN SALARY ($/HR)= ',F7.2,5X,'SUPERVISORS BASE SALARY 00038200
2($/HR)= ',F7.2,5X/8X,'SECRETARY SALARY ($/HR)= ',F7.2/8X, 00038210
3'MASS RATE OF INLET SLUDGE (LB/HR)= ',E15.4/8X,'OPERATING HOURS PE 00038220
4 R DAY= ',F7.2,5X,'OPERATING DAYS PER YEAR= ',F7.2) 00038230
WRITE(6,201) 00038240
201 FORMAT('1') 00038250
WRITE(6,200) PSUPS,PCHEMS,LTEKS,NTEK,COPERS,OPERS,NOPER,YARDS 00038260
1,NYARD,SECS,NSEC,PAYEXP,SUPP,TOTLAB 00038270
200 FORMAT(25X,'OPERATING LABOR OUTPUT'//10X,'SUPERVISOR SALARY($/YR)= 00038280
1 ',15X,F9.0/10X,'LABORATORY SUPERVISOR($/YR)= ',11X,F9.0/ 00038290
2 10X,'LABORATORY TECHNICIANS SALARY($/YR) = ',F9.0,1X,'FOR',I2, 00038300
3 ' LAB TECHNICIANS'/10X.'CHIEF OPERATORS SALARY($/YR) = ',9X,F9.0/00038310
410X, 'OPERATORS SALARY($/YR) = ',15X,F9.0,' FOR',I2,' OPERATORS 00038320
4. /' 00038330
5 10X,'YARD WORKERS SALARY($/YR) = ',12X,F9.0,' FOR',I2,' WORKERS. 00038340
5/' 00038350
6 10X,'SECRETARIES SALARY($/YR) = ',13X,F9.0,' FOR',I2,' SECRETAR' 00038360
6.'IES'/' 00038370
7 10X,'PAYROLL EXPENSES(20% OF LABOR=' ,10X,F9.0/10X,'COST IN $/YR) 00038380
7 '/' 00038390
8 10X,'SUPPLIES AND OTHER MISC.($/YR)= ',8X,F9.0/ 00038400
8 10X,'-----', 00038410
9'-----'/10X,'TOTAL EXPENSES($/YR)= ',18X,F9.0/00038420
A//) 00038430
RETURN 00038440
END 00038450
SUBROUTINE OPERAT 00038460
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00038470
1 .XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00038480
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00038490
1 .IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00038500
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00038510
4,CUTVN,CMBST,TCH 00038520
3,KRB,FXH,S316,S304,S347,NI200,MD400,ING600,IN825, TI,HS,UTB,HM1,HM2 00038530
CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTMNE*5 00038540
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00038550
2 ,SCRNME*20 00038560
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL. 00038570
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00038580
2 ,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9) 00038590
COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00038600
1 ,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00038610
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00038620
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00038630
2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00038640
3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTD,TLTOT,TOTMAN 00038650
COMMON/COST/ SHLCST,DRVCST,BRKTO,TASHCST,STMCST,DCTCST(9) 00038660
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00038670
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTD00038680
1 ,AOP,WATRAT,TOTDP,NTU,AQQ,CSTSTD,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00038690
2 ,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00038700
3 ,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO 00038710
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK 00038720
1 ,DCTTST.CSTMTC,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST 00038730
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPPR,CSTCRT,CSTENG,DCDIA(9),CSTINT00038740
3 ,DSDIA(9),CSTLDD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN. 00038750
4 TOTELC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR, 00038760
5 TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV, 00038770
6 EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK 00038780
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEB 00038790
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS 00038800
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP 00038810
COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9) 00038820
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00038830
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00038840

```

```

1,PCKCHS(4),PCKNAME(7,4),DCMATL(9),MTLDCT,MTLBRK          00038850
2,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)                  00038860
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI
1,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00038880
2,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN  00038890
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TD,HS,UTB,HM1,HM2  00038900
CSTBAS=CSTBAS*DAY*YEAR                                     00038910
WSTOPR=-O.00018*WTRTOT/62.4/35.45*264./.60.0+2.15        00038920
WSTOPR=WSTOPR*WTRTOT/62.4/35.45*264./.1000.0*DAY*YEAR      00038930
CSTST=(CSTINC+AFTINC)*O.02+(CSTHTR+CSTQUE+CSTVEN+CSTPAK)*O.01 00038940
1 +(CSTFAN+CSTSTK)*O.01                                    00038950
00038960

CSTFUL=FLTOT*CSTFUL*DAY*YEAR                           00038970
CSTH20=WTRTOT*WTRCST*DAY*YEAR                         00038980
CSTDSP=ASH*DSPCST*DAY*YEAR                           00038990
CALL LABOR                                              00039000
TAX=TOTTOT*O.02                                         00039010
ZINSUR=TOTTOT*O.006                                      00039020
CSTLEC=TOTELC=CSTELC                                    00039030
00039040

C C EPA HAZARDOUS WASTE INCINERATION TESTS             00039050
C COST 20000 DOLLARS PER RUN LASTING 22 HOURS         00039060
C 00039070

RECSTM=STMREC*DAY*YEAR*(-1.0)                          00039080
TTOPR= TOTLAB+CSTLEC+CSTFUL+CSTH20+CSTDSP+ZINSUR+RECSTM 00039090
1 +TOTMAN+CSTSTR+CSTBAS+DEPREC+WSTOPR                 00039100
WRITE(6,10)                                            00039110
10 FORMAT('1',30X,'ANNUAL OPERATING COSTS')            00039120
WRITE(6,20) (WSTNME(I),I=1,6)                         00039130
20 FORMAT(30X,6(A5))                                    00039140
WRITE(6,30)MASSSL                                     00039150
30 FORMAT(30X,'FEED RATE ',F7.0,' LB/HR//')           00039160
WRITE(6,40) TOTLAB                                     00039170
40 FORMAT(10X,'LABOR ',32X,F12.0/)                   00039180
WRITE(6,50) CSTLEC,CSTFUL,CSTH20,CSTDSP,CSTBAS       00039190
50 FORMAT(10X,'UTILITIES'/15X,'-----'/15X,          00039200
1 'ELECTRICITY ',21X,F12.0/                          00039210
2 15X,'FUEL',29X,F12.0/                            00039220
3 15X,'WATER',28X,F12.0/                           00039230
4 15X,'WASTE DISPOSAL',19X,F12.0/                 00039240
5 15X,'BULK LIME',24X,F12.0/)                      00039250
WRITE(6,101) WSTOPR                                    00039260
101 FORMAT(15X,'WASTE WATER TREATMENT',12X,F12.0/)    00039270
WRITE(6,100) CSTSTR                                    00039280
100 FORMAT(10X,'STARTUP COSTS ',24X,F12.0/)          00039290
110 FORMAT(10X,'ANNUAL MAINTENENCE',20X,F12.0)        00039300
WRITE(6,111) ZINSUR                                  00039310
111 FORMAT(10X,'INSURANCE COST'                      00039320
1, 24X,F12.0//)                                     00039330
WRITE(6,110) TOTMAN                                 00039340
IF(ROTARY) WRITE(6,120)                             00039350
IF(FLUID) WRITE(6,130)                            00039360
IF(LIQI) WRITE(6,140)                            00039370
120 FORMAT(15X,'ROTARY KILN (10% EQUIPMENT',/15X,'COST')/) 00039380
130 FORMAT(15X,'FLUIDIZED BED (7% EQUIPMENT'/15X,'COST')/) 00039390
140 FORMAT(15X,'LIQUID INJECTION INCINERATOR (5%'/15X,'COST')/) 00039400
WRITE(6,150) RECSTM                                00039410
150 FORMAT(10X,'HEAT RECOVERY UNIT',20X,F12.0/15X,'(80% EFFICIENCY)') 00039420
WRITE(6,160) TTOPR                                 00039430
160 FORMAT(40X,'-----'/10X,'TOTAL OPERATING COST',18X00039440
1 ,F12.0///)                                     00039450
RETURN                                              00039460
END                                                 00039470
SUBROUTINE STACK(NPRD)                            00039480
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00039490
1 ,XXFUEL,XXAIR,MASSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00039500
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00039510
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00039520
2 ,SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00039530
4,CUTVN,CMBST,TCH                                00039540
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TD,HS,UTB,HM1,HM2  00039550
CHARACTER BRIKNM=4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00039560

```

```

1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2      00039570
2 ,SCRNME*20
COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL,          00039580
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP          00039590
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9)           00039600
COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL           00039610
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00039630
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC          00039640
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS          00039650
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST        00039660
3,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN          00039670
COMMON/COST/ SHLCST,DRVCST,BRKTOT,ASHCST,STM CST,DCTCST(9)             00039680
1,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9)                00039690
COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTEBC,DPTOT00039700
1,AOP,WATRAT,TOTDP,NTU,AQ,CS TSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100)        00039710
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME                      00039720
3,QSAT,VENH20,DAMPY(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO            00039730
COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK           00039740
1 ,DCTTST,CSTM TB,CSTSIT,CSTSTC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST         00039750
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTS PR,CSTCRT,CSTENG,DCDIA(9),CSTINT00039760
3 ,DSDIA(9).CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,                   00039770
4 ,TOTE LC,TOTH20,TTFUEL,TTWSTD,TTCAUS,TTOPR,                            00039780
5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,          00039790
6 ,EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK                         00039800
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEB,FACCEB                         00039810
1 .FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS                           00039820
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP                  00039830
COMMON/DCT/ EBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9)                         00039840
COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS          00039850
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11)        00039860
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK                         00039870
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)                                00039880
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00039890
1 ,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00039900
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN        00039910
3 ,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2        00039920
C
C   INITIALIZE VARIABLES                                         00039930
IF(METRIC) CALL ENG(NREAC,NPRD)
DO 45 I=1,NPRD
  MLPRDT(I,III)=MLPRDT(I,III-1)
45 CONTINUE
CALL VL RATE(T1,PINC,NPRD)
C   VEL IN FT/MIN                                         00040000
VEL=9000.0
00040010
STKMAS=MSTOT(III)
RHO=MSTOT(III)/VOLRAT(III)
00040020
DIA(III)=(STKMAS/60.0*4.0/RHO/VEL)**(0.5)
00040030
HEIGHT=100.0
00040040
ZNUM=1.0
00040050
DIA(III)=DIA(III)*12.0
00040060
IF(HEIGHT.GT.200.0) GOTO 550
00040070
105 IF(DIA(III).LT.60.0) GOTO 100
00040080
IF(IDEBUG.GT.5) WRITE(6,200) DIA(III)
00040100
200  FORMAT(10X,'STACK DIA(III) METER IS TO LARGE AT ',F7.2,' INCHES')00040110
1'
ZNUM=ZNUM+1.
00040120
STKMAS=MSTOT(III)/ZNUM
00040140
210  FORMAT(10X,F3.0,'STACKS WILL BE DESIGNED')
00040150
WRITE(6,210) ZNUM
00040160
GOTO 105
00040170
100 IF(DIA(III).LE.54.0) GOTO 115
00040180
CSTSTK=1265.0+87.4*HEIGHT
00040190
GOTO 500
00040200
115 IF(DIA(III).LE.48.0) GOTO 120
00040210
CSTSTK=1265.0+83.9*HEIGHT
00040220
GOTO 500
00040230
120 IF(DIA(III).LE.42.0) GOTO 125
00040240
CSTSTK=1035.+79.3*HEIGHT
00040250
GOTO 500
00040260
125 IF(DIA(III).LE.36.0) GOTO 130
00040270
CSTSTK=977.+70.0*HEIGHT
00040280

```

```

        GOTO 500                               00040290
130 IF(DIA(III).LE.30.0) GOTO 135          00040300
        CSTSTK=862.+65.5*HEIGHT               00040310
        GOTO 500                               00040320
135 IF(DIA(III).LE.24.0) GOTO 140          00040330
        CSTSTK=862.+59.8*HEIGHT               00040340
        GOTO 500                               00040350
140 CSTSTK=862.0+49.4*HEIGHT               00040360
        GOTO 500                               00040370
550 DIA(III)=DIA(III)/12.0                 00040380
560 IF(DIA(III).LE.40.0) GOTO 145          00040390
        ZNUM=ZNUM+1                           00040400
        WRITE(6,220) DIA(III),ZNUM             00040410
220 FORMAT(10X,'DIA(III) METER OF SATELLITE IS TOO LARGE AT',F10.2,'AND'
1 ',F3.0,'STACKS WILL BE DESIGNED')       00040420
        GOTO 560                               00040430
        00040440
145 IF(DIA(III).LE.30.0) GOTO 150          00040450
        CSTSTK=1000.0*(0.0097*HEIGHT+1.14)   00040460
        GOTO 500                               00040470
150 IF(DIA(III).LE.20.) GOTO 155           00040480
        CSTSTK=1000.0*(0.083*HEIGHT-1.063)   00040490
        GOTO 500                               00040500
155 IF(DIA(III).LE.15) GOTO 160            00040510
        CSTSTK=1000.0*(0.0085*HEIGHT-1.30)   00040520
        GOTO 500                               00040530
160 CSTSTK=1000.0*(0.0051125*HEIGHT-0.7725) 00040540
500 CSTSTK=CSTSTK=ZNUM                     00040550
        NNUM=ZNUM                             00040560
        CSTSTK=CSTSTK/228.0*FACCES            00040570
        FLGPAS=.FALSE.                         00040580
        CSTIIN=CSTIIN+0.57*CSTSTK             00040590
        IF(IDEBUG.GT.5)WRITE(6,620) CSTSTK,DIA(III),HEIGHT,NNUM      00040600
620 FORMAT(10X,'THE TOTAL COST OF THE STACK IS '/10X,F12.2,'U.S.',
1 ' DOLLARS DIAMETER OF STACK IS ',F12.2,'INCHES'/10X,
2 ' HEIGHT OF STACK IS ',F12.2,'AND ',I3,' STACKS ARE DESIGNED')
        DIA(III)=DIA(III)/12.0                00040610
        WRITE(6,300) HEIGHT,DIA(III),STKMAS,NNUM,VEL              00040620
        00040630
300 FORMAT(35X,'EXHAUST STACK DESIGN DATA OUTPUT'
1 15X,'HEIGHT OF EXHAUST STACK=          ',F10.2,' FEET'/
2 15X,'DIAMETER OF EXHAUST STACK=        ',F10.2,' FEET'/
3 15X,'MASS OF STACK=                   ',F10.2,' LBS'/
4 15X,'NUMBER OF STACKS=                  ',I4/
5 15X,'EXIT VELOCITY OF GAS IN STACK=    ',F10.2,' FEET/MINUTE') 00040640
        TOTMAN=TOTMAN+CSTSTK*0.05             00040650
        RETURN                                00040660
        END                                   00040670
        SUBROUTINE METRC(NREAC,NPRD)           00040680
        REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD      00040690
1 .XXFUEL.XXAIR.MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00040700
        LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00040710
1 .IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00040720
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00040730
4 CUTVN,CMBST,TCH                          00040740
3,KRB,FXH,S316,S304,S347,NI200,MO400,IN600,IN825,TI,HS,UTB,HM1,HM2 00040750
        CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00040760
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00040770
2 ,SCRNME*20                               00040780
        COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00040790
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00040800
2 ,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLF2(9,9) 00040810
        COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00040820
1 ,VISCG,EFFABS,TOCDST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT 00040830
        COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00040840
1 .BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00040850
2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00040860
3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00040870
        COMMON/COST/ SHLCST,DRVCS,CRKTOT,ASHCST,STMCST,DCTCST(9) 00040880
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00040890
        COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DPTD 00040900
1 ,AOP,WATRAT,TOTDP,NTU,ADQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00040910
2 ,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME 00040920
3 ,QSAT,VENH20,DAMP(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPND 00040930
        00040940
        00040950
        00040960
        00040970
        00040980
        00040990
        00041000

```

```

COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK    00041010
1 ,DCTTST,CSTMTC,CSTSIT,CSTSC,CSTEM,CSTCNT,PREXT,PREXTI,SKRCST    00041020
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT00041030
3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,            00041040
4 TOTELC,TOTH2O,TTFUEL,TTWSTD,TTCAUS,TTOPR,                      00041050
5 TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVOPR,EQVREV,    00041060
6 EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK                      00041070
COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEB,FACCEB                 00041080
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS                     00041090
COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP           00041100
COMMON/DCT/ ELBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9)                  00041110
COMMON/INT/ IDEBUG,NRES(8),NUNIT,III,NSET,UPIK,IYEAR,NUMBRN,NPRTS  00041120
COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00041130
1 ,PCKCHS(4),PCKNM(7,4),DCMATL(9),MTLDCT,MTLBRK                00041140
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)                         00041150
COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI00041160
1 ,IC,TCG,SSG,VOLTL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS00041170
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00041180
3 ,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00041190
   MASSL=MASSL/2.20467*1000.0                                     00041200
   H2OM=H2OM/2.20467*1000.0                                     00041210
   VAPNO=VAPNO/2.20467*1000.0                                     00041220
   MASSFL=MASSFL/2.20467*1000.0                                     00041230
   FLTOT=FLTOT/2.20467*1000.0                                     00041240
   WTRTOT=WTRTOT/2.20467*1000.0                                     00041250
   MASSAR=MASSAR/2.20467*1000.0                                     00041260
   VOLIT=VOLIT/2.20467*1000.0                                     00041270
   ASH=ASH/2.20467*1000.0                                         00041280
   FREH2O=FREH2O/2.20467*1000.0                                     00041290
   ZFLHT=ZFLHT/0.453/1000.0/9.486E-4                                00041300
   ZSLHT=ZSLHT/0.453/1000.0/9.486E-4                                00041310
   PINC=PINC/14.696                                                 00041320
C   CONVERT HEAT OF VAPORIZATION OF H2O FROM BTU/LB(INPUT)          00041330
C   TO J/G.                                                       00041340
   DELTAH=DELTAH/9.486E-4                                         00041350
   HTCOMB=HTCOMB/9.486E-4/453.96                                    00041360
   T1=(T1-32.0)/1.8                                              00041370
   T2=(T2-32.0)/1.8                                              00041380
   TA=(TA-32.0)/1.80                                             00041390
   DO 20 J=1,NUNIT                                              00041400
C   CONVERT VOLRAT FROM FT^3/TIME TO M^3/TIME                      00041410
   VOLRAT(J)=VOLRAT(J)*0.028317                                    00041420
C
   TTMP(J)=(TTMP(J)-32.0)/1.8                                      00041430
   MSTOT(III)=MSTOT(III)*453.96                                    00041440
   DO 10 I=1,NPRD                                              00041450
   MLPRT(I,J)=MLPRT(I,J)*453.96                                  00041460
10 CONTINUE                                              00041470
20 CONTINUE                                              00041480
   DO 40 JJ=1,NPRD                                              00041490
   FEED(JJ)=FEED(JJ)*453.96                                    00041500
40 CONTINUE                                              00041510
   ENGL=.FALSE.                                                 00041520
   METRIC=.TRUE.                                                 00041530
   RETURN                                                   00041540
   END                                                       00041550
   SUBROUTINE ENG(NREAC,NPRD)                                     00041560
   REAL MSSLUD,MSTOT,MLPRT,TTMP,MSFUEL,MSAIR,XXSLUD             00041580
1 ,XXFUEL,XXAIR,MASSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS        00041590
   LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00041600
1 ,IC,SSG,VOLTL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00041610
2 ,SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00041620
4 ,CUTVN,CMBST,TCH                                         00041630
3 ,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM2 00041640
   CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00041650
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00041660
2 ,SCRNME*20                                               00041670
   COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSL,MASSFL, 00041680
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00041690
2 ,VOLIT,ASH,FREH2O,HTCNT,FULC,FEED(15),TA,DELTAB,ZLF2(9,9)    00041700
   COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH2O,RHOL,RHO,VISCL 00041710
1 ,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT00041720

```

```

COMMON/DES/RLD(9), DESVOL(9), TKOND(9), EXCESS(9), DP(9), TTL(9), HTC
1 , BCOST(8), TLIM(8), ZLOSS, TTMP(9), DIABRK, CSTTRT, RETIM(9), FANCLS
2 , HTCOMB, AREA(9), VOLRAT(9), REPCST, HPTOT, TOTCAP, STMREC, YRNUM, RTINST
3 , INCLEN(9), MSTOT(9), MLPRDT(15,9), PINC, PEXT, WTRTOT, FLTOT, TOTMAN
COMMON/COST/ SHLCST, DRVCST, BRKTOT, ASHCST, STM CST, DCTCST(9)
1 , CSTFUL, DFHCLL, DFHCLG, EXTRA, CSTINC, WTPRT(100), EXFUEL(9)
COMMON/INPUT/ CP(6,15), PRDMW(15), HEIGHT, WTRCST, DSPCST, CSTECL, DPTOTOOO41790
1 , AOP, WATRAT, TOTDP, NTU, AQ, CSTSTO, ASHGAS, PERUPT, FEDRG2, DIAPT(100)
2 , QTEMP, WASCAP, H2OM, VENWAT, CLMS, HCLRM, ELEVAT, CSTLME
3 , QSAT, VENH20, DAMPT(10), DCIBC(10), CSTBAS, EXTRA2, DIFH20, VAPNO
COMMON/DUTPUT/ AFTINC, CSTHTR, CSTQUE, CSTVEN, CSTPAK, CSTFAN, CSTSTK
1 , DCTTST, CSTMTB, CSTSIT, CSTSTC, CSTEM, CSTCNT, PREXT, SKRCST
2 , CSTIIN, EXTRA1, CSTSTR, CSTSCR, CSTSPR, CSTCRT, CSTENG, DCDIA(9), CSTINTOOO41850
3 , DSDIA(9), CSTLOD, DCTBCS(9), TDCTCS(9), TOTLAB, TTMAIN,
4 , TOTELC, TOTH20, TTFUEL, TTWSTD, TTCAUS, TTOPR,
5 , TOTTOT, DEPREC, EQV PFT, REVLB, CONTEM, ZINSUR, TOT, EQVOPR, EQVREV,
6 , EQVCP, FINCRG, REFIN, THCKIN, EQVFIN, DCBRIK
COMMON/UPDATE/ FACCES, FACMSC, FACCEE, FACCFF, FACCEB
1 , FACPVF, FACPC, FACPI, FACENG, FACLAB, FACPRS
COMMON/SALARY/TEKC, SUPC, SECC, DAY, YEAR, ZTOT, SUPP, PAYEXP
COMMON/DCT/ ELBNUM(9), DCTLEN(9), DCTVEL(9), DIA(9)
COMMON/INT/IDEBUG, NRES(8), NUNIT, III, NSET, JPIK, IYEAR, NUMBRN, NPRTS
COMMON/ALPHA/MATL(20), BRIKNM(6,8), FUELNM(4,5), UNIT(20), SUNIT(11)
1 , PCKCHS(4), PCKNM(7,4), DCMATL(9), MTLDC, MTLBK
2 , WSTNME(6), BNMFR(6), BNMN(6), SCRNM(6)
COMMON/LOGIC/ROTARY, FLUID, LIQI, METRIC, ENGL, LCOST, HTLS, RECT, BAL, PRI00041980
1 , IC, TCH, SSG, VOLTIL, BARREL, SEMI, DCTFLG, SS, CS, DIC, DSS, DCS, DWC, FLGPAS00041990
2 , SLD, SCRW, VENAUT, FG, BRN, ADIA, PLASMA, SIEVE, VALVE, CMBST, LQD, CUTVN
3 , KRB, FXH, S316, S304, S347, NI200, MD400, IN600, IN825, TI, HS, UTB, HM1, HM2
MASSSL=MASSSL*2.20467/1000.0
H2OM=H2OM*2.20467/1000.0
VAPNO=VAPNO*2.20467/1000.0
MASSFL=MASSFL*2.20467/1000.0
FLTOT=FLTOT*2.20467/1000.0
WTRTOT=WTRTOT*2.20467/1000.0
MASSAR=MASSAR*2.20467/1000.0
VOLIT=VOLIT*2.20467/1000.0
ASH=ASH*2.20467/1000.0
FREH20=FREH20*2.20467/1000.0
ZFLHT=ZFLHT*0.453*1000.0*9.486E-4
ZSLHT=ZSLHT*0.453*1000.0*9.486E-4
PINC=PINC*14.696
DELTAH=DELTAH*9.486E-4
HTCOMB=HTCOMB*9.486E-4*453.96
T1=T1*1.8+32.
T2=T2*1.80+32.0
TA=TA*1.80+32.0
DO 20 J=1,NUNIT
    TTMP(J)=TTMP(J)*1.8+32.0
    VOLRAT(J)=VOLRAT(J)/0.028317
    MSTOT(III)=MSTOT(III)/453.96
DO 10 I=1,NPRD
    MLPRDT(I,J)=MLPRDT(I,J)/453.96
10 CONTINUE
20 CONTINUE
DO 40 JJ=1,NPRD
    FEED(JJ)=FEED(JJ)/453.96
40 CONTINUE
METRIC=.FALSE.
ENGL=.TRUE.
RETURN
END
FUNCTION FXPACK(X,Y)
LOGICAL Y
IF(Y) GOTO 10
C BERL SADDLE PACKING FACTOR
    FXPACK=9558.4-37171.2*X+50495.3*X**2.0-28383.5*X**3.0
    1 +5620.97*X**4.0
    RETURN
10 FXPACK=3714.4-17151.2*X+34461.1*X**2.-34065.6*X**3.+14944.*X**4.
    1 -278.7*X**5.-1866.2*X**6.+364.04*X**7.+69.6*X**8.-19.18*X**9.
    RETURN

```

```

        END
        FUNCTION FX1(X)                                00042450
        IF(X.GT.1.0.AND.X.LE.8.0) FX1=0.0236-7.42E-2*X+5.94E-4*X**2. 00042460
C  LOBO CORELATION FROM MODERN POLLUTION CONTROL TECHNOLOGY 23.41 00042470
C  FIG 145.                                              00042480
        IF(X.GT.0.10.AND.X.LE.1.0) FX1=0.112-0.219*X+0.131*X**2. 00042490
        IF(X.GT.0.01.AND.X.LE.0.1) FX1=0.2827-3.981*X+22.91*X**2. 00042500
        IF(X.GT.8.0.OR.X.LE.0.01) FX1=.05               00042510
        RETURN
        END
        FUNCTION FX3(X,Y)                                00042520
        LOGICAL Y                                         00042530
        IF(X.LT.5.0.OR.X.LT.100.0) WRITE(6,20)           00042540
20 FORMAT(10X,'PACK BED DIAMETER IS OUT OF RANGE FOR ACCURATE CALCS') 00042550
        IF(Y) GOTO 10
          FX3=24.285+7.707*X-3.546E-4*X**2.+3.095E-4*X**3. 00042560
        RETURN
10   FX3=28.91+22.027*X-0.16561*X**2.+2.92E-3*X**4. 00042570
C  COST OF PACKED TOWER PER FT OF HEIGHT.            00042580
C  FROM M.P.C.T. VOL 1, 23.40 FIGURE 144            00042590
        RETURN
        END
        FUNCTION FANFXN(X,Y)                                00042600
        A=LOG(X)                                         00042610
        IF(Y.LT.1800.0) GOTO 10
        B=4.546+0.125*A+0.103*A**2.0                 00042620
        FANFXN=EXP(B)                                     00042630
        GOTO 100
10   IF(Y.LT.1200) GOTO 20
        B=4.721+0.225*A+0.093*A**2.0                 00042640
        FANFXN=EXP(B)                                     00042650
        GOTO 100
20   IF(Y.LT.900) GOTO 30
        B=5.924-0.185*A+0.159*A**2.0                 00042660
        FANFXN=EXP(B)                                     00042670
        GOTO 100
30   IF(Y.LT.600) WRITE(6,200)                      00042680
200  FORMAT(10X,'RPM SPEED IS TOO LOW IN THE FUNCTION') 00042690
        B=4.337+0.088*A+0.0965*A**2.0                 00042700
        GOTO 100
100  FANFXN=EXP(B)                                     00042710
        IF(IDEBUG.GE.0) WRITE(6,300) Y,X,FANFXN         00042720
300  FORMAT(10X,'MOTOR RPMs= ',F10.2/              00042730
        1      10X,'GAS VOLUME RATE= ',F10.2,'FT^3/MIN/1000' 00042740
        2      10X,'COST OF MOTOR= ',F10.2,'U.S. DOLLARS') 00042750
        RETURN
        END
        SUBROUTINE CAPTAL
        REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00042760
1 ,XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00042770
        LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00042780
1 .IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00042790
2 .SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00042800
4 ,CUTVN,CMBST,TCH
3 ,KRB,FXH,S316,S304,S347,NI200,M0400,IN600,IN825,TI,HS,UTB,HM1,HM2 00042810
        CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5 00042820
1 .BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2 00042830
2 .SCRNME*20
        COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL, 00042840
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP 00042850
2 ,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9) 00042860
        COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL 00042870
1 ,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKAGR(7,4),Z,CSTINS,TBRNTT 00042880
COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC 00042890
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS 00042900
2 ,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00042910
3 ,INCLEN(9),MSTOT(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN 00042920
        COMMON/COST/ SHLCST,DRV CST,BRKTOT,ASHCST,STM CST,DCTCST(9) 00042930
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9) 00042940
        COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTRCST,DSPCST,CSTECL,DP 00042950
1 ,ADP,WATRAT,TOTDP,NTU,AQ,CSSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00042960
2 ,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLM 00042970

```

```

3.QSAT, VENH20, DAMPT(10), DCIBC(10), CSTBAS, EXTRA2, DIFH20, VAPNO      00043170
  COMMON/OUTPUT/ AFTINC, CSTHTR, CSTQUE, CSTVEN, CSTPAK, CSTFAN, CSTSTK    00043180
  1 .DCTTST, CSTMTB, CSTSIT, CSTSTC, CSTEM, CSTCNT, PREXT, PREXTI, SKRCST   00043190
  2 ,CSTIIN, EXTRA1, CSTSTR, CSTSCR, CSTSPPR, CSTCRT, CSTENG, DCDIA(9), CSTINT00043200
  3 .DSDIA(9), CSTLOD, DCTBCS(9), TDCTCS(9), TOTLAB, TTMAIN,               00043210
  4 TOTELC, TOTH20, TTFUEL, TTWSTD, TTCAUS, TTOPR,                         00043220
  5 TOTTOT, DEPREC, EQVPFT, REVLB, CONTEN, ZINSUR, TOT, EQVOPR, EQVREV,     00043230
  6 EQVCAP, FINCRG, REFIN, THCKIN, EQVFIN, DCBRIK                         00043240
  COMMON/UPDATE/ FACCES, FACMSC, FACCEE, FACCEF, FACCEB                   00043250
  1, FACPVF, FACPC, FACPI, FACENG, FACLAB, FACPRS                      00043260
  COMMON/SALARY/TEKC, SUPC, SECC, DAY, YEAR, ZTOT, SUPP, PAYEXP            00043270
  COMMON/DCT/ ELBNUM(9), DCTLEN(9), DCTVEL(9), DIA(9)                     00043280
  COMMON/INT/IDEBUG, NRES(8), NUNIT, III, NSET, JPIK, IYEAR, NUMBRN, NPRTS   00043290
  COMMON/ALPHA/MATL(20), BRIKNM(6,8), FUELNM(4,5), UNIT(20), SUNIT(11)    00043300
  1, PCKCHS(4), PCKNAM(7,4), DCMATL(9), MTLDC, MTLBRK                     00043310
  2, WSTNME(6), BNMF(6), BNMIN(6), SCRNM(6)                           00043320
  COMMON/LOGIC/ROTARY, FLUID, LIQI, METRIC, ENGL, LCOST, HTLS, RECT, BAL, PRI00043330
  1, IC, TCH, SSG, VOLTIL, BARREL, SEMI, DCTFLG, SS, CS, DIC, DSS, DCS, DWC, FLGPAS00043340
  2, SLD, SCRW, VENAUT, FG, BRN, ADIA, PLASMA, SIEVE, VALVE, CMBST, LQD, CUTVN 00043350
  3, KRB, FXH, S316, S304, S347, NI200, MO400, IN600, IN825, TI, HS, UTB, HM1, HM2 00043360
  X=MASSSL/1000.0                                                       00043370
C   COST OF WASTE WATER TREATMENT PLANT                                     00043380
  WATER=WTRTOT/62.4/35.45*264.4/60.0                                      00043390
C23456
  WASCAP=1000*(1.221*WATER-11.00)*FACCES/320.0                         00043410
  TOTCAP=CSTINC+AFTINC+CSTHTR+CSTQUE+CSTVEN+CSTPAK+CSTFAN+CSTSTK       00043420
  1 +DCTTST+CSTMTB+CSTSIT+CSTSTC+CSTEM+CSTCNT+CSTSTO+WASCAP             00043430
C
C   THIS SUBROUTINE CALCULATES ADDITIONAL CAPITAL INFORMATION FOR SITEWORK00043450
C   SITEWORK, STRUCTURAL STEEL, METAL BUILDING, ELECTRICAL MATERIALS,      00043460
C   AND INSTRUMENTS AND CONTROLS                                         00043470
C
C
C   THIS EQUATION CONVERTS THE WASTE FEED RATE TO                         00043480
C   UNITS CURVFIT FROM DATA OBTAINED IN LITERATURE.                      00043490
C
C
C   THIS SECTION OF THE SUBROUTINE CALCULATES THE COST OF A METAL        00043530
C   BUILDING. REF.                                                        00043540
C
C   LEPEAU, MATEO, "EVALUATING HEAT RECOVERY FROM                         00043550
C   BURNING REFUSE", CHEMICAL ENGINEERING, MARCH 21                      00043560
C   , 1983.                                                               00043570
C
C   IF(MASSSL.GT.13000.) GOTO 100                                         00043580
C     IF(MASSSL.GT.11000.) GOTO 110                                         00043590
C       CSTMTB = 220000.0                                                 00043600
  110  IF(CSTMTB.LT. 9000.) GOTO 120                                         00043610
C       CSTMTB = 180000.0                                                 00043620
C       GOTO 200                                                       00043630
  120  IF(CSTMTB.LT. 750.) GOTO 130                                         00043640
C       CSTMTB= 73.95+17.81*X+2.721*X**2.+0.2323*X**3.                  00043650
C       GOTO 200                                                       00043660
  130  CSTMTB=90000.0                                                 00043670
C       GOTO 200                                                       00043680
  100 WRITE(6,300)                                                       00043690
  300 FORMAT(5X,'*** ERROR *** THE FEED RATE OF WASTE IS TOO LARGE',    00043700
  1 ' FOR ACCURATE PREDICTION OF METAL BUILDING COSTS')                 00043710
  GOTO 120                                                       00043720
  200 CONTINUE                                                       00043730
  CSTMTB=CSTMTB*FACCEB /232.7                                         00043740
C
C   THIS SECTION OF THE SUBROUTINE CALCULATES THE COST OF SITEWORK00043750
C   AND FOUNDATION COST FOR AN INCINERATION FACILITY                    00043760
C   REF.                                                               00043770
C
C   SAME AS METAL BUILDING                                              00043780
C
C   IF(MASSSL.GT.9500.) GOTO 210                                         00043790
C     IF(MASSSL.GT.750.0) GOTO 220                                         00043800
C       CSTSIT=90000.0                                                 00043810
C       GOTO 305                                                       00043820
  220  IF(MASSSL.GT.7500.0) GOTO 221                                         00043830
C
C   IF(MASSSL.GT.20000.) GOTO 230                                         00043840
C     IF(MASSSL.GT.15000.0) GOTO 240                                         00043850
C       CSTSIT=150000.0                                                 00043860
C       GOTO 305                                                       00043870
  240  IF(MASSSL.GT.15000.0) GOTO 250                                         00043880

```

```

CSTSIT=67.8571+34.643*X-2.50*X**2.          00043890
    GOTO 305                                  00043900
221 CSTSIT=264.73+1.756*X+0.387*X**2.      00043910
    GOTO 305                                  00043920
210  WRITE(6,310)                            00043930
310 FORMAT(5X,'*** ERROR *** THE FEED RATE OF WASTE IS TOO LARGE',00043940
1 'FOR ACCURATE PREDICTION OF SITWORK COST') 00043950
CSTSIT=520000.0                             00043960
305 CONTINUE                                00043970
CSTSIT=CSTSIT*FACCEB/232.7                 00043980
C     THIS SECTION OF THE SUBROUTINE CALCULATES THE COST OF 00043990
C     THE STRUCTURAL STEEL NEEDED FOR AN INCINERATION FACILITY. 00044000
C     REF                                         00044010
C     SAME AS METAL BUILDING COST             00044020
C                                         00044030
C                                         00044040
C IF(MASSSL.GT.8000.0) GOTO 340            00044050
C     IF(MASSSL.LT.1000.0) GOTO 350          00044060
C     CSTSTC= 30000.0                         00044070
C     GOTO 400                                00044080
350  CSTSTC= 25000.0                         00044090
C     GOTO 400                                00044100
340  IF(MASSSL.GT.10000.0) GOTO 360         00044110
C     CSTSTC= 50000.0                         00044120
C     GOTO 400                                00044130
360  CSTSTC= 60000.0                         00044140
400  CONTINUE                                00044150
C     CSTSTC=CSTSTC*FACCES/281.2            00044160
C     CSTCNT=(51.182 - 2.544*X+1.053*X**2.)*1000.000 00044170
C     IF(X.GT.7) GOTO 501                  00044180
C     CSTEM= (32.+ 3.57*X)*1000.0           00044190
C     GOTO 500                                00044200
501  IF(X.GT.11) GOTO 502                  00044210
C     CSTEM=(-582.94+137.09*X-6.57*X**2.)*1000.0       00044220
C     GOTO 500                                00044230
502  IF(X.GT.16) GOTO 503                  00044240
C     CSTEM=(-1300.+203.33*X-6.67*X**2.)*1000.0       00044250
C     GOTO 500                                00044260
503  WRITE(6,600) MASSSL                   00044270
600  FORMAT(10X,'THE FACILITY WASTE FEED RATE IS TOO LARGE FOR ',00044280
1 'ACCURATE CALCULATION FROM DATA AVAILABLE',F12.0,'LB/HR') 00044290
500 CONTINUE                                00044300
C     THIS SECTION IS DEVOTED TO THE CALCLATION OF INDIRECT CAPITAL 00044310
C     EXPENDITURES                           00044320
C     VARIABLES ARE:                         00044330
C     CSTIIN- INSTALLATION COST OF FACILITY 00044340
C     CSTSTR- FIRST TIME START-UP COSTS      00044350
C     CSTSPR- COST OOF SPARE PARTS STOCK REQUIRED 00044360
C     CSTCRT- COST OF CERTIFICATION FOR HAZARDOUS WASTE 00044370
C                                         00044380
C                                         00044390
C                                         00044400
C     CALCULATION OF FACILITY INSTALLATION 00044410
CSTSTR = TOTCAP *0.10                      00044420
CSTSPPR = TOTCAP * 0.08                     00044430
CSTCRT = TOTCAP * 0.10                     00044440
CSTENG = TOTCAP * 0.07                     00044450
CSTINT = TOTCAP * 0.20+64000.0*2.          00044460
RETURN                                     00044470
END                                         00044480
FUNCTION PRESSR(TOTMS,RHO,DIA,X)          00044490
FRIC=0.0045                               00044500
PRESSR= 2.0*FRIC*(TOTMS/(DIA**2.0*3.1416/4.0))**0.5/RHO/DIA*X 00044510
PRESSR= PRESSR *12.0*33.9/14.696/3600.0/32.074 00044520
RETURN                                     00044530
END                                         00044540
SUBROUTINE EQIV                           00044550
REAL MSSLUD,MSTOT,MLPRDT,TTMP,MSFUEL,MSAIR,XXSLUD 00044560
1 .XXFUEL,XXAIR,MASSSL,MASSFL,MASSAR,INCDIA,INCLEN,LTEKS 00044570
LOGICAL ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRI 00044580
1 ,IC,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,AUTODP, 00044590
2 SSB,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,FLGPAS,SLD,LQD 00044600

```

```

4,CUTVN,CMBST,TCH          00044610
3,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00044620
  CHARACTER BRIKNM*4,UNIT*3,MATL*4,FUELNM*3,PCKCHS*4,WSTNME*5      00044630
1 ,BNMFR*4,BNMIN*4,SUNIT*3,PCKNAM*4,MTLDCT*3,MTLBRK*3,DCMATL*2    00044640
2 ,SCRNME*20                00044650
  CHARACTER MATLC*2          00044660
  DIMENSION MATLC(4)         00044670
  COMMON/MASS/ MSSLUD(9,9),MSFUEL(9,9),MSAIR(9,9),MASSSL,MASSFL,    00044680
1 MASSAR,ZFLHT,ZSLHT,T1,T2,XXSLUD(9),XXFUEL(9),XXAIR(9),HSTVAP   00044690
2,VOLIT,ASH,FREH20,HTCNT,FULC,FEED(15),TA,DELTAH,ZLFD2(9,9)     00044700
  COMMON/PCKBED/ PSIZE(7),PCKSIZ,CSTPK(7),PAKH20,RHOL,RHO,VISCL    00044710
1,VISCG,EFFABS,TOCOST,CONST(7,8),SLPABS,PAKRAG(7,4),Z,CSTINS,TBRNTT 00044720
  COMMON/DES/RLD(9),DESVOL(9),TKOND(9),EXCESS(9),DP(9),TTL(9),HTC   00044730
1 ,BCOST(8),TLIM(8),ZLOSS,TTMP(9),DIABRK,CSTTRT,RETIM(9),FANCLS  00044740
2,HTCOMB,AREA(9),VOLRAT(9),REPCST,HPTOT,TOTCAP,STMREC,YRNUM,RTINST 00044750
3,INCLEN(9),MSTD(9),MLPRDT(15,9),PINC,PEXT,WTRTOT,FLTOT,TOTMAN   00044760
  COMMON/COST/ SHLCST,DRV CST,BRKTO T,ASHCST,STM CST,DCTCST(9)    00044770
1 ,CSTFUL,DFHCLL,DFHCLG,EXTRA,CSTINC,WTPRT(100),EXFUEL(9)        00044780
  COMMON/INPUT/ CP(6,15),PRDMW(15),HEIGHT,WTR CST,DS PC ST,CSTE LC,DPTD 00044790
1 ,AOP,WATRAT,TOTDP,NTU,AQ,CSTSTO,ASHGAS,PERUPT,FEDRG2,DIAPT(100) 00044800
2,QTEMP,WASCAP,H2OM,VENWAT,CLMS,HCLRM,ELEVAT,CSTLME               00044810
3,QSAT,VENH20,DAMPT(10),DCIBC(10),CSTBAS,EXTRA2,DIFH20,VAPNO    00044820
  COMMON/OUTPUT/ AFTINC,CSTHTR,CSTQUE,CSTVEN,CSTPAK,CSTFAN,CSTSTK   00044830
1 ,DCTTST,CSTMTB,CSTSIT,CSTSTC,CSTE M,CSTCNT,PREXT,PREXTI,SKRCST  00044840
2 ,CSTIIN,EXTRA1,CSTSTR,CSTSCR,CSTSPR,CSTCRT,CSTENG,DCDIA(9),CSTINT 00044850
3 ,DSDIA(9),CSTLOD,DCTBCS(9),TDCTCS(9),TOTLAB,TTMAIN,             00044860
4 ,TOTE L,C, TOTH20,TT FUEL,TT WSTD,TT CAUS,TT OPR,                 00044870
5 ,TOTTOT,DEPREC,EQVPFT,REVLB,CONTEN,ZINSUR,TOT,EQVO PR,EQVREV,  00044880
6 ,EQVCAP,FINCRG,REFINS,THCKIN,EQVFIN,DCBRIK                  00044890
  COMMON/UPDATE/ FACCES,FACMSC,FACCEE,FACCEF,FACCEB            00044900
1 ,FACPVF,FACPC,FACPI,FACENG,FACLAB,FACPRS                  00044910
  COMMON/SALARY/TEKC,SUPC,SECC,DAY,YEAR,ZTOT,SUPP,PAYEXP       00044920
  COMMON/DCT/ EBNUM(9),DCTLEN(9),DCTVEL(9),DIA(9)              00044930
  COMMON/INT/IDEBUG,NRES(8),NUNIT,III,NSET,JPIK,IYEAR,NUMBRN,NPRTS 00044940
  COMMON/ALPHA/MATL(20),BRIKNM(6,8),FUELNM(4,5),UNIT(20),SUNIT(11) 00044950
1 ,PCKCHS(4),PCKNAM(7,4),DCMATL(9),MTLDCT,MTLBRK             00044960
2 ,WSTNME(6),BNMFR(6),BNMIN(6),SCRNME(6)                      00044970
  COMMON/LOGIC/ROTARY,FLUID,LIQI,METRIC,ENGL,LCOST,HTLS,RECT,BAL,PRIO 00044980
1 ,IC,TCH,SSG,VOLTIL,BARREL,SEMI,DCTFLG,SS,CS,DIC,DSS,DCS,DWC,FLGPAS 00044990
2 ,SLD,SCRW,VENAUT,FG,BRN,ADIA,PLASMA,SIEVE,VALVE,CMBST,LQD,CUTVN 00045000
3 ,KRB,FXH,S316,S304,S347,NI200,MD400,IN600,IN825,TI,HS,UTB,HM1,HM2 00045010
  REVNU E= +MASSSL*DAY*YEAR*REVLB                           00045020
  EQVO PR=O.O                                              00045030
  EQVREV=O.O                                              00045040
  EQVOPR=-TTOPR*AQ                                     00045050
  EQVREV=REVNUE*AQ                                     00045060
  EQVFIN=-FINCRG*AQ*TOTTOT/100.0                     00045070
  EQVCAP=-TOTTOT*AOP                                 00045080
  EQVPFT=EQVREV+EQVOPR+EQVFIN+EQVCAP           00045090
  EQVLB=EQVPFT/(MASSSL*DAY*YEAR)                   00045100
  WRITE(6,10)                                         00045110
10 FORMAT(21X,'***** FUTURE WORTH COST ANALYSIS *****') 00045120
  WRITE(6,20) (WSTNME(I),I=1,6),MASSSL             00045130
20 FORMAT(///32X,'ANNUAL EQUIVALENT PROFIT'/32X,6(A5)/30X,'FEED RATE' 00045140
  1 ,'.2X,F6.0,'LB/HR')                            00045150
  IF(ROTARY) WRITE(6,200)                           00045160
  IF(FLUID) WRITE(6,210)                           00045170
  IF(LIQI) WRITE(6,220)                           00045180
200 FORMAT(32X,'ROTARY KILN')                      00045190
220 FORMAT(29X,'LIQUID INJECTION')//               00045200
210 FORMAT(30X,'FLUIDIZED BED')                    00045210
  WRITE(6,300) EQVCAP,ADP                         00045220
300 FORMAT(//15X,'ANNUALIZED EQUIVALENT',2BX,F12.2/15X,'CAPITAL COST' 00045230
  1 /15X,                                           00045240
  1 ,('F5.2,' ANNUALIZING FACTOR'))              00045250
  WRITE(6,310) EQVOPR,ADP                         00045260
310 FORMAT(15X,'ANNUALIZED OPERATING COST',24X,F12.2/15X,('F5.2 00045270
  1 , ' ANNUALIZING FACTOR'))                     00045280
  WRITE(6,320) EQVREV,ADP                         00045290
320 FORMAT(15X,'ANNUALIZED REVENUE EARNINGS',22X,F12.2/15X, 00045300
  1 ,('F4.1,' ANNUALIZING FACTOR'))              00045310
  WRITE(6,330) EQVFIN,ADP                         00045320

```

```

380 FORMAT(15X,'ANNUALIZED FINANCE CHARGES',22X,F13.2/15X,'(',
1 F4.2,' ANNUALIZING FACTOR)'/15X,'-----') 00045330
2-----) 00045340
WRITE(6,340)EQVPFT 00045350
00045360
340 FORMAT(15X,'ANNUALIZED EQUIVALENT REVENUES',19X,F12.2/) 00045370
WRITE(6,350) EQVLB 00045380
350 FORMAT(15X,'REVENUE GENERATED PER POUND',21X,F13.2) 00045390
RETURN 00045400
END 00045410
FUNCTION LOADR(X,C) 00045420
LOGICAL C 00045430
IF(C) GOTO 10 00045440
LOADR=(X+1.1667)/0.3667*1000.0 00045450
RETURN 00045460
10 IF(X.GT.90.) GOTO 20 00045470
C DRUM LOADER 00045480
C 00045490
LOADR=175000.0 00045500
RETURN 00045510
20 LOADR=300000.0 00045520
RETURN 00045530
END 00045540
FUNCTION SCRFED(X) 00045550
C 00045560
C COST OF SCREQ FEED SYSTEM INCLUDES 00045570
C INCLUDES: 00045580
C      5 FT LENGTH SCREW 00045590
C      CONVEYOR WITH TROUGH 00045600
C      FEED HOPPER 00045610
C      DRIVE AND MOTOR 00045620
C 00045630
IF(X.GT.15.) GOTO 10 00045640
SCRFED=7000.0 00045650
RETURN 00045660
10 IF(X.GT.75.) GOTO 20 00045670
SCRFED=10000.0 00045680
RETURN 00045690
20 SCRFED=22000.0 00045700
RETURN 00045710
END 00045720
FUNCTION TRAYCS(A,B,C,D) 00045730
LOGICAL A,B 00045740
IF(A.AND.B) WRITE(6,10) 00045750
10 FORMAT(10X,'ONLY ONE TYPE OF PACKING IS SELECTED') 00045760
IF(A.AND.B) B=.FALSE. 00045770
IF(A) GOTO 100 00045780
IF(D.EQ.1) TRAYCS=1.0*(2.00+0.157*C+0.111*C**2.) 00045790
IF(D.EQ.2) TRAYCS=1.0*(2.91-0.185*X+0.212*X**2.) 00045800
GOTO 200 00045810
100 IF(D.EQ.1) TRAYCS=1.0*(2.813-0.462*C+0.103*C**2.) 00045820
IF(D.EQ.2) TRYACS=1.0*(1.28+0.589*C-0.066*C*2.+7.52E-3*C**3.) 00045830
200 RETURN 00045840
END 00045850
FUNCTION WTPPRT(Z,PD) 00045860
IF(PD.GT.20.) GOTO 30 00045870
WTPPRT=1.0*(67.6+8.9)*Z 00045880
IF(Z.GT.4.5) WTPPRT=1.0 00045890
GOTO 90 00045900
30 IF(PD.GT.30) GOTO 35 00045910
WTPPRT=1.0*(51.496+67.07*Z-32.9*Z**2.+5.35*Z**3.) 00045920
IF(Z.GT.3.0) WTPPRT=1.0 00045930
GOTO 90 00045940
35 IF(PD.GT.40) GOTO 40 00045950
WTPPRT=1.0*(62.2+84.71*Z-64.857*Z**2.+16.0*Z**3.) 00045960
IF(Z.GT.2.0) WTPPRT=1.0 00045970
GOTO 90 00045980
40 IF(PD.GT.60) GOTO 42 00045990
WTPPRT=1.0*(98.1+9.2*Z) 00046000
IF(Z.GT.1.5) WTPPRT=1. 00046010
GOTO 90 00046020
42 IF(PD.GT.80.) GOTO 45 00046030
WTPPRT=1.0*(95.0+5.0*Z) 00046040

```

```

        IF(Z.GT.1.0) WTPPRT=1.0          00046050
        GOTO 90                          00046060
45  WTPPRT=1.0                      00046070
90  RETURN                           00046080
        END
        FUNCTION PAKDIA(U,RL,RG,F,GM,WL) 00046090
        FF=1                            00046100
        FFF=0.0                         00046110
        DD=1.0                          00046120
        DDIA=7.0                        00046130
11  AT=3.1416*DDIA**2.0/4.0          00046140
        RES1=(28.6*GM/60.0*AT/RG/(RL/RG)**0.50)*(F*U**0.2))**(.1./3.) 00046150
        RES2=(WL/60.0*AT/62.40/(RL/RG)**0.50*(F*U**0.20))**(.1./3.) 00046160
        RES=RES1+RES2                  00046170
        IF(ABS(18.91-RES).LT.0.005) GOTO 50 00046180
        IF(RES.GT.18.91) GOTO 20          00046190
        DDIA=DDIA+DD                  00046200
        IF(FF.EQ.0) DD=DD/2.0            00046210
        IF(FFF.EQ.0) FFF=1              00046220
        IF(FFF.EQ.1) GOTO 11            00046230
        FF=0.                            00046240
        GOTO 11                          00046250
20  DDIA=DDIA-DD                  00046260
        IF(FF.EQ.0) DD=DD/2.0            00046270
        IF(FFF.EQ.0) FFF=-1             00046280
        IF(FFF.EQ.-1) GOTO 11           00046290
        FF=0.                            00046300
        GOTO 11                          00046310
50  CONTINUE                         00046320
        PAKDIA=DDIA                  00046330
        RETURN                           00046340
        END
        SUBROUTINE DCFRR(TOTTOT,TTOPR,YRNUM,MASSSL,DAY,YEAR,REVLB) 00046350
        DIMENSION ACRS(16,4),DEP(16),TXABLE(16),TAX(16),OPR(16)
1 ,ATXINC(16),CSHFLW(16),ZINC(16),ADJCST(16) 00046360
        REAL MASSSL
        ICONV=0
        IDEBUG=0.0
        NYR=YRNUM
        NNN=3
        TOTTOT=TOTTOT/1000000.0
        RINC=MASSSL*DAY*YEAR*400.0/2000.0/1000000.0
        TXRT = 0.50
        IF(NYR.LE.4) NNN= 1
        IF(NYR.GT.4.AND.NYR.LE.8) NNN=2
        IF(NYR.GT.8.AND.NYR.LE.12) NNN=3
        IF(NYR.GE.12) NNN=4
C INPUT ACRS DEPRECTION RATE VALUES
C ***** 3 YR DEPRECTIATTION
        DATA ACRS/0.,.25,.38,.37,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
1          0,,15,.22,.21,.21,0,0,0,0,0,0,0,0,0,0,0,0,0,0,
2          0,.08,.14,.12,.10,.10,.09,.09,.09,0,0,0,0,0,0,0,0,
3          0,.05,.10,.09,.08,.07,.06,.06,.06,.06,.06,.06,.06,.06,.
3          .06,.06/
        NYR = YRNUM
        IF(IDEBUG.GE.25) WRITE(6,320) MASSSL,DAY,YEAR,REVLB,RINC
320 FORMAT(5X,'MASSSL,DAY,YEAR,REVLB',5F10.2)
        TOTINC = RINC * YRNUM
        DO 5 I = 1,16
          DEP(I) = 0.0
          TXABLE(I) = 0.0
          TAX(I) = 0.0
          OPR(I) = 0.0
          ATXINC(15) = 0.0
          CSHFLW(I) = 0.0
          ZINC(I)=0.0
5  CONTINUE
        IF(IDEBUG.GE.25) WRITE(6,200) ((ACRS(J,I),I=1,4),J=1,16)
200 FORMAT(5X,4F10.3)
        DO 10 I = 1,NYR+1
C   I IS THE NUMBER OF YEARS STARTING WITH YEAR 0.
        IF(I.NE.1) GOTO 11

```

```

      CSHFLW(I) = - TOTTOT          00046770
      IF(IDEBUG.GE.25) WRITE(6,330) CSHFLW(I)          00046780
 330 FORMAT(10X,'CASH FLOW YEAR ZERO',F9.4)          00046790
      GOTO 10          00046800
 11 CONTINUE          00046810
      OPR(I) = TTOPR/1000000.0          00046820
      ZINC(I) = RINC          00046830
      IF(IDEBUG.GE.25) WRITE(6,340)ZINC(I),RINC,NNN          00046840
 340 FORMAT(5X,'ZINC(I) AND RINC',2F9.3)          00046850
      DEP(I) = TOTTOT*ACRS(I,NNN)          00046860
      TXABLE(I) = ZINC(I)-OPR(I)-DEP(I)          00046870
      IF(TXABLE(I).GT.0.0) TAX(I) = TXABLE(I)*TXRT          00046880
      ATXINC(I)=TXABLE(I) - TAX(I)          00046890
      CSHFLW(I) = ATXINC(I) + DEP(I)          00046900
      IF(IDEBUG.GE.25) WRITE(6,310) ZINC(I),OPR(I),DEP(I),TXABLE(I)
      1,TAX(I),ATXINC(I),          00046910
      1 CSHFLW(I)          00046920
 310 FORMAT((3X,F6.3))          00046930
 10 CONTINUE          00046940
      FFF= 0          00046950
      FF = 1          00046960
      DTRTI = 0.10          00046970
      RTI=0.50          00046980
 30 CONTINUE          00046990
      SUMCST = 0.0          00047000
      SUMCSH=0.0          00047010
      ICONV=ICONV+1          00047020
      IF(ICONV.GE.100) STOP          00047030
      DO 20 I=2,NYR+1          00047040
          SUMCST=SUMCST+CSHFLW(I)/EXP(I*RTI)          00047050
          SUMCSH=SUMCSH+CSHFLW(I)          00047060
          ADJCST(I) = CSHFLW(I)/EXP(I*RTI)          00047070
          EXPFAC=EXP(I*RTI)          00047080
          IF(IDEBUG.GE.25) WRITE(6,390) ADJCST(I),SUMCST,EXPFAC,I,RTI          00047090
 390 FORMAT(5X,'ADJCST',F6.2,'SUMCST',F6.2,'EXPFAC',F6.2,I2,F6.2)          00047100
 20 CONTINUE          00047110
      SUMCSH=SUMCSH +CSHFLW(1)          00047120
      IF(IDEBUG.GE.25) WRITE(6,300) RTI,DTRTI          00047130
 300 FORMAT(5X,'INTEREST RATE= ',F9.5,'DTRTI= ',F9.4)          00047140
      RESID = SUMCST-CSHFLW(1)          00047150
      IF(ABS(RESID).LT.(-CSHFLW(1)*0.010)) GOTO 500          00047160
      IF(SUMCST.LT.-CSHFLW(1)) GOTO 15          00047170
      RTI=RTI+DTRTI          00047180
      IF(FF.EQ.0) DTRTI=DTRTI/2.0          00047190
      IF(FFF.EQ.0) FFF=1          00047200
      IF(FFF.EQ.1) GOTO 30          00047210
      FF=0          00047220
      GOTO 30          00047230
 15 RTI = RTI -DTRTI          00047240
      IF(FF.EQ.0) DTRTI=DTRTI/2.0          00047250
      IF(FFF.EQ.0) FFF=-1          00047260
      IF(FFF.EQ.-1) GOTO 30          00047270
      FF=0          00047280
      GOTO 30          00047290
      00047300
C INTERVAL HALVING METHOD TO DETERMINE DISCOUNTED CASH FLOW RATE OF
C RETURN INTEREST FACTOR.          00047310
 500 CONTINUE          00047320
      WRITE(6,876)          00047330
      876 FORMAT('1.'',22X,'DISCOUNTED CASH FLOW RATE OF RETURN'/35X,
      1 'ANALYSIS OUTPUT'/27X,'(MILLIONS OF U.S. DOLLARS)' //)          00047340
      999 FORMAT(20X,'DISCOUNTED CASH FLOW RATE OF RETURN = ',F5.1,'%')          00047350
      WRITE(6,100) (I,I=0,NYR)          00047360
 100 FORMAT(1X,'YEAR      ',11(4X,I2))          00047370
      WRITE(6,130)          00047380
      WRITE(6,110)(ZINC(I),I=1,NYR+1)          00047390
 110 FORMAT(1X,'INCOME      ',11(1X,F5.1))          00047400
      WRITE(6,120)(OPR(I),I=1,NYR+1)          00047410
 120 FORMAT(1X,'OPERATE      ',11(1X,F5.1))          00047420
      WRITE(6,165)(DEP(I),I=1,NYR+1)          00047430
 165 FORMAT(1X,'DEPREC.      ',11(1X,F5.1))          00047440
      WRITE(6,130)          00047450
 130 FORMAT(1X,'-----',          00047460
      00047470
      00047480

```

```

1 '-----')
WRITE(6,140)(TXABLE(I),I=1,NYR+1)
140 FORMAT(1X,'TAXABLES ',11(1X,F5.1))
WRITE(6,150)(TAX(I),I=1,NYR+1)
150 FORMAT(1X,'TAXES      ',11(1X,F5.1))
WRITE(6,130)
WRITE(6,160)(ATXINC(I),I=1,NYR+1)
160 FORMAT(1X,'NET INC. ',11(1X,F5.1))
WRITE(6,165)(DEP(I),I=1,NYR+1)
WRITE(6,170)CSHFLW(1)
170 FORMAT(1X,'CAPITAL    ',F5.1,' - - - - -')
1 ' - - - - -')
WRITE(6,130)
WRITE(6,190)(CSHFLW(I),I=1,NYR+1)
190 FORMAT(1X,'CASH FLW ',11(1X,F5.1))
WRITE(6,410) SUMCSH
410 FORMAT('//20X,'THE TOTAL CASH FLOW = ',F6.2,' MILLION DOLLARS')
RTI=RTI*100.0
WRITE(6,999)RTI
WRITE(6,987)
987 FORMAT(////)
STOP
END
FUNCTION RPM(A1,I,C)
A=LOG(A1)
RPM=0.0
IF(I.EQ.9) Y=1.416423*A+10.04325
IF(I.EQ.8) Y=1.44121*A+8.98720
IF(I.EQ.7) Y=1.4764*A+8.00637
IF(I.EQ.6) Y=1.4412*A+7.60090
IF(I.EQ.5) Y=1.73115*A+5.97017
IF(I.EQ.4) Y=1.571183*A+5.838497
IF(I.EQ.3) Y=1.440643*A+5.58771
IF(I.EQ.2) Y=1.24444*A+5.5406
IF(I.EQ.1) Y=1.44904*A+4.898956
Y=EXP(Y)
IF(Y.GE.C) RPM=1.0
IF(Y.LT.C) RPM=0.0
IF(IDEBUG.GE.50) WRITE(6,100) A1,Y,C
100 FORMAT(10X,'PRESSURE DROP= ',F12.2,'INCHES H2O'
1      10X,'ESTIMATED RPMS= ',E12.2/
2      10X,'ACTUAL VOLUME RATE= ',E15.5,'FT^3/MIN/1000')
RETURN
END
FUNCTION FX4(A1,I,C)
A=LOG(A1)
FX4=0.0
IF(I.EQ.9) Y=-1.08*A+14.88
IF(I.EQ.8) Y=-1.00*A+13.8155
IF(I.EQ.7) Y=-1.00*A+13.12236
IF(I.EQ.6) Y=-1.08*A+12.4292
IF(I.EQ.5) Y=-1.00*A+11.5129
IF(I.EQ.4) Y=-1.00*A+10.81978
IF(I.EQ.3) Y=-1.06*A+10.12663
IF(I.EQ.2) Y=-1.00*A+9.21034
IF(I.EQ.1) Y=-0.999*A+8.5172
Y=EXP(Y)
IF(Y.GE.C) FX4=1.0
IF(Y.LT.C) FX4=0.0
IF(IDEBUG.EQ.50) WRITE(6,100) A1,Y,C
100 FORMAT(10X,'PRESURE DROP= ',F12.2,' INCHES H2O'
1/ 10X,'CALCULATED VOLUME RATE= ',E15.5,'FT^3/MIN/1000'/
2 10X,'ACTUAL VOLUME RATE=     ',E15.5,'FT^3/MIN/1000')
RETURN
END
FUNCTION THICK(A,B,I)
IF(I.EQ.7) Y=-0.9302*LOG(B)+9.796
IF(I.EQ.1) Y=-1.0*LOG(B)+6.6846
IF(I.EQ.2) Y=-1.0*LOG(B)+7.6009
IF(I.EQ.3) Y=-1.0455*LOG(B)+8.535
IF(I.EQ.4) Y=-1.0*LOG(B)+8.8882
IF(I.EQ.5) Y=-0.9910*LOG(B)+9.294

```

```
IF(I.EQ.6) Y=-0.9562*LOG(B)+9.509          00048210
Y2=EXP(Y)                                     00048220
IF(Y2.GE.A) THICK=1.0                         00048230
IF(Y2.LT.A) THICK=0.0                         00048240
RETURN                                         00048250
END                                            00048260
```

APPENDIX E

OPERATING MANUAL

PROGRAM HWSTBRN OPERATING MANUAL

By

JEFFREY DEAN MATHIS
Oklahoma State University
Stillwater, Oklahoma

August, 1986

Overview

Introduction

The HWSTBRN program is designed to aid the engineer in the design, cost estimation and economic comparision of a hazardous waste incineration facility. This program provides, as an option, a selection of combustor and pollution control process equipment. Also, included in the package, is an interactive program to view existing data sets or create new ones. The main program HWSTBRN is run as a batch.

The capabilities of this program include;

- 1) Selection of rotary kiln, fluidized bed or liquid injection combustors for the primary incineration process.
- 2) Selection of a quench chamber, a heat recovery boiler, venturi scrubber, induction fan, packed bed absorber, and exhaust stack for emission controls.
- 3) Provide several different levels of output depending on the user's requirements.
- 4) Provide alternate methods for the design and cost estimation of the process equipment.

The objectives of this program are made possible with a minimum amount of physical and technical data.

Operation of Programs

Operation of the computer package requires the use of 4 computer programs. These programs are called INCIN, INPUT, KILN, and HWSTBRN. Physical data for the program is listed in the data file CP(See Appendix D). Each of these programs will be discussed separately.

Program INCIN controls the selection of the names of the files to be created by program INPUT for use by program HWSTBRN. Program INCIN allows the use of program INPUT interactively on the IBM 3081D system. When the user selects the name(s) of the data sets to be used, program INPUT is called to create a new input file.

Program INPUT allows the user to read old data files already created or allows the user to create new data files. The program INPUT is used in the interactive mode. Further discussion of program is included in the Input section.

Once a new file has been created and checked by the user, program KILN can be accessed. The name of the input data file accessed by program HWSTBRN must be specified in program KILN(See Figure 1 line 1000). This must be done by entering the edit mode with program KILN. Program KILN is used to control the input and output files and the calling of program HWSTBRN. Program KILN request the user number and password for computer charges. Program HWSTBRN is then run as a batch job. All design and cost calculations for the incineration process are controlled by program HWSTBRN. When this program has run, the output is stored on hard-disk and can be retrieved using the Interactive Output Files (IOF) system. Information on using IOF files can be obtained from the University Computer Center.

Input For Program HWSTBRN

Information that must be provided for the program is divided into four categories. These include:

- 1) Waste Feed Characteristics
- 2) Process Facility Variables
- 3) Design and Cost Data Particular to each Process Unit.
- 4) Information for Economic Analysis

When all of the data has been input by the user, the program reprints all of the data for inspection before it is written to an output file. Inspection of files already created is also possible. Changes can also be made if required. When all changes are complete, an output file is created. This file is used to input data to program HWSTBRN.

Figure 1

```
//U15500AC JOB (?,XXX-XX-XXXX),'XXX',TIME=(0,10),CLASS=A.          00000100
// REGION=3000K,MSGCLASS=X,NOTIFY=*,MSGLEVEL=(1,1)                  00000200
/*PASSWORD ?                                                       00000300
/*JOBPARM ROOM=E                                                 00000400
// EXEC FORTVCLG,FVREGN=3000K,GOREGN=3000K,FVLNSPC='3200,(100,20)' 00000500
//FORT.SYSIN DD DSN=U15500D.FACIL.CNTL,DISP=SHR                 00000600
//GO.FT04FO01 DD DSN=U15500D.CP.DATA,DISP=SHR                   00000900
//GO.FT15FO01 DD DSN=U15500D.KODAK.DATA,DISP=SHR                 00001000
//GO.SYSIN DD *                                                 00001100
//GO.FT10FO01 DD UNIT=STORAGE,DISP=(OLD,CATLG),                  00001200
// SPACE=(TRK,(100,25),RLSE),                                         00001300
// DCB=(LRECL=80,BLKSIZE=7440,RECFM=FB),                           00001400
// DSN=U15500D.CCP.DATA                                         00001500
//                                                       00001600
```

This figure presents the controlling computer program used to design and cost estimate a hazardous waste incineration facility. In this program, program FACIL is the main program. Program CP contains all of the physical data used by program FACIL. Program FINAL is the data set for a specific facility.

PROGRAM INPUT

Introduction

Creating an input file is handled by program INPUT. Different types of data are required depending on the process selected. If the program prompts the user to enter letter characters, they must be in single quotes. Samples of the inputs are provided below.

Inputs

Program HWSTBRN first requires the user to specify the names of the files that will be used. This is requested by printing:

IS THIS A NEW PROBLEM ?

The user should respond by typing YES or NO. If Yes, the program asks for the name of the new file(including .data). If no, the program asks for the name of the old file to be retained and the name of a new file for the output.

SELECT METRIC(ENTER 1) OR ENGLISH(ENTER 2) SYSTEM OF MEASUREMENTS

The user responds by entering 1 or 2.

The next section of input corresponds to the characteristics of the waste feed to be incinerated. The program begins by printing:

INPUT THE WASTE FEED IDENTIFICATION NAME

This will label the output with a name or phrase identifying the facility to be designed. The name should not exceed 20 characters.

FOR THE WASTE FEED

INPUT THE WEIGHT FRACTION OF HYDROGEN IN WASTE FEED

Input a number between 0 and 1. This process is repeated for Carbon, Oxygen, Nitrogen, Chlorine, Sulphur, Fluorine, and Phosphorous. If the total weight percent of the waste exceeds one, the process must be repeated. If the total weight percent of the waste is less than 0.98, then the components are normalized to one.

INPUT THE HEAT OF COMBUSTION OF THE WASTE SLUDGE

Input the heat value of the waste feed. This should range from 4,000 Btu/lb to 12,000 Btu/lb.

FOR THE WASTE FEED, INPUT THE WEIGHT FRACTION OF VOLATILES

This value should range between 0 and 1.0. It includes all the combustable or volatile components in the waste feed. This value does not include water in the waste

INPUT THE WEIGHT FRACTION OF FREE H₂O IN THE WASTE

This value should range between 0 and 1.0.

SELECT ONE OF THE FOLLOWING

- 1 - WASTE IS NON-VOLATILE
- 2 - WASTE IS VOLATILE
- 3 - WASTE IS VOLATILE AND COMBUSTABLE

This input is used primarily for determination of storage tank costs and accessories. If the user specifies non-volatile, no special accessories are included. If the user indicates that the waste is volatile, a nitrogen blanketing system is included in the design. If the waste is volatile and combustable, a nitrogen blanketing system and special condensors are included as accessories.

The next section of input is for the facility process variables

ENTER PRESSURE OF INLET AIR(PSIA)

The user should respond by entering the ambient pressure at the facility site.

ENTER AMBIENT TEMPERATURE(FAHRENHEIT)

The user should respond by entering the ambient temperature at the facility site.

ENTER THE ELEVATION OF THE HWSTBRNITY(ABOVE SEA LEVEL)

Enter the height above sea level, in feet, to determine the extra compression requirements for the induction fan design.

INPUT THE FEED RATE OF THE WASTE STREAM(LB/HR)

Enter the mass rate at which the waste is fed to the incinerator. Program HWSTBRN is designed to handle waste feed rates between 100 and 10,000 lb/hour.

The next section of input is to determine the amount and type of output required from program HWSTBRN.

ENTER 1 FOR HWSTBRNITY DESIGN ONLY. ENTER 2 IF DESIGN AND COST ANALYSIS DESIRED.

If 1 is entered, the output of all cost data is suppressed. If 2 is entered by the user, all major design and cost data is printed.

The next section of input pertains to the particular piece of process equipment selected by the user. First, the user is asked to select a piece of equipment (up to 9 units). The program responds with questions pertaining to that specific unit. The user must select an incinerator as the first unit. After that, any piece of equipment may be specified. For the incinerator, the input program asks the following questions.

INPUT THE TYPE OF INCINERATOR TO BE DESIGNED
1 - ROTARY KILN 2 - LIQUID INJECTION
3 - FLUIDIZED BED

One of these units must be selected by entering the appropriate number.

SELECT ONE OF THE FOLLOWING

- 1 - WASTE IS A SOLID
- 2 - WASTE IS A PUMPABLE LIQUID

This question is used for the selection of the waste feed mechanism and in limiting the type of incinerator that may be selected.

WASTE FEED MECHANISM

- 1 - WASTE FEED BURNERS
- 2 - BARREL FEED
- 3 - SCREW FEED SYSTEM

Here, the waste feed system for the incinerator is selected.

SELECT ONE OF THE FOLLOWING

- 1 - SET THE OUTLET INCINERATOR TEMPERATURE
- 2 - ADIABATIC COMBUSTION

If the user selects 1, the heat balance in program HWSTBRN will calculate the fuel requirements to incinerate the waste feed at the specified temperature. If the combustion of the waste exceeds this temperature, the program will determine the adiabatic combustion temperature. If the user selects 2, the heat balance will directly calculate the temperature at which the waste feed combusts without the aid of fuel.

SPECIFY ONE OF THE FOLLOWING

- 1 - INCLUDE A 10 PERCENT HEAT LOSS
- 2 - NO HEAT LOSSES INCLUDED

This question determines if a heat loss factor of 10 percent is included in the heat balance of the primary and secondary combustor.

INPUT THE EXCESS AIR REQUIRED

This prompts the user to specify the excess air for the combustion of the waste. This number should be a fraction between 0 and 1(0 to 100 percent).

INPUT EXCESS FUEL REQUIRED

This prompts the user to specify the amount of excess fuel that is added to the combustor

over the required amount. This number should be a fraction between 0 and 1(0 to 100 percent).

INPUT AN ESTIMATE OF THE LENGTH TO DIAMETER RATIO

The user should respond by entering a number between 2 and 9.

INPUT THE RETENTION TIME OF THE INCINERATOR(SECONDS)

Input the time in which the combusted gas should remain within the incinerator(usually 2 seconds for hazardous waste).

EXTRA COSTS FOR INCINERATOR

The user should input a factor(between 0 and 0.50) for extra costs required with the combustor. This factor is multiplied by the total equipment cost of the combustor.

This section includes the input requirements for an afterburner combustor.

INPUT THE EXIT TEMPERATURE OF THE COMBUSTOR

This prompts the user to input the combustion temperature in the afterburner(Fahrenheit).

INPUT THE RETENTION TIME OF COMBUSTOR

Input the retention time of the afterburner in seconds.

INPUT THE EXTRA COSTS FOR INCINERATOR

Input a contingency fee factor for the afterburner. This cost is a percentage of the afterburner equipment cost and should range bewteen 0.0 to 0.50.

This section of input pertains to the design and cost of heat recovery boilers.

TYPE OF HEAT RECOVERY BOILER
1 - FIXED HEAT 2 - KETTLE REBOILER

3 - U-TUBE

The user should select one of these types of heat exchanger for the production of steam. A kettle reboiler is suggested as the best choice.

MATERIALS OF CONSTRUCTION

- | | |
|-------------------------|-------------------------|
| 1 - STAINLESS STEEL 316 | 2 - STAINLESS STEEL 304 |
| 3 - STAINLESS STEEL 347 | 4 - NICKEL 200 |
| 5 - MONEL 400 | 6 - INCONEL 600 |
| 7 - INCOLOY 825 | 8 - TITANIUM |
| 9 - HASTALLOY | |

Select one of these materials for the construction of the heat recovery boilers.

INPUT THE OVERALL HEAT TRANSFER COEFFICIENT

Specify the heat transfer coefficient for the heat recovery boiler for the waste gas and boiling water at 360 Fahrenheit. This value should range between 1 and 5 Btu/Hr/ft²/Fahrenheit.

This section includes the input requirements for quench chambers.

SPECIFY ONE OF THESE OPTIONS

- 1 - Specify outlet temperature
- 2 - Saturated outlet temperature

The type of quench chamber must be specified. If option number one is selected, a heat balance is used to calculate the amount of water required to cool the stream to a specific temperature. If option two is specified, water will be added to cool the gas stream to the saturation temperature.

Specification of the design parameters for the venturi scrubber begins with the prompt:

SELECT THE VENTURI THROAT MECHANISM

- 1 - Automatic throat control
- 2 - Manual throat control

If option one is selected, an automatic throat adjustment(for a specific pressure drop) is specified for the design. If option two is selected, manual throat adjustment is included.

INPUT THE WATER RATE TO THE VENTURI SCRUBBER

This prompts the user to specify the flow rate of water(used to remove particulates in the gas stream). The recommended range, for high energy scrubbers is 3 to 10 lb H₂O / 1000 cubic feet of gas.

SELECT ONE OF THE FOLLOWING

- 1 - PARTICULATE REMOVAL EFFICIENCY FROM EXPERIMENTAL DATA
- 2 - DIRECT SPECIFICATION OF VENTURI SCRUBBER PRESSURE DROP
- 3 - PARTICULATE REMOVAL EFFICIENCY USING EXPERIMENTAL DATA AND THE CUT-DIAMETER METHOD.

If option two is selected, the pressure drop is specified by the user. This value should range between 40 - 100 in H₂O. With this option, no particulate distribution is specified. If option one is selected, experimental data for removal efficiency versus particulate diameter is implemented. Data is available at pressure drops of 40, 60, and 80 inches H₂O. If option 3 is selected, the cut-diameter for a given pressure drop is determined. This data is also generated from experimental data.

SPECIFY THE OVERALL REMOVAL EFFICIENCY

This prompts the user to indicate the maximum particulate concentration allowed to exit the venturi scrubber. Present federal regulations specify a maximum concentration of 0.0005 lb particulates per actual cubic feet of gas. This print is not required if the venturi scrubber pressure is directly specified.

INPUT THE NUMBER OF DATA POINTS FOR THE PARTICULATE DISTRIBUTION.

This prompts the user to indicate the number of data points for the particulate distribution. This input is only required if the pressure drop is not directly specified. The maximum allowed number of data points is 100.

SPECIFY THE AVERAGE DIAMETER AND WEIGHT PERCENT FOR THE PARTICULATE DISTRIBUTION

Here the user inputs the average particulate diameter(of a specific range) and the weight percent of the total. Repeat this for the number of data points specified.

SELECT THE FOLLOWING OPTIONS

- 1 - FIBERGLASS LINED THROAT
- 2 - UNLINED THROAT

Option one is specified for highly corrosive environments. For relatively mild conditions, the unlined throat is acceptable.

This section of the input pertains to the design of Induction fans.

ENTER THE PRESSURE HEAD FOR THE COMPRESSION PROCESS

Input the pressure head in inches of water. A recommended range is from 40 to 80 inches of H₂O.

This section of input is used to input the variables for a packed bed absorber.

INPUT MAJOR CAUSTIC TO BE SCRUBBED BY THE ABSORPTION COLUMN

This prompts the user to name the chemical absorbed for identification of the diffusion coefficients. The name should not exceed 20 characters, and must be enclosed in single quotes.

INPUT THE CAUSTIC REMOVAL EFFICIENCY

Specify the percent removal of the caustic to be scrubbed. The value should range from 0 to 100.

INPUT THE RELATIVE WATER FEED RATE TO THE PACKED BED ABSORBER.

Specify the water rate(in gallons of water per 1000 cubic feet of gas flow) added to the absorber. The rate should range from 15 to 30 gallons of water per 1000 cubic feet of gas flow.

INPUT THE PACKING TYPE

- 1 - Berl Saddles
- 2 - Raschig Rings

Two types of packing are available. One of these must be specified to select absorption data.

INPUT SIZE OF PACKING USED

- | | |
|-----------------------|----------------------|
| 1 - 0.50 inch packing | 2 - 1.0 inch packing |
| 3 - 1.50 inch packing | 4 - 2.0 inch packing |

One of these packing sizes must be specified.

INPUT THE EFFECTIVE ABSORPTION FACTOR

This prompts the user to specify an efficiency factor for the packed bed absorber. This value should range from 0.10 to 1.0.

INPUT THE PERCENT FLOODING IN THE PACKED BED

The user should specify the percent flooding in the packed bed absorber.

INPUT THE NUMBER OF ABSORPTION TRANSFER UNITS

This print prompts the user to specify the number of mass transfer units required to absorb the caustic. This value is determined from an equilibrium diagram(See figure 2).

INPUT THE SLOPE OF THE EQUILIBRIUM CURVE

Input the slope of the equilibrium curve at the outlet concentration. Figure 2 represents the equilibrium curve for hydrogen chloride. For pollution control with high caustic removal, the slope of this curve is approximated by zero.

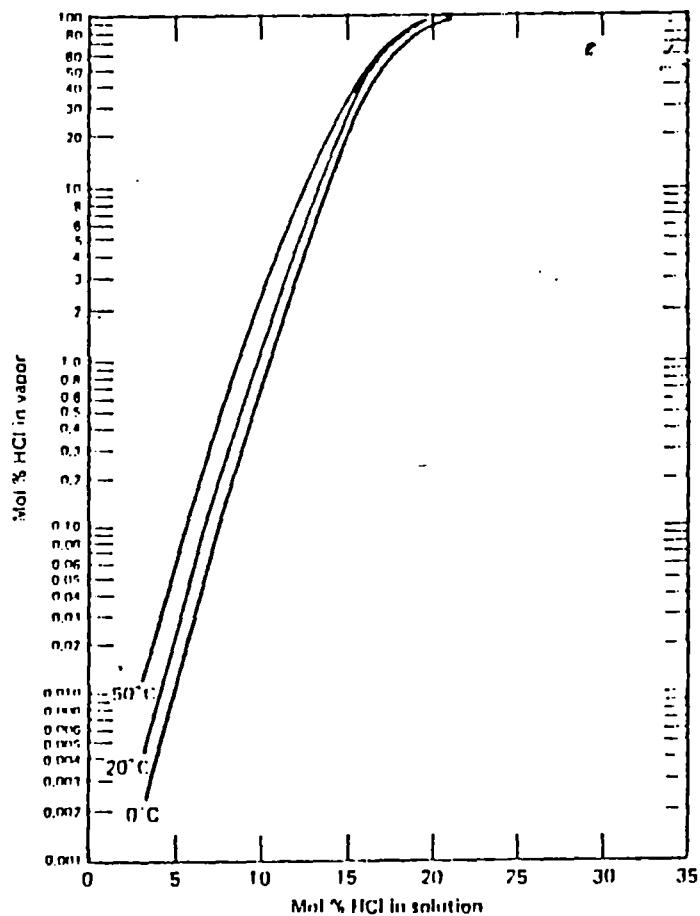


Figure 2 - Vapor liquid equilibrium curve used to calculate the slope (m) for absorption calculations (85).

INPUT THE DIFFUSION COEFFICIENT FOR THE CAUSTIC IN THE GAS PHASE

Input the diffusion coefficient in square feet per second. For hydrogen chloride, this value is 30.0 square feet per second.

INPUT THE DIFFUSION COEFFICIENT FOR THE CAUSTIC IN THE LIQUID PHASE

Input the diffusion coefficient in square feet per second. For hydrogen chloride, this value is 0.05 square feet per second.

INPUT THE SCHMIDT NUMBER FOR THE ABSORPTION PROCESS

The schmidt number is a dimensionless number. If unknown, input 1.0.

The next section of input pertains to exhaust stack design.

INPUT THE HEIGHT OF THE EXHAUST STACK

The height of the stack must be specified(in feet).

The following input requirements pertain to the economic analysis of the facility.

YEAR TO DATE THE CAPITAL COST OF THE HWSTBRNITY

Input the year when the construction of the facility will take place. This is the year to which the cost update factors are specified.

HOW MANY HOURS PER DAY IS THE INCINERATOR IN OPERATION

Specify the hours per day(including reheat time if used less than 24 hours per day) that the facility is in operation. This number is almost always 24 hours per day.

HOW MANY DAYS PER YEAR IS THE HWSTBRNITY IN OPERATION

Specify the number of days per year for operation. This value can range up to 300 days per year. The balance of the year is required for facility maintenance and start-up.

REVENUE GENERATED FROM INCINERATOR OPERATION

Specify the amount of revenue generated from incineration of the waste. This value can range from 20 to 1,200 U.S. Dollars per ton of waste feed; depending on the type of waste incinerated.

LENGTH OF PROCESS LIFE

Specify the total process life of the incineration facility. This value is recommended to be 3,5,10 or 15 years(for depreciation purposes).

INPUT THE SPECIFIC COST INDEX FACTORS FROM CHEMICAL ENGINEERING EQUIPMENT COST FACTORS

For the year to date for the incineration facility, cost update factors must be specified from Chemical Engineering magazine (See Table I for 1986 cost factors). These factors are requested individually.

INPUT THE COST UPDATE FACTOR FOR EQUIPMENT MACHINERY AND SUPPORTS

INPUT THE COST UPDATE FACTOR FOR ELECTRICAL EQUIPMENT

INPUT THE COST UPDATE FACTOR FOR FABRICATED EQUIPMENT

INPUT THE COST UPDATE FACTOR FOR STRUCTURAL SUPPORTS AND OTHER MISCELLANIOUS COSTS

INPUT THE COST UPDATE FACTOR FOR BUILDING COSTS

INPUT THE COST FACTOR FOR PIPES VALVES & FITTINGS

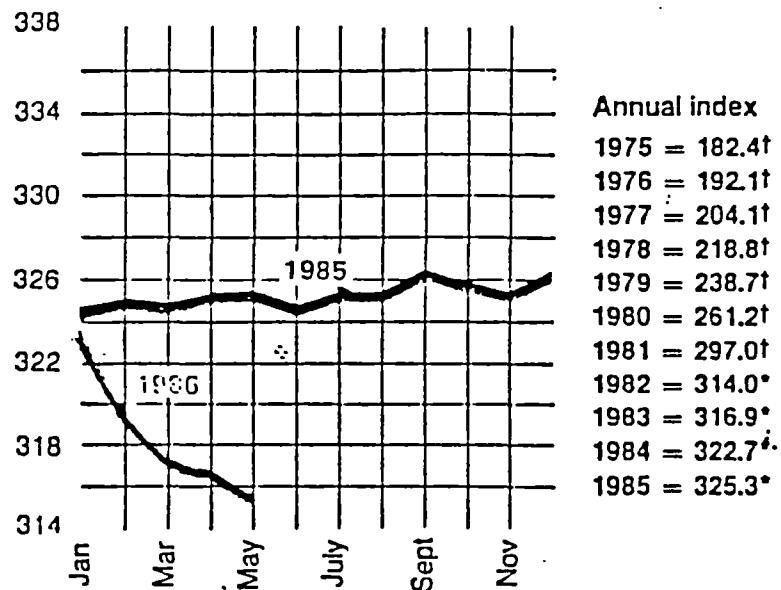
INPUT THE COST FACTOR FOR PUMPS AND COMPRESSORS

INPUT THE COST FACTOR PROCESS INSTRUMENTS

INPUT THE COST FACTOR FOR ENGINEERING & SUPERVISION

INPUT THE COST FACTOR FOR CONSTRUCTION LABOR

Table I

**CE plant cost index**

(1957-59 = 100)

	May '86 Prelim.	Apr.'86 Final	Mar.'86 Final	May '85 Final
Equipment, machinery, supports	315.2	316.7	317.4	325.4
Construction labor.....	332.1	334.4	336.9	347.0
Buildings	260.8	261.3	257.9	265.8
Engineering & supervision.....	303.7	303.5	301.9	305.3
Fabricated equipment.....	305.1	310.6	317.0	336.0
Process machinery.....	324.6	324.6	326.3	331.0
Pipe, valves & fittings.....	373.0	374.7	375.1	386.5
Process instruments	324.1	323.2	325.6	323.5
Pumps & compressors	425.1	425.1	419.8	417.5
Electrical equipment	252.9	252.9	252.2	252.3
Structural supports & misc.	340.3	340.9	341.2	345.6

*Revised; productivity factor = 1.75.

†Unrevised; productivity factor = 2.50.

See "CE Plant Cost Index—Revised," Apr. 19, 1982, p. 153. For description of original Index, see Feb. 18, 1963 issue. For past annual averages of CE Plant Cost Index and M&S Equipment Cost Indexes, refer to issues of Apr. 25, 1966, May 5, 1969, Nov. 13, 1972, Apr. 28, 1975, May 8, 1978, Apr. 19, 1982 and Apr. 29, 1985. For reprint containing all foregoing articles, request Reprint No. 122 on order form in back of any issue.

This table represents an example of the cost updating factors from CHEMICAL ENGINEERING magazine for the engineering plant cost index. This example was obtained from the July 21, 1986 issue.

INPUT THE COST FACTOR FOR PROCESS MACHINERY

Each of these cost update factors are represented under a specific category for cost updating factors(See Table I).

SPECIFY THE PERCENTAGE OF EQUIPMENT COST FOR THE CONTINGENCY COSTS

This print requests a factor(between 0 and 1.0) to estimate the contingency fees that are required for facility construction. A value of 0.20 is recommended.

Program HWSTBRN Output

Different levels of output are available, depending on the users specifications. This section provides examples of the different levels of output.

Output for the incineration process are listed in Table II. This printout is provided with every run and cannot be switched off. Table III shows an example of the design and cost breakdown for the combustor(in this case the primary combustor). The cost breakdown is an optional printout and is not shown if the user specifies no cost estimation.

Output for the pollution control components are listed in Table IV. Design output for ductwork connecting these units and waste storage for the facility is presented in Table V. From the above output, a summary table of the Total Capital Cost is printed(See Table VI). To view this table, the cost estimation option must be specified by the user(See the section on INPUT). Also, if specified, the operating costs are presented. If an economic analysis is requested by the user, a table representing the present value discounted rate of return factor is calculated. An example of this output is listed in Table VII.

Table II

INCINERATOR DESIGN AND COST FOR
ROTARY KILN

*****INPUT STREAM CHARACTERISTICS*****

COMBUSTED GAS EXIT RATE	189708.69 LB/HR
ASH FEED RATE	0.00 LB/HR
VOLITILES FEED RATE	9000.00 LB/HR
FREE WATER IN SLUDGE FEED	0.00 LB/HR
FUEL FEED RATE	3252.70 LB/HR
AIR FEED RATE (AT 50.00% EXCESS)	177514.50 LB/HR

PROCESS DESIGN VARIABLES

PERCENT EXCESS AIR IS	50.00 PERCENT
PERCENT EXCESS FUEL IS	0.00 PERCENT
INCINERATOR TEMPERATURE	2000.00 DEG. FAHRENHEIT
AMBIENT TEMPERATURE	80.00 DEG. FAHRENHEIT.
DAILY USE	24.00 HOURS/DAY.
LENGTH OF PROCESS RUN	289.00 DAYS/YEAR.
SHUTDOWN LENGTH	76.00 DAYS/YEAR.
RETENTION TIME	2.00 SECONDS
LENGTH TO DIAMETER RATIO ESTIMATE	5.00

This table represents the output printed for incineration facility design parameters.

Table III

INCINERATOR PROCESS DESIGN SPECIFICATIONS

INCINERATOR DIAMETER (FT)=	12.8267		
INCINERATOR LENGTH (FT)=	58.4393		
MATERIALS OF CONSTRUCTION FOR THE INCINERATOR			
REFRACTORY SELECTED =	90% ALUMINA FIREBRICK	THICKNESS =	1.5 INCHES
INSULATION SELECTED =	INSULATING PIPEBRICK	THICKNESS =	5.3 INCHES
INCINERATOR SURFACE AREA (FT**2)	6269.8516		
INCINERATOR VOLUME (FT**3)	6269.8789		
INCINERATOR BURNER DATA			
NUMBER OF FUEL BURNERS =	5		
WASTE FEED BURNER HEAT LOAD =	0.810E+08 BTU/HR		
OPTIONS IN EFFECT			
A 10 PERCENT HEAT LOSS (OF TOTAL HEAT RELEASED) IS INCLUDED IN THE HEAT/MASS BALANCE			
WASTE FEED IS A LIQUID. WASTE BURNERS ARE SELECTED			
INCONEL WAS SELECTED TO CONSTRUCT THE SHELL			

INCINERATOR COST BREAKDOWN

TOTAL BRICK COST \$	197151.25
TOTAL SHELL COST \$	409029.87
COST OF BURNER SYSTEM \$	70604.44
COST OF ASH SYSTEM \$	0.00
COST OF DRIVE SYSTEM \$	165264.56
COST OF SKIRTING \$	10000.00
EXTRA COSTS \$	137357.06

TOTAL INCINERATOR COST	989407.19

Output sample of the combustor process design specifications and cost breakdown.

Table IV

HEAT RECOVERY SYSTEM DESIGN

CHARACTERISTICS OF STEAM PRODUCED

PRESSURE OF STEAM FORMFD=	185. PSIA
QUANTITY OF STEAM PRODUCED =	71252. LB/HR
COST RECOVERED FROM STEAM PRODUCTION =	287.29 U.S. DOLLARS/HR

MATERIALS OF CONSTRUCTION

MATERIAL OF CONSTRUCTION IS INCONEL

QUENCH CHAMBER DESIGN SPECIFICATIONS

QUENCH TEMPERATURE = 180.0 FAHRENHEIT
 QUENCH DIAMETER = 10.6 FEET
 QUENCH LENGTH = 31.7 FEET
 WATER RATE = 0.111E+05 LB/HR
 WATER OUT = 0.000E+00 LB/HR
 OPTIONS IN EFFECT

INCONEL WAS SELECTED AS THE MATERIAL OF CONSTRUCTION
 QUENCH CHAMBER DESIGNED FOR SPECIFIC OUTLET TEMPERATURE

VENTURI SCRUBBER DESIGN OUTPUT

TOTAL PRESSURE DROP= 60. INCHES H2O
 WATER FEED RATE= 0.21106E+05LB/HR
 VENTURI SHELL THICKNESS= 0.50 INCHES
 FEDERAL PARTICULATE LEVELS= 0.5000E-04LB/ACF
 CALCULATED EMISSION LEVELS= 0.0000E+00LB/ACF
 LENGTH OF VENTURI SEPARATOR(FT)= 16.
 DIAMETER OF VENTURI SEPARATOR(FT)= 9.
 OPTIONS SELECTED
 PRESSURE DROP DIRECTLY SPECIFIED
 AUTOMATIC THROAT CONTROL SPECIFIED
 THROAT LINED WITH FIBERGLASS
 VENTURI CONSTRUCTED OF INCONEL

Table IV cont.

INDUCED DRAFT FAN DESIGN

TOTAL PRESSURE DROP(INCLUDING ADJUSTMENT FOR ELEVATION) = 60.00 IN H₂O
 ELEVATION OF FACILITY= 9000. FEET
 PRESSURE DROP PER STAGE = 20.00 IN H₂O
 VOLUME RATE PER PARALLEL FEED = 36.60FT³/MIN/1000
 NUMBER OF FANS PER STAGE = 3
 MOTOR RPMs = 1800.00
 TOTAL HORSEPOWER REQUIRED TO COMPRESS GAS = 200.00 HP
 NUMBER OF INLET STREAMS= 1
 DIAMETER OF IMPELLOR = 35. INCHES
 OPTIONS SELECTED
 MATERIAL OF CONSTRUCTION FOR FANS IS INCONEL
 CLASS 4 FANS ARE SPECIFIED(HIGH PERFORMANCE)
 COST OF INDUCTION FANS
 COST OF FANS= 63000. U.S. DOLLARS
 COST OF DAMPERS= 3917. U.S. DOLLARS
 COST OF MOTORS= 4865. U.S. DOLLARS

 TOTAL INDUCTION FAN COST= 71783. U.S. DOLLARS

PACKED BED DESIGN PARAMETERS
 DIAMETER OF COLUMN(FT)= 2.65 TOTAL HEIGHT OF COLUMN(FT)= 10.00 .
 CALCULATED COST OF COLUMN= 64307.96 U.S. DOLLARS
 CALCULATED FEED RATE= 0.00
 AREA OF BED=
 OPTIONS SELECTED
 PACKING SELECTED IS BERL SADDLES
 PACKING SIZE IS 0.5 INCHES
 PACKED COLUMN IS CONSTRUCTED OF CARBON STEEL

EXHAUST STACK DESIGN
 HEIGHT OF EXHAUST STACK= 100.00 FEET
 DIAMETER OF EXHAUST STACK= 3.67 FEET
 MASS OF STACK= 125467.12 LBS
 NUMBER OF STACKS= 1
 EXIT VELOCITY OF GAS IN STACK= 9000.00FEET/MINUTE

This table represents a sample of the output
 provided by program FACIL to indicate some
 of the important design parameters
 determined.

Table V

DUCTWORK DESIGN OUTPUT

UNITS	OUTER DIAMETER	BRICK DIAMETER	MATERIALS OF CONSTRUCTION	DUCT LENGTH	NUMBER OF ELBOWS
1 TO 2	75.6	0.00	IC	10.00	1.
2 TO 3	81.8	0.00	IC	10.00	2.
3 TO 4	38.8	0.00	IC	10.00	0.
4 TO 5	39.0	0.00	CS	10.00	1.
5 TO 6	39.0	0.00	CS	15.00	3.
6 TO 7	39.0	0.00	CS	15.00	3.
7 TO 8	0.0	0.00	CS	0.00	0.

COST OF DUCTWORK

	DUCTWORK COST	FIREBRICK COST	DAMPERS COST	TOTAL COST
1 TO 2	11628.8	16310.2	8143.1	36082.0
2 TO 3	21746.4	21935.2	9030.3	52711.8
3 TO 4	1448.8	0.0	4061.2	5509.9
4 TO 5	1152.9	0.0	4080.4	5233.2
5 TO 6	2841.8	0.0	4081.5	6923.3
6 TO 7	2841.9	0.0	4081.5	6923.4
7 TO 8	0.0	0.0	0.0	0.0

LIQUID WASTE STORAGE FACILITY

NUMBER OF 25,000 GALLON TANKS =	4
NUMBER OF 10,000 GALLON TANKS =	2
NUMBER OF 1,000 GALLON TANKS =	1
TOTAL STORAGE TANK COST=	608000. U.S. DOLLARS
CSTNIT=	0. U.S. DOLLARS
NITROGEN BLANKET SYSTEM=	0. U.S. DOLLARS
CONDENSOR COST=	0. U.S. DOLLARS

The table represents a sample of the output for the design specifications and cost of the ductwork connecting the combustor and pollution control process units. Also shown, is output representing the number of storage tanks and the cost of a waste storage facility.

Table VI

TOTAL CAPITAL COST	
COMBUSTION CHAMBERS:	1976 \$
PRIMARY COMBUSTOR	989407.19
SECONDARY COMBUSTOR	1006837.00
ENERGY RECOVERY ROLLER	149723.69
AIR POLLUTION CONTROL SYSTEM	
QUENCH CHAMBER	45399.73
VENTURI SCRUBBER AND SEPARATOR	91359.50
PACKED-BED SCRUBBER	4691.82
INDUCTION FAN	179274.37
EXHAUST STACK(0 FEET HIGH)	0.00
WASTE WATER TREATMENT FACILITY	173989.2
STORAGE TANK FACILITY	608000.00
TOTAL DUCTWORK	113383.56
METAL BUILDING	143025.25
SITWORK AND FOUNDATIONS	217.82
STRUCTURAL STEEL	35935.28
ELECTRICAL MATERIAL	118699.69
INSTRUMENTS AND CONTROLS	113578.75
TOTAL-----	3773546.00
 TOTAL INSTALLATION COST	2459029.00
START-UP (10 % OF EQUIPMENT COST)	377354.69
SPARE PARTS (8 % OF EQUIPMENT COST)	301883.56
CERTIFICATION (10 % OF EQUIPMENT COST)	377354.69
ENGINEERING (7 % OF EQUIPMENT COST)	264148.19
INSTRUMENTATION (20 % OF EQUIPMENT COST)	882709.12
CONTINGENCY FEE (20 % OF EQUIPMENT COST)	754709.12
 TOTAL INDIRECT COSTS	5417186.00
 ***** TOTAL CAPITAL COST=	9190732.00

This table represents the output generated by program FACIL listing the total capital cost of the incineration facility.

Table VII

DISCOUNTED CASH FLOW RATE OF RETURN
ANALYSIS OUTPUT
(MILLIONS OF U.S. DOLLARS)

YEAR	0	1	2	3	4	5	6	7	8	9	10
INCOME	0.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5
OPERATE	0.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
DEPREC.	0.0	0.7	1.3	1.1	0.9	0.9	0.9	0.8	0.8	0.8	0.8
TAXABLES	0.0	7.8	7.2	7.4	7.6	7.6	7.6	7.7	7.7	7.7	7.7
TAXES	0.0	3.9	3.6	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.8
NET INC.	*****	3.9	3.6	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.8
DEPREC.	0.0	0.7	1.3	1.1	0.9	0.9	0.9	0.8	0.8	0.8	0.8
CAPITAL	-9.2	-	-	-	-	-	-	-	-	-	-
CASH FLW	-9.2	4.6	4.9	4.8	4.7	4.7	4.7	4.7	4.7	4.7	4.7

THE TOTAL CASH FLOW = 38.00 MILLION DOLLARS
DISCOUNTED CASH FLOW RATE OF RETURN = 30.6%

This table represents an example of the Discounted Cash Flow Rate of Return (DCFRR) analysis generated by program FACIL. The rate of return(in this case 30.6 percent) of different facilities can be compared to determine the most profitable option. The greater the rate of return, the greater the profitability.

APPENDIX F

**EXAMPLES OF PROGRAM HWSTBRN
OUTPUT**

***** SUMMARY OF INPUT DATA FILE *****

24.0 300.0

0.0300	0.7000	0.0700	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0130	0.9870	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.2332	0.7672	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10000.0000		6000.0000							
13970.0									

T

F

F

F

T

F

O.0000000

1.0000000

F

T

T

8

80.00

14.70

3000.00

0.00

INC IC	1800.00	10.00000	1.0	IC
AFT IC	2000.00	15.00000	2.0	IC
HTE	500.00	10.00000	0.0	CS
QUE IC	180.00	10.00000	1.0	CS
VEN CS	180.00	15.00000	3.0	CS
IND CS	180.00	15.00000	3.0	CS
PCK CS	180.00	0.00000	0.0	CS
STK CS	180.00	0.00000	0.0	

T

F

F

T

2.00

3.00

0.50

0.50

O.2000000

F

F

T

7.00000

2.00000

O.2000000

F

T

F

F

F

F

T

F

F

F

F

F

2.50

O.01.0

8.00

60.00

F

0.50000E-03

T

F

60.00

BERL SADDLES	C.500.5000000C	10	1.000	70.00							
18.000	0.00	99.9900									
HCL											
	0.03										
	30.00										
100.0											
T											
308.4	212.3	305.9	257.2	310.9	344.9	368.6	265.5	232.3	214.3	287.2	1986
10.0	0.0	400.000		0.000							

HEAT LOAD IS TOO LARGE FOR BURNER SYSTEMS

12 BURNERS ARE REQUIRED

INCINERATOR DESIGN AND COST FOR
ROTARY KILN

****INPUT STREAM CHARACTERISTICS****

COMBUSTED GAS EXIT RATE	299910.19	LB/HR
ASH FEED RATE	0.00	LB/HR
VOLATILES FEED RATE	9999.99	LB/HR
FREE WATER IN SLUDGE FEED	0.00	LB/HR
FUEL FEED RATE	8381.95	LB/HR
AIR FEED RATE (AT 50.00% EXCESS)	281619.44	LB/HR

PROCESS DESIGN VARIABLES

PERCENT EXCESS AIR IS	50.00	PERCENT
PERCENT EXCESS FUEL IS	0.00	PERCENT.
INCINERATOR TEMPERATURE	1800.00	DEG. FAHRENHEIT
AMBIENT TEMPERATURE	80.00	DEG. FAHRENHEIT.
DAILY USE	24.00	HOURS/DAY.
LENGTH OF PROCESS RUN	300.00	DAYS/YEAR.
SHUTDOWN LENGTH	65.00	DAYS/YEAR.
RETENTION TIME	2.00	SECONDS
LENGTH TO DIAMETER RATIO ESTIMATE	3.00	

INCINERATOR PROCESS DESIGN SPECIFICATIONS

INCINERATOR DIAMETER (FT)=	16.5191
INCINERATOR LENGTH (FT)=	47.0572
MATERIALS OF CONSTRUCTION FOR THE INCINERATOR	
REFRACTORY SELECTED = 90%-ALUMINA FIREBRICK	
THICKNESS = 1.0 INCHES	
INSULATION SELECTED = INSULATING FIREBRICK	
THICKNESS = 4.0 INCHES	
INCINERATOR SURFACE AREA (FT**2)	9093.4102
INCINERATOR VOLUME (FT**3)	9093.4375
INCINERATOR BURNER DATA	
NUMBER OF FUEL BURNERS = 12	
WASTE FEED BURNER HEAT LOAD = 0.600E+08 BTU/HR	
OPTIONS IN EFFECT	
A 10 PERCENT HEAT LOSS (OF TOTAL HEAT RELEASED) IS INCLUDED	
IN THE HEAT/MASS BALANCE CALCULATIONS	
WASTE FEED IS A LIQUID. WASTE BURNERS ARE SELECTED	
INCONEL WAS SELECTED TO CONSTRUCT THE SHELL	

INCINERATOR COST BREAKDOWN

TOTAL BRICK COST \$	230925.31
TOTAL SHELL COST \$	690082.75
COST OF BURNER SYSTEM \$	169517.44
COST OF ASH SYSTEM \$	0.00
COST OF DRIVE SYSTEM \$	278821.25
COST OF SKIRTING \$	10000.00
EXTRA COSTS \$	220104.94

TOTAL INCINERATOR COST 1589450.00

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T=	80.00 FAHRENHEIT	OUTPUT STREAM T=	1800.00 FAHRENHEIT
P=	14.70 PSIA	P=	14.69 PSIA
LB/HR			LB/HR
-----			-----
FUEL	8381.95		0.00
AIR	281619.44		0.00
WASTE	9999.99		0.00
ASH	0.00		0.00
H2O	0.00		3144.05
HCL	0.00		2054.53
CO2	0.00		55915.13
CO	0.00		0.00
N2	0.00		215929.87
O2	0.00		22866.70
NO	0.00		0.00
NO2	0.00		0.00
CL2	0.00		0.00
SO2	0.00		0.00
H2SO4	0.00		0.00
F2	0.00		0.00
HF	0.00		0.00
P2O5	0.00		0.00
NE	0.00		0.00

1

1

INCINERATOR DESIGN AND COST FOR
LIQUID INJECTION AFTERBURNER

****INPUT STREAM CHARACTERISTICS****

COMBUSTED GAS EXIT RATE	301481.25 LB/HR
ASH FEED RATE	0.00 LB/HR
VOLATILES FEED RATE	0.00 LB/HR
FREE WATER IN SLUDGE FEED	0.00 LB/HR
FUEL FEED RATE	1571.62 LB/HR
AIR FEED RATE (AT 0.00% EXCESS)	0.00 LB/HR
GAS FEED FROM PREVIOUS UNIT	299910.19 LB/HR

PROCESS DESIGN VARIABLES

PERCENT EXCESS AIR IS	0.00 PERCENT
PERCENT EXCESS FUEL IS	0.00 PERCENT.
INCINERATOR TEMPERATURE	2000.00 DEG. FAHRENHEIT
AMBIENT TEMPERATURE	80.00 DEG. FAHRENHEIT.
DAILY USE	24.00 HOURS/DAY.
LENGTH OF PROCESS RUN	300.00 DAYS/YEAR.
SHUTDOWN LENGTH	65.00 DAYS/YEAR.
RETENTION TIME	2.00 SECONDS
LENGTH TO DIAMETER RATIO ESTIMATE	7.00

INCINERATOR PROCESS DESIGN SPECIFICATIONS

INCINERATOR DIAMETER (FT)= 13.3097
 INCINERATOR LENGTH (FT)= 85.1958
 MATERIALS OF CONSTRUCTION FOR THE INCINERATOR
 REFRACTORY SELECTED = 90%-ALUMINA FIREBRICK
 THICKNESS = 1.5 INCHES
 INSULATION SELECTED = INSULATING FIREBRICK

THICKNESS = 5.3 INCHES
 INCINERATOR SURFACE AREA (FT**2) 2740.5830
 INCINERATOR VOLUME (FT**3) 9911.7500
 INCINERATOR BURNER DATA
 NUMBER OF FUEL BURNERS = 3
 OPTIONS IN EFFECT
 A 10 PERCENT HEAT LOSS (OF TOTAL HEAT RELEASED) IS INCLUDED
 IN THE HEAT/MASS BALANCE CALCULATIONS
 INCONEL WAS SELECTED TO CONSTRUCT THE SHELL

INCINERATOR COST BREAKDOWN

TOTAL BRICK COST \$	447886.19
TOTAL SHELL COST \$	944377.87
COST OF BURNER SYSTEM \$	30000.00
EXTRA COSTS \$	284452.56
<hr/>	
TOTAL INCINERATOR COST	1706715.00

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 1800.00 FAHRENHEIT OUTPUT STREAM T= 2000.00 FAHRENHEIT
 P= 14.69 PSIA P= 14.65 PSIA

	LB/HR	-----	LB/HR	-----
FUEL	1571.62		0.00	
AIR	0.00		0.00	
H ₂ O	3144.05		3326.48	
HCl	2054.53		2054.53	
CO ₂	55915.12		61594.08	
CO	0.00		0.00	
N ₂	215929.69		215929.75	
O ₂	22866.68		18576.51	
NO	0.00		0.00	
NO ₂	0.00		0.00	
CL ₂	0.00		0.00	
SO ₂	0.00		0.00	
H ₂ S ₀ 4	0.00		0.00	
F ₂	0.00		0.00	
HF	0.00		0.00	
P ₂ O ₆	0.00		0.00	
NE	0.00		0.00	

1

HEAT RECOVERY SYSTEM DESIGN

CHARACTERISTICS OF STEAM PRODUCED
 PRESSURE OF STEAM FORMED= 185. PSIA
 QUANTITY OF STEAM PRODUCED = 182134. LB/HR
 COST RECOVERED FROM STEAM PRODUCTION = 734.36 U.S. DOLLARS/HR
 MATERIALS OF CONSTRUCTION

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 2000.00 FAHRENHEIT OUTPUT STREAM T= 500.00 FAHRENHEIT
 P= 14.65 PSIA P= 11.36 PSIA

	LB/HR	-----	LB/HR	-----
H ₂ O	3326.48		3326.48	
HCl	2054.53		2054.53	
CO ₂	61594.09		61594.05	
CO	0.00		0.00	
N ₂	215929.56		215929.69	
O ₂	18576.50		18576.50	

NO	0.00	0.00
NC2	0.00	0.00
CL2	0.00	0.00
S02	0.00	0.00
H2S04	0.00	0.00
F2	0.00	0.00
HF	0.00	0.00
P206	0.00	0.00
NE	0.00	0.00

1
1

QUENCH CHAMBER DESIGN SPECIFICATIONS

QUENCH TEMPERATURE = 180.0 FAHRENHEIT
 QUENCH DIAMETER = 19.2 FEET
 QUENCH LENGTH = 57.6 FEET
 WATER RATE = 0.282E+05 LB/HR
 WATER OUT = 0.000E+00 LB/HR
 OPTIONS IN EFFECT

1

INCONEL WAS SELECTED AS THE MATERIAL OF CONSTRUCTION
 QUENCH CHAMBER DESIGNED FOR SPECIFIC OUTLET TEMPERATURE

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T=	500.00 FAHRENHEIT	OUTPUT STREAM T=	180.00 FAHRENHEIT
P=	11.36 PSIA	P=	11.36 PSIA

	LB/HR	LB/HR
	-----	-----
H2O	3326.47	31539.01
HCL	2054.53	2054.53
CO2	61594.08	61594.01
CO	0.00	0.00
N2	215929.44	215929.62
O2	18576.49	18576.50
NO	0.00	0.00
NO2	0.00	0.00
CL2	0.00	0.00
S02	0.00	0.00
H2S04	0.00	0.00
F2	0.00	0.00
HF	0.00	0.00
P206	0.00	0.00
NE	0.00	0.00

1
1

VENTURI SCRUBBER DESIGN OUTPUT

TOTAL PRESSURE DROP= 60. INCHES H2O
 WATER FEED RATE= 0.55594E+05LB/HR
 VENTURI SHELL THICKNESS= 0.50 INCHES
 FEDERAL PARTICULATE LEVELS= 0.50000E-03LB/ACF
 CALCULATED EMISSION LEVELS= 0.00000E+00LB/ACF
 LENGTH OF VENTURI SEPARATOR(FT)= 31.
 DIAMETER OF VENTURI SEPARATOR(FT)= 15.
 OPTIONS SELECTED
 PRESSURE DROP DIRECTLY SPECIFIED
 AUTOMATIC THROAT CONTROL SPECIFIED
 VENTURI SCRUBBER CONSTRUCTED OF CARBON STEEL

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T=	180.00 FAHRENHEIT	OUTPUT STREAM T=	180.00 FAHRENHEIT
-----------------	-------------------	------------------	-------------------

	P= 11.36 PSIA	P= 11.36 PSIA
	LB/HR	LB/HR
H2O	31546.85	31539.01
HCL	2054.53	2054.53
CO2	61594.08	61594.01
CO	0.00	0.00
N2	215929.44	215929.62
O2	18576.49	18576.50
NO	0.00	0.00
NO2	0.00	0.00
CL2	0.00	0.00
SO2	0.00	0.00
H2SO4	0.00	0.00
F2	0.00	0.00
HF	0.00	0.00
P206	0.00	0.00
NE	0.00	0.00

1
MOTOR RPMs = 900.00
GAS VOLUME RATE = 500.00FT³/MIN/1000
COST OF MOTOR = 55000.06U.S. DOLLARS
1 INDUCED DRAFT FAN DESIGN

TOTAL PRESSURE DROP(INCLUDING ADJUSTMENT FOR ELEVATION) = 60.00 IN H2O
ELEVATION OF FACILITY= 3000. FEET
PRESSURE DROP PER STAGE = 20.00 IN H2O
VOLUME RATE PER PARALLEL FEED = 121.75FT³/MIN/1000
NUMBER OF FANS PER STAGE = 3
MOTOR RPMs = 900.00
TOTAL HORSEPOWER REQUIRED TO COMPRESS GAS = 1000.00 HP
NUMBER OF INLET STREAMS= 2
DIAMETER OF IMPELLOR = 64. INCHES
OPTIONS SELECTED
MATERIAL OF CONSTRUCTION OF THE FANS IS CARBON STEEL
CLASS 4 FANS ARE SPECIFIED(HIGH PERFORMANCE)

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 180.00 FAHRENHEIT	P= 11.36 PSIA	OUTPUT STREAM T= 212.73 FAHRENHEIT	P= 13.52 PSIA
	LB/HR		LB/HR
H2O	31546.85	31539.01	
HCL	2054.53	2054.53	
CO2	61594.08	61594.01	
CO	0.00	0.00	
N2	215929.44	215929.62	
O2	18576.49	18576.50	
NO	0.00	0.00	
NO2	0.00	0.00	
CL2	0.00	0.00	
SO2	0.00	0.00	
H2SO4	0.00	0.00	
F2	0.00	0.00	
HF	0.00	0.00	
P206	0.00	0.00	
NE	0.00	0.00	

1

THE DIAMETER OF THE PACKED BED IS TOO LARGE FOR COST CALCULATIONS
DIAMETER(IN)= 261. NUMBER OF INLET STREAMS INCREASED BY ONE
THE DIAMETER OF THE PACKED BED IS TOO LARGE FOR COST CALCULATIONS
DIAMETER(IN)= 185. NUMBER OF INLET STREAMS INCREASED BY ONE
THE DIAMETER OF THE PACKED BED IS TOO LARGE FOR COST CALCULATIONS

DIAMETER(IN)= 151. NUMBER OF INLET STREAMS INCREASED BY ONE
 THE DIAMETER OF THE PACKED BED IS TOO LARGE FOR COST CALCULATIONS
 DIAMETER(IN)= 131. NUMBER OF INLET STREAMS INCREASED BY ONE
 THE DIAMETER OF THE PACKED BED IS TOO LARGE FOR COST CALCULATIONS
 DIAMETER(IN)= 117. NUMBER OF INLET STREAMS INCREASED BY ONE
 THE DIAMETER OF THE PACKED BED IS TOO LARGE FOR COST CALCULATIONS
 DIAMETER(IN)= 107. NUMBER OF INLET STREAMS INCREASED BY ONE
 PACK BED DIAMETER IS OUT OF RANGE FOR ACCURATE CALCS
 COST OF ABSORBER COLUMN PER FOOT = 3358.31
 COST OF ABSORBER PACKING = 10746.12
 TOTAL ABSORBER COST = 310304.81

1

PACKED BED DESIGN PARAMETERS

DIAMETER OF COLUMN(FT)= 8.23
 TOTAL HEIGHT OF COLUMN(FT)= 10.00
 CALCULATED COST OF COLUMN= 310304.81 U.S. DOLLARS
 CALCULATED FEED RATE= 102024.62
 AREA OF BED= 53.20FT**2
 NUMBER OF MASS TRANSFER UNITS= 10
 AMOUNT OF LIME ADDED= 2080.00LB/HR

OPTIONS SELECTED

PACKING SELECTED IS BERL SADDLES
 PACKING SIZE IS 0.5 INCHES
 PACKED COLUMN IS CONSTRUCTED OF CARBON STEEL

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 180.00 FAHRENHEIT	P= 13.52 PSIA	OUTPUT STREAM T= 180.00 FAHRENHEIT	P= 13.52 PSIA
LB/HR		LB/HR	
-----	-----	-----	-----
H2O	31546.85	31539.01	
HCL	2054.53	2054.53	
CO2	61594.08	61594.01	
CO	0.00	0.00	
N2	215929.44	215929.62	
O2	18576.49	18576.50	
NO	0.00	0.00	
NO2	0.00	0.00	
CL2	0.00	0.00	
S02	0.00	0.00	
H2SO4	0.00	0.00	
F2	0.00	0.00	
HF	0.00	0.00	
P206	0.00	0.00	
NE	0.00	0.00	

1

EXHAUST STACK DESIGN DATA OUTPUT
 HEIGHT OF EXHAUST STACK= 200.00 FEET
 DIAMETER OF EXHAUST STACK= 6.56 FEET
 MASS OF STACK= 327647.00 LBS
 NUMBER OF STACKS= 1
 EXIT VELOCITY OF GAS IN STACK= 9000.00FEET/MINUTE

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 180.00 FAHRENHEIT	P= 13.52 PSIA	OUTPUT STREAM T= 180.00 FAHRENHEIT	P= 13.52 PSIA
LB/HR		LB/HR	
-----	-----	-----	-----
H2O	31546.85	31539.01	
HCL	0.21	2054.53	

CO2	61594.08	61594.01
CO	0.00	0.00
N2	215929.44	215929.62
O2	18576.49	18576.50
NO	0.00	0.00
NO2	0.00	0.00
CL2	0.00	0.00
SO2	0.00	0.00
H2SO4	0.00	0.00
F2	0.00	0.00
HF	0.00	0.00
P2O6	0.00	0.00
NE	0.00	0.00

1 **** WARNING. THE EXHAUST STACK EXIT PRESSURE IS LESS THAN
THE AMBIENT FACILITY PRESSURE
DUCTWORK DESIGN OUTPUT

UNITS	OUTER DIAMETER	BRICK MATERIALS OF CONSTRUCTION	DUCT LENGTH	NUMBER OF ELBOWS
1 TO 2	84.5	0.00 IC	10.00	1.
2 TO 3	91.5	0.00 IC	15.00	2.
3 TO 4	48.7	0.00 CS	10.00	0.
4 TO 5	48.6	0.00 CS	10.00	1.
5 TO 6	48.6	0.00 CS	15.00	3.
6 TO 7	48.6	0.00 CS	15.00	3.
7 TO 8	44.4	0.00 CS	0.00	0.
8 TO 9	0.0	0.00	0.00	0.

COST OF DUCTWORK

	DUCTWORK COST	FIREBRICK COST	DAMPERS COST	TOTAL COST
1 TO 2	20818.3	31247.8	14238.0	66304.0
2 TO 3	43286.5	67410.9	15943.9	*****
3 TO 4	780.6	0.0	7550.4	8331.0
4 TO 5	2293.0	0.0	7531.8	9824.8
5 TO 6	5713.5	0.0	7534.0	13247.5
6 TO 7	5713.5	0.0	7534.1	13247.6
7 TO 8	0.0	0.0	6918.2	6918.2
8 TO 9	0.0	0.0	0.0	0.0

1 LIQUID WASTE STORAGE FACILITY

NUMBER OF 25,000 GALLON TANKS =	5
NUMBER OF 10,000 GALLON TANKS =	1
NUMBER OF 1,000 GALLON TANKS =	1
TOTAL STORAGE TANK COST=	662000. U.S. DOLLARS
CSTNIT=	0. U.S. DOLLARS
NITROGEN BLANKET SYSTEM=	0. U.S. DOLLARS
CONDENSOR COST=	10000. U.S. DOLLARS

1 *** ERROR *** THE FEED RATE OF WASTE IS TOO LARGEFOR ACCURATE PREDICTION OF SITWORK C
*** ERROR *** THE FEED RATE OF WASTE IS TOO LARGEFOR ACCURATE PREDICTION OF SITWORK C
1 TOTAL CAPITAL COST

COMBUSTION CHAMBERS:	1986 \$
PRIMARY COMBUSTOR	1599450.00
SECONDARY COMBUSTOR	1706715.00
ENERGY RECOVERY BOILER	539945.69
AIR POLLUTION CONTROL SYSTEM	
QUENCH CHAMBER	84481.50
VENTURI SCRUBBER AND SEPARATOR	101700.69
PACKED BED SCRUBBER	310304.81
INDUCTION FAN	318808.25
EXHAUST STACK(200 FEET HIGH)	14996.14

WASTE WATER TREATMENT FACILITY	82579.50
STORAGE TANK FACILITY	671999.81
TOTAL DUCTWORK	244514.37
METAL BUILDING	198951.31
SITEWORK AND FOUNDATIONS	574748.44
STRUCTURAL STEEL	55280.93
ELECTRICAL MATERIAL	130960.94
INSTRUMENTS AND CONTROLS	131041.19
 TOTAL-----	 6766471.00
 TOTAL INSTALLATION COST	4130972.00
START-UP (10 % OF EQUIPMENT COST)	676647.25
SPARE PARTS (8 % OF EQUIPMENT COST)	541317.56
CERTIFICATION (10 % OF EQUIPMENT COST)	676647.25
ENGINEERING (7 % OF EQUIPMENT COST)	473652.87
INSTRUMENTATION (20 % OF EQUIPMENT COST)	1481294.00
CONTINGENCY FEE (20 % OF EQUIPMENT COST)	0.00
 TOTAL INDIRECT COSTS	 7980529.00
 ***** TOTAL CAPITAL COST=	 14747000.00

1

OPERATING LABOR OUTPUT

SUPERVISOR SALARY(\$/YR)=	55111.
LABORATORY SUPERVISOR(\$/YR)=	55111.
LABORATORY TECHNICIANS SALARY(\$/YR) =	20160. FOR 1TECHNICIANS
CHIEF OPERATORS SALARY(\$/YR) =	41698.
OPERATORS SALARY(\$/YR) =	147168. FOR 2 OPERATORS
YARD WORKERS SALARY(\$/YR) =	48384. FOR 2 WORKERS.
SECRETARIES SALARY(\$/YR) =	18144. FOR 1 SECRETARIES
PAYROLL EXPENSES(20% OF LABOR=	82666.
COST IN \$/YR)	
SUPPLIES AND OTHER MISC.(\$/YR)=	55111.
 TOTAL EXPENSES(\$/YR)=	 468440.

1

ANNUAL OPERATING COSTS

FEED RATE 10000. LB/HR

LABOR	468440.
 UTILITIES	
ELECTRICITY	421295.
FUEL	5310783.
WATER	71040.
WASTE DISPOSAL	0.
BULK LIME	250848.
 WASTE WATER TREATMENT	 72434.
 STARTUP COSTS	 676647.
 INSURANCE COST	 88482.
 ANNUAL MAINTENENCE	 577788.
ROTARY KILN (10% EQUIPMENT	
COST)	
 HEAT RECOVERY UNIT	 -5287423.

(80% EFFICIENCY)

TOTAL OPERATING COST

2650332.

1

DISCOUNTED CASH FLOW RATE OF RETURN
ANALYSIS OUTPUT
(MILLIONS OF U.S. DOLLARS)

YEAR	0	1	2	3	4	5	6	7	8	9	10
INCOME	0.0	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
OPERATE	0.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
DEPREC.	0.0	1.2	2.1	1.8	1.5	1.5	1.5	1.3	1.3	1.3	1.3
TAXABLES	0.0	10.6	9.7	10.0	10.3	10.3	10.3	10.4	10.4	10.4	10.4
TAXES	0.0	5.3	4.8	5.0	5.1	5.1	5.1	5.2	5.2	5.2	5.2
NET INC.	0.0	5.3	4.8	5.0	5.1	5.1	5.1	5.2	5.2	5.2	5.2
DEPREC.	0.0	1.2	2.1	1.8	1.5	1.5	1.5	1.3	1.3	1.3	1.3
CAPITAL	-14.7	-	-	-	-	-	-	-	-	-	-
CASH FLW	-14.7	6.5	6.9	6.8	6.6	6.6	6.6	6.5	6.5	6.5	6.5

THE TOTAL CASH FLOW = 51.37 MILLION DOLLARS
 DISCOUNTED CASH FLOW RATE OF RETURN = 27.8%

***** SUMMARY OF INPUT DATA FILE *****

24.0 300.C

0.0300	0.7000	0.0700	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0130	0.9870	C.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.2332	0.7672	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5000.0000	6000.0000								
		13970.0							

T
F
F
F
T
F
O.0000000
1.0000000
F
T
T
8
80.00
14.70
3000.00
0.00

INC IC	1800.00	10.00000	1.0 IC
AFT IC	2000.00	15.00000	2.0 IC
HTE	500.00	10.00000	0.0 CS
QUE IC	180.00	10.00000	1.0 CS
VEN CS	180.00	15.00000	3.0 CS
IND CS	180.00	15.00000	3.0 CS
PCK CS	180.00	0.00000	0.0 CS
STK CS	180.00	0.00000	0.0

F
T
F
T
2.00
1.50
0.50
0.500.2000000
F
F
T
7.00000
2.00000
0.2000000
F
T
F
F
F
F
F
T
F
F
F
2.50
0.01.0
8.00
60.00
F
0.50000E-03
T
F
60.00

BERL SADDLES C.500.5000000C 1C 1.000 7C.00
 18.000 0.00 99.9900
 HCL
 0.03
 30.00
 100.0
 T
 308.4 212.3 305.9 257.2 310.9 344.9 368.6 265.5 232.3 214.3 287.2 1986
 10.0 0.0 400.000 0.000

MOTOR RPMs= 1800.00
 GAS VOLUME RATE= 200.00FT³/MIN/1000
 COST OF MOTOR= 3293.54U.S. DOLLARS
 1 INDUCED DRAFT FAN DESIGN

TOTAL PRESSURE DROP(INCLUDING ADJUSTMENT FOR ELEVATION) =138.40 IN H2O
 ELEVATION OF FACILITY= 3000. FEET
 PRESSURE DROP PER STAGE = 20.00 IN H2O
 VOLUME RATE PER PARALLEL FEED = 31.90FT³/MIN/1000
 NUMBER OF FANS PER STAGE = 6
 MOTOR RPMs = 1800.00
 TOTAL HORSEPOWER REQUIRED TO COMPRESS GAS = 200.00 HP
 NUMBER OF INLET STREAMS= 1
 DIAMETER OF IMPELLOR = 33. INCHES
 OPTIONS SELECTED
 MATERIAL OF CONSTRUCTION FOR FANS IS INCONEL
 CLASS 4 FANS ARE SPECIFIED(HIGH PERFORMANCE)
 1 INCINERATOR DESIGN AND COST FOR
 FLUIDIZED BED

****INPUT STREAM CHARACTERISTICS****

COMBUSTED GAS EXIT RATE	149954.94 LB/HR
ASH FEED RATE	0.00 LB/HR
VOLATILES FEED RATE	5000.00 LB/HR
FREE WATER IN SLUDGE FEED	0.00 LB/HR
FUEL FEED RATE	4190.97 LB/HR
AIR FEED RATE (AT 50.00% EXCESS)	140809.75 LB/HR

PROCESS DESIGN VARIABLES

PERCENT EXCESS AIR IS	50.00 PERCENT
PERCENT EXCESS FUEL IS	0.00 PERCENT.
INCINERATOR TEMPERATURE	80.00 DEG. FAHRENHEIT
AMBIENT TEMPERATURE	80.00 DEG. FAHRENHEIT.
DAILY USE	24.00 HOURS/DAY.
LENGTH OF PROCESS RUN	300.00 DAYS/YEAR.
SHUTDOWN LENGTH	65.00 DAYS/YEAR.
RETENTION TIME	2.00 SECONDS
LENGTH TO DIAMETER RATIO ESTIMATE	1.50

INCINERATOR PROCESS DESIGN SPECIFICATIONS

INCINERATOR DIAMETER (FT)=	31.6678
INCINERATOR LENGTH (FT)=	46.2518
MATERIALS OF CONSTRUCTION FOR THE INCINERATOR	
REFRACTORY SELECTED =	90%-ALUMINA FIREBRICK
THICKNESS =	1.0 INCHES
INSULATION SELECTED =	INSULATING FIREBRICK
THICKNESS =	4.0 INCHES
INCINERATOR SURFACE AREA (FT ²)	0.0000
INCINERATOR VOLUME (FT ³)	4546.7148
INCINERATOR BURNER DATA	
NUMBER OF FUEL BURNERS =	6
WASTE FEED BURNER HEAT LOAD =	0.300E+08 BTU/HR

OPTIONS IN EFFECT

A 10 PERCENT HEAT LOSS (OF TOTAL HEAT RELEASED) IS INCLUDED
 IN THE HEAT/MASS BALANCE CALCULATIONS
 WASTE FEED IS A LIQUID. WASTE BURNERS ARE SELECTED
 INCONEL WAS SELECTED TO CONSTRUCT THE SHELL

INCINERATOR COST BREAKDOWN

TOTAL BRICK COST \$	437143.87
TOTAL SHELL COST \$	1437269.00
COST OF BURNER SYSTEM \$	99773.44
COST OF SUPPORT TRAYS \$	18475.59
COST OF ASH SYSTEM \$	0.00
EXTRA COSTS \$	400532.12
<hr/>	
TOTAL INCINERATOR COST	2403192.00

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T=	80.00 FAHRENHEIT	OUTPUT STREAM T=	80.00 FAHRENHEIT
P=	14.70 PSIA	P=	14.70 PSIA

	LB/HR		LB/HR
<hr/>			
FUEL	4190.97		0.00
AIR	140809.75		0.00
WASTE	5000.00		0.00
ASH	0.00		0.00
H ₂ O	0.00		1572.02
HCl	0.00		1027.27
CO ₂	0.00		27957.56
CO	0.00		0.00
N ₂	0.00		107964.81
O ₂	0.00		11433.36
NO	0.00		0.00
NO ₂	0.00		0.00
CL ₂	0.00		0.00
SO ₂	0.00		0.00
H ₂ SO ₄	0.00		0.00
F ₂	0.00		0.00
HF	0.00		0.00
P ₂ O ₅	0.00		0.00
NE	0.00		0.00

INCINERATOR DESIGN AND COST FOR
LIQUID INJECTION AFTERBURNER

*****INPUT STREAM CHARACTERISTICS*****

COMBUSTED GAS EXIT RATE	150740.50 LB/HR
ASH FEED RATE	0.00 LB/HR
VOLATILES FEED RATE	0.00 LB/HR
FREE WATER IN SLUDGE FEED	0.00 LB/HR
FUEL FEED RATE	785.81 LB/HR
AIR FEED RATE (AT 0.00% EXCESS)	0.00 LB/HR
GAS FEED FROM PREVIOUS UNIT	149954.94 LB/HR

PROCESS DESIGN VARIABLES

PERCENT EXCESS AIR IS	0.00 PERCENT
PERCENT EXCESS FUEL IS	0.00 PERCENT.
INCINERATOR TEMPERATURE	2000.00 DEG. FAHRENHEIT
AMBIENT TEMPERATURE	80.00 DEG. FAHRENHEIT.

DAILY USE	24.00 HOURS/DAY.
LENGTH OF PROCESS RUN	300.00 DAYS/YEAR.
SHUTDOWN LENGTH	65.00 DAYS/YEAR.
RETENTION TIME	2.00 SECONDS
LENGTH TO DIAMETER RATIO ESTIMATE	7.00

INCINERATOR PROCESS DESIGN SPECIFICATIONS

INCINERATOR DIAMETER (FT)= 10.7967
 INCINERATOR LENGTH (FT)= 67.6045
 MATERIALS OF CONSTRUCTION FOR THE INCINERATOR
 REFRACTORY SELECTED = 90%-ALUMINA FIREBRICK
 THICKNESS = 1.5 INCHES
 INSULATION SELECTED = INSULATING FIREBRICK
 THICKNESS = 5.3 INCHES
 INCINERATOR SURFACE AREA (FT**2) 1721.6831
 INCINERATOR VOLUME (FT**3) 4952.4687
 INCINERATOR BURNER DATA
 NUMBER OF FUEL BURNERS = 2
 OPTIONS IN EFFECT
 A 10 PERCENT HEAT LOSS (OF TOTAL HEAT RELEASED) IS INCLUDED
 IN THE HEAT/MASS BALANCE CALCULATIONS
 INCONEL WAS SELECTED TO CONSTRUCT THE SHELL

INCINERATOR COST BREAKDOWN

TOTAL BRICK COST \$	287080.62
TOTAL SHELL COST \$	610282.50
COST OF BURNER SYSTEM \$	20000.00
EXTRA COSTS \$	183472.56
<hr/>	
TOTAL INCINERATOR COST	1100835.00

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 1800.00 FAHRENHEIT	OUTPUT STREAM T= 2000.00 FAHRENHEIT
P= 14.70 PSIA	P= 14.66 PSIA

	LB/HR	-----	LB/HR	-----
FUEL	785.81		0.00	
AIR	0.00		0.00	
H ₂ O	1572.02		1663.24	
HCl	1027.27		1027.27	
CO ₂	27957.55		30797.04	
CO	0.00		0.00	
N ₂	107964.75		107964.75	
O ₂	11433.35		9288.27	
NO	0.00		0.00	
NO ₂	0.00		0.00	
CL ₂	0.00		0.00	
SO ₂	0.00		0.00	
H ₂ SO ₄	0.00		0.00	
F ₂	0.00		0.00	
HF	0.00		0.00	
P ₂ O ₅	0.00		0.00	
NE	0.00		0.00	

1

HEAT RECOVERY SYSTEM DESIGN

CHARACTERISTICS OF STEAM PRODUCED	
PRESSURE OF STEAM FORMED=	185. PSIA
QUANTITY OF STEAM PRODUCED =	91067. LB/HR
COST RECOVERED FROM STEAM PRODUCTION =	367.18 U.S. DOLLARS/HR
MATERIALS OF CONSTRUCTION	

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 2000.00 FAHRENHEIT OUTPUT STREAM T= 500.00 FAHRENHEIT
 P= 14.66 PSIA P= 11.38 PSIA

	LB/HR	LB/HR
H2O	1663.24	1663.24
HCL	1027.27	1027.27
CO2	30797.02	30797.04
CO	0.00	0.00
N2	107964.69	107964.69
O2	9288.26	9288.27
NO	0.00	0.00
NO2	0.00	0.00
CL2	0.00	0.00
SO2	0.00	0.00
H2SO4	0.00	0.00
F2	0.00	0.00
HF	0.00	0.00
P206	0.00	0.00
NE	0.00	0.00

1

QUENCH CHAMBER DESIGN SPECIFICATIONS

QUENCH TEMPERATURE = 180.0 FAHRENHEIT
 QUENCH DIAMETER = 13.6 FEET
 QUENCH LENGTH = 40.7 FEET
 WATER RATE = 0.141E+05 LB/HR
 WATER OUT = 0.000E+00 LB/HR
 OPTIONS IN EFFECT

INCONEL WAS SELECTED AS THE MATERIAL OF CONSTRUCTION
 QUENCH CHAMBER DESIGNED FOR SPECIFIC OUTLET TEMPERATURE

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 500.00 FAHRENHEIT OUTPUT STREAM T= 180.00 FAHRENHEIT
 P= 11.38 PSIA P= 11.37 PSIA

	LB/HR	LB/HR
H2O	1663.24	15769.50
HCL	1027.26	1027.27
CO2	30797.01	30797.03
CO	0.00	0.00
N2	107964.62	107964.62
O2	9288.25	9288.26
NO	0.00	0.00
NO2	0.00	0.00
CL2	0.00	0.00
SO2	0.00	0.00
H2SO4	0.00	0.00
F2	0.00	0.00
HF	0.00	0.00
P206	0.00	0.00
NE	0.00	0.00

1

VENTURI SCRUBBER DESIGN OUTPUT

TOTAL PRESSURE DROP= 60. INCHES H2O
 WATER FEED RATE= 0.27759E+05LB/HR
 VENTURI SHELL THICKNESS= 0.50 INCHES

FEDERAL PARTICULATE LEVELS= 0.5000E-03LB/ACF
 CALCULATED EMISSION LEVELS= 0.0000E+00LB/ACF
 LENGTH OF VENTURI SEPARATOR(FT)= 21.
 DIAMETER OF VENTURI SEPARATOR(FT)= 11.
 OPTIONS SELECTED
 PRESSURE DROP DIRECTLY SPECIFIED
 AUTOMATIC THROAT CONTROL SPECIFIED
 VENTURI SCRUBBER CONSTRUCTED OF CARBON STEEL

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 180.00 FAHRENHEIT	OUTPUT STREAM T= 180.00 FAHRENHEIT
P= 11.37 PSIA	P= 11.37 PSIA

	LB/HR	LB/HR
H2O	15773.42	15769.50
HCL	1027.26	1027.27
CO2	30797.01	30797.03
CO	0.00	0.00
N2	107964.62	107964.62
O2	9288.25	9288.26
NO	0.00	0.00
NO2	0.00	0.00
CL2	0.00	0.00
S02	0.00	0.00
H2SO4	0.00	0.00
F2	0.00	0.00
HF	0.00	0.00
P206	0.00	0.00
NE	0.00	0.00

1

MOTOR RPMs= 1800.00
 GAS VOLUME RATE= 500.00FT³/MIN/1000
 COST OF MOTOR= 10947.02U.S. DOLLARS
 1 INDUCED DRAFT FAN DESIGN

1

TOTAL PRESSURE DROP(INCLUDING ADJUSTMENT FOR ELEVATION) =138.40 IN H2O
 ELEVATION OF FACILITY= 3000. FEET
 PRESSURE DROP PER STAGE = 20.00 IN H2O
 VOLUME RATE PER PARALLEL FEED = 64.17FT³/MIN/1000
 NUMBER OF FANS PER STAGE = 6
 MOTOR RPMs = 1800.00
 TOTAL HORSEPOWER REQUIRED TO COMPRESS GAS = 500.00 HP
 NUMBER OF INLET STREAMS= 1
 DIAMETER OF IMPELLOR = 46. INCHES
 OPTIONS SELECTED
 MATERIAL OF CONSTRUCTION OF THE FANS IS CARBON STEEL
 CLASS 4 FANS ARE SPECIFIED(HIGH PERFORMANCE)

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 180.00 FAHRENHEIT	OUTPUT STREAM T= 250.18 FAHRENHEIT
P= 11.37 PSIA	P= 16.37 PSIA

	LB/HR	LB/HR
H2O	15773.42	15769.50
HCL	1027.26	1027.27
CO2	30797.01	30797.03
CO	0.00	0.00
N2	107964.62	107964.62
O2	9288.25	9288.26
NO	0.00	0.00

NC2	0.00	0.00
CL2	0.00	0.00
SO2	0.00	0.00
H2SO4	0.00	0.00
F2	0.00	0.00
HF	0.00	0.00
P206	0.00	0.00
NE	0.00	0.00

1

THE DIAMETER OF THE PACKED BED IS TOO LARGE FOR COST CALCULATIONS
DIAMETER(IN)= 193. NUMBER OF INLET STREAMS INCREASED BY ONE
THE DIAMETER OF THE PACKED BED IS TOO LARGE FOR COST CALCULATIONS
DIAMETER(IN)= 136. NUMBER OF INLET STREAMS INCREASED BY ONE
THE DIAMETER OF THE PACKED BED IS TOO LARGE FOR COST CALCULATIONS
DIAMETER(IN)= 111. NUMBER OF INLET STREAMS INCREASED BY ONE
PACK BED DIAMETER IS OUT OF RANGE FOR ACCURATE CALCS
COST OF ABSORBER COLUMN PER FOOT = 3240.59
COST OF ABSORBER PACKING = 10252.13
TOTAL ABSORBER COST = 170632.06

1

PACKED BED DESIGN PARAMETERS

DIAMETER OF COLUMN(FT)=	8.04
TOTAL HEIGHT OF COLUMN(FT)=	10.00
CALCULATED COST OF COLUMN=	170632.06 U.S. DOLLARS
CALCULATED FEED RATE=	73743.44
AREA OF BED=	50.76FT ²
NUMBER OF MASS TRANSFER UNITS=	10
AMOUNT OF LIME ADDED=	1040.00LB/HR

OPTIONS SELECTED
PACKING SELECTED IS BERM SADDLES
PACKING SIZE IS 0.5 INCHES
PACKED COLUMN IS CONSTRUCTED OF CARBON STEEL

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 180.00 FAHRENHEIT	P= 16.37 PSIA	OUTPUT STREAM T= 180.00 FAHRENHEIT	P= 16.37 PSIA
LB/HR	-----	LB/HR	-----
H2O	15773.42	15769.50	
HCl	1027.26	1027.27	
CO2	30797.01	30797.03	
CO	0.00	0.00	
N2	107964.62	107964.62	
O2	9288.25	9288.26	
NO	0.00	0.00	
NO2	0.00	0.00	
CL2	0.00	0.00	
SO2	0.00	0.00	
H2SO4	0.00	0.00	
F2	0.00	0.00	
HF	0.00	0.00	
P206	0.00	0.00	
NE	0.00	0.00	

1

EXHAUST STACK DESIGN DATA OUTPUT
HEIGHT OF EXHAUST STACK= 100.00 FEET
DIAMETER OF EXHAUST STACK= 4.22 FEET
MASS OF STACK= 163823.37 LBS
NUMBER OF STACKS= 1
EXIT VELOCITY OF GAS IN STACK= 9000.00FEET/MINUTE

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 180.00 FAHRENHEIT
P= 16.37 PSIA OUTPUT STREAM T= 180.00 FAHRENHEIT
P= 16.37 PSIA

	LB/HR	LB/HR
H2O	15773.42	15769.50
HCL	0.10	1027.27
CO2	30797.01	30797.03
CO	0.00	0.00
N2	107964.62	107964.62
O2	9288.25	9288.26
NO	0.00	0.00
NO2	0.00	0.00
CL2	0.00	0.00
S02	0.00	0.00
H2S04	0.00	0.00
F2	0.00	0.00
HF	0.00	0.00
P206	0.00	0.00
NE	0.00	0.00

1

DUCTWORK DESIGN OUTPUT

UNITS	OUTER DIAMETER	BRICK DIAMETER	MATERIALS OF CONSTRUCTION	DUCT LENGTH	NUMBER OF ELBOWS
1 TO 2	52.7	0.00	IC	10.00	1.
2 TO 3	68.7	0.00	IC	15.00	2.
3 TO 4	34.4	0.00	CS	10.00	0.
4 TO 5	34.3	0.00	CS	10.00	1.
5 TO 6	34.3	0.00	CS	15.00	3.
6 TO 7	34.3	0.00	CS	15.00	3.
7 TO 8	28.5	0.00	CS	0.00	0.
8 TO 9	0.0	0.00		0.00	0.

COST OF DUCTWORK

COST	DUCTWORK COST	FIREBRICK COST	DAMPERS COST	TOTAL COST
1 TO 2	7463.5	0.0	8168.7	15632.3
2 TO 3	19862.5	50061.2	10905.5	80829.2
3 TO 4	545.2	0.0	5516.3	6061.5
4 TO 5	1483.7	0.0	5503.7	6987.3
5 TO 6	3636.9	0.0	5505.1	9142.0
6 TO 7	3636.9	0.0	5505.2	9142.1
7 TO 8	0.0	0.0	4725.7	4725.7
8 TO 9	0.0	0.0	0.0	0.0

1

LIQUID WASTE STORAGE FACILITY

NUMBER OF 25,000 GALLON TANKS = 2
 NUMBER OF 10,000 GALLON TANKS = 1
 NUMBER OF 1,000 GALLON TANKS = 2
 TOTAL STORAGE TANK COST= 370000. U.S. DOLLARS
 CSTNT= 0. U.S. DOLLARS
 NITROGEN BLANKET SYSTEM= 0. U.S. DOLLARS
 CONDENSOR COST= 10000. U.S. DOLLARS

1

TOTAL CAPITAL COST

-----	-----
COMBUSTION CHAMBERS:	1986 \$
-----	-----
PRIMARY COMBUSTOR	2403192.00
SECONDARY COMBUSTOR	1100835.00
ENERGY RECOVERY BOILER	280848.31
AIR POLLUTION CONTROL SYSTEM	

QUENCH CHAMBER	63886.80
VENTURI SCRUBBER AND SEPARATOR	51383.38
PACKED BED SCRUBBER	170632.06
INDUCTION FAN	86292.69
EXHAUST STACK(100 FEET HIGH)	13165.51
WASTE WATER TREATMENT FACILITY	49353.11
STORAGE TANK FACILITY	379999.87
TOTAL DUCTWORK	132519.94
METAL BUILDING	198951.31
SITEWORK AND FOUNDATIONS	197.37
STRUCTURAL STEEL	33168.55
ELECTRICAL MATERIAL	49849.93
INSTRUMENTS AND CONTROLS	64786.85
 TOTAL-----	 5079055.00

TOTAL INSTALLATION COST	2999661.00
START-UP (10 % OF EQUIPMENT COST)	507905.56
SPARE PARTS (8 % OF EQUIPMENT COST)	406324.31
CERTIFICATION (10 % OF EQUIPMENT COST)	507905.56
ENGINEERING (7 % OF EQUIPMENT COST)	355533.81
INSTRUMENTATION (20 % OF EQUIPMENT COST)	1143810.00
CONTINGENCY FEE (20 % OF EQUIPMENT COST)	0.00
 TOTAL INDIRECT COSTS	 5921138.00

***** TOTAL CAPITAL COST= 11000193.00

1

OPERATING LABOR OUTPUT

SUPERVISOR SALARY(\$/YR)=	55111.
LABORATORY SUPERVISOR(\$/YR)=	55111.
LABORATORY TECHNICIANS SALARY(\$/YR) =	20160. FOR 1TECHNICIANS
CHIEF OPERATORS SALARY(\$/YR) =	41698.
OPERATORS SALARY(\$/YR) =	147168. FOR 2 OPERATORS
YARD WORKERS SALARY(\$/YR) =	48384. FOR 2 WORKERS.
SECRETARIES SALARY(\$/YR) =	18144. FOR 1 SECRETARIES
PAYROLL EXPENSES(20% OF LABOR=	82666.
COST IN \$/YR)	
SUPPLIES AND OTHER MISC.(\$/YR)=	55111.
 TOTAL EXPENSES(\$/YR)=	 468440.

1

ANNUAL OPERATING COSTS

FEED RATE 5000. LB/HR

LABOR	468440.
 UTILITIES	

ELECTRICITY	352741.
FUEL	2655397.
WATER	45732.
WASTE DISPOSAL	0.
BULK LIME	125424.
 WASTE WATER TREATMENT	 46739.
 STARTUP COSTS	 507906.
 INSURANCE COST	 66001.

ANNUAL MAINTENENCE FLUIDIZED BED (7% EQUIPMENT COST)	330886.
HEAT RECOVERY UNIT (80% EFFICIENCY)	-2643707.

TOTAL OPERATING COST	1955557.

1 DISCOUNTED CASH FLOW RATE OF RETURN
 ANALYSIS OUTPUT
 (MILLIONS OF U.S. DOLLARS)

YEAR	0	1	2	3	4	5	6	7	8	9	10
INCOME	0.0	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
OPERATE	0.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
DEPREC.	0.0	0.9	1.5	1.3	1.1	1.1	1.1	1.0	1.0	1.0	1.0
TAXABLES	0.0	4.4	3.7	3.9	4.1	4.1	4.1	4.3	4.3	4.3	4.3
TAXES	0.0	2.2	1.9	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1
NET INC.	0.0	2.2	1.9	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1
DEPREC.	0.0	0.9	1.5	1.3	1.1	1.1	1.1	1.0	1.0	1.0	1.0
CAPITAL	-11.0	-	-	-	-	-	-	-	-	-	-
CASH FLW	-11.0	3.1	3.4	3.3	3.2	3.2	3.2	3.1	3.1	3.1	3.1

THE TOTAL CASH FLOW = 20.72 MILLION DOLLARS
 DISCOUNTED CASH FLOW RATE OF RETURN = 18.4%

***** SUMMARY OF INPUT DATA FILE *****

24.0 300.0

0.0300	0.7000	0.0700	0.0000	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0130	0.9870	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.2332	0.7672	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1000.0000		6000.0000							
13970.0									

T
F
F
F
F
T
F
O.0000000
1.0000000
F
T
T
8
80.00
14.70
3000.00
0.00

INC IC	1800.00	10.00000	1.0	IC
AFT IC	2000.00	15.00000	2.0	IC
HTE	500.00	10.00000	0.0	CS
QUE IC	180.00	10.00000	1.0	CS
VEN CS	180.00	15.00000	3.0	CS
IND CS	180.00	15.00000	3.0	CS
PCK CS	180.00	0.00000	0.0	CS
STK CS	180.00	0.00000	0.0	

F
F
T
T
2.00
5.00
0.50
0.50

0.2000000

F
F
T
7.00000
2.00000

0.2000000

F
T
F
F
F
F
F
T
F
F
F
2.50

0.01.0

8.00

60.00

F
0.50000E-03T
F
60.00

BERL SADDLES	C.500.5000000C	10	1.000	70.00
18.000	C.00	98.9900		
HCL				
	0.03			
	30.00			
100.0				
T				
308.4	212.3	305.9	257.2	310.9
10.0	0.0	400.000	0.000	344.9
				368.6
				265.5
				232.3
				214.3
				287.2
				1986

1 INCINERATOR DESIGN AND COST FOR
LIQUID INJECTION

****INPUT STREAM CHARACTERISTICS****

COMBUSTED GAS EXIT RATE	29815.66 LB/HR
ASH FEED RATE	0.00 LB/HR
VOLATILES FEED RATE	1000.00 LB/HR
FREE WATER IN SLUDGE FEED	0.00 LB/HR
FUEL FEED RATE	828.81 LB/HR
AIR FEED RATE (AT 50.00% EXCESS)	27995.92 LB/HR

PROCESS DESIGN VARIABLES

PERCENT EXCESS AIR IS	50.00 PERCENT
PERCENT EXCESS FUEL IS	0.00 PERCENT.
INCINERATOR TEMPERATURE	1800.00 DEG. FAHRENHEIT
AMBIENT TEMPERATURE	80.00 DEG. FAHRENHEIT.
DAILY USE	24.00 HOURS/DAY.
LENGTH OF PROCESS RUN	300.00 DAYS/YEAR.
SHUTDOWN LENGTH	65.00 DAYS/YEAR.
RETENTION TIME	2.00 SECONDS
LENGTH TO DIAMETER RATIO ESTIMATE	5.00

INCINERATOR PROCESS DESIGN SPECIFICATIONS

INCINERATOR DIAMETER (FT)=	6.9621
INCINERATOR LENGTH (FT)=	30.6440
MATERIALS OF CONSTRUCTION FOR THE INCINERATOR	
REFRACTORY SELECTED = 90%-ALUMINA FIREBRICK	
THICKNESS = 1.0 INCHES	
INSULATION SELECTED = INSULATING FIREBRICK	
THICKNESS = 4.0 INCHES	
INCINERATOR SURFACE AREA (FT**2)	904.0422
INCINERATOR VOLUME (FT**3)	904.0449
INCINERATOR BURNER DATA	
NUMBER OF FUEL BURNERS = 2	
WASTE FEED BURNER HEAT LOAD = 0.600E+07 BTU/HR	
OPTIONS IN EFFECT	
A 10 PERCENT HEAT LOSS (OF TOTAL HEAT RELEASED) IS INCLUDED	
IN THE HEAT/MASS BALANCE CALCULATIONS	
WASTE FEED IS A LIQUID. WASTE BURNERS ARE SELECTED	
INCONEL WAS SELECTED TO CONSTRUCT THE SHELL	

INCINERATOR COST BREAKDOWN

TOTAL BRICK COST \$	62532.44
TOTAL SHELL COST \$	183992.31
COST OF BURNER SYSTEM \$	48999.99
EXTRA COSTS \$	61104.93
-----	-----
TOTAL INCINERATOR COST	366629.56

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 80.00 FAHRENHEIT OUTPUT STREAM T= 1800.00 FAHRENHEIT
 P= 14.70 PSIA P= 14.69 PSIA

	LB/HR	-----	LB/HR	-----
FUEL	828.81		0.00	
AIR	27995.92		0.00	
WASTE	1000.00		0.00	
ASH	0.00		0.00	
H ₂ O	0.00		313.32	
HCl	0.00		205.45	
CO ₂	0.00		5557.61	
CO	0.00		0.00	
N ₂	0.00		21465.68	
O ₂	0.00		2273.61	
NO	0.00		0.00	
NO ₂	0.00		0.00	
Cl ₂	0.00		0.00	
SO ₂	0.00		0.00	
H ₂ SO ₄	0.00		0.00	
F ₂	0.00		0.00	
HF	0.00		0.00	
P ₂ O ₅	0.00		0.00	
NE	0.00		0.00	

1 REACTANT 3 WAS LESS THAN ZERO -0.004CHECK BALANCE OF EQUATION
 1 INCINERATOR DESIGN AND COST FOR
 LIQUID INJECTION AFTERBURNER

****INPUT STREAM CHARACTERISTICS****

COMBUSTED GAS EXIT RATE	29971.99 LB/HR
ASH FEED RATE	0.00 LB/HR
VOLATILES FEED RATE	0.00 LB/HR
FREE WATER IN SLUDGE FEED	0.00 LB/HR
FUEL FEED RATE	156.38 LB/HR
AIR FEED RATE (AT 0.00% EXCESS)	0.00 LB/HR
GAS FEED FROM PREVIOUS UNIT	29815.66 LB/HR

PROCESS DESIGN VARIABLES

PERCENT EXCESS AIR IS	0.00 PERCENT
PERCENT EXCESS FUEL IS	0.00 PERCENT.
INCINERATOR TEMPERATURE	2000.00 DEG. FAHRENHEIT
AMBIENT TEMPERATURE	80.00 DEG. FAHRENHEIT.
DAILY USE	24.00 HOURS/DAY.
LENGTH OF PROCESS RUN	300.00 DAYS/YEAR.
SHUTDOWN LENGTH	65.00 DAYS/YEAR.
RETENTION TIME	2.00 SECONDS
LENGTH TO DIAMETER RATIO ESTIMATE	7.00

INCINERATOR PROCESS DESIGN SPECIFICATIONS

INCINERATOR DIAMETER (FT)=	6.7774
INCINERATOR LENGTH (FT)=	39.4693
MATERIALS OF CONSTRUCTION FOR THE INCINERATOR	
REFRACTORY SELECTED = 90%-ALUMINA FIREBRICK	
THICKNESS = 1.5 INCHES	
INSULATION SELECTED = INSULATING FIREBRICK	
THICKNESS = 5.3 INCHES	
INCINERATOR SURFACE AREA (FT**2)	583.6919
INCINERATOR VOLUME (FT**3)	985.5383
INCINERATOR BURNER DATA	

NUMBER OF FUEL BURNERS = 1
 OPTIONS IN EFFECT
 A 10 PERCENT HEAT LOSS (OF TOTAL HEAT RELEASED) IS INCLUDED
 IN THE HEAT/MASS BALANCE CALCULATIONS
 INCONEL WAS SELECTED TO CONSTRUCT THE SHELL

INCINERATOR COST BREAKDOWN

TOTAL BRICK COST \$	103806.19
TOTAL SHELL COST \$	226498.87
COST OF BURNER SYSTEM \$	5000.00
EXTRA COSTS \$	67060.94
<hr/>	
TOTAL INCINERATOR COST	402365.94

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 1800.00 FAHRENHEIT OUTPUT STREAM T= 2000.00 FAHRENHEIT
 P= 14.69 PSIA P= 14.66 PSIA

	LB/HR	LB/HR
	-----	-----
FUEL	156.38	0.00
AIR	0.00	0.00
H ₂ O	313.32	331.47
HCl	205.45	205.45
CO ₂	5557.61	6122.68
CO	0.00	0.00
N ₂	21465.68	21465.68
O ₂	2273.60	1846.72
NO	0.00	0.00
NO ₂	0.00	0.00
CL ₂	0.00	0.00
SO ₂	0.00	0.00
H ₂ SO ₄	0.00	0.00
F ₂	0.00	0.00
HF	0.00	0.00
P ₂ O ₅	0.00	0.00
NE	0.00	0.00

HEAT RECOVERY SYSTEM DESIGN

CHARACTERISTICS OF STEAM PRODUCED
 PRESSURE OF STEAM FORMED= 185. PSIA
 QUANTITY OF STEAM PRODUCED = 18107. LB/HR
 COST RECOVERED FROM STEAM PRODUCTION = 73.01 U.S. DOLLARS/HR
 MATERIALS OF CONSTRUCTION

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 2000.00 FAHRENHEIT OUTPUT STREAM T= 500.00 FAHRENHEIT
 P= 14.66 PSIA P= 11.38 PSIA

	LB/HR	LB/HR
	-----	-----
H ₂ O	331.47	331.47
HCl	205.45	205.45
CO ₂	6122.68	6122.68
CO	0.00	0.00
N ₂	21465.67	21465.68
O ₂	1846.72	1846.72
NO	0.00	0.00
NO ₂	0.00	0.00
CL ₂	0.00	0.00
SO ₂	0.00	0.00

H2SO4	0.00	C.00
F2	0.00	0.00
HF	C.00	0.00
P206	0.00	0.00
NE	0.00	0.00

1
1

QUENCH CHAMBER DESIGN SPECIFICATIONS

QUENCH TEMPERATURE = 180.0 FAHRENHEIT
 QUENCH DIAMETER = 6.0 FEET
 QUENCH LENGTH = 16.1 FEET
 WATER RATE = 0.281E+04 LB/HR .
 WATER OUT = 0.000E+00 LB/HR
 OPTIONS IN EFFECT

INCONEL WAS SELECTED AS THE MATERIAL OF CONSTRUCTION
 QUENCH CHAMBER DESIGNED FOR SPECIFIC OUTLET TEMPERATURE

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 500.00 FAHRENHEIT	P= 11.38 PSIA	OUTPUT STREAM T= 180.00 FAHRENHEIT	P= 11.37 PSIA
LB/HR	-----	LB/HR	-----
H2O	331.47	3136.89	
HCL	205.45	205.45	
CO2	6122.68	6122.68	
CO	0.00	0.00	
N2	21465.66	21465.67	
O2	1846.72	1846.72	
NO	0.00	0.00	
NO2	0.00	0.00	
CL2	0.00	0.00	
SO2	0.00	0.00	
H2SO4	0.00	0.00	
F2	0.00	0.00	
HF	0.00	0.00	
P206	0.00	0.00	
NE	0.00	0.00	

1
1

VENTURI SCRUBBER DESIGN OUTPUT

TOTAL PRESSURE DROP= 60. INCHES H2O
 WATER FEED RATE= 0.55197E+04LB/HR
 VENTURI SHELL THICKNESS= 0.50 INCHES
 FEDERAL PARTICULATE LEVELS= 0.50000E-03LB/ACF
 CALCULATED EMISSION LEVELS= 0.00000E+00LB/ACF
 LENGTH OF VENTURI SEPARATOR(FT)= 11.
 DIAMETER OF VENTURI SEPARATOR(FT)= 6.
 OPTIONS SELECTED
 PRESSURE DROP DIRECTLY SPECIFIED
 AUTOMATIC THROAT CONTROL SPECIFIED
 VENTURI SCRUBBER CONSTRUCTED OF CARBON STEEL

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 180.00 FAHRENHEIT	P= 11.37 PSIA	OUTPUT STREAM T= 180.00 FAHRENHEIT	P= 11.37 PSIA
LB/HR	-----	LB/HR	-----

H2C	3137.67	3136.89
HCL	205.45	205.45
CO2	6122.68	6122.68
CO	0.00	0.00
N2	21465.66	21465.67
O2	1846.72	1846.72
NO	0.00	0.00
NO2	0.00	0.00
CL2	0.00	0.00
SO2	0.00	0.00
H2SO4	0.00	0.00
F2	0.00	0.00
HF	0.00	0.00
P206	0.00	0.00
NE	0.00	0.00

1
MOTOR RPMs= 3600.00
GAS VOLUME RATE= 100.00FT³/MIN/1000
COST OF MOTOR= 1489.25U.S. DOLLARS
1 INDUCED DRAFT FAN DESIGN

TOTAL PRESSURE DROP(INCLUDING ADJUSTMENT FOR ELEVATION) = 60.00 IN H2O
ELEVATION OF FACILITY= 3000. FEET
PRESSURE DROP PER STAGE = 20.00 IN H2O
VOLUME RATE PER PARALLEL FEED = 12.09FT³/MIN/1000
NUMBER OF FANS PER STAGE = 3
MOTOR RPMs = 3600.00
TOTAL HORSEPOWER REQUIRED TO COMPRESS GAS = 100.00 HP
NUMBER OF INLET STREAMS= 1
DIAMETER OF IMPELLOR = 21. INCHES
OPTIONS SELECTED
MATERIAL OF CONSTRUCTION OF THE FANS IS CARBON STEEL
CLASS 4 FANS ARE SPECIFIED(HIGH PERFORMANCE)

1

PROCESS STREAM CONDITIONS AND COMPOSITION

INPUT STREAM T= 180.00 FAHRENHEIT	OUTPUT STREAM T= 212.69 FAHRENHEIT
P= 11.37 PSIA	P= 13.54 PSIA

	LB/HR	-----	LB/HR	-----
H2O	3137.67		3136.89	
HCL	205.45		205.45	
CO2	6122.68		6122.68	
CO	0.00		0.00	
N2	21465.66		21465.67	
O2	1846.72		1846.72	
NO	0.00		0.00	
NO2	0.00		0.00	
CL2	0.00		0.00	
SO2	0.00		0.00	
H2SO4	0.00		0.00	
F2	0.00		0.00	
HF	0.00		0.00	
P206	0.00		0.00	
NE	0.00		0.00	

1
PACK BED DIAMETER IS OUT OF RANGE FOR ACCURATE CALCS
COST OF ABSORBER COLUMN PER FOOT = 2581.02
COST OF ABORBER PACKING = 7481.01
TOTAL ABSORBER COST = 33291.25
1 PACKED BED DESIGN PARAMETERS

DIAMETER OF COLUMN(FT)= 6.87
TOTAL HEIGHT OF COLUMN(FT)= 10.00
CALCULATED COST OF COLUMN= 33291.25 U.S. DOLLARS

THE AMBIENT FACILITY PRESSURE
DUCTWORK DESIGN OUTPUT

UNITS	OUTER DIAMETER	BRICK DIAMETER	MATERIALS OF CONSTRUCTION	DUCT LENGTH	NUMBER OF ELBOWS
1 TO 2	33.5	0.00	IC	10.00	1.
2 TO 3	38.2	0.00	IC	15.00	2.
3 TO 4	20.2	0.00	CS	10.00	0.
4 TO 5	20.1	0.00	CS	10.00	1.
5 TO 6	20.1	0.00	CS	15.00	3.
6 TO 7	20.1	0.00	CS	15.00	3.
7 TO 8	20.1	0.00	CS	0.00	0.
8 TO 9	C.O	0.00		0.00	0.

COST OF DUCTWORK

COST	DUCTWORK COST	FIREBRICK COST	DAMPERS COST	TOTAL COST
1 TO 2	4036.2	11946.8	5393.9	21376.9
2 TO 3	8530.8	26887.6	6039.4	41457.8
3 TO 4	310.5	0.0	3614.3	3924.8
4 TO 5	784.5	0.0	3607.1	4391.6
5 TO 6	1889.9	0.0	3607.9	5497.8
6 TO 7	1889.9	0.0	3607.9	5497.8
7 TO 8	0.0	0.0	3611.9	3611.9
8 TO 9	C.O	0.0	0.0	0.0

1 LIQUID WASTE STORAGE FACILITY

NUMBER OF 25,000 GALLON TANKS =	0
NUMBER OF 10,000 GALLON TANKS =	1
NUMBER OF 1,000 GALLON TANKS =	1
TOTAL STORAGE TANK COST=	102000. U.S. DOLLARS
CSTNIT=	0. U.S. DOLLARS
NITROGEN BLANKET SYSTEM=	0. U.S. DOLLARS
CONDENSOR COST=	10000. U.S. DOLLARS

1 TOTAL CAPITAL COST

COMBUSTION CHAMBERS:	1986 \$
-----	-----
PRIMARY COMBUSTOR	366629.56
SECONDARY COMBUSTOR	402365.94
ENERGY RECOVERY BOILER	78659.87
AIR POLLUTION CONTROL SYSTEM	
QUENCH CHAMBER	47432.45
VENTURI SCRUBBER AND SEPARATOR	18192.60
PACKED BED SCRUBBER	33291.25
INDUCTION FAN	16324.46
EXHAUST STACK(100 FEET HIGH)	9329.72
WASTE WATER TREATMENT FACILITY	34489.83
STORAGE TANK FACILITY	111999.87
TOTAL DUCTWORK	85758.31
METAL BUILDING	198951.31
SITEWORK AND FOUNDATIONS	110.53
STRUCTURAL STEEL	27640.46
ELECTRICAL MATERIAL	35569.98
INSTRUMENTS AND CONTROLS	49690.99
-----	-----
TOTAL-----	1516432.00

TOTAL INSTALLATION COST	373148.37
START-UP (10 % OF EQUIPMENT COST)	151643.19
SPARE PARTS (8 % OF EQUIPMENT COST)	121314.50
CERTIFICATION (10 % OF EQUIPMENT COST)	151643.19
ENGINEERING (7 % OF EQUIPMENT COST)	106150.19
INSTRUMENTATION (20 % OF EQUIPMENT COST)	431286.37

CONTINGENCY FEE (20 % OF EQUIPMENT COST)	0.00
TOTAL INDIRECT COSTS	----- 1335185.00
***** TOTAL CAPITAL COST=	2851617.00

1

OPERATING LABOR OUTPUT

SUPERVISOR SALARY(\$/YR)=	23386.
LABORATORY SUPERVISOR(\$/YR)=	0.
LABORATORY TECHNICIANS SALARY(\$/YR) =	20160. FOR 1TECHNICIANS
CHIEF OPERATORS SALARY(\$/YR) =	0.
OPERATORS SALARY(\$/YR) =	60480. FOR 1 OPERATORS
YARD WORKERS SALARY(\$/YR) =	24192. FOR 1 WORKERS.
SECRETARIES SALARY(\$/YR) =	12096. FOR 1 SECRETARIES
PAYROLL EXPENSES(20% OF LABOR=	35078.
COST IN \$/YR)	
SUPPLIES AND OTHER MISC.(\$/YR)=	23386.

TOTAL EXPENSES(\$/YR)=	175392.

1

ANNUAL OPERATING COSTS

FEED RATE 1000. LB/HR

LABOR	175392.
-------	---------

UTILITIES

ELECTRICITY	102560.
FUEL	525135.
WATER	34411.
WASTE DISPOSAL	0.
BULK LIME	25085.

WASTE WATER TREATMENT	35206.
-----------------------	--------

STARTUP COSTS	151643.
---------------	---------

INSURANCE COST	17110.
----------------	--------

ANNUAL MAINTENENCE	86007.
--------------------	--------

LIQUID INJECTION INCINERATOR (5% COST)	-----
HEAT RECOVERY UNIT (80% EFFICIENCY)	-525657.

TOTAL OPERATING COST	626890.
----------------------	---------

1

DISCOUNTED CASH FLOW RATE OF RETURN
ANALYSIS OUTPUT
(MILLIONS OF U.S. DOLLARS)

YEAR	0	1	2	3	4	5	6	7	8	9	10
INCOME	0.0	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
OPERATE	0.0	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
DEPREC.	0.0	0.2	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
TAXABLES	0.0	0.6	0.4	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6
TAXES	0.0	0.3	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3

NET INC.	0.0	0.3	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.5	0.3
DEPREC.	0.0	0.2	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
CAPITAL	-2.9	-	-	-	-	-	-	-	-	-	-
CASH FLW	-2.9	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5

THE TOTAL CASH FLOW = 2.64 MILLION DOLLARS
DISCOUNTED CASH FLOW RATE OF RETURN = 10.9%

VITA

Jeffrey Dean Mathis

Candidate for the Degree of
Master of Science

Thesis: A COMPUTER PROGRAM FOR THE DESIGN AND COST
ESTIMATION OF HAZARDOUS WASTE INCINERATION
FACILITIES

Major Field: Chemical Engineering

Biographacal:

Personal Data: Born in Houston, Texas, November
11, 1961, the son of J.D. and Ebba Mathis.
Married to Marianne Witmer on September 1,
1984.

Education: Graduated from Edmond Memorial High
School, Edmond Oklahoma, in May, 1980;
received Bachelor of Science Degree from
Oklahoma State University in May, 1984;
completed requirements for the Master of
Science degree at Oklahoma State University,
December, 1986.

Professional Experience: Teaching Assistant,
Introduction to Computer Science Fortran 77
for freshman engineering students, Oklahoma
State University, January 1985, to May 1986;
Research Assistant, Department of Chemical
Engineering, in the field of biochemical
engineering, Oklahoma State University,
September, 1982 to August, 1986; Organic
Chemistry Storeroom Manager, Organic
Chemistry Department, Oklahoma State
University, September, 1982 to January 1985.