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MILITARY HANDBOOK

INCINERATORS

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ABSTRACT

This handbook provides basic, general design guidance and technical data for the planning and design of incinerators. Included are field-erected, modular, and special purpose incinerators, as well as a brief discussion concerning the feasibility for the application of the heat recovery incinerator.

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FOREWORD

This military handbook has been developed primarily from information obtained through various case histories as well as recognized industry practice and standards. Due to the rapidly increasing technology in the field of incinerators, however, much of the information provided in the text is general in nature and provided for preliminary planning and general design guidance. It is not intended to provide detailed techniques of design for any particular application. Each specific application will require investigation into the most recent technologies associated with that particular application. This handbook was prepared using, to the maximum extent feasible, national professional society, association, and institute standards. Deviations from these criteria in the planning, engineering, design, and construction of Naval shore facilities cannot be made without prior approval of NAVFACENGCOM HQ (Code 04).

Design cannot remain static any more than can the functions it serves or the technologies it uses. Accordingly, recommendations for improvement are encouraged and should be furnished to Commander, Naval Facilities Engineering Command, Southern Division, Code 04A3, 2155 Eagle Drive, P.O. Box 10068, Charleston, SC 29411.

THIS HANDBOOK SHALL NOT BE USED AS A REFERENCE DOCUMENT FOR PROCUREMENT OF FACILITIES CONSTRUCTION. IT IS TO BE USED IN THE PURCHASE OF FACILITIES ENGINEERING STUDIES AND DESIGN (FINAL PLANS, SPECIFICATIONS, AND COST ESTIMATES). DO NOT REFERENCE IT IN MILITARY OR FEDERAL SPECIFICATIONS OR OTHER PROCUREMENT DOCUMENTS.

MECHANICAL ENGINEERING CRITERIA MANUALS

Criteria Manual	Title	PA
DM-3.01	Plumbing Systems	WESTDIV
MIL-HDBK-1003/2	Incinerators	SOUTHDIV
DM-3.03	Heating, Ventilating, Air Conditioning, and Dehumidifing Systems	WESTDIV
DM-3.4	Refrigeration Systems for Cold Storage	SOUTHDIV
DM-3.5	Compressed Air and Vacuum Systems	WESTDIV
DM-3.6	Central Heating Plants	NEESA
MIL-HDBK-1003/7	Fossil Fuel Power Plants (proposed)	NEESA
MIL-HDBK-1003/8	Exterior Distribution of Utility Steam, HTW, CHW, Fuel Gas and Compressed Air	CHESDIV
DM-3.09	Elevators, Escalators, Dumbwaiters, Access Lifts, and Pneumatic Tube Systems	WESTDIV
DM-3.10	Noise & Vibration Control of Mechanical Equipment (Tri-Service)	ARMY
MIL-HDBK-1003/11	Diesel-Electric Generating Plants	WESTDIV
MIL-HDBK-1003/12	Thermal Heating Plant Controls (proposed)	NEESA
MIL-HDBK-1003/13A	Solar Heating of Buildings and Domestic Hot Water	WESTDIV
DM-3.14	Power Plant Acoustics (Tri-Service)	ARMY
DM-3.15	Air Pollution Control Systems/Boilers and Incinerators (Tri-Service)	ARMY
DM-3.16	Thermal Storage Systems (Retired)	WESTDIV
MIL-HDBK-1003/17	Industrial Ventilation Systems	NEESA
MIL-HDBK-1003/19	Design Procedures for Passive Solar Buildings	CESO

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Section 1: INTRODUCTION

1.1 Scope. This handbook provides guidance concerning the design of field-erected, refractory-lined grate-type mass-burn incinerators, modular incinerators and incinerators that burn pathological waste and demilitarized waste. Section 2 of this handbook discusses planning factors. Section 3 discusses feasibility of heat recovery. Section 4 gives a detailed description of the Mayport heat recovery incinerator plant and Section 5 reviews special purpose incinerators designed for disposal of municipal solid waste, waste oil, and sludge.

1.2 Purpose. The guidelines presented herein shall be used by facility planners, engineers, and architects to plan individual projects, prepare engineering documentation and prepare contractual documents for construction.

1.3 Review and Application of Incinerators

1.3.1 Mass Burn Incinerators (Mayport). Mass burn units, such as at the Mayport Naval Station, Jacksonville, Florida, are field-erected units consisting of a refractory-lined furnace and a reciprocating grate stoker.

1.3.2 Special Purpose Incinerators

1.3.2.1 Modular Refuse Incinerators. This type of incinerator consists of a refractory-lined furnace (primary chamber) and an afterburner section (secondary chamber). The furnace and afterburner components are package or modular type, which are off-the-shelf, pre-designed and highway shippable.

1.3.2.2 Pathological Waste Incinerators. This type of incinerator, usually the controlled air modular incinerator,is designed to burn human and animal remains, consisting of carcasses, organs and solid wastes from hospitals, laboratories, slaughterhouses, and animal pounds.

1.3.2.3 Demilitarized Waste Incinerators. These incinerators are designed for the demilitarization of small Ammunition, Explosives and other Dangerous Articles (AEDA), which are not easily detonated or burned by other means. The incinerator consists of a steel primary combustion chamber containing a burner and water cooled dump grate stoker and a secondary chamber containing an afterburner.

1.4 Environmental Factors

1.4.1 Air Pollution Regulations. Incinerator facilities shall be designed to meet the requirements of all Federal, State and local air pollution regulations, including the Clean Air Act of 1970, as amended.

1.4.2 Water Pollution Regulations. Incinerator facilities should be designed to meet the requirements of all Federal, State and local waste pollution regulations, including the Clean Water Act of 1977, as amended.

1.4.3 Hazardous Waste Regulations. State hazardous waste regulations should be addressed early in the design process to determine if a treatment permit will be necessary for any constituents of the feed stream. Many states now regulate waste oil as hazardous waste. If a hazardous waste treatment permit is required, it must be obtained prior to construction.

Section 2: PLANNING FACTORS

2.1 Waste Classification and Characterization

2.1.1 Quantity. The quantity of refuse available for incineration shall be determined by survey or estimated in accordance with NAVFAC DM 5.10, Solid Waste Disposal.

2.1.2 BTU Value. Table 1 shows BTU values of various types of waste.

2.1.3 Special Considerations

2.1.3.1 Explosive Wastes. Explosive wastes, in general, shall not be incinerated. Explosive wastes which are small enough, however, may be incinerated in specially designed facilities.

2.1.3.2 Toxic Wastes. Toxic wastes are defined in the Code of Federal Regulations (CFR). A waste is classified as a toxic waste if it has the following characteristics:

a) Extraction Procedure (EP) toxicity as described in 40 CFR 261.24, Characteristics of EP Toxicity.

b) Toxic as described in 40 CFR 261.33(f), Discarded Commercial Chemical Products, Off-Specification Species, Container Residues, and Spill Residues Thereof.

These wastes are assigned the hazard code of (E) for EP toxic and (T) for toxic. They shall be incinerated only in facilities specifically designed for hazardous wastes.

2.1.3.3 Classified. Classified materials consist almost completely of paper and cardboard and small amounts of plastic. The density of this type of waste varies from 5 pounds per cubic foot (80 kilograms/cubic meter) to 50 pounds per cubic foot (801 kilograms/cubic meter). This waste is essentially the same as Type 0 waste, except for the difference in density.

2.1.3.4 Hazardous. Hazardous wastes are all classified based upon their characteristic properties. These properties are defined in 40 CFR 261.20, Characteristics of Hazardous Waste--General. The basic categories and hazard codes are; ignitable (I), corrosive (C), reactive (R), EP toxic (E), acute hazardous (H), and toxic (T).

2.2 Plant Sizing Considerations

2.2.1 Quantity of Waste Throughput Desired. Determine quantity of waste throughput based on the quantity of waste available, its composition, and, in the case of heat recovery incinerators, variations in steam demand.

2.2.2 Type of Waste. Determine the type of waste (general refuse, pathological, waste oil, sludge, etc.) and its composition (heat value, moisture, chemical and ash content) prior to selection and design of the incinerators, air pollution control equipment and waste processing equipment.

Table 1
Classification and Data for Waste Suitable for Incineration

TYPE	WASTE Description	Principal Components and Sources	Approx. Composition (% by weight)	Moisture Content	Incombustible Solids (%)	Heat Value BTU/lb (kJ/kg) of Refuse as Fired	Aux Fuel BTU/lb (kJ/kg) of Waste to be included in Combustion Calculations
0[1]	Trash	Highly combustible waste: paper, wood, cardboard cartons, including up to 10% treated paper, plastic or rubber scraps - commercial and industrial sources.	Trash 100	10	5	8500 (19771)	0
1[1]	Rubbish	Combustible waste; paper cartons, rags, wood scraps, floorsweepings - domestic, commercial, and industrial sources.	Rubbish 100 (garbage up to 20)	25	10	6500 (15119)	0
2[1]	Refuse	Rubbish and garbage - residential sources.	Rubbish 50 Garbage 50	50	7	4300 (10002)	0
3[1]	Garbage	Animal and vegetable wastes - subsistence buildings, civilian cafeterias, markets, hospitals, prisons, clubs as sources.	Garbage 100 (rubbish up to 35)	70	5	2500 (5815)	1500 (3489)
4	Animal solids and organic wastes	Carcases, organs, solid organic wastes - hospital, laboratory, abatoirs, animal pound, and similar sources.	Animal and human tissue 100	85	5	1000 (2326)	3000 (6978)
5[2]	Gaseous liquid or semi-liquid wastes	Industrial process wastes.	Variable	Dependent on predominant components	Variable according to wastes survey	Variable according to wastes survey	Variable according to wastes survey
6[2]	Semi-solid and solid wastes	Combustibles requiring hearth, retort, or grate burning equipment.	Variable	Dependent on predominant components	Variable according to wastes survey	Variable according to wastes survey	Variable according to wastes survey

[1]The above figures on moisture content, ash, and BTU as fired have been determined by analysis of many samples. They are recommended for use in computing heat release, burning rate, velocity, and other details of incinerator designs. Any design based on these calculations can accommodate minor variations.

[2]Due to the wide variations in the waste characteristics, this waste must be sampled and analyzed prior to the design of system components.

2.2.3 Collection/Delivery Vehicles. The various types of collection and delivery vehicles that will use the incinerator facility should be determined prior to the design of the site roadways, weigh stations, tipping floor and the tipping floor entrance, exit ramps, and roll-up doors.

2.2.4 Plant Location and Site Constraints. Incinerators should be centrally located near the source of the waste and near access roads suitable for trucks. Other factors such as the physical size of the site, wind direction, soil conditions, topography, utility locations, building restrictions, drainage and climate should also be considered.

2.2.5 Waste Collection and Delivery Logistics/Schedule. The number of days per week and the time of day that refuse is collected and delivered should be considered in the sizing of the incinerator facility.

2.3 Plant Location

2.3.1 Accessibility. The incinerator plant should be accessible from major roadways.

2.3.2 Waste Storage. The waste storage area or pit shall be designed to contain a minimum of 72 hours of design capacity of the incinerator. If the facility incorporates heat recovery, the storage area shall be designed to ensure that sufficient refuse is available to meet the heat recovery demands during periods when waste is not delivered.

2.3.3 Restrictions on Emissions. Waste products that must be controlled are particulate and gas concentrations in the stack gases, residual ash, and water or sludge from gas scrubbers, plant drains and cooling towers. Individual state regulations usually govern particulate emissions for incinerators with a burning capacity of 50 TPD (45.36 metric tons per day) or less. State requirements vary according to the ambient particulate level in a given geographic area.

If potentially hazardous residual ash or scrubber sludge is to be disposed of in a landfill, the leaching capability of the waste must be determined by testing in accordance with 40 CFR 261.24, Subpart C. Municipal wastewater limitations shall be observed if effluent is discharged into a sanitary sewer system. A plant shall also obtain a National Pollutant Discharge Elimination System (NPDES) permit if it discharges effluent into streams, rivers, or lakes. Obtain permit information from the State or from the regional office of the EPA.

2.3.4 Soil Conditions. The seismic zone classification, frost depth, soil resistivity, soil pH and soil boring information should be obtained and used in the design of the facility foundations and underground utilities.

2.3.5 Topography. The topography of the land will affect the design of the access ramps to the tipping floor, the dispersion of gases and particulates to the atmosphere, the design of utilities, site drainage and the orientation and aesthetics of the facility.

2.3.6 Waste Treatment Facilities. Waste treatment facilities associated with an incinerator installation are sanitary waste treatment and industrial waste treatment. These waste treatment facilities are typically located nearby the incinerator. The sanitary waste treatment system is subject to NPDES regulations, and the industrial waste treatment system is subject to 40 CFR 257, Criteria for Classification of Solid Waste Disposal Facilities and Practices.

2.3.7 Electric Service. Electric power requirements vary with the size and sophistication of the plant equipment. The major users of electricity within the plant include the forced draft fan(s), overfire air fan(s), induced draft fan(s), pumps, refuse crane, air pollution control equipment, air compressors and grate-driving mechanisms. Future electrical needs should be considered in the planning and sizing of the electrical distribution system.

2.3.8 Water Supply. The quality of the water required for the incinerator facility will depend on its use. Sources of water may include city water, on-site or off-site wells, rivers, lakes and wastewater treatment plant effluents. An analysis of the water source(s) should be obtained to determine the extent of treatment required, if any, for its intended use. When waste heat is used to produce steam or hot water, the boiler feedwater and make-up water will require treatment.

2.3.9 Fire Protection. Fire detection systems, automatic and manual fire protection systems, fire hose stations, portable extinguishers and exterior hydrants should be provided and designed and constructed in accordance with the requirements of the National Fire Protection Association (NFPA).

2.3.10 Ambient Conditions. Winter and summer design temperatures, prevailing wind direction, relative humidity, and amount of precipitation should be obtained and used in the design of building heating, ventilating and air conditioning systems, site drainage systems, building roof drainage systems and cooling towers.

2.3.11 Permanence. Consider the possibility of incinerator portability for use at other installations.

2.3.12 Odor. Odor controls must be considered, especially for incinerators located in populated areas. Odors and emissions from incinerators are the primary concerns of the general public. The incinerator facility design should consider the use of ventilation air from the tipping area and refuse pit for combustion air. In addition, maintenance procedures should incorporate frequent cleaning and disinfection of the tipping area and the use of disinfectant sprays in the refuse pit.

2.4 Energy Production

2.4.1 Steam Generation. Consider the use of waste heat to produce steam for district heating and cooling, hot water production, cooking and laundry uses, and for driving plant equipment, such as pumps and fans.

2.4.2 Hot Water Generation. Consider the use of waste heat to produce hot water.

2.4.3 Electricity Generation. Consider the use of waste heat to generate steam for the production of electricity via a steam turbine generator.

2.5 Environmental Factors

2.5.1 Air and Water Pollution Regulations

2.5.1.1 Federal Regulations. The Federal Regulations referenced below are those which currently apply; however, in all cases the regional EPA office should be contacted to obtain the latest regulations for the required incinerator.

a)	40 CFR 50	National Primary and Secondary Ambient Air Quality Standards
b)	40 CFR 51	Requirements for Preparation, Adoption, and Submittal of Implementation Plans
c)	40 CFR 52	Approval and Promulgation of Implementation Plans
d)	40 CFR 60 (E)	Standards of Performance for New Stationary Sources
e)	40 CFR 122	National Pollutant Discharge Elimination System
f)	40 CFR 123	State Program Requirements
g)	40 CFR 125	Criteria and Standards for the National Pollutant Discharge Elimination System
h)	40 CFR 130	Water Quality Planning and Management
i)	40 CFR 240	Guidelines for the Thermal Processing of Solid Wastes
j)	40 CFR 257	Criteria for Classification of Solid Waste Disposal Facilities and Practices
k)	40 CFR 261	Identification and Listing of Hazardous Waste
l)	40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities
m)	40 CFR 265	Interim Status Standards for Owners and Operators of Hazardous Waste Facilities
n)	42 USC 7401 P.L. 91-604	Clean Air Act Amendment to the Clean Air Act
o)	33 USC 1251 P.L. 95-217	Clean Water Act Amendment to the Clean Water Act
p)	P.L. 94-580	Resource Conservation and Recovery Act [RCRA]

2.5.1.2 State and Local Regulations. Regulations at the state, county, or city level may be the same as the EPA regulations or more stringent. Contact the state, local, and regional agencies to obtain the latest regulations.

2.5.2 Pollution Control Equipment

2.5.2.1 Afterburners. Afterburners are typically employed for reducing the emissions of organic vapors present in dilute concentrations. They are capable of handling waste gases which have a heating value insufficient to maintain sustained combustion.

2.5.2.2 Scrubbers. Scrubbers of both the wet and dry types are effective in reducing acid gas emissions to acceptable levels. Dry scrubbers are very effective in reducing emissions of hydrochloric acid, dioxins, and furans. Wet scrubbers, which typically employ lime in the scrubbing liquid, are effective in reducing emissions of acid gases.

2.5.2.3 Electrostatic Precipitators (ESP's) and Baghouses. Electrostatic precipitators (ESP's) are used to reduce the emissions of particulate matter as small as 2 microns (0.002 mm). Baghouses (fabric filters) are used extensively to remove all sizes of particulate matter but do not offer the long term reliability for some applications that has been shown by ESP's.

2.5.2.4 Mechanical Dust Collectors. Mechanical dust collectors (sometimes referred to as cyclone collectors) can reduce particulate emissions. However, due to their low collection efficiency and today's stringent particulate emissions limits, they are seldom used without some other type of particulate collection equipment, such as baghouses or precipitators. Mechanical dust collectors are sometimes used upstream from baghouses to prevent baghouse fires caused by cinder carryover.

2.5.3 Permitting

2.5.3.1 Federal Permitting Requirements. Contact the regional EPA office to obtain the latest regulations for the particular incinerator installation. A list of the current Federal Regulations is provided in para. 2.5.1.1. The EPA has proposed the development of National Emission Guidelines within two years. Although the issuance of permits is handled by State and local regulatory agencies, it is always prudent to discuss the plans for new or modified incinerator facilities with the regional EPA office.

2.5.3.2 State Permitting Requirements. Air and water permits are required for construction and operation of incinerators; discuss these requirements with the state regulatory agency as early as possible for new construction to allow adequate lead time. This is especially important for large incinerator facilities which may require a lengthy permitting process. "Large" incinerator facilities are those of greater than 250 million BTU/hr (73.27 million watts) heat input or the potential to emit 100 tons/year (90.72 metric tons/year) or more of pollutants regulated by 40 CFR 52.22.

2.5.3.3 Local Permitting Requirements. The local permitting agency should also be contacted early in the planning stages. The local permitting agency may impose more stringent regulations than the EPA or State for incinerator construction and operating permits. In all cases, they should be contacted for good community relations and adequate information exchange.

2.6 Hazardous Waste Considerations. An incinerator may not burn a hazardous waste unless it has been designed and permitted as a hazardous waste treatment, storage and disposal facility as described in 40 CFR 264. Incineration of hazardous waste is one of the best available methods of disposal. The decision to incinerate hazardous waste will depend on its environmental adequacy and total costs compared to other disposal options.

If a hazardous waste (such as toxic residue) is generated in an incinerator facility not designed to burn hazardous waste, then the facility must conform to 40 CFR 262, Standards Applicable to Generators of Hazardous Waste. The hazardous waste can be stored onsite without a special permit for a limited time then must be transported by a prepared manifest to a facility permitted to handle hazardous waste. If an incinerator facility is classified as a large hazardous waste generator (greater than 2200 lb/month [997.90 kg/month] generated), then there is no limit to amount of hazardous waste accumulated within a 90-day period.

2.7 Backup Considerations

2.7.1 Equipment Redundancy. Redundant equipment such as pumps and steam turbine drives should be considered for emergency conditions and to increase plant availability. Dual drives, such as electric motors and steam turbines, should be considered for large components, such as induced draft fans.

2.7.2 Backup Energy Production Equipment. Provisions should be made to bypass the energy recovery equipment to protect it from damage in an emergency condition, such as a loss of boiler water level. Also consider bypassing the energy recovery equipment during maintenance periods and when there is no requirement for the recovered heat so that the incineration process is not discontinued. Operation on bypass, however, may be restricted by air pollution regulations.

2.7.3 Landfill. The use of a landfill shall be maintained in the event that the incinerator facility is shut down for an extended period of time.

2.8 Health and Safety

2.8.1 Federal, State and Local Regulations. The design of incinerators shall comply with 29 CFR 1910, Occupational Safety and Health Standards, as well as applicable state and local regulations. Particular attention should be paid to preventing explosive and highly flammable materials, such as cans of solvents and compressed gas cylinders, from entering the incinerator. It is also important to make access to systems easy for maintenance and to provide adequate guard rails around pits and on platforms. Ensure that all mechanical, electrical and hydraulic systems can be de-energized and locked in a safe position for maintenance and repair.

2.9 Threshold Economic Requirements. Initial, operating and maintenance costs should be estimated to determine the total investment required. The total investment shall then be compared to the savings associated with reduced disposal and energy costs.

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Section 3: HEAT RECOVERY INCINERATION FEASIBILITY

3.1 Heat Recovery Incineration (HRI) Feasibility. The decision for implementation of a Heat Recovery Incineration (HRI) plant on any Activity requires a comprehensive, systematic, decision-making analysis. This analysis includes investigation into many or all of the following topics:

a) Accessibility of outside Solid Waste Management (SWM) operations,

b) Availability of cost savings for outside SWM operations,

c) Approvability of a Navy/outside SWM operation joint venture, or if none, the possibility of future outside SWM operations,

d) Acceptability of present SWM costs at activity,

e) Solid waste flow continuity and magnitude of waste energy,

f) Cost benefits and compatibility of SWM plan with Navy's needs,

g) Projected disposal and energy costs,

h) Possibility of solid waste from other Government activities,

i) Economic viability of the HRI concept,

j) HRI cost effectiveness compared to outside joint venture,

k) Navy capital requirement for outside joint ventures,

l) Application of energy obtained as a result of HRI,

m) Economic feasibility for the application described above,

n) Preliminary design/performance/cost package,

o) Possibility of Navy funding project,

p) Availability of full service contractors (build, own and operate), followed by preparation and distribution of Request For Technical Proposal (RFTP) and acceptability of offerer's terms and conditions,

q) Preparation and submittal of DD 1391 if no full service contractor found suitable,

r) Investigation into a Navy-owned/contractor-operated facility.

These topics have been expanded into an HRI decision diagram by NCEL in an attempt to provide a systematic approach to analyzing the topics associated with the feasibility of the HRI plant (see Figure 1). For additional analysis information, refer to NCEL Technical Note N-1746, Application Guide for Heat Recovery Incinerators.

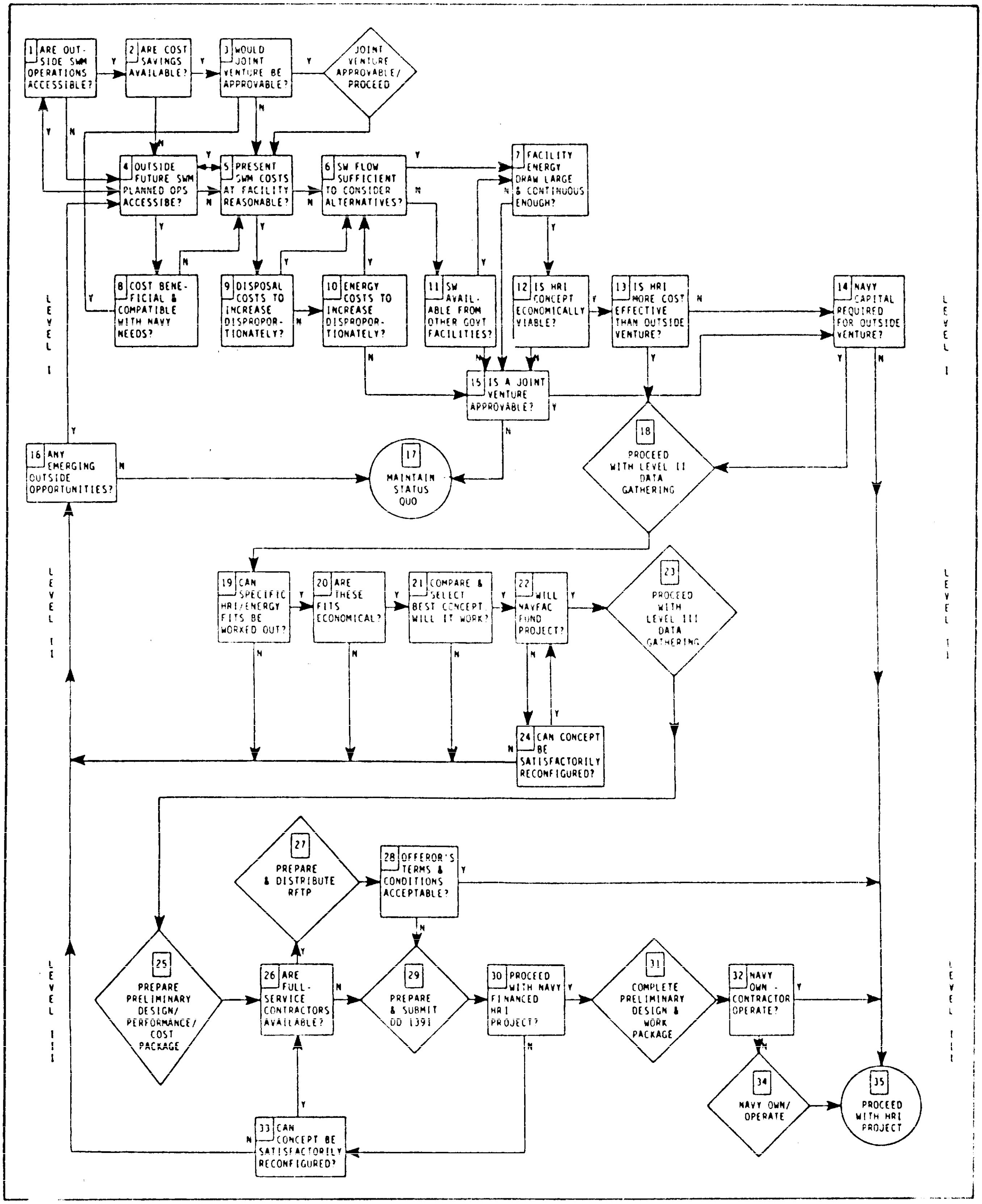


Figure 1
HRI Decision Diagram

Section 4: MAYPORT HEAT RECOVERY INCINERATOR PLANT

4.1 Purpose. The Mayport Naval Station HRI Plant has had a very good operating record since its initial start-up in 1979. This section describes the facility, modifications made, and problems encountered. It is not intended to provide specific design requirements, but to serve as a guide to improve future facility designs, based on the lessons learned.

4.2 Background. The Mayport Naval Station HRI Plant was built for several reasons. First, the on-base landfill needed to be closed; second, U.S. Department of Agriculture requires that all garbage from ships returning from overseas be incinerated or cooked, ground and injected into a sanitary sewer system; third, nearby landfill sites off-base were expected to close, resulting in expensive transportation costs to more distant landfills. During the study phase of the project, many incinerator technologies were considered. The technology that was utilized is the refractory wall stoker grate system. The plant is located next to the destroyer pier power plant and configured as shown in Figures 2 and 3. The purpose of the plant is to burn both solid waste and waste oil and to generate less than 250 psig (1723.69 kPa) saturated steam for export to the pier steam distribution system.

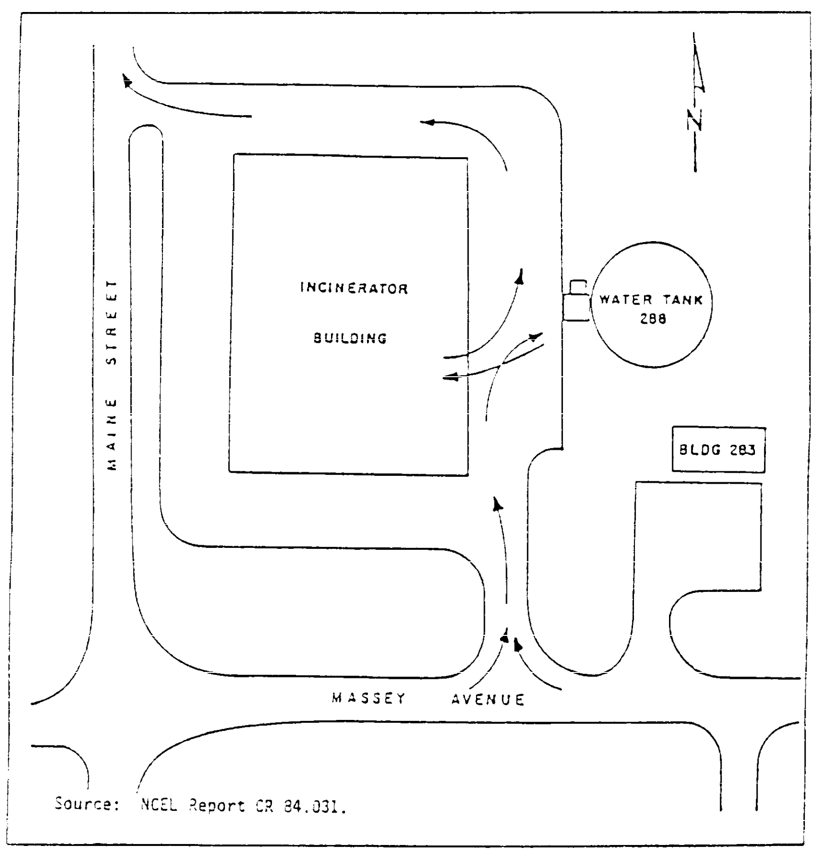
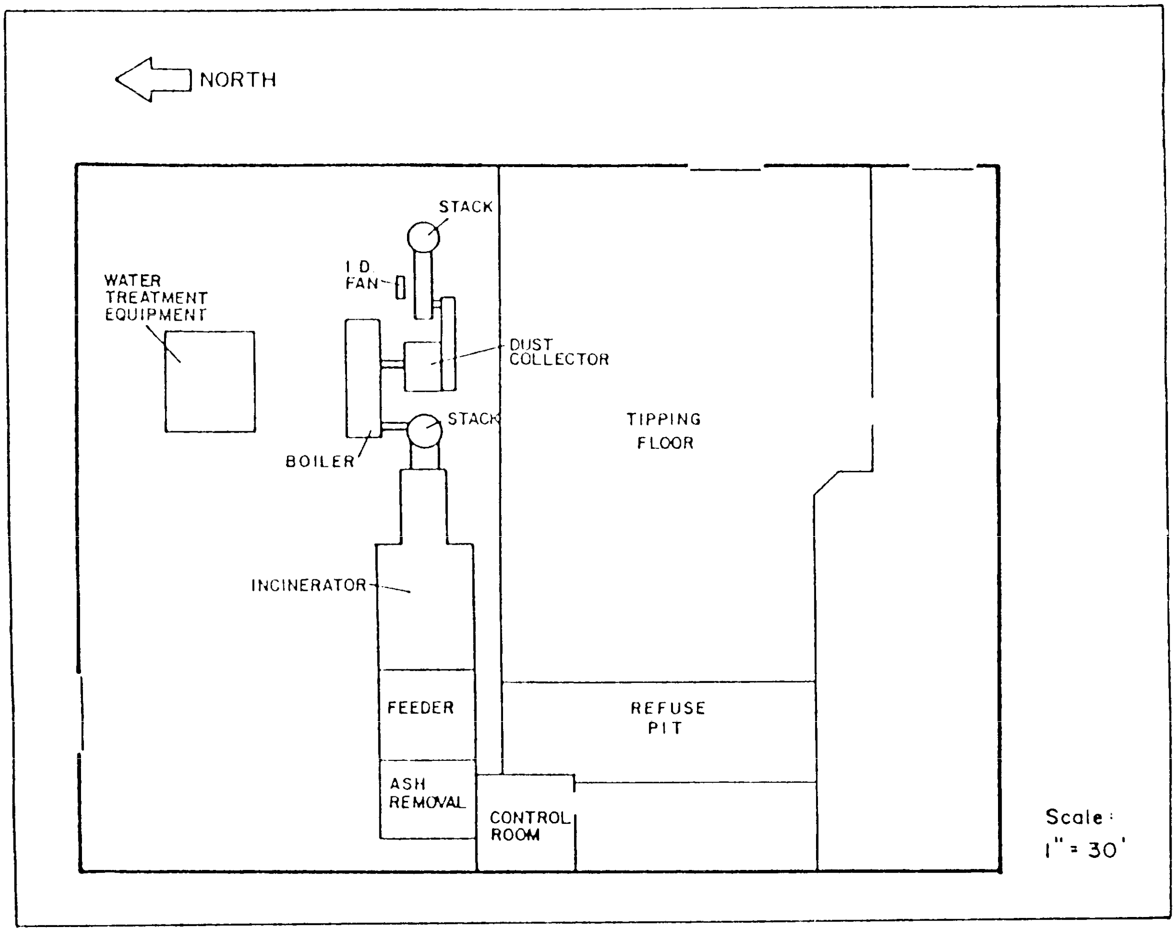


Figure 2
MS Mayport HRI Site Plan



Source: NCEL Report CR 84.031.

Figure 3
NS Mayport HRI Facility Layout

4.3 System Descriptions

4.3.1 Receiving and Storage

4.3.1.1 Truck Scale. A 35-ton (31.75 metric ton) truck scale, located south of the incinerator building, is available for recording the weight of incoming refuse and outgoing nonprocessibles. Readout of the weights is provided in the incinerator control room.

4.3.1.2 Tipping Floor. The tipping floor measures 60 ft x 100 ft (18.288 m x 30.48 m) and provides storage for 50 to 60 tons (45.36 to 54.43 metric tons) of refuse, depending upon the type of waste received. The refuse is manually sorted on the tipping floor and an open top container is provided for disposal of large metallic waste items.

4.3.1.3 Refuse Pit. The concrete refuse pit measures 60 ft x 20 ft x 11 ft (18.288 m x 6.096 m x 3.352 m) deep and is capable of holding 50 tons (45.36

metric tons) of sorted refuse, which is equivalent to 24 hours of as-designed incinerator capacity. A 20-ft (6.096 m) high concrete wall extends along 44 ft (13.411 m) of the length of the front of the pit. This wall adds storage capacity to the pit and the tipping floor. The last 16 ft (4.876 m) of this wall is open for front end loader dumping of sorted refuse into the pit.

4.3.1.4 Modifications and Design Deficiencies. The truck scale is not normally used, except to periodically determine the waste generation associated with a particular activity. The scale does not have sufficient capacity to weigh a full ash container, estimated to be 37 tons (33.56 metric tons). The ash containers must be weighed at another scale located on the base.

The tipping floor size is inadequate for storage of the refuse, especially when a carrier is in port, or when the incinerator is shut down for repairs, or when refuse is delivered on Saturdays and Sundays when the incinerator is not operated.

The tipping floor and refuse pit walls do not extend to the roof of the building, and therefore dust and odors from this area can migrate into the incinerator area. Ventilation in the tipping floor and refuse pit area is via the roll-up door and roof turbine vents. There is no communications system nor indoor access from the tipping floor to the rest of the plant.

4.3.2 Crane System. An overhead crane is provided to transport the sorted refuse from the pit to the incinerator feed-hopper. The crane is an under-running type consisting of a motor driven double girder, double hoist clamshell bucket trolley system, full length dual runway beam system, full length fixed power conductor system, load measurement system and radio control transmitter. The trolley system contains two multiple speed motor drive heads, two sets of idler wheels, two multiple-speed winch hoists (one-bucket close, one-load), motor control panels, power collectors, radio receiver, relay unit and 1-1/2 cubic yard (1.15 m^3) clamshell bucket. Limit switches and hydraulic bumpers are also provided to automatically reduce trolley speed near the ends of its travel to protect the structure. Maximum trolley speed is 300 ft/min (1.524 m/sec); maximum hoist speed is 80 ft/min (0.406 m/sec).

The crane is operated by a radio control transmitter located on the platform outside the incinerator control room. The transmitter controls the following functions of the crane: crane-start/off, trolley-north/south, and buckets-open/close, up/down. A section of the runway beams above the feeder-hopper is structurally separated from the rest of the runway system and is supported through load cells. Signals from these load cells are electronically processed to provide an accurate load weight on a digital indicator in the control room.

4.3.2.1 Modifications and Design Deficiencies. The crane must be controlled from a platform outside the incinerator control room, because the pit cannot be viewed from within the control room. The crane control limit switches are a maintenance/access problem, because they are enclosed within the crane trolley. Electrical power is supplied to the crane via brushes. This design is subject to frequent disconnection, especially when a heavy bucket load swings slightly sideways. To reconnect the power supply, the operator must climb up onto the crane.

The power supply to the crane controls was increased from 60 amps to 100 amps. A ladder and access platform were added at each end of the runway to facilitate crane maintenance. The brake system was removed, because it required continual maintenance. The crane is now stopped by reversing the motor. The crane radio controller was originally powered by batteries, but due to frequent failures, a plug-in ac power supply is now used.

4.3.3 Incinerator Feed System. The incinerator feed system consists of a ram feeder-hopper assembly. This assembly includes a feed chute with hydraulically operated hinged cover doors and a structurally reinforced ram powered by two hydraulic cylinders. The feeder-hopper has a holding capacity of 20 cubic yards (15.291 m^3) with the cover doors closed. This is equivalent to two to three tons (1.814 to 2.72 metric tons) of uncompacted refuse or one to one and a half hours of furnace operation at two tons per hour (1.814 metric tons/hr). The ram automatically pushes the refuse from the hopper into the furnace at an adjustable rate to suit the furnace capacity. The ram stroke length is also controlled to ensure the development of a compressed wedge of refuse at the furnace charging opening to minimize the burn-back of refuse into the feeder-hopper. Also, the feeder-hopper, when closed, is pressurized by a hopper air fan to further prevent burn-back. The fan is rated 6000 cfm (2.83 m^3/sec) at 4 inches H_2O (101.6mm H_2O) static pressure, 1623 rpm and 5.3 bhp (3.952 kw).

The feeder ram is actuated by two hydraulic cylinders capable of exerting 100,000 lbs (444,822 N) of forward thrust against the refuse and rides on four, greased lubricated roller wheels. The feed rate for a mixture of Type 1 and Type 2 wastes is approximately 2 tons (1.814 metric tons) per hour.

The hydraulic unit consists of a 120 gallon (454.2 L) hydraulic fluid tank, a low pressure and a high pressure pump driven by a single motor, and piping, valves, filters, instrumentation and controls.

4.3.3.1 Modifications and Design Deficiencies. The feeder-hopper floor has been rebuilt with 3/8-inch (9.525 mm) carbon steel plate supported underneath with I-beams. The ram feed assembly has also been rebuilt, because the original installation was not square with the feed throat and therefore, resulted in frequent jamming. The wheels of the ram were severely worn and the hydraulic pistons and rods overheated because of their locations at the front of the unit. The rod end connections were moved back about 10 inches (254 mm) by adding an I-beam at the front. The hydraulic cylinders have been subject to leaking, requiring rod seal replacement, and the cylinder bearings and bushings have been changed to reduce seal wear. The hydraulic cylinder was not fully supported at full extension causing excessive force on the seals. The I-beam addition reduced the required length of rod extension and thus reduced stress on the seals. The original carbon steel ram guide wheels wore to form flat spots and have been replaced with cast hardened steel wheels.

The feeder-hopper doors are not closed during operation, because of ram feeder jamming. Consequently, the hopper air fan is not used either. Because no wear plates were provided on the wedge seal throat, the throat metal has become thin, heavily worn, and is leaking cooling water.

4.3.4 Primary Combustion Chamber and Burner System

4.3.4.1 Primary Combustion Chamber. Refuse from the feeder-hopper is pushed through the water-cooled throat into the primary combustion chamber in a dense compacted condition. Combustion of the refuse, as it passes through the throat, is inhibited by the compacting action of the ram. The chamber consists of a stepped fire brick hearth with refractory covered side walls and roof, reciprocating stoker, and oil burner. High velocity air jets are provided to aerate the refuse and to disassociate the refuse from its compacted condition. Cooling air is forced through the cracks between the side wall fire bricks alongside the hearth to prevent clinker adhesion to the walls. Overfire air jets, consisting of three rows in the roof, one row at the end of the hearth and one row in the bridge wall, are also provided. The refuse is dried and ignited on the refractory hearth and is pushed off onto the reciprocating grate by the successive loading action of the ram.

The primary combustion chamber was designed for 20 million BTU's per hour (5861 kw), which is equivalent to 2 tons (1.814 metric tons) per hour of a mixture of Type 1 and Type 2 wastes having a combined heating value of 5,000 BTU's per pound (11630 kJ/kg).

4.3.4.2 Burner System. A 10 gph (10.515 mL/sec) oil-fired burner is provided in the sidewall of the primary combustion chamber to ignite the refuse and to aid in drying the refuse during wet conditions. The burner is equipped with a continuous propane gas pilot. The burner is capable of firing waste oil or diesel fuel marine oil.

4.3.4.3 Air System. A high pressure fan system supplies air at about 28 inches (711.2 mm) of water to the primary combustion chamber overfire air nozzles, ignition burner, chamber view ports and side wall. The system also supplies air to the secondary chamber burner and secondary chamber view ports. The air distribution and balancing in the system is controlled by branch dampers and orifices.

4.3.4.4 Modifications and Design Deficiencies. Other than a complete replacement of brickwork and refractory in 1985, no major modifications have been made to the primary combustion chamber. It does appear, however, that the refractory will have to be replaced every 3 to 4 years.

A greater than normal amount of slagging occurs in the primary combustion chamber. Most of the combustion occurs on the grate and not on the hearth.

The first three rows of underfire air jets are no longer used because the refuse would burn too completely on the hearth and form clinkers. The stepped hearth becomes filled with dirt and grit from the refuse, and the refuse does not tumble and ignite completely. The air supply system was designed to operate automatically utilizing chamber exit gas temperature as the controlling set-point. As the chamber temperature increased, the air flow was to increase; however, in practice, the increasing air flow typically resulted in a further increase in chamber gas temperature. This occurred due to the overfire air increase, and it caused surface burning of the refuse on the hearth. Consequently, the controls are manually set so that the forced draft, underfire and overfire air dampers are open 20 to 30 percent.

4.3.5 Stoker System. When the refuse has traveled the length of the hearth, it is dried, ignited and partially burned. It then falls off the hearth and tumbles about three feet (0.914 m) onto the stoker grate. The grate consists of alternate rows of fixed and reciprocating cast iron plates in a series of shallow steps arranged to provide a downward slope of about six degrees. Each row of movable grates slides back and forth between the fixed rows of grates above and below to slowly move the refuse down the inclined grate. A hydraulic cylinder and linkage system provides the back and forth movement of the grate. The combination of the tumbling action of the refuse, as it falls from the hearth to the grate, and the reciprocating movement of the grate disassociates and redistributes the refuse so that unburned surfaces are exposed to the furnace heat. The grate plates have several rows of 1/4-inch (6.35 mm) holes to allow air passage up through the plates, as well as between the rows. The grates are directly open from below to the residue quench tank/windbox. Grate siftings can fall directly into the quench tank.

The hydraulic cylinder for the stoker is powered by the same hydraulic unit as used for the ram.

A stoker fan system is provided to supply low pressure air (4 inches [101.6mm] of water maximum) to the stoker windbox. This air, which is controlled in response to furnace demands, serves to cool the cast iron grates and provides combustion air to the refuse on the grate.

4.3.5.1 Modifications and Design Deficiencies. The cast iron grate bars wear quickly and have therefore been replaced with steel type.

4.3.6 Ash Removal System. Ash and non-combustible material drop off the end of the grate into an 8-ft (2.439 m) wide by 22-ft (6.706 m) long by 4-ft 9 in. (1.448 m) deep steel tank. The tank serves to quench and cool the ash residue prior to collection and disposal. A continuous drag conveyor, running below the water level of the tank, collects the ash residue and moves it up an incline trough section to the unloading point. At the end of the conveyor, the ash falls into a large open refuse container.

The conveyor consists of two forged steel chains running inside the width of the tank, with the flights riding on wear strips at the bottom of the conveyor. The flights are spaced on 8-ft (2.439 m) centers. At the discharge point, the chain travels under sprockets then up to a system of over-head idler sprockets and traction wheel assemblies and then returns to the tank where the process starts over again. Each flight is capable of conveying 50 pounds (22.680 kg) of wet ash residue.

The conveyor is driven by an electric motor through a gear reducer. The gear reducer is capable of varying the chain speed from 6.6 fpm to 19.8 fpm (0.034 m/sec to 0.101 m/sec). The slow conveyor speed minimizes wear, improves the settling performance of the solids in the tank and provides more time for dewatering the ash residue as it is moved up the incline to the unloading point.

4.3.6.1 Modifications and Design Deficiencies. The rear sprocket of the ash conveyor is below the grate discharge. Residue falling on this sprocket often causes jamming. The sprocket is inaccessible and the lack of a reversing function for the chain makes it very difficult to clear a jam.

4.3.7 Secondary Combustion Chamber and Burner System

4.3.7.1 Secondary Combustion Chamber. The gaseous products of combustion pass over a bridge wall as they leave the primary chamber. An air-cooled baffle forces the gas downward into the secondary combustion chamber. Combustion products are detained in the refractory-lined secondary combustion chamber for an average of three seconds to ensure completion of the combustion process and to settle out the large particulate matter.

4.3.7.2 Burner System. A 50 gph (52.575 mL/sec) oil burner (afterburner) is located in the side wall of the secondary combustion chamber at the bridge wall. This burner reheats the gases from the primary chamber to ensure complete combustion, but its primary function is to burn surplus high moisture content diesel fuel marine oil.

4.3.7.3 Air System. Air for the secondary combustion chamber burner and chamber view ports is provided by the high pressure fan system discussed in para. 4.3.4.3.

4.3.7.4 Modifications and Design Deficiencies. The walls between the primary and secondary combustion chambers are made of loose stacked firebrick, separated by a gap to provide heat release. About 1983-1984, several of the secondary chamber wall bricks moved, resulting in a concave wall. This has resulted in the formation of leaks, which have been patched using plastic refractory. Several leaks, however, still exist and are a source of gas and fly ash emissions whenever the chamber pressure becomes positive. Slag accumulation must be removed weekly from the baffle wall throat area and from the settling chamber at the end of the secondary chamber beneath the gas exit. New brickwork and refractory was installed in 1985.

The location of the secondary combustion chamber burner was changed twice. At its current location close to the bridge wall, the flame may impinge on the opposite wall during maximum burner firing. The burner controls were mounted on the secondary combustion chamber wall and became excessively hot due to the wall heat. The panel was remounted on stand-off plates to permit cooling air to flow behind the panel.

Originally, exit gas temperatures were measured at the exit of the primary combustion chamber, the inlet of the heat recovery boiler and the inlet of the dust collector. To satisfy the local air quality agency's concern that proper secondary combustion chamber temperatures be maintained, a temperature sensing device was added to the secondary combustion chamber.

4.3.8 Boiler. Under normal operating conditions, the relief stack damper is closed and combustion products from the incinerator pass through breeching to the heat recovery boiler. The boiler is a single pass, fire tube design. It has a surface area of 4426 ft^2 (411.188 m^2) and is designed to produce 14,184 lbs/hr (1.787 kg/sec) of saturated steam at 250 psig (1723.7 kPa) maximum.

The boiler contains 475 two-inch (50.8 mm) OD tubes. Each tube is 19.53-ft (5.953 m) long. Hot gases from the incinerator pass through these tubes, and water, contained by the boiler shell, surrounds the tubes. Heat is transferred from the hot gases through the tubes to the water producing steam. Steam generated by the boiler is piped from the incinerator building to the existing steam header in Building No. 250.

Make-up water to the de-aerator is routed to a shell and tube heat exchanger where it is heated by the continuous blowdown water from the boiler. A secondary advantage of the heat exchanger is that the continuous blowdown water used to heat the make-up is cooled prior to discharge to the sanitary sewer system. The preheating of the make-up water reduces the amount of steam required for the de-aerator and increases the amount of steam flowing through the existing steam header in Building No. 250. Intermittent blowdown is routed through a steam/water separator prior to discharge to the sanitary sewer. A raw water supply line, containing a temperature control valve, is connected to the discharge piping from the separator. Also provided in the discharge piping is a temperature sensing element, which is connected to the control valve. The control valve automatically adjusts the quantity of raw water required to maintain the blowdown discharge temperature below 140° F (60° C).

4.3.8.1 Modifications and Design Deficiencies. The boiler fire tubes have been re-rolled, and seven upper rows of tubes, which warped due to low boiler water level, were replaced. The refractory on the inlet side of the boiler has been replaced. The continuous blowdown exiting the heat exchanger was originally routed to the ash handling quench tank. The blowdown, however, would raise the temperature of the quench water so high that cleaning of the quench tank screen could not be performed. Consequently, the piping was rerouted to drain in lieu of the quench tank.

A steam separator was added to improve the quality of the steam leaving the plant.

4.3.9 Air Pollution Control System. Gases from the heat recovery boiler flow through insulated steel breeching to a multiple cyclone dust collector, which removes particulate matter. The dust collector consists of 40 collector elements arranged for parallel flow. The collector imparts a high velocity cyclonic spin and reversal of direction to the gas stream, which throws the heavier solid particles out of the lighter gas. The dust particles fall by gravity into a hopper located below the collector. Connected to the hopper is a double flap valve and piping to sealed 55-gallon (208.2 L) drums. The double flap valve permits the unloading of fly ash to the collection drums, while preventing leakage of air into the flue gas system.

4.3.9.1 Modifications and Design Deficiencies. Measurements have shown that the particulates entering the multiple cyclone dust collector are much finer than it can efficiently collect. During a three day test in December 1980, 20 pounds (9.07 kg) of particulates were collected by the multiple cyclone. Sizing analysis of these particulates indicated that 95 percent by weight were larger than 46 microns (0.046 mm). During the same period, as calculated from several stack gas sample runs, 1,332 pounds (604.2 kg) of particulates were carried up the stack with the flue gas. Size distribution analyses indicated that 50 percent (by weight) of the stack particulates were smaller than 1.4 microns (0.0014 mm), 75 percent smaller than 5.7 microns (.0057 mm), and 90 percent smaller than 11.7 microns (0.0117 mm). Refer to para. 5.1.5.2 for additional discussion of Emission Control equipment.

4.3.10 Breeching and Induced Draft System. Furnace gases from the dust collector flow through insulated steel breeching to the induced draft fan. The fan is designed to provide the necessary draft required to overcome the flow resistance of the dust collector, heat recovery boiler, and the interconnecting breeching as well as maintaining a residual sub-atmospheric pressure in the primary furnace. The fan outlet damper is controlled by the fan motor amperage sensor. The damper will close if the amperage increases beyond 80 amperes. An atmospheric inlet damper is provided in a teed section of breeching on the inlet of the fan. The damper is controlled by a pressure sensor located in the primary combustion chamber. The damper will close as the pressure in the primary combustion chamber increases.

4.3.10.1 Modifications and Design Deficiencies. The atmospheric damper tends to lag behind the chamber pressure changes. Positive pressures have occurred during periods of high gas flow, because the induced draft fan outlet damper closes due to high fan motor amperage.

The fan motor has been re-wound, and the fan bearings have been replaced. A new fan has been ordered because of the poor condition of the fan blades. The fan may have been mounted incorrectly, causing a vibration problem, which may have caused the motor and fan bearing problems. Two of the six fan support legs were mounted on the rigid building foundation, while the other four legs were mounted on a separate pad. The vibration springs were worn or broken and were replaced with stiffer springs.

4.3.11 Stack System. Gases from the induced draft fan flow through insulated steel breeching to the main stack. A dump stack, located between the incinerator and the heat recovery boiler, is also provided and is utilized when the heat recovery boiler is not in use.

4.3.11.1 Main Stack. The main stack is 4 ft-8 in. (1.4224 m) OD, 75-ft (22.86 m) high and constructed of steel. The inside of the stack is lined with 4-inch (101.6 mm) thick refractory. The stack is in the incinerator building and protrudes through the roof. There is a 2 ft x 3 ft (0.609 m x 0.914 m) personnel access door near the base of the stack.

4.3.11.2 Dump Stack. The dump stack is 6 ft-4 in. (1.93 m) OD, 50-ft (15.24 m) high and constructed of steel. The inside of the stack is lined with 4-inch (101.6 mm) thick refractory and 2-inch (50.8 mm) thick mineral wool insulation. The stack is inside the incinerator building and protrudes through the roof. The stack can be isolated by a cap constructed of steel and lined with 4 inches (101.6 mm) of castable refractory.

The cap is weighted such that pressure must be exerted to keep the cap closed. This pressure is exerted by means of a cable attached to a hydraulic cylinder. The lack of such pressure due to one of several unsafe signals or the lack of electric power will cause the cap to open, thereby diverting gases from the incinerator to the atmosphere instead of through the heat recovery boiler, dust collector, induced draft fan, and main stack.

4.3.11.3 Modifications and Design Deficiencies. The main stack has functioned as expected without any difficulties. The dump stack cap seal has been replaced several times, and the metal frame was rebuilt after it warped.

4.3.12 Instrumentation and Control. The incinerator control room contains a free standing vertical control panel and a console type control panel. The free standing panel contains the following instrumentation and controls:

a) Gauges:

(1) Gas Pressure Entering Boiler

(2) Gas Pressure Leaving Boiler

(3) Gas Pressure Leaving Dust Collector

(4) Overfire Air Pressure

(5) Hearth Air Pressure

(6) Grate Air Pressure

(7) Boiler Shell Side Pressure

(8) Feedwater Pressure

(9) Hydraulic High Pressure

(10) Hydraulic Low Pressure

b) Recorders:

(1) Steam Flow

(2) Multipoint Temperature (Primary Furnace, Secondary Furnace, Boiler Inlet, Boiler Outlet)

c) Recorder/Controllers:

(1) Induced Draft Fan Current

(2) Primary Furnace Draft

(3) Primary Furnace Temperature

d) Annunciators:

(1) Relief Vent Valve Open

(2) Ram Feeder Alarm

(3) High Gas Temperature

(4) Primary Burner Flame Safeguard

(5) Low Water Level

(6) Secondary Burner Flame Safeguard

(7) High Boiler Pressure

(8) Low Combustion Air Pressure

e) Indicating Lights:

(1) Ram Position

(2) Damper Motor 2 Position

(3) Damper Motor 6 Position

f) Switches:

(1) Damper Motor 2 Open/Close

(2) Damper Motor 2 Auto/Manual

(3) Damper Motor 6 Open/Close

(4) Damper Motor 6 Auto/Manual

g) Digital Indicators:

(1) Refuse Tonnage to Feeder-Hopper

(2) Truck Scale Tonnage

h) Controllers:

(1) Feedwater Flow to Boiler

The console type panel contains the following instrumentation and controls:

a) Selector Switches:

(1) Primary Furnace Burner On/Off

(2) Secondary Furnace Burner On/Off

(3) Ram On/Off

(4) Damper Motor No. 5 On/Off

(5) Water for Hopper On/Off

(6) Hopper Cover On/Off

b) Pushbuttons and Indicating Lights:

(1) Induced Draft Fan Start and Stop

(2) Forced Draft Fan Start and Stop

(3) Waste Oil Transfer No. 1 Start and Stop

(4) Waste Oil Transfer No. 2 Start and Stop

(5) Diesel Oil Transfer No. 3 Start and Stop

(6) Diesel Oil Transfer No. 4 Start and Stop

(7) Stoker Fan Start and Stop

(8) Hopper Fan Start and Stop

(9) Residue Conveyor Start and Stop

(10) Dust Collector Dump Valve Start and Stop

(11) Feedwater Pump No. 1 Start and Stop

(12) Feedwater Pump No. 2 Start and Stop

(13) Hydraulic Pump Start and Stop

c) Ram Timer

4.3.12.1 Control Functions. Incinerator functions are controlled as described below.

a) Draft -- primary combustion chamber temperature is measured by a thermocouple, located in the chamber, which generates a signal to the control room temperature recorder/controller. The controller, in the auto mode, can regulate the overfire and underfire air. Primary furnace draft can be controlled by a draft sensor, located in the primary combustion chamber, which generates a signal to the control room draft recorder/controller. The controller regulates the barometric damper located at the inlet to the induced draft fan. Induced draft fan control is accomplished using a current relay, which measures the electric current to the fan and provides a signal to the control room fan current recorder/controller. The controller regulates the induced draft fan discharge damper.

b) Refuse charging -- control is performed utilizing the automatic adjustable cycle timer located in the control room. The refuse charging hopper covers can be closed by the switch on the control room console. The hopper fan discharge damper is interlocked to close when the covers are open and to open when the covers are closed. The stoker drive cylinder is equipped with a pilot reversing mechanism to provide the reversing action of the grates. Grate speed is regulated by a pressure compensating valve at the hydraulic pump assembly.

c) Dump stack -- a system of safety controls automatically opens the dump stack cap and closes the induced draft fan discharge damper, in the event of high boiler inlet or outlet gas temperature, low boiler water level, or high boiler pressure. Operation can also be accomplished manually from the control room.

d) Feedwater -- feedwater flow control is regulated automatically by a two-element control system, which senses steam flow and boiler water level and regulates the feedwater control valve. The control valve can also be regulated manually from the control room.

4.3.12.2 Modifications and Design Deficiencies. The incinerator controls were originally wired from the equipment through a floor junction box into the control room. That situation was suspected of causing alarm failures that ultimately led to costly boiler damage. In 1983, these controls were re-wired through overhead conduit. Most of the other controls were originally wired through the concrete floor and because of inaccessibility were eventually replaced.

In general, the control room panels are adequate. There are, however, deficiencies as listed below.

a) No burner controls on the panels -- the operator does not have any indication if the burner is off or on when the system is running in the automatic mode. As a result, the burners must be operated manually.

b) Temperature control -- the automatic temperature control loops, designed to add more air as the temperature increased, are not used.

c) Boiler level control -- boiler level was originally monitored by alarms, since there were no control mechanisms on the panel. Also, the feedwater pumps were started and stopped based on boiler water level. A two-element feedwater control system that varies boiler water flow in proportion to the steaming rate and boiler water level signal was added.

d) Operating data records -- the control system includes a pneumatically operated feedwater regulating valve and control room panel mounted auto/manual feedwater control station and boiler water level indication. Operating data are recorded on continuous strip charts. The operators would prefer that the recording mechanism be changed to daily circular charts.

e) Secondary chamber temperature indicator -- originally, no secondary combustion chamber temperature indication was provided. A thermocouple was added to the chamber and indication was added to the control room panel.

f) Draft logic -- the logic for the automatic furnace draft control together with the induced draft fan current control was faulty. The automatic furnace draft control was generally ineffective and seldom used as originally installed.

4.3.13 Waste Treatment. All plant wastewater, such as tipping floor washdown water, boiler blowdown, quench tank overflow, softener regeneration wastewater and incinerator and boiler area washdown, flow by gravity to a wastewater lift station located outside the plant. From the lift station, the water is pumped to the sanitary sewer system.

4.3.14 Boiler Water Treatment. The boiler system is designed to operate with 100 percent make-up water. Water is supplied to the plant from the central water distribution system. Since the raw water contains materials capable of scaling and corroding the boiler, the make-up water is passed through a zeolite water softener to remove minerals. Since the water softener must be periodically taken off-line and regenerated, two softener units are provided so that at least one may be in service at all times.

The softened water is then heated to approximately 220°F (104.4°C) before being fed into the boiler. This heating process is accomplished in two stages. The first stage is accomplished by the exchange of heat with a portion of the boiler water, which is continuously removed as blowdown. The second state of heating occurs in the de-aerator, where some of the steam generated by the boiler is used to heat the water and to remove oxygen and non-condensible gases. Phosphate and sodium sulfite are added to the feedwater to maintain proper alkalinity and to remove or scavenge oxygen. The dissolved salts, which remain in solution in the water and would rapidly concentrate in the boiler as the steam boils off, are removed by continually blowing down a portion of the water in the boiler. Provision is also made to manually blow down water from the boiler on an intermittent basis to remove floating scum and impurities.

The de-aerator is 5 ft (1.52 m) in diameter by 8 ft (2.44 m) long and is elevated. Steam from the boiler heats the water in the de-aerator. Two 100 percent capacity motor driven boiler feedwater pumps are located below the de-aerator. The pumps take suction from the de-aerator and provide feedwater to the boiler. Each pump is connected to an auxiliary power supply so that water flow can continue to the boiler in the event of a power failure.

4.3.14.1 Modifications and Design Deficiencies. The water softener was originally specified to provide 11 gal/min (0.694 L/sec) of water with a 48-hr recharge cycle. The softener has been changed to provide 25 gal/min (1.577 L/sec) of water with a 24-hr recharge cycle. It was later determined that even with the softener producing the higher capacity of water, the recharge cycle could be changed back to 48 hours.

The original boiler feedwater pumps had thrust bearing problems. Further, water hammer, occurring when the pumps stopped, caused the pump seals to break. A new pump was installed in 1983 and the pump controls and boiler water level controls were also replaced. The original control system started and stopped the pumps based on the water level in the boiler. This system caused many problems and was replaced with a two element feedwater control system. The feedwater supply piping to the boiler now contains a pneumatic feedwater regulating valve and a pump recirculation line to the de-aerator has been added. A feedwater pump is operated continuously and flow to the boiler is regulated by the control valve based on the steaming rate and boiler water level. Feedwater controls and boiler water level indication were also added in the incinerator control room.

4.4 Waste Types Accommodated

4.4.1 Municipal Solid Waste (MSW). The incinerator was designed to accept a mixture of Type 0, 1, 2 and 3 wastes (see Table 1) from the ships, station and housing area. The incinerator is limited by the size of the refuse it can accommodate. Pieces which are more than 48 inches (1219.2 mm) long, or greater than 12 inches by 12 inches (304.8 mm by 304.8 mm) in the shorter dimensions, are not acceptable. Scrap metal from ship repair work and explosives are also not acceptable.

4.4.2 Waste Oils. The primary and secondary combustion chamber burners are designed to burn water contaminated shipboard waste oil, which has been passed through settling and skimming processes. For acceptable burner performance, the oil must comply in all respects, except moisture content, to the specifications for No. 2 Diesel Fuel, and its moisture content cannot be greater than 5 percent. Waste oil should not be used until the furnace has reached operating temperature.

4.4.3 Wood. The incinerator was designed to accommodate items 4-ft (1.22 m) long and to burn wood mixed with the other waste. Large pieces of wood, however, tend to jam in and damage the water-cooled throat. Also, large pieces of wood do not burn completely because of insufficient burn time in the furnace.

4.5 Energy Recovery

4.5.1 Waste Fuel High Heating Value (HHV). Analyses of the waste oil to be burned in the incinerator show that the oil's HHV is typically in the range of 19,700 BTU/lb (45,822 kJ/kg) to 19,800 BTU/lb (46,055 kJ/kg).

4.5.2 Steam Conditions. Steam generated by the heat recovery boiler is piped from the incinerator building to the existing steam header in Building No. 250. Therefore, the heat recovery boiler was designed to produce up to 250 psig (1723.7 kPa) saturated steam for compatibility with the conditions of the existing steam system.

4.6 Energy Utilization and Economic Benefits. An economic analysis of the facility, as-operated, was performed for the period from October 1980 to August 1983. The results of that analysis are shown in Table 2. During that time frame, the facility burned an average of 6534 tons (5927.5 metric tons) of refuse per year and offset 4574 tons (4149.5 metric tons) of waste per year that would have gone to a landfill. The facility also produced an average of 4.00×10^4 MBTU/yr (4.220×10^{10} kJ/yr) of steam and offset the use of 4,074 barrels (6.477×10^5 L) of diesel fuel marine oil by burning waste oil. The discounted life cycle cost savings of the facility was $3,301,350 and the savings to investment ratio was 0.97. The payback period, however, exceeded the twenty-year expected life of the facility.

4.7 Permitting

4.7.1 Federal Permitting Requirements. None. Refer to para. 4.7.3.

4.7.2 State Permitting Requirements. Refer to para. 4.7.3.

4.7.3 Local Permitting Requirements. In Jacksonville, Florida, the city's Bio-Environmental Services Division (BESD) acts as the permitting and enforcing agency for air pollution control, for both the city and the state, by agreement with the Florida Department of Environmental Regulation (FDER).

The BESD has adopted virtually all the state regulations by reference. Any exceptions do not apply to the Mayport Naval Station incinerator. Each state permit in this area is issued jointly by the BESD and the FDER. The permitting process regulations are in Chapter 17-4 of the Florida Administrative Code (FAC). Applications for permits are made on forms provided by the FDER and submitted to the BESD. The Mayport incinerator was originally permitted as a carbonaceous fuel burner (refer to Chapter 17-2.100(36) of the FAC), having a heat input less than 30 million BTU/hr (8792 kw). The emission requirements for this category are that visible emissions can be no greater than 20 percent opacity, except that visible emissions of 40 percent opacity are permissible for not more than two minutes in any one hour (refer to Chapter 17-2.600(10)(a) of the FAC).

Since 1985, when Operation Permit No. A016-17873 expired, and the Naval Station submitted an application for a renewal permit as a carbonaeous fuel burner, the unit has been operated without a permit. In the meantime, the BESD has issued a series of waivers, maintaining that the unit should be re-permitted as an incinerator (refer to Chapter 17-2.100(90) of the FAC), which would have more stringent emission limits. For an incinerator with a charging rate of less than 50 tons (45.36 metric tons) per day, the requirements are:

a) 5 percent opacity, equivalent to no visible emissions, except that visible emissions of 20 percent are allowed for up to three minutes in any one hour; and

b) No objectionable odor (Chapter 17-2.600(1) of the FAC).

On July 29, 1987, the BESD issued a formal notice of its intent to deny the permit as a carbonaceous fuel boiler. The Naval Station then petitioned for an administrative hearing on the matter (refer to Chapter 28-5.15 of the FAC). Unless an agreement is reached before the hearing or during the hearing, an officer appointed by the Florida Division of Administrative Hearings (FDAH) will hear both sides and make a recommendation to the Secretary of the FDER. The Secretary will make the final decision whether the Mayport unit is to be permitted as a carbonaceous fuel burner or as an incinerator.

4.8 Waste Disposal. Refuse which is not suitable to be burned in the incinerator and ash from the incinerator and cyclone collector are disposed of off-base in a landfill.

4.9 System Availability. Availability results for the incinerator and heat recovery boiler systems, for the period from October 1980 to August 1983, are shown in Table 3. As identified in the table, the incinerator and heat recovery boiler systems had identical availability records ranging from as low as 41.7 percent to as high as 86.5 percent.

4.10 Operating Costs. Annual operating costs for the period from October 1980 to August 1983 are shown in Table 2 and total $1,232,540. These costs include the cost of capital, facility and equipment modifications, labor, consumables, residue disposal, and other similar costs spread over a 20 year period.

Table 2
NS Mayport Actual HRI Cost and Performance Report

$ 52.82	=	Inflated per ton cost of disposing waste of the type generated at the site to the landfill
$ 11.49	=	Inflated per MBtu cost of the fossil fuel boiler to wich the HRI is being compared
6,534	=	Tons of trash burned annually by the HRI
4.00E+04	=	MBtu's produced annually by the HRI (considering no downtime)
4,074	=	Virgin petroleum fuel offset annually by the HRI in barrels of oil equivalent
4,574	=	Landfill space conserved annually by the HRI in tons
$ 902,760	=	Cost of using a boiler to produce the annual no downtime quantity of steam produced by the HRI and landfilling all waste
$ 3,447,470	=	Inflated total capital cost of the HRI (includes equipment, support facilities and construction, and setup
$ 1,232,540	=	Uniform annual cost of the HRI (the cost of capital, modifications, labor, consumables, reside disposal, downtime, and other costs spread over the economic life of the HRI)
$ 9,703,790	=	Discounted life cycle cost of using a boiler to produce the life cycle no-downtime quantity of steam produced by the HRI and landfilling all waste (discounted to point of initial funding)
$ 9,797,880	=	Discounted life cycle cost of the HRI
$ 96,317	=	Discounted life cycle cost of auxiliary fuels used by the HRI
$ 611,567	=	Discounted life cycle cost of noncombustible waste, ash, and scheduled downtime waste disposal
$ 0	=	Discounted life cycle cost of HRI downtime
$ 74.97	=	Discounted life cycle cost of the HRI per ton of waste fired
$ 25.26	=	Discounted life cycle savings of the HRI per ton of waste fired
$ 14.74	=	Discounted life cycle cost of the HRI per MBtu produced
$ 4.97	=	Discounted life cycle savings of the HRI per Mbtu produced
$33,301,350	=	Discounted life cycle savings of the HRI
+0.97	=	HRI savings to investment ratio

Payback period in years (includes project lead time) greater than project life.

Source: NCEL Report CR 84.031

Table 3
As-Operated Performance Summary, NS Mayport HRI Facility

ACTIVITY	OCT/80-MAR/81	APR/81-SEP/81	OCT 81-MAR/82	APR/82-SEP/82	OCT/82-MAR/83	APR/83 AUG/83	TOTAL
System Availability							
Burn Refuse (M2)	0.537	0.417	0.664	0.706	0.724	0.865	
Steam from Refuse and Oil (M1)	0.537	0.417	0.664	0.706	0.724	0.865	
Refuse Processed (Tons)	1904.92	1671.36	3231.36	3287.10	3307.84 1168.68	2970.14	16372.72 14233.56
Steam Produced (FFO, BOE/Ton)	0.281	0.216	0.642	0.378	0.539	0.548	
Operator Man years (Manhour per MBTU Steam)	0.366	0.462	0.313	0.387	0.322	0.420	

UTILITY REQUIREMENTS	JUL/82-AUG/83
1. Electrical kwh/hr	169.31
Electrical BTU	1.175×10^{10}
Cost @ 0.06/kwh	$10.16/hr
2. Diesel fuel-fed loader front-end loader	1403 gal
BTU	0.046×10^{10}
@ 1.22/gal	$1,712
3. Fuel oil gal	502
Fuel oil BTU	6.968×10^{7}
Fuel oil @ 1.12/gal	$562

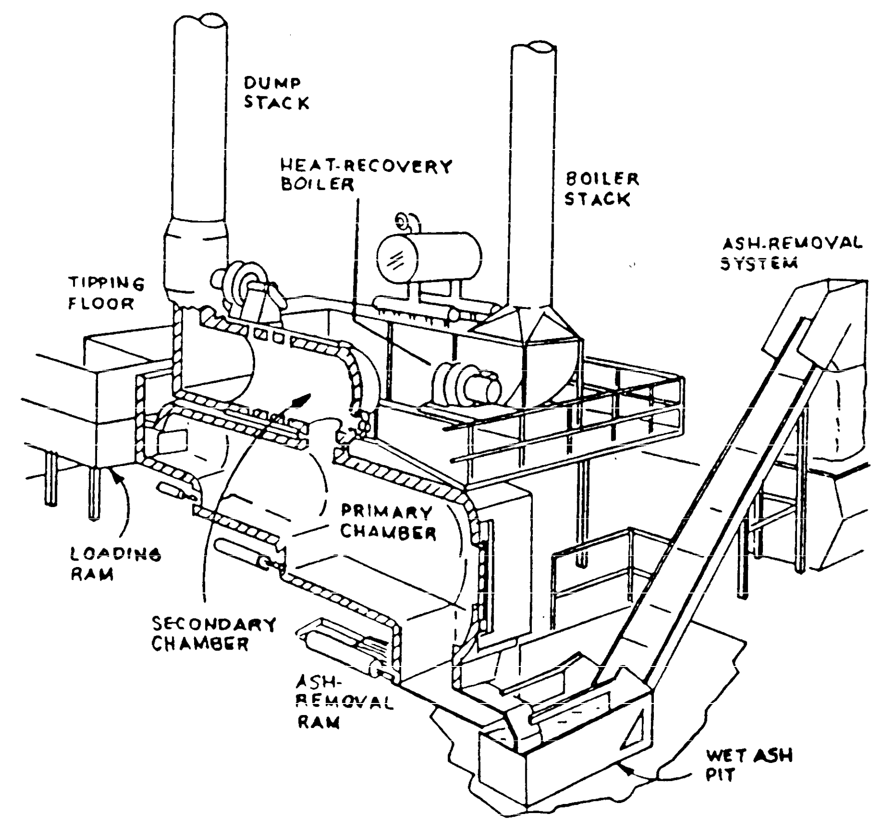
SOURCE: NCEL Report CP.84.031

Section 5: SPECIAL PURPOSE INCINERATORS

5.1 Modular Incinerators

5.1.1 Discussion of Applications

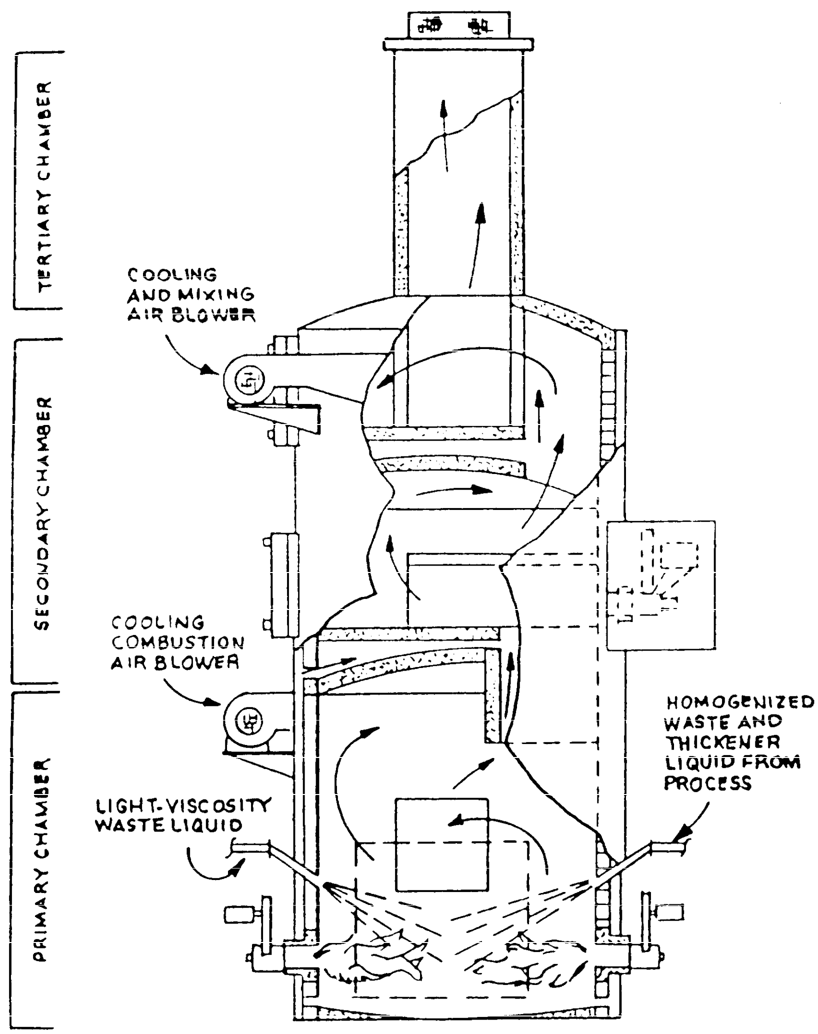
5.1.1.1 Municipal Solid Waste (MSW). Municipal solid waste streams up to about 100 tons (90.72 metric tons) per day are most commonly burned in controlled air dual chamber, modular incinerators, similar to that shown in Figure 4. The waste is injected into the primary combustion chamber by a ram-type feeder. In this chamber, the refuse is burned and particulates and gases pass to the secondary combustion chamber where further combustion takes place. The temperature in the secondary chamber is normally higher than in the primary chamber. Either batch or continuous waste feeding systems are used in modular incinerators. Residual ash is removed manually from batch type units and automatically from continuous type feed units using a conveyor or ram.



SOURCE: Plant Engineering Magazine, August 20, 1981.

Figure 4
Modular Incinerator

5.1.1.2 Waste Oils. Waste oils include contaminated fuel, used lubricating oil and fuel tank bottom residue. Liquid waste incinerators, such as the type shown in Figure 5, are generally used for waste oil. Atomizing nozzles are normally utilized to inject the waste oil into the primary combustion chamber. Waste oils can also be burned in an oil burner located in the primary combustion chamber of a solid waste controlled air dual chamber incinerator.

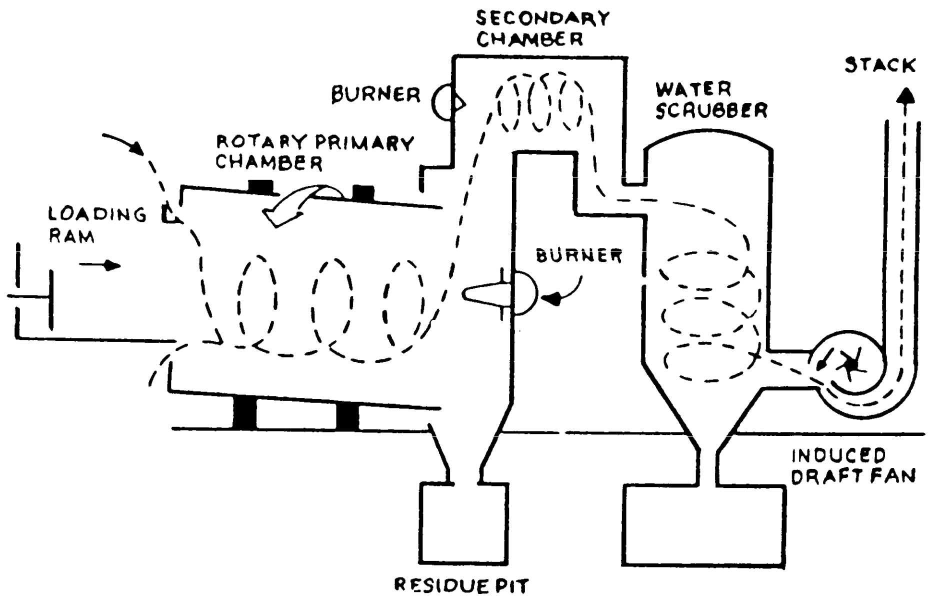


SOURCE: Plant Engineering Magazine, August 20, 1981.

Figure 5
Liquid Waste Incinerator

5.1.1.3 Classified Material. Modular incinerators shall reduce the paper component to white or off-white ash. All other materials containing classified information shall be oxidized or melted to preclude recovery of any information for intelligence purposes.

5.1.1.4 Sludge. Sludge is residue from sanitary and industrial waste water treatment plants. Sludge is usually mixed with solid waste and burned in a rotary kiln incinerator, similar to that shown in Figure 6. The tumbling action of the rotary kiln allows more of the waste to be exposed to the combustion process than stationary units. Sludge can also be burned in modular units, but the sludge must be injected separately from the solid waste, where in a rotary kiln they can be injected concurrently. In the modular units, the solid waste is fed into the primary combustion chamber and the sludge is injected on top of the solid waste.



SOURCE: Plant Engineering Magazine, August 20, 1981.

Figure 6
Rotary Kiln Incinerator

5.1.2 Discussion of Operating Alternatives

5.1.2.1 Automatic Operation/Manual Operation. Manual loading is generally employed on incinerators less than about 500 lbs/hr (0.063 kg/sec) and on systems which require loading at infrequent intervals. Automatic charging systems are generally used on incinerators greater than about 500 lbs/hr (0.063 kg/sec) and where controlled charging rates are required.

5.1.2.2 Dump Stack Operation. The solids in an incinerator may take up to 30 minutes to burn even after all waste feed has been stopped. Therefore, many incinerator designs incorporate dump stacks to prevent serious damage to the incinerator, heat recovery equipment and air pollution control devices. Dump stacks also prevent the accumulation of combustible gas in a hot closed chamber which poses an explosion potential. The dump stack is typically located just downstream of the combustion equipment. It is provided with a lid which is designed to open automatically when an upset condition occurs such as a loss of power, loss of induced draft, loss of HRI equipment, loss of air pollution control equipment, excessive build-up of pressure in the combustion equipment and other special considerations. Some dump stacks are connected to the air pollution control equipment, however in some installations this is not possible and emissions will be discharged directly to the atmosphere for the length of time it takes for the solids in the combustion chamber to burn completely.

5.1.2.3 Operating Shifts Per Day. Batch type incinerators generally require one to two shifts per day. Continuous feed incinerators generally require three shifts per day.

5.1.2.4 Waste Types to be Burned. Refer to para. 5.1.3.2.

5.1.3 Preliminary Data

5.1.3.1 Waste Quantification. Determine the quantity of refuse available for incineration by survey, or estimate in accordance with NAVFAC DM 5.10.

5.1.3.2 Waste Classification and Characterization. Modular incinerators are capable of processing all waste types listed in Table 1. Different configurations of certain features would be needed to optimally burn some of the various wastes; it is doubtful that any single modular incinerator configuration could effectively burn all types. This is particularly true for sludges, which are more effectively burned in a rotary kiln incinerator. The composition of the waste to be burned should be determined by laboratory analysis. Waste volume and make-up usually vary from day to day and therefore, the incinerator should be capable of performing efficiently at minimum and maximum feed loads. The laboratory tests that should be done include proximate, ultimate, heating value, and ash analyses.

5.1.3.3 Heat Recovery Applications. Heat released from modular incinerators can be recovered by boilers, heat exchangers and superheaters to provide steam, hot water, hot air, hot oil and electricity. The temperatures and pressures and steam and water quality produced by the heat recovery equipment shall satisfy the needs of the user equipment. Steam produced in excess of user needs should be condensed on-site or vented to the atmosphere. The typical turndown ratio for heat recovery equipment is 3 to 1.

5.1.3.4 Environmental Constraints. Modular incinerators, in general, must meet the same environmental emission requirements for both air and water as other types of incinerators. Since modular type incinerators may employ more than one module at a given location, the environmental permitting may entail separate testing to insure compliance of stack emissions. Additionally, if another module is installed at an existing site, the operating permit would require a modification. If the sum of heat inputs or potential to emit certain pollutants exceeded specified values, a Prevention of Significant Deterioration (PSD) review would be required.

5.1.3.5 Siting Constraints. Refer to para. 2.2.4.

5.1.4 Combustion Calculations

5.1.4.1 General Refuse Incineration. Calculate incinerator air requirements and flue gas quantities and temperature as follows:

For combustion of wastes and auxiliary fuel, determine from Figure 7 the air requirement for type of wastes, percent of excess air required for optimum furnace operating temperature, and corresponding pounds of air per pound of waste. In Figure 7, the basis for percent excess air is the total combustion air, expressed as a percentage, in excess of the theoretical air required for complete combustion. The total combustion air, consisting of primary air (combustion air fed under the fire) and secondary air (combustion air fed over the fire), requirements for waste only are based on 7.5 pounds (3.40 kg) of theoretical air for complete combustion per 10,000 BTU (10550 kJ) of waste on an ash- and moisture-free basis. As an example, the heat value of waste Type No. 1 with 25 percent moisture and 10 percent ash, as fired, is calculated by Equation 1.

EQUATION: $$H_w = 10{,}000 \text{ BTU/lb } (23{,}260 \text{ kJ/kg}) \times (1 - M - A) \qquad (1)$$

where:
H_w = Heat value of waste
M = moisture fraction by weight
A = incombustible solid fraction by weight

For the example fuel:

$$H_w = 10{,}000 \text{ BTU/lb} \times (1 - 0.25 - 0.10)$$
$$= 6{,}500 \text{ BTU/lb}$$

or

$$= 23{,}260 \text{ kJ/kg} \times (1 - 0.25 - 0.10)$$
$$= 15{,}119 \text{ kJ/kg}$$

The total combustion air requirement in pounds of air per pound of waste (kg air/kg waste) is calculated by Equation 2.

EQUATION: $$\text{lb air/lb waste} = \frac{7.5 \text{ lb air}}{10{,}000 \text{ BTU}} \times \text{excess air ratio} \times H_w \qquad (2)$$

or

$$\text{kg air/kg waste} = \frac{3.40 \text{ kg air}}{10{,}550 \text{ kJ}} \times \text{excess air ratio} \times H_w$$

where: Air_{Th} = Theoretical Air
excess air ratio = total air divided by Air_{Th}
= (1 + percent excess air/100)

For the example fuel fired with 100 percent excess air, the lb air/lb waste is determined from Equation 2:

$$\text{Excess air ratio} = (1 + \text{percent excess air}/100) = (1 + 100 \text{ percent}/100) = 2.0$$

$$\text{lb air/lb waste} = \frac{7.5 \text{ lb air}}{10{,}000 \text{ BTU}} \times 2.0 \times 6{,}500 \text{ BTU/lb waste}$$

$$= 9.75 \text{ lb air/lb waste}$$

or

$$\text{kg air/kg waste} = \frac{3.40 \text{ kg air}}{10{,}550 \text{ kJ}} \times 2.0 \times 15{,}119 \text{ kJ/kg waste}$$

$$= 9.75 \text{ kg air/kg waste}$$

The result can also be determined from Figure 7.

The combustion air requirement in pounds of air per second (kg/sec) is calculated by Equation 3.

EQUATION: $$\text{lb air/sec} = \frac{\text{lb waste/hr of DEScap}}{3600 \text{ sec/hr}} \times \text{lb air/lb waste} \qquad (3)$$

or

$$\text{kg air/sec} = \frac{\text{kg waste/hr of DEScap}}{3600 \text{ sec/hr}} \times \text{kg air/kg waste}$$

where: DEScap = Design capacity of system

Note that, since the values of moisture and ash in the waste will vary continuously, the values in the chart on Figure 7 are average values only. Theoretical air for auxiliary fuel, as called for in Table 1, has to be added to the air requirements for waste on the chart, and is generally introduced with the auxiliary fuel burner. Excess air is unnecessary for the auxiliary fuel, since sufficient excess air has been introduced with the waste.

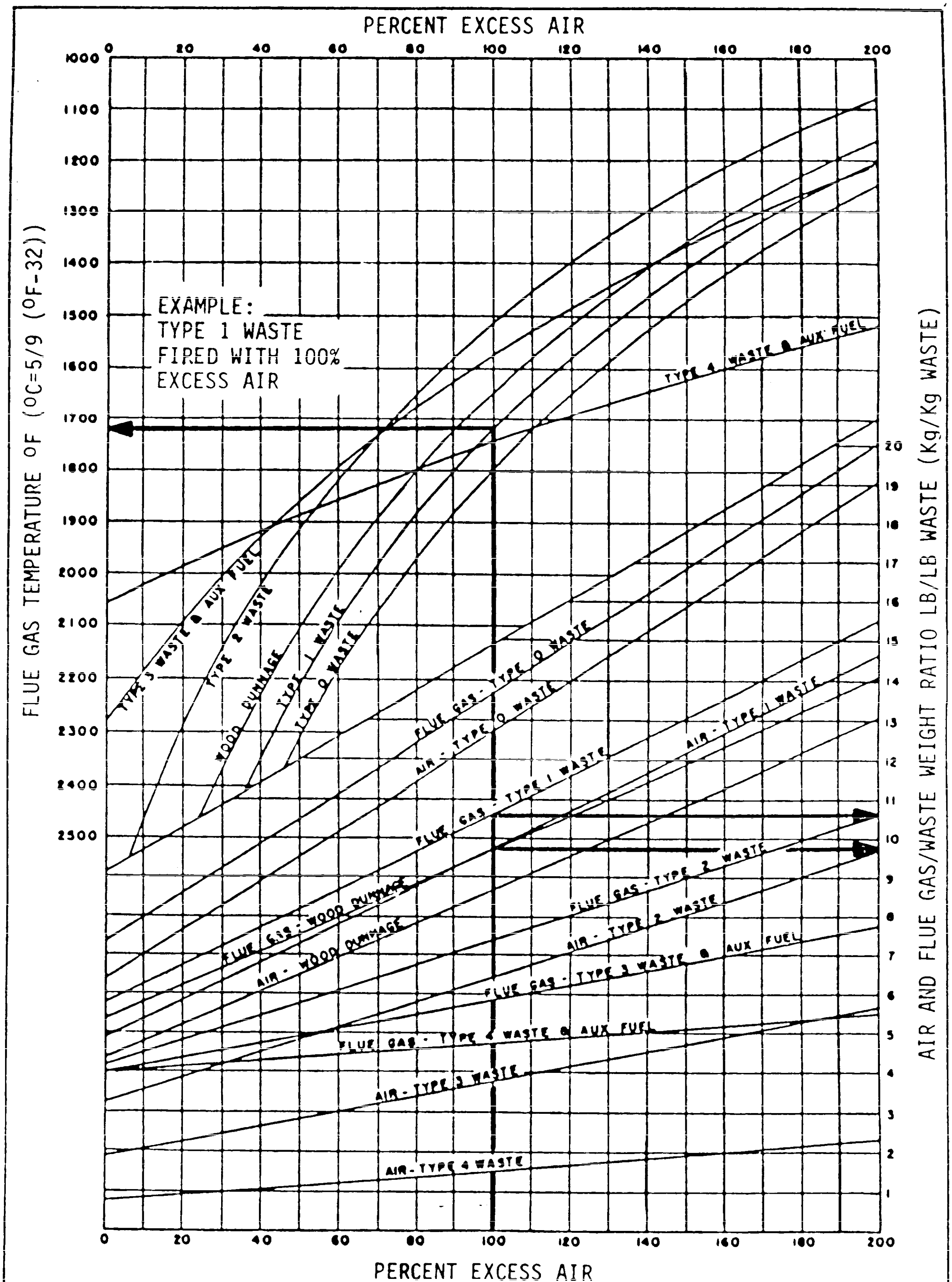


Figure 7
Air and Flue Gas Weights and Temperatures

EQUATION: (4)

$$\text{lb air/lb waste for aux fuel} = \frac{\text{lb Air}_{Th}}{10{,}000\ \text{BTU}} \times \frac{\text{BTU of aux fuel}}{\text{lb waste}}$$

or

$$\text{kg air/kg waste for aux fuel} = \frac{\text{kg Air}_{Th}}{10{,}550\ \text{kJ}} \times \frac{\text{kJ of aux fuel}}{\text{kg waste}}$$

EQUATION: (5)

$$\text{lb air/sec for aux fuel} = \frac{\text{lb waste/hr of DEScap}}{3600\ \text{sec/hr}} \times \frac{\text{lb air}}{\text{lb waste for aux fuel}}$$

$$\text{kg air/sec for aux fuel} = \frac{\text{kg waste/hr of DEScap}}{3600\ \text{sec/hr}} \times \frac{\text{kg air}}{\text{kg waste for aux fuel}}$$

(2) Determine from Figure 7 the flue gas quantities and temperatures resulting from combustion of waste and auxiliary fuel. Figure 7 is based on the following calculations (Equations 6 through 10).

(a) Flue gas from combustion of waste.

EQUATION: (6)

$$\frac{\text{lb flue gas}}{\text{lb waste}} = 1 - \frac{\text{lb ash}}{\text{lb waste}} + \frac{\text{lb air required}}{\text{lb waste}}$$

or

$$\frac{\text{kg flue gas}}{\text{kg waste}} = 1 - \frac{\text{kg ash}}{\text{kg waste}} + \frac{\text{kg air required}}{\text{kg waste}}$$

For the example Type No. 1 waste, with 25 percent moisture and 10 percent ash, fired with 100 percent excess air:

lb ash/lb waste (kg ash/kg waste) = 0.10 (Type No. 1 waste)
lb air/lb waste (kg air/kg waste) = 9.75 (from Equation 2)

Therefore, from Equation 6:

lb flue gas/lb waste = 1 - 0.10 + 9.75 = 10.65
kg flue gas/kg waste = 1 - 0.10 + 9.75 = 10.65

The result can also be determined from Figure 7.

$$\text{lb flue gas/sec} = (\text{lb flue gas/lb waste}) \times \frac{\text{lb waste/hr of DEScap}}{3600\ \text{sec/hr}} \qquad (7)$$

or

$$\text{kg flue gas/sec} = (\text{kg flue gas/kg waste}) \times \frac{\text{kg waste/hr of DEScap}}{3600 \text{ sec/hr}}$$

(b) Flue gas from combustion of auxiliary fuel.

EQUATION:

$$\frac{\text{lb flue gas}}{\text{lb waste}} = \text{lb Air}_{Th} \text{ for fuel/lb waste} + \text{lb fuel/lb waste} \qquad (8)$$

or

$$\frac{\text{kg flue gas}}{\text{kg fuel}} = \text{kg Air}_{Th} \text{ for fuel/kg waste} + \text{kg fuel/kg waste}$$

The pounds fuel per pound waste can be obtained by dividing the auxiliary fuel required in Table 1 by the heat value of the fuel.

EQUATION:

$$\text{lb flue gas/sec} = \frac{\text{lb flue gas}}{\text{lb waste}} \times \frac{\text{lb waste/hr of DEScap}}{3600 \text{ sec/hr}} \qquad (9)$$

or

$$\text{kg flue gas/sec} = \frac{\text{kg flue gas}}{\text{kg waste}} \times \frac{\text{kg waste/hr of DEScap}}{3600 \text{ sec/hr}}$$

(c) Flue gas from the combustion of waste and auxiliary fuel is the sum of (a) and (b) above where called for in Table 1.

(d) Calculate flue gas temperature.

EQUATION:

$$T = t + \frac{H \times K}{C \times \text{lb flue gas/lb waste}} \qquad (10)$$

Where:

T = flue gas temperature, °F (°C)
t = 80° F air temperature, °F (26.7° C)
K = 0.70, correction factor for air infiltration and radiation heat losses (dimensionless)
C = 0.25 specific heat BTU/lb °F of flue gas at approx. 1400° F

or

= 1.0468 specific heat kJ/kg°C of flue gas at approx. 760° C

$H = h_1 + h_2$, BTU/lb waste (kJ/kg waste)

h_1 = (BTU waste/lb waste) - (lb moisture/lb waste) x (1040 BTU/lb moisture)

or

h_1 = (kJ waste/kg waste) - (kg moisture/kg waste) x (2419.04 kJ/kg moisture)

h_2 = (BTU aux fuel/lb waste) - $\frac{\text{lb moisture in fuel}}{\text{10,000 BTU fuel}}$ x (BTU fuel/lb waste) x (1040 BTU/lb moisture)

or

h_2 = (kJ aux fuel/kg waste) - $\frac{\text{kg moisture in fuel}}{\text{10,550 kJ}}$ x (kJ fuel/kg waste) x (2419.04 kJ/kg moisture)

1040 = BTU/lb (2419.04 kJ/kg) heat required to vaporize moisture in fuel

For the example Type No. 1 waste, with 25 percent moisture and 10 percent ash, fired with 100 percent excess air:

t = 80° F (26.7° C)

BTU/lb waste = 6,500 from Equation 1

or

kJ/kg waste = 15,119

lb moisture/lb waste = 0.25 (Type No. 1 waste)

or

kg moisture/kg waste = 0.25

h_1 = 6,500 - (0.25 x 1040) = 6,240 BTU/lb waste

or

h_1 = 15,119 - (0.25 x 2419.04) = 14,514.24 kJ/kg

$h_2 = 0$ (No auxiliary fuel)

$H = h_1 + h_2 =$ 6,240 BTU/lb waste

or

= 14,514.24 kJ/kg waste)

lb flue gas/lb waste = 10.65 (from Equation 6)

or

(kg flue gas/kg waste = 10.65

Therefore, from Equation 10:

$$T = 80 + \frac{6240 \times 0.70}{0.25 \times 10.65} = 1720° \text{ F}$$

or

$$T = 26.7 + \frac{14,514.24 \times 0.70}{1.0468 \times 10.65} = 938° \text{ C}$$

The result can also be determined from Figure 7.

5.1.4.2 Waste Oils. Provide combustion air using the forced draft fan. For fan sizing requirements, refer to para. 5.1.5.3.

5.1.4.3 Classified Material Incineration. For air requirements, combustion calculations are similar to those for general refuse. Use values for Type 0 waste from Figure 7.

5.1.5 System Design

5.1.5.1 Incinerator. Modular incinerators should be of the controlled air batch feed or ram feed type. The incinerator should consist of refractory-lined, cylindrical steel primary and secondary combustion chambers, hydraulic charging and transfer rams, primary and secondary combustion chamber burners, stainless steel or refractory lined steel stack, and combustion air fan. Each component of the incinerator should be assembled, checked-out, and packaged in the factory. These types of incinerators use less than the theoretical quantity of air necessary for combustion in the primary combustion chamber. By doing this turbulence and particulate air emissions are reduced. The gases and particulate matter from the primary combustion chamber flow to the secondary combustion chamber where air and fuel are added to complete combustion. Single module capacities are available up to 100 TPD (90.72 metric tons/day). Larger capacity installations such as 500 TPD (453.6 metric tons/day) can be designed using five 100-TPD (90.72 metric tons/day) units.

5.1.5.2 Emission Control Equipment. New regulations may require particulate and acid gas removal. Scrubbers can remove both particulates and acid gas, while fabric filters and ESP's remove only particulates. Depending upon the facility, the most economic approach may be one type of device for particulate removal and another type for acid gas removal. The combination of scrubber and baghouse is becoming popular in the United States. The high collection efficiency of a fabric filter is further enhanced when used with an acid gas scrubber. A fabric filter's removal efficiency is not as sensitive to changes in flue gas volumes, inlet concentrations, and small excursions in temperature as is an ESP. The components of a precipitator, however, have a longer service life than the bags in a fabric filter. Currently, dry scrubbers are the most popular acid gas removal device used in the United States, but the most efficient are packed tower or mobile bed wet scrubbers. For particulate removal, venturi type wet scrubbers can attain high efficiencies.

5.1.5.3 Forced Draft Fans, Induced Draft Fans and Stack. Forced draft fans provide the combustion air in modular controlled air incinerators. Induced draft fans handle the gas resulting from the combustion of the fuel. The fans should be centrifugal type. Fan design capacity should be 120 percent of the air capacity required. Fan design static pressure should be 130 percent of the static pressure required to deliver the combustion air. Stacks of proper size and height must be provided to produce the proper draft requirements for an incinerator. Natural draft stacks or induced draft fans are used to produce negative draft throughout the entire system from the primary combustion chamber to the stack outlet.

The selection of either natural draft induced draft systems depends on the density, velocity and volume of the flue gases to be handled plus the draft losses. Stack height shall be determined based on the draft required and in accordance with EPA 450/4-80-023, Guideline For Determination Of Good Engineering Practice Stack Height (Technical Support Document For The Stack Height Regulations).

5.1.5.4 Supplementary Fuel Requirements. Burners should be provided for the primary and secondary combustion chambers. Gas burning installations should be in accordance with NFPA 54, National Fuel Gas Code, and NFPA 58, Storage and Handling of Liquified Petroleum Gases. Oil burning installations should be in accordance with NFPA 31, Standard for the Installation of Oil Burning Equipment. Burners for all incinerators should be equipped with safety controls which will automatically shut off the fuel supply to the burner in the event the burner fails to ignite, or its flame becomes extinguished, or in the event of insufficient draft. Fuel oil burners shall be equipped with atomizers. Mechanical atomizers provide turndown ratios between 1.5 and 3.0 depending upon the pressure of the fuel oil supply system. Steam and air atomizing type burners provide turndowns as high as 8 to 1 and have the advantage of being able to burn low-quality fuel efficiently.

5.1.5.5 Weigh Scale. Truck scales are not normally required but are useful in obtaining waste collection rates and residue or nonprocessible disposal data. If a scale is required, it should have a minimum capacity of 60 tons (54.4 metric tons), be 60-ft (18.29 m) long by 10-ft (3.05 m) wide and be provided with all necessary controls for automatic operation. The punchcard system should be tamperproof and should automatically prepare tickets printed with truck tare, gross and net weight of delivered waste, truck identification and time and date. It should also accumulate net weights for totalization. Voice communication should be provided between the scale and the incinerator control room.

5.1.5.6 Tipping Floor. The tipping area should be totally enclosed with overhead roll-up door(s). The tipping floor should be concrete and of sufficient size to permit rapid unloading of the refuse. If segregation of waste is required, the tipping floor should have additional space for stockpile of waste not to be incinerated. For small facilities, the tipping floor should also serve as the storage area for the waste and the front-end loader should serve to load the waste directly into the incinerator.

The anticipated flow of trucks should be carefully estimated so that the area of the tipping floor and the entrances and exits are adequate. Roll-up doors should be sized for the largest truck anticipated.

5.1.5.7 Refuse Pit. The refuse pit should be enclosed in a building and constructed of reinforced concrete. The pit volume should be adequate for a minimum of three days of as-designed incinerator refuse capacity. Water-supply fixtures should be provided for cleaning of the pit. A sump with pump(s) should be provided for drainage of the pit.

5.1.5.8 Refuse Crane. A refuse crane should be provided for facilities having a refuse pit. In large facilities, two cranes may be required so that periodic maintenance can be performed without shutdown of the facility. The cranes should be bridge type with grapples suitable to handle solid waste. The cranes should conform to applicable OSHA standards and should meet CMAA specification No. 70 for Class F service. Each crane should be equipped with load cells to weigh the amount of refuse fed to the incinerator.

The weighing system should have digital readout in the control room with a printout of hourly and daily totals. Locate crane controls so that the operator can see all portions of the pit and the charging hopper(s).

5.1.5.9 Removal of Combustion Residue and Flyash. Remove combustion residue manually by raking, semi-automatically using a discharge ram and ash collection cart, or automatically using a discharge ram and a submerged drag chain conveyor which discharges to an open container. Flyash from dust collectors, fabric filters, and ESP's should be conveyed to the submerged drag chain conveyor or collected in sealed containers.

5.1.5.10 Heat Recovery and Distribution System Intertie. Provide heat recovery equipment between the incinerator and the air pollution control device(s). Where applicable, the heat recovery equipment should be designed, constructed, inspected and tested in accordance with the latest edition of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. In installations where steam is produced for use on base, a steam separator should be provided. A dump stack should be provided to protect the incinerator, heat recovery equipment, and air pollution control equipment during upset conditions. For further details, refer to para. 5.1.2.2.

5.1.5.11 Instrumentation. The incinerator control system should be automatic with manual override capability. Mount controls and monitoring instruments on a single panel, if possible. Refuse crane controls may be external to the central panel. Batch feed controls should be easily accessible to the front-end loader operator. Provide temperature sensing and monitoring devices for the primary and secondary combustion chambers, in the duct between the primary and secondary combustion chambers, and upstream and downstream of heat recovery and pollution control equipment.

Provide interlocks to ensure that the secondary combustion chamber has been pre-warmed and is up to set-point temperature, prior to incineration in the primary combustion chamber. Provide incinerator and stack monitoring instrumentation and test ports for performance of acceptance tests and emissions testing and monitoring.

5.1.5.12 Foundations. Concrete work should conform to American Concrete Institute (ACI) Standards 301 and 318. Concrete should have a compressive strength of not less than f'c = 4,000 psi (2.758×10^4 kPa) in 28 days. Primary reinforcing steel should be Grade 60 in accordance with American Society for Testing and Materials (ASTM) A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

5.1.5.13 Building. Structural steel and miscellaneous steel should conform to ASTM A36, Standard Specification for Structural Steel. Material design and fabrication should be in accordance with American Institute of Steel Construction (AISC) and American Welding Society (AWS) specifications. Framing should be designed to resist wind loads as specified in the local building code. Where applicable, buildings should be designed for seismic loads as specified in the local building code. Roof live load should be in accordance with local building code requirements, but should not be less than 20 psf (957.6 kPa). In addition, the roof load should include snow loads and wind loads as specified in the local building code.

For additional requirements, refer to NAVFAC DM 1.01, Basic Architectural Requirements and Design Considerations, MIL-HDBK-1002/2, Loads, and MIL-HDBK-1002/3, Steel Structures.

5.1.5.14 Plumbing. Water should be provided for fire protection, restroom uses, wash-down of the tipping floor, refuse pit and incinerator area, dust suppression, cooling of incinerator parts, and make-up to the ash conveyor trough, scrubber and heat recovery boiler feedwater system. Floor and equipment drains should be provided in the incinerator area. A sump should be provided for the refuse pit. Sanitary sewer connections should be provided for waste water. Storm sewers should be provided for rainwater drainage. An oil interceptor should be provided in the floor and equipment drain system, particularly in installations burning waste oil.

5.1.5.15 Heating, Ventilating and Air Conditioning. Except for the control room(s) and offices, the incinerator facility should be heated and ventilated. The control room(s) and offices should be heated, ventilated and air conditioned. For design considerations concerning heating, ventilating and air conditioning, refer to NAVFAC DM-3.03, Heating, Ventilating, Air Conditioning and Dehumidifying Systems.

5.1.5.16 Electrical. Provide exterior and interior lighting in accordance with Illuminating Engineering Society (IES) recommended lighting levels. Indoor lighting should include emergency lighting with exit signs as required. Power supply for pumps, motors and lighting should be provided from motor control centers or power panels, as required. Provide an uninterruptible power supply system to serve critical communications, fire protection and instrumentation systems. Provide a public address and telephone communications system should be provided inside and outside the plant.

5.1.5.17 Fire Safety. Fire protection systems should be provided for the various areas of the plant as identified in Table 4. Table 4 provides design guidelines for the Fire Protection System, however, the authority having jurisdiction may have different requirements which must be evaluated on an individual project basis. In addition, an underground yard fire protection system shall be provided with two-way yard fire hydrants. The fire protection system shall be designed in accordance with the requirements of NFPA and MIL-HDBK-1008, Fire Protection for Facilities.

5.1.6 Start-up and Acceptance Testing

5.1.6.1 Start-up Requirements. Prior to start-up of the incinerator, all necessary support systems should be in operation. The secondary combustion chamber should be pre-warmed and up to set-point temperature prior to the charging of fuel in the primary combustion chamber.

5.1.6.2 Air Pollution Test Requirements. The air pollution test requirements for modular incinerators are similar to those for all incinerators. In general, the test requirements and testing frequencies are identified as Special Conditions on the air permit, which is issued by the respective state and/or local agency. These requirements may be more stringent than EPA regulated emissions, based upon the respective state implementation plan for compliance with the national ambient air quality standards, and based upon the local (city or county) air emissions requirements.

The following tests and test methods per 40 CFR 60, Subpart E, and Appendix A will typically be required:

Test	Test Method
Particulate Matter	EPA No. 5
Sample and Velocity Traverses	EPA No. 1
Velocity and Volumetric Flow Rate	EPA No. 2
Gas Analysis and Calculation of Excess Air	EPA No. 3
Opacity of Emissions	EPA No. 9

Table 4
Fire Protection System Requirements

AREA	HAZARD CLASS.(1)	SPRINKLER SYSTEM	SPRAY SYSTEM	STANDPIPE AND HOSE	FIRE EXTINGUISHER	DETECTION
Tipping Floor	Ordinary	Note 3	No	Yes	Yes	No
Refuse Pit	Ordinary	Yes	No	Yes and Monitors	Yes	No
Administration Bldg.						
Single Story	Light	Yes	No	Yes	Yes	Yes
Multiple Story	Light	Yes	No	Yes	Yes	Yes
Water Treatment Area	Ordinary	No	No	Note 2	Note 2	No
Lube Oil Area	Extra	Yes	No	Note 2	Note 2	No
Hydraulic Power Unit Skid and Stoker Front	Extra	No	Yes	Note 2	Note 2	Yes
Transformer	Extra	No	Yes	Note 2	Note 2	Yes
Fire Pump Area	Ordinary	Yes	No	No	Yes	Yes
Incinerator Building	Ordinary	No	No	Yes	Yes	Yes
Ash Handling Area	Ordinary	No	No	Yes	Yes	No
Maintenance Shop	Ordinary	Yes	No	Yes	Yes	Yes
Control Room	Light	No	No	Yes[4]	Yes	Yes
Electrical Rooms	Light	No	No	Yes[4]	Yes	Yes
Battery Rooms	Light	No	No	Yes[4]	Yes	Yes

1. For a detailed discussion of hazard classification, refer to NFPA-13.
2. Standpipe and hose and portable extinguishers should be located throughout the Incinerator Building.
3. Automatic sprinkler protection should be provided for the portion of the tipping floor extending 20 feet from the refuse pit.
4. Hose stations shall be located outside of the room.

If a PSD review indicates that allowable emissions for Clean Air Act pollutants are exceeded, continuous monitoring for specific pollutants will be required.

5.1.6.3 Acceptance Test Requirements. After all equipment and systems have been adjusted, tested and balanced, the complete incinerator train(s), including heat recovery and air pollution equipment, should be operated for a minimum of 120 hours to confirm that the unit(s) meet the specified performance requirements and guarantees. Waste processed during this period should be representative of that normally collected at the naval base.

5.2 Pathological Incinerators

5.2.1 Preliminary Data

5.2.1.1 Waste Quantification. The major sources of pathological waste are hospitals, laboratories, slaughterhouses and animal pounds. The quantity of pathological waste varies with the size of the institution and to some degree on the handling procedures at the facility. Hospitals tend to increase the pathological waste volume by mixing it with other materials through ineffective separation at the point of generation.

5.2.1.2 Waste Classification and Characterization. Pathological waste consists of animal carcasses, organs and solid organic wastes which may carry infectious materials. In general, pathological waste material is high in moisture, about 85 percent, with a heating value of about 1,000 BTU per pound (2326 kJ/kg). Non-combustible solids makeup only about 5 percent of the material. Pathological waste density is in the range of 45 to 55 pounds per cubic foot (720.8 to 881.0 kg/m^3). Hospital waste, however, can contain a high percentage of paper, plastics and other wastes with high heating value. Infectious (Red Bag) waste should be no more than 10 percent of the total volume by weight. Therefore, an accurate survey must be made of the waste prior to design of the incinerator equipment.

5.2.1.3 Environmental Constraints. Since pathological incinerators currently incinerate both infectious (certain hospital wastes) and non-infectious (crematorium applications), the regulations are in a state of transition. EPA has been directed to promulgate regulations specific to infectious waste that will define the incineration requirement. An EPA position statement has been issued, but has not been promulgated yet. The EPA position is that infectious waste be generally treated as a hazardous waste (refer to EPA Publication PB-86199130, Guide for Infectious Waste Management). An incinerator that will process only non-infectious pathological waste is typically required to comply with a maximum visible emission and have no odors. Infectious hospital wastes are generally placed in red plastic bags. Other colored bags are used for non-infectious waste.

5.2.1.4 Siting Constraints. To minimize the handling distances for pathological waste, location of the incinerator at the generating facility is common. Therefore, most hospitals have an on-site incinerator. Laboratory facilities in the vicinity would generally contract with the larger facility to handle the laboratory waste. Place incinerator out of sight as much as possible and minimize access by non-essential personnel.

5.2.2 System Design

5.2.2.1 Incinerator. Pathological incinerators should be modular controlled air type with primary and secondary combustion chambers. They are similar to MSW modular units, described in para. 5.1.5.1, but usually require additional burners in the primary combustion chamber, due to lower heating value and higher moisture content of the fuel. Incinerators designed to burn infectious waste should have an oversized upper chamber blower to provide combustion air for the spontaneous burn rate of the volatile waste and possibly extra stack sections to increase draft. Burn rate may have to be reduced to maintain a constant design heat release. Many states now require a one- or two-second retention of gases within the secondary combustion chamber when burning infectious wastes. This will require larger volume secondary combustion chambers and possibly tertiary combustion chambers.

5.2.2.2 Emission Control Equipment. Small modular units of this type, with staged combustion, generally do not require additional emission control equipment, but as noted in para. 5.2.1.3, new regulations may change the requirements. Scrubbers, ESP's, fabric filters or combinations of these may be required depending upon the regulations.

5.2.2.3 Forced Draft Fans. Refer to para. 5.1.5.3.

5.2.2.4 Supplementary Fuel Requirements. Refer to para. 5.1.5.4.

5.2.2.5 Waste Receiving, Storage and Handling. Pathological waste should be transported to the incinerator facility and stored in sealed plastic, mild steel or stainless steel carts. A cart handling system should be considered for dumping the waste into the incinerator.

5.2.2.6 Removal of Combustion Residue and Flyash. Refer to para. 5.1.5.9.

5.2.2.7 Instrumentation. The incinerator control system should be automatic with manual override capability. Temperature sensing and monitoring devices should be provided for the primary and secondary combustion chambers. Interlocks should be provided to ensure that the secondary combustion chamber has been pre-warmed and is up to set-point temperature, prior to incineration in the primary combustion chamber. Incinerator and stack monitoring instrumentation and test ports should be provided for the performance of acceptance tests and emissions testing and monitoring.

5.2.2.8 Foundations. Refer to para. 5.1.5.12.

5.2.2.9 Building. Refer to para. 5.1.5.13.

5.2.2.10 Utilities. Refer to para. 5.1.5.14, 5.1.5.15 and 5.1.5.16.

5.2.2.11 Fire Safety. Refer to para. 5.1.5.17.

5.2.2.12 Waste Destruction Requirements. Refer to para. 5.2.1.3.

5.2.3 Start-up and Acceptance Testing

5.2.3.1 Start-up Requirements. Refer to para. 5.1.6.1.

5.2.3.2 Air Pollution Test Requirements. Test requirements for pathological incinerators handling non-infectious waste are generally for Visible Emissions (VE) and odor only. EPA requirements for VE are currently being established. Contact the local EPA office for information.

Typically the odor requirement is that the emission has no odor. Quantification of odors is based on odor threshold measurements established by local odor committees. Test requirements for infectious waste pathological incinerators are currently in transition due to concerns that infectious waste may be classified as a hazardous waste. (Refer to EPA-530/SW-86/014).

5.2.3.3 Acceptance Test Requirements. Refer to para. 5.1.6.3.

5.3 Demilitarized Incinerators

5.3.1 Waste Quantification and Classification. The demilitarization incinerator is not to be considered a high production incinerator. It is intended to provide an effective means of demolition and disposal for small groups of ammunition, explosives and other dangerous articles (AEDA). Table 5 lists AEDA suitable for burning. Quantities (batch sizes) are the maximum quantities that can be disposed of per burn and meet present interim EPA requirements.

5.3.2 Environmental Constraints. EPA emission standards are minimum design requirements. Many states and local governments have adopted more stringent regulations which must be adhered to. EPA standards are as follows:

a) Allowable Smoke Density and Dust Loading In Flue Gas. Incinerators burning 200 pounds (90.72 kg) of refuse or more per hour should not exceed an emission rate of 0.20 grains (0.013 g) of particulate matter per standard cubic foot (0.028 m^3) of dry flue gas corrected to 12 percent carbon dioxide, without the contribution of auxiliary fuel. Incinerators burning less than 200 pounds (90.72 kg) of refuse are permitted an emission rate of 0.3 grains (0.019 g) of particulate matter per standard cubic foot (0.028 m^3).

b) Smoke and Flyash Production. Except during start-up and cleaning, new incinerators should not produce smoke greater in density than Ringleman No. 1.

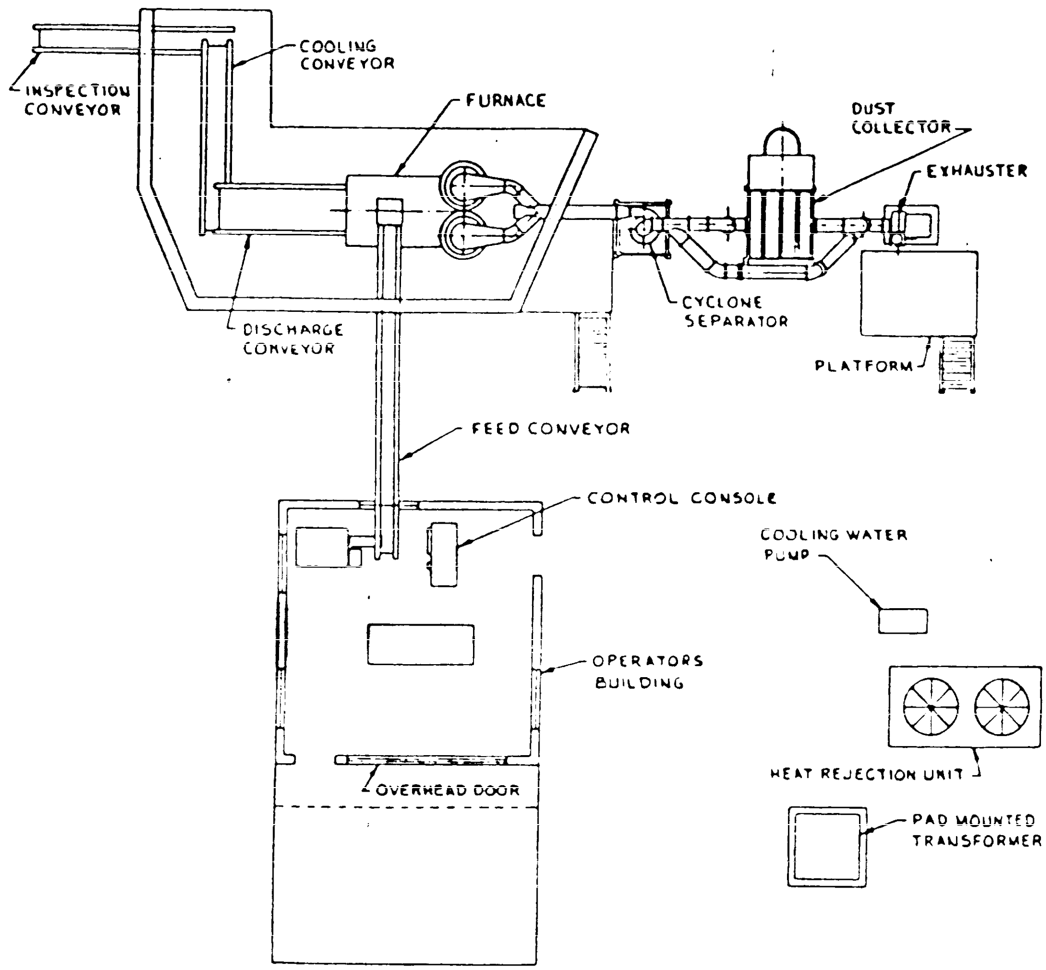
5.3.3 Siting Constraints. Demilitarization incinerators are intended to provide a safe and effective means of demilitarization disposal for small groups of AEDA near populated/inhabited areas.

5.3.4 System Design

5.3.4.1 Incinerator. Figures 8 and 9 show a typical demilitarized incinerator system. The incinerator box should be constructed of ASTM A515, Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service, Grade 65, 1-inch (25.4 mm) thick steel plate including the bottom. No refractory or fire brick is required within the furnace box or combustion areas. Incinerators should be provided with primary and secondary combustion chambers. Incinerator boxes will be provided by the Government.

Table 5
Recommended Batch Sizes for Various AEDA Items

ITEM	BATCH SIZE (NUMBER)
Cartridge, .30 cal. tracer, M25	300
Cartridge, .50 cal. INC, M1	75
Cartridge, signal, bomb, practice, Mk 4	1
Signal, light, Very, white star, Mk II	10
Simulator, booby trap, flash, M117	25
Fuse, hand grenade, M205	25
Cartridge, 7.62mm blank, M82	200
Cartridge, .45 cal., line throwing, M32	300
Cartridge, 7.62mm ball, M80	100
Primers, cartridge, 40mm, Mk 22 Mods	10
Tracers, Mk 5 and Mk 9	5
Cartridge, .38 cal. ball, M41	200
Fuse, smoke pot, Mk 243 Mods	10
Cartridge, impulse, blank, Mk 2 Mods	10
Cartridge, ignition, turbo jet engine, Mk 243 Mods	1
Cap, blasting, special electric, M6	6
.22 caliber hornet	500
12-gauge "Beehive" shotgun shell	75
5.56-mm ball	250
Cartridge, .50 cal. API (M8)	20
Fuse, P.D., Mk 27 Mod 0	3
Mk 100 Mod 2 rocket fuse	30
Cartridge impulse, Mk 13 Mod 0	300
Cartridge, vial, life raft	40
.50-cal. blanks, M1	150
Signal kit, flash, Mk 47 Mod	
Extender, flash signal Mk 47 Mod 0	20
Signal, flash Mk 34 Mod 0	4
.50-cal. INC, API, with or without tracers (projectiles only)	200
Cartridge, .22 cal., long rifle	1,000

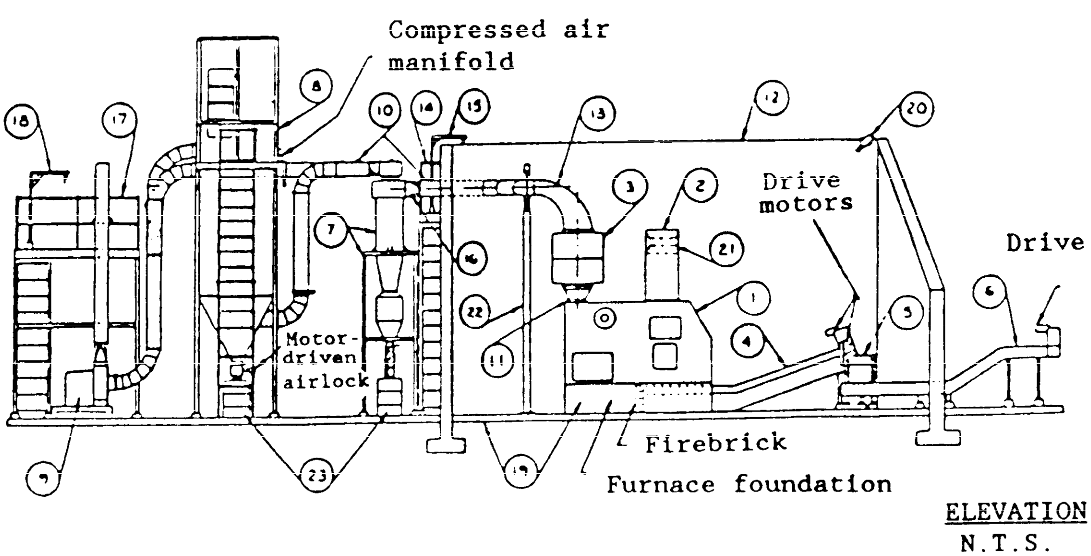


Source: Installation of Stationary Furnace System, Naval Weapons Station Charleston. SC

Figure 8
Demilitarized Incinerator Installation--Plan View

EQUIPMENT SCHEDULE

Item	Nomenclature	Quantity
1	Stationary Furnace	1
2	Feed Chute	1
3	Heat Recovery Unit	4
4	Discharge Conveyer	1
5	Cooling Conveyor	1
6	Inspection Conveyor	1
7	Cyclone Separator and Support	1
8	Dust collector with Clean Air Walk-in Plenum	1
9	Exhauster	1
10	U/V Detector Nipple	1
11	Duct Transition	1
12	Barricade	1
13	Connecting Duct	1
14	Sampling Platform	1
15	Jib Crane	1
16	Transition Duct	1
17	Sampling Platform	1
18	Jib Crane	1
19	Foundation	1
20	TV Camera with pan and tilt zoom	1
21	Feed Conveyor	1
22	Furnace Exhaust Pipe Support	
23	55-gallon drum	2



Source: Installation of Stationary Furnace System, Naval Weapons Station Charleston, SC

Figure 9
Demilitarized Incinerator Installation -- Section View

Provide an exhaust system with minimum of 0.25-inch (6.35 mm) wall thickness black steel pipe with slip-on, flat-face steel flanges complying with Society of Automotive Engineers (SAE) Standard 1040, Roll-over Protective Structure for Machines. No refractories are required for the exhaust system.

5.3.4.2 Heat Rejection System. The primary equipment should consist of heat recovery units and a heat rejection unit. The heat recovery units should be constructed in a cylindrical configuration, capable of withstanding a flue gas design temperature of 1600° F (871.1° C) and a tube side design pressure of 1000 psig (6894.8 kPa).

Provide coil and fin construction of type 304 stainless steel including headers. Design conditions are as follows:

Exhaust Quantity	700 SCFM (330.4 L/sec)
Temp. Exhaust Gas Entering	1400°F (760.0° C)
Temp. Exhaust Gas Leaving (Max.)	400°F (204.4° C)
Temp. Entering Water	160°F (71.1° C)
Temp. Leaving Water (Max.)	200°F (93.3° C)
Water Quantity	40 GPM (2.524 L/sec)

Heat rejection units should be constructed of 1/2-inch (12.7 mm) O.D. seamless copper tubes with aluminum fins. Coil should be capable of withstanding a tube-side design pressure of 250 psig (1723.7 kPa). Provide units with fans, motors, and starters and casing suitable for exposure to the elements. Design conditions are as follows:

Water Quantity	80 GPM (5.047 L/sec)
Temp. Entering Water	200°F (93.3° C)
Temp. Leaving Water	160°F (71.1° C)
Total Heat Rejection (@ Minimum Ambient of 95° F) (35° C)	1,600,000 BTU/Hr (468.91 KW)

5.3.4.3 Cooling Water System. Provide primary equipment consisting of a cooling water circulating pump, expansion tank, and air separator. The cooling water pump should be of the centrifugal type. Provide expansion tanks of welded steel design for a working pressure of 125 psig (861.8 kPa). Air separators should be of the tangential type to remove air entrained in the cooling water system.

5.3.4.4 Fuel Oil System. The fuel oil system serves the primary burner and afterburner on the furnace. Fuel oil supply and fuel oil return piping should be required. Provide an underground fuel oil storage tank for the storage of No. 2 fuel oil. Minimum size should be 1000 gallons (3785.4 L).

5.3.4.5 Compressed Air System. A compressed air system should be provided for operation of the furnace dump grate air cylinder and cleaning of the dust collector filter bags. Primary equipment consists of an air compressor and refrigerated air dryer. The air compressor should be a tank mounted unit with minimum capacity of 10 SCFM (4.719 L/sec) at 125 psig (861.8 kPa). The refrigerated air dryer should have a minimum capacity of 10 SCFM (4.719 L/sec) at 125 psig (861.8 kPa) and should provide a dewpoint temperature of -12° F (-24.4° C). The required capacity for the Furnace Dump Grate Air Cylinder should be 1.5 SCFM (0.708 L/sec) at 100 psig (689.5 kPa). The required capacity for the Bag Filter Cleaning System should be 8.25 SCFM (3.894 L/sec) at 100 psig (689.5 kPa).

5.3.4.6 Exhaust System. Provide an exhaust system to cleanse incinerator exhaust air sufficiently to conform to national, state, and local EPA requirements. The system should be capable of collecting and disposing of combustion dust at the rate of 10 pounds (4.536 kg) per operating hour. Primary equipment should consist of a cyclone separator, dust collector, and an exhaust fan to induce air through the cyclone separator and dust collector.

The cyclone separator should remove the heavier particles of combustion. The cyclone separator should have a maximum capacity of 1600 SCFM (755.1 L/sec) at 4 inches (101.6 mm) water gauge differential pressure. Continuous discharge should be provided. The dust collector should have a maximum air to cloth ratio (A/C) of 3.45 ft/min (0.017 m/sec) based on 2600 ACFM (1227.1 L/sec) maximum, and 400° F (204.4° C) and 17 inches (431.8 mm) water gauge, minimum. Provide centrifugal exhaust fan with a maximum capacity of 2600 ACFM (1227.1 L/sec) at 400° F (204.4° C) and 8 inches (203.2 mm) H_2O static pressure; or 1600 SCFM (755.1 L/sec) at 400° F (204.4° C) and a pressure drop of 13 inches (330.2 mm) water gauge.

5.3.4.7 Waste Receiving, Storage and Handling. Waste should be brought in by wheeled vehicle, unloaded by forklift and placed on the floor of the operator building. No storage space is required as all materials brought in should be burned during a normal work day. No ordinance items should be left overnight. Loading of the incinerator feed conveyor should be by hand.

5.3.4.8 Combustion Residue Removal. Combustion residue consists of metal casings from the burned ordinance such as tracers, primers, flares and small arms ammunition. The combustion residue should be dumped from the pneumatic activated dump grate in the incinerator onto a discharge conveyor which in turn dumps the residue onto a cooling conveyor.

From the cooling conveyor, the residue should be dumped onto an inspection conveyor. The inspection conveyor discharges residue to a dumpster or metal bin which should be hauled to a dumping area designated by the using facility. The conveyors for the three processes above should be of the hinged steel belt type. The speed of the three conveyors should be synchronized.

5.3.4.9 Flyash Handling. Combustion gases should be cooled from 1400° F (760° C) to 400° F (204.4° C) in each stack by stack mounted heat exchangers. The combustion gases should be directed from the incinerator first through the cyclone separator, then through the dust collector and finally through the exhaust fan and discharged to the atmosphere. A valved bypass, with fixed orifice for static pressure control, should be provided around the dust collector to allow temporary bypassing of combustion gases when combustion gas temperature is 700° F (371.1° C) or above.

Combustion residue collected by the cyclone separator and dust collector should be dumped through a continuous discharge with a positive seal to a hopper or drum.

5.3.4.10 Instrumentation. A control console is required to control burners, conveyors, dump grate, fans, pumps and for indicating/recording temperatures and pressures and monitoring. The control console should be located in the operators building.

5.3.4.11 Foundations. Refer to para. 5.1.5.12.

5.3.4.12 Building. An operator building is required for each incinerator. Provide a pre-engineered metal building 20 ft (6.1 m) square with an overhang over a 10 ft x 12 ft (3.05 m x 3.66 m) rollup door. Provide with a minimum of two mandoors. Toilet facilities are not required. Provide 6-inch (152.4 mm) thick concrete slab floors with spark resistant finish. For other building design requirements, refer to para. 5.1.5.13.

5.3.4.13 Water. Provide water for fire protection, make-up to the heat rejection system, and to yard hydrants for general washdown.

5.3.4.14 Sanitary. No sanitary system will be required.

5.3.4.15 Electrical. Provide lighting for the Operators Building and area lighting on the barricade wall. Provide explosion-proof fixtures in the Operators Building. For other electrical requirements, refer to para. 5.1.5.16.

5.3.4.16 Storm Drains. Grade site and provide sufficient catch basins to remove all storm water.

5.3.4.17 Fire Safety. Provide a dry pipe sprinkler system for the Operator's Building and the dust collector. Locate the dry pipe valve assemblies in the Operators Building. In addition, provide exterior fire hydrants. Refer to MIL-HDBK-1008 and NFPA 13, Standard for Installation of Sprinkler System, for fire extinguishing systems design considerations.

5.3.4.18 Television Monitoring System. Provide remote television cameras with pan and tilt capability and zoom lenses for mounting on barricade wall to observe furnace and conveyor operation. Provide television monitor in control console in the Operators Building.

5.3.4.19 Lightning Protection. Provide lightning protection as follows.

a) Primary lightning protection. Provide lightning mast with primary ground grid. System should be designed to protect all above ground structures and equipment.

b) Secondary Lightning Protection. Provide a secondary grounding grid around all above ground structures and equipment to which the following items are to be grounded:

(1) Operators Building

(2) Equipment Grounding Bus

(3) Conveyors

(4) Operators Building Spark Resistant Floor Finish

(5) Incinerator

(6) Barricade Wall

(7) Cyclone Separator

(8) Dust Collector

(9) Exhaust Fan

(10) Sampling Platforms

(11) Cooling Water Pump

(12) Heat Rejection Unit

(13) Pad Mounted Transformer

5.3.5 Start-up Requirements. Prior to start-up of incinerator primary and afterburners, all secondary systems should be in operation.

5.3.5.1 Heat Rejection System. The cooling water pump should be on and providing the proper cooling water quantity to the stack mounted heat recovery units and the heat rejection unit.

5.3.5.2 Compressed Air System. The air compressor should be on and cycling to maintain the required air pressure. All pneumatic operated valves, including the incinerator dump grate, should be checked for proper operation.

5.3.5.3 Combustion Residue Removal System. All conveyors should be on and operational.

5.3.5.4 Exhaust System. The exhaust fan should be started and be at operating conditions.

5.3.5.5 Surveillance System. The remote TV camera and the monitor in the control panel should be actuated and proven operational.

5.3.5.6 Fire Protection System. Verify the availability of water for fire protection.

5.3.6 Air Pollution Test Requirements. Air pollution tests should be performed by the Environmental Section of the regional Engineering Field Division. Applications should be submitted to both Federal and State regulating agencies for approval.

5.3.7 Acceptance Test Requirements. After all equipment and systems have been started and proven to be functioning properly, run the incinerator through a complete operational cycle. Items to be burned will be furnished by the Navy.

REFERENCES

NOTE: Unless otherwise specified in the text, users of this handbook should utilize the latest revisions of the documents cited herein.

FEDERAL/MILITARY SPECIFICATIONS, STANDARDS, BULLETINS, HANDBOOKS, AND NAVFAC GUIDE SPECIFICATIONS:

The following specification and handbooks form a part of this document to the extent specified herein. Unless otherwise indicated, copies are available from Commanding Officer, Naval Publications and Forms Center (NPFC), ATTENTION: NPODS, 5801 Tabor Avenue, Philadelphia, PA 19120-5099.

MILITARY HANDBOOKS

MIL-HDBK-1002/2	Loads
MIL-HDBK-1002/3	Steel Structures
MIL-HDBK-1008	Fire Protection for Facilities

GUIDE SPECIFICATION

NFGS-11171	Incinerators, Packaged, Controlled-Air Type

NAVY MANUALS:

Available from Commanding Officer, Naval Publications and Forms Center (NPFC), 5801 Tabor Avenue, Philadelphia, PA 19120-5099. To order these documents, Government agencies must use the Military Standard Requisitioning and Issue Procedure (MILSTRIP). The private sector must write to NPFC, ATTENTION: Cash Sales, Code 1051, 5801 Tabor Avenue, Philadelphia, PA 19120-5099.

DM 1.1	Basic Architectural Requirements and Design Consideration
DM-3.03	Heating, Ventilating, Air Conditioning, and Dehumidifing Systems
DM 5.10	Solid Waste Disposal

OTHER GOVERNMENT PUBLICATIONS:

The following Government documents and publications form a part of this document to the extent specified herein.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA-450/4-80-023	Guideline For Determination of Good Engineering Practice Stack Height (Technical Support Document For the Stack-Height Regulations) (revised)
EPA-530/SW-86/014	Guide for Infectious Waste Management

(Copies are available from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161, (703) 487-4600.)

FLORIDA STATE GOVERNMENT

Florida Administrative Code

(Copies are available from Florida Department of Environmental Regulations, Twin Office Building, 2600 Blair Stone Rd., Tallahassee, FL 32399, (904) 488-4805.)

NAVAL CIVIL ENGINEERING LABORATORY (NCEL)

NCEL Report CR 81.012	Test and Evaluation of the Heat Recovery Incinerator System at Naval Station, Mayport Florida
NCEL Report CR 84.031	Evaluation of HRI Facilities at NS Mayport and NAS Jacksonville, Florida--Lessons Learned Report
NCEL Tech Note N-1746	Application Guide for Heat Recovery Incinerators

(Copies are available from Naval Civil Engineering Laboratory, Port Hueneme, CA 93043, (805) 982-4651.)

SOUTHERN DIVISION, NAVAL FACILITIES ENGINEERING COMMAND (NAVFACENGCOM)

Report On Post-Occupancy Evaluation, Refuse Incinerator at the Mayport Naval Station, Jacksonville, Florida

(Copies are available from SOUTHNAVFACENGCOM, 2155 Eagle Drive, P.O. Box 10068, Charleston, SC 29411.)

U.S. LAWS, CODES, AND REGULATIONS

PUBLIC LAW

P.L. 94-580	Resource Conservation and Recovery Act

(Copies are available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, (202) 275-2091. An RCRA hotline is available from 8:30 a.m. until 7 p.m. EST to answer general questions on hazardous waste regulations: (202) 382-3000 or (800) 424-9346.)

U.S. CODES

42 USC 7401	Clean Air Act
Amendment P.L.91-604	Amendment to Clean Air Act
33 USC 1251 and	Clean Water Act
Amendment P.L.95-217	Amendment to Clean Water Act

(Copies are available from the Bureau of National Affairs (BNA), Inc., 1231 25th Street, N.W., Washington, D.C. 20037, (202) 452-4200 or (800) 452-7773.)

CODE OF FEDERAL REGULATIONS

29 CFR 1910	Occupational Safety and Health Standards
40 CFR 50	National Primary and Secondary Ambient Air Quality Standards
40 CFR 51	Requirements for Preparation, Adoption, and Submittal of Implementation Plans
40 CFR 52	Approval and Promulgation of Implementation Plans
40 CFR 52.22	Maintenance of National Standards
40 CFR 60	Standards of Performance for New Stationary Sources
40 CFR 122	EPA-Administered Permit Programs: The National Pollutant Discharge Elimination System
40 CFR 123	State Program Requirements
40 CFR 125	Criteria and Standards for the National Pollutant Discharge Elimination System
40 CFR 130	Water Quality Planning and Management

40 CFR 240	Guidelines for the Thermal Processing of Solid Wastes
40 CFR 257	Criteria for Classification of Solid Waste Disposal Facilities and Practices
40 CFR 261	Identification and Listing of Hazardous Waste
40 CFR 261.20	Characteristics of Hazardous Waste --General
40 CFR 261.24	Characteristics of EP Toxicity
40 CFR 261.33(f)	Discarded Commercial Chemical Products, Off-Specification Species, Container Residues, and Spill Residues Thereof
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities
40 CFR 265	Interim Status Standards for Owners and Operators of Hazardous Waste Facilities

(Copies are available from the Bureau of National Affairs (BNA), Inc., 1231 25th Street, N.W., Washington, D.C. 20037, (202) 452-4200 or (800) 452-7773.)

NON-GOVERNMENT PUBLICATIONS:

The following publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the Department of Defense Index of Specifications and Standards (DODISS).

AMERICAN CONCRETE INSTITUTE (ACI)

ACI 301	Specifications for Structural Concrete for Buildings
ACI 318	Building Code Requirements for Reinforced Concrete, (DOD adopted)

(Copies are available from American Concrete Institute (ACI), 22400 West Seven-Mile Road, Box 19150, Redford Station, Detroit, Michigan 48219-0150, (313) 532-2600.)

AMERICAN INSTITUTE OF STEEL CONSTRUCTION

(Standards are available from American Institute of Steel Construction, 400 North Michigan Avenue, Chicago, IL 60611, (312) 670-2400.)

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME	Boiler and Pressure Vessel Code

(Copies are available from American Society of Mechanical Engineers (ASME), 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300, (201) 882-1167.)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A36	Standard Specification for Structural Steel, (DOD adopted)
ASTM A515	Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service, (DOD adopted)
ASTM A615	Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, (DOD adopted)

(Copies are available from American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103-1187, (215) 299-5585.)

AMERICAN WELDING SOCIETY

(Standards are available from American Welding Society, Inc., 550 N.W. LeJeune Road, P.O. Box 351040, Miami, FL 33135, (305) 443-9353.)

CRANE MANUFACTURERS ASSOCIATION OF AMERICA, INC. (CMAA)

CMMA 70	Specifications for Electric Overhead Travelling Cranes

(Copies are available from Crane Manufacturers Association of America, Inc., 1326 Freeport Rd., Pittsburg, PA 15238.)

ILLUMINATING ENGINEERING SOCIETY

(Standards are available from Illuminating Engineering Society, 345 East 47th Street, New York, NY 10017, (212) 705-7920.)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 13	Standard for Installation of Sprinkler System
NFPA 31	Standard for the Installation of Oil Burning Equipment
NFPA 54	National Fuel Gas Code
NFPA 58	Storage and Handling of Liquified Petroleum Gases

(Copies are available from the National Fire Protection Association (NFPA), Batterymarch Park, Quincy, MA 02169, (800) 344-3555.)

SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)

SAE 1040	Roll-over Protective Structure for Machines

(Copies are available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096, (412) 776-4841.)

PLANT ENGINEERING MAGAZINE

Helmstetter, Arthur, 1981, Waste Energy Conversion Systems: Plant Engineering Magazine, August 20, p. 83-85.

(Copies are available from Cahners Publishing Co., 1350 E. Touhy Avenue, Des Plaines, ILL 60018, (312) 635-8800.)

GLOSSARY

Afterburner. An auxiliary fuel burner used to control gaseous emissions. The afterburner raises the temperature of the flue gas stream for the purpose of thermally oxidizing incompletely combusted materials.

Baghouse. A type of dust and particle collector which uses a fabric filter. As flue gas passes through the pores of the fabric bag, dust is filtered out by the fabric and by the dust cake that forms on the bag's inner surface.

Controlled Air. A combustor design consisting of a primary zone in which waste is burned with limited combustion air flow and velocity to minimize particulate emissions, and a secondary zone in which volatile gases and unburned particulate material in the flue gas reach complete combustion.

Cyclone Dust Collector. A type of mechanical flue gas dust collector which removes particles from flue gas by introducing the dust-laden gas stream tangentially into the body of the collector, where centrifugal force separates particles from the gas stream.

Electrostatic Precipitator (ESP). A type of flue gas dust collector. ESP's produce an electric charge on dust particles and an opposite charge on collecting electrodes. The charged particles are attracted to the collecting electrodes and removed from the gas stream.

Heat Recovery Boiler. A boiler which generates steam through the transfer of sensible heat contained in a hot flue gas stream to the water flowing in a pressurized heat exchanger.

Mechanical Dust Collector. Refer to Cyclone Dust Collector.

Natural Draft. A flow of air or gas (draft) created solely by the difference in pressure of gases at different points in a system. An example is the higher pressure inside a chimney and lower atmospheric pressure at the chimney outlet.

Refractory Material. Heat resistant material commonly used in furnaces, breeching, and stacks.

Rotary Kiln Combustor. A type of combustor which utilizes an inclined turning cylinder, either refractory or waterwall design, to tumble and thereby mix the waste as it is burned.

Scrubber. A device used to clean combustion gases by removing acid-forming or odor-forming chemicals from flue gas through direct contact of a suitable aqueous solution with the flue gas stream.

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