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Center for Environmental
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Cincinnati OH 45268

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CERI 89-247

EPA

Seminar— Medical and Institutional Waste Incineration:

Regulations, Management, Technology, Emissions, and Operations

CERI 89-247
November 1989

MEDICAL AND INSTITUTIONAL WASTE INCINERATION: REGULATIONS, MANAGEMENT, TECHNOLOGY EMISSIONS, AND OPERATIONS

Seminar Handout

Center for Environmental Research Information
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

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U.S. ENVIRONMENTAL PROTECTION AGENCY

WORKSHOP ON MEDICAL AND INSTITUTIONAL WASTE INCINERATION:
REGULATIONS, MANAGEMENT, TECHNOLOGY, EMISSIONS, AND OPERATIONS

WORKSHOP AGENDA

DAY ONE

12:00 p.m.	**Registration**
1:00 p.m.	**Introduction**
1:15 p.m.	**State Experience with Medical and Institutional Waste Incineration**
1:45 p.m.	**Medical Waste Regulatory and Guidelines Update** Jacqueline Sales, HAZMED, Silver Spring, MD Regulations, Standards, Guidelines EPA Other Federal, e.g. NIH, CDC, OSHA, RCRA, NRC Other, e.g. JCAHO, NFPA
3:15 p.m.	**Questions/Discussion**
3:30 P.M.	**BREAK**
3:45 p.m.	**Waste Management and Disposal, Part 1** Larry Doucet/John Bleckman, Doucet & Mainka, P.C. Peekskill, NY Sources, Quantities and Characteristics Treatment and Disposal Alternatives
5:00 p.m.	**Questions/Discussion**
5:15 p.m.	**ADJOURN**

DAY TWO

8:30 a.m.	**Waste Management and Disposal, Part 2** Larry Doucet/John Bleckman Planning and Implementing Treatment & Disposal Programs
9:15 a.m.	**Incineration Fundamentals** Larry Doucet/John Bleckman Combustion and Control Fundamentals Time, Temperature, and Turbulance Incineration Capacity and Sizing Selection and Design Criteria
10:15 a.m.	**Break**
10:30 a.m.	**Alternate Institutional Waste Incineration Technologies** Larry Doucet/John Bleckman Multiple Chamber Rotary Kiln Controlled Air Other
11:15 a.m.	**Questions/Discussion**
11:30 a.m.	**Incineration Systems and Equipment, Part 1** Larry Doucet/John Bleckman Waste Handling and Loading Residue Removal and Handling
12:15 p.m.	**Questions/Discussion**
12:25 p.m.	**LUNCH**
1:30 p.m.	**Incineration Systems and Equipment, Part 2** Larry Doucet/John Bleckman Heat Recovery Stacks and Breeching Systems Controls and Instrumentation
2:15 p.m.	**Incinerator Emissions, Air Pollution Control, Risks, and Testing** Larry Doucet/John Bleckman

DAY TWO, Continued

3:00 p.m.	**Questions/Discussion**
3:15 p.m.	**BREAK**
3:30 p.m.	**Incinerator Regulatory and Permitting Issues** Larry Doucet/John Bleckman
4:15 p.m.	**Procurement, Performance, Acceptance, and Operations** Larry Doucet/John Bleckman
4:45 p.m.	**Evaluating and Upgrading Current Systems** Larry Doucet/John Bleckman
5:00 p.m.	**Questions/Discussion**
5:15 p.m.	**ADJOURN**

SPEAKER BIOGRAPHIES

JOHN BLECKMAN
Doucet & Mainka, P.C.
Consulting Engineers
2123 Crompond Road
Peekskill, NY 10566
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John Bleckman received both his Bachelor and Masters degrees at Cornell University. He has nearly 20 years of experience in consultation, engineering and management of health care facilities, with emphasis on issues in energy and the environment. Mr. Bleckman has had documents featured in a wide range of publications, including the Wall Street Journal and documents prepared by the World Health Organization. He works with Doucet & Mainka, P.C.

LAWRENCE DOUCET
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Lawrence Doucet received a Bachelor of Science at the U.S. Merchant Marine Academy, and earned his Masters in Environmental Engineering at City College of New York. Mr. Doucet has 20 years of comprehensive experience in the fields of incineration, waste management, waste heat recovery, and air pollution control. He has worked for numerous hospitals, universities and research facilities involved in treatment of infectious, pathological, toxic chemical, chemotherapy, and low-level radioactive waste. Mr. Doucet has worked on numerous projects with the U.S. EPA relative to hazardous waste management, storage, and incineration. Currently, Mr. Doucet is a Principal Executive with Doucet & Mainka, P.C.

JACQUELINE SALES
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Jacqueline Sales is a two-time recipient of the prestigious EPA Special Act Award. She received her Bachelor and Masters degrees from Howard University in Washington, DC. Ms. Sales is an expert in the management of hazardous waste, biological testing and analysis, and infectious waste, where she has provided extensive guidance to Federal, State and local agencies on policy and regulations. She has been a Faculty Member of the American Hospital Association since 1985. Ms. Sales is the founder and president of HAZMED, an environmental engineering and consulting firm specializing in infectious waste management and hazardous waste regulation development, implementation, and policy.

MEDICAL WASTE REGULATORY AND GUIDELINES UPDATE

Jacqueline W. Sales
Hazardous and Medical Waste Services, Inc. [HAZMED]

I. Environmental Protection Agency (EPA) Medical Waste Program

A. Historical Perspective

1. EPA 1986 infectious waste guidance document
2. Beach wash-ups of medical waste debris

B. Medical Waste Tracking Act of 1988

1. Two year demonstration program
2. Tracking system for medical waste
3. Implementation date July 30, 1989

C. List of Medical Wastes tracked under the EPA Program

1. Cultures and stocks of infectious agents
2. Pathological Wastes
3. Human blood and blood products
4. Sharps (used and unused)
5. Contaminated Animal Wastes

D. Waste excluded from regulation

1. Domestic sewage
2. Hazardous waste
3. Household waste
4. Treated and destroyed waste
5. Human remains
6. Samples collected for enforcement purposes

E. Enforcement authorities - RCRA Subtitle C

F. Generator standards

1. Must segregate, package, and label all regulated medical waste to be shipped off-site.
2. Must use medical waste tracking form or log.
3. Must maintain records.

G. Types of generators

1. Hospital, medical clinics, drug treatment centers
2. Clinical and research laboratories
3. Physician's offices, dental offices, and veterinary practices
4. Nursing homes, hospices, etc.
5. Funeral homes, dialysis centers
6. Military vessels at port

H. Transporter requirements

1. Must notify EPA
2. Comply with vehicle requirements
3. Comply with tracking form requirements
4. Maintain records
5. Submit reports to EPA

I. Destination Facility Requirements

1. Operate and manage regulated medical waste in accordance with applicable requirements.
2. Comply with tracking form requirements.
3. Maintain required records.
4. Prepare and submit reports to EPA and State agencies.

J. EPA implementation efforts

1. Outreach
2. Training
3. Assistance to states

II. Occupational Safety and Health Administration (OSHA) Requirements

A. Addresses protection of health care workers

B. Requires personal protective equipment

C. Establishes housekeeping standards

D. Establishes sanitation and waste disposal standards

E. Contains general duty clause.

III. Nuclear Regulatory Commission (NRC) requirements

A. Addresses disposal of low level radioactive medical waste.

B. Certain medical waste may be decayed in storage before disposal.

IV. Centers for Disease Control (CDC) Guidelines

A. Establishes guidelines for prevention and control of disease outbreaks.

B. CDC guidelines address proper procedures to protect workers from acquiring blood-borne diseases such as AIDS and Hepatitis B.

V. Joint Commission on Accreditation of Healthcare Organizations (JCAHO) Standards

A. Establishes standards for healthcare facility certification.

B. Standards address safety, patient care, staffing, and training programs.

C. Requires a process for handling hazardous and infectious materials.

VI. National Institutes of Health (NIH)

A. Develops standard operating procedures for management and disposal of infectious waste.

B. The following wastes are managed as infectious:

1. Surgery and autopsy wastes
2. Contaminated research animals and bedding
3. Contaminated laboratory wastes
4. Contaminated and unused needles and syringes
5. Patient care wastes contaminated with blood, secretions, excretions, or exudates.

C. Infectious wastes are subject to certain packaging and labeling standards.

VII. Resource Conservation and Recovery Act (RCRA)

A. RCRA regulations cover management and handling of hazardous waste.

B. Hazardous wastes are either listed, exhibit one or more of the characteristics, or are commercial chemical products.

C. Generators of 100 kg per month or more of hazardous waste are subject to certain storage, permitting, tracking, and recordkeeping requirements.

D. Generators of less than 100 kg per month of hazardous waste are exempt from the Federal program (State regulations may be more stringent).

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Medical Waste Demonstration Program

Historical Background Events Leading to Passage of MWTA

- Medical Waste Has Been Historically Regulated as General Refuse Under RCRA Subtitle D
- "EPA Guide for Infectious Waste Management" Was Issued in 1986
- Numerous Wash-ups of Debris Occurred During the Summers of 1987 and 1988:
  - Some Resulted in Beach Closures
  - Medical Waste Was a Small Portion of the Total
- Beach Closures and Resulting Economic Impacts Heightened Public and Congressional Concern
- Medical Waste Tracking Act of 1988 Was Passed by Congress and Signed by the President

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Sources of Medical Waste That Washed Up On Our Beaches

- Mismanagement of Municipal Solid Waste (Including Medical Waste)
- Sewer Discharge and Combined Sewer Overflows
- Illegal Drug Use
- Beach Litter (Including Refloatables)
- Commercial and Military Shipping and Pleasure Boating
- Illegal Dumping Activities

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Medical Waste Tracking Act of 1988 (MWTA)

- Signed by the President on November 1, 1988
- Requires EPA to:
  - Establish a 2-year Demonstration Program
  - List the Types of Medical Waste to Be Tracked
  - Develop a Tracking System for RMW
  - Provide for States to Petition In or Opt Out
  - Prepare Reports to Congress
- Deadline for Program Implementation: July 30, 1989

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List of Medical Waste Types to Be Tracked

- EPA is Required by the MWTA to Include the Following Waste Types:

  1. Cultures and Stocks
  2. Pathological Wastes
  3. Human Blood and Blood Products
  4. Sharps
  5. Contaminated Animal Wastes

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List of Medical Waste Types to Be Tracked (Continued)

- EPA May Exclude the Following Waste Types if They Do Not Substantially Threaten Human Health or the Environment When Mismanaged:

  6. Waste from Surgery or Autopsy
  7. Other Laboratory Wastes
  8. Dialysis Wastes
  9. Discarded Medical Equipment and Parts
  10. Isolation Wastes

- EPA May Also Add Other Medical Wastes Based on a Finding That They Pose a Threat to Human Health or the Environment

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Enforcement Authorities

- Similar to RCRA Subtitle C in Inspection and Enforcement Authorities
- Applies to All Generators (Including Federal Facilities) in Covered States
- Penalties:
  - Criminal - $50,000 Per Violation, Per Day, or Up to 5 Years Imprisonment
  - Civil - $25,000 Per Violation, Per Day

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Standards for the Tracking and Management of Medical Waste

- These Regulations Apply to:
  - RMW That is Generated in a Covered State
  - Generators of RMW in a Covered State
  - Transporters and Owners or Operators of Intermediate Handling Facilities or Destination Facilities Who Transport, Offer for Transport, or Otherwise Manage RMW, Even if Such Transport or Management Occurs in a Non-Covered State
- Persons Claiming Non-Regulatory Status Must Demonstrate, Through Shipping Papers or Other Documentation, That the RMW Was Generated in a Non-Covered State

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List of Medical Wastes to be Tracked

- Cultures and Stocks

  Human Pathological Waste
- Human Blood and Blood Products
- Used Sharps
- Research Animal Waste
- Certain Isolation Waste
- Certain Unused, Discarded Sharps

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List of Medical Wastes to be Tracked (Continued)

- Waste Types Not Specifically Listed in the Regulations Include:
  - Surgery and Autopsy Waste
  - Other Laboratory Waste
  - Dialysis Waste
  - Contaminated Medical Equipment and Parts
- Many of the Specific Waste Items of Concern Are Already Included in Waste Classes 1-5 (e.g., Tissues From Surgery)
- Other Waste Items Have Been Specifically Listed (e.g., Contaminated Slides and Cover Slips From Laboratories)

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List of Medical Wastes to be Tracked (Continued)

- The Wastes Not Captured:
  - Generally Pose Little Potential to Cause or Transmit Disease
  - Pose Little Potential to Cause Physical Harm
  - Have Not Been Responsible for Beach Closures
- The List Represents a Virtual Consensus of Opinion of the State and Federal Public Health and State Waste Management Officials Who Participated in the Development of the Rule

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Class 1 - Cultures and Stocks

Cultures and stocks of infectious agents and associated biologicals, including: cultures from medical and pathological laboratories; cultures and stocks of infectious agents from research and industrial laboratories; waste from the production of biologicals; discarded live and attenuated vaccines; and culture dishes and devices used to transfer, inoculate, and mix cultures.

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Class 2 - Pathological Wastes

Human Pathological wastes, including tissues, organs, body parts, *and body fluids* that are removed during surgery or autopsy, *or other medical procedures, and specimens of body fluids and their containers.*

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Class 3 - Human Blood and Blood Products

(1) *Liquid* waste human blood; (2) products of blood; (3) *items saturated and/or dripping with human blood;* or (4) *items that were saturated and/or dripping with human blood that are now caked with dried human blood;* including serum, plasma, and other blood components, *and their containers, which were used or intended for use in either patient care, testing and laboratory analysis, or the development of pharmaceuticals. Intravenous bags are also included in this category.*

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Class 4 - Used Sharps

Sharps that have been used in *animal or human* patient care or *treatment* or in medical, research, or industrial laboratories, including hypodermic needles, syringes *(with or without the attached needle)*, pasteur pipettes, scalpel blades, *blood vials, test tubes, needles with attached tubing, and culture dishes (regardless of presence of infectious agents). Also included are other types of* broken *or unbroken glassware* that were in contact with infectious agents, such as used slides and cover slips.

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Class 5 - Animal Waste

Contaminated animal carcasses, body parts, and bedding of animals that were *known to have been* exposed to infectious agents during research *(including research in veterinary hospitals),* production of biologicals, or testing of pharmaceuticals.

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Class 6 - Isolation Wastes

Biological waste and discarded materials contaminated with blood, excretion, exudates, or secretions from humans who are isolated to protect others from *highly* communicable diseases, or isolated animals *known to be infected with highly* communicable diseases.

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Class 7 - Unused Sharps

Hypodermic needles, suture needles, syringes, and scalpel blades

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Wastes Not Subject to the Requirements of the Regulations

- Wastes Excluded by Statute Are:
  - Domestic Sewage
  - Hazardous Waste
  - Household Waste
- Wastes Excluded or Exempt From the Rule Are:
  - Treated and Destroyed Waste (e.g., Incinerator Ash)
  - Etiologic Agents Shipped Pursuant to Other Federal Regulations
  - Human Remains Intended for Interment or Cremation
  - Samples Collected for Enforcement Purposes

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Treatment and Destruction Exemption

- RMW That Has Been Both Treated and Destroyed is No Longer RMW
- Treated RMW - RMW That Has Been Treated to Substantially Reduce or Eliminate Its Potential for Causing Disease
- Destroyed RMW - RMW That Has Been Ruined, Torn Apart, or Mutilated Through Processes Such as Thermal Treatment, Melting, Shredding, Grinding, Tearing or Breaking, So That It is No Longer Generally Recognizable as Medical Waste

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Generator Standards
Applicability

- Standards Apply to Generators of RMW in a Covered State
- Intermediate Handlers Who Treat or Destroy RMW Must Comply With These Standards
- Transporters (Transfer Facilities) Who Consolidate or Remanifest RMW Must Also Comply With These Standards

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Generator Standards
General Requirements

- Generators Must Properly Segregate, Package, Label, and Mark all RMW Intended for Transport Off-site
- Generators Must Use the Medical Waste Tracking Form or Appropriate Logs to Document Each Shipment of RMW
- Generators Must Maintain the Necessary Records and Submit Exception Reports as Required
- Generators Who Incinerate RMW On-site Must Submit Additional Reports

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Generator Standards
Types of Generators

- Generators Include, but are Not Limited to, the Following:
  - Hospitals (Including On-site Laboratories); Medical Clinics Including Drug Treatment Centers
  - Clinical and Research Laboratories That Perform Health Related Analysis Including Universities
  - Physicians' Offices, Dental Offices, and Veterinary Practices
  - Long-term Health Care Facilities Including Nursing Homes, Hospices, and Non-residential Medical Day Care Facilities
  - Funeral Homes, Ambulance Services, Blood Banks, and Dialysis Centers
  - Miscellaneous: Commercial and Military Vessels at Port in Covered States

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Pre-Transport Standards
Segregation Requirements

- Generators Must Segregate RMW That is Intended for Transport Off-site
- RMW Must be Segregated into the Following Categories:
  - Sharps and Their Residual Fluids (Classes 4 and 7)
  - Fluids (in Quantities Greater Than 20 cc)
  - All Other RMW
- Mixtures of RMW With Other Solid Waste Must Be Handled as RMW
- Additional Requirements May Apply to Mixtures of RMW With Hazardous Waste and Radioactive Waste

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Pre-Transport Standards
Packaging Requirements

- RMW Must be Packaged in Containers That are:
  - Rigid
  - Leak-resistant
  - Impervious to Moisture
  - Resistant to Tearing or Bursting
  - Sealed to Prevent Leakage
- In Addition to the Above Requirements:
  - Sharps Must be Packaged in Puncture-Resistant Containers
  - Fluids Must be Packaged in Break-Resistant, Tightly Lidded or Stoppered Containers
- Generators May Use One or More Containers to Meet These Standards

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Pre-Transport Standards
Storage Requirements

- Any Person Who Stores RMW Prior to Treatment or Disposal On-site or Transport Off-site Must:
  - Store the Waste in a Manner That Protects the Integrity of the Container and Does Not Provide a Breeding Place or Food Source for Insects or Rodents
  - Protect the Container From Water, Rain, and Wind
  - Maintain the Waste in a Non-putrescent State
  - Lock Outdoor Storage Areas
  - Limit Access to On-site Storage Areas

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Pre-Transport Standards
Labeling Requirements

- Each Container of Untreated RMW Must Be Labeled (Identification of Its Contents) as Follows:
  - The Label Must Contain the Words "Medical Waste" or "Infectious Waste" or Display the Universal Biohazard Symbol
  - When a Red Plastic Bag is Used, as an Inner Container, a Label is Not Necessary
- The Label Must be Water-Resistant and Affixed or Printed on the Outside of the Container
- Containers of Treated RMW Need Not Be Labeled

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Pre-Transport Standards
Marking Requirements

- Each Package of RMW Must Have Attached on Its Outer Surface an Identification Tag Marked as Follows:
  - Generator's or Intermediate Handler's Name and Address
  - Transporter's Name and Address
  - Date of Shipment
  - Identification of Contents as Medical Waste
- Each Inner Container, Including Sharps and Fluid Containers, Must be Marked with the Generator's or Intermediate Handler's Name and Address

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Pre-Transport Standards
Decontamination Requirements

- All Non-rigid Containers and Inner Liners Must Be Managed as RMW and Must Not Be Reused
- Any Rigid Container to Be Reused Must Be Decontaminated Prior to Reuse if It Exhibits Any Visible Contamination
- If Container Cannot Be Decontaminated and Rendered Free of Visible Contamination It Must Be Managed and Disposed of as RMW
- Inner Liners Used in Conjunction With Reusable Containers Must Be Disposed of With the RMW They Contain

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Medical Waste Tracking Form

Who Must Use a Tracking Form

- Generators Who:
  - Generate 50 Pounds or More of RMW in Any Calendar Month
  - Generate Less Than 50 Pounds of RMW in a Calendar Month but Make Any Single Shipment of More Than 50 Pounds
- Intermediate Handlers Who:
  - Change the Composition or Category of the RMW
  - Repackage the RMW
- Transporters (Including Transfer Facilities) Who:
  - Consolidate and/or Remanifest RMW
  - Repackage the RMW

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Medical Waste Tracking Form

Parties Initiating a Form

- Must Complete and Sign the Tracking Form for Each Shipment of RMW
- Must Prepare the Number of Copies That Will Provide:
  - The Generator (Initiator) with a Copy
  - Each Transporter with a Copy
  - Each Intermediate Handler with a Copy (if Applicable)
  - The Destination Facility with Two Copies; One for Its Records and One for the Party Initiating the Form
- Must Obtain the Handwritten Signature of the Initial Transporter and Date of Acceptance on the Completed Tracking Form

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Generator Standards
Tracking Form Exemptions

- Generators of Less Than 50 Pounds Per Month Are Exempt From the Use of the Tracking Form When They:
  - Use a Transporter Who Has Notified EPA and Who Uses the Logs to Document Each Shipment
  - Personally Transport the RMW to a Receiving Facility
  - Ship Sharps to a Destination Facility Via the U.S. Postal Service
- Generators of 50 Pounds or More Per Calendar Month Are Exempt From the Use of the Tracking Form When RMW is Transported Between Satellite Facilities

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Generator Standards
Recordkeeping Requirements

- Generators Must Maintain the Following Records:
  - Copies of All Signed Tracking Forms and/or Shipping Logs
  - Copies of All Exception Reports
- Generators Must Maintain These Records for at Least Three (3) Years from the Date:
  - The Signed Tracking Form was Received by the Initial Transporter
  - The Exception Report was Filed
- Generators Must Maintain Any Records Relevant to an Enforcement Action Until the Resolution of that Enforcement Action

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Generator Standards
On-Site Treatment and Destruction

- Generators Who Treat and Destroy RMW On-site, Other Than by Incineration, Must Maintain the Following Records:
  - Quantity, by Weight, of RMW That is Treated and Destroyed
  - Percent, by Weight, of the Total Waste Treated and Destroyed That is RMW
- For Waste Accepted from Off-site Sources for Treatment and Destruction, the Generator Must Also Maintain the Following Information:
  - Identification of the Off-site Source
  - The Date the Waste was Accepted
  - Quantity, by Weight, of Waste Accepted
  - The Date the Waste was Treated and Destroyed

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Generator Standards
On-site Incinerator Requirements

- Generators Must Maintain Incinerator Operation Logs
- Generators Accepting RMW From Off-site Sources for On-site Incineration Must Maintain Information That Identifies the Generator and the Amount of Waste Accepted
- Generators With On-site Incinerators Must Submit Two Reports to EPA Summarizing Information Collected During the First and Third 6-Month Periods of the Demonstration Program

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Transporter Standards
General Requirements

- Each Transporter Accepting RMW Generated in a Covered State Must:
  - Notify EPA and That Covered State of its Intent Prior to Commencing Such Activity
  - Operate and Maintain Vehicles for Transport of RMW in Accordance With All Applicable Requirements
  - Comply With All Tracking Form and Logging Requirements
  - Maintain All Required Records of RMW-Related Activities
  - Prepare and Submit Requisite Reports to EPA and the States

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Transporter Standards
Vehicle Requirements

- Vehicles Used to Transport RMW Must:
  - Have a Fully Enclosed, Leak-Resistant Cargo Carrying Body That Is Capable of Being Locked
  - Be Marked With Identification Information on Both Sides and Rear, Including:
    - Company Name
    - Company's State Permit or Identification Number
    - "MEDICAL WASTE" or "REGULATED MEDICAL WASTE"
  - Not Subject RMW to Mechanical Stress or Compaction During Loading and Unloading and During Transit

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Transporter Standards
Use of the Tracking Form

- Transporters Accepting RMW Accompanied by a Tracking Form Must:
  - Ensure That the Tracking Form is Properly Completed and Accurate
  - Inspect the Shipment to Ensure it is Properly Packaged, Labeled, and Marked
  - Sign and Date the Tracking Form and Return a Signed Copy to the Generator Representative
- Ensure That the Remaining Copies Accompany the RMW During Transit

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Destination Facility Standards
General Requirements

- These Standards Apply to All Facilities that Accept RMW that is Generated in a Covered State for Treatment, Destruction, Off-site Incineration or Disposal
- All Such Facilities are Required To:
  - Operate and Manage All Accepted RMW in Accordance With Applicable Requirements
  - Comply With All Tracking Form Requirements
  - Maintain All Required Records of RMW-Related Activities
  - Prepare and Submit Requisite Reports to EPA and State Agencies (e.g., Discrepancy Reports)
- These Standards Apply to Such Facilities Even if the Facility is Located in a Non-Covered State

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Program Enforcement
Serious Violations

- Serious Violations Requiring Formal Enforcement Actions Include:
  - Transporting, or Delivering/Offering for Transportation RMW Without a Tracking Form
  - Improper Labeling of the RMW
  - Failure of the RMW Transporter to Comply With One-Time Notification to EPA
  - Failure of Generators to File Exception Reports
  - Failure of Owners/Operators of Intermediate Handling and Destination Facilities to File Discrepancy Reports

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EPA Implementation Efforts

- Short-term Initiatives Will Include:
  - Develop and Distribute Educational and Outreach Materials
  - Participate in Workshops and Conferences
  - Assist States' Implementation of the Regulations
  - Assist in the Training of State Personnel
- Long-term Initiatives Will Include:
  - Develop Data Management System
  - Develop Guidance for States Not Participating
  - Prepare and Submit the Required Reports to Congress
  - Evaluate the Success of the Demonstration Program

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EPA and ATSDR Health Effects Assessment

- EPA and ATSDR are Evaluating the Health Effects Posed By the Mismanagement of Medical Waste
  - Researching Past Incidents of Exposure
  - Identifying Past and Potential Health and Environmental Effects
  - Reviewing Systematically the Available Literature
  - Meeting With Experts to Identify and Evaluate the Risks

- Epidemiological Evidence to Date Has Not Been Found to Indicate Mismanaged Medical Waste Poses a Significant Human Health Problem

RESOURCE CONSERVATION AND RECOVERY ACT

- HAZARDOUS WASTE REGULATIONS -

Definition of Hazardous Waste

- A Solid Waste
- Not excluded from regulation
- And either:

  A listed hazardous waste

  A mixture containing a listed hazardous waste

  An unlisted waste possessing any of the four characteristics

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Exclusions

These are NOT considered hazardous wastes:

- Household garbage
- Municipal resource recovery waste
- Agriculture residues
- Waste discharged to the sewer

CHARACTERISTICS

Ignitability
Corrosivity
Reactivity
EP Toxicity

A solid waste which exhibits any of these characteristics is a hazardous waste whether or not listed

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LISTS OF HAZARDOUS WASTES

Nonspecific sources

- Solvents
- Electroplating wastes
- Metal-heat treating wastes
- Air emission scrubber sludges

Specific Sources

- Wood Preserving
- Inorganic Pigments
- Organic Chemicals
- Pesticides
- Explosives
- Iron and Steel

Commercial Chemical Products (when discarded or burned)

- product itself
- off-specification species
- spill residue and debris

ANTINEOPLASTICS

The following antineoplastics are listed as hazardous waste and therefore regulated when discarded:

Chlorambucil
Mitomycin C
Streptozotocin
Uracil Mustard
Daunomycin
Melphalan

GENERATOR STATUS AND REQUIREMENTS

Small Quantity Generators of Hazardous Waste

Generators of less than 100 kilograms (220 lbs) of hazardous waste per month are excluded from the hazardous waste regulations:

- o wastes must be disposed in a State licensed or permitted facility
- o consult State to determine whether lower limit exists

Acutely hazardous waste (i.e., certain commercial chemical products) are subject to a lower one kilogram per month exclusion

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Generators of 100-1000 Kilograms per Month

Must comply with the regulations, but are exempt from certain reporting requirements

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Generators of 1000 Kilograms or More per Month

Must comply with the following requirements:

- o Notify EPA and obtain a Federal ID number
- o Prepare a manifest for off-site shipments of hazardous waste
- o Treat, store, and dispose of hazardous waste in a Federally permitted facility
- o Federal reporting and recordkeeping requirements

DO NOT:

- burn hazardous waste in pathological or resource recovery incinerators, or boilers unless you are a small quantity generator (<100 kilograms per month)
- transport hazardous waste off-site without a manifest
- store hazardous waste on-site for 90 days without a permit (180 days for generators of 100-1000 kilograms per month)
- provide hazardous waste for shipment by a non-licensed transporter

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DO:

- call the RCRA/Superfund Hotline if you need information 1-800-424-9346 (toll free)
- call your State department of public health or environmental protection for information on State requirements

NATIONAL INSTITUTES OF HEALTH (NIH)

NIH has developed standard operating procedures for management and disposal of infectious waste. Infectious waste is defined as wastes contaminated with infectious agents.

The following wastes are managed as infectious waste:

- surgery and autopsy wastes (including pathological and clinical specimens)
- contaminated research animals and bedding
- contaminated laboratory wastes
- contaminated and unused needles and syringes
- patient care wastes contaminated with blood, secretions, excretions, or exudates

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Infectious wastes are segregated from the general waste stream and packaged according to the following standards:

- dedicated boxes with a plastic liner (at least 3 mil)
- wet materials are placed in two liners
- boxes are labelled "medical/pathological waste"
- box is printed with biohazard symbol
- waste must be identified as either experimental animal waste, patient care waste, or laboratory waste

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Infectious waste is incinerated on-site. Autoclaved (steam sterilized) medical waste is discarded in the general waste stream.

Antineoplastics are segregated from the general waste stream and incinerated on-site. Antineoplastics covered under RCRA are managed as hazardous chemical waste management.

PROPOSED
OSHA REQUIREMENTS

for

HEALTH CARE FACILITIES

OVERVIEW OF OSHA REQUIREMENTS

1) OSHA REQUIREMENTS ARE PRIMARILY FOR PROTECTION OF HEALTH CARE WORKERS WORKING WITH PATIENTS AND PATIENT RELATED ITEMS.

2) FACILITY MAY BE CITED FOR NON-PROTECTION OF OTHER EMPLOYERS' EMPLOYEES TO THE EXTENT THAT THEY CAN CONTROL THE HAZARD.

HEALTH CARE FACILITY

- STANDARD INDUSTRIAL CLASSIFICATION CODE (SIC) 80 (HEALTH SERVICES)
- STANDARD INDUSTRIAL CLASSIFICIATION CODE 7261 (FUNERAL SERVICES and CREMATORIES)

OSHA REGULATIONS COVER <u>ALL</u> HEALTH CARE WORKERS, for example:

- Physicians, nurses, dentists, dental workers, and others whose work involves direct contact with body fluid.

OSHA REQUIREMENTS protect health care workers from occupational exposure to blood-borne diseases. It addresses:

- Personal protection
- Housekeeping
- Sanitation and waste disposal
- Specications for accident prevention
- General duty clause for health care facilities

PERSONAL PROTECTION

PERSONAL PROTECTIVE EQUIPMENT

- Gloves
- Gowns
- Masks and Eye protectors
- Protective Shields and Barriers

The following procedures require use of personal protective equipment

- Invasive procedures
- Phlebotomy (blood drawing) gloves
- Postmortem procedures

HOUSEKEEPING

- All places of employment, passsageways, storerooms, and service rooms shall be kept clean and orderly and in sanitary condition.
- Keep the floor of every workroom clean and dry.
- Room cleaning where body fluids are present.

SANITATION

and

WASTE DISPOSAL

CONTAINER STANDARDS

- LEAK RESISTANT
- CLEANED and MAINTAINED in a sanitary condition
- EQUIPPED with a SOLID, TIGHT-FITTING cover

SHARP INSTRUMENTS and DISPOSABLE ITEMS

- Disposable sharps should be placed in puncture resistant containers
- Such a container should be accessible to personnel where needles are used, including patient rooms.

Specifications for accident prevention signs and tags:

- Biological hazard tags need to identify the actual or potential presence of a biological hazard

GENERAL DUTY CLAUSE

- Hepatitis B vaccination
- Linen
- Reusable equipment (Cleaning standard sterilization disinfection)
- Handwashing

NUCLEAR REGULATORY COMMISSION (NRC)

NRC regulations address disposal of low level radioactive medical waste

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Animal carcasses and liquid scintillation fluids containing <0.50 microcuries/gram of tritium or C14 may be discarded.

Animal carcasses and liquid scintillation fluids containing >0.50 microcuries/gram or other radiological components must be disposed in accordance with NRC regulations contained in 10CFR20.

Medical waste with a half-life <65 days (except iridium) may decay in storage. The waste must be held for a minimum of 10 half lives. For example, waste with a half-life of 6 days must be held for 60 days.

Waste must meet background levels at the container surface before disposal. All radiation warning labels must be removed or obliterated before disposal.

Must keep the following records for three (3) years:

- date of storage
- storage date
- background levels
- instruments used
- nuclides disposed
- date of disposal
- contact person

CENTERS FOR DISEASE CONTROL (CDC)

CDC epidemiologically defines outbreaks of disease in the health care environment (and the community) and develops strategies for prevention and control.

CDC is NOT a regulatory agency.

CDC INFECTIVE WASTE CATEGORIES

- Isolation Wastes
- Microbiological Cultures and Stocks
- Blood and Blood Products
- Pathological Wastes
- Sharps

CDC recommends the following waste disposal procedures to reduce risks of AIDS and Hepatitis B:

- Incineration or decontamination of infective waste before disposal in a sanitary landfill
- Disposal of sharps in puncture-proof containers
- Blood-contaminated items should be placed in leak-proof bags
- Blood and body fluids may be discharged to the sewer

Joint Commission
on
Accreditation of Healthcare Organizations
(JCAHO)

JCAHO establishes standards for:

- o Safety
- o Patient care
- o Staffing
- o Training programs

Health care organizations that meet the standards receive a 3 year JCAHO accreditation

---

Requires a management process for handling hazardous and infectious materials within the organization:

- o Labeling of containers
- o Space and equipment requirements
- o Waste stream segregation
- o Training

Labeling of Containers

- o Types of containers
  - new products
  - in use and transfer
  - accumulation
  - shipping
- o Printed Information
  - product name
  - chemical name
  - manufacturer information
  - precautions
  - personal protective equipment
  - hazard class
  - regulatory labels

Waste Stream Segregation

- o Chemically incompatible materials
- o Waste from food and food preparation areas
- o Waste from patient care areas

Training

The following employees must receive training:

- o Employees who use and/or are exposed to hazardous and infectious materials
- o Employees who handle these wastes
- o Emergency response teams
- o Supervisory personnel

Training programs must address:

- o Regulatory requirements
- o New employee orientation
- o Annual continuing education

Each employee should know their role in:

- o Internal disaster plan
- o Emergency response plan
- o Contingency plans

JCAHO requires Health care facilities to establish a Safety Committee

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Safety Committee Responsibilities:

- o Analyze identified issues
- o Develop recommendations for resolution
- o Infection control
- o Risk management
- o Quality assurance

MEDICAL & INSTITUTIONAL WASTE MANAGEMENT & INCINERATION WORKSHOP

Presented by: Lawrence G. Doucet, Doucet & Mainka, P.C.
John Bleckman, Doucet & Mainka, P.C.

I. WASTE MANAGEMENT & DISPOSAL

A. Overview & Perspectives

B. Waste Categories & Designations

C. Regulatory Framework & Recap

D. Infectious Waste
1. Types, characteristics, definitions & designations
2. Sources
3. Generation factors & quantities

E. Infectious Waste Treatment & Disposal Alternatives
1. On-site treatment
   a. Steam sterilization
   b. Shredding/chlorination
   c. Incineration
   d. Other
   e. Emerging technologies
2. Off-site treatment & disposal
   a. Contract disposal
   b. Shared incinerator
   c. Regional incineration

F. Other "Special" Wastes
1. Chemical (hazardous) waste
   a. Sources and quantities
   b. Treatment & disposal alternatives
   c. Incineration
2. Antineoplastic waste
   a. Bulk & contaminated
   b. Treatment & disposal alternatives
3. Low-level radioactive
   a. Sources and quantities
   b. Treatment & disposal alternatives
   c. "Mixed waste"

G. Planning an Integrated Waste Management Program
1. Concerns & objectives
2. Step 1 - Surveys & data collection
   a. Waste characterization & composition
   b. Waste quantification
   c. Regulatory data
   d. Other data
   e. Summary

3. Step 2 – Technical & Economic Evaluations
   a. Disposal options & variables
   b. Incinerator options & add–ons
   c. Siting
   d. Other variables & issues
   e. Economics
4. Planning recommendations

H. Assessment of Waste Management Practices
   1. Compliance & conformance
   2. Economic incentives

Waste

Management

And

Disposal

Medical Waste Disposal

Is A

National Dilemma

Waste Management Regulations

vs.

Incinerator Regulations

"Infectious" Waste Quantities Are

Increasing

while

Viable Disposal Options Are

Decreasing

Hospital And Institutional Waste

- General
- "Special"

"Special" Waste

- Infectious
- Pathological
- Chemical/Hazardous
- Radioactive
- Sharps
- Other

Medical Waste

Regulatory

Update

Hospital "Hazardous" Waste Management

• Overall Framework	• JCAHO
• Infectious Wastes	• States, "Guidelines" and MWTA of 1988 (RCRA Sub-Title J)
• Chemical Waste	• USEPA and States RCRA (40CFR260-265, 40CFR122-124)
• Cytotoxic Waste	• USEPA, VA Directives and "Guidelines"
• Radioactive Waste	• NRC *Stds for Protection Against Radiation* (10CFR20) and NESHAPS (40CFR61)

JCAHO Standards

A "System" Is Required to Safely
Manage Hazardous Materials And
Wastes From Points Of Entry
To Final Disposal

JCAHO Accreditation Manual For Hospitals (AMH)

- **Standard IC.2 – Infection Control**
- **Standard PL.1.10 – Hazardous Waste Management**

JCAHO Requirements for Hazardous/ Infectious Waste Management

- **Policies/Procedures for Identification/Management**
- **Establishment of Committees – Annual Review**
- **Job Training**
- **Compliance With Laws/Regulations**

Infectious Waste

Management And

Disposal

- Biohazardous Waste
- Biological Waste
- Biomedical Waste
- Contaminated Waste
- Infectious Waste
- Medical Waste
- Pathogenic Waste
- Pathological Waste
- Red Bag Waste
- Regulated Waste
- RMW

Infectious Waste Requires All Of the Following

- Presence of Virulent Pathogen
- Sufficient Concentration of Pathogen
- Presence Of A Host
- Portal of Entry
- Host Susceptibility

Infectious Waste Generation Parameters

- Regulatory "Definitions"
- Interpretations Of Definitions
- Internal Policies And Protocols
- Waste Management Effectiveness

CDC Infectious Waste Designation

- Microbiology Lab Waste
- Pathological Waste
- Sharps
- Blood/Blood Products

Ref: 1985 Handwashing Guide/1987 Mortality Weekly

EPA Infectious Waste "Guide" Designations

- Isolation Waste
- Cultures and Stocks of Etiological Agents
- Human Blood and Blood Products
- Pathological Waste
- Contaminated Sharps
- Contaminated Animal Carcasses, Parts and Bedding

Ref: 1989 EPA Guide for Infectious Waste Management

EPA Infectious Waste "Optional" Categories

- Surgery and Autopsy Wastes
- Dialysis Unit Wastes
- Contaminated Equipment
- Miscellaneous Laboratory Wastes

Ref: 1989 EPA Guide for Infectious Waste Management

Hospital Departments Designated Infectious Waste Sources

- Autopsy Department
- Emergency Department
- Intensive Care Units
- Isolation Rooms
- Clinical Laboratories
- Morgue

Ref: Proposed EPA Regulations in 1978 Fed Register

Hospital Department Sources (Cont'd)

- Obstetrics Department (Incl Patient Rooms)
- Pathology Department
- Pediatrics Department
- Surgery Department (Incl Patient Rooms)

Ref: Proposed EPA Regulations in 1978 Fed Register

Medical Waste Tracking Act (MWTA)
Regulated Medical Waste (RMW)

1. Cultures & Stocks
2. Pathological Wastes
3. Human Blood & Blood Products
4. Sharps
5. Contaminated Animal Wastes

MWTA Potentially Excluded Waste Types

6. Waste from Surgery or Autopsy
7. Other Laboratory Wastes
8. Dialysis Wastes
9. Discarded Medical Equipment & Parts
10. Isolation Wastes

("Other Medical Wastes may be added")

"Universal Precautions"

or

"Universal Blood and Body-Fluid Precautions"

OSHA HBV/HIV Standards

"Infectious" Waste Generation

		% Of Total
•	CDC Guidelines	3–5
•	EPA Guidelines (1986)	7–15
•	Proposed EPA Regs (1978)	20–35
•	All Patient "Contact" Waste	60–80
•	Hauler/Disposal Facility Restrictions	0–100

INFECTIOUS WASTE ACCORDING TO THE CDC

"There is no epidemiologic evidence to suggest that most hospital waste is any more infective than residential waste. Moreover, there is no epidemiologic evidence that hospital waste has caused disease in the community as a result of improper disposal. Therefore, identifying wastes for which special precautions are indicated is largely a matter of judgment about the relative risk of disease transmission. The most practical approach to the management of infective waste is to identify those wastes with the potential for causing infection during handling and disposal and for which some special precautions appear prudent. Hospital wastes for which special precautions appear prudent include microbiology laboratory waste, pathology waste, and blood specimens or blood products. While any item that has contact with blood, exudates, or secretions may be potentially infective, it is not usually considered practical or necessary to treat all such waste as infective. Infective waste, in general, should either be incinerated or should be autoclaved before disposal in a sanitary landfill. Bulk blood, suctioned fluids, excretions, and secretions may be carefully poured down a drain connected to a sanitary sewer. Sanitary sewers may also be used to dispose of other infectious wastes capable of being ground and flushed into the sewer."

Ref: CDC, "Guideline for Handwashing & Hospital Environmental Control", 1985," NTIS PB85-923404, 1985.

CDC, "Recommendations for Prevention of HIV Transmission in Health-Care Settings," Morbidity and Mortality Weekly Report, Vol. 36, August 21, 1987.

United States Environmental Protection Agency | Office of Solid Waste and Emergency Response Washington DC 20460 | EPA/530-SW-86-014 May 1986

PB86-199130

Solid Waste

EPA Guide for Infectious Waste Management

EXECUTIVE SUMMARY

The purpose of this document is to provide guidance on the management of infectious waste. The document presents the EPA perspective on acceptable infectious waste management practices. Discussions are limited to technologies that are typically and frequently used for treating and managing infectious waste; however, the EPA in no way intends to imply that alternative methods or new technologies are not available or acceptable.

EPA Recommendations for Infectious Waste Management

The EPA recommends that a responsible person or committee at the facility prepare an Infectious Waste Management Plan outlining policies and procedures for the management of infectious waste. This plan should include the following elements:

- Designation
- Segregation
- Packaging
- Storage
- Transport
- Treatment
- Disposal
- Contingency Planning
- Staff training

Ref: U.S.EPA, Guide for Infectious Waste Management, NTIS PB86-19913, May 1986.

1. Designation of Infectious Waste

EPA recommends that the following categories of waste be designated as infectious waste:

Waste Category	Examples*
Isolation wastes	• refer to Centers for Disease Control (CDC), Guidelines for Isolation Precautions in Hospitals, July 1983
Cultures and stocks of infectious agents and associated biologicals	• specimens from medical and pathology laboratories • cultures and stocks of infectious agents from clinical, research, and industrial laboratories; disposable culture dishes, and devices used to transfer, inoculate and mix cultures • wastes from production of biologicals • discarded live and attenuated vaccines
Human blood and blood products	• waste blood, serum, plasma, and blood products
Pathological waste	• tissues, organs, body parts, blood, and body fluids removed during surgery, autopsy, and biopsy
Contaminated sharps	• contaminated hypodermic needles, syringes, scalpel blades, pasteur pipettes, and broken glass
Contaminated animal carcasses, body parts, and bedding	• contaminated animal carcasses, body parts, and bedding of animals that were intentionally exposed to pathogens

*These materials are examples of wastes covered by each category. The categories are not limited to these materials.

The EPA has identified an optional infectious waste category which consists of miscellaneous contaminated wastes. While there is not a unanimity of opinion regarding the hazards posed by these wastes, EPA believes that the decision whether to handle these wastes as "infectious" should be made by a responsible authorized person or committee at the individual facility. However, the Agency recommends that wastes from patients known to be infected with blood-borne diseases should be managed as infectious waste (for example, dialysis waste from known hepatitis B patients).

Miscellaneous Contaminated Wastes	Examples
Wastes from surgery and autopsy	• soiled dressings, sponges, drapes, lavage tubes, drainage sets, underpads, and surgical gloves
Miscellaneous laboratory wastes	• specimen containers, slides, and cover slips; disposable gloves, lab coats, and aprons
Dialysis unit wastes	• tubing, filters, disposable sheets, towels, gloves, aprons, and lab coats
Contaminated equipment	• equipment used in patient care, medical laboratories, research, and in the productio and testing of certain pharmaceuticals

Ref: U.S.EPA, Guide for Infectious Waste Management, NTIS PB86-19913, May 1986.

II. Segregation of Infectious Waste

EPA recommends:

- segregation of infectious waste at the point of origin
- segregation of infectious waste with multiple hazards as necessary for management and treatment
- use of distinctive, clearly marked containers or plastic bags for infectious waste
- use of the universal biological hazard symbol on infectious waste containers, as appropriate

III. Packaging of Infectious Waste

EPA recommends:

- selection of packaging materials that are appropriate for the type of waste:
  - plastic bags for many types of solid or semi-solid infectious waste
  - puncture-resistant containers for sharps
  - bottles, flasks, or tanks for liquids
- use of packaging that maintains its integrity during storage and transport
- use of plastic bags that are impervious, tear resistant, and distinctive in color or markings
- closing the top of each bag by folding or tying as appropriate for the treatment or transport
- placement of liquid wastes in capped or tightly stoppered bottles or flasks
- no compaction of infectious waste or packaged infectious was before treatment

IV. Storage of Infectious Waste

EPA recommends:

- minimizing storage time
- proper packaging that ensures containment of infectious waste and the exclusion of rodents and vermin
- limited access to storage area
- posting of universal biological hazard symbol on storage area door, waste containers, freezers, or refrigerators

V. Transport of Infectious Waste

EPA recommends:

- avoidance of mechanical loading devices which may rupture packaged wastes
- frequent disinfection of carts used to transfer wastes within the facility
- placement of all infectious waste into rigid or semi-rigid containers before transport off-site
- transport of infectious waste in closed leak-proof trucks or dumpsters

Ref: U.S.EPA, Guide for Infectious Waste Management, NTIS PB86-19913, May 1986.

VI. Treatment of Infectious Waste

For the purposes of this document, EPA defines treatment as any method, technique or process designed to change the biological character or composition of waste.

EPA recommends:

- establishing standard operating procedures for each process used for treating infectious waste
- monitoring of all treatment processes to assure efficient and effective treatment
- use of biological indicators to monitor treatment (other indicators may be used provided that their effectiveness has been successfully demonstrated)
- the following treatment techniques for each of the six infectious waste categories (table 1):

Treatment of Infectious Waste (cont'd)

EPA recommends:

- the following treatment methods for miscellaneous contaminated wastes (when a decision is made to manage these wastes as infectious):
  - wastes from surgery and autopsy - incineration or steam sterilization
  - miscellaneous laboratory wastes - incineration or steam sterilization
  - dialysis unit wastes - incineration or steam sterilization
  - contaminated equipment - incineration, steam sterilization, or gas/vapor sterilization

VII. Disposal of Treated Infectious Waste

EPA recommends:

- contacting State and local governments to identify approved disposal options (institutional programs must conform to State and local requirements)
- discharge of treated liquids and ground up solids (such as pathological waste or small animals) to the sewer system
- land disposal of treated solids and incinerator ash
- rendering body parts unrecognizable before land disposal (for aesthetic reasons)

Ref U.S.EPA, Guide for Infectious Waste Management, NTIS PB86-19913, May 1986.

RECOMMENDED TECHNIQUES FOR TREATMENT OF INFECTIOUS WASTE[a]

Type of Infectious Waste[b]	Recommended Treatment Techniques				
	Steam Sterilization	Incineration	Thermal Inactivation	Chemical Disinfection[c]	Other
Isolation wastes	X	X			
Cultures and stocks of infectious agents and associated biologicals	X	X	X	X	
Human blood and blood products	X	X		X	X[d]
Pathological wastes	X[e]	X			X[f]
Contaminated sharps	X	X			
Contaminated animal carcasses, body parts, bedding:					
• carcasses and parts	X[e]	X			
• bedding		X			

a. The recommended treatment techniques are those that are most appropriate and, generally, in common use; alternative treatment technique may be used to treat infectious waste, if it provides effective treatment.
b. See Chapter 2 for descriptions of infectious waste types.
c. Chemical disinfection is most appropriate for liquids.
d. Discharge to sanitary sewer for treatment in municipal sewerage system (provided that secondary treatment is available)
e. For aesthetic reasons, steam sterilization should be followed by incineration of the treated waste or by grinding with subsequent flushing to the sewer system in accordance with State and local regulations.
f. Handling by a mortician (burial or cremation).

Ref: U.S.EPA, Guide for Infectious Waste Management, NTIS PB86-19913, May 1986.

Infectious Waste Treatment Alternatives

- Steam Sterilization
- Shredding/Chemical Disinfection
- Incineration
- Other (Small Scale) Systems
  - Dry Heat Sterilization
  - Gas/Vapor Sterilization
  - Irradiation
- Emerging/Developing Technologies

Steam Sterilization System

- Waste Transport/Treatment Containers
- Autoclavable Bags
- Autoclave Chamber
- Ventilation
- Container Dumper
- Biological/Temperature Indicators

Steam Sterilization Technologies

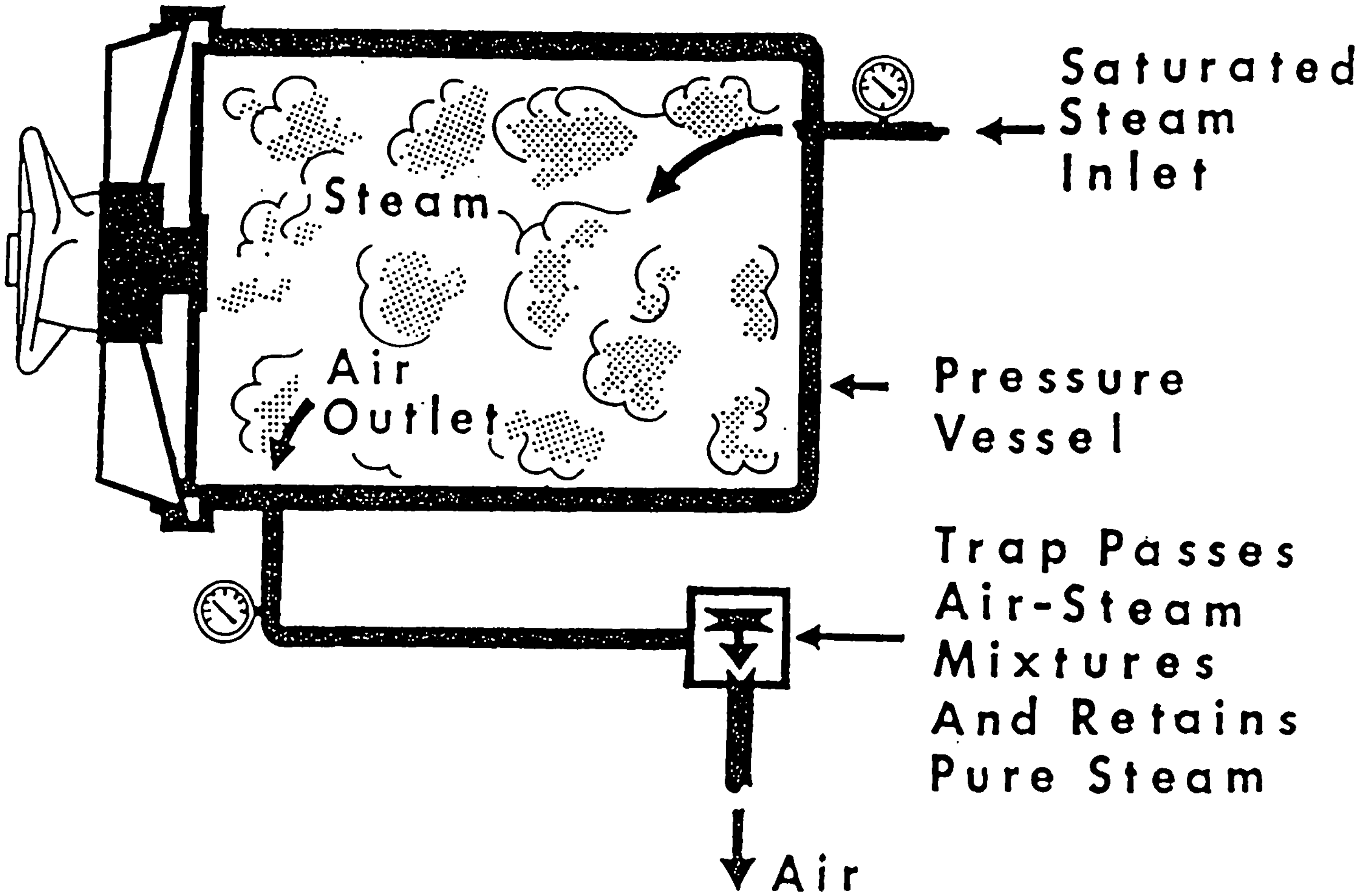
- Gravity Systems
- Pre-Vacuum Systems
- Retort Systems
- Combination Autoclaves/Trash Compactors

Steam Sterilization Performance

- Based upon Direct Steam Contact
- Permeation of Entire Mass with Heat and Moisture
- Factors:
  - Air Evacuation
  - Physical Barriers
  - Density of Materials

Autoclaving Is NOT Recommended For:

- Sealed Containers
- Bulk Fluids
- Pathological Waste
- Hazardous Chemicals
- Chemonuclear Waste
- Antineoplastic Waste



GRAVITY STEAM STERILIZATION SYSTEM

Ref: Block, S. S., Disinfection, Sterilization and Preservation, Lea and Febiger, Philadelphia, 1977.

Autoclaving System Advantages

- Low Costs
- Low Space Requirements
- Ease of Implementation
- Simplicity

Autoclaving System Disadvantages

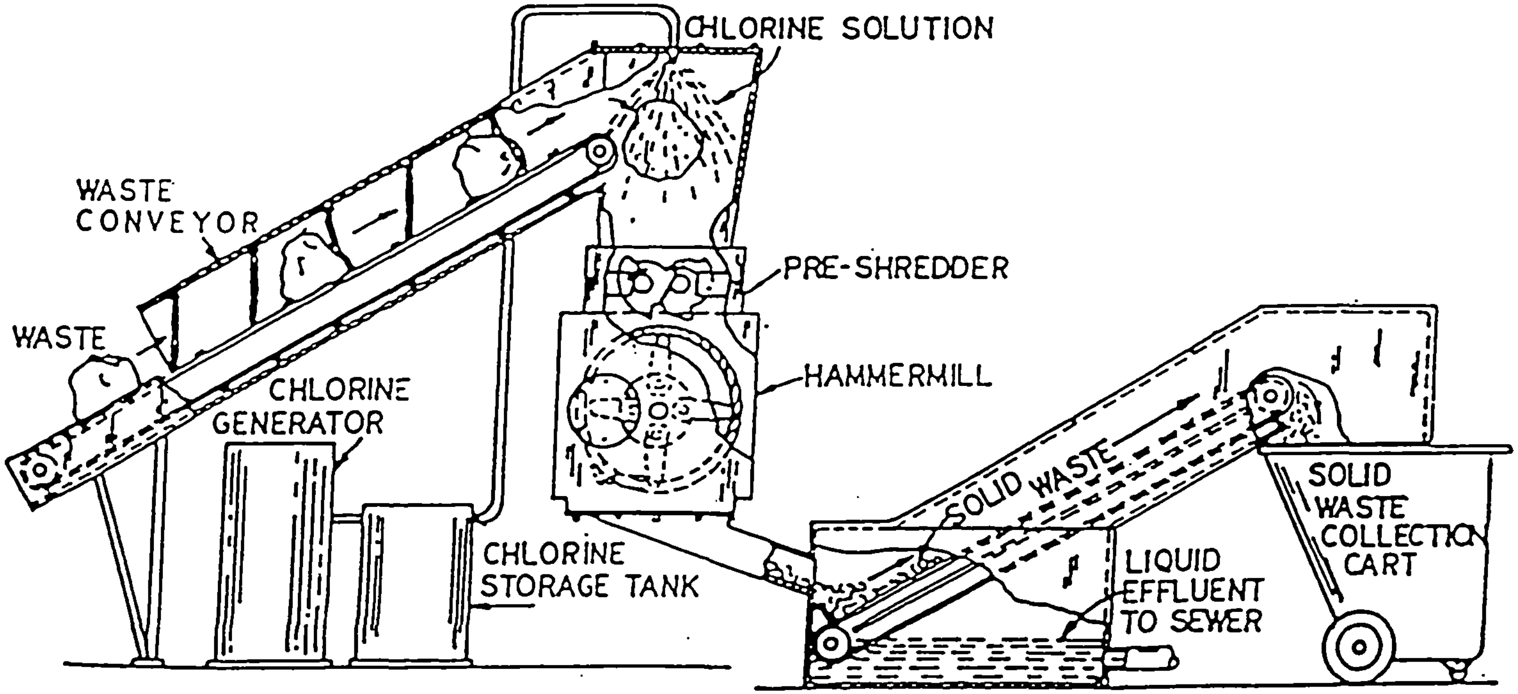
- Limited Capacity
- Not Suitable For All Wastes
- Waste Handling System/Bags
- Odor Control
- Volume Unchanged
- Appearance/Form Unchanged

Shredding/Chlorination Systems

- Small-Scale Sharps/
  Lab Waste Processing Systems
- Large-Scale Total Infectious
  Waste Processing System

Shredding/Chlorination
Disinfection System

- Waste Feed Conveyor
- Pre-Shredder
- Hammermill
- Debris Conveyor/Separator
- HEPA Filtration System
- Sodium Hypochlorite System



SHREDDING/CHLORINATION DISINFECTION SYSTEM

Ref: Medical SafeTec, Inc.

Shredding/Chlorination System Advantages

- Substantial Volume Reduction
- Suitable For Many Wastes
- Relative Simplicity
- Alters Waste Form And Appearance

Shredding/Chlorination System Disadvantages

- Relatively High Costs
- Waste Handling
- Limited Capacity
- Liquid Effluent Contaminants
- Room Noise and Chlorine Levels
- Limited Experience
- Single Manufacturer

Incineration Systems

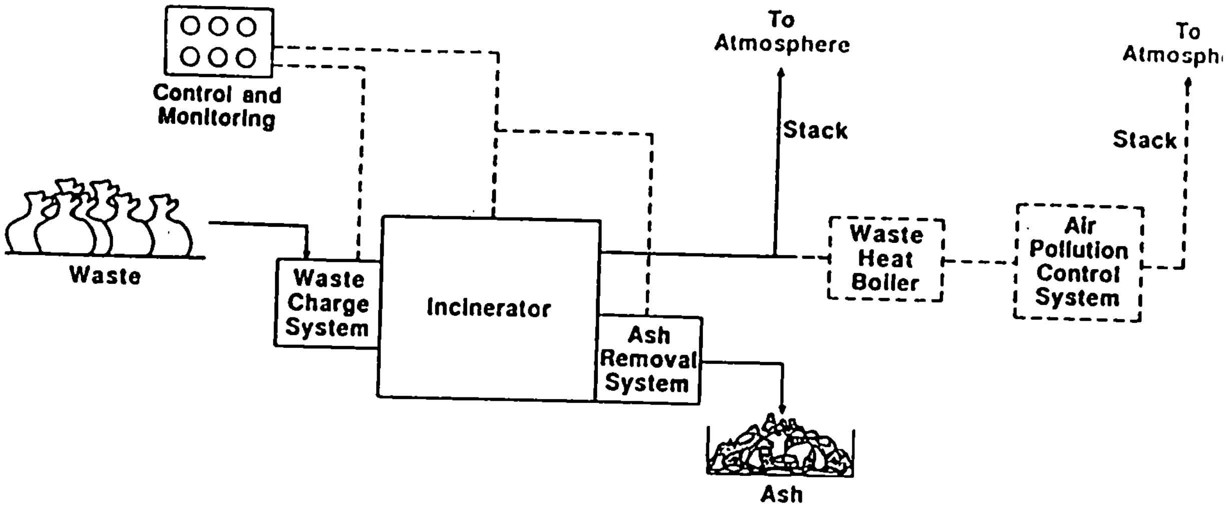
- Waste Handling and Loading
- Incinerator
- Burners and Blowers
- Ash Removal and Handling
- Breeching, Blowers and Dampers
- Stacks(s)
- Air Pollution Control
- Waste Heat Recovery
- Controls and Instrumentation

Incineration System Advantages

- Disposal Of Most Waste Items And Forms
- Suitable For Large Volumes
- Largest Weight And Volume Reductions
- Sterilization And Detoxification
- Heat Recovery
- Unrecognizable Residues
- Favorable Life-Cycle Costing

Incineration System Disadvantages

- High Capital Costs
- High M&R Costs And Requirements
- Stack Emissions And Concerns
- Siting Difficulties
- Permitting Difficulties
- Public Opposition



MAJOR COMPONENTS OF AN INCINERATION SYSTEM

Ref: Hospital Incineration Operator Training Course Manual, EPA-450/3-89-004, March 1989.

Other (Small Scale) Systems

- Dry Heat Sterilization
- Gas/Vapor Sterilization
- Radiation

"Emerging" Technologies?

- Glass Slagging
- High-Temperature Plasmas
- Shredding/Radiation
- Shredding/Chemical Injection
- Wet Oxidation
- etc.

Off-Site Disposal Options

- Contract Haulage And Disposal
- Another Hospital's Incinerator
- Regional or Shared-Service Incinerator
  - Private Development Facility
  - Cooperative Development Facility

Off-Site Disposal Advantages

- Negligible Capital Investment
- Relative Simplicity of Implementation
- Avoid On-Site Disposal Permitting

Off-Site Disposal Disadvantages

- Location Reliable And Reputable Firm
- Potential Liabilities And Concerns
- High Costs
- Manifesting And Tracking

Regional or Shared-Service Facility Pros And Cons

- Advantages
  - Favorable Economics
  - Single Permit
  - Centralized Operations
- Disadvantages
  - Siting and Permitting Difficulties
  - Waste Transport Requirements
  - "Hazardous" Designation

(Compared To Individual)

Off-Site Disposal Contractor Considerations

- Capabilities & Capacities
- Experience & Track Record
- Permits & Certifications
- Insurance & Indemnification

Infectious Waste Disposal Costs

- On-Site Incineration: $0.05 - $0.20/lb
- Off-Site Disposal: $0.30 - $2.00/lb

Institutional Chemical Waste Sources

- Clinical & Research Laboratories
- Patient-Care Activities
- Pharmacy (Spills & Out-dated Items)
- Physicians' Offices (Out-dated Items)
- Physical Plant Department
- Buildings & Grounds Department

Hazardous Waste Management Options

- Recycling/Recovery
- Chemical Treatment
- Physical Treatment
- Thermal Treatment
- Disposal

Chemical Waste Minimization

- Process Modification
  - Eliminate Use
  - Substitution
- Volume Reduction
- Reclaim/Recycle
  - Recovery
  - Distillation
  - Waste Exchange

Hazardous (Chemical) Waste

- Listed
- Characteristics
  - Ignitable
  - Corrosive
  - Reactive
  - Toxic
    (Extraction Procedure)

Chemotherapy Waste Disposal Criteria

- Regulated (Bulk)
  - 7 cytotoxic drugs listed as acutely toxic (40CFR261.33f)
  - Containers/vials with 3% capacity or greater
- Unregulated
  - Containers/vials with less than 3% capacity
  - Trace-contaminated

Sources of Radioactive Hospital Waste

- Research Laboratory Activities
- Clinical Laboratory Procedures
- Nuclear Medicine
  - Diagnostic Applications
  - Radiotherapy

Forms of Radioactive Institutional Waste

- Solid Waste
  - Animal Carcasses
  - Clinical Items
  - Contaminated "Dry" Materials
- Liquid Waste
  - Scintillation Fluids (LSC)
  - Biological & Chemical Research Chemicals
  - Decontamination of Radioactive Spills

Radioactive Waste Disposal

- Concentration and Confinement
  - Decay-in-Storage
- Dilution and Dispersion
  - Discharge to Sewer
- Volume Reduction and Dispersion
  - Incineration
- Off-Site Disposal

Planning an

Integrated Waste

Management Program

Waste Disposal
Planning Concerns

- Risks And Concerns - Safety And Health
- Regulations And Accreditation
- Off-Site Liabilities And Exposure
- Costs

Waste Disposal
Program Objectives

- Compliance With Regulations And Standards
- Manageable And Enforceable
- Flexibility
- Safety And Security
- Environmental Integrity
- Cost Effectiveness

Waste Disposal Evaluations

<u>Task 1: Data Collection</u>

1. Waste Characterization
2. Waste Quantification
3. Waste Management Practices
4. Site(s)
5. Utilities
6. Costs
7. Regulatory And Permitting Requirements
8. Summary And Review

Institutional Waste Forms

Classes	Examples
• Dry And Solid	- Paper, Plastic, Cloth - Cage Waste
• Pathological	- Carcasses/Tissues - Body Parts/Cadavers
• Liquid	- Solvents/Chemicals - Blood/Body Fluids

Waste Characterization

- General Parameters
  - Composition/Constituents
  - Forms
  - Categories
- Physical Parameters
- Chemical Parameters
- Heating Values

Waste Characterization

- Composition/Components
- Heating Value
- Moisture
- Ash
- Plastics - PVC
- Physical Form

Proximate Analysis

Weight Percentages Of

- Moisture
- Volatiles
- Fixed Carbon
- Non-Combustibles

Ultimate Analysis

Weight Percentages Of Elemental Constituents

- Carbon
- Hydrogen
- Oxygen
- Nitrogen
- Chlorine
- Sulfur
- Metals
- etc.

WASTE DATA CHART

Material	B.T.U. value/lb. as fired	Wt. in lbs. per cu. ft. (loose)	Wt. in lbs. per cu. ft.	Content by weight in percentage	
				ASH	MOISTURE
Type 0 Waste	8,500	8-10		5	10
Type 1 Waste	6,500	8-10		10	25
Type 2 Waste	4,300	15-20		7	50
Type 3 Waste	2,500	30-35		5	70
Type 4 Waste	1,000	45-55		5	85
Acetic Acid	6,280		65.8	0.5	0
Animal fats	17,000	50-60		0	0
Benzene	18,210		55	0.5	0
Brown paper	7,250	7		1	6
Butyl sole composition	10,900	25		30	1
Carbon	14,093		138	0	0
Citrus rinds	1,700	40		0.75	75
Coated milk cartons	11,330	5		1	3.5
Coffee grounds	10,000	25-30		2	20
Corn cobs	8,000	10-15		3	5
Corrugated paper	7,040	7		5	5
Cotton seed hulls	8,600	25-30		2	10
Ethyl Alcohol	13,325		49.3	0	0
Hydrogen	61,000		0.0053	0	0
Kerosene	18,900		50	0.5	0
Latex	10,000	45	45	0	0
Linoleum scrap	11,000	70-100		20-30	1
Magazines	5,250	35-50		22.5	5
Methyl alcohol	10,250		49.6	0	0
Naphtha	15,000		41.6	0	0
Newspaper	7,975	7		1.5	6
Plastic coated paper	7,340	7		2.6	5
Polyethylene	20,000	40-60	60	0	0
Polyurethane (foamed)	13,000	2	2	0	0
Rags (linen or cotton)	7,200	10-15		2	5
Rags (silk or wool)	8,400-8,900	10-15		2	5
Rubber waste	9,000-11,000	62-125		20-30	0
Shoe Leather	7,240	20		21	7.5
Tar or asphalt	17,000	60		1	0
Tar paper ⅓ tar-⅔ paper	11,000	10-20		2	1
Toluene	18,440		52	0.5	0
Turpentine	17,000		53.6	0	0
⅓ wax-⅔ paper	11,500	7-10		3	1
Wax paraffin	18,621		54-57	0	0
Wood bark	8,000-9,000	12-20		3	10
Wood bark (fir)	9,500	12-20		3	10
Wood sawdust	7,800-8,500	10-12		3	10
Wood sawdust (pine)	9,600	10-12		3	10

The above chart shows the various B.T.U. values of materials commonly encountered in incinerator designs. The values given are approximate and may vary based on their exact characteristics or moisture content.

Ref: Incinerator Institute of America, Incinerator Standards, 1968.

IIA WASTE CLASSIFICATIONS

Classification of Wastes Type	Description	Principal Components	Approximate Composition % by Weight	Moisture Content %	Incombustible Solids %	B.T.U. Value/lb. of Refuse as Fired
0	Trash	Highly combustible waste, paper, wood, cardboard cartons, including up to 10% treated papers, plastic or rubber scraps; commercial and industrial sources	Trash 100%	10%	5%	8500
1	Rubbish	Combustible waste, paper, cartons, rags, wood scraps, combustible floor sweepings; domestic, commercial and industrial sources	Rubbish 80% Garbage 20%	25%	10%	6500
2	Refuse	Rubbish and garbage; residential sources	Rubbish 50% Garbage 50%	50%	7%	4300
3	Garbage	Animal and vegetable wastes, restaurants, hotels, markets; institutional, commercial and club sources	Garbage 65% Rubbish 35%	70%	5%	2500
4	Animal solids and organic wastes	Carcasses, organs, solid organic wastes; hospital, laboratory, abattoirs, animal pounds and similar sources	100% Animal and Human Tissue	85%	5%	1000

Ref: Incinerator Institute of America, Incinerator Standards, 1968.

IIA WASTE GENERATION FACTORS

CLASSIFICATION	BUILDING TYPES	QUANTITIES OF WASTE PRODUCED
INDUSTRIAL BUILDINGS	Factories Warehouses	Survey must be made 2 lbs. per 100 sq. ft. per day
COMMERCIAL BUILDINGS	Office Buildings Department Stores Shopping Centers Supermarkets Restaurants Drug Stores Banks	1 lb. per 100 sq. ft. per day 4 lbs. per 100 sq. ft. per day Study of plans or survey required 9 lbs. per 100 sq. ft. per day 2 lbs. per meal per day 5 lbs. per 100 sq. ft. per day Study of plans or survey required
RESIDENTIAL	Private Homes Apartment Buildings	5 lbs. basic & 1 lb. per bedroom 4 lbs. per sleeping room per day
SCHOOLS	Grade Schools High Schools Universities	10 lbs. per room & ½ lb. per pupil per day 8 lbs. per room & ½ lb. per pupil per day Survey required
INSTITUTIONS	Hospitals Nurses or Interns Homes Homes for Aged Rest Homes	15 lbs. per bed per day 3 lbs. per person per day 3 lbs. per person per day 3 lbs. per person per day
HOTELS, ETC.	Hotels—1st Class Hotels—Medium Class Motels Trailer Camps	3 lbs. per room and 2 lbs. per meal per day 1½ lbs. per room & 1 lb. per meal per day 2 lbs. per room per day 6 to 10 lbs. per trailer per day
MISCELLANEOUS	Veterinary Hospitals Industrial Plants Municipalities	Study of plans or survey required

Ref: Incinerator Institute of America, Incinerator Standards, 1968.

Waste Quantification Data Methods

- Empirical Factors And Approximations
- Off-Site Haulage/Disposal Records
  - Billing Records
  - Volumes And Frequencies
  - Truck Scales
- Surveys And Weighing Programs

Waste Survey Variables

• Disposal Area(s) vs.	• Specific Sources
• Weighing vs.	• Estimating
• Cart/Bulk Volumes vs.	• Ind. Containers (Bags)
• Random vs.	• Continuous
• Specific Identification vs.	• Approximations
• One Day vs.	• Week(s)

Waste Disposal Evaluations

<u>Task 2: Technical And Economic Evaluations</u>

1. Matrix Of Alternatives
2. Technical Evaluations
3. Schematics
4. Economic Analysis
5. Selection

Typical Disposal Option Variables

- Degree Of On-Site Treatment
  - None
  - Selected
  - Maximum
- Alternate Technologies/Combinations
- Treatment Technology Options/Add-Ons
- Redundancy And Back-Up
- Siting

Typical Incineration System Options

- Operating Period
- Retention Time
- Ash Removal
- Waste Heat Recovery
- Monitoring And Recording
- Degree Of Automation
- Redundancy

Waste Burning Options

- Flammable Solvents
- Cytotoxics (Antineoplastics)
  - Bulk
  - Trace Contaminants
- Low-Level Radioactive

Site Selection

- Space And Accessibility
- Waste And Residue Handling
- Flue Gas Handling
- Visibility And Aesthetics
- Acceptability
- Operations

Cost Estimating

- Capital
- Annual Operating and Maintenance
- Life-Cycle

Waste Disposal Planning Recommendations

- Consider The Total Economic Picture
- Consider Contingencies and Outages
- Consider Future Scenarios and Changes
- Consider Non-Economic Issues

Assessments of Waste Management Practices and Protocols

Help Wanted

Waste Watcher:

Full-Time Position,

No Experience Necessary,

On-The-Job Training

A Case For Segregation

- 600–Bed Hospital
- 12,000 lb/d Total Waste
- Under Present "Policies"
  - 60% Infectious (7,200 lb/d)
- Infectious Waste Disposed Off–Site At $0.30/lb

Segregation Case Study Continued

•	Present Disposal Costs (@ 60% Infectious)	$674,000/yr
•	Potential Disposal Costs (@ 30% Infectious)	$337,000/yr
•	Potential Savings	$337,000/yr
•	Costs For 5 "Waste Watchers"	$120,000/yr
•	Net Annual Savings	$217,000/yr

MEDICAL & INSTITUTIONAL WASTE MANAGEMENT & INCINERATION WORKSHOP

Presented by: Lawrence G. Doucet, Doucet & Mainka, P.C.
John Bleckman, Doucet & Mainka, P.C.

I. INCINERATION FUNDAMENTALS

A. Overview & Perspectives

B. Combustion Fundamentals
1. Combustion reactions
2. Combustion processes & controls
   a. Perfect, theoretical or stoichiometric
   b. Starved-air, sub-stoichiometric or incomplete
   c. Complete combustion
   d. Excess air
   e. Two-stage combustion
   f. PIC's

C. 3 Ts of Combustion
1. Time
   a. Solids
   b. Gases
2. Temperature
   a. Primary
   b. Secondary
   c. Control
3. Turbulence
   a. Mechanical
   b. Aerodynamic

D. Incinerator Sizing & Rating
1. Primary chamber criteria
   a. Heat release
   b. Burning rate
   c. Waste type, form & size
2. Secondary chamber criteria
3. Chamber shapes of configurations

E. Incineration Capacity Determination
1. Capacity selection criteria & factors
2. Operating cycles/modes
3. Burn rate vs. charge rate

F. Calculations
1. Equipment sizing
2. Mass balances
3. Heat balances
4. Flue gas handling systems
5. Other

Incineration

Fundamentals

What Is Incineration?

- "Burn To Ashes"
- Combustion Process

Incineration

- Thermal Oxidation
- Thermal Destruction
- High Temperature Destruction
- Resource Recovery

Incineration

- Combustion Process
- Controlled
- Engineered
- High Technology
- Proven

Modern Incineration

Only About 30 Years Old

Combustion Process

<u>Waste Chemistry</u>

Carbon (C)

Hydrogen (H)

Oxygen (O)

Moisture

Inorganics

Nitrogen (N)

Sulfur (S)

Chlorine (Cl)

Etc.

Hydrocarbons

- Combustibles
- Carbon and Hydrogen
- Fuel

Actual Combustion

Hydrocarbons		Carbon Dioxide
Plus	→	Water Vapor
Oxygen		Heat

Perfect, Theoretical Or Stoichiometric Combustion

Carbon + Oxygen → Carbon Dioxide

Hydrogen + Oxygen → Water

Perfect Combustion

$$C + O_2 \xrightarrow[\Delta]{} CO_2$$

$$H_2 + 0.5\ O_2 \xrightarrow[\Delta]{} H_2O$$

Combustion Reactions

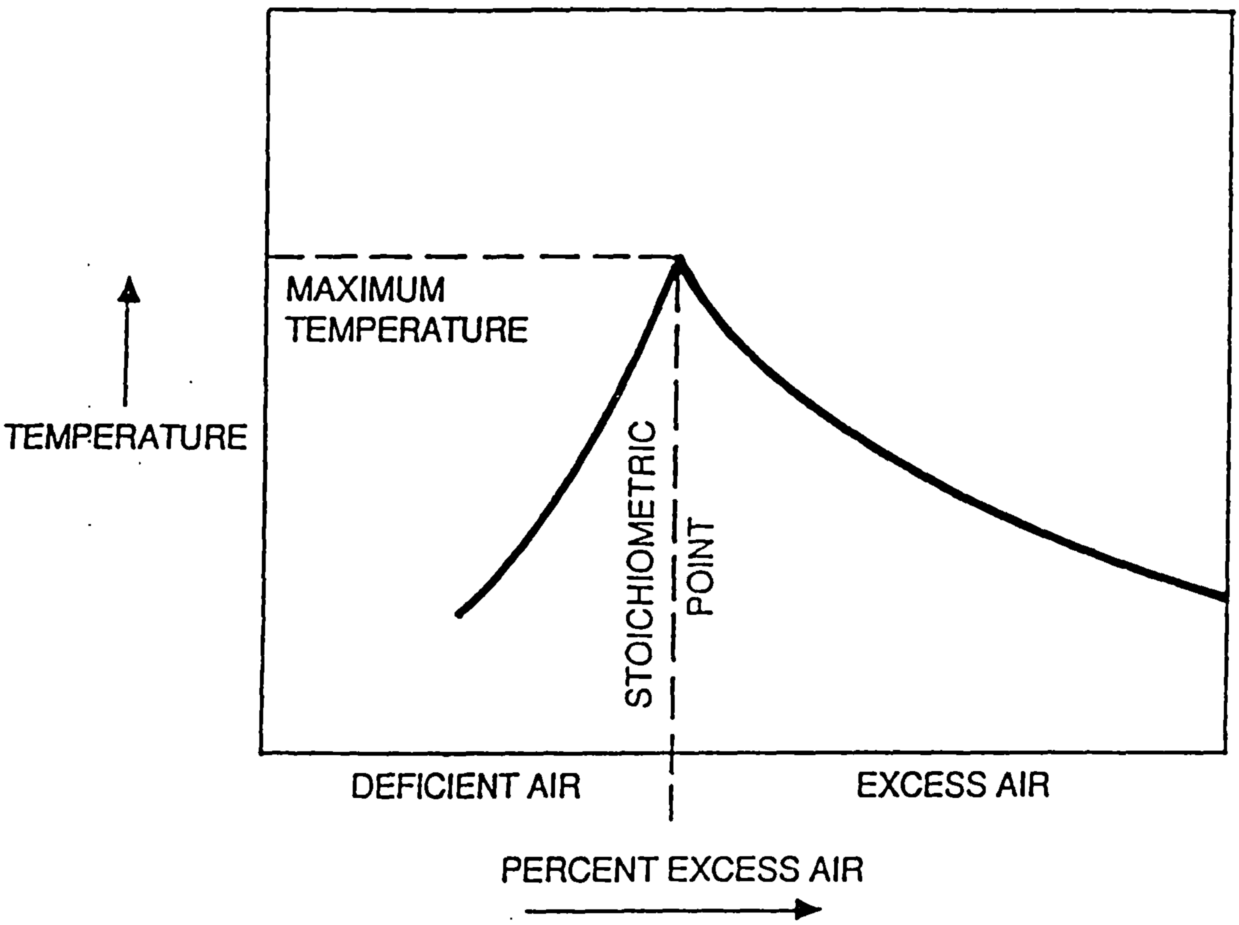
C + O2	→	CO2
H2 + 0.5 O2	→	H2O
O & N	→	Unchanged
Moisture	→	Unchanged
Inorganics	→	Ash

Starved-Air, Sub-Stoichiometric or Incomplete Combustion

Hydrocarbons plus O2 Deficiency → Carbon Dioxide, Water Vapor, Carbon Monoxide, PICs, Less Heat

Sub-Stoichiometric Air

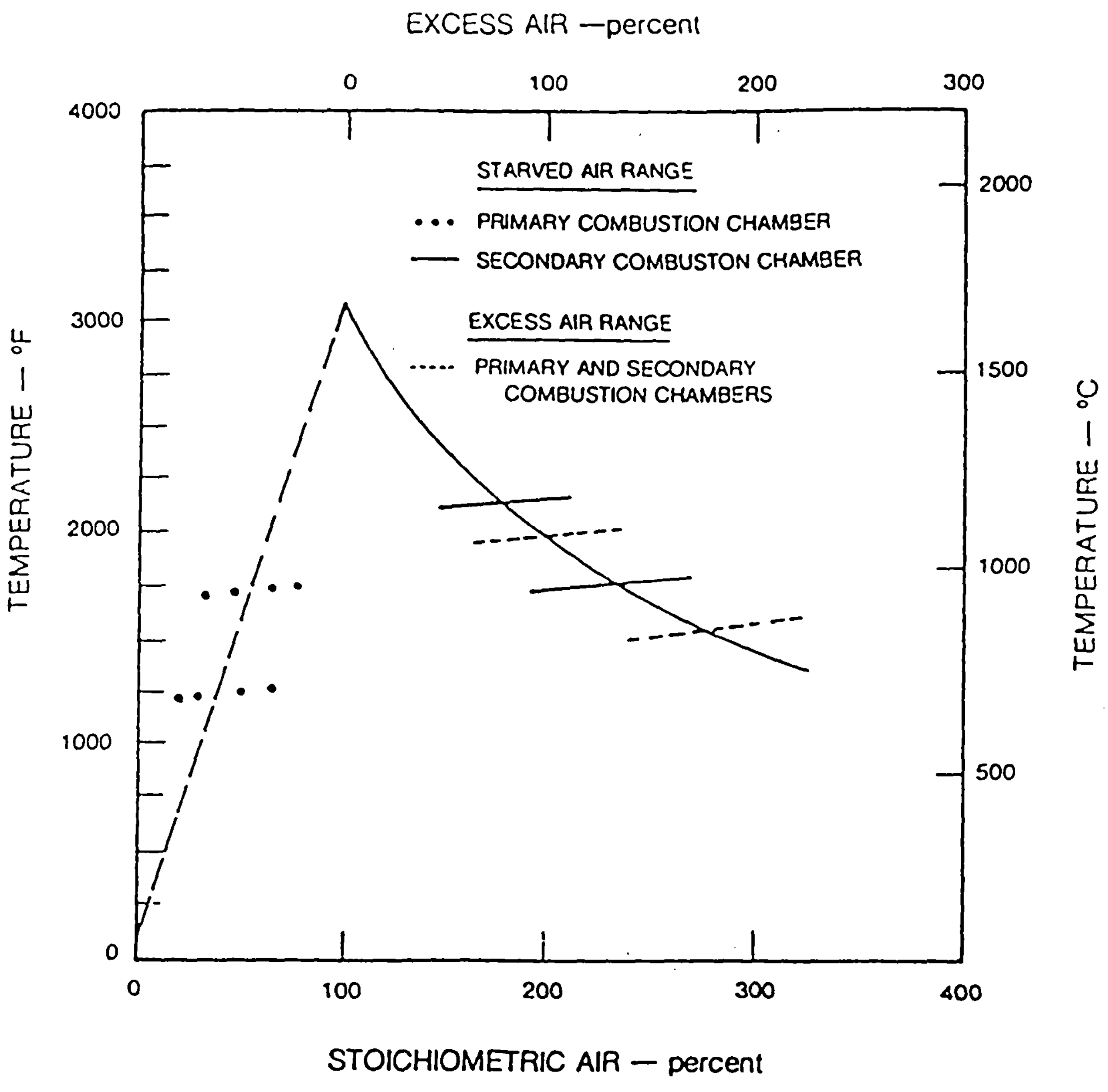
- Less Than Theoretical Air
- Smoke, Volatiles, And Hydrocarbons Formed
- Reduced Temperatures
  - Carbon to CO2 Releases 14,400 Btu/lb
  - Carbon to CO Releases 4,300 Btu/lb



CONTROL OF TEMPERATURE AS A FUNCTION OF EXCESS AIR

Ref: McRee, R., "Operation and Maintenance of Controlled Air Incinerators," Joy Energy Systems, Inc. (formerly Ecolaire Environmental Control Products) Undated.

TWO-STAGE INCINERATION



Ref: Joy Energy System, Inc. (Formerly Ecolaire Combustion Products, Inc.)

- Perfect Combustion
- Complete Combustion

Goal Is <u>Complete</u> Combustion

- Excess Air Required
- Good Controls Required
- PICs Are Inevitable

Excess Air

- Needed For Complete Combustion
- Typically 100-300% (Solids)
- Too Much ⟶ Inefficiencies
- Too Little ⟶ Poor Combustion

Too Much Excess Air

- Lower Temperatures
- More Auxiliary Fuel
- More Entrainment
- Larger Flue Gas Volumes
- More Horsepower
- Less Efficiency

Too Little Excess Air

- Poor Combustion
- Increased Emissions

Actual Combustion

HCs		CO_2 + H_2O
+ Inorganics	⟩	+ Excess Air
+ O_2		+ PICs
+ Excess Air		+ Inorganics

PICs

Products

of

Incomplete

Combustion

PICs

- Unburned HCs
- Reformed Molecules
- Trace Concentrations
- Ubiquitous To Combustion

Combustion

- Perfect, Theoretical or Stoichiometric
- Starved Air, Partial Pyrolysis or Sub-Stoichiometric
- Excess Air
- Two-Stage
- Complete

Basic Combustion Principles

- Temperature
- Time
- Turbulence

3 Ts Of Combustion

- Time
- Temperature
- Turbulence

Time

- Retention or Residence Time
- Solids
  - Ash Burnout
  - Hours
  - Function of design of operations
- Gases
  - Complete combustion
  - Seconds
  - Function of volume

Temperature

- Primary Chamber
- Secondary Chamber
- Function of Heat Balance
- Easiest of 3 Ts to Control

Temperature Control

- Combustion Air Modulation
- Auxiliary Fuel
- Waste Feed
- Water Injection

Turbulence

- Mixing of Combustion Reactants
- Increased Combustion Efficiencies
- Mechanical - Solids
- Aerodynamic - Gases

Mechanical Turbulence

- Hand Pokers
- Grates
- Rams
- Rotary Kiln
- Pulse Hearths

Aerodynamic Turbulence

- High Velocity Air Injection
- Baffles and Restrictions
- Directional Changes
- Cyclonic Flow
- Suspension Firing

Turbulence Factor:

Demonstrated Methodology

And

Proven Principles

Incinerator Design Principles

- 3 Ts
- Heat Release Rate
- Burning Rate
- Waste Type, Form and Size

Primary Chamber Sizing

- Heat Release Rate (Btu/cu ft/hr)
- Burning Rate (Btu or lb/sq ft/hr)

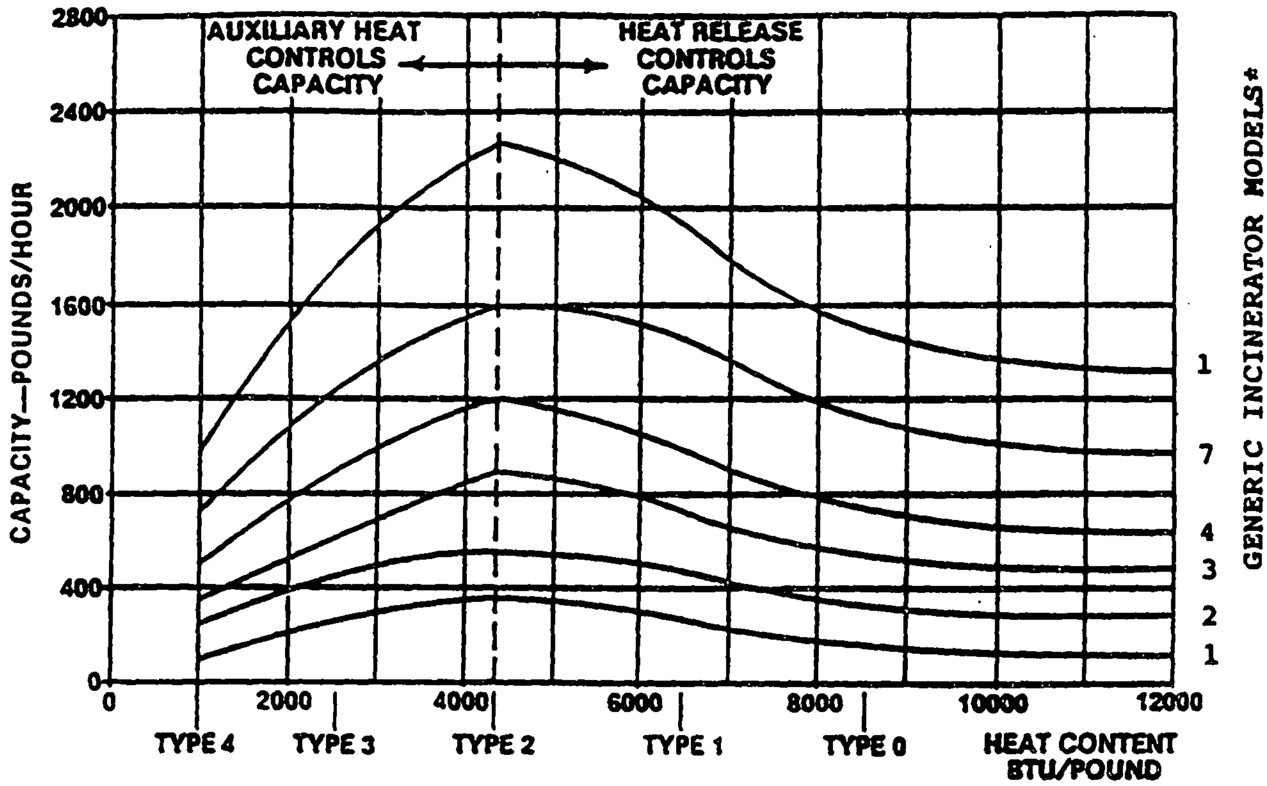
Heat Release Rate:

$$\frac{\text{(Btu/lb of Waste)} \times \text{(lb/hr of Waste)}}{\text{(cu ft of Primary Chamber Volume)}}$$

Burning Rate:

$$\frac{\text{(lb/hr of Waste)}}{\text{(sq ft of Primary Chamber Floor)}}$$

INCINERATION CAPACITIES AS A FUNCTION OF WASTE TYPES



MAXIMUM BURNING RATES

FOR SPECIFIC TYPES OF WASTE IN POUNDS PER HOUR

INCINERATOR* MODEL	TYPE 0	TYPE 1	PHS†	TYPE 2	TYPE 3	TYPE 4
30	225	290	300	375	285	240
50	375	480	500	575	475	400
75	575	735	750	900	600	600
100	750	975	1000	1200	900	800
150	1125	1475	1500	1800	1250	1200
200	1500	1950	2000	2300	1800	1600
250	1875	2400	2500	2900	2250	2000

† Public Health Service specified waste

*Generic Models (not related to any specific vendor)

MAXIMUM BURNING RATE LBS/SQ FT/HR
OF VARIOUS TYPE WASTE

CAPACITY Lbs./Hr.	LOGARITHM	#1 WASTE FACTOR 13	#2 WASTE FACTOR 10	#3 WASTE FACTOR 8	#4 WASTE NO FACTOR
100	2.00	26	20	16	10
200	2.30	30	23	18	12*
300	2.48	32	25	20	14*
400	2.60	34	26	21	15*
500	2.70	35	27	22	16*
600	2.78	36	28	22	17*
700	2.85	37	28	23	18*
800	2.90	38	29	23	18*
900	2.95	38	30	24	18*
1000	3.00	39	30	24	18*

*The maximum burning rate in lbs./sq. ft./hr. for Type 4 Waste depends to a great extent on the size of the largest animal to be incinerated. Therefore whenever the larges. animal to be incinerated exceeds 1/3 the hourly capacity of the incinerator, use a rating of 10# sq. ft./hr. for the design of the incinerator.

Above Figures calculated as follows:

MAXIMUM BURNING RATE LBS. PER SQ. FT. PER HR. FOR TYPES #1, #2 & #3 WASTES USING FACTORS AS NOTED IN THE FORMULA.

BR=FACTOR FOR TYPE WASTE X LOG OF CAPACITY/HR.

#1 WASTE FACTOR 13
#2 WASTE FACTOR 10
#3 WASTE FACTOR 8
BR=MAX. BURNING RATE LBS./SQ. FT./HR.

I.E.–ASSUME INCINERATOR CAPACITY OF 100 LBS./HR. FOR TYPE #1 WASTE

BR=13 (FACTOR FOR #1 WASTE) X LOG 100 (CAPACITY/HR.)
13 X 2 = 26 LBS./SQ. FT./HR.

Ref: Incinerator Institute of America <u>Incinerator Standards</u>, 1968

Secondary Chamber
Design Criteria

- Retention Time
- Temperature
- Turbulence

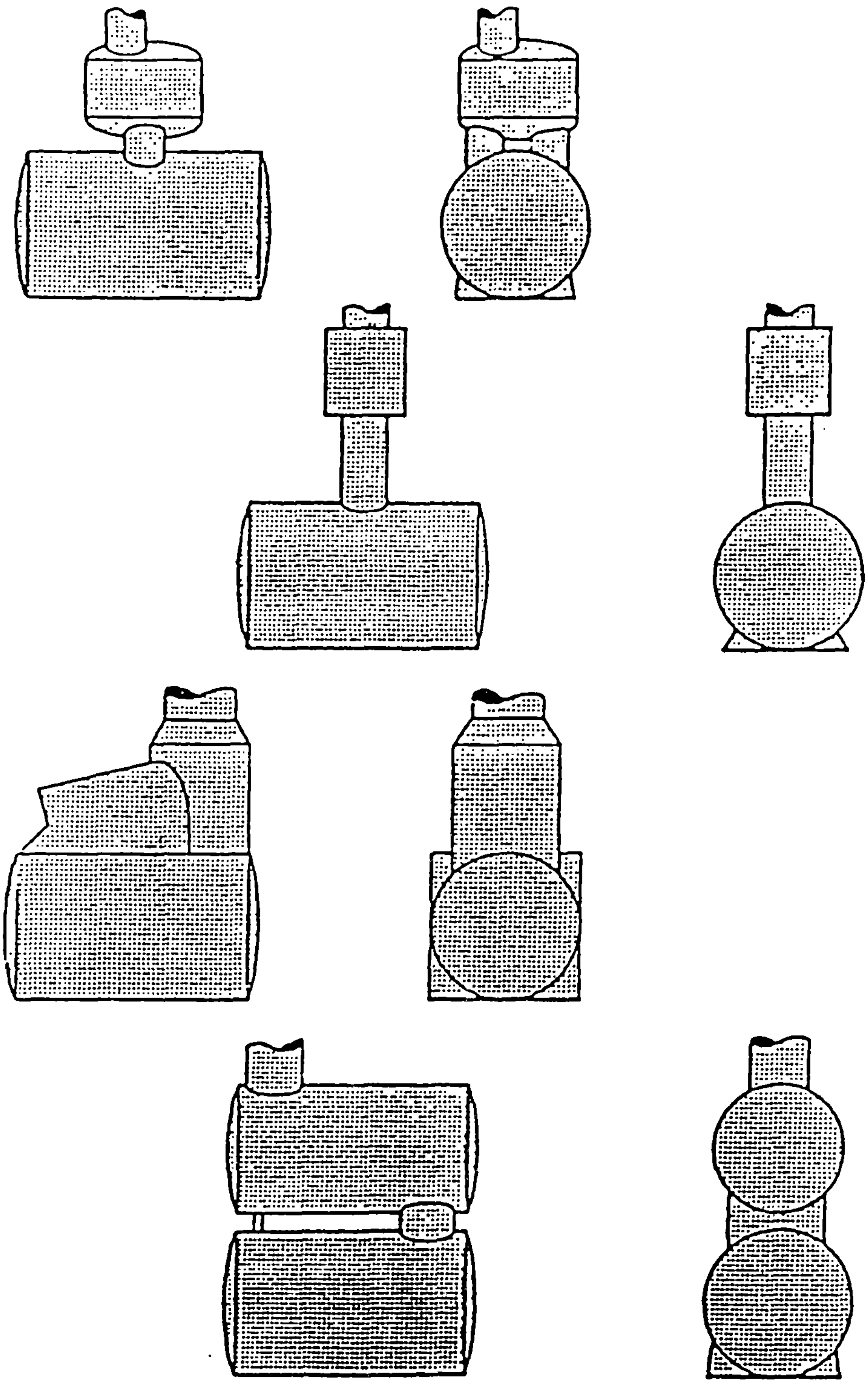
Secondary Chamber Sizing

- Retention Time (cu ft/sec)
- Turbulence
- Regulatory Requirements/Formulas

Retention Time:

$$\frac{\text{(cu ft Secondary Chamber Volume)}}{\text{(Actual cu ft/sec Flue Gas Flow)}}$$

TYPICAL CONTROLLED AIR INCINERATOR PROFILES



Ref: Doucet, L. G., State-of-the-Art Hospital & Institutional Waste Incineration: Selection, Procurement and Operations, 1980

Incineration

Capacity

Selection

Incineration Capacity Determination

- Selected Operating Hours
- Waste Generation Rates
- Waste Types
- Waste Forms
- Waste Load Sizes

Incinerator Operating Modes

- Single Batch
- Intermittent Duty
- Continuous Duty

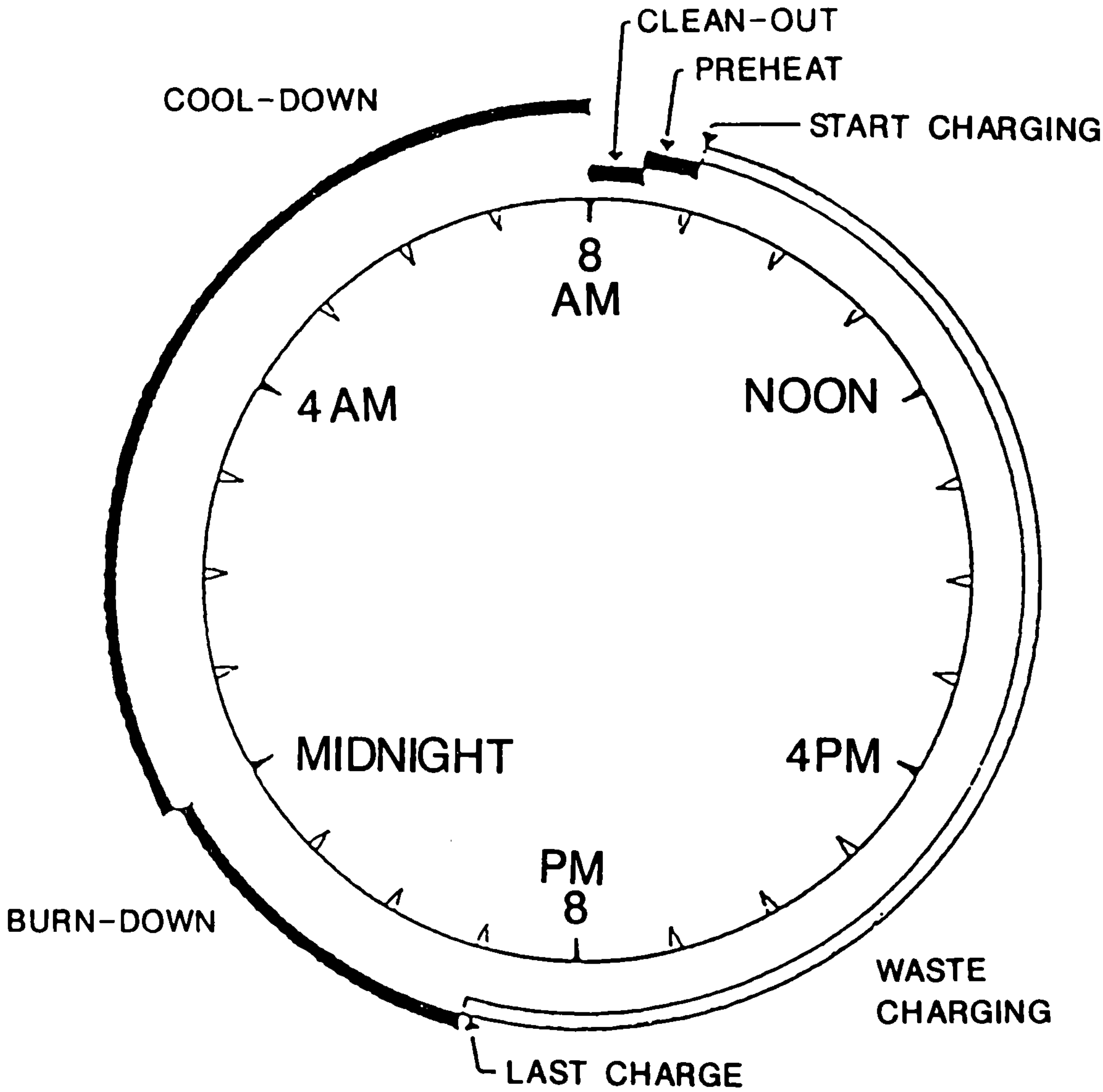
Intermittent Duty Operating Cycle with Manual Ash Removal

• Clean-Out	15-30 minutes
• Preheat	15-60 minutes
• Loading	12-14 hours
• Burndown	2-4 hours
• Cool Down	5-8 hours

Incineration System Calculations

- Sizing
  - Heat Release
  - Retention Time
- Combustion
  - Mass Flows
  - Combustion Air
  - Flue Gas Volumes
- Heat Balance
  - Operating Temperatures
  - Auxiliary Fuel & Excess Air
- Flue Gas System Sizing
  - Velocities
  - Pressure Losses
  - Draft

TYPICAL INTERMITTENT DUTY OPERATING CYCLE WITH MANUAL ASH REMOVAL



Ref: Doucet, L. G., State-of-the-Art Hospital & Institutional Waste Incineration: Selection, Procurement and Operations, 1980

MEDICAL & INSTITUTIONAL WASTE MANAGEMENT & INCINERATION WORKSHOP

Presented by: Lawrence G. Doucet, Doucet & Mainka, P.C.
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III. ALTERNATE INCINERATION TECHNOLOGIES

A. Multiple Chamber Incinerators
   1. Principles & background
   2. Types
      a. Retort
      b. In-line
   3. Design and operating criteria
   4. Applications

B. Rotary Kiln Incinerators
   1. Principles & background
   2. Design and operating criteria
   3. Applications

C. Controlled Air Incinerators
   1. Principles & background
   2. Design & operating criteria
   3. Variations and developments
   4. Applications

D. Other
   1. Alternate & emerging technologies
   2. "Innovative" technologies

Alternative

Incineration

Technologies

Basic Institutional Incinerator Technologies

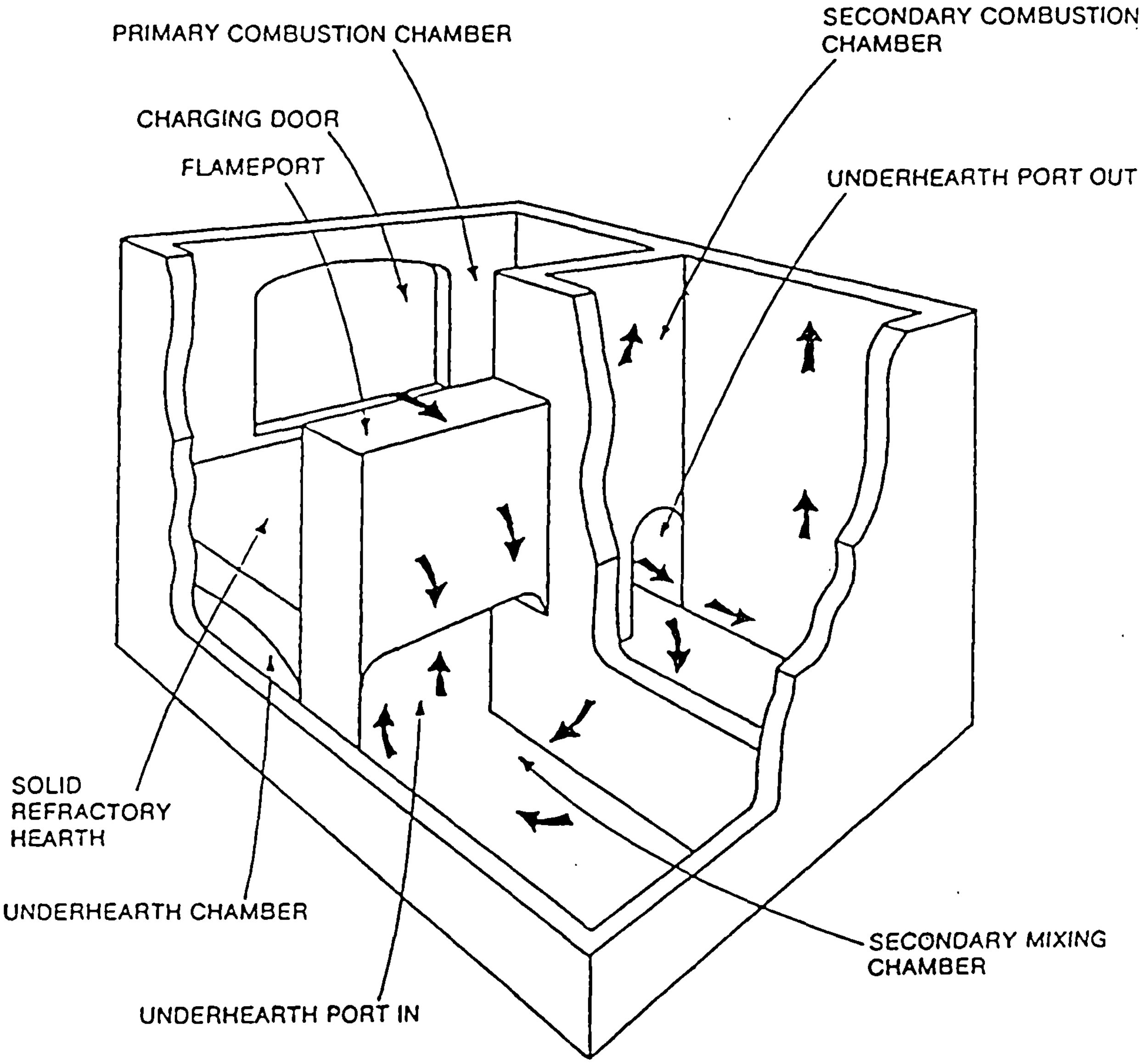
- Multiple-Chamber (IIA)
  - Retort
  - In-Line
- Rotary Kiln
- Controlled Air
- "Innovative" Systems

Multiple-Chamber Incinerators

- Incinerator Institute of America (IIA)
- Developed in mid-1950s
- Very High Excess-Air Levels
- Retort and In-line Designs

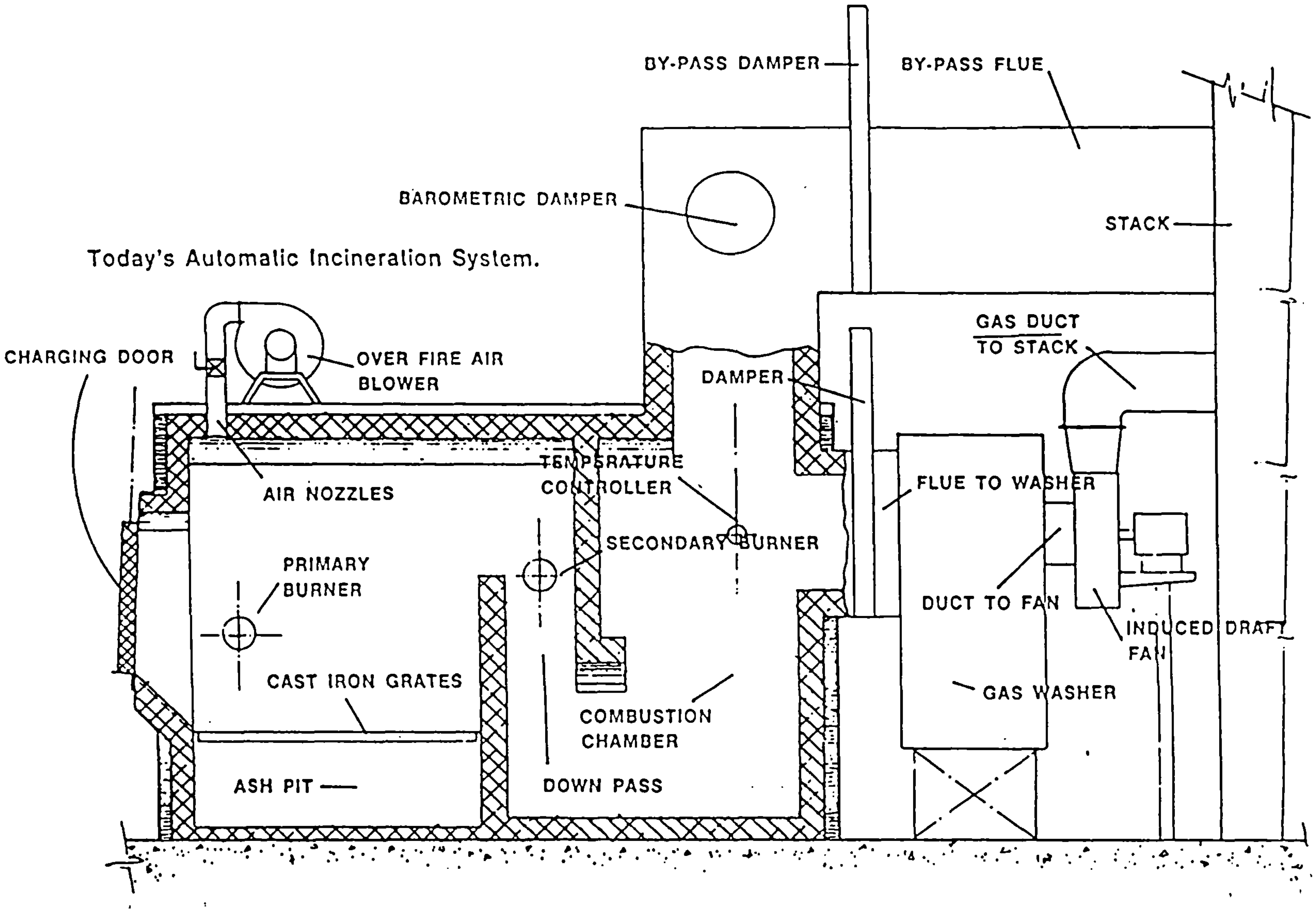
Multiple-Chamber Incinerators

- Retort
- In-Line



RETORT TYPE MULTIPLE CHAMBER INCINERATION

IN-LINE MULTIPLE CHAMBER INCINERATION SYSTEM



Today's Automatic Incineration System.

INCINERATOR INSTITUTE OF AMERICA (IIA) INCINERATOR CLASSIFICATIONS

CLASS I

Portable, packaged, completely assembled, direct fed incinerators, having not over 5 cu. ft. storage capacity, or 25 lbs. per hour burning rate, suitable for Type 1 or Type 2 Waste.

CLASS IA

Portable, packaged or job assembled, direct fed incinerators, 5 cu. ft. to 15 cu. ft. primary chamber volume, or 25 lbs. per hour up to but not including 100 lbs. per hour burning rate, suitable for Type 1 or Type 2 Waste.

CLASS II

Flue fed incinerators, with more than 2 sq. ft. burning area, suitable for Type 1 or Type 2 Waste. (Not recommended for industrial wastes.) This type of incinerator served by one flue to function both as a chute for charging waste and to carry the products of combustion.

CLASS IIA

Flue fed incinerators, with more than 2 sq. ft. burning area, suitable for Type 1 or Type 2 Waste. (Not recommended for industrial wastes.) This type of incinerator served by two flues, one for charging waste, and one for carrying the products of combustion.

CLASS III

Direct fed incinerators with a burning rate of 100 lbs. per hour and over, suitable for Type 1 or Type 2 Waste.

CLASS IV

Direct fed incinerators with a burning rate of 75 lbs. per hour or over, suitable for Type 3 Waste.

CLASS V

Municipal incinerators.

CLASS VI

Crematory and pathological incinerators, suitable for Type 4 Waste.

CLASS VII

Incinerators designed for specific by-product wastes, Type 5 or Type 6.

Ref: Incinerator Institute of America Incinerator Standards, 1968

MULTIPLE-CHAMBER INCINERATOR DESIGN FACTORS

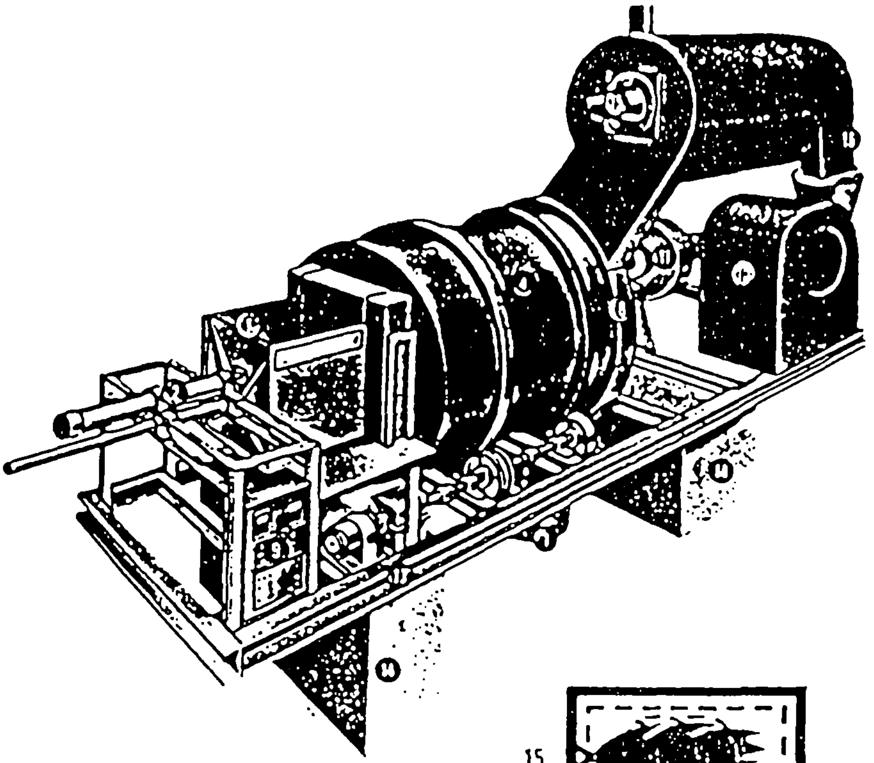
Item and symbol	Recommended value	Allowable deviation
Primary combustion zone:		
Grate loading, L_G	10 Log R_c: lb/hr-ft^2 where R_c equals the refuse combustion rate in lb/hr (refer to Figure 341)	± 10%
Grate area, A_G	R_c - L_G: ft^2	± 10%
Average arch height, H_A	4/3 $(A_G)^{4/11}$: ft (refer to Figure 342)	--
Length-to-width ratio (approx):		
Retort	Up to 500 lb/hr, 2:1; over 500 lb/hr, 1.75:1	--
In-line	Diminishing from about 1.7:1 for 750 lb/hr to about 1:2 for 2,000 lb/hr capacity. Over-square acceptable in units of more than 11 ft ignition chamber length.	--
Secondary combustion zone:		
Gas velocities:		
Flame port at 1,000°F, V_{FP}	55 ft/sec	± 20%
Mixing chamber at 1,000°F, V_{MC}	25 ft/sec	± 20%
Curtain wall port at 950°F, V_{CWP}	About 0.7 of mixing chamber velocity	--
Combustion chamber at 900°F, V_{CC}	5 to 6 ft/sec; always less than 10 ft/sec	--
Mixing chamber downpass length, L_{MC}, from top of ignition chamber arch to top of curtain wall port.	Average arch height, ft	± 20%
Length-to-width ratios of flow cross sections:		
Retort, mixing chamber, and combustion chamber	Range - 1.3:1 to 1.5:1	--
In-line	Fixed by gas velocities due to constant incinerator width	--
Combustion air:		
Air requirement batch-charging operation	Basis: 300% excess air. 50% air requirement admitted through adjustable ports; 50% air requirement met by open charge door and leakage	
Combustion air distribution:		
Overfire air ports	70% of total air required	--
Underfire air ports	10% of total air required	--
Mixing chamber air ports	20% of total air required	--
Port sizing, nominal inlet velocity pressure	0.1 inch water gage	--
Air inlet ports oversize factors:		
Primary air inlet	1.2	
Underfire air inlet	1.5 for over 500 lb/hr to 2.5 for 50 lb/hr	
Secondary air inlet	2.0 for over 500 lb/hr to 5.0 for 50 lb/hr	
Furnace temperature:		
Average temperature, combustion products	1,000 °F	± 20°F
Auxiliary burners:		
Normal duty requirements:		
Primary burner	3,000 to 10,000 Btu per lb of moisture in the refuse	
Secondary burner	4,000 to 12,000 Btu per lb of moisture in the refuse	
Draft requirements:		
Theoretical stack draft, D_T	0.15 to 0.35 inch water gage	--
Available primary air induction draft, D_A. (Assume equivalent to inlet velocity pressure.)	0.1 inch water gage	
Natural draft stack velocity, V_S	Less than 30 ft/sec at 900°F	--

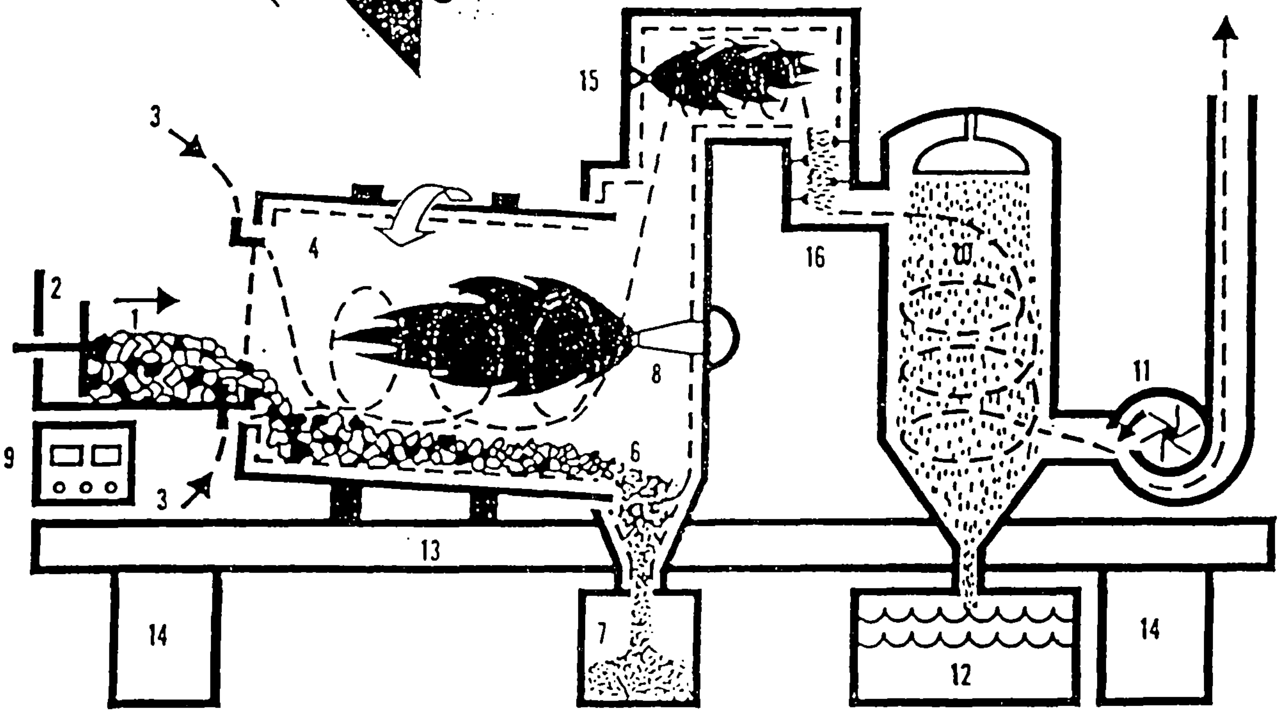
Ref: U.S. Dept. HEW, Air Pollution Engineering Manual, 2nd Edition, PHS Pub. AP-40, Air Pollution Control District, County of Los Angeles, 1973

Rotary Kiln Incinerators

- Versatile and Good Ash Quality
- Costly and Maintenance Intensive
- Waste Processing ("Auger" Loader)
- Infectious Waste Shredding Problems

ROTARY KILN INCINERATOR





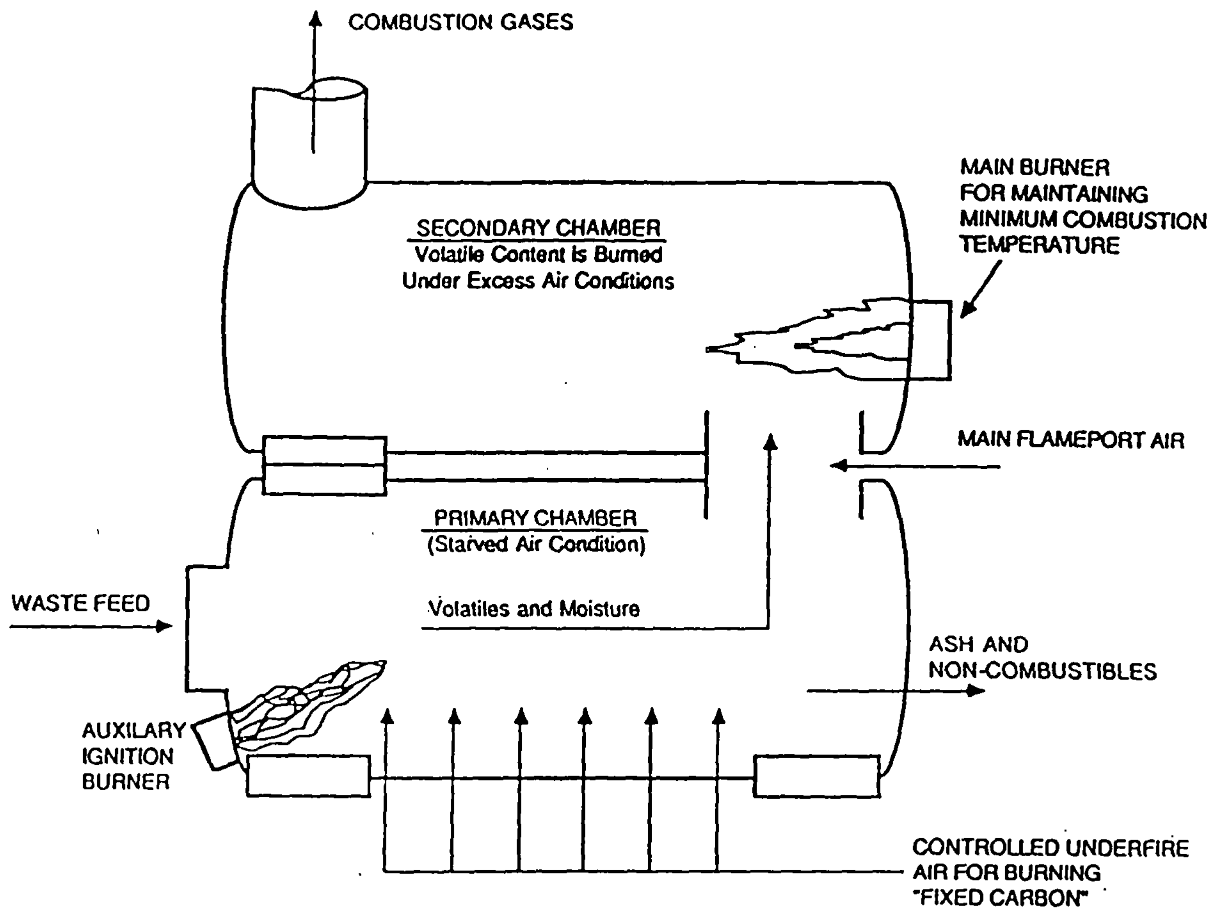
1 Waste to Incinerator
2 Auto-cycle feeding system: feed hopper, pneumatic feeder, slide gates
3 Combustion air in
4 Refractory-lined, rotating cylinder
5 Tumble-burning action
6 Incombustible ash
7 Ash bin
8 Auto-control Burner Package: programmed pilot burner
9 Self-compensating instrumentation-controls
10 Wet-Scrubber Package: stainless steel, corrosion-free wet scrubber; gas quench
11 Exhaust fan and stack
12 Recycle water, fly-ash sludge collector
13 Support frame
14 Support piers
15 Afterburner chamber
16 Precooler

Ref: C. E. Raymond, Inc.

Controlled Air Incinerators

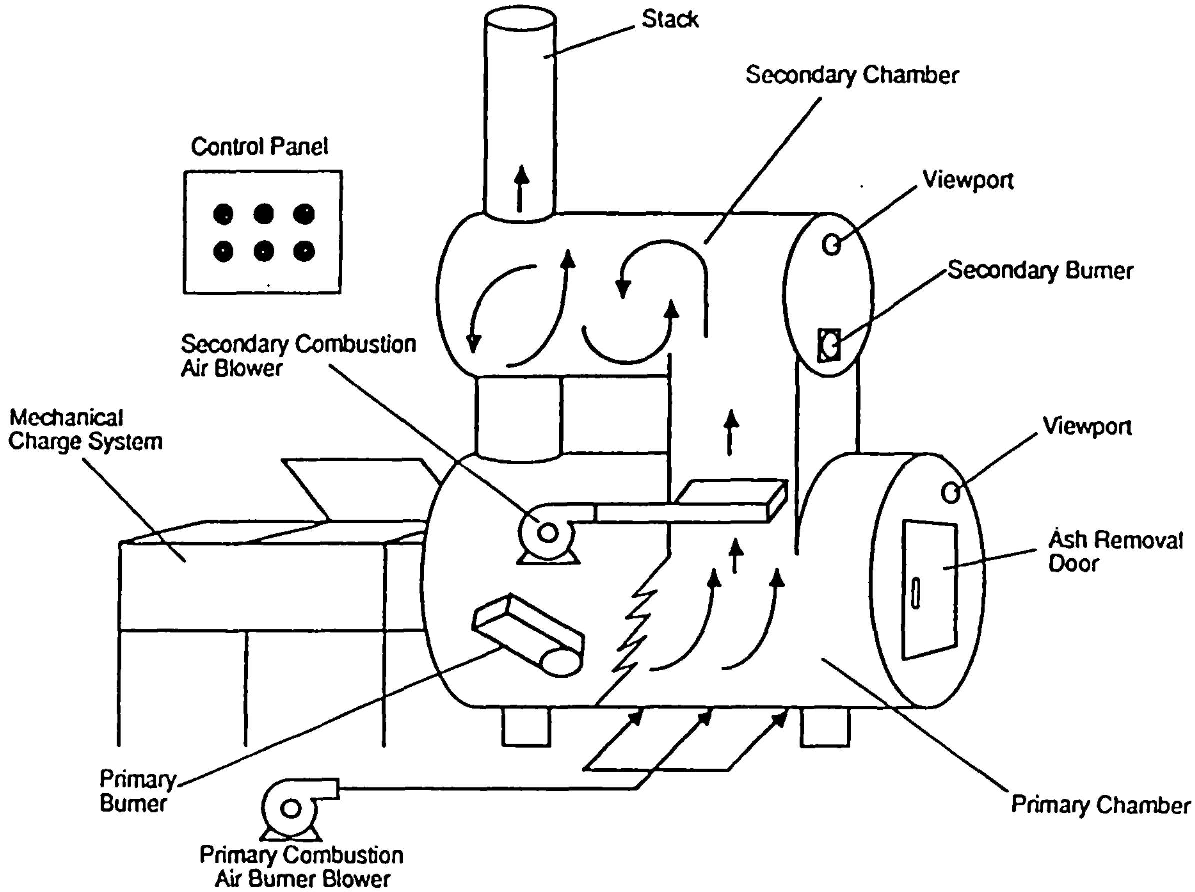
- Modular, "Starved Air", and Pyrolytic
- Two-Stage Combustion
  - Air deficient primary stage
  - Excess-air secondary stage
- Most Widely Used Technology

- Controlled Air Incinerators
- Modular Combustion Units
- Starved Air Incinerators
- Two-Stage Combustion Units
- "Pyrolytic" Incinerators
- "Stuff-and-Burn" Units



PRINCIPLE OF CONTROLLED-AIR INCINERATION

Ref: Joy Energy Systems, Inc. (Formerly Ecolaire) Article: "Principles of Controlled Air Incineration." Undated.



MAJOR COMPONENTS OF A CONTROLLED-AIR INCINERATOR

Ref: Hospital Incineration Operator Training Course Manual, EPA-450/3-89-004, March 1989.

"Innovative" Systems

- Avante Garde Designs
- Unusual Applications
- Many Unproven/Experimental
- "Perpetual Motion" Machines

MEDICAL & INSTITUTIONAL WASTE MANAGEMENT & INCINERATION WORKSHOP

Presented by: Lawrence G. Doucet, Doucet & Mainka, P.C.
John Bleckman, Doucet & Mainka, P.C.

IV. INCINERATION SYSTEMS & EQUIPMENT

A. Hearths, Grates & Combinations

B. Refractory & Linings

C. Auxiliary Fuel Systems
1. Primary chamber
2. Secondary chamber
3. Controls

D. Waste Handing & Loading
1. Handling & transport alternatives
2. Waste loading systems
3. Waste charging systems

E. Residue Removal & Handling
1. Alternative removal systems
2. Alternative handling systems

F. Waste Heat Recovery
1. Potential benefits
2. Alternative systems
3. Auxiliaries

G. Chemical Waste Incineration
1. Regulatory considerations
2. Alternative methods & systems
3. Design considerations

H. Radioactive Waste Incineration
1. Alternatives
2. Regulatory Considerations

I. Flue Gas Handling Systems
1. Stack design & construction
2. Stack height determination
3. Breeching systems
4. Draft & draft control
5. Dampers

J. Controls, Instrumentation & Monitoring
1. Combustion controls
2. C&I systems
3. Monitoring & recording
4. Continuous emissions monitoring (CEM)

Incineration

Systems And

Equipment

Basic Incinerator Burning Surface

- Refractory Hearths
  - Cold
  - Hot
- Grates
  - Fixed
  - Moving
- Combinations

Refractory

- Containment Of Combustion Process
- Reradiation
- Support Burning Mass And Residues
- Protection Of Personnel And Environment

Incinerator Linings

- Refractory
  - Castable
  - Fire Brick
- Insulation
- Casings
- Air Jacketing
- Shrouding

Auxiliary Fuel

- Ignition
- Pre-Heat
- Maintain High Temperatures
- Burn-Down

Primary Chamber Auxiliary Fuel

- Ignition
- Pre-Heat
- Low Energy Waste

Secondary Chamber Auxiliary Fuel

- Pre-Heat
- High Temperature Maintenance
- Flame Presence

Burner Controls

- Manual Switch
- Timer Switch
- Automatic On-Off Or High/Low
- Modulation
- Modulation With Air Blowers

Waste

Handling

Waste Handling System

- Collection And Transport
- Interim Storage
- Pre–Treatment
- Incinerator Loading

Incinerator

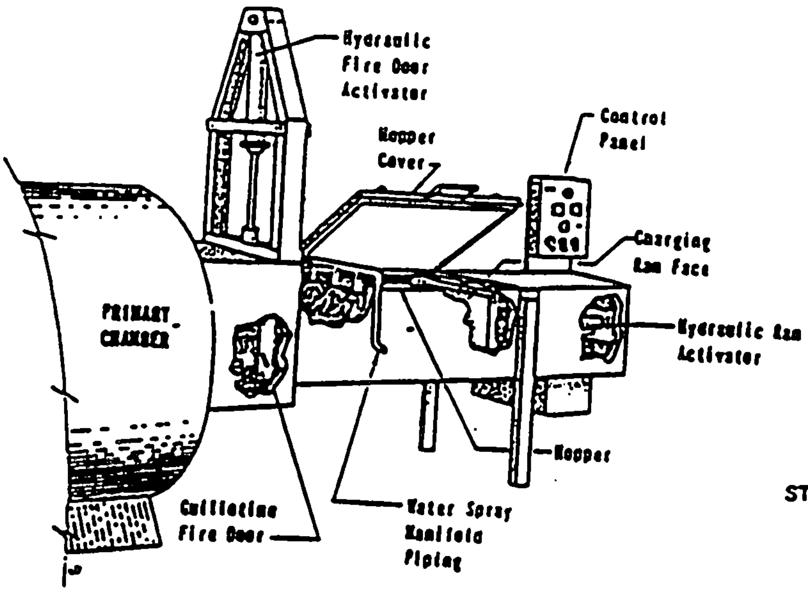
Loading

Incinerator Loading Systems

- Hopper/Ram Loaders
- Auger Feeders
- Top Loaders
- High-Volume Loaders

Incinerator Charging Methods

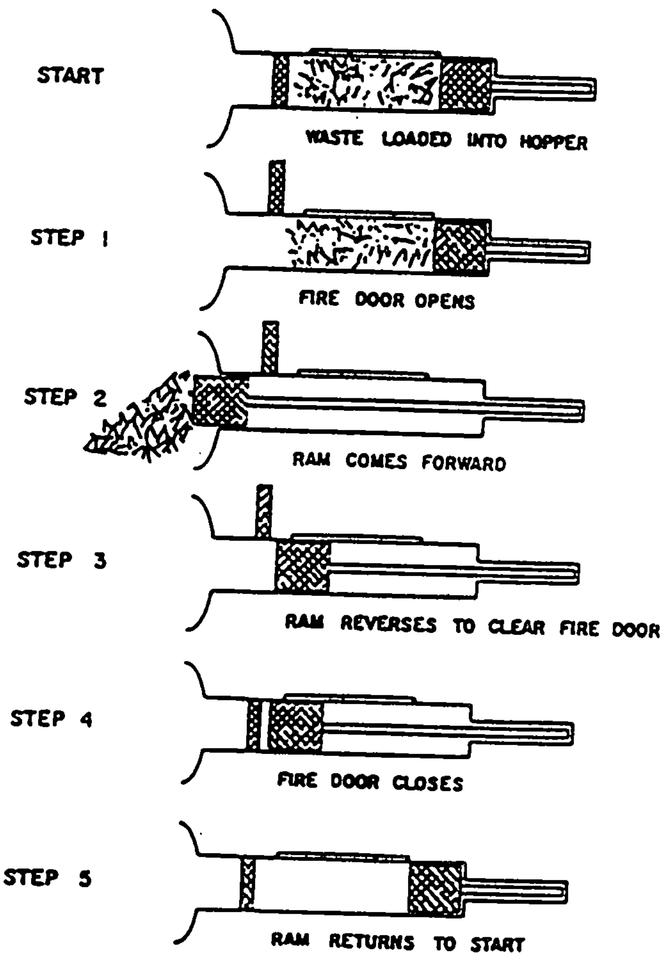
- Manual
- Tilt Carts
- Cart Dumpers
- Tractors
- Conveyors



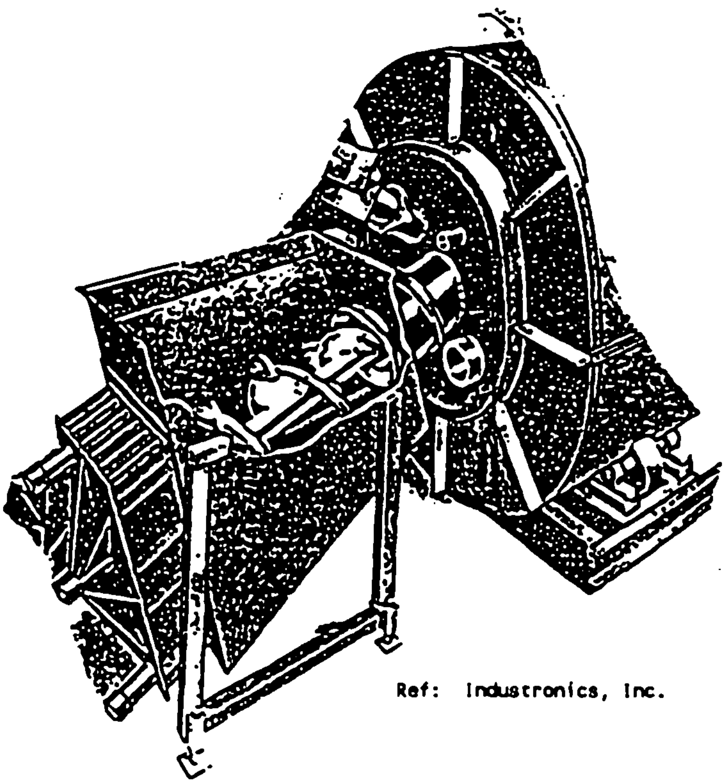
HOPPER/RAM LOADER SYSTEM

Ref: Doucet, L. G., <u>NFPA Fire Protection Handbook</u>, "Waste Handling Systems and Equipment," 16th Edition, Chapter 14, Section 12, 1985

LOADER SCHEMATIC



Ref: Consumat Energy Systems, Inc.



ROTARY KILN AUGER FEEDER

Ref: Industronics, Inc.

Residue

Handling

Residue Handling

- Incinerator Discharge/Removal
- Collection/Containment
- Sampling And Analysis
- Disposal

Ash Removal Technologies

- Manual
- Bomb-Bay Doors
- Batch Ejectors
- Continuous Systems
  - Stokers
  - Transfer Rams
  - Pulse Hearths

Ash Handling Methods

- Fully Manual
- Semi-Automatic (Carts)
- Fully-Automatic
  - Drag Conveyors
  - Back-Hoes or Scoops

Waste Heat Recovery

Comparative Energy Values (As-Fired)

- Propane Gas 22,000 Btu/lb
- Distillate Fuel Oil 19,500 Btu/lb
- Bituminous Coal 12,000 Btu/lb
- Wood 8,500 Btu/lb
- Mixed Paper 7,500 Btu/lb
- Medical Waste 7,000 -9,000 Btu/lb

Reasons For Heat Recovery

- Favorable Economics
- Regulatory Requirement
- Energy Grant
- Conditioning For APC System

Waste Heat Recovery

- Fire-Tube Boilers
- Water-Tube Boilers
- Fired-Boilers
  - Combined
  - Separate

Chemical Waste Incineration Options

- Dedicated Incinerator
- Boiler Firing
- Co-Disposal in Solid Waste Incinerator

Alternates for Co-incinerating Chemical Waste in Solid Waste Systems

- Bulk Loading (Containers)
- Injector Nozzles
- Dedicated Liquid Waste Burner
- Dual-Fired Burner (Fuel & Waste)

Chemical Waste Incineration System

- Collection & Transport
- Storage/Holding Tank
- Pumping System
- Burner or Injector System
- Controls, Safeguards, & Monitors
- Special Enclosure

Enclosure Room

- Fire Rated
- Special Ventilation
- Explosion Proof Electrical
- NFPA 30: "Flammable and Combustible Liquids Code"

Ignitable (I) Hazardous Waste Incineration

- Flammability - Flashpoint <140F
- Incinerator Not "Hazardous"
- Part B Permit Required For TSD Operations

"Hazardous" Waste Incineration

- RCRA Regulations
- Part B Permitting
- Trial Burn Testing
- Continuous Monitoring

RCRA (Sub-Part O)
Incineration Requirement

- Part B Permit
- Trial Burn Test
  - 99.99% destruction and removal efficiency (DRE)
  - Particulate <0.08 grain/dscf @ 7% CO_2
  - HCl <4 lb/hr or 99% removed
- Continuous Monitoring and Control

POHCs

Principal

Organic

Hazardous

Constituents

Part B Permit

- Waste S & A Plans
- Inspection
- Contingency Plans
- Record Keeping
- Personnel Training

- Security Plans
- Closure Plans
- Liability Coverage
- Etc.

Radioactive Waste Incineration

- NESHAPs Dose Levels and 10% of 10CFR20 Levels
- Biomedically Exempt
- DIS for 10 Half-lives

Mixed Waste

- RCRA and NRC Regulations
- NESHAPS

Flue Gas Handling

- Breeching
  - High Temperature
  - Low Temperature
- Stacks
  - Main
  - Abort, Dump Or By-Pass
- Dampers
- Draft Inducers

Stack Height Determination

- Surroundings
- Building And Fire Codes
- Draft Requirements
- Entrapment Avoidance
- Ambient Modeling/Dispersion

Stack Accessories

- Exit Cone
- Spark Arrestor
- Test Ports (with platform)
- Ladder with Safety Cage
- Lightning Protection
- Aircraft Warning Lights
- Clean-Out Door
- Drain
- Instrumentation

Stack Construction

- High Temperature - Refractory
- Low Temperature - FRP
- Masonry
- Special

Incinerator Draft

- Natural
- Forced
- Induced
- Balanced

Draft Controls

- Barometric Damper
- Modulating Damper
- Variable Speed Fan

Controls, Instrumentation

and

Monitoring

Combustion Controls

- Waste Charging (Fuel)
- Burner Modulation
- Air Modulation
- Draft Modulation
- Integration Of All The Above

C & I Systems

- Mechanical/Electrical Systems
- Solid State PC's System
  - Tough Screen
  - Self-Checking/Self-Calibration
  - Modems

Typical Monitoring and Recording

- Temperatures
  - Primary/Secondary Chambers
  - Boiler Inlet/Outlet
  - APC Inlet/Outlet
- Pressures
  - Primary Chamber (Draft)
  - APC Pressure Drop
  - Boiler Pressure Drop
  - Combustion Air Manifolds
  - Scrubber Water
- Flows
  - Scrubber Water and Blowdown
  - Auxiliary Fuel
  - Recovered Steam
- Scrubber pH
- Emissions

Gas Monitor Certification

- EPA Testing Protocol
- Proof of Accuracy

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V. EMISSIONS, APC & RISKS

A. Incinerator Emissions
1. Particulate
2. Gaseous
3. HCl

B. Air Pollution Control
1. Wet scrubbers
a. Scrubber types & applications
b. Design & operational criteria
c. Scrubber system components
d. Reheating
2. Dry scrubbers
a. Fabric filters (baghouse filters)
b. Electrostatic precipitators (ESPs)
c. "Dry" scrubbers
d. Gas conditioning

C. Ambient Impact Assessments
1. Methodologies
2. Health & environmental risks

VI. INCINERATOR REGULATIONS & PERMITTING ISSUES

A. Regulatory Categories
1. Equipment & components
2. Operating conditions
3. Stack emissions
4. Monitoring & recording
5. Testing
6. Permitting & recertification
7. Operator training/certification
8. Risk/environmental assessments

B. BACT & Regulatory Justification

C. Public Hearings & Acceptance
1. Public concerns
2. The real issues

Incinerator

Emissions

Incinerator Emissions

- Particulate
- Gaseous

Particulate Emissions

- Combustible
  - Char
  - Soot
- Mineral (Inorganics)
  - Metals
  - Silicates
  - Salts

Gaseous Emissions

- Combustible
  - Hydrocarbons
  - CO
  - PCDD And PCDF
- Non-Combustibles
  - Nitrogen Oxides
  - Acid Gases
  - Volatile Metals (Uncondensed)
  - Excess Air

Gaseous Emissions

Dry and Wet	CO, NOx, H2O, etc.
Combustibles	Volatiles, CO, HCs, etc.
Noncombustibles	NOx, SOx, HCl, etc.
Hazardous Compounds	POHCs
Products of Incomplete Combustion	PICs, Dioxins, Furans, etc.

HCl Emission Concerns

- Corrosion/Deterioration
  - Equipment
  - Other Structures

- Regulatory
  - Mass Rates
  - Flue Gas Concentration
  - Ambient Concentrations
  - Emission Control Equipment

- "Possible" Precursor of PCDD/PCDF Formation

- Polyvinyl Chlorides (PVC)

- Hydrogen Chloride (HCl)

- 2–3 lb PVC = 1 lb HCl

- "PVC" Plastics Are ~30–50% PVC

- PVC Plastics = ~10% Total Plastics

Air

Pollution

Control

Incineration Air Pollution Control

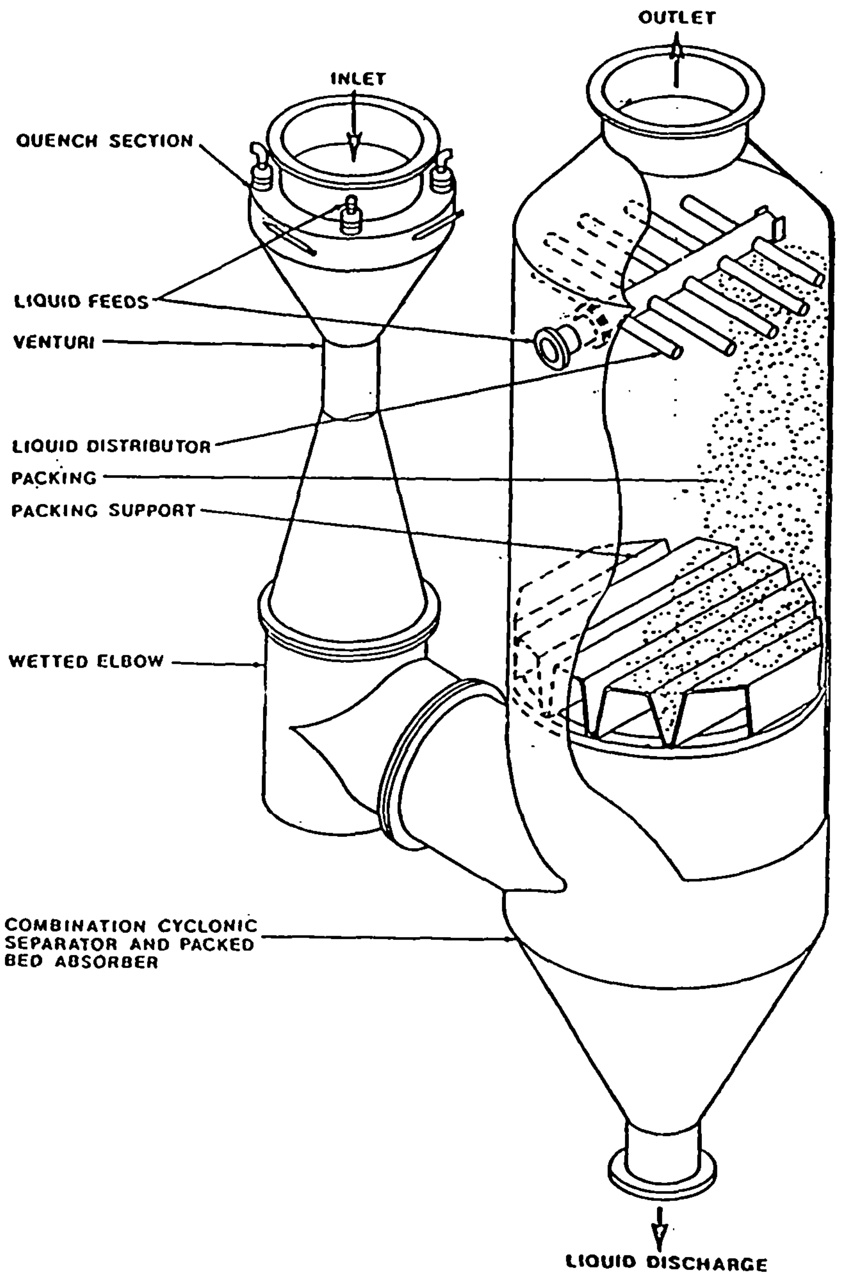
- Wet Scrubbers
  - Spray tower
  - Impingement tray
  - Venturi
  - Ionizing wet scrubber
  - Packed tower
- Dry Scrubbers
  - Baghouse filter
  - Electrostatic precipitator
  - Electrified granular filter
  - "Dry scrubber"

Wet Scrubbers

- Spray Towers
- Venturi Scrubbers
- Packed-Bed Scrubbers

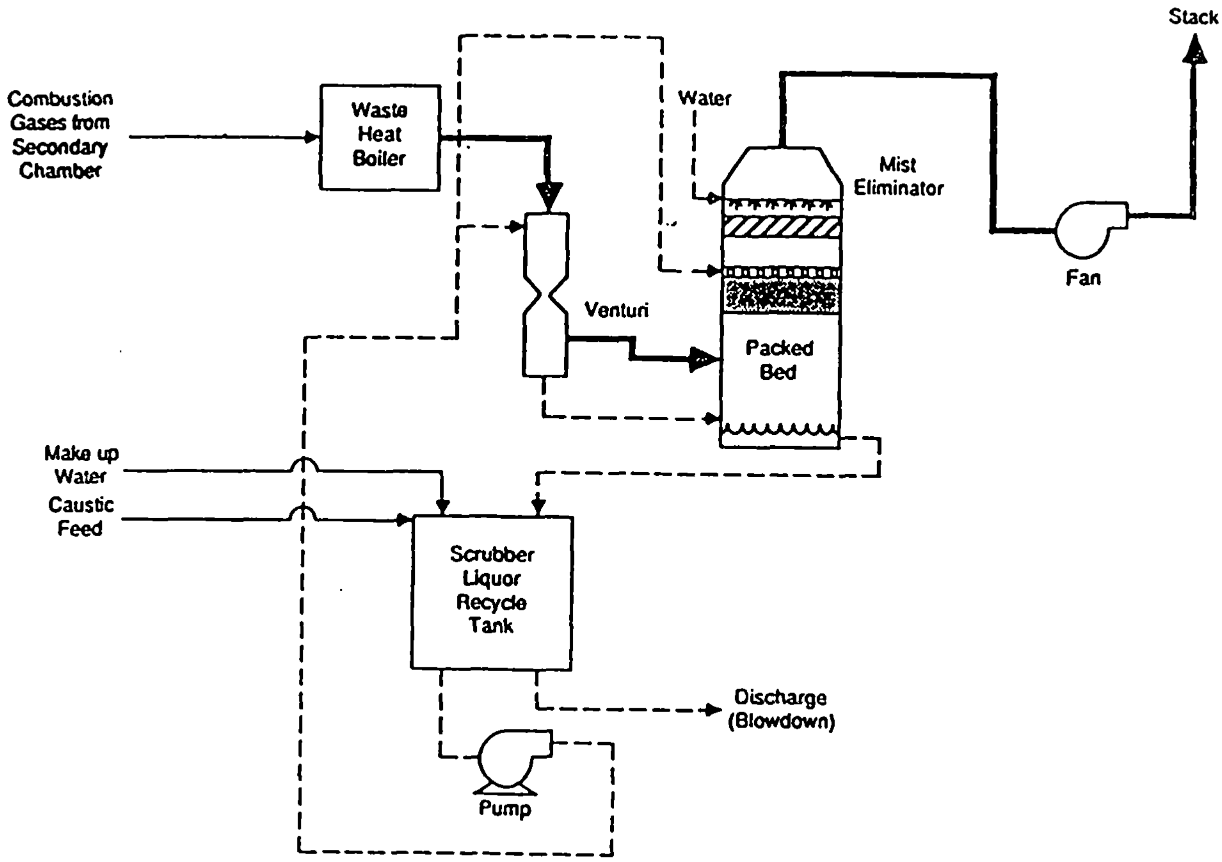
Venturi Scrubber System Components

- Quench
- Venturi
- Separator
- Packing Section
- Mist Eliminator
- Sub-Cooler
- Water System
- Caustic Feed



VENTURI SCRUBBER SYSTEM

Ref: Andersen 2000, Inc.



VENTURI SCRUBBER WITH PACKED BED

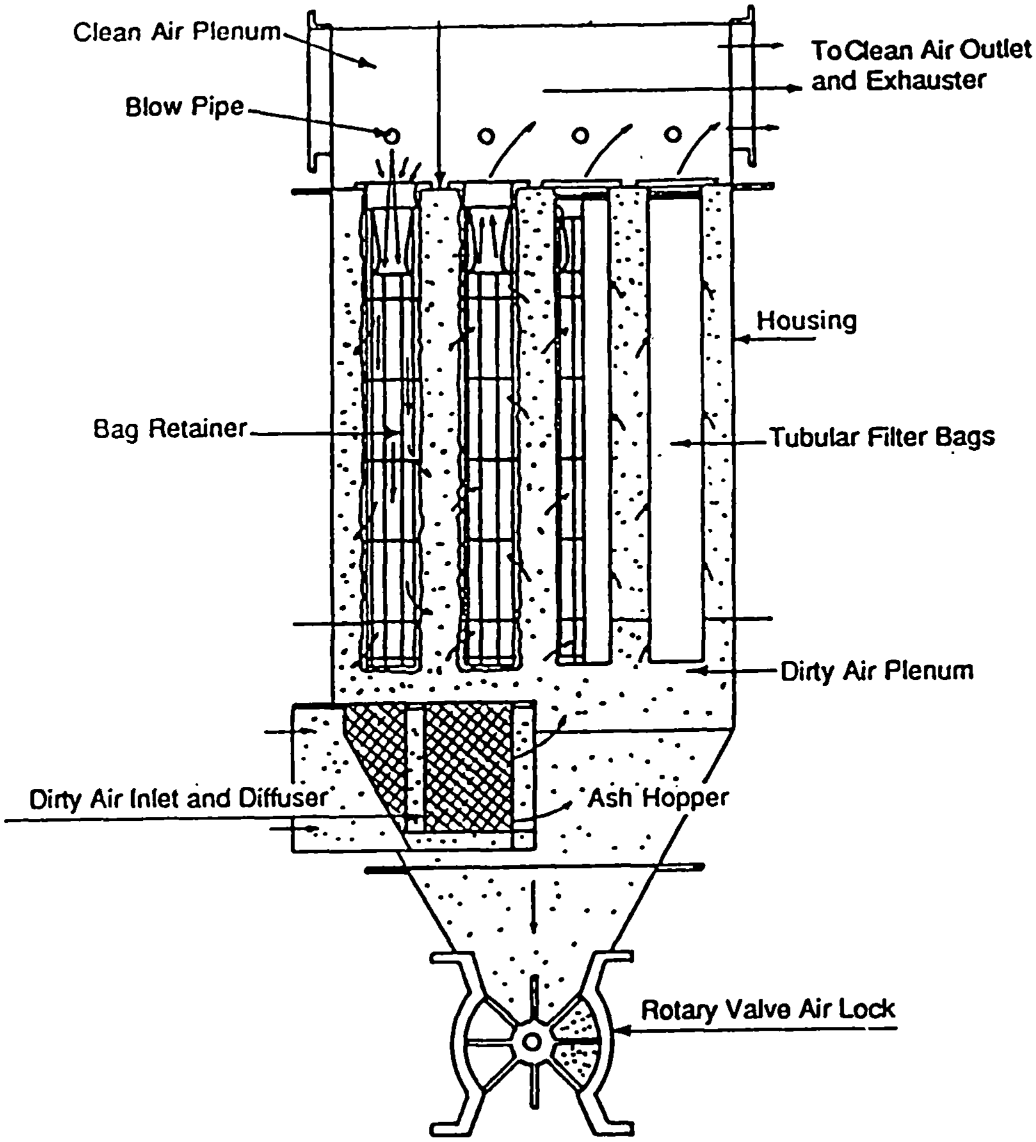
Ref: <u>Hospital Incineration Operator Training Course Manual</u>, EPA-450/3-89-004, March 1989.

Dry Scrubbers

- Fabric Filters
- Electrostatic Precipitators
- "Dry" Scrubbers
  - Dry Injection
  - Spray Dryer

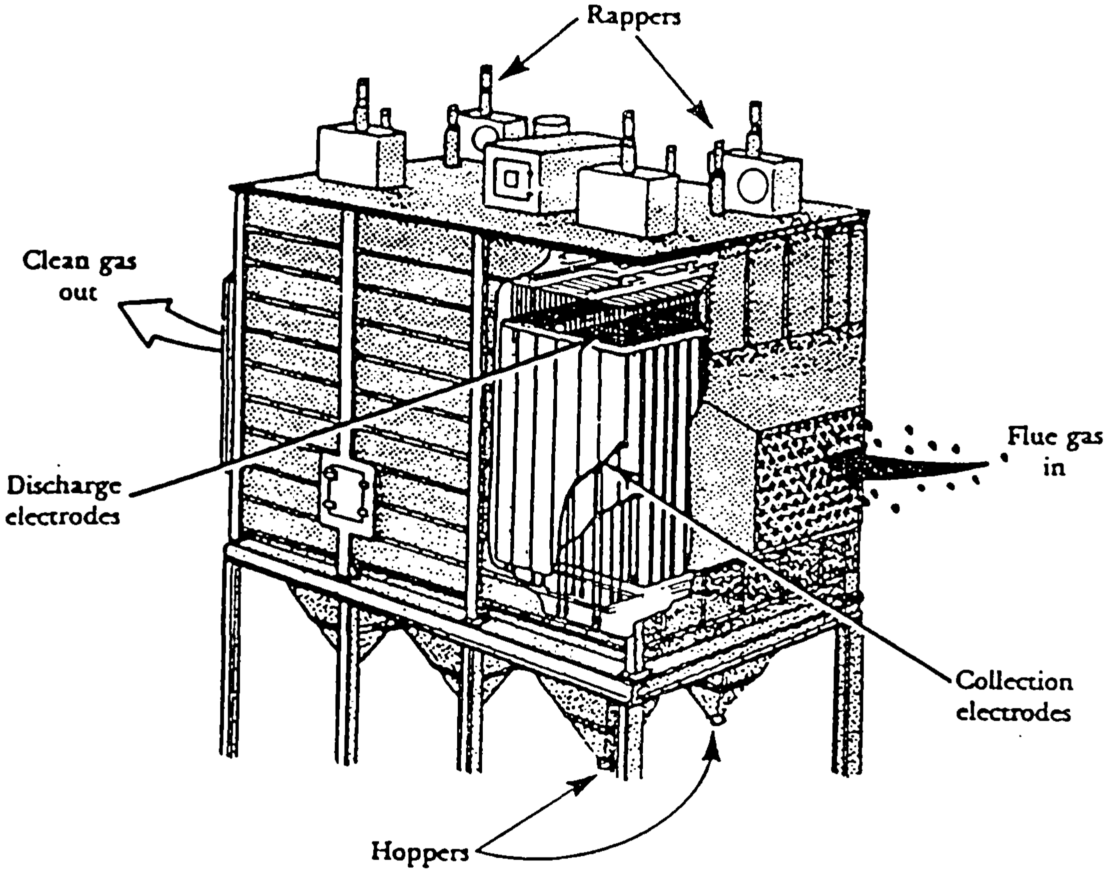
Flue Gas Conditioning

- Air Attenuation
- Evaporative Cooling
- Heat Exchanger



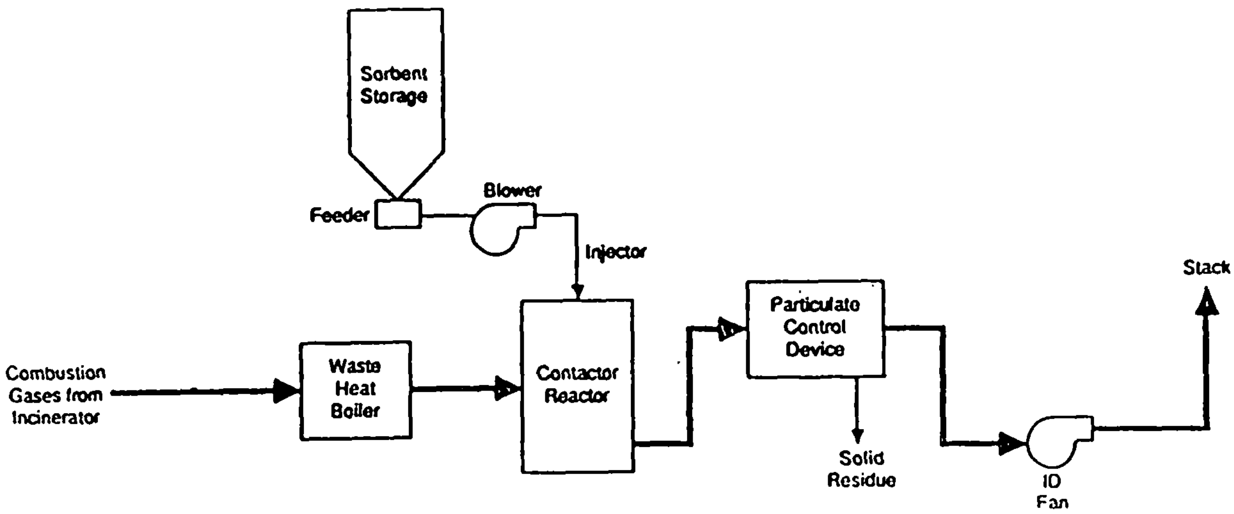
PULSE JET TYPE BAGHOUSE FILTER

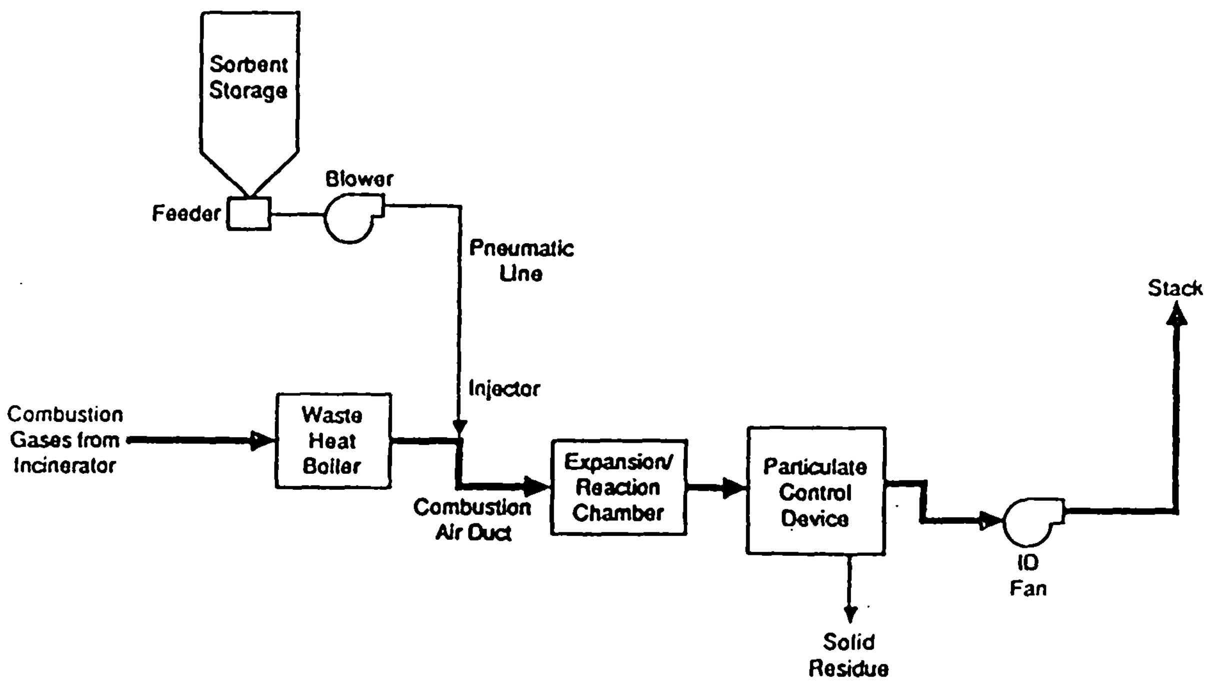
Ref: U.S. Environmental Protection Agency, "Controlled Techniques for Particulate Emissions from Stationary Sources," Volume 1. EPA-450/3-81-005a. (NTIS PB 83-127498) September 1982



ELECTROSTATIC PRECIPITATOR

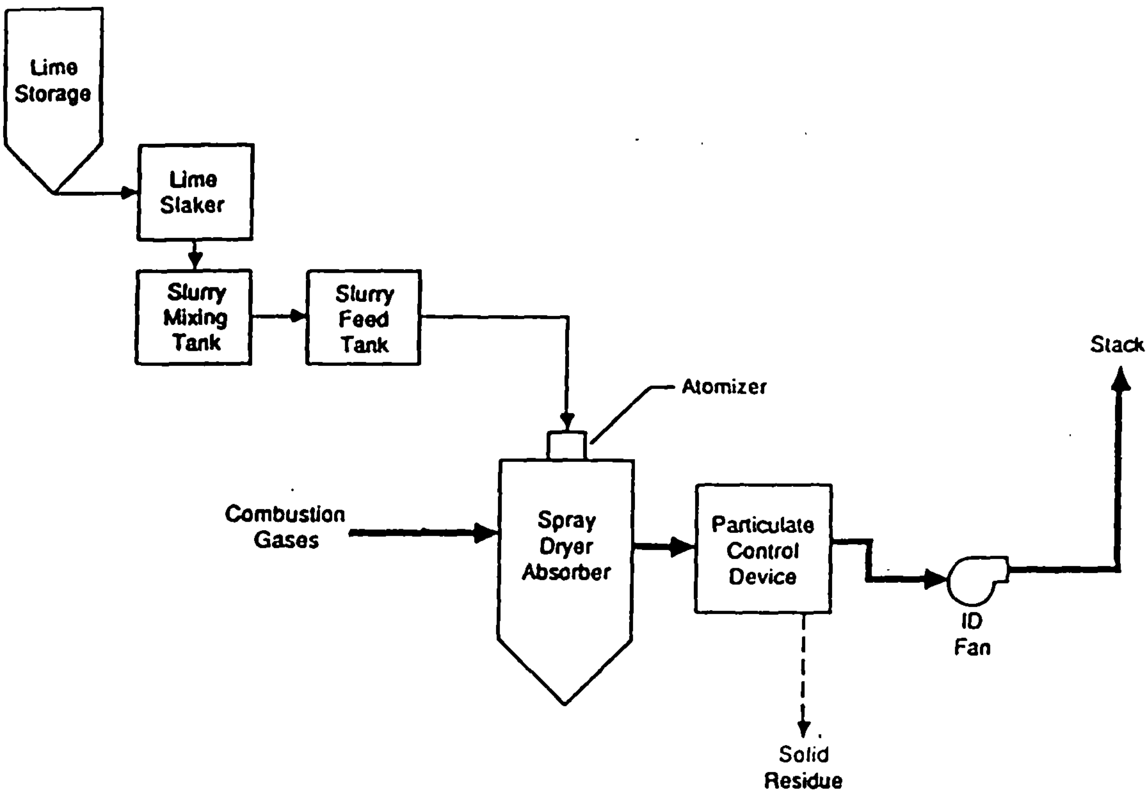
Ref: U.S. Environmental Protection Agency, APTI Course SI:412B, "Electrostatic Precipitator Plan Review," Self-Instructional Guidebook. EPA-450/2-82-019. July 1983





DRY INJECTION ABSORPTION SYSTEMS

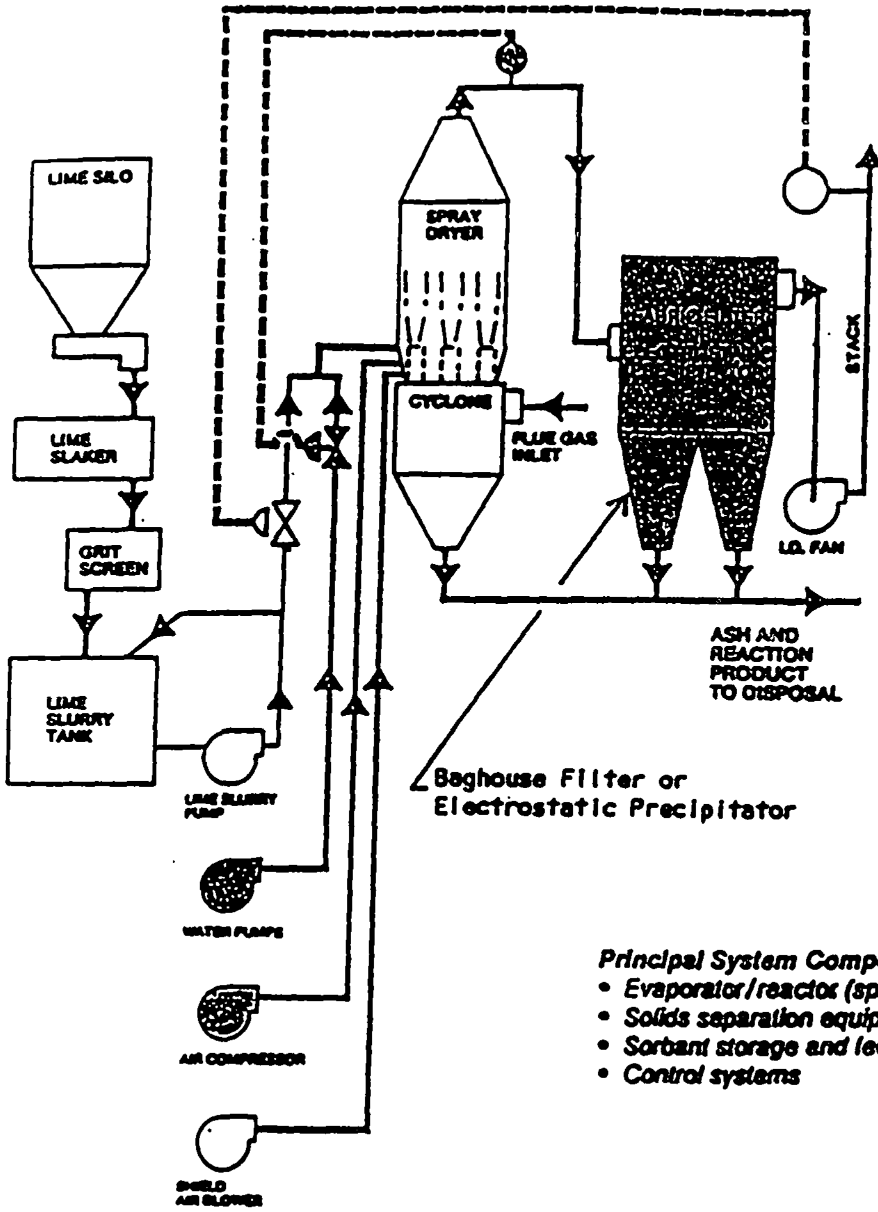
Ref: Hospital Incineration Operator Training Course Manual, EPA-450/3-89-004, March 1989.



SPRAY DRYER ABSORPTION SYSTEM

Ref: Hospital Incineration Operator Training Course Manual, EPA-450/3-89-004, March 1989.

DRY SCRUBBER SYSTEM

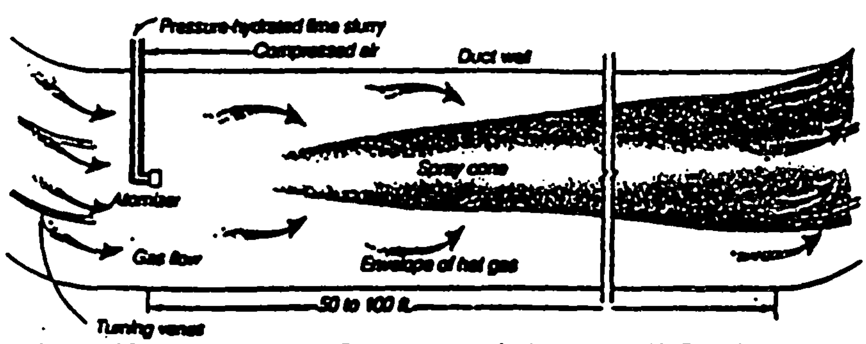


Major Reactions

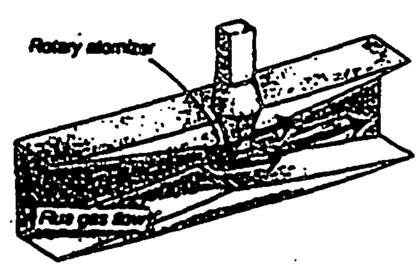
$Ca(OH)_2 + 2\,HCl$	$CaCl_2 + 2\,H_2O$
$Ca(OH)_2 + 2\,HF$	$CaF_2 + 2\,H_2O$
$Ca(OH)_2 + SO_2$	$CaSO_3 + H_2O$
$Ca(OH)_2 + SO_2 + \frac{1}{2}\,O_2$	$CaSO_4 + H_2O$
$Ca(OH)_2 + CO_2$	$CaCO_3 + H_2O$

alkaline materials:
- $Ca(OH)_2$—Calcium Hydroxide (hydrated lime)
- Na_2CO_3—Sodium Carbonate (soda ash)
- Na OH—Sodium Hydroxide (caustic soda)
- Sodium Sesquicarbonate (trona)
- NH_3—Ammonia

Principal System Components Are:
- *Evaporator/reactor (spray dryer)*
- *Solids separation equipment (baghouse or precipitator)*
- *Sorbent storage and feeding equipment*
- *Control systems*



1. In-duct SO_2-removal scheme relies on pressure-hydrated dolomitic-lime slurry injected with a dual-fluid nozzle to distribute it into the flue gas



2. Rotary atomizer is used in a horizontal ductwork configuration

Ref: Power, July 1986 (Interel Corp.)

Ambient Impact Assessment

1. Emissions Estimate
2. Ambient Modeling
3. Risk Estimates

- Ambient Impact Assessment
- Modeling/Risk Assessment
- Risk Analyses

Health Risk And Environmental Assessment Reports

- Worst-Case Condition
- Maximum Exposed Individual (MEI)
- Short-Term (1-hr) For Irritants
- Long-Term (Annual) For Carcinogens

INCINERATOR RISK ANALYSIS PROCESS

Step	Step Name	Parameters	Models Required In Place Of Measurement
1	Waste material source Control - Input mix Measure - Input waste stream	Identity of each substance Amount of each substance	Estimate of amount and identity of unidentified waste streams
2	Combustion process Control - Combustion process Measure - Process parameters	Process type, time, temperature	In-service/in-test performance model feed rate, etc.
3	Stack Release Control - Waste stream removal processes Measure - Concentration at the stack	Height, location, removal of waste stream products Waste stream removal efficiency	Destruction removal efficiency model Models of PICs Interaction of chemicals during combustion
4	Dispersion to air and surface	Terrain, weather patterns	Dispersion models Deposition models
5	Dose To critical organs Measure - Remote air concentration and deposition	Intake to lung, wholebody, ingestion Dose level via each pathway	Metabolic models Environmental dose commitment model for persistent substances
6	Population exposed at each dose level Measure - Actual population at each dose level	Number at each dose level, time profile of exposure, levels from other Competing sources and ambients	Population averaging models Differential metabolism for ambient levels via inhalation, ingestion, etc.
7	Dose to effect transformation Measure - Epidemiological or direct experiments in humans at levels of dose encountered	Dose at each level to each organ for each disease and resulting effect in excess of backgound levels	Dose/effect extrapolation for doses below measured effect levels Conversion of tests in animals or other media to man Extrapolation models vs. uncertainty and need for margins of safety
8	Risk estimate Measure - Latent and immediate health effects Premature death illness, etc.	Maximum individual risk collective risk	Additional risk of premature death and illness

Ref: U.S.EPA, "RCRA Incinerator Regulation Support" Documents

RANGES OF UNCERTAINTY IN MODEL ASSUMPTIONS AND THE DEGREES OF CONSERVATISM INVOLVED

STEP	MODEL	UNCERTAINTY FACTOR RANGE	BASIS
1. Waste Characterization			
	Identification In-Service	±1 to 3	Heterogeneity
	Concentration Estimate	±1 to 3	Of Wastes
2. Pathways.			
	Diffusion Models	+2 to +10	Conservatism In Models
3. Metabolic Pathways and Fate.			
	Inhalation Models	±2	Variation From Average
	Retention Models	-2 to +4	Worst To Best Case
4. Dose Estimate.			
	Exposure Time Profile	+2 to +10	Hypothetical MEI
	Maximum vs.Average Individual	5 to 80	Measured Range
	Persistence In Environment	-1 to -4	Persistence Not Taken Into Account For Ingestion
5. Dose-Effect Relationship.			
	Extrapolation From Animal To Man		
	Choice of Scaling Model	+40	Factor Of +5 for Surface/Weight Ratio Over Weight Ratio
	Metabolic Differences	-2 to +100	Human Less Sensitive Than Mice
	Extrapolation From High To Low Dose		
	Choice Of Model*	+1000	95% Linerized Multistage Model vs Nonlinearized
	Margins of Safety In ADIs*	+10 to +1000	Built In
6. Individual Risk Estimate.			
	Real vs Hypothetical Individual	+4 to +20	Personal Mobility
7. Population Risk Estimate			
	Integration vs Averaging Models	-2 to +10	Model Oversimplification

* Use either, but not both. The first is for non-threshold dose-effect relationships, the latter for threshold types

\+ Overestimate Of Risk, - Underestimate Of Risk, +1 or -1 Indicates No Uncertainty

Ref: U.S.EPA, "RCRA Incinerator Regulation Support" Documents

Risk Assumptions

- <u>Maximum</u> Exposure
- 24 hr/d, 365 d/yr for 70 yrs
- Running In Place

Acceptable Risk Level

One Per Million

Theoretical Death Risks

Individual Action	Death Risk	Basis
Smoking Cigarettes	0.07 x 10–6	Cancer
1 Hospital X-Ray	1.0 x 10–6	Cancer by Radiation
1 Cal.-Rich Dessert	3.5 x 10–6	Cancer & Cholesterol
Coast-to-Coast Drive	70.0 x 10–8	Accident
1 Diet Soft Drink	4.0 x 10–8	Cancer by Saccharin
Crossing A Street	2.0 x 10–8	Accident

10-6 = 1 per million

Incinerator Regulations

And

Permitting Issues

Infectious Waste Incineration Regulatory Categories

- Equipment And Component Requirements
- Incinerator Operating Conditions
- Stack Emissions
- Monitoring And Recording
- Testing (Stack Emissions And Ash)
- Health Risk Or Environmental Assessment
- Permitting And Recertification
- Operator Training

Typical Equipment And Component Requirements

- Design And Combustion Calculations
- Air-Lock Type And Interlocked Waste Loaders
- Modulating Burners
- Enclosed Ash Removal Systems
- Etc.

Typical Regulated Operating Conditions

- Primary Chamber Temperature
- Secondary Chamber Temperature
- Secondary Chamber Retention Time
- Preheat Temperature
- Burndown Temperature And Duration
- APC System Performance

Typical Regulated Stack Emissions

- Opacity
- Particulate
- Acid Gases (HCl and SO2)
- Carbon Monoxide (CO)
- Metals (12–14 Different)
- Dioxins (PCDD) And Furans (PCDF)

Typical Monitoring And Recording Requirements

- Loading Rates
- Primary And Secondary Temperatures
- Flue Gas Constituents (CEM)
  -O2, CO, CO2, HCl, SO2, etc.
- Capacity
- APC System Operations

Typical Testing Requirements

- Flue Gases
  - Regulated Pollutants
  - Startup for "Permit to Operate"
  - Retesting

- Ash Residues
  - Constituents
  - Frequency

Permitting And Recertification

- Permits To Install And Operate
- Health Risks And Environmental Assessment
- Multi-Departments
- Annual Inspection Reports
- Periodic Re-Testing

Operator Training

- Certified Program
- Operation And Maintenance
- Environmental Impacts

- Best Available Technology (BAT)
- Best Available Control Technology (BACT)
- Lowest Achievable Emission Rates (LAER)

- BACT
- Regulatory Impact Assessment (RIA)
- Cost/Benefit Assessment

BACT

- Statutorily Defined
- Requires Analysis of:
  - Environmental Benefits
  - Capital and Operating Costs
  - Energy Requirements
  - Facility Impacts
  - etc.

Public

Hearings

Public Concerns

- Environmental Impacts
- Health And Well-Being
- Aesthetics And Visibility
- Traffic Levels
- Property Levels
- NIMBY

- 1940s Technology vs. Modern Technology
- "Proven" Technology vs. Latest Technology
- State-of-Art Technology vs. Adequate Technology

What Are The Real Issues?

Emotionalism	vs.	Rationalism
False Perceptions	vs.	Informed Opinions
Hidden Agenda	vs.	Legitimate Concerns

MEDICAL & INSTITUTIONAL WASTE MANAGEMENT & INCINERATION WORKSHOP

Presented by: Lawrence G. Doucet, Doucet & Mainka, P.C.
John Bleckman, Doucet & Mainka, P.C.

VII. PERFORMANCE, OPERATIONS, PROCUREMENT & ACCEPTANCE

A. Incinerator Performance
   1. Problems & Inefficiencies
   2. Causes of poor performance
      a. Selection/design deficiencies
      b. Fabrication/installation deficiencies
      c. Operational/maintenance deficiencies

B. Recommended Procurement Steps

C. Acceptance
   1. Operating tests
   2. Performance tests
   3. Emissions/compliance tests
   4. Performance bonds

D. Operations & Maintenance
   1. Normal operating conditions
   2. Operational deficiencies
   3. Operator instructions
   4. Service contracts

VIII. EVALUATING & UPGRADING EXISTING SYSTEMS

A. Reasons for Upgrading

B. Typical Considerations

Incinerator

Performance

Success Rate: 75%

Incineration Performance Problems

- Objectionable stack emissions
- Inadequate capacity
- Poor burnout
- Excessive repairs and downtime
- Unacceptable working environment
- System inefficiencies

Incineration System Performance Problems

Inadequate Capacity

- Cannot Accept "Standard"Size Waste Containers
- Low Hourly Charging Rates
- Low Daily Burning Rates (Throughput)

Incineration System Performance Problems

Poor Burnout

- Low Waste Volume Reduction
- Recognizable Waste Items In Ash Residue
- High Ash Residue Carbon Content (Combustibles)

Incineration System Performance Problems

Objectionable Stack Emissions

- Out of Compliance with Regulations
- Visible Emissions
- Odors
- HCl Gas Deposition/Deterioration
- Entrapment Into Building Air Intakes

Incineration System Performance Problems

Unacceptable Working Environment

- Dusting Conditions and Fugitive Emissions
- Excessive Waste Spillage
- High Heat Radiation and Exposed Hot Surfaces
- Exfiltration of Combustion Products

Incineration System Performance Problems

System Inefficiencies

- Excessive Auxiliary Fuel Usage
- Low Steam Recovery Rates
- Excessive Operating Labor Costs

Waste Characterization Deviations Reducing Incinerator Capacities

- Heating Values Excessive
- Moisture Excessive
- Volatiles Excessive
- Densities Excessive
- Ash Formation Tendencies

20 COMMON PROBLEMS FOUND

IN SMALL WASTE-TO-ENERGY PLANT'S

Results of 1983 Survey of 52 Heat Recovery Incineration Systems (5-50 TPD) Conducted by U.S. Army Construction Engineering Research Laboratory.

PROBLEMS	PERCENT OF INSTALLATIONS REPORTING
1. Castable Refractory	71%
2. Underfire Air Ports	35%
3. Tipping Floor	29%
4. Warping	29%
5. Charging Ram	25%
6. Fire Tubes	25%
7. Air Pollution	23%
8. Ash Conveyor	23%
9. Not On-Line	21%
10. Controls	19%
11. Inadequate Waste Supply	19%
12. Water Tubes	17%
13. Internal Ram	15%
14. Low Steam Demand	13%
15. Induced Draft Fans	12%
16. Feed Hopper	10%
17. High pH Quench Water	8%
18. Stack Damper	4%
19. Charging Grates	2%
20. Front-End Loaders	2%

Concensus

17% Very Pleased
71% Generally Satisfied-Minor Improvements Needed
12% Not Happy

Ref: Ducey, R. A., et al, Heat Recovery Incineration: A Summary of Operational Experience, Technical Report No. CERL SRE-85/06, prepared for U.S. Army Construction Engineering Research Laboratory, March 1985

Reasons for Poor Performance

- Selection and/or Design Deficiencies
- Fabrication and/or Installation Deficiencies
- Operational and/or Maintenance Deficiencies

Typical "Specification"

"Furnish Incinerator to

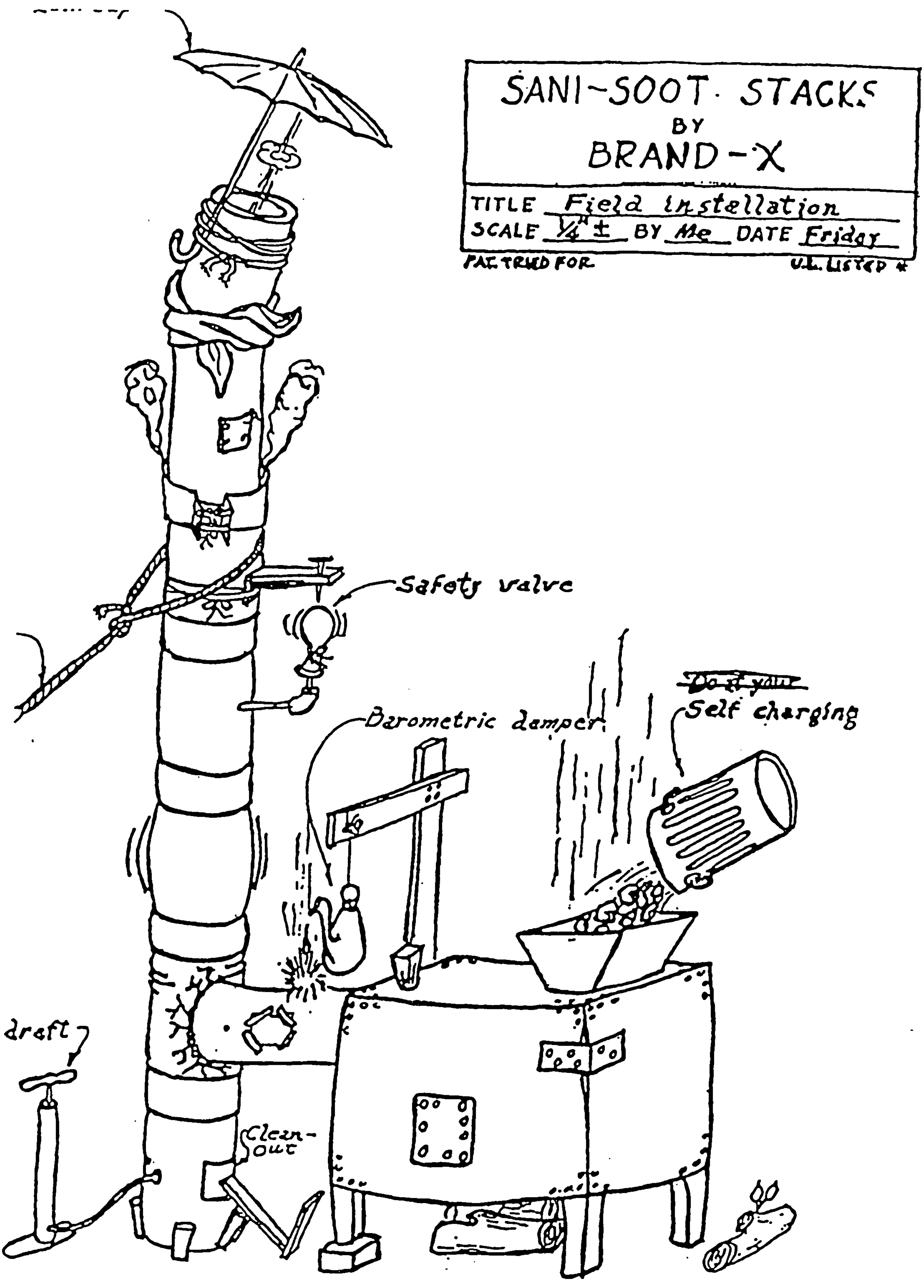
Burn X lb/hr of

Waste in Compliance

With Regulations"

Microwave Oven Mentality

- Order From Catalog
- Plug It In
- Cook Away


SANI-SOOT STACKS
BY
BRAND-X
TITLE Field installation
SCALE 1/4" ± BY Me DATE Friday
PAT. TRIED FOR
U.L. LISTED *
Safety valve
Barometric damper
Self charging
draft
Clean-out

Principle No. 1

Incineration Technology

Is Not

an

Exact Science

Principle No. 2

There Is

No

"Universal"

Incinerator

Principle No. 3

Each

Application

Is

Unique

Principle No. 4

All

Manufacturers

Are Not

Equal

Incineration

System

Procurement

Incineration System Implementation Steps

1. Evaluations and Selections
2. Design (Contract) Documents
3. Contractor Evaluation and Selection
4. Construction and Equipment Installation
5. Startup and Final Acceptance
6. Operation and Maintenance

Bid/Proposal Evaluation:

Least Cost Or Value Assessment?

FIVE PHASES FOR A SUCCESSFUL INCINERATION SYSTEM

PHASE 1

FEASIBILITY EVALUATIONS & SYSTEM SELECTION

BASIC STEPS

1. Data Collection
   - Waste
   - Costs
   - Utilities
   - Site(s)
   - Regulations
   - Etc.
2. Identification of Alternatives
   - On-Site vs. Off-Site
   - Technologies
   - Design Variations/Options
   - Add-Ons
   - Etc.
3. Technical & Economical Analyses
4. Schematic Drawings
5. Recommendations
6. Selection

PHASE 2

CONTRACT DOCUMENTS & BID SOLICITATION

BASIC STEPS

1. Design Documents
   - Conceptuals
   - Preliminaries
   - Intermediates
2. Final Contract Drawings & Specifications
3. "Permit to Install" Application*
4. Risk Assessment Analyses & Report*
5. Public Hearings*
6. Advertise or Request Bids or Proposals

* Site Specific Regulatory Requirements

PHASE 3

CONSTRUCTION & INSTALLATION

BASIC STEPS

1. Bid/Proposal Evaluations
   - Quality
   - Completeness
   - Alternates & Deviations
   - References
   - Cost Breakdown
   - Payment Terms
   - Negotiations
2. Shop Drawing & Submittal Review
3. Periodic Field Inspections & Observations
4. "Punch-Out" for Compliance with Contract Documents

PHASE 4

START-UP, TESTING & FINAL ACCEPTANCE

BASIC STEPS

1. System Start-Up, Adjustment & Calibration
2. Operator Training
3. Operational Testing
4. Performance Testing
   - Capacity
   - Burnout
   - Heat Recovery
   - Fuel Usage
   - Efficiencies
5. Emissions Testing
6. "Permit to Operate"

PHASE 5

SUCCESSFUL SYSTEM OPERATIONS & PERFORMANCE

BASIC STEPS

1. Qualified Operators
2. Periodic Operator Retraining**
3. Maintenance of Operating Data & Records**
4. Frequent Maintenance, Repair, Adjustment & Calibration**
5. Preventive Maintenance Program or Service Contract
6. Retesting**

**Mandatory in Several States

Incineration

Operations And

Maintenance

Incinerator Operating Conditions

- High Temperatures and Spikes
- Thermal Shocks
- Slagging Residues
- Exploding Items
- Corrosive Gases
- Mechanical Spalling

Common Reasons For O&M Deficiencies

- Unqualified Operators
- Negligent Operators
- Inadequate Operator Supervision
- Inadequate Operator Training
- Inadequate O&M Manuals
- Inadequate Recordkeeping
- Inadequate Preventive Maintenance Program
- Equipment Usage When Repairs Are Needed

Excerpt From Operating Instructions For An Institutional Incinerator

"The incinerator causes some smoke and noise and may produce odor while it's being loaded. Try to use it when it will inconvenience others as little as possible."

Operator Instructions

- Training Problems
- Operating and Maintenance Manuals
- Operating and Maintenance Charts
- Periodic Retraining

Incinerator Testing

- Operating Test
- Performing Test
- Emissions/Compliance Test
- Trial Burn Test

Operating Tests

- Normal Conditions
- Failure Simulations
- Alarms, Safeties and Cut-Outs

Performance Test

- Capacity
- Burnout
- Energy Recovery
- Fuel Usage

Incineration System

Upgrading, Modernization

And Retrofitting

Reasons For Upgrading

- Eliminate Problems
- Improve Performance
- Regulatory Compliance
  - Costs
  - Permitting Difficulties

Evaluating And Upgrading

Existing System

Incineration System

Operational Audits

Typical Incinerator Modernization Considerations

- **Revised Performance Objectives**
- **Furnace Arrangement/Configuration**
- **Furnace Lining/Construction**
- **Burner/Blower Capacities**
- **Combustion Controls**

- **Instrumentation/Monitoring**
- **Waste Loading**
- **O&M Considerations**

Infectious Waste Incineration Status Summary

- Increasing Demands
- Increasing Developments
- Increasing Deterrents

Successful Incinerators

- Design Them Conservatively
- Keep Them Simple
- Build Them Tough
- Treat Them Well

SELECTED PAPERS

- HOSPITAL/INFECTIOUS WASTE INCINERATION DILEMMAS & RESOLUTIONS
  Lawrence G. Doucet
  Doucet & Mainka, P.C.
  Presented at the 1st National Symposium on Incineration of Infectious Wastes
  Washington, D.C., May 6, 1988

- INFECTIOUS WASTE TREATMENT & DISPOSAL ALTERNATIVES
  Lawrence G. Doucet
  Doucet & Mainka, P.C.
  Presented at the Symposium on Infection Control: Dilemmas and Practical Solutions
  Philadelphia, PA, November 3–4, 1988

- STATE-OF-THE-ART HOSPITAL & INSTITUTIONAL WASTE INCINERATION: SELECTION, PROCUREMENT AND OPERATIONS
  Lawrence G. Doucet
  Doucet & Mainka, P.C.
  Presented at the 75th Annual Meeting of the Association of Physical Plant Administrators of Universities and Colleges, Washington, D.C., July 24, 1988

HOSPITAL/INFECTIOUS WASTE INCINERATION DILEMMAS & RESOLUTIONS

Presented By

LAWRENCE G. DOUCET, P.E.

at the

1st National Symposium On

INCINERATION OF INFECTIOUS WASTES

Washington, D.C.

May 6, 1988

HOSPITAL/INFECTIOUS WASTE INCINERATION DILEMMAS & RESOLUTIONS

Lawrence G. Doucet, P.E.
DOUCET & MAINKA, P.C.

INTRODUCTION

Infectious waste management and disposal are becoming increasingly important issues to hospitals, universities, research facilities and similar institutions. Major reasons include increasingly stringent and changing regulations, rapidly escalating treatment and disposal costs, growing difficulties in locating suitable disposal facilities, and heightened sensitivities to the potential risks and liabilities associated with improper infectious waste management and disposal.

Broadening legislation, more restrictive guidelines and other factors have substantially increased the percentages of waste to be managed and disposed as "potentially infectious" at most hospitals and other institutions. Order-of-magnitude increases are being experienced at numerous hospitals across the country. Simultaneously, regulations and guidelines for infectious waste treatment and disposal are becoming increasingly restrictive.

In light of these trends, hospitals and other infectious waste generators are being pressured by apparently opposing regulatory forces and other factors. Regulations and guidelines enacted to protect the general public against "potential" hazards from improper infectious waste disposal are forcing more and more hospitals and other institutions to consider on-site incineration as the only viable disposal method. On the other hand, guidelines and other restrictions intended to protect the general public against "potentially dangerous" incinerator emissions are concurrently making on-site, infectious waste incineration increasingly restrictive, if not prohibitive, for many of these same hospitals and institutions. This situation is literally out of control, without direction and accelerating to a state of crisis. Prompt actions are needed to resolve this situation in a rational manner based upon comprehensive regulatory impact assessment.

INFECTIOUS WASTE GENERATION TRENDS

Infectious waste, which is also commonly called "contaminated," "biohazardous," "biological," "biomedical," "pathogenic" and "red bag" waste, is loosely defined as any waste material that is a potential health hazard because of "infectious characteristics." It is more specifically defined on state and local levels. Approximately 30 states currently designate or define "infectious" waste for regulatory or policy-making purposes, and at least 7 states include infectious waste under their hazardous waste regulations.

State and local designations and definitions for "infectious" waste are widely varying and often vague and ambiguous. On a nationwide basis, there are great differences in the types and quantities of waste requiring management and disposal as "infectious" for regulatory compliance. For example, infectious waste would typically comprise about 3 to 5 percent of a hospital's total waste stream according to regulations based upon early CDC guidelines[1], roughly 10 percent of total waste according to regulations based upon the 1986 U.S.EPA Guide for Infectious Waste Management[2], and up to about 20 to 35 percent of total waste according to legislation based upon U.S.EPA regulations proposed in

1978 [3] . Furthermore, site-specific and individual interpretations of the regulatory language also substantially affect infectious waste percentages. It is not uncommon for regulatory agencies and individual institutions to have widely divergent opinions as to which waste stream components and sources shou__ be regulated as infectious.

Without question, "infectious" waste generation rates have been increasing steadily, if not dramatically, throughout the country over the past few years. In all likelihood, this trend will continue at an escalating rate for at least the next several years. The major reasons for this include:

- Broadening Legislation
- AIDS Fears and Precautions
- Tightening Instituional Policies
- Off-site Disposal Limitations

<u>Broadening Legislation</u>

A recent survey by the National Solid Wastes Management Association (NSWMA) [4] determined that roughly 20 states are planning to either promulgate new infectious waste legislation or tighten existing infectious waste legislation and/or guidelines within the year.

<u>AIDS Fears and Precautions</u>

Recent studies have predicted a doubling of isolation waste every year for at least the next several years due to increased AIDS patients and related concerns. Many hospitals have thus begun categorizing <u>all</u> patient-contact waste as potentially infectious. As much as 70 to 90 percent of total hospital waste are typically included in this category.

Last August, the CDC issued "Recommendations for Prevention of Human Immunodeficiency Virus (HIV) Transmission in Health-Care Settings"[5] . Referred to as "Universal Precautions," these basically recommend that "<u>all</u> patients be considered potentially infected with HIV and/or other blood-borne pathogens." It seems likely that most hospitals will begin categorizing all patient-contact waste as potentially infectious to achieve compliance with these Guidelines.

<u>Tightening Institutional Policies</u>

In light of increasing liabilities and punitive provisions associated with infectious waste legislation, as well as public image concerns in a competitive hospital market, waste management policies and protocols at many institutions are effectively broadening the designations of "infectious" waste to include more sources and materials than might normally be covered by applicable regulations and guidelines. Likewise, more and more institutions are tending to be over-conservative in their infectious waste segregation practices such that significant quantities of general, non-infectious, waste are intermixed with red bag waste. These practices also drive "infectious" waste quantities to higher levels.

Off-Site Disposal Limitations

The present fear of hospital waste is rampant. In some metropolitan areas, general waste haulers, landfill operators and municipal waste incineration facilities have refused to handle or dispose of any hospital waste. In other areas, some hospitals have gone to great lengths and expense to autoclave their infectious waste only to find that it would still not be accepted at the local landfill or municipal incinerator because the waste bags were still "red" colored and perceived to be infectious.

Some municipal waste incineration (resource recovery) facilities impose severe fines on and, sometimes, terminate services to hospitals that allow "infectious" waste to be intermixed in their general waste streams. Therefore, such hospitals are forced to great lengths to assure that any items remotely resembling patient-contact or contaminated waste, including such things as baby diapers, sanitary napkins from public facilities, plastic tubing and any items colored with red stains, dyes or medicines, are segregated from their general waste. Surveys at some of these hospitals have determined that such segregated waste, which effectively become "infectious," are typically 2 to 3 times the quantities defined under the regulations and/or guidelines.

ON-SITE INCINERATION INCENTIVES

As a result of substantially increasing "infectious" waste quantities, tightening legislation and off-site disposal limitations and restrictions, on-site incineration has clearly emerged as the preferred, most viable infectious waste disposal option for most hospitals and institutions. First of all, from a technological standpoint, incineration offers several major advantages as compared to other treatment technolgies. More importantly, it may be the only treatment method with a processing capacity suitable for the "infectious" waste generation rates of most hospitals and other institutions. Incineration not only sterilizes pathogenic waste constituents but also provides typical weight and volume reductions of 90 to 95 percent. In addition, it converts obnoxious waste, such as animal carcasses, to innocuous ash, provides the potential for waste heat recovery and, in some cases, can be used for simultaneously disposing of hazardous chemicals and low-level radioactive waste.

On-site incineration attractiveness is also greatly enhanced by various current and developing legislation. About half of the states and several major cities currently mandate that infectious wastes be treated on-site, restrict its off-site transport and/or prohibit it from being landfilled. Many additional states are planning similar, restrictive legislative measures within the next few years. Likewise, virtually all states either require, recommend or advocate incineration as the preferred method for treating infectious waste. Furthermore, incineration is the only treatment technique recommended in the U.S.EPA Guide for virtually all designated infectious waste types.

Off-site disposal difficulties and limitations probably contribute the greatest incentives for many hospitals and other institutions to consider or select on-site incineration as the preferred infectious waste treatment method. It has become increasingly difficult, if not impossible, to locate reliable, dependable infectious waste disposal service contractors. Many institutions able to obtain such services are literally required to transport their infectious waste across the country to disposal facilities. Furthermore, such services are typically very costly, if not prohibitive. Off-site disposal contractors are typically charging from about $0.30 to about $0.80 per pound of infectious waste, and some are charging as much as $1.50 per pound. For many hospitals and other institutions, this equates to hundreds of thousands of dollars per year. Several hospitals are paying more than a million dollars per year.

About 3,500 hospitals currently incinerate their infectious waste on-site. However, based upon conservative estimates, on the order of 5,000 new and upgraded incineration systems will be needed within the next few years to handle the demands imposed by increasing "infectious" waste quantities and changing regulatory requirements [6].

ON-SITE INCINERATION LIMITATIONS

Despite the increasing attractiveness, incentives and needs for hospitals and other institutions to incinerate their infectious waste on-site, regulatory restrictions, socio-political opposition and other factors are concurrently making on-site incineration increasingly prohibitive, if not impossible. These are discusssed as follows:

Regulatory Restrictions

In an effort to protect the environment and public welfare against potentially unacceptable emissions, an increasing number of state and local pollution control agencies are proposing and promulgating extremely restrictive regulations and criteria for permitting and operating infectious waste incinerators. Unfortunately, many such regulations appear to have no technical basis. They are also often reflective of unproven technology, unrealistic and sometimes unattainable.

As an example, one northeastern state recently proposed:

-- Stack emission limitations more stringent than can be achieved with even "best available control technologies" (BACT)

-- Instrumentation and monitoring devices that are not only superfluous, redundant, and very costly, but also, in a few instances, unproven or not commercially available for the required applications

-- Exceptionally high incinerator operating temperatures which must be maintained at <u>all</u> times, even without wastes being burned

-- Stack testing, modeling and risk assessment analysis requirements that are far more severe than comparable requirements for hazardous waste incinerators under RCRA regulations, and which are more costly than the installed equipment.

A study by the Hospital Association in that state determined that compliance with the proposed regulations would increase incineration system capital cost requirements by nearly 100 percent and would add as much as $150,000 to $450,000 to annual operating costs.

Obviously, the effect of these, as well as similar regulations being promulgated in other states, is to severely inhibit on-site incineration feasibilities. What is most disturbing, however, is that there appears to be no evidence or documentation which show that there will be any significant environmental benefits or reduced health risks if these proposed regulations are enacted.

"Capricious rulemaking" and "unofficial policymaking" are regulatory activities which also inhibit or restrict the implementation of new on-site incineration systems. "Capricious rulemaking" basically involves the seemingly arbitrary, unpredictable and frequent changing of permit conditions and requirements. "Unofficial policymaking" basically involves the setting of permit conditions and requirements that are different from published, or "written," regulatory policies. Possibly because infectious waste legislation and policies of many agencies are in a state of flux, these activities appear to be increasingly commonplace.

Socio-Political Opposition

It seems that public opposition to incineration has increased dramatically within the last several years. This is apparently due to the workings and campaigns of various environmental extremists, political opportunists and various special-interest groups. Many so-called environmentalists are more interested in stopping incineration at any cost, regardless of the overall environmental consequences. In fact, several environmentalists and pseudo-experts have become national celebrities because of their willingness to expound on the "evils" and (potential) health hazards associated with incinerator emissions. Although such opinions are sometimes half-truths, exaggerations and without technical or scientific merit, they are usually taken very seriously by the general public and are widely reported by the press.

Because of a proclivity for seeking and reporting sensational, newsworthy events, the press is often negligent in differentiating between facts and opinions. Statements relative to the "dangers" and "risks" of incineration are often reported in an unfiltered, unchecked manner. At best, sensational but unsubstantiated opinions from unqualified, special-interest oriented individuals are presented on an equivalent basis with statements that are factual and well-documented. To the general public, such contradictory "viewpoints" appear to be little more than differences of opinion.

For those seeking to permit new incineration facilities and gain acceptance at public hearings, the starting premise is almost always "guilty until proven innocent." It is likewise becoming more and more difficult, if not impossible, for permit applicants to "prove" or otherwise demonstrate that properly designed and operated incineration systems are environmentally benign and pose no significant increased risks. The major reason for such difficulties is that most public opposition is emotionally based. Issues such as fear, mistrust and the "not-in-my-backyard" (NIMBY) syndrome cannot be effectively countered with scientific data or logic. Consequently, since most regulatory agencies tend to take a passive or neutral position at public hearings, an increasing number of infectious waste incinerator permits are being denied or indefinitely postponed.

Residue Disposal Restrictions

A growing national trend is for various general waste haulers and/or associated landfill operators to claim that infectious waste incinerator ashes are "hazardous." This is despite the fact such materials are neither classified as hazardous under state or federal regulations, nor does there exist data or documentation which show these ashes to be hazardous or contain significant concentrations of hazardous constituents. It appears that such "hazard" claims may primarily be economically motivated. By charging very high rates for the handling and disposing of incinerator ashes as "hazardous waste," off-site disposal firms may be seeking to offset revenues which they are losing because of on-site incineration activities. These high ash disposal charges also substantially reduce the economic incentives for hospitals and other institutions to install or operate infectious waste incinerators.

Fallacies and Misconceptions

It is likely that most of the regulatory trends, over-reactions and perceived fears are the result of various misconceptions relative to hospital/infectious waste management and incineration. Some of the misconceptions and misunderstandings are at least based upon a modicum of technical data and rationale, but many have no technical merit whatsoever. Unfortunately, most of the opportunists and special interest groups seldom make efforts to distinguish between known facts, reasonable hypothesis, hypothetical speculations or imaginary situations when expounding or lobbying on their positions. In addition, despite best intentions, many of those formulating and promulgating regulations and guidelines in the various states simply do not have adequate technical background or documentation to make such distinctions or judgements. They, therefore, often take the most over-conservative, if not worst-case, positions when drafting their regulations and quidelines.

The following are some of the more common fallacies and misconceptions:

- Fallacy No. 1 - Hospital/Infectious Waste is More Hazardous than Municipal Solid Waste (MSW)

Those expounding this assumption point out that hospital waste is more hazardous not only because of infectiousness but also because it may contain more plastics than MSW, as well as (potential) incidental quantities of radioactive waste, chemical waste and chemotherapy, or cytotoxic, agents. It has also been claimed that the high plastic content, particularly PVC plastics, of hospital waste creates a greater potential for emiting dioxins and furans during incineration.

Obviously, this assumption has directly resulted in increasing difficulties and exhorbitant costs relative to off-site transport and disposal of hospital waste. As noted, some regulatory agencies have even incorporated hospital/infectious waste under their hazardous waste rules and regulations. In some states, this assumption has also served as a basis for the inclusion of hospital/infectious waste incinerators under the BACT provision - in direct correlation to MSW incineration facilities.

The fact is that properly managed hospital waste is far less hazardous than MSW. First of all, according to the CDC, "there is no epidemiological evidence to suggest that hospital waste is any more infective than residential (MSW) waste."[1][4] Almost without exception, and as required to maintain accreditation[7], hospitals and other healthcare organizations segregate, sterilize, or otherwise destroy "potentially infectious" waste, i.e., blood and blood products, microbiology laboratory waste, pathology waste, sharps and waste from patients on isolation, per CDC recommendations.

Although some hospitals generate radioactive waste through diagnostic, therapeutic and research activities, the treatment and disposal of these are highly regulated by the Nuclear Regulatory Commission (NRC).[8] All radioactive waste materials must be thoroughly accounted for, and it is extremely unlikely that any low-level radioactive materials could be "incidentally" disposed in a hospital's general waste stream.

Hospital chemical wastes are regulated according to state and/or federal hazardous waste regulations. These basically comprise a complex set of requirements for monitoring and regulating hazardous wastes from cradle to grave. Although very small amounts of disposed chemicals, including miscellaneous items contaminated with trace amounts of chemicals and cytotoxic agents, may find their way into the general waste stream, such quantities are extremely small - particularly in comparison to chemicals, ranging from household cleaners to pharmaceuticals, paint thinners, garden chemicals and used motor oils, routinely discarded in MSW streams. Also according to accreditation requirements, hospitals must establish a program and appoint a responsible individual for managing all hazardous materials (and wastes) "from entry to final disposal." This includes making every effort to eliminate such disposed chemicals, while there is usually no such control on MSW.

The same can be said with respect to metals disposed in MSW as compared to hospital waste streams. MSW waste typically comprises about 10 percent metals, or as much as five times more than in hospital waste. In addition, high concentrations of metals are usually segregated from the hospital waste incinerated on-site, while there is virtually no control over metals typically disposed in MSW. Furthermore, MSW contains much higher percentages of items such as batteries, electrical components and the like which tend to have more toxic heavy metal constituents.

While it is true that most hospital waste contains more plastics than MSW, the mere presence of plastics is not environmentally unacceptable. A recent study by the New York State Energy Research and Development Authority on a MSW incineration facility in Pittsfield, Massachusetts reported that "there is no statistical relationship between the amount of PVC plastic in the waste and the levels of dioxins or furan emission when burning under good combustion conditions." Furthermore, the fact that most plastics have substantially higher heating values and burn more rapidly than other waste stream components is also not necessarily bad for the environment. These petroleum-based products, when burned in a properly designed, controlled and operated incineration system, can serve to improve combustion and system efficiencies by helping to maintain elevated temperature levels while minimizing supplemental fuel usage.

- Fallacy No. 2 - Hospital/Infectious Waste is as Hazardous (or Toxic) as Chemical Waste

Those expounding this viewpoint cite arguments similar to those in Fallacy No. 1, above, except that they tend to emphasize potential chemical and radioactive hazards. The regulatory consequences and impacts on hospitals are comparable to those noted above, except that in some states, hospital/infectious waste incinerator regulations are more stringent than those for hazardous chemical waste incinerators.

As per above, facts are that hospital wastes are far less hazardous than hazardous chemical wastes.

- Fallacy No. 3 - Infectious Waste Incineration is More Hazardous than General Waste Incineration

Based upon various, recent state regulations and guidelines dealing with hospital/infectious waste incineration, it appears that many believe that the incineration of infectious waste results in more hazardous or more concentrations of toxic emissions than comparable systems incinerating only non-infectious, or general, waste. For example, a regulation recently promulgated in one state spells out highly stringent criteria and permitting requirements for "hospital/infectious waste incinerators," but this regulation specifically excludes, or exempts, "incinerators located in any hospital or in any medical facility...used to incinerate only general refuse."

The assumption that infectious waste burns differently from non-infectious waste and, therefore, requires special legislation is nonsensical. There is essentially very little difference between infectious and non-infectious waste except for the presence of disease producing microorganisms, or pathogens. Blood and body fluid contamination are the chief sources of such pathogens, and there is no technical or scientific reason for discarded paper or plastic items to burn differently or less efficiently simply because of the presence of such blood or fluid contamination.

A possible related concern may be a fear that microorganisms may survive the incineration process and be discharged into the environment. However, this is also a fallacious assumption. It is well documented that no microorganisms can survive normal incineration temperatures. In fact, the kill rate is nearly instantaneous at temperatures exceeding 1400°F.

COMMENTARY & RECOMMENDATIONS

The basic objectives of most of the developing and changing infectious waste legislation and guidelines are certainly valid; that is, to protect the environment and public welfare. However, it seems obvious that many of these are being proposed and enacted impetuously and without regard to economic implications or assessments of actual risks and/or expected benefits. For example, most legislation being enacted to safeguard against improper infectious waste disposal activities are largely the result of increased public awareness and concerns of "potential" hospital waste hazards, as stimulated by widely reported incidents of "red bag" waste being dumped in landfills, abandoned buildings, along roadsides and even in oceans and waterways. However, as noted, according to the CDC and most epidemiologists and other experts, "there is <u>no</u> epidemiologic evidence to suggest that most hospital waste is any more infective than residential waste. Moreover, there is no epidemiologic evidence that hospital waste disposal practices have caused disease in the community" [1][4]. Furthermore, excluding reports of infections caused by needlesticks, the only published incident of an infectious waste treatment method being associated with infectious disease transmission concerned a waste disposal chute connected to a hydropulping system.

The basic objectives of the infectious waste incinerator regulations being proposed and promulgated by most regulatory agencies are also valid. Improperly designed and operated incinerators of almost any type, age or capacity may potentially result in unacceptable emissions. However, best available data clearly show that properly designed and operated systems are environmenally benign and pose insignificant increased risks. The mere fact that some toxic contaminants can be measured in hospital waste incinerator stacks does not necessarily or automatically mean that their concentrations are harmful to the environment or public welfare. For example, because dioxins and furans have been "measured" in the stacks of several hospital waste incinerators, these contaminants have been the cause of much opposition to new systems. However, their reported concentrations are literally at molecular levels, and modeling and risk assessment analyses of these routinely show resultant increased health risk levels to be orders-of-magnitude less than acceptable (one in a million) levels.

While on the subject of dioxins and furans, it is worth noting that these have been detected in trace amounts in combustion processes that occur everywhere. Research has verified their presence in not only incinerator emissions but also in emissions from fossil-fuel fired boilers, gasoline and diesel powered automobiles and trucks, fireplaces, charcoal grills and even cigarettes.[9] In 1986, 26 international scientists and physicians convened by the World Health Organization concluded that modern "refuse-burning" plants are very minor sources of dioxins and furans in the environment, (less than one percent) when considering the current body burden of dioxins and furans in the populations of developed countries[10] . (For comparison, hospital waste incinerator emissions comprise only a tiny fraction of total emission from "refuse-burning" plants.) In addition, studies and current literature have not reported any scientifically proven, permanent adverse health effects from dioxins and furans.

It is likely that many of the concerns and fears of hospital waste incinerator emissions stem from selective extrapolation of data and conclusions from reports covering municipal solid waste incineration facilities and incinerators burning hazardous industrial wastes. In addition, some regulators and anti-incinerator advocates affirm their positions by citing objectionable performance and emissions data from hospital waste incinerators of obsolete designs, as well as from those which are obviously improperly designed, controlled and operated.

Clearly, prompt and rational measures are needed to relieve hospitals and other institutions across the country from the crushing effects of the opposing regulatory forces. More and more waste quantities are required to be treated as "infectious," of which smaller percentages are truly infectious; but, simultaneously, viable treatment and disposal options are being eliminated or made cost-prohibitive. Certainly such relief measures must not be at the expense of the environment or public welfare; however, it is strongly advocated that such remediation involve the enactment or revision of legislation, requirements and guidelines that are based upon a comprehensive assessment of environmental benefits and economic implications. In fact, such assessments, which are termed "regulatory impact analyses" (RIA), are statutorily required of the U.S.EPA prior to their promulgating any new regulations.

The specific point that most regulatory agencies seem to be using to justify their positions in setting severe, often unattainable hospital/infectious waste incinerator regulations or policies is that "legislation" or "statutes" require the application of BACT. However, by most definitions, BACT requires taking into account such factors as energy, costs, economic and environmental impacts. Such accounting is essentially what is normally provided under RIA. Such analyses are necessary not only to establish a sound basis for setting regulatory policies but also for justifying the setting of specific technical requirements, such as incinerator emission limits and operating conditions. For example, without such analysis, an agency cannot justify whether setting a particulate emission limit of 0.015 grains/dry standard cubic-foot (gr/dscf) will provide any significant reduction in health risk levels, or other environmental improvements, as compared to a standard of 0.10 gr/dscf, or other intermediate level. Certainly, the cost differences between these various levels are substantial and would have major impacts on the viabilities of the technology. Many regulating agencies have taken a short-sighted, short-cut approach to the BACT issue by selecting a 0.015 gr/dscf particulate limit level simply because this is considered BACT for MSW incinerators using "dry scrubber" emission control technology. This is despite the fact that this emission control technology has never been successfully demonstrated on a hospital waste incinerator application.

Other examples of setting regulatory criteria without justification include incinerator operating temperatures and retention times. Most regulatory agencies seem to be proposing secondary chamber retention times of at least 2 seconds. However, the fact is that there are no studies or data to show that 2 seconds (alone) provides significantly better emissions (or performance) than 1 second. Some manufacturers have proprietary designs whereby secondary chamber turbulent mixing is sufficiently high to provide superior gas phase combustion within 1 second (or less) than other manufacturers' systems with poor turbulent mixing at 2 seconds or more.

The fundamental bases for the incinerator regulations and criteria of many states appear to be "copy cat" or "upmanship" actions. For example, some state agencies simply make reference to or copy documentation, criteria and guidelines from other states in order to support their own policies. Also, it often appears that some states set emission levels and criteria "a little more stringent" than other states only because they want to be considered a little more prudent or more concerned about the environment. However, as noted, the basic problem is that the documents, guidelines and regulations being "mimicked" or "bettered" have <u>not</u> been based upon RIA or other assessments.

Clearly, actions and cooperation are needed from both the regulatory and institutional sectors in order to relieve the tightening legislative bind and resolve the present dilemmas. Specific recommendations for each of these are as follows:

State and local regulatory sectors should -

1. Develop or commission RIA and other supporting documentation prior to proposing and/or promulgating new legislation. If not yet done, subject existing legislation to RIA review. Make appropriate ammendments and/or revisions should existing legislation be found excessively restrictive and without significant benefits. If resources are limited, consider combining forces with other agencies or neighboring states. If enough states become involved, the U.S.EPA should possibly be requested to provide needed support and documentation.

2. Establish and enforce responsible permitting procedures. Assure that "capricious rulemaking" and "unofficial policymaking" do not take place. Also, process permit applications with consistency and reasonable promptness.

3. Be prepared and willing to take a hard stand and an active position at public hearings. Even if all environmental concerns and risks are demonstrated or proven to be non-existent or negligible, there will continue to be special-interest groups and environmental extremists

who will protest and try to impede the implementation and permitting of incineration facilities. Strive to identify, properly assess and responsibly act upon the genuine environmental and technological issues. However, actively endorse and approve incinerator permit applications in such cases where protests and objections are supported by only emotional issues or selfish concerns.

Hospitals and other institutions should -

1. Take an active role to help resolve the tightening regulatory bind. Through state and regional hospital and environmental associations, technical societies and other representative groups, stay abreast of proposed legislation and guidelines and challenge those which are unrealistic, unreasonable and which cannot be supported from a technical or scientific basis. Demand that existing and proposed legislation and guidelines be subject to RIA, or other environmental assessment/cost-benefit analyses, as well as peer reviews and public commenting.

2. Challenge regulatory agencies that act irresponsibly or inconsistently with regard to permitting procedures. Insist that the regulators abide by "written" policies and requirements.

3. Contest waste haulers and disposal firms that are charging "hazardous waste" rates for disposing of incinerator ashes. Such practices are potentially scandalous, possibly unethical and should not be allowed to continue unchallenged.

As of this writing, a few state hospital associations have begun implementing some of the above recommendations. However, more importantly, the American Society for Hospital Engineering (ASHE) has recently formed a committee and has initiated activities to develop RIA and related background documentation relative to hospital/infectious waste management and incineration. Other groups, including the U.S.EPA and the Waste Combustion Equipment Council, of the NSWMA, have expressed interest in endorsing and participating in this project. It is anticipated that the results of this ASHE project will prove invaluable to the state hospital associations and the regulatory sector.

In final summary, failure to resolve this situation expeditiously and <u>responsibly</u> may have far-reaching and major, adverse consequences on the country as a whole. It must be recognized that with respect to waste management and disposal, there is no such thing as a zero risk, particularly in our modern, industrialized society. In addition, in the evaluation of disposal options, risks from incineration must be viewed and assessed in comparison to the risks associated with other, alternate treatment and disposal technologies. Unnecessary and insupportable restrictions and prohibitions which effectively eliminate incineration as a cost-effective and environmentally safe disposal technology may likely result in more severe environmental consequences and other problems.

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INFECTIOUS WASTE TREATMENT & DISPOSAL ALTERNATIVES

Presented By

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INFECTIOUS WASTE TREATMENT AND DISPOSAL ALTERNATIVES

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INTRODUCTION

Infectious waste management and disposal issues are of prominent national concern. Widely reported illegal disposal incidences and beach washups over the last few years have stirred public fears and anger. Politicians and legislators have responded by enacting stringent legislation for the management, manifesting and disposal of infectious waste.

As a result of recent legislation and guidelines on a state and national level, as well as other concerns, the quantities of waste to be managed and disposed as potentially infectious at many hospitals and other institutions have increased enormously. At some hospitals, "infectious" waste quantities have increased from a level of about 3 percent of total solid waste to nearly 90 percent of total solid waste. Such rapid and voluminous increases have created severe difficulties for many hospitals to locate or select reliable, safe and cost-effective alternatives for treating and disposing of their infectious waste.

On-site infectious waste treatment technologies, such as steam sterilization, shredding with chlorination, incineration, and off-site disposal services have comparative advantages and disadvantages which substantially affect their viabilities on a case-by-case basis. Technological, environmental, regulatory, economic and socio-political factors must all be carefully considered prior to selecting and implementing one of these alternatives.

INFECTIOUS WASTE GENERATION

The first and most important step in evaluating and selecting an infectious waste treatment and disposal program is to identify or define the types, sources and quantities of waste which require management and disposal as potentially infectious. Such definitions must not only consider present generation rates but also potential future increases due to policy or regulatory changes. Inaccurate estimates or projections could result in the procurement of a waste treatment system of either inadequate capabilities or which is excessively complex and costly.

There are five primary factors which influence or determine the quantities of waste which require treatment and disposal as potentially infectious. These are:

1. Regulatory Definitions and Guidelines

   Federal, state and local designations and definitions for "infectious" waste vary widely and are sometimes vague and ambiguous.

2. Interpretations of the Regulations and Guidelines

   Site-specific and individual interpretations of regulatory definitions, and the intentions of such definitions, can substantially affect infectious waste generation rates. Regulatory agencies and individual institutions may have widely divergent opinions as to which waste stream components and sources need to be regulated as infectious.

3. Waste Management Policies and Protocols

   Individual hospitals and other institutions establish protocols and procedures for segregating and managing infectious waste in compliance with regulatory and accreditation requirements. The conservatism of such policies also varies widely. For example, many hospitals have set a policy whereby all patient-contact waste is considered potentially infectious in line with their own interpretations of CDC "universal precaution" guidelines.

4. Waste Management Program Effectiveness

   The ability to implement and effectively administrate an infectious waste segregation program can substantially impact the quantities of waste requiring treatment and disposal as "infectious" waste. The best protocols and written procedures are no better than the personnel assigned to implement them. Sloppy and unsupervised waste handling and packaging procedures could easily result in large quantities of (non-infectious) trash being intermixed with infectious waste items. Likewise, infectious waste items could also be inadvertantly intermixed with general trash and cause other problems.

5. Off-Site Haulage and Disposal Restrictions

This factor is the most significant of all. Regardless of regulatory requirements or other in-house programs, local restrictions or prohibitions by general waste haulers, sanitary landfill operators or municipal waste incineration facilities can effectively result in all of the waste from a hospital being considered "infectious." There is little recourse should the municipal waste transporters and disposal firms within a municipality or region refuse to handle or dispose of any hospital waste by unilaterally claiming that all of it is "infectious." This has happened in several municipalities.

The quantities or generation rates of infectious waste resulting from the above factors are site-specific. The variations can range from as little as 3 percent of total solid waste to as much as 100 percent of total solid waste. Table 1 shows typical, approximate ranges for these factors.

TABLE 1

INFECTIOUS WASTE GENERATION COMPARISONS

TYPICAL PARAMETERS	APPROXIMATE INFECTIOUS WASTE GENERATION RANGES (PERCENTAGES OF TOTAL WASTE)
• Centers for Disease Control (CDC) Designations \a	3 - 5%
• U.S.EPA Guidelines \b	7 - 15%
• Designated Departments \c	20 - 35%
• All Patient-Contact Waste \d	60 - 90%
• Hauler/Disposal Facility Restrictions	0 - 100%

\a Reference 3

\b Reference 7

\c Proposed U.S.EPA RCRA, Sub-Title C, Hazardous Waste Regulations, 1978; Departments include Autopsy, Emergency, ICU's, Isolation Rooms, Clinical Labs, Obstetrics (including patient rooms), Pathology, Pediatrics & Surgery (including patient rooms)

\d Based upon site specific - interpretations of "Universal Precautions" per CDC "Recommendations for Prevention of HIV Transmission..." Morbidity & Mortality Weekly Report, Vol. 36, August 21, 1987

INFECTIOUS WASTE TREATMENT TECHNOLOGIES

The only proven technologies for treating and disposing of the large and increasing quantities of infectious waste being generated at many hospitals and other institutions are steam sterilization, or autoclaving, shredding with chlorination and incineration. Other technologies, such as dry heat sterilization, gas/vapor sterilization and radiation are either too limited in capacity or are unproven for processing large waste volumes. Innovative or emerging technologies, such as glass slagging systems, high-temperature plasma systems and systems combining shredding and radiation are in the development stage and are years away (if ever) from being proven or made commercially available. Alternative infectious waste treatment technologies are shown on Table 2.

TABLE 2

ALTERNATIVE INFECTIOUS WASTE TREATMENT TECHNOLOGIES

- STEAM STERILIZATION
  - Gravity Systems
  - Pre-Vacuum Systems
  - Retort Systems
  - Combination Trash Compactor/Autoclave Units
- SHREDDING/CHLORINATION
  - Small Scale Sharps/Lab Waste Processing Systems
  - Large Scale Total Infectious Waste Processing Systems
- INCINERATION
  - Multiple Chamber Systems
  - Controlled Air Systems
  - Rotary Kiln Systems
  - Innovative Systems
- OTHER (SMALL SCALE) SYSTEMS
  - Dry Heat Sterilization
  - Gas/Vapor Sterilization
  - Radiation
- EMERGING TECHNOLOGIES
  - Glass Slagging
  - High-Temperature Plasmas
  - Shredding/Radiation
  - Etc.

The principal, proven technologies are as follows:

1. Steam Sterilization

Autoclaving basically involves a system whereby steam is brought into contact with waste materials in a controlled manner and for sufficient duration to kill pathogenic micro-organisms which may be contaminating the waste. The different types of autoclave systems and designs relate to steam contact efficiencies and waste volumes which can be processed, or sterilized, within the shortest possible time periods. Sterilization performance, or efficiency, is a direct function of steam penetration into the packages of waste being treated by the system. Factors such as waste type and density, packaging materials and waste loading procedures directly affect steam penetration and the exposure times necessary for effective sterilization. Inadequate steam penetration is usually the limiting factor in achieving sterilization within a reasonable time period.

In systems whereby steam pressure alone is used to evaluate air from the autoclave chamber, termed gravity systems, only about 15 minutes of direct steam contact is typically required with steam temperatures of about 250°F, which is equivalent to about 250 psi of steam pressure. However, actual cycle times for gravity systems are usually about 60 to 90 minutes (per load) in order to allow for full steam penetration into the most densely packed waste loads. Other designs using vacuum pumps to evacuate air from the chamber, termed pre-vacuum systems, have more rapid and efficient steam penetration. Therefore, cycle times for pre-vacuum systems range from only about 30 to 60 minutes (per load).

Retort type autoclave systems, basically comprise large volume chambers designed for high steam pressures, and hence, minimal cycle times. At least one commercial disposal firm on the west coast uses retort autoclaves for treating infectious waste.

A unique, autoclave system variation features a combination, integral pre-vacuum sterilizer and general waste compactor. After the autoclave cycle is completed, sterilized infectious waste is automatically ejected into the trash compactor section. All treated waste and trash is then compacted into a close-coupled, roll-off type container for off-site disposal.

Two types of packaging are viable for autoclaving infectious waste as follows:

- Heat-resistant autoclavable bags, typically made of polypropylene plastic, which are sturdy and will not melt at steam temperatures. This type of bag needs to be opened prior to autoclaving to allow steam penetration into the waste.

- Heat-sensitive, low-density polyethylene bags which will melt at steam temperatures. Such melting facilitates steam penetration and air evacuation. The use of these bags requires secondary containment to prevent spillage of waste from the melted bags.

In order to assure that the autoclave systems are loaded, operated and maintained properly, temperature probes and frequent biological challenging are required. Biological challenging involves the insertion of heat resistant spore samples (such as bacillus stearothermophillus) into worst-case waste loads in order to monitor and verify sterilization efficiencies. Some states have imposed stringent requirements for such challenging and monitoring.

The principal advantages of steam sterilizations systems include low capital and operating costs, relatively small space requirements and simplicity of operations.

The principal disadvantages of steam sterilization systems are that they have relatively limited capacity, may require special waste packaging and handling and need special provisions to prevent odor and drainage problems. Autoclaving is not recommended or suitable for all wastes, including pathological waste, such as carcasses and body parts, high liquid content waste, such as bulk fluids and blood, and waste contaminated with volatile chemicals, such as chemotherapy waste.

A potentially serious problem of using autoclaves to treat infectious waste is that of disposing of the treated waste. After autoclaving, waste appearances are basically unchanged, and color-coded bags and international biohazard symbols remain intact and visible. Needles, syringes, IV tubing, red colored and blood stained waste items and the like may be totally sterile, but are still recognizable and possibly not acceptable for disposal with general waste. Compacting autoclaved infectious waste tends to break open waste bags and other containers and expose and spill their contents. Consequently, waste haulers and landfill operators may not accept autoclaved waste even if they are proven to be sterilized.

2. Shredding with Chlorination

Within the last few years, a technology featuring a combination of shredding and chemical sterilization has been widely promoted by a midwestern firm. Two models are available. One is designed for relatively small and limited quantities of laboratory waste and sharps. The other is a relatively large capacity system designed for treating almost all infectious waste generated in a hospital.

With the large capacity system, waste is manually loaded onto an inclined, conveyor belt which feeds a high-torque, low-speed shredder. Waste is discharged from the bottom of this shredder into a high-speed hammermill which granulates the waste. During both shredding stages, waste is continuously sprayed and saturated with sodium hypochlorite solution. An inclined, perforated conveyor at the discharge of the hammermill separates the granulated waste, or debris, from the excess liquids, or slurry. The slurry is collected in a basin and piped to a sewer drain, and the solids are discharged into a cart where they are retained for off-site disposal. Reportedly, sodium hypochlorite contact time in the system and cart is sufficient for sterilization.

The sodium hypochlorite can be generated on site in an electrolysis process from water and salt pellets, or it can be purchased in bulk quantities. The standard, or base, generator furnished with the system requires about 24 hours to generate sufficient sodium hypochlorite solution for about 90 minutes of operation.

To prevent airborne contamination from the process, a blower draws air from the discharge hoods of the feed and debris conveyors and maintains a negative pressure on the entire system. The air passes through a series of prefilters and a (chlorine resistant) HEPA filter before being discharged to atmosphere.

The principal advantages of shredding/chlorination systems are that they are relatively simple, provide a substantial volume reduction, alter the waste appearance and form such that all items are unrecognizable and are suitable for most types and forms of infectious waste, except pathological remains. Hourly processing capacity is about 800 to 1,000 pounds, but it reportedly can be as high as 2,000 pounds. Daily throughput is a function of system sodium hypochlorite generation capacity or purchase. Waste volume reduction is estimated to be about 5 to 1, but it reportedly can be as high as about 8 to 1.

The principal disadvantages of shredding/chlorination systems are that they have relatively high costs, relatively limited throughput capacities and potential problems with slurry contaminants, workplace chlorine concentrations and noise levels. A standard, large capacity system can cost as much as a small to medium capacity incineration system. The slurry discharged to sewer may have concentrations of metals, organics and other contaminants such that a discharge permit may be required. In addition, special precautions may be needed to assure compliance with occupational workplace standards and requirements.

Another important consideration is that shredding/chlorination systems are currently only offered by a single manufacturer, and only a single, large capacity, operational system is currently in existence. This larger system is installed at a midwestern hospital which incinerates most of its waste on-site. However, it has been reported that two large capacity systems have been purchased by the Ontario Ministry of the Environment for demonstration purposes. Also, it should be noted, that there are several, reportedly successful small capacity systems in operation.

3. <u>Incineration</u>

Incineration is basically a process using controlled, high temperature combustion to destroy organics in waste materials. Modern incineration systems are well engineered, proven, high technology processes designed to maximize combustion efficiencies and completeness with minimum emissions.

There are four basic hospital/institutional waste incineration technologies suitable for disposing of infectious waste. These are as follows:

1. Multiple-Chamber Incinerators

This technology was developed in the mid-1950's and it was virtually the exclusive type of hospital/institutional waste incineration system installed through the mid-1960's. This type of system is also termed Incinerator Institute of America, or IIA, technology. Multiple-chamber incineration processes are designed for very high excess-air levels and have settling chambers in order to control combustion and help limit emissions. However, virtually all of these systems need air pollution control devices in order to comply with emission regulations. In addition, they cannot meet the current performance and operating requirements in many states without substantial upgrading and the addition of state-of-art combustion control equipment.

Very few multiple-chamber incinerators are being built today, but almost all of the existing incinerators that are more then 25 years old are of this type. The smaller capacity systems feature solid hearths which were strictly designed for burning pathological waste. Many hospitals have attempted to use these small capacity, solid hearth pathological incinerator systems for burning infectious waste. However, severe operating and emission problems usually result from this type of misoperation. Some of the other larger capacity, multiple-chamber units were built with grates in the solid waste (primary) burning chamber. When infectious waste is burned in these systems, uncombusted waste materials fall through the grates into the ash pit. Operators are exposed to potential hazards when cleaning infectious items and sharps from the ash pits under the grates.

2. Rotary Kiln Incinerators

A rotary kiln incinerator basically features a cylindrical, refractory-lined, combustion chamber which rotates on a slightly inclined, horizontal axis. Waste is loaded at one end of the kiln, and the rotation moves the waste slowly towards the opposite end where it is discharged as ash. The kiln rotation helps promote good burnout and a superior ash quality. Rotary kiln systems require secondary combustion chambers and air pollution control equipment in order to comply with emission regulations.

Rotary kiln incinerators are widely used in industrial applications for burning hazardous waste. This is largely because the technology is very versatile and suitable for most types and forms of waste, including solids, sludges, liquids and even fumes. Within the last few years, these systems have been widely promoted for burning hospital waste. However, today there are only about half-dozen rotary kiln incinerators installed in hospitals and similar institutions across the country.

One of the reasons why there are so few rotary kilns installations at hospitals is that they have relatively high capital and operating costs. For comparable capacities, they are roughly twice as costly as other institutional waste incineration technologies. Rotary kilns also have relatively high maintenance and repair requirements because of the abrasive and scraping effects of waste being tumbled and dragged along the refractory lining of the kiln as it rotates.

Another potentially major problem with using rotary kilns for incinerating infectious waste on-site is that, in most applications, the waste is required to be processed as it is being loaded. This is usually accomplished with a special type of loader, termed an "auger feeder," which uses a teethed, screw mechanism, that shreds, crushes and extrudes waste into the kiln. Such processing spills and disperses the contents of infectious waste bags and containers within the feeding mechanism, thus creating potential maintenance and clean-up hazards.

3. Controlled Air Incinerators

This is also commonly called modular combustion and starved air incineration. Controlled air incineration is basically a two-stage combustion process. Solid waste is burned in a starved air, or reducing, environment in the first stage, or the primary chamber. Combustion products and volatile gases generated from the solid waste in the primary chamber are burned under excess air conditions in the second stage, or secondary chamber.

The first controlled air incinerators were installed in this country in about 1962. The technology was initially popular because of its relatively low costs, but its popularity grew quickly primarily because most systems could readily comply with air pollution control regulations without needing emission control equipment. On the order of 7 to 10 thousand controlled air incinerators have been installed in the last twenty years, and more than 95 percent of all the hospital/infectious waste incinerators installed in the past 20 years have been this type of system. It should be noted, however, that no controlled air incinerators will be able to comply with the stringent emission control regulations being legislated in many states without air pollution control equipment.

4. Innovative Systems

This type of incineration technology includes a wide range of "designs," "new" developments, unusual applications and avante garde systems offered by various "progressive" manufacturers and promoters. Although many such systems are continually being "developed" and may appear promising on the surface, the majority have never been demonstrated in actual operation. Some "designs" are based upon reincarnations of old failures, and some defy the laws of physics and thermodynamics. Anyone considering a new technology or "innovative" system should understand that there is a wide difference between an idea or conceptual schematic and a proven application.

An incineration system is an integration of various components of which the incinerator proper is only a single element. All components must be properly designed and coordinated to function with the other components in order for the system to operate successfully. Incineration system components include waste handling and loading systems, burners and blowers, ash removal and handling systems, waste heat recovery systems, emission control systems, breechings and stack systems and controls and instrumentation.

There have been numerous developments over the last several years which have improved incineration system operations and efficiencies. For example, waste loaders have recently been developed for accepting larger waste capacities. Some newer loader designs can hold as much as an hour's worth of loading at one time. Burner and blower systems are available with state-of-art controls and full-integration so as to minimize auxiliary fuel usage and provide maximum combustion control during the full cycle of system operations. Modern ash removal systems featuring backhoes and scoops have been developed which appear to be more reliable and less maintenance intensive than cart and drag type conveyor systems. Some manufacturers have developed controls and instrumentation packages with solid-state programmable controllers, graphic displays and even touch-screens.

The addition of a waste heat recovery boiler to an incineration system is not nearly as cost-effective as it was ten years ago; in fact, nowadays, it is rare for a hospital/institutional waste incinerator to be justified strictly on the basis of heat recovery benefits. On average, about 3 to 4 pounds of steam can be recovered for each pound of infectious waste incinerated. However, at the higher operating temperatures required by many states, about 5 to 6 pounds of steam can be recovered for each pound of waste incinerated. Although such recovery rates are seldom sufficient to provide a rapid return-on-investment for a total system, the addition of a heat recovery system may have other advantages. For example, incineration with heat recovery is usually considered more acceptable, or less objectionable, to the general public than one without heat recovery. Also, a heat recovery system may help to condition flue gases upstream of an air pollution control system. Finally, energy grants may be available for systems with heat recovery.

In many states, new legislation requires that hospital/infectious waste incinerators be equipped with air pollution control systems and equipment meeting "Best Available Controlled Technology," or BACT. Such systems are very sophisticated and energy intensive as needed to achieve <u>extremely</u> stringent particulate and acid gas, or hydrogen chloride (HCl), emission levels. The most proven and widely used emission controls systems applicable to hospital/infectious waste incinerators are high-energy venturi scrubbers with packing sections, sub-coolers, mist eliminators, caustic feeders (pH controllers) and water recirculation systems. Fired reheaters are also available for eliminating visible steam plumes from the stacks of systems with wet scrubbers.

There have been recent attempts to develop relatively small capacity "dry" scrubbing systems which use baghouse filters and alkaline injectors for combination high efficiency particulate removal and (moderately efficient) acid gas removal. However, not only are such "dry" systems nearly twice as costly and space intensive as wet scrubber systems, but also, to date, none have been used successfully on any on-site hospital/infectious waste incineration system in the country. Nonetheless, some state regulatory agencies are essentially requiring that such "dry" systems be installed on all new infectious waste incinerators.

By and large, on-site incineration has emerged as the preferred, most viable infectious waste treatment option for most hospitals and institutions. From a technological standpoint, incineration offers several major advantages as compared to other treatment technologies. More importantly, it may be the only treatment method with a processing capacity suitable for the infectious waste generation rates of most hospitals and other institutions. Incineration not only sterilizes infectious waste but also provides typical weight and volume reductions of 90 to 95 percent. Incineration of total hospital waste minimizes many difficulties and problems associated with the segregation of infectious waste. In addition, it converts obnoxious waste, such as animal carcasses, to innocuous ash, provides the potential for waste heat recovery and, in some cases, can be used for simultaneously disposing of hazardous chemicals and low-level radioactive waste.

On-site incineration attractiveness is also greatly enhanced by various current and pending legislation. About half of the states and several major cities currently mandate that infectious waste be treated on-site, restrict its off-site transport and/or prohibit it from being landfilled. Many additional states are planning similar, restrictive legislative measures within the next few years. Virtually all states either require, recommend or advocate incineration as the preferred method for treating infectious waste. Furthermore, incineration is the only treatment technique recommended in the U.S.EPA Guide for virtually all designated infectious waste types.

Off-site disposal difficulties and limitations probably contribute the greatest incentives for many hospitals and other institutions to consider or select on-site incineration as the preferred infectious waste treatment method. It has become increasingly difficult, if not impossible, to locate reliable, dependable infectious waste disposal service contractors. Many hospitals able to obtain such services are literally required to transport their infectious waste across the country to disposal facilities. Furthermore, such services are typically very costly, if not prohibitive. Off-site disposal contractors are typically charging from about \$0.30 to about \$0.80 per pound of infectious waste, and some are charging as much as \$1.50 per pound. On the other hand the total, annual owning and operating costs for hospital/infectious waste incinerators in states with even the most stringent legislation range from about \$0.05 to about \$0.2 per pound of waste incinerated. This is inclusive of system amortization costs, utility costs, operating labor, ash disposal, testing and maintenance and repair.

A major disadvantage of on-site incineration, compared to other treatment technologies, are its high capital, operating and maintenance costs. However, more importantly, regulatory restrictions, socio-political opposition and related permitting difficulties have made on-site incineration increasingly prohibitive, if not impossible, in more and more sections of the country. In an effort to protect the environment and public welfare against potentially unacceptable emissions, an increasing number of state and local pollution control agencies are enacting extremely restrictive regulations and criteria for permitting and operating infectious waste incinerators. Unfortunately, many such regulations appear to have no technical basis, and they are often unrealistic and sometimes unattainable.

It is likewise becoming more and more difficult, if not impossible, for permit applicants to prove or otherwise demonstrate that properly designed and operated incineration systems are environmentally benign and pose no significant increased risks. The major reason for such difficulties is public opposition. Issues such as fear, mistrust and the "not-in-my-backyard" (NIMBY) syndrome cannot be effectively countered with scientific data or logic. Consequently, since most regulatory agencies tend to take a passive or neutral position at public hearings, an increasing number of infectious waste incinerator permits are being denied or indefinitely postponed.

Table 3 summarizes the major components of the three principal treatment technologies, and Table 4 summarizes their comparative advantages and disadvantages.

OFF-SITE TREATMENT AND DISPOSAL

There are basically only three options potentially available as an alternative to on-site treatment. These are as follows:

1. <u>Contract Disposal</u>

   This involves paying a fee to an independent, commercial firm to transport and dispose of infectious waste at an off-site facility. Almost all of the contractors use incineration for disposal. Some contractors provide waste transport and incinerate at their own facilities, and others only provide transport and use the incineration facilities of another contractor. Some disposal contractors have arrangements to use, or share, on-site incineration facilities at various hospitals. Contract disposal rates are typically set at a cost per pound or a cost per box basis. Contractors often furnish packaging materials and boxes as part of their services. Some offer refrigerated trucks for longer term, interim storage and transport.

2. <u>Disposal at another Institution's Incinerator</u>

   Some hospitals have excess incineration capacity and offer disposal services to other regional hospitals, clinics and medical facilities. Such services are on a fee arrangement or shared cost basis which is typically very competitive with contract disposal rates. Excess incineration capacity at most hospitals is only incidental to their existing operations, but at some hospitals it is a planned investment opportunity.

3. <u>Disposal at a Regional Incineration Facility</u>

A regional incineration facility, as opposed to a contractor owned facility, is basically developed, owned and operated on behalf of and under the control of an independent hospital group or association. An association could develop, administrate and finance such a facility through either a private developer or through their own internal organization. The facility could be either at a neutral site or at the site of a membering hospital.

The advantages of off-site treatment and disposal include simplicity and relatively short implementation time. It avoids problems and uncertainties of siting and permitting an on-site treatment system. Building space and associated support services are not required. In addition, off-site treatment and disposal eliminates major capital investment requirements for on-site treatment facilities.

As discussed, a major difficulty with off-site treatment and disposal services in many parts of the country is locating reliable, reputable and affordable contractors and facilities. At present, there is a severe shortage of off-site incineration capacity on a national level. Most existing, permitted facilities are operating at peak capacity. Some states have moratoriums on new, off-site, contract incineration facilities, and, in the other states contractors are finding it extremely difficult to site and permit new facilities.

Despite potentially attractive economic incentives, most hospitals are hesitant or reluctant to incinerate waste from other hospitals. They appear to have major concerns as to potential liabilities and adverse neighborhood reactions to such operations. Furthermore, there are few, if any, operational regional incineration facilities. The implementation of such facilities has also been stymied by siting and permitting problems.

Also, as discussed, another major disadvantage of off-site transport and disposal, as compared to on-site treatment, are the high annual costs. The costs for off-site, contract disposal are many times greater than those for on-site incineration. The differential is such that many on-site, hospital waste incineration systems realize payback periods of less than 2 years due to off-site disposal cost savings.

The Medical Waste Tracking Act of 1988 (Act) and comparable legislation in many states also impose difficulties and additional, increasing costs for the off-site disposal of infectious waste. Packaging, manifesting and tracking requirements, as well as the severe penalties associated with the violation of the requirements, are significant deterrents to off-site disposal. It has been estimated that the costs for many hospitals to administrate and adhere to the manifesting and tracking requirements under the Act will be greater than those for incinerating their infectious waste on-site. Civil penalties for noncompliance are as much as $25,000 per violation, and criminal penalties are as much as $50,000 and 5 years imprisonment per violation.

A regional incineration facility, as compared to individual, on-site incineration facilities, has the advantage of favorable economics, centralized control and operations and the need to obtain only a single permit. However, as noted, locating a site that can be permitted for incinerating infectious waste with minimal public opposition is extremely difficult and may be comparable to siting a nuclear power plant. In addition, packaging, manifesting and tracking requirements could also have a major impact on the hospitals using the regional facility, even if they own and operate it.

The comparable advantages and disadvantages of the various off-site treatment and disposal alternates are shown on Table 5.

A schematic of the infectious waste treatment and disposal alternatives discussed above is shown on Figure 1.

TABLE 3

PRINCIPAL INFECTIOUS WASTE TREATMENT SYSTEM COMPONENTS

AUTOCLAVING SYSTEM	SHREDDING/CHLORINATION SYSTEM	INCINERATION SYSTEM
• Waste Transport/Treatment	• Waste Feed Conveyor	• Waste Handling & Loading
• Autoclavable Bags	• Pre-Shredder	• Incinerator
• Autoclave Chamber	• Hammermill	• Burners & Blowers
• Ventilation System	• Debris Conveyor/Separator	• Ash Removal & Handling
• Container Dumper (Optional)	• HEPA Filtration System	• Breeching, Blowers, Dampers & Stack(s)
• Biological/Temperature Indicators	• Sodium Hypochlorite System	• Air Pollution Control
		• Waste Heat Recovery
		• Controls & Instrumentation

TABLE 4

INFECTIOUS WASTE TREATMENT TECHNOLOGY COMPARISONS

PRINCIPAL TREATMENT TECHNOLOGIES	ADVANTAGES	DISADVANTAGES
• AUTOCLAVING	• Low Costs • Low Space Requirements • Ease of Implementation • Simplicity of Operation	• Limited Capacity • Not Suitable for all Wastes • Waste Handling System/Bags • Odor Control • Waste Volume Unchanged • Waste Appearance & Form Unaltered
• SHREDDING/CHLORINATION	• Substantial Volume Reduction • Suitable for Many Wastes • Relative Simplicity • Alters Waste Forms	• Relatively High Costs • Manual Waste Handling • Limited Capacity • Liquid Effluent Contaminants • Room Noise & Chlorine Levels • Single Manufacturer • Limited Experience
• INCINERATION	• Disposes of Most Waste Types & Forms • Suitable for Large Volumes • Largest Weight & Volume Reductions • Sterilization & Detoxification • Heat Recovery	• Relatively High costs • High M&R Requirements • Stack Emissions & Concerns • Permitting Difficulties • Public Opposition

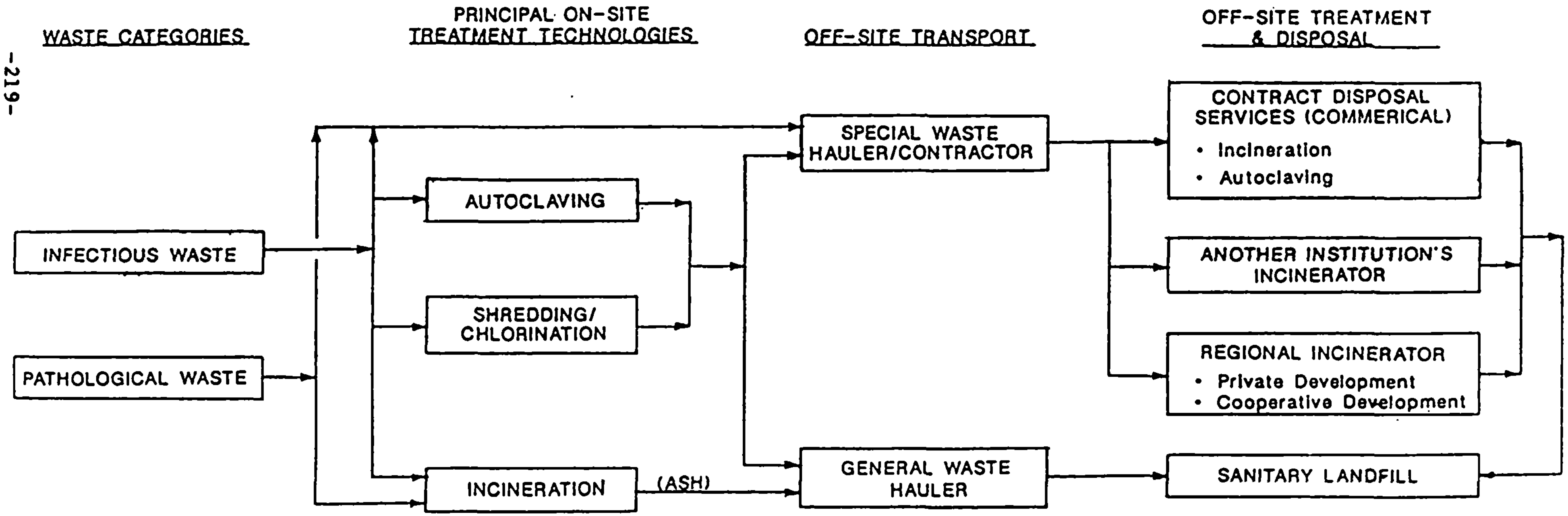
TABLE 5

OFF-SITE INFECTIOUS WASTE TREATMENT & DISPOSAL COMPARISONS

	ADVANTAGES	DISADVANTAGES
• OFF-SITE DISPOSAL -- Commercial Facility -- Another Institution's Incinerator -- Regional Facility	• Negligible Capital Investment • Minimal (On-Site) Space Requirements • Simplicity • Short Implementation Time • Avoid On-Site Disposal Permitting	• Locating Reliable & Reputable Firms & Facilities • Potential Liabilities & Concerns • High Annual Costs • Special Packaging Requirements • Manifesting & Tracking
• REGIONAL OR SHARED-SERVICE INCINERATION FACILITY (vs. Individual On-Site Incinerators)	• Favorable Economics • Single Permit • Centralized Operations	• Siting & Permitting Difficulties • Special Packaging & Transport Requirements • Manifesting & Tracking • "Hazardous" Designation (some states)

FIGURE 1

INFECTIOUS WASTE TREATMENT & DISPOSAL ALTERNATIVES



EVALUATION AND SELECTION

Two steps are recommended for evaluating infectious waste treatment and disposal options and alternatives or for planning a waste management program. These are as follows:

1. Data Collection, Confirmation & Summary

   The initial step is to compile and consolidate all data and information necessary for identifying and evaluating the options and alternatives. Such data typically include waste characterization and quantification, waste handling practices and procedures, site availability and constraints, utility availability, costs for labor, utilities and off-site disposal and the latest regulatory requirements. This also includes a review of in-house policies regarding infectious waste management and disposal, particularly with regard to the likelihood of their being revised in the near and long-term.

   Waste characterization and quantification are the key parameters in formulating a waste management and disposal plan and selecting the best disposal alternative. The efforts required for collecting such data can vary widely, ranging from the use of empirical factors and approximations to the implementation of extensive waste weighing and survey programs. Likewise, such survey programs can range widely in complexity and scope. They require careful planning, organization and coordination to obtain the needed data at minimum cost and effort.

2. Technical and Economic Evaluations

   After all relevant data have been compiled and confirmed, this step involves the identification and evaluation of all waste disposal options and alternatives. A typical matrix of options would include varying degrees of on-site treatment, different types of waste treatment technologies and equipment, various potential treatment system add-on features and redundancies. It would not be unusual for a dozen or more viable options to be identified for any particular facility.

   Other factors which need to be considered include such parameters as back-up capabilities and contingencies, future facility growth, future waste generation scenarios, potential liabilities and public image.

   The important disposal option variables are shown on Table 6.

It is important that the advantages, disadvantages and limitations of the various on-site treatment technologies and off-site disposal options be thoroughly understood. In short, these assessments provide the foundation for ultimately selecting and implementing the best, most cost effective alternative.

TABLE 6

TYPICAL DISPOSAL OPTION VARIABLES

- DEGREE OF ON-SITE TREATMENT
  - None
  - Selected
  - Maximum
- ALTERNATE TECHNOLOGIES/COMBINATIONS
- TREATMENT TECHNOLOGY OPTIONS/ADD-ONS
- REDUNDANCY & BACK-UP
- SITING

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STATE-OF-THE-ART HOSPITAL & INSTITUTIONAL WASTE INCINERATION: SELECTION, PROCUREMENT AND OPERATIONS

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INTRODUCTION

On-site incineration is becoming an increasingly important alternative for the treatment and disposal of institutional waste. Incineration reduces the weight and volume of most institutional solid waste by upwards of 90 to 95 percent, sterilizes pathogenic waste, detoxifies chemical waste, converts obnoxious waste, such as animal carcasses, into innocuous ash and also provides heat recovery benefits. At most institutions, these factors provide a substantial reduction in off-site disposal costs such that on-site incineration is highly cost-effective. Many systems have payback periods of less than one year. In addition, on-site incineration reduces dependence upon off-site disposal contractors which, in turn, minimizes potential exposures and liabilities associated with illegal or improper waste disposal activities.

Clearly, the most important factor currently affecting the importance of on-site incineration for healthcare organizations and research institutions across the country relates to infectious waste management and disposal. First of all, recent legislation and guidelines have dramatically increased the quantities of institutional waste to be disposed as "potentially infectious". For many institutions, particularly hospitals, incineration is the only viable technology for processing the increased, voluminous quantities of waste. Secondly, about half of the states and several major cities currently mandate that infectious waste be treated on-site, restrict its off-site transport and/or prohibit it from being landfilled. Many additional states are planning similar, restrictive legislative measures within the next few years.

Off-site disposal difficulties and limitations probably contribute the greatest incentives for many healthcare and other institutions to consider or select on-site incineration as the preferred infectious waste treatment method. It has become increasingly difficult, if not impossible, to locate reliable, dependable infectious waste disposal service contractors. Many institutions able to obtain such services are literally required to transport their infectious waste across the country to disposal facilities. Furthermore, such services are typically very costly, if not prohibitive. Off-site disposal contractors are typically charging from about $0.30 to about $0.80 per pound of infectious waste, and some are charging as much as $1.50 per pound. For many hospitals and other institutions, this equates to hundreds of thousands of dollars per year, and several are paying in excess of a million dollars per year.

INCINERATION TECHNOLOGIES

Before the early 1960's, institutional incineration systems were almost exclusively multiple-chamber types, designed and constructed according to Incinerator Institute of America (IIA) Incinerator Standards. Since these systems operated with high excess air levels, most required scrubbers in order to comply with air pollution control standards. Multiple-chamber type systems are occasionally installed at modern facilities, because they represent proven technology. However, the most widely and extensively used incineration technology over the past 20 years is "controlled air" incineration. This has also been called "starved-air" incineration, "two-stage" incineration, "modular" combustion and "pyrolytic" combustion. More than 7,000 controlled air type systems have been installed by approximately two dozen manufacturers over the past two decades.

Controlled air incineration is generally the least costly solid waste incineration technology - a factor that has undoubtedly influenced its popularity. Most systems are offered as low cost, "pre-engineered" and prefabricated units. Costly air pollution control equipment is seldom required, except for compliance with some of the more current, highly stringent emission regulations, and overall operating and maintenance costs are usually less than for other comparable incineration technologies.

The first controlled air incinerators were installed in the late 1950's, and the first U.S. controlled air incinerator company was formed in 1964. The controlled air incineration industry grew very slowly at first. The technology received little recognition because it was considered unproven and radically different from the established and widely accepted IIA Incinerator Standards.

Approximately every five years the controlled air incineration industry has gone through periods of rapid growth. In the late 1960's, this was attributable to the Clean Air Acts, in the early and late 1970's to the Arab Oil embargos, in the early 1980's to the enactment of hazardous waste regulations, and, recently, to the enactment of infectious waste disposal regulations. Dozens of "new" vendors and equipment suppliers appeared on the scene during each of these growth periods. However, increased competition and rapid changes in the technology and market structure forced most of the smaller and less progressive companies to close. Generally, the controlled air incineration industry has been in a state of almost constant development and change, with frequent turnovers, mergers and company failures.

Today there are approximately a dozen listed "manufacturers" of controlled air incinerators. However, only about half of these have established successful track records with demonstrated capabilities and qualifications for providing first-quality installations. In fact, some of the "manufacturers" listed in the catalogs have yet to install their first system, and a few are no more than brokers who buy and install incinerator equipment manufactured by other firms.

Controlled air incineration is basically a two-stage combustion process. Waste is fed into the first stage, or primary chamber, and burned with less than stoichiometric air. Primary chamber combustion reactions and turbulent velocities are maintained at very low levels to minimize particulate entrainment and carryover. This starved air burning condition destroys most of the volatiles in the waste materials through partial pyrolysis. Resultant smoke and pyrolytic products, along with products of combustion, pass to the second stage, or secondary chamber. Here, additional air is injected to complete combustion, which can occur either spontaneously or through the addition of auxiliary fuel. Primary and secondary combustion air systems are usually automatically regulated, or controlled, to maintain optimum burning conditions despite varying waste loading rates, composition, and characteristics.

Rotary kiln type incineration systems have been widely promoted within the past few years. A rotary kiln basically features a cylindrical, refractory-lined combustion chamber which rotates slowly on a slightly inclined, horizontal axis. Kiln rotation provides excellent mixing, or turbulence, of the solid waste fed at one-end - with high quality ashes discharged at the opposite end. However, in general, rotary kiln systems have relative high costs and maintenance requirements, and they usually require size reduction, or shredding, in most institutional waste applications. There are only a handful of rotary kiln applications in hospitals and other institutions in the U.S. and Canada.

"Innovative" incineration technologies also frequently appear on the scene. Some of such systems are no more than reincarnations of older "failures", and others feature unusual applications and combinations of ideas and equipment. Probably the best advice when evaluating or considering an innovative system is to first investigate whether or not any similar successful installations have been operating for a reasonable period of time. Remember, so called innovative systems should still be designed and constructed consistent with sound, proven principles and criteria.

SIZING AND RATING

Classifications systems have been developed for commonly encountered waste compositions. These systems identify "average" characteristics of waste mixtures, including such properties as ash content, moisture, and heating value. The classification system published in the IIA Incinerator Standards is the most widely recognized and is almost always used by the incinerator manufacturers to rate their equipment. In this system, shown in Figure 1, wastes are classified into seven types. Types 0 through 4 are mixtures of typical, general waste materials, and Types 5 and 6 are industrial wastes requiring special analysis.

Primary Combustion Chambers

Heat Release Rates

Incinerator capacities are commonly rated as pounds of specific waste types, usually Types 0 through 4, that can be burned per hour. Incinerators usually have a different capacity rating for each type. For example, an incinerator rated for 1,000 pounds per hour of Type 1 waste may only be rated for about 750 pounds per hour of Type 0 waste or about 500 pounds per hour of Type 4 waste. Such rating variations exist because primary chamber volumes are sized on the basis of internal heat release rates, or heat concentrations. Typical design heat release values range from about 15,000 to 25,000 Btu per cubic foot of volume per hour (Btu/cu-ft/hr). In order to maintain design heat release rates, waste burning capacities vary inversely with the waste heating values (Btu/lb). As heating values increase less waste can be loaded.

Since Type 3 waste, food scraps, and Type 4 (pathological) waste have heat contents of only 3,500 and 1,000 Btu per pound, respectively, it might be assumed that even higher capacity ratings could be obtained for these waste types. However, this is not the case. The auxiliary fuel inputs required to vaporize and superheat the high moisture contents of Types 3 and 4 wastes limits effective incineration capacities.

In essence, primary chamber heat release criterion establishes primary chamber volume for a specific waste type and charging rate. Heat release values are simply determined by multiplying burning rate (lb/hr) by heating value (Btu/lb) and dividing by primary volume (cu-ft).

Burning Rates

The primary chamber burning rate generally establishes burning surface, or hearth area, in the primary chamber. It indicates the maximum pounds of waste that should be burned per square foot of projected surface area per hour (lb/sq-ft/hr). Recommended maximum burning rates for various waste types are based upon empirical data, and are published in the IIA Incinerator Standards. Figure 2 tabulates this criteria.

Secondary Combustion Chambers

Secondary chambers are generally sized and designed to provide sufficient time, temperature, and turbulence for complete destruction of combustibles in the flue gases from the primary chamber. Unless specified otherwise, secondary chamber design parameters are usually manufacturer specific. Typical parameters include:

- Flue gas retention times ranging from 0.25 seconds to at least 2.0 seconds.

- Combustion temperatures ranging from 1,400°F to as high as 2,200°F.

- Turbulent mixing of flue gases and secondary combustion air through the use of high velocity, tangential air injectors, internal air injectors, abrupt changes in gas flow directions, or refractory orifices, baffles, internal injectors and checkerwork in the gas flow passages.

Retention times, temperatures, and turbulence are interdependent. For example, secondary chambers that are specially designed for maximum turbulence but that have relatively short retention times may perform as well as other designs with longer retention times but less effective turbulence. On many applications, increased operating temperatures may allow for decreased retention times, or vice versa, without significantly affecting performance. Regulatory standards and guidelines often dictate secondary chamber retention time and temperature requirements.

Flue gas retention time (sec) is determined by dividing secondary chamber volume (cu-ft) by the volumetric flue gas flow rate (cu-ft/sec). Flue gas flow rates are basically a function of waste type, combustion air quantities and operating temperatures. They can be calculated or measured. However, during normal incinerator operations, flue gas flow rates vary widely and frequently.

Shapes & Configurations

Primary and secondary chamber shapes and configurations are generally not critical as long as heat release rates, retention time, and air distribution requirement are satisfactory. Chamber geometry is most affected by the fabrication and transport considerations of the equipment manufacturers. Although some primary and secondary chambers are rectangular or box-like, most are cylindrical.

Controlled air incinerators with a capacity of less than about 500 pounds per hour are usually vertically oriented, with primary and secondary chambers integral, or combined, within a single casing. Larger capacity controlled air incinerators are usually horizontally oriented and have non-integral, or separated, primary and secondary chambers. A few controlled air incinerator manufacturers offer systems with a third stage, or tertiary chamber, following the second stage. One manufacturer offers a fourth stage, termed a "reburn tunnel," which is primarily used to condition flue gases upstream of a heat recovery boiler.

Most manufacturer "variations" are attempts to improve efficiency and performance. However, some of these may be no more than "gimmicks" that offer no advantages or improvements over standard, conventional systems. Adherence to proper design fundamentals, coupled with good operations, are the overall keys to the success of any system. Acceptance of unproven variations or design deviations is usually risky.

SELECTION AND DESIGN FACTORS

Highly accurate waste characterization and quantification data are not always required for selecting and designing incineration systems. However, vague or incomplete data can be very misleading and result in serious problems.

Waste characterization involves identification of individual waste constituents, relevant physical and chemical properties and presence of any hazardous materials. A number of terms commonly used to characterize waste can be very misleading when used in specifications. As examples, vague terms such as "general waste," "trash," "biological waste," "infectious waste" and "solid waste" provide little information about the waste materials. An incineration system designed for waste simply specified as "general" waste would probably be inadequate if waste contained high concentrations of plastics. Likewise, the term "pathological" waste is frequently, but incorrectly, used to include an assortment of materials, including not only animal carcasses but also cage waste, laboratory vials and biomedical waste items of all types. "Pathological" incinerators are usually specifically designed for burning animal carcasses, tissues and similar types of organic wastes. Unless the presence of other materials is clearly specified, resultant burning capacities may be inadequate for waste streams to be incinerated.

Waste characterization can range from simple approximations to complex and costly sampling and analytical programs. As discussed, the most frequently used approximation method is to categorize "average" waste mixtures into the five IIA classes, Types 0 through 4. The popularity of this waste classification system is enhanced by the fact that most of the incinerator manufacturers rate their equipment in terms of these waste types. However, it should be noted that actual "average" waste mixtures rarely have the exact characteristics delineated for any of these indicated waste "types".

The other end of the characterization spectrum involves sampling and analysis of specific "representative", waste samples or items in order to determine "exact" heating values, moisture content, ash content and the like. This approach is not generally recommended because it is too costly and provides no significant benefit over other acceptable approximation methods.

Virtually all components found in typical institutional type solid waste have been sufficiently well characterized in various engineering textbooks, handbooks and other technical publications. An example is presented in Figure 3. In many cases, a reasonably accurate compositional analysis of the waste stream, in conjunction with such published data and information, could provide reliable and useful characterization data.

A key factor is that incineration systems must be designed to handle the entire range of the waste stream properties and characteristics, not just the "averages." System capacity and performance may be inadequate if the waste data does not indicate such ranges.

Capacity Determination

One of the primary criteria for selecting incineration system capacity is the quantity of waste to be incinerated. Such data should include not only average waste generation rates, but also peak rates and fluctuation cycles. The most accurate method of determining such data is a comprehensive weighing program over a period of about two weeks. However, the most common procedure has been to estimate waste quantities from the number and volume of waste containers hauled off-site to land disposal. Large errors have resulted from such estimates because of failures to account for container compaction densities or from faulty assumptions that the waste containers were always fully loaded.

Three major variables affect the selection of incineration system capacity, or hourly burning rate: waste generation rates; waste types, forms, and sizes; and operating hours.

The quantity of waste to be incinerated is usually the primary basis for selecting system capacities. When waste generation rates are grossly underestimated, incineration capacity may be inadequate for the planned, or available, periods of operation. In such cases, the tendency is to overload the system, and operational problems ensue. On the other hand, grossly overestimating waste generation rates can be equally bad. Since incineration systems must be operated near their rated, or design, capacities for good performance, an oversized system must be operated less hours per day than may have been anticipated. Such reduced operating hours could cause difficult problems with waste handling operations, particularly if waste storage areas are marginal. Furthermore, if waste heat recovery is necessary to justify system economics, insufficient waste quantities could be a serious problem.

Since incinerators are primarily sized according to heat release rates, waste heating value is a fundamental determinant of capacity. However, the physical form, or consistency, of waste may have a more significant impact on burning capacities. For example, densely packed papers, books, catalogs and the like, may have an effective incinerability factor of only about 20 percent compared to burning loosely packed paper. Likewise, animal bedding, or cage waste, typically has high ash formation tendencies that may reduce burning rates by as much as 50 percent. Furthermore, highly volatile wastes, such as plastics and containers of flammable solvents, may require burning rate reductions of as much as 65 percent to prevent smoking problems.

The physical size of individual waste items and containers is also an important factor in the selection of incineration capacity. One rule-of-thumb is that an average incinerator waste load, or largest item, should weigh approximately 10 percent of rated, hourly system capacity. On this basis, a minimum 300 pounds per hour incinerator would be required for, say, Type 1 waste packaged in up to about 30 pound containers or bags. This capacity would be required regardless of the total daily quantity of Type 1 waste requiring incineration.

A typical daily operating cycle for a controlled air incinerator without automatic ash removal is as follows:

Operating Steps	Typical Durations
• Clean-out	15 - 30 minutes
• Preheat	15 - 60 minutes
• Waste loading	12 - 14 hours
• Burn-down	2 - 4 hours
• Cool-down	5 - 8 hours

It is important to note that waste loading for systems with manual clean-out is typically limited to a maximum of 12 to 14 hours per operating day.

Burning Rate vs. Charging Rate

When evaluating incineration equipment, it is important to distinguish between the terms "burning or combustion rate" and "charging or loading rate." Manufacturers may rate their equipment or submit proposals using either term. "Burning rate" refers to the amount of waste that can be burned or consumed per hour, while "charging rate" is the amount of waste that can be loaded into the incinerator per hour. For systems operating less that 24 hours per day, "charging rates" typically exceed "burning rates" by as much as 20 percent. Obviously, failure to recognize this difference could lead to selecting a system of inadequate capacity.

INCINERATOR SYSTEM AUXILIARIES

The incinerator proper is only a single component in a typical incineration "system." Other components, or sub-systems, which require equal attention in the design and procurement process, include:

- Waste handling and loading systems
- Burners and blowers
- Residue, or ash, removal and handling systems
- Waste heat recovery boiler systems
- Emission control systems
- Breeching, stacks and dampers
- Controls and instrumentation

Features of the major sub-systems are as follows:

Waste Handling and Loading Systems

Incinerators with capacities less than about 200 pounds per hour are usually available only with manual loading capabilities. Manual loading entails charging waste directly into the primary chamber without the aid of a mechanical system. Units with capacities in the 200 to 500 pound per hour range are usually available with mechanical loaders as a special option. Mechanical loaders are standardly available for most incinerators with capacities of more than about 500 pounds per hour.

The primary advantage of mechanical loaders is that they provide personnel and fire safety by preventing heat, flames and combustion products from escaping the incinerator. In addition, mechanical loading systems prevent, or limit ambient air infiltration into the incinerator. In most cases, air infiltration affects combustion conditions and, if excessive, substantially lowers furnace temperatures and causes smoking at the stack and into charging room areas. Infiltration also increases auxiliary fuel usage and usually accelerates refractory deterioration. Several states have recently enacted regulations requiring mechanical loaders on all institutional waste incinerators.

Mechanical loaders enable incinerators to be charged with relatively small batches of waste at regulated time intervals. Such charging is desirable because it provides relatively stabilized combustion conditions and approximates steady-state operations. Limiting waste batch sizes and loading cycles also helps protect against over-charging and resultant operating problems.

The development of safe, reliable mechanical loaders has been a major step toward modernizing institutional waste incineration technology. The earliest incinerators were restricted to manual charging, which limited their capacities and applications. Of the loader designs currently available, most manufacturers use the hopper/ram system. With this system, waste is loaded into a charging hopper, a hopper cover closes, a primary chamber fire-door opens and a charging ram then pushes the waste into the primary chamber.

Hopper/ram systems are available with charging hopper volumes ranging from several cubic-feet to nearly 10 cubic yards. The selection of proper hopper volume is a function of waste type, waste container size, method of loading the hopper and incinerator capacity. An undersized hopper could result in spillage during waste loadings, an inability to handle bulky waste items, such as empty boxes, or the inability to charge the incinerator at rated capacity. On the other hand, an oversized hopper could result in frequent incinerator overcharging and associated operational problems.

A few manufacturers have recently developed mechanical loader systems which are capable of accepting as much as an hour's worth of waste loading at one time. These systems use internal rams to charge the primary chamber at intervals, as well as to prevent hopper bridging. Although these systems have had reportedly good success, they are still generally in the developmental stage.

One particular rotary kiln manufacturer uses an integral shredder at the bottom of the waste feed hopper. This system is termed an "auger feeder". It basically serves to process waste into a size that is compatible with the kiln dimensions.

With small capacity incinerators, less than about 500 pounds per hour, waste is usually loaded manually, bag by bag, into the charging hopper. Larger capacity systems frequently employ waste handling devices such as conveyors, cart dumpers and, sometimes, skid-steer tractors to charge waste into the hopper. Pneumatic waste transport systems have been used to feed incinerator loading hoppers at a few institutions, but these have limited success.

A cart-dumper loader basically combines a standard hopper/ram system with a device for lifting and dumping waste carts into the loading hopper. Several manufacturers offer these as integrated units. Cart dumpers can also be procured separately from several suppliers and adapted or retro-fitted to almost any hopper/ram system. Cart-dumper loader systems have become increasingly popular because using standard, conventional waste carts for incinerator loading reduces extra waste handling efforts and often eliminates the need for intermediate storage containers and additional waste handling equipment.

Most modern hopper/ram assemblies are equipped with a water system to quench the face of the charging ram face after each loading cycle. This prevents the ram face from overheating due to constant, direct exposures to high furnace temperatures during waste injection. Without such cooling, plastic waste bags or similar materials could melt and adhere to the hot ram face. If these items did not drop from the ram during its stoking cycle, they could ignite and be carried back into the charging hopper, where they could ignite other waste remaining in the hopper or new waste loaded into the hopper. For additional protection against such possible occurrences, loading systems can also be equipped with hopper flame scanners and alarms, hopper fire spray systems and/or an emergency switch to override the normal charging cycle timers and cause immediate injection of hopper contents into the incinerator.

Residue Removal and Handling Systems

Residue, or ash, removal has always been a particular problem for institutional type incineration systems. Most small capacity incinerators (less than about 500 pounds per hour) and most controlled air units designed and installed before the mid-1970's, must be cleaned manually. Operators must rake and shovel ashes from the primary chamber into outside containers. Small capacity units can be cleaned from the outside, but large capacity units often require operators to enter the primary chamber to clean ashes. The practice of manual clean-out is especially objectionable from many aspects, including:

- Difficult labor requirements.

- Hazards to operating personnel because of exposures to hot furnace walls, pockets of glowing ashes, flaming materials, airborne dusts and noxious gases.

- Daily cool-down and start-up cycling requirements which substantially increase auxiliary fuel usage and reduce available charging time.

- Detrimental effects of thermal cycling on furnace refractories.

- Severe aesthetic, environmental and fire safety problems when handling hot, unquenched ashes outside the incinerator.

- Possible regulatory restrictions

In multiple-chamber incinerators, automatic ash removal systems usually feature mechanical grates, or stokers. In rotary kiln systems, ash removal is accomplished via the kiln rotation. However, automatic, continuous ash removal has historically been difficult to achieve in controlled air systems which have conventionally featured stationary, or fixed, hearths.

Early attempts at automatic ash removal in controlled air incinerators employed a "bomb-bay" door concept. With these systems, the bottom of the primary chamber would swing open to drop ashes into a container or vehicle located below. Serious operating problems led to the discontinuance of these systems. More recent automatic ash removal systems use rams or plungers to "push" a mass of residue through the primary chamber and out a discharge door on a batch basis. Most of these systems have had only limited success.

Controlled air incinerator automatic ash removal systems that have shown the most promise use the waste charging ram of the hopper/ram system to force waste and ash residues through the primary chamber to an internal discharge, or drop, chute for removal. Although charging rams usually extend no more than about 12 to 18 inches into the furnace during loading, this is sufficient to move materials across the primary chamber via the repetitive, positive-displacement actions of the ram. With proper design and operations, the waste should be fully reduced to ash by the time it reaches the drop chute. For incinerators with capacities greater than about 800 to 1000 pounds per hour, internal transfer rams are usually provided to help convey ashes through the furnace to the drop chute. Transfer rams are necessary because the ash displacement capabilities of charging rams are typically limited to a maximum length of about 8 feet. Primary chambers longer than about 16 feet usually have two or more sets of internal transfer rams.

The most innovative residue removal system uses a "pulse hearth" to transfer ashes through the incinerator. The entire floor of the primary chamber is suspended on cables and pulses intermittently via sets of end-mounted air cushions. The pulsations cause ash movement across the chamber and toward the drop chute.

After the ashes drop from the primary chamber through the discharge chute, there are two basic methods, other than manual, for collecting and transporting them from the incinerator. The first is a semi-automatic system using ash collection carts positioned within an air-sealed enclosure beneath the drop chute. A door or seal gate at the bottom of the chute opens cyclically to drop ashes into ash carts. Falling ashes are sprayed with water for dust suppression and a minor quenching. Because of weight considerations, ash cart volumes are usually limited to about one cubic-yard.

Loaded ash carts are manually removed from the ash drop enclosure and replaced with empty carts. After the removed carts are stored on-site long enough for the hot ashes to cool, they are either emptied into a larger container for off-site disposal or are brought directly to the landfill and dumped. Adequate design and proper care are needed when dumping ashes into larger on-site containers to avoid severe dusting problems. In addition, some ashes could still be hot and may tend to ignite when exposed to ambient air during the dumping operations.

The second method of ash removal is a fully automatic system using a water quench trough and ash conveyor that continuously and automatically transports wet ashes from the quench trough to a container or vehicle. With these systems, the discharge chute terminates below water level in a quench trough in order to maintain a constant air seal on the primary chamber. Most manufacturers use drag, or flight, type conveyors, but a few offer "backhoe" or "scoop" type designs to batch grab ashes from the quench trough. The important factor is that the selected ash conveyor system be of proven design and of heavy-duty construction for the severe services of ash handling.

Waste Heat Recovery

In most incineration systems, heat recovery is accomplished by drawing the flue gases through a waste heat boiler to generate steam or hot water. Most manufacturers use conventional firetube type boilers for reasons of simplicity and low costs. Both single and multi-pass firetube boilers have been used successfully at many installations. Several facilities incorporate supplemental fuel-fired waste heat boilers so that steam can be generated when the incinerator is not operating. Also, automatic soot blowing systems are being installed on an increasing number of firetube boilers, in order to increase on-line time and recovery efficiencies.

One manufacturer uses single-drum, watertube type waste heat boilers on incineration systems. Watertube boilers are also used by other manufacturers on installations where high steam pressures and flow rates are required. Another manufacturer offers heat recovery systems with waterwall, or radiant sections, in the primary chamber. These waterwall sections, which are usually installed in series with a convective type waste heat boiler, can increase overall heat recovery efficiencies by as much as 10 to 15 percent.

Many incinerator manufacturers typically "claim" system heat recovery efficiencies for their equipment ranging from 60 to as high as 80 percent. However, studies and EPA-sponsored testing programs have shown that realistic heat recovery efficiencies are typically on the order of 50 to 60 percent. The amount of energy, or steam, that can be recovered is basically a function of flue gas mass flow rates and inlet and outlet temperatures. Depending on boiler type and design, gas inlet temperatures are usually limited to a maximum of 2,200°F. Outlet temperatures are limited to the dewpoint temperature of the flue gases in order to prevent condensation and corrosion of heat exchanger surfaces. Depending upon flue gas constituents, incinerator dewpoint temperatures are usually on the order of 400°F.

For estimating purposes, about 3 to 4 pounds of steam can be recovered for each pound of typical institutional type solid waste incinerated. However, the economic feasibilities of providing a waste heat recovery system usually depend upon the ability to use the recovered energy. If only half of recovered steam can be used because of low seasonal steam demands, heat recovery may not be cost-effective.

Some controlled air incinerator manufacturers offer air preheating, or "economizer packages," with their units. These primarily consist of metal jacketing, or shrouds, around sections of the primary or secondary chambers. Combustion air is heated by as much as several hundred degrees when pulled through the shrouds by combustion air blowers. This preheating can reduce auxiliary fuel usage by as much as 10 to 15 percent. In addition, the shrouding on some systems also helps limit incinerator skin temperatures to within OSHA limits.

For safety and normal plant shutdown, waste heat boilers are equipped with systems to divert flue gases away from the boiler and directly to a stack. One such system comprises an abort, or dump, stack upstream of the boiler. Another system includes a bypass breeching connection between the incinerator and stack. Modern, well-designed bypass systems are equipped with isolation dampers either in the dump stack or in the bypass breeching section. In systems without isolation dampers, either hot flue gases can bypass the boiler or ambient air can dilute gases to the boiler. Because of these factors, boiler isolation dampers may improve overall heat recovery efficiencies by at least 5 percent.

Chemical Waste Incineration

An increasing number of institutions are disposing of chemical waste in their incineration systems. Incinerated chemicals are usually flammable waste solvents that are burned as fuels with solid waste. A simple method of firing solvents has been to inject them through an atomizer nozzle into the flame of an auxiliary fuel burner. Larger capacity and better designed systems use special, packaged burners to fire waste solvents. Such burners are either dedicated exclusively for waste solvent firing or have capabilities for switching to fuel oil firing when waste solvents are not available. Waste solvent firing is usually limited to the primary chamber in order to assist in the burning of solid wastes and to maximize retention time by fully utilizing secondary chamber volumes. Injectors and burners must be located and positioned so as not to have impingement on furnace walls or other burners. Such impingement results in poor combustion and often causes emission problems.

Chemical waste incineration systems must also include properly designed chemical waste handling systems. These include a receiving and unloading station, a storage tank, a pump set to feed the injector or burner, appropriate diking and spill protection, monitoring and safety protection devices. Most of these components must be enclosed within a separate, fire-rated room that is specially ventilated and equipped with explosion-proof electrical fixtures.

When transporting, storing and burning chemical waste, local, state and federal hazardous waste regulations must be followed. If the incinerated waste is regulated as a "hazardous waste," very costly trial burn testing, (Part B) permitting and monitoring equipment are required. In addition, obtaining the permits could delay starting a new facility by as much as 12 to 18 months. Incinerators burning chemical solvents which are only hazardous due to "ignitability" are not likely to be considered "hazardous waste incinerators," and the costly and lengthy hazardous waste incinerator permitting process is avoided. However, the storage and handling of these solvents will likely require a hazardous waste (Part B) permit.

At many institutions, bottles and vials of chemical wastes are often mixed with solid waste for incineration. If the quantities, or concentrations, of such containers and chemicals are very small with respect to the solid waste, incinerator operations may be unaffected. However, whenever solid waste loads are mixed with excessive concentrations of chemical containers, serious operating problems are likely, including rapid, uncontrolled combustion and volatilization resulting in heavy smoke emissions and potentially damaging temperature excursions. In addition, glass vials and containers tend to melt and form slag that can damage refractory and plug air supply ports.

Emission Control Systems

In general, only controlled air incinerators are capable of meeting the stringent emission standard of 0.08 grains of particulate per dry standard cubic foot of flue gas (gr/DSCF), corrected to 12 percent carbon dioxide, without emission control equipment. However, no incineration systems can meet the emission limits being recently enacted by many states which require compliance with Best Available Control Technology (BACT) levels. The BACT particulate level identified by many of the states is 0.015 gr/DSCF, corrected to 12 percent carbon dioxide. However, this is a controversial level which is being challenged by some in that it is only applicable to municipal waste incineration technology. Compliance with a 0.015 level will likely require a very high pressure drop, energy intensive, venturi scrubber system. Although "dry scrubbers," which comprise alkaline injection into the flue gas stream upstream of a baghouse filter, may also achieve a 0.015 level, as of this writing, this technology has yet to be demonstrated on an institutional waste incineration system.

Most institutional solid waste streams, particularly hospitals, include significant concentrations of polyvinyl chloride (PVC) plastics. Upon combustion, PVC plastics break down and form hydrogen chloride (HCl) gas. The condensation of HCl gases results in the formation of highly corrosive hydrochloric acid. Therefore, flue gas handling systems, and particularly waste heat boilers, must be designed and operated above the dewpoint of the flue gases. Protection of scrubbing systems typically includes the provision of an acid neutralization system on the scrubber water circuitry and the use of acid resistant components and materials.

Some states have identified BACT for HCl emissions as either 90 percent removal efficiency or 30 to 50 PPM, by volume, in the exhaust gases. For most well-designed wet scrubbers, 99 percent removal efficiencies are readily achievable. With respect to minimizing emissions of products of incomplete combustion (PIC's), such as carbon monoxide and even dioxins and furans, the keys are proper furnace sizing, good combustion controls designed to accommodate varying waste compositions and charging rates, good operations and proper care and adjustment of system components. Inadequacies in any of these could result in objectionable emissions.

INCINERATION PERFORMANCE AND PROCUREMENT

Success Rates

Incineration is considered proven technology in that a great many systems readily comply with stringent environmental regulations and performance requirements. Properly designed and operated incineration systems provide "good" performance if they satisfy specific user objectives in terms of burning capacity, or throughput, burnout, or destruction, environmental integrity and on-line reliability. However, many incineration systems of both newer and older designs perform poorly. Performance problems range from minor nuisances to major disabilities, and needed corrective measures range from simple adjustments to major modifications or even total abandonment. Furthermore, performance problems occur as frequently and as extensively in small, dedicated systems as in large, complex facilities. The most common incineration system performance problems are shown on Figure 4.

It has been estimated that roughly 25 percent of incineration systems installed within the last 10 years either do not operate properly or do not satisfy user performance objectives. A 1981 University of Maryland survey of medical and academic institutions incinerating low-level radioactive wastes indicated that only about 50 percent of the institutions surveyed (23 total) "reported no problems," and about 47 percent of the institutions (20 total) reported problems ranging from mechanical difficulties to combustion difficulties. A survey conducted by the U.S. Army Corps of Engineers Research Laboratory in 1985 at 52 incineration facilities reported that 17 percent of the users were "very pleased with their systems," 71 percent were "generally satisfied with the performance of their systems" (but indicated that minor changes were needed to reduce maintenance and improve efficiency) and 12 percent were "not happy with their systems" (reporting severe problems). Results of this Army survey are summarized on Figure 5.

Fundamental Reasons for Poor Performance

Underlying causes or reasons for poor incineration system performance are not always obvious. When performance difficulties are encountered, a typical reaction is often to "blame" the incinerator contractor for furnishing "inferior" equipment. While this may be the case on some installations, there are other possible reasons which are more common and sometimes more serious. Generally, incineration system performance problems can be related to deficiencies or inadequacies in any or all of three areas:

1. Selection and/or design - Before procurement

2. Fabrication and/or installation - During installation

3. Operation and/or maintenance - After acceptance

Examples of deficiencies in these three areas are as follows:

1. System Selection and/or Design Deficiencies

Deficiencies in this area are usually the result of basing incineration system selection and design decisions on incorrect or inadequate waste data, as well as failures to address specific, unique facility requirements. The resultant consequences are that system performance objectives and design criteria are also inadequate. An example of this is the procurement of an incineration system of inadequate capacity because of underestimated waste generation rates. Not so obvious examples include the relationships between operating problems and inadequate waste characterization data.

Since incinerators are designed and controlled to process specific average waste compositions, vague identification of waste types or wide variances between actual waste parameters and "selected" design parameters often result in poor system performance. Significant deviations in parameters such as heating values, moisture, volatility, density and physical form could necessitate a capacity reduction of as much as two-thirds in order to avoid objectionable stack emissions, unacceptable ash quality and other related problems. Figure 6 indicates examples of improper waste characterization affecting incineration capacity.

The establishment of good performance objectives based upon sound data and evaluations is only the initial step towards procuring a successful installation. The next step would be to assure that system design criteria and associated contract documents are adequate to satisfy the performance objectives. A prime example of design inadequacies is the failure to relate incinerator furnace volumes to any specific criteria auch as acceptable heat release rates. Another example is the specification of auxiliary components, such as waste loaders and ash removal systems, that are not suitable for the required operating schedules or rigors.

2. Fabrication and/or Installation Deficiencies

Deficiencies in this area relate to inferior workmanship and/or materials in either the fabrication or installation of the system. The extent and severity of such deficiencies are largely dependent upon the qualifications and experience of the incinerator contractor. Unqualified incineration system contractors may be incapable or disinterested in providing a system in compliance with specified criteria. This could be either because of general inexperience in the field of incineration or because of a disregard of criteria that is different from their "standard way of doing business or furnishing equipment."

It is typical for even the most experienced and qualified incineration system contractors to deviate to some extent from design documents or criteria. This is largely because there are no such things as "standard" or "universal" incineration systems or "typical" applications or facilities. Unless design documents are exclusively and entirely based upon and awarded to a specific, pre-selected incinerator manufacturer, different manufacturers usually propose various substitutions and alternate methodologies when bidding a project. The key to evaluating such proposed variations is to assess whether they comply with fundamental design and construction criteria and whether they reflect proven design and application. On the other hand, allowing such variations without proper assessment could have unfortunate consequences.

The number and severity of fabrication and installation deficiencies are also directly related to quality control efforts during construction phases of a project. For example, a review of contractor submittals, or shop drawings, usually helps assure compliance with contract documents before equipment is delivered to the job site. Site inspections during installation work may detect deficiencies in design or workmanship before they lead to operational problems and performance difficulties. In addition, specific operating and performance testing as a prerequisite to final acceptance is a key element in assuring that a system is installed properly.

Figure 7 lists some of the most common reasons for deficiencies in the fabrication and installation of incineration systems.

3. Operational and/or Maintenance Deficiencies

Deficiencies in this area are basically "self-inflicted" in that they usually result from Owner, or user, omissions or negligence, and related problems occur after a system has been successfully tested and officially accepted.

Successful performance of even the best designed, most sophisticated and highest quality incineration systems is ultimately contingent upon the abilities, training and dedication of the operators. The employment of unqualified, uncaring, poorly trained and unsupervised operators is one of the most positive ways of debilitating system performance in the shortest time.

Incineration systems are normally subject to severe operating conditions, and they require frequent adjustments and routine preventive maintenance in order to maintain good performance. Failures to budget for and provide such adjustments and maintenance on a regular basis leads to increasingly bad performance and accelerated equipment deterioration. Also operating incineration equipment until it "breaks down" usually results in extensive, costly repair work and substantially reduced reliability.

Figure 8 lists some of the most common operational and maintenance deficiencies which could result in poor incineration system performance.

The above problems are usually inter-related, and they usually occur in combination. They occur as frequently and as extensively in small, dedicated facilities as in large, complex facilities. They may range in severity from objectionable nuisances to major disabilities. Also, required corrective measures may range from minor adjustments to major modifications or even total abandonment.

Selection and design deficiencies are probably the most common as well as the most serious causes of problem incineration systems. Reputable incinerator contractors usually make every effort to satisfy specified design and construction criteria and meet their contractual obligations. Operating and maintenance deficiencies can usually be corrected. However, once a system has been installed and started, very little can be done to compensate for fundamental design inadequacies. Major, costly modifications and revisions to performance objectives are usually required.

The relatively frequent occurrence of design deficient systems may largely be attributable to a general misconception of the incineration industry as a whole. Incinerators are often promoted as standard, off-the-shelf equipment that can be ordered directly from catalogs, shipped to almost any job-site and, literally, "plugged in". This impression has been enhanced by many of the incinerator vendors in a highly competitive market. Exaggerations, half-truths and, sometimes, false claims are widespread relative to equipment performance capabilities. In addition, attractive, impressive brochures often suggest that implementation of an incineration system is simpler than it really is.

Incineration systems are normally subject to extremely severe operating conditions. These include very high and widely fluctuating temperatures, thermal shock from wet materials, slagging residues which clinker and spall furnace materials, explosions from items such as aerosol cans, corrosive attacks from acid gases and chemicals and mechanical abrasion from the movement of waste materials and from operating tools. These conditions are compounded by the complexity of the incineration process. Combustion processes are complicated in themselves, but in incineration this complexity is magnified by frequent, unpredictable and often tremendous variations in waste composition and feed rates. To properly manage such severe and complex operating conditions, incineration systems require well-trained, dedicated operating personnel, frequent and thorough inspections, maintenance and repair, and administrative and supervisory personnel attuned to these requirements.

At many facilities, the practice is to operate the incineration system continuously until it breaks down because of equipment failures. This type of operation accelerates both bad performance and equipment deterioration rates. Repairs done after such breakdowns are usually far more extensive and costly than those performed during routine, preventive maintenance procedures. Also, items which are typically capable of lasting many years can fail in a fraction of that time if interrelated components are permitted to fail completely.

KEY STEP

A first step in procuring a good incineration system is to view the incineration "industry" in a proper perspective. There are four basic principles to bear in mind:

1. Incineration technology is not an "exact" science - it is still more of an art than a science, and there are no shortcuts, simplistic methods or textbook formulas for success.

2. There is no "universal" incinerator - no design is universally suited for all applications. Incinerators must be specifically selected, designed and built to meet the needs of each facility on an individual basis. Manufacturers' catalogs identify typical models and sizes, but these are rarely adequate for most facilities without special provisions or modifications.

3. There is no "typical" incinerator application - even institutions of similar type, size and activities have wide differences in waste types and quantities, waste management practices, disposal costs, space availability and regulatory requirements. Each application has unique incineration system requirements that must be identified and accommodated on an individual basis.

4. Incinerator manufacturers are not "equal" - there are wide differences in the capabilities and qualifications of the incinerator equipment manufacturers. Likewise, there are wide differences in the various systems and equipment, which are offered by different manufacturers.

RECOMMENDED PROCUREMENT STEPS

Figure 9 outlines six steps, recommended for implementing an incineration system project. Each is considered equally important towards minimizing or eliminating the deficiencies discussed above and for increasing the likelihood of obtaining a successful installation.

Performance difficulties on <u>most</u> problem incineration systems can usually be traced to a disregard or lack of attention to details in the first two steps; namely, 1) evaluations and selections and 2) design documents. For example, many facilities have been procured strictly on the basis of "purchase orders" containing generalized requirements such as:

> "Furnish an incineration system to burn ________ lb/hr of institutional waste in compliance with applicable regulations."

Obviously, the chances for success are marginal for any incineration system procured on the basis of such specifications.

On many projects, incinerator contractor evaluation and selection, under Step 3, involve no more than a solicitation of prices from a random listing of vendors with the award of a contract to that firm proposing a system for the "least cost." There are two basic problems with this approach. First, the selected incinerator contractors are assumed to have equivalent capabilities and qualifications. Second, "least cost" acceptance assumes that the equipment offered by each of the contractors is equivalent, or identical. A comparative "value" assessment of proposals usually results in the procurement of a superior quality system for a negligible price difference. It is not uncommon to see cost proposals "low" by no more than 10 percent, but the equipment offered of only half the quality of the competition.

Again, although incineration is considered a proven technology, in many ways it is still more of an art than a science. There are no shortcuts, textbook formulas or shortcut methods for selecting and implementing a successful system, and there are no guarantees that a system will not have difficulties and problems. However, the probabilities of procuring a successful, cost-effective system increase proportionally with attention to details and utilization of proven techniques, methodologies and experience.

FIGURE 1

CLASSIFICATION OF WASTES

Classification of Wastes Type	Description	Principal Components	Approximate Composition % by Weight	Moisture Content %	Incombustible Solids %	B.T.U. Value/lb. of Refuse as Fired
0	Trash	Highly combustible waste, paper, wood, cardboard cartons, including up to 10% treated papers, plastic or rubber scraps; commercial and industrial sources	Trash 100%	10%	5%	8500
1	Rubbish	Combustible waste, paper, cartons, rags, wood scraps, combustible floor sweepings; domestic, commercial and industrial sources	Rubbish 80% Garbage 20%	25%	10%	6500
2	Refuse	Rubbish and garbage; residential sources	Rubbish 50% Garbage 50%	50%	7%	4300
3	Garbage	Animal and vegetable wastes, restaurants, hotels, markets; institutional, commercial and club sources	Garbage 65% Rubbish 35%	70%	5%	2500
4	Animal solids and organic wastes	Carcasses, organs, solid organic wastes; hospital, laboratory, abattoirs, animal pounds and similar sources	100% Animal and Human Tissue	85%	5%	1000

Ref: 11

FIGURE 2

MAXIMUM BURNING RATE LBS./SQ. FT./HR.
OF VARIOUS TYPE WASTES

CAPACITY Lbs./Hr.	LOGARITHM	#1 WASTE FACTOR 13	#2 WASTE FACTOR 10	#3 WASTE FACTOR 8	#4 WASTE NO FACTOR
100	2.00	26	20	16	10
200	2.30	30	23	18	12*
300	2.48	32	25	20	14*
400	2.60	34	26	21	15*
500	2.70	35	27	22	16*
600	2.78	36	28	22	17*
700	2.85	37	28	23	18*
800	2.90	38	29	23	18*
900	2.95	38	30	24	18*
1000	3.00	39	30	24	18*

*The maximum burning rate in lbs./sq. ft./hr. for Type 4 Waste depends to a great extent on the size of the largest animal to be incinerated. Therefore whenever the largest animal to be incinerated exceeds 1/3 the hourly capacity of the incinerator, use a rating of 10# sq. ft./hr. for the design of the incinerator.

Above Figures calculqted as follows:

MAXIMUM BURNING RATE LBS. PER SQ. FT. PER HR. FOR TYPES #1, #2 & #3 WASTES USING FACTORS AS NOTED IN THE FORMULA.

BR=FACTOR FOR TYPE WASTE X LOG OF CAPACITY/HR.
#1 WASTE FACTOR 13
#2 WASTE FACTOR 10
#3 WASTE FACTOR 8
BR=MAX. BURNING RATE LBS./SQ. FT./HR.

I.E.–ASSUME INCINERATOR CAPACITY OF 100 LBS./HR, FOR TYPE #1 WASTE

BR=13 (FACTOR FOR #1 WASTE) X LOG 100 (CAPACITY/HR.)
13 X 2 = 26 LBS./SQ. FT./HR.

Ref: 11

FIGURE 3

WASTE DATA CHART

Material	B.T.U. value/lb. as fired	Wt. in lbs. per cu. ft. (loose)	Wt. in lbs. per cu. ft.	Content by weight in percentage	
				ASH	MOISTURE
Type 0 Waste	8,500	8-10		5	10
Type 1 Waste	6,500	8-10		10	25
Type 2 Waste	4,300	15-20		7	50
Type 3 Waste	2,500	30-35		5	70
Type 4 Waste	1,000	45-55		5	85
Acetic Acid	6,280		65.8	0.5	0
Animal fats	17,000	50-60		0	0
Benzene	18,210		55	0.5	0
Brown paper	7,250	7		1	6
Butyl sole composition	10,900	25		30	1
Carbon	14,093		138	0	0
Citrus rinds	1,700	40		0.75	75
Coated milk cartons	11,330	5		1	3.5
Coffee grounds	10,000	25-30		2	20
Corn cobs	8,000	10-15		3	5
Corrugated paper	7,040	7		5	5
Cotton seed hulls	8,600	25-30		2	10
Ethyl Alcohol	13,325		49.3	0	0
Hydrogen	61,000		0.0053	0	0
Kerosene	18,900		50	0.5	0
Latex	10,000	45	45	0	0
Linoleum scrap	11,000	70-100		20-30	1
Magazines	5,250	35-50		22.5	5
Methyl alcohol	10,250		49.6	0	0
Naphtha	15,000		41.6	0	0
Newspaper	7,975	7		1.5	6
Plastic coated paper	7,340	7		2.6	5
Polyethylene	20,000	40-60	60	0	0
Polyurethane (foamed)	13,000	2	2	0	0
Rags (linen or cotton)	7,200	10-15		2	5
Rags (silk or wool)	8,400-8,900	10-15		2	5
Rubber waste	9,000-11,000	62-125		20-30	0
Shoe Leather	7,240	20		21	7.5
Tar or asphalt	17,000	60		1	0
Tar paper ⅓ tar-⅔ paper	11,000	10-20		2	1
Toluene	18,440		52	0.5	0
Turpentine	17,000		53.6	0	0
⅓ wax-⅔ paper	11,500	7-10		3	1
Wax paraffin	18,621		54-57	0	0
Wood bark	8,000-9,000	12-20		3	10
Wood bark (fir)	9,500	12-20		3	10
Wood sawdust	7,800-8,500	10-12		3	10
Wood sawdust (pine)	9,600	10-12		3	10

The above chart shows the various B.T.U. values of materials commonly encountered in incinerator designs. The values given are approximate and may vary based on their exact characteristics or moisture content.

Ref: 11

FIGURE 4

INCINERATION SYSTEM PERFORMANCE PROBLEMS

MAJOR PERFORMANCE DIFFICULTIES	EXAMPLES
1. OBJECTIONABLE STACK EMISSIONS	• Out of compliance with air pollution control requlations
	• Visible emissions
	• Odors
	• Hydrochloric acid gas (HCl) deposition and deterioration
	• Entrapment of stack emissions into building air intakes
2. INADEQUATE CAPACITY	• Cannot accept "standard" size waste containers
	• Low hourly charging rates
	• Low daily burning rates (throughput)
3. POOR BURNOUT	• Low waste volume reduction
	• Recognizable waste items in ash residue
	• High ash residue carbon content (combustibles)
4. EXCESSIVE REPAIRS & DOWNTIME	• Frequent breakdowns and component failures
	• High maintenance and repair costs
	• Low system reliability
5. UNACCEPTABLE WORKING ENVIRONMENT	• High dusting conditions and fugitive emissions
	• Excessive waste spillage
	• Excessive heat radiation and exposed hot surfaces
	• Blowback of smoke and combustion products from the incinerator
6. SYSTEM INEFFICIENCIES	• Excessive auxiliary fuel usage
	• Low steam recovery rates
	• Excessive operating labor costs

Ref: 7

FIGURE 5

20 COMMON PROBLEMS FOUND IN SMALL WASTE-TO-ENERGY PLANT'S

Results of 1983 Survey of 52 Heat Recovery Incineration Systems (5-50 TPD) Conducted by U.S. Army Construction Engineering Research Laboratory.

PROBLEMS	PERCENT OF INSTALLATIONS REPORTING
1. Castable Refractory	71%
2. Underfire Air Ports	35%
3. Tipping Floor	29%
4. Warping	29%
5. Charging Ram	25%
6. Fire Tubes	25%
7. Air Pollution	23%
8. Ash Coveyor	23%
9. Not On-Line	21%
10. Controls	19%
11. Inadequate Wast Supply	19%
12. Water Tubes	17%
13. Internal Ram	15%
14. Low Steam Demand	13%
15. Induced Draft Fans	12%
16. Feed Hopper	10%
17. High pH Quench Water	8%
18. Stack Damper	4%
19. Charging Grates	2%
20. Front-End Loaders	2%

Concensus

17% Very Pleased
71% Generally Satisfied-Minor Improvements Needed
12% Not Happy

Ref: 8

FIGURE 6

WASTE CHARACTERIZATION DATA DEFICIENCIES NECESSITATING SYSTEM CAPACITY REDUCTIONS

ACTUAL WASTE CHARACTERIZATION DEVIATIONS FROM SELECTED "DESIGN" VALUES	TYPICAL EXAMPLES	BASIC REASONS FOR REDUCED CAPACITIES[1]
• HEATING VALUES (Btu/lb) EXCESSIVE	-- Greater concentrations of paper and plastic components (or less moisture) than originally identified and specified	-- Incinerator volumetric heat release rates (Btu/cu-ft/hr) exceed design limits[2]
• MOISTURE CONCENTRATIONS EXCESSIVE	-- Greater concentrations of high water content wastes, such as animal carcasses or food scraps (garbage), than originally identified and specified	-- Increased auxiliary fuel firing rates and additional time required for water evaporation and superheating
• VOLATILES EXCESSIVE	-- Greater concentrations of plastic (such as polyethylene and polystyrene) or flammable solvents than originally identified and specified	-- Rapid (nearly instantaneous) releases of combustibles (volatiles) in large quantities along with excessively high temperature surges
• DENSITIES EXCESSIVE	-- Computer printout, compacted waste, books, pamphlets and blocks of paper	-- Difficulties in heat and flames penetrating and burning through dense layers of waste
• HIGH ASH FORMATION TENDENCIES	-- Animal bedding or cage wastes - wood chips, shavings or sawdust	-- Ash layer formation on surface of waste pile insulates bulk of waste from heat, flames and combustion air

1) Failure to reduce capacities, or hourly waste loading rates, to accommodate indicated deviations would likely result in other more serious operational problems.

2) Based upon accepted, empirical values, primary chamber heat release rates should be in the range of 15,000 to 20,000 Btu/cu-ft/hr.

Ref: 7

FIGURE 7

COMMON REASONS FOR FABRICATION & INSTALLATION DEFICIENCIES

- Incineration equipment vendor (manufacturer) unqualified
- Equipment installation contractor (GC) unqualified
- Inadequate instructions (and supervision) from the manufacturer for system installation by the GC.
- No clear lines of system performance responsibility between the manufacturer and the GC
- Failure to review manufacturer's shop drawings, catalog cuts and materials and construction data to assure compliance with contract (design) documents
- Inadequate quality control during and following construction to assure compliance with design (contract) documents
- Payment schedules inadequately related to system performance milestones
- Final acceptance testing not required for demonstrating system performance in accordance with contract requirements

Ref: 7

FIGURE 8

COMMON REASONS FOR OPERATIONAL & MAINTENANCE DEFICIENCIES

- Unqualified operators
- Negligent, irresponsible and/or uncaring operators
- Inadequate operator training programs
- Inadequate operating and maintenance manuals
- No record keeping or operating logs to monitor and verify performance
- Inadequate operator supervision
- Lack of periodice inspections, adjustments and preventative maintenance
- Extending equipment usage when repairs and maintenance work are needed

Ref: 7

FIGURE 9

RECOMMENDED INCINERATION SYSTEM IMPLEMENTATION STEPS

1. EVALUATIONS & SELECTIONS

   - o Collect and consolidate waste, facility, cost and regulatory data
   - o Identify and evaluate options and alternatives
   - o Select system and components

2. DESIGN (CONTRACT) DOCUMENTS

   - o Define wastes to be incinerated - avoid generalities and ambiguous terms
   - o Specify performance requirements
   - o Specify full work scope
   - o Specify minimum design and construction criteria

3. CONTRACTOR SELECTION

   - o Solicit bids from prequalified contractors
   - o Evaluate bids on quality and completeness - not strictly least cost
   - o Evaluate and negotiate proposed substitutions and deviations
   - o Negotiate payment terms
   - o Consider performance bonding

4. CONSTRUCTION AND EQUIPMENT INSTALLATION

   - o Establish lines of responsibility
   - o Require shop drawing approvals
   - o Provide inspections during construction and installation

5. STARTUP AND FINAL ACCEPTANCE

   - o "Punch-out" system for contract compliance
   - o Require comprehensive testing: system operation, compliance with performance requirements and emissions
   - o Obtain operator training

6. AFTER FINAL ACCEPTANCE

   - o Employ qualified and trained operators
   - o Maintain operator supervision
   - o Monitor and record system operations
   - o Provide regular inspections and adjustments
   - o Implement preventive maintenance and prompt repairs - consider service contract

Ref: 7

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