EPA Hospital Incinerator Operator Training Course: Volume II Presentation Slides
HOSPITAL INCINERATOR OPERATOR
TRAINING COURSE:
VOLUME II
PRESENTATION SLIDES

CONTROL TECHNOLOGY CENTER

SPONSORED BY:

Emission Standards Division
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Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, OH 46268

March 1989
HOSPITAL INCINERATOR OPERATOR TRAINING COURSE:
VOLUME II
PRESENTATION SLIDES

EPA Contract No. 68-02-4395
Work Assignment 16

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DISCLAIMER

This document generally describes the proper operation of a hospital waste incinerator. It is based on EPA's review and assessment of various scientific and technical sources. The EPA does not represent that this document comprehensively sets forth procedures for incinerator operation, or that it describes applicable legal requirements, which vary according to an incinerator's location. Proper operation of an incinerator is the responsibility of the owner and operator.

Mention of trade names or commercial products does not constitute endorsement or recommendation for use.
ACKNOWLEDGEMENT

This document was prepared by Midwest Research Institute located in Cary, North Carolina. Principal authors were Roy Neulicht and Linda Chaput; Dennis Wallace, Mark Turner, and Stacy Smith were contributing authors. Participating on the project team for the EPA were Ken Durkee and James Eddinger of the Office of Air Quality Planning and Standards, Charles Masser of Air and Energy Engineering Research Laboratory, James Topsale of Region III, Charles Pratt of the Air Pollution Training Institute, and Justice Manning of the Center for Environmental Research Information. Also participating on the project team were Carl York and William Paul of the Maryland Air Management Administration.

Numerous persons were very helpful throughout this project and provided information and comments for these course materials. Listed below are some who deserve special acknowledgement for their assistance.

- Mr. Larry Doucet, Doucet and Mainka, who provided a thorough review of the student handbook.

- The following persons and facilities who provided our staff access to their facilities:
  
  Messrs. Steve Shuler and Greg Swan, Joy Energy Systems; William Tice, Rex Hospital; Dean Clark, Bio-Medical Services, Inc.; Gary Kamp, Presbyterian--University Medical Center; Don Rust, Duke University Medical Center; Chip Priester, Southland Exchange Joint Venture; and Gregory Price, The Johns Hopkins Hospital.

- The following manufacturers who provided us with detailed operating and maintenance information:
  

- Mr. Charles Bollack and his staff, Mercy Medical Center, who hosted the first trial run of this course and Mr. Robert J. Winterbottom, R. J. Winterbottom, Inc., who assisted during the course at Mercy Medical Center.
PREFACE

The program for development of a training course for operators of hospital medical waste incinerators was funded as a project of EPA's Control Technology Center (CTC).

The CTC was established by EPA's Office of Research and Development (ORD) and Office of Air Quality Planning and Standards (OAQPS) to provide technical assistance to State and local air pollution control agencies. Three levels of assistance can be accessed through the CTC. First, a CTC HOTLINE has been established to provide telephone assistance on matters relating to air pollution control technology. Second, more in-depth engineering assistance can be provided when appropriate. Third, the CTC can provide technical guidance through publication of technical guidance documents, development of personal computer software, and presentation of workshops on control technology matters. The technical guidance projects, such as this one to develop training materials for hospital waste incinerator operators, focus on topics of national or regional interest that are identified through contact with State and local agencies.

The CTC became interested in developing a basic training course for operators of hospital waste incinerators with the idea that properly trained operators can improve operating and maintenance procedures and, consequently, minimize air emissions. This training course was prepared to provide the operator with a basic understanding of the principles of incineration and air pollution control and to identify, in a general sense, good operating practices. The course is not intended as a substitute for site-specific hands-on training of the operator with the specific equipment to be operated.

The course consists of three volumes:

Volume I--Student Handbook
Volume II--Course Presentation Slides
Volume III--Instructor Handbook

This volume contains the classroom materials including a copy of the presentation slides and student worksheets. A copy of the presentation slides is provided in Part I so that you can easily follow along during the class. You may want to make notes on the slides to remind yourself later of important points brought up by the instructor or other students. Several worksheets also are included in Part II. Your instructor will allow time for you to complete these worksheets during class.
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SESSION 8. MAINTENANCE INSPECTION--A NECESSARY PART OF YOUR JOB
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LIST OF SOURCES FOR DRAWINGS

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2. INCINERATOR SYSTEM INFORMATION
3. INCINERATOR SYSTEM INFORMATION
4. OPERATING REVIEW
5. OPERATING PROBLEMS REVIEW
6. INCINERATOR SYSTEM INFORMATION
7. SAFETY REVIEW
PART C.

REFERENCES FOR SLIDES
References for Slides

Session 2


Session 3


Session 4


Session 5


Session 6


Session 9

PART I. SLIDE PRESENTATION

This section presents the slides and worksheets which will be used during the classroom portion of the course. The slides are organized by session. The slides presented here will be supplemented with actual photographs (which are not presented in this hand-out) during the presentation. Some drawings have been taken from other documents; the sources for these drawings are listed at the end of this part.
COURSE GOALS

To provide you with an understanding of:

-- Basic principles of incineration
-- Proper operation and maintenance practices
-- Regulatory requirements and safety concerns
Upon completing this course you should:

- Understand air pollution problems and how to minimize them

- Understand the cause of common operating problems and safety hazards and how to minimize them

- Know how to monitor operation to aid in complying with regulatory requirements
SESSION 1.

PROTECTING THE ENVIRONMENT - YOUR RESPONSIBILITY
WHY INCINERATE?

- Reduces weight and volume of waste
- Sterilizes the waste
- Destroys organic materials that may degrade and produce harmful by-products in landfills
- Aesthetic reasons—destroys wastes such as body parts that public finds objectionable
ENVIROMENTAL CONCERNS

- Pathogen destruction
- Air emissions
- Ash quality
Particulate Carbon Monoxide
Organic Compounds
Pathogens

Waste Feed (May contain pathogens)

Fugitive Particulate (windblown ash)

Ash (May contain pathogens)

ENVIRONMENTAL CONCERNS
THE OPERATOR--YOUR ROLE

It is your role and responsibility to protect the environment by:

- Minimizing pollutant emissions through proper operation
- Maintaining acceptable ash quality through proper operation
- Preventing particulate emissions from ash handling and storage
- Identifying maintenance problems by performing regular inspections
SESSION 2.

BASIC COMBUSTION PRINCIPLES
Organics in Auxiliary Fuel

Air to O₂

Organics in Hospital Waste

Heat

Combustion Gases

Energy

Ash

THE COMBUSTION PROCESS
Combustion

Air

I

if

N₂ (79%)

React

0₂ (21%)

Carbon
and
Hydrogen

Organic Feed and Fuel

N₂ Passes
Through

CO₂

H₂O₂

FATE OF COMBUSTION AIR
FATE OF COMBUSTION AIR

Combustion Air

N₂ (79%)

O₂ (21%)

React

Carbon and Hydrogen

N₂ Passes Through

CO₂

H₂O
OXYGEN REACTION
OPERATING FACTORS RELATED TO COMBUSTION

- Combustion air
  -- Flow rate
  -- Distribution

- Operating temperatures

- Waste feed characteristics
SLIDE 2-5

Combustion Air → \( O_2 \)

Waste / Fuel → Organics

Combustion Chamber

Combustion Gas: No \( O_2 \)

No Organics

Ash

STOICHIOMETRIC AIR LEVEL
Combustion Gas: No $O_2$
Organics Remain

Combustion Air $O_2$
Waste/Fuel Organics

AIR LEVEL BELOW STOICHIOMETRIC
"STARVED-AIR"
AIR LEVEL ABOVE STOICHIOMETRIC
"EXCESS AIR"
Control of temperature as a function of excess air
### Hospital Waste Characteristics

<table>
<thead>
<tr>
<th>Waste Type</th>
<th>High Heat Value, Btu/lb</th>
<th>Moisture, %</th>
<th>Heat Value as-fired, Btu/lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gauze, Pads, Swabs, Garments, Paper</td>
<td>8,000-12,000</td>
<td>0-30</td>
<td>5,600-12,000</td>
</tr>
<tr>
<td>Plastics</td>
<td>9,700-20,000</td>
<td>0-1</td>
<td>9,600-20,000</td>
</tr>
<tr>
<td>Human Anatomical</td>
<td>8,000-12,000</td>
<td>70-90</td>
<td>800-3,600</td>
</tr>
</tbody>
</table>
Slide 2-10

KEY OPERATING PARAMETERS

• Combustion air

• Mixing

• Temperature

• Residence time/retention time

• Waste characteristics
  -- Heating value
  -- Moisture content
  -- Chlorine content
SLIDE 2-11

COMPLETE COMBUSTION
SLIDE 2-12

INCOMPLETE COMBUSTION
OPACITY

- Poor Mixing
- Starved-Air Conditions
- Low Temperatures
- Acid Gases
STACK GAS $O_2$ AND $CO$

- **Low $O_2$**
  -- INSUFFICIENT AIR

- **High $O_2$**
  -- TOO MUCH EXCESS AIR COOLS GAS

- **High CO means poor combustion**
ASH QUALITY

• VISUAL APPEARANCE

• NO RECOGNIZABLE MEDICAL WASTES

• BURNOUT--CARBON REMAINING
  -- WHITISH GRAY VS BLACK
SESSION 3.

BASIC INCINERATOR DESIGN
MAJOR COMPONENTS OF AN INCINERATION SYSTEM
INCINERATOR TYPES

- Multiple Chamber--excess air
- Controlled (starved) air
- Rotary kiln
MULTIPLE-CHAMBER INCINERATORS

- Combustion occurs in two or more chambers
- Primary and secondary chamber operate with air levels above stoichiometric
- Primarily use overfire combustion air
- In-line and retort designs
IN-LINE MULTIPLE-CHAMBER EXCESS-AIR INCINERATOR
RETORT MULTIPLE-CHAMBER, EXCESS-AIR INCINERATOR
CONTROLLED-AIR INCINERATION

- Combustion occurs in two or more chambers

- Amounts and distribution of combustion air to each chamber are controlled
  -- Primary chamber below stoichiometric
  -- Secondary chamber above stoichiometric
Control of temperature as a function of excess air.
COMBUSTION GASES

SECONDARY CHAMBER
Volatile Content is Burned
Under Excess Air Conditions

MAIN BURNER
For Maintaining
Minimum Combustion
Temperature

MAIN FLAMEPORT AIR

WASTE FEED

PRIMARY CHAMBER
(Starved Air Condition)

Volatiles and Moisture

ASH AND NON-COMBUSTIBLES

AUXILIARY
IGNITION BURNER

CONTROLLED UNDERFIRE
AIR FOR BURNING
"FIXED CARBON"

PRINCIPLE OF CONTROLLED-AIR INCINERATION
SLIDE 3-9

MAJOR COMPONENTS OF A CONTROLLED-AIR INCINERATOR
ROCKY KILNS

- Combustion occurs in multiple chambers
- Primary chamber is rotating cylinder --- produces turbulence in waste bed
ROTARY KILN WITH AUGER FEED
OPERATING MODE

- SINGLE BATCH
- INTERMITTENT DUTY
- CONTINUOUS DUTY
WASTE FEED LOADING/CHARGING SYSTEMS

- Consistent with incinerator capacity
- Consistent with operating mode
- Manual vs mechanical vs automated
HOPPER RAM ASSEMBLY
HOPPER RAM CHARGING SEQUENCE

START
WASTE LOADED INTO HOPPER

STEP 1
FIRE DOOR OPENS

STEP 2
RAM COMES FORWARD

STEP 3
RAM REVERSES TO CLEAR FIRE DOOR

STEP 4
FIRE DOOR CLOSES

STEP 5
RAM RETURNS TO START
ASH DISCHARGE AND REMOVAL SYSTEMS

- Consistent with operating mode
- Consistent with capacity
- Manual vs mechanical
MECHANICAL ASH REMOVAL

- Transfer of ash to end of hearth
- Collection container
- Transfer from collection point
INCINERATOR WITH STAGED HEARTH AND AUTOMATIC ASH REMOVAL
COMBUSTION GAS HANDLING SYSTEMS

- Natural draft
- Induced draft
- Balanced draft
Slide 3-20

**MAJOR COMPONENTS OF BURNER SYSTEM**

- Forced air blower(s)
- Fuel train
- Pilot and main burner
- Flame safe guard system
INCINERATOR WITH WASTE HEAT BOILER AND BYPASS STACK
SESSION 4.

AIR POLLUTION CONTROL EQUIPMENT

DESIGN AND FUNCTIONS
## CONTROL STRATEGIES FOR AIR POLLUTANTS

<table>
<thead>
<tr>
<th>CONTROL STRATEGY</th>
<th>PARTICULATE MATTER</th>
<th>HYDROCHLORIC ACID</th>
<th>TOXIC ORGANICS</th>
<th>TOXIC METALS</th>
<th>CARBON MONOXIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controlling feed material</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Combustion control</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Add-on pollution control equipment:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spray tower</td>
<td>a</td>
<td>X</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Venturi</td>
<td>X</td>
<td></td>
<td>a</td>
<td>a</td>
<td>X</td>
</tr>
<tr>
<td>Packed-bed</td>
<td>a</td>
<td>X</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Fabric filter</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Dry injection&lt;sup&gt;b&lt;/sup&gt;</td>
<td>X</td>
<td>X</td>
<td>a</td>
<td>a</td>
<td>X</td>
</tr>
<tr>
<td>Dry scrubber&lt;sup&gt;b&lt;/sup&gt;</td>
<td>X</td>
<td>X</td>
<td>a</td>
<td>a</td>
<td>X</td>
</tr>
<tr>
<td>ESP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Achieves limited control; not designed for high efficiency.

<sup>b</sup>Followed by high-efficiency particulate control.
AIR POLLUTION CONTROL SYSTEMS FOR
HOSPITAL WASTE INCINERATORS

• Wet scrubbers
  -- Spray towers
  -- Venturi scrubbers
  -- Packed-bed scrubbers

• Fabric filters

• Dry scrubbers
  -- Dry injection
  -- Spray dryers

• Electrostatic precipitators
SLIDE 4-3

SPRAY TOWER

- Low energy
- Limited particulate control
- Limited HCL acid gas control
COUNTERCURRENT-FLOW SPRAY TOWER

Dirty Flue Gas

Liquid Sprays

Clean Exhaust Gas

Water Drain
Water inlet

Combustion gases from secondary chamber

Spray Tower

Waste water to drain

ID Fan

Stack

Spray Tower System
VENTURI SCRUBBER

- High energy
- High efficiency particulate control
- Limited HCL acid gas control
SLIDE 4-7

DIRTY FLUE GAS

CYCLONIC MIST ELIMINATOR

SPRAY NOZZLES

LIQUID INLET

VENTURI THROAT

SPRAY VENTURI WITH RECTANGULAR THROAT
Cyclonic mist eliminator
VENTURI SCRUBBER SYSTEM WITH RECIRCULATED SCRUBBER LIQUOR
PACKED TOWER

- Low energy
- High efficiency acid gas control
VENTURI SCRUBBER WITH PACKED BED
SLIDE 4-13

FABRIC FILTER

- Oft en called "bag house"

- Particulate control
  -- Especially effective for fine particulate

- Acid gas control
  -- If used in conjunction with dry scrubber
SLIDE 4-14

Clean Air Plenum
Blow Pipe

To Clean Air Outlet and Exhauster

Tubular Filter Bags

Housing

Dirty Air Plenum

Dirty Air Inlet and Diffuser

Ash Hopper

Rotary Valve Air Lock

PULSE JET BAGHOUSE²
DRY SCRUBBERS

- Acid gas control

- In conjunction with particulate control
  -- Fabric filter
  -- Electrostatic precipitator
DRY INJECTION ABSORPTION SYSTEM
Combustion War0 Contactor

DRY INJECTION ABSORPTION SYSTEM
Sorbent Slurry

Flue Gas

Spray Nozzle

To Particulate Control Device

SPRAY DRYER ABSORBER VESSEL
COMPONENTS OF A SPRAY DRYER ABSORBER SYSTEM
Electrostatic Precipitators

- Particulate control
- Larger regional facility most likely application
- Sometimes used with dry scrubbers
COMPONENTS OF AN ESP
GAS FLOW THROUGH A PLATE PRECIPITATOR
SESSION 5.
MONITORING AND AUTOMATIC CONTROL SYSTEMS
TEMPERATURE MONITORING SYSTEM
THERMOSTAT WITH TEMPERATURE "SET POINT"
SCHEMATIC OF TEMPERATURE CONTROL LOOP
TEMPERATURE CONTROLLER/METER
WITH LOW/HIGH SETPOINTS

- Rotate outer dial to select temperature setpoint or proportional setpoint.
- Rotate inner dial to select temperature setpoint.
- Temperature indicator.
- Locking screw locks dial position.
TEMPERATURE CONTROLLER WITH DIGITAL DISPLAY
BASIC TYPES OF INCINERATOR PROCESS CONTROL SYSTEMS

- Manual
- Automatic timer sequence
- Automatic modulated control
AUTOMATIC TIMER SEQUENCE

• Preset timer sequence
  -- Activates on/off or high/low settings
  - burners
  - combustion air
  - charge feeder

• Setpoint limits override timer sequence
AUTOMATIC MODULATED CONTROL

- **Setpoint for controlled parameter is chosen**

- **Operating parameters are continuously adjusted to maintain setpoint**
  -- Combustion air
MONITORED AND CONTROLLED PROCESS PARAMETERS FOR INCINERATORS

<table>
<thead>
<tr>
<th>Monitored/controlled parameter</th>
<th>Incinerator functions controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Combustion air</td>
</tr>
<tr>
<td>(primary and secondary chambers)</td>
<td>Auxiliary burners</td>
</tr>
<tr>
<td>Draft</td>
<td>Barometric damper</td>
</tr>
<tr>
<td></td>
<td>ID fan damper</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Combustion air</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>--</td>
</tr>
<tr>
<td>Opacity</td>
<td>--</td>
</tr>
<tr>
<td>Charge rate</td>
<td>Automatic feed interlock</td>
</tr>
<tr>
<td>Monitored parameter</td>
<td>Scrubber functions controlled</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Pressure and pressure drop</td>
<td>Venturi throat</td>
</tr>
<tr>
<td></td>
<td>ID fan</td>
</tr>
<tr>
<td>Scrubber liquid flow rate or pressure</td>
<td>Liquid flow control valve</td>
</tr>
<tr>
<td>Scrubber liquid pH</td>
<td>Caustic flow control valve</td>
</tr>
<tr>
<td>Inlet temperature</td>
<td>Prequench</td>
</tr>
<tr>
<td></td>
<td>Emergency quench</td>
</tr>
<tr>
<td></td>
<td>Bypass stack</td>
</tr>
<tr>
<td></td>
<td>Dilution air</td>
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</tbody>
</table>
**MONITORED AND CONTROLLED PROCESS PARAMETERS FOR FABRIC FILTERS**

<table>
<thead>
<tr>
<th>Monitored Parameter</th>
<th>Fabric Filter Operating Functions Controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Drop</td>
<td>Cleaning Cycle</td>
</tr>
<tr>
<td>Inlet Gas Temperature</td>
<td>Emergency Bypass Stack</td>
</tr>
<tr>
<td></td>
<td>Emergency Quench</td>
</tr>
<tr>
<td></td>
<td>Dilution Air</td>
</tr>
</tbody>
</table>
### MONITORED AND CONTROLLED PROCESS PARAMETERS FOR ESP's

<table>
<thead>
<tr>
<th>Monitored Parameter</th>
<th>ESP Operating Functions Controlled</th>
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</thead>
<tbody>
<tr>
<td><strong>Power Input</strong></td>
<td>Power Supply</td>
</tr>
<tr>
<td>-- Primary Voltage</td>
<td>T/R Settings</td>
</tr>
<tr>
<td>-- Primary Current</td>
<td></td>
</tr>
<tr>
<td>-- Secondary Voltage</td>
<td></td>
</tr>
<tr>
<td>-- Secondary Current</td>
<td></td>
</tr>
<tr>
<td><strong>Spark Rate</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Inlet Gas Temperature</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Conditioning Agents</strong></td>
<td></td>
</tr>
<tr>
<td>(Resistivity)</td>
<td></td>
</tr>
<tr>
<td><strong>Increase/Decrease</strong></td>
<td></td>
</tr>
<tr>
<td>Incinerator or Boiler</td>
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<tr>
<td>Outlet Temperature</td>
<td></td>
</tr>
<tr>
<td>Condition Gas</td>
<td></td>
</tr>
</tbody>
</table>
TEMPERATURE

- Thermocouple(s)
- Degrees Fahrenheit
- Exit of secondary combustion chamber
- Middle of primary chamber
- Before/after APC
THERMOCOUPLE AND DRAFT GAUGE CONNECTIONS
INCINERATOR DRAFT AND APCS PRESSURE DROP

• Differential pressure gauge, $\Delta P$

• Inches of water column, in. w.c.

• Difference of pressure at two points

Draft:

$\Delta P$ of incinerator chamber and atmospheric pressure

APCS pressure drop:

$\Delta P$ before and after APC
SLIDE 5-17

METER FOR DIFFERENTIAL PRESSURE GAUGE
Air → "Draft" → Incinerator → Stack → To Atmosphere

BAROMETRIC/AUTOMATIC DAMPER
SLIDE 5-19

Damper Fully Open

Fan

Stack

Damper Partially Closed

Fan

Stack

ID FAN DAMPER CONTROL
COMBUSTION BLOWER WITH AUTOMATIC CONTROLLER
OXYGEN AND CO MONITORS

- Continuous emission monitoring systems, CEMS
- Percent oxygen, % O₂
- Parts per million carbon monoxide, ppm CO

Monitor location
  -- combustion chamber outlet
  -- stack
  -- somewhere in between
IN SITU VS EXTRACTIVE CEMS
EXTRACTIVE MONITORING SYSTEM
OPACITY MONITORING SYSTEM
(Transmissometer)
SLIDE 5-25

CHARGE RATE

- LB/LOAD
- LB/H
- Weigh scale/log book
- Automatic weigh scale or weigh hopper
APC MONITORS

- Scrubber liquid flow
  -- gallons per minute, GPM
  -- flow meter
  -- pump pressure

- pH of scrubber liquid
  -- pH meter

- Temperature
  -- thermocouple

- Pressure drop, ΔP
  -- differential pressure gauge
SESSION 6.

INCINERATOR OPERATION
Slide 6-1

TOPICS

- Waste Handling
- Operation of Controlled-Air Incinerators
- Operation of Excess-Air Incinerators
SLIDE 6-2

WASTE HANDLING

- Sturdy containers
- Minimize handling
- Properly operate/maintain waste charging devices
- Safe storage—even for short times
INCINERATOR OPERATION

- Key operating parameters
- Operating ranges
- Monitoring operation
- Controlling operation
- Waste charging procedures
- Ash handling procedures
- Startup/shutdown procedures
KEY OPERATING PARAMETERS FOR
CONTROLLED-AIR INCINERATORS

- Charging rate
- Primary chamber temperature
- Secondary chamber temperature
- Combustion chamber draft
- Primary chamber combustion air level
- Total combustion air level
- Combustion gas oxygen concentration
Slide 6-5

KEY OPERATING PARAMETER--WASTE CHARGING RATE

Operating range:

- Heat input consistent with design
- Single batch operation
  -- Fill chamber; do not overfill
- Intermittent and continuous duty
  -- Small batches at frequent intervals
  -- 10 to 25 percent rated capacity at 5 to 15 minutes

Factors:

- Waste properties
- Operating mode of incinerator
Slide 6-6

**KEY OPERATING PARAMETER—WASTE CHARGING RATE**

**Operator monitors:**

- **Charge rate, lb/h**
  -- Amount and frequency of charge
- **Ash bed**
  -- Buildup
- **Ash quality**
  -- "Good" burnout
- **Temperature trends**
  -- Low temperature—Charge needed?
  -- High secondary temperature—Wait?

**Control by:**

- Smaller or larger batches
- Less or more frequent charges
TEMPERATURE TREND
Slide 6-8

PRIMARY CHAMBER TEMPERATURE

**Lower Limit:** Minimum operating temperature

- Achieve adequate burnout
- Sterilize ash

**Upper Limit:** Maximum operating temperature

- Limit slagging of ash

There may be a regulatory requirement on lower limit
KEY OPERATING PARAMETER--PRIMARY CHAMBER TEMPERATURE

RECOMMENDED OPERATING RANGE:

- Batch - 1000° to 1800°F
- Intermittent - 1000° to 1800°F
- Continuous - 1400° to 1800°F

OPERATOR MONITORS

- Temperature reading
- Temperature trend

CONTROL BY:

- Adjusting charging rate
- Adjusting primary combustion air level
- Auxiliary burner operation
SECONDARY CHAMBER TEMPERATURE

**LOWER LIMIT:** Minimum operating temperature

- High enough temperature to combust all organic compounds

**UPPER LIMIT:** Maximum temperature

- Prevent damage to refractory

There may be a regulatory requirement on lower limit.
KEY OPERATING PARAMETER—SECONDARY CHAMBER TEMPERATURE

RECOMMENDED OPERATING RANGE:

• 1800° to 2200°

OPERATOR MONITORS:

• TEMPERATURE READING
  • TEMPERATURE TREND

CONTROL BY:

• ADJUSTING SECONDARY COMBUSTION AIR LEVEL
• SECONDARY BURNER OPERATION
• ADJUSTING PRIMARY CHAMBER PARAMETERS
• ADJUSTING CHARGING RATE
SLIDE 6-12

PRIMARY CHAMBER COMBUSTION AIR LEVEL

- Controls combustion rate and temperature in primary chamber
- Controls release rate of combustible gases to secondary chamber
- Maintained below stoichiometric
KEY OPERATING PARAMETER--PRIMARY CHAMBER COMBUSTION AIR

Recommended operating range:

- 30 to 80 percent of stoichiometric

Monitor:

- Visual observation
  -- Dark red smokey combustion zone
- Primary chamber temperature

Control by:

- Increase/decrease combustion airflow
SECONDARY CHAMBER AND TOTAL COMBUSTION AIR LEVEL

- Controls temperature of secondary chamber

- Excess air assures sufficient oxygen for complete combustion
KEY OPERATING PARAMETER--TOTAL COMBUSTION AIR LEVEL

Recommended operating range:

- 140 to 200 percent excess air

Monitoring:

- Secondary combustion chamber temperature
- Stack gas opacity
  -- Black smoke: Deficient air
- Combustion gas oxygen level

Control by:

- Adjusting secondary airflow
Slide 6-16

COMBUSTION CHAMBER DRAFT

- Prevent excessive particulate matter entrainment
- Prevent air out-leakage
Slide 6-17

KEY OPERATING PARAMETER--COMBUSTION CHAMBER DRAFT

Recommended range:

- Negative 0.05 to 0.1 inches water

Monitor:

- Draft gauge

Control by:

- Natural draft damper setting  
  -- Barometric, automatic, manual

- Fan damper setting
OTHER PARAMETERS TO MONITOR

STACK GAS OPACITY

- Easy to do
- Indicator of particulate emission/poor combustion
- Adjust secondary air or charge rate
- Check secondary burner
SLIDE 6-19

OTHER PARAMETERS TO MONITOR

ASH QUALITY

- Easy to do
- Pieces of unburned waste not good
- Gray color better than black
- Increase primary temperature
- Decrease charge rate
- Increase burnout time
Slide 6-20

**OTHER PARAMETERS TO MONITOR**

Stack gas carbon monoxide

- Indicator of combustion efficiency
- Need instrument
- Should be <100 ppm
OTHER PARAMETERS TO MONITOR

SECONDARY BURNER FLAME PATTERN

- Bright yellow/orange
- No smoke
- No impingement
CONTROL AND MONITORING SUMMARY

- Waste composition, charge rate, temperatures, air levels are all interrelated

- Within limits of design—automatic control system adjusts air level to control heat release and temperature

- Operator can control charge rate
CONTROL AND MONITORING SUMMARY (CONTINUED)

- To operate incinerator within design limits, the operator

-- Monitors:
  - Temperatures
  - Charge rate
  - Waste bed appearance
  - Ash quality
  - Opacity

-- Adjusts:
  - Charge rate
  - Combustion air levels
  - Burners
ININCINERATOR CAPACITY VERSUS HEAT CONTENT OF WASTE
PROPER WASTE CHARGING PROCEDURES

SINGLE BATCH OPERATION

- Charge incinerator cold
- Do not "stuff" incinerator
- Close and seal door before ignition
- Preheat secondary chamber before ignition
- Decrease size of load, as necessary, to prevent emissions at startup
PROPER WASTE CHARGING PROCEDURES

INTERMITTENT DUTY AND CONTINUOUS DUTY

- More frequent smaller charges are better than one large charge

- Adjust charge volume and frequency to account for waste variations
PATHOLOGICAL WASTES

- LIMIT AMOUNT OF PATHOLOGICAL WASTE IF INCINERATOR IS NOT A PATHOLOGICAL DESIGN

- OPERATE PRIMARY BURNERS DURING INCINERATION

- CHARGE WASTE TO HEARTH IN SHALLOW LAYER
  -- Do not pile
  -- Expose to flame
PROPER ASH HANDLING PROCEDURES

SINGLE BATCH/INTERMITTENT OPERATION

- Allow incinerator to cool
- Do not spray water into combustion chamber
- Use flat/blunt tool for ash removal
- Avoid pushing ash into underfire ports
- Place ash in metal container
- Dampen ash to prevent fugitive dust
- Properly dispose of ash
- Make sure ash door is properly sealed
- Inspect ash quality;
  make corrections to operation, if necessary
PROPER ASH HANDLING PROCEDURES

CONTINUOUS DUTY

- Watch for jams in conveyor systems
- Assure quench water flow is adequate
- Replace full ash container with empty container
- Keep ash wet or cover to prevent fugitive dust
- Inspect ash quality
  Adjust incinerator operation, if necessary
STARTUP AND SHUTDOWN

SINGLE BATCH UNIT

STARTUP:

- Charge incinerator cold
- Preheat the secondary chamber before igniting waste

SHUTDOWN:

- Increase primary combustion chamber air to promote combustion of fixed carbon
- After primary temperature decreases to preset level, shut down secondary burner
- Keep combustion blowers operating to cool incinerator
- Remove ash after incinerator cools
**Slide 6-31**

**STARTUP AND SHUTDOWN**

**INTERMITTENT AND CONTINUOUS DUTY**

**STARTUP:**

- Preheat secondary chamber before initiating charging
- Charge waste
- Ignite waste

**SHUTDOWN:**

- Intermittent duty--same as batch
- Continuous duty
  -- Stop charging system
  -- Maintain operation of incinerator and ash system until all waste is discharged from incinerator
  -- Shutdown incinerator
OPERATOR'S LOG

- Written log book

- Record significant events
  -- Startup/shutdown
  -- Adjustments
  -- Changes in charge rate

- Record unusual problems and corrective actions
DO

- Pay careful attention to charging rate
  -- Adjust charging rate, if necessary

- Monitor combustion temperatures
  -- Learn to recognize trends

- Monitor stack opacity

- Inspect the chambers through viewports

- Inspect ash quality
  -- Adjust operation, if necessary

- Properly handle and dispose of ash

- Preheat the secondary chamber before startup

- Keep an operating log
DON'T

- Ignore problems indicated by monitors
- Overcharge the incinerator
### KEY OPERATING PARAMETERS:
**MULTIPLE-CHAMBER, EXCESS-AIR INCINERATORS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Recommended Operating Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Charge Rate</td>
<td>10-25% of rated capacity at 10-15 minute intervals</td>
</tr>
<tr>
<td>--Red bag</td>
<td>Single layer on hearth</td>
</tr>
<tr>
<td>--Pathological</td>
<td></td>
</tr>
</tbody>
</table>
### KEY OPERATING PARAMETERS:
**MULTIPLE-CHAMBER, EXCESS-AIR INCINERATORS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Recommended Operating Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Chamber Temperature</strong></td>
<td></td>
</tr>
<tr>
<td>--General Refuse</td>
<td>1000°–1400°F</td>
</tr>
<tr>
<td>--Pathological</td>
<td>1600°–1800°F</td>
</tr>
<tr>
<td><strong>Secondary Chamber Temperature</strong></td>
<td>1800°–2200°F</td>
</tr>
</tbody>
</table>
### KEY OPERATING PARAMETERS:
**MULTIPLE-CHAMBER, EXCESS-AIR INCINERATORS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Recommended Operating Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Chamber Combustion Air</td>
<td>80-150% Excess Air</td>
</tr>
<tr>
<td>Total Combustion Air</td>
<td>120 to 300% Excess Air</td>
</tr>
<tr>
<td>Combustion Gas Oxygen Con.</td>
<td>10-16%</td>
</tr>
<tr>
<td>Combustion Chamber Draft</td>
<td>Negative 0.05 to 0.1 in. W.C.</td>
</tr>
</tbody>
</table>
SUMMARY OF OPERATION

- Units are batch or intermittent duty

- Primary chamber is excess air atmosphere
  -- Heat release rate is controlled by charge rate and burners
  -- For pathological waste heat release rate is controlled by primary burners
SUMMARY OF MONITORING AND CONTROL

Operator Monitors:

- Charging rate
- Temperatures of both chambers
- Temperature trends
- Draft
- Ash bed appearance
- Ash quality
- Opacity
SUMMARY OF MONITORING AND CONTROL

Operator Controls:

- Charge rate
- Air damper settings
- Auxiliary burner operation
WASTE CHARGING PROCEDURES

- Adjust charge volume and frequency to account for waste variations

- More frequent smaller charges are better than one large charge

- Do not "stuff" incinerator

- Assure primary burner is off prior to charging

- Gently push old waste to back of hearth; charge new waste at front of hearth
Frequent Small Charges

PROPER CHARGE PROCEDURES
IMPROPER CHARGE PROCEDURES

"Stuff and Burn"
Ash Bed Stoked To Rear:
Load To Front

PROPER LOADING ON HEARTH
IMPROPER LOADING ON HEARTH
PATHOLOGICAL WASTES

- Charge waste to hearth in a shallow layer
  -- Do not pile
  -- Expose to flame

- Turn off primary burner before charging
PROPER ASH HANDLING PROCEDURES

- Allow incinerator to cool
- Do not spray water into combustion chamber
- Use flat/blunt tool for ash removal
- Place ash in metal container
- Dampen ash to prevent fugitive dust
- Properly dispose of ash
- Inspect ash quality; make corrections in operation, if necessary
STARTUP AND SHUTDOWN

STARTUP:

- Preheat secondary chamber before initiating charging
- Charge waste
- Ignite waste

SHUTDOWN:

- Shut down burners
- Allow incinerator to cool
- Remove ash
DO

- Preheat the secondary chamber
- Pay careful attention to charging procedures and rates
- Shut off primary burner when charging
- Monitor combustion chamber temperatures
- Monitor combustion chamber draft
- Monitor stack gas opacity--especially after charging
- Inspect ash quality
- For pathological wastes, operate primary burner at all times
SESSION 7.

AIR POLLUTION CONTROL SYSTEMS OPERATION
AIR POLLUTION CONTROL SYSTEMS FOR HOSPITAL INCINERATORS

- Wet scrubbers
  -- Spray towers
  -- Venturi scrubbers
  -- Packed-bed scrubbers

- Fabric filters

- Dry scrubbers
  -- Dry injection
  -- Spray dryers

- Electrostatic Precipitators
## RECOMMENDED OPERATING RANGES FOR KEY PARAMETERS

### VENTURI SCRUBBER

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure drop</td>
<td>20-30 in. w.c.</td>
</tr>
<tr>
<td>Liquid supply</td>
<td>7-10 gal/1,000 ACF</td>
</tr>
<tr>
<td>pH</td>
<td>5.5-7.0</td>
</tr>
<tr>
<td>Suspended solids</td>
<td>0-3 percent</td>
</tr>
</tbody>
</table>
VENTURI SCRUBBER PARAMETERS USUALLY MONITORED BY OPERATOR

- Pressure drop
- Liquid flow rate
- pH
- Fan
  - Static pressure
  - RPM
  - Amperage
### VENTURI SCRUBBER OPERATION

<table>
<thead>
<tr>
<th>Key Parameter</th>
<th>Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure Drop</td>
<td>Variable Throat</td>
</tr>
<tr>
<td>Liquid Supply</td>
<td>Fan Damper</td>
</tr>
<tr>
<td>Suspended Solids</td>
<td>Fan Speed</td>
</tr>
<tr>
<td>pH</td>
<td>Liquid Flow Rate</td>
</tr>
<tr>
<td></td>
<td>Makeup Water</td>
</tr>
<tr>
<td></td>
<td>Blowdown</td>
</tr>
<tr>
<td></td>
<td>Makeup Caustic</td>
</tr>
</tbody>
</table>
VENTURI SCRUBBER STARTUP SEQUENCE

1. Turn on liquid supply and recirculation
2. Set liquid flow to manufacturer specifications
3. Close fan damper
4. Start fan
5. Gradually open damper
6. Adjust liquid flow to obtain desired liquid supply
7. Adjust venturi throat, fan amperage, or damper to obtain desired pressure drop
8. Adjust blowdown
S L I D E  7-6

**VENTURI SCRUBBER SHUTDOWN SEQUENCE**

1. Shut off scrubber fan
2. Shut off recirculation
3. Shut off makeup water
### RECOMMENDED OPERATING RANGES FOR KEY PARAMETERS

#### PACKED-BED SCRUBBER

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid supply</td>
<td>15-25 gal/1,000 ACF</td>
</tr>
<tr>
<td>pH</td>
<td>5.5-7.0</td>
</tr>
<tr>
<td>Suspended solids</td>
<td>0-3 percent</td>
</tr>
<tr>
<td>Inlet gas temperature</td>
<td>Specified by manufacturer</td>
</tr>
<tr>
<td>Pressure drop</td>
<td>1-5 in. w.c.</td>
</tr>
</tbody>
</table>
SLIDE 7-8

PACKED-BED SCRUBBER PARAMETERS USUALLY MONITORED BY OPERATOR

- LIQUID FLOW RATE
- PRESSURE DROP
- INLET GAS TEMPERATURE
- PH

- FAN
  -- STATIC PRESSURE
  -- RPM
  -- AMPERAGE
### Packed-Bed Scrubber Operation

<table>
<thead>
<tr>
<th>Key Parameter</th>
<th>Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Supply</td>
<td>Liquid Flow Rate</td>
</tr>
<tr>
<td>pH</td>
<td>Caustic Feed Rate</td>
</tr>
<tr>
<td>Suspended Solids</td>
<td>Makeup Water</td>
</tr>
<tr>
<td></td>
<td>Blowdown</td>
</tr>
<tr>
<td>Inlet Gas Temperature</td>
<td>Incinerator Exhaust Temperature</td>
</tr>
<tr>
<td></td>
<td>Prequench</td>
</tr>
</tbody>
</table>
RECOMMENDED OPERATING RANGES FOR KEY PARAMETERS

SPRAY TOWER

- **Liquid Supply**: 5 to 20 gal/1,000 ACF
- **Pressure Drop**: 1 to 3 in. W.C.
**RECOMMENDED OPERATING RANGES FOR KEY PARAMETERS**

**PULSE-JET FABRIC FILTER**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flue gas temperature:</td>
<td></td>
</tr>
<tr>
<td>Upper limit</td>
<td>Specified by manufacturer</td>
</tr>
<tr>
<td>Lower limit</td>
<td>Above dewpoint</td>
</tr>
<tr>
<td>Pressure drop</td>
<td>5-9 in. W.C.</td>
</tr>
<tr>
<td>Cleaning air pressure</td>
<td>60-100 psig</td>
</tr>
</tbody>
</table>
SLIDE 7-12

FABRIC FILTER PARAMETERS USUALLY MONITORED BY OPERATOR

- Opacity
- Pressure drop
- Inlet gas temperature
- Outlet gas temperature
### FABRIC FILTER OPERATION

<table>
<thead>
<tr>
<th>Key Parameter</th>
<th>Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flue Gas Temperature:</strong></td>
<td></td>
</tr>
<tr>
<td>Upper Limit</td>
<td>Bypass fabric filter</td>
</tr>
<tr>
<td>Lower Limit</td>
<td>Lower incinerator (Boiler)</td>
</tr>
<tr>
<td>Pressure Drop</td>
<td>Exhaust temperature</td>
</tr>
<tr>
<td>Cleaning Air Pressure</td>
<td>Introduce cool ambient air</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase auxiliary fuel</td>
</tr>
<tr>
<td></td>
<td>Bag cleaning frequency</td>
</tr>
<tr>
<td></td>
<td>Compressed air system</td>
</tr>
</tbody>
</table>
FABRIC FILTER STARTUP

- PRECOAT BAGS
- USE AUXILIARY FUEL-FIRING TO BRING SYSTEM TO OPERATING TEMPERATURE
- GRADUALLY BUILDUP DUST CAKE
FABRIC FILTER SHUTDOWN

- Stop waste charging
- Maintain secondary chamber burner firing until waste is combusted
- Shut off incinerator
- Purge remaining combustion products
- Clean bags
RECOMMENDED OPERATING RANGES FOR KEY PARAMETERS

DRY INJECTION

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorbent Injection Rate</td>
<td>Specified by manufacturer</td>
</tr>
<tr>
<td>Sorbent Particle Size</td>
<td>90 percent by weight through 325 mesh screen</td>
</tr>
</tbody>
</table>
RECOMMENDED OPERATING RANGES FOR KEY PARAMETERS

SPRAY DRYERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Slurry sorbent content</td>
<td>5-20 percent</td>
</tr>
<tr>
<td>• Wet bulb/dry bulb temperature difference</td>
<td>90° to 180°F</td>
</tr>
<tr>
<td>Key Parameter</td>
<td>Adjustment</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Slurry sorbent content</td>
<td>Dry sorbent/water ratio</td>
</tr>
<tr>
<td>Wet bulb/dry bulb temperature difference</td>
<td>Slurry flow rate</td>
</tr>
</tbody>
</table>
Slide 7-19

Spray Dryer Startup/Shutdown

Startup Alternatives:

1. Use auxiliary fuel-firing to bring system up to operating temperature before injecting slurry

2. Gradually increase slurry feed as exhaust temperature increases to maintain 90° to 180°F wet bulb/dry bulb difference

Shutdown:

1. Use auxiliary fuel-firing to maintain temperature above saturation until all waste is combusted

2. Shut off spray dryer
RECOMMENDED OPERATING RANGES FOR KEY PARAMETERS

ELECTROSTATIC PRECIPITATORS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>INLET GAS TEMPERATURE</td>
<td></td>
</tr>
<tr>
<td>-- HOT SIDE ESP</td>
<td>570° to 800°F</td>
</tr>
<tr>
<td>-- COLD SIDE ESP</td>
<td>&lt;400°F</td>
</tr>
<tr>
<td>PARTICULATE RESISTIVITY</td>
<td>10⁻⁷ to 10⁻⁰ OHM-CM</td>
</tr>
<tr>
<td>POWER RATIO</td>
<td>0.5 to 0.9</td>
</tr>
</tbody>
</table>
### ESP Operation

**Key Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary voltage/current</td>
<td>Power supply</td>
</tr>
<tr>
<td></td>
<td>Clean/adjust electrodes</td>
</tr>
<tr>
<td>Secondary voltage/current</td>
<td>T/R</td>
</tr>
<tr>
<td></td>
<td>Resistivity</td>
</tr>
<tr>
<td>Resistivity</td>
<td>Gas temperature</td>
</tr>
<tr>
<td>Gas temperature</td>
<td>Conditioning agent addition</td>
</tr>
<tr>
<td></td>
<td>Combustion/carbon content</td>
</tr>
<tr>
<td></td>
<td>Condition gas stream</td>
</tr>
<tr>
<td></td>
<td>Incinerator/boiler operation</td>
</tr>
</tbody>
</table>
Slide 7-22

ESP STARTUP/SHUTDOWN

**STARTUP**

- Check hopper/ash handling operation
- Preheat hoppers
- Set rapper cycle
- Check rapper operation
- Check T/R setting
- Sequentially energize T/R by field

**SHUTDOWN**

- Shutdown incinerator
- Deenergize T/R by field
- After 4 hours deenergize heaters
- After 8 hours shutdown rappers
SESSION 8.

MAINTENANCE INSPECTION--A NECESSARY PART OF YOUR JOB
PREVENTIVE MAINTENANCE

- Program to conduct maintenance on regular scheduled basis

- Responsibility of maintenance department?

- You can help
  -- inspect unit
  -- identify minor problems
  -- report to maintenance department
### TYPICAL MAINTENANCE INSPECTION SCHEDULE

<table>
<thead>
<tr>
<th>Activity</th>
<th>Frequency</th>
<th>Incinerator Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hourly</td>
<td>Ash Removal Conveyor, Water Quench Pit, Ram Cooling System</td>
</tr>
<tr>
<td></td>
<td>Daily</td>
<td>Stack, Thermocouples, Limit Switches, Underfire Air Ports, Opacity Monitor, Oxygen Monitor</td>
</tr>
<tr>
<td></td>
<td>Weekly</td>
<td>Blower Intakes, Induced-Draft Fans, Control Panels, Refractory</td>
</tr>
<tr>
<td></td>
<td>Monthly</td>
<td>External Surface of Incinerator and Stack</td>
</tr>
<tr>
<td></td>
<td>90 Day</td>
<td>Shut down and do complete walkthrough (first year)</td>
</tr>
</tbody>
</table>
**Typical Maintenance Inspection Schedule for a Wet Scrubber**

<table>
<thead>
<tr>
<th>Inspection Frequency</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>Scrubber liquid pump</td>
</tr>
<tr>
<td></td>
<td>Variable throat activator</td>
</tr>
<tr>
<td></td>
<td>Scrubber liquid lines</td>
</tr>
<tr>
<td></td>
<td>Reagent feed system</td>
</tr>
<tr>
<td></td>
<td>Fan</td>
</tr>
<tr>
<td></td>
<td>pH meter</td>
</tr>
<tr>
<td></td>
<td>ΔP meter</td>
</tr>
<tr>
<td>Monthly</td>
<td>Duct work</td>
</tr>
</tbody>
</table>
**TYPICAL MAINTENANCE INSPECTION SCHEDULE FOR A FABRIC FILTER SYSTEM**

<table>
<thead>
<tr>
<th>Inspection Frequency</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>Stack</td>
</tr>
<tr>
<td></td>
<td>Manometer</td>
</tr>
<tr>
<td></td>
<td>Compressed Air System</td>
</tr>
<tr>
<td></td>
<td>Collector/Clean Cycle</td>
</tr>
<tr>
<td></td>
<td>Hoppers/Dust Removal System</td>
</tr>
<tr>
<td></td>
<td>Fan</td>
</tr>
</tbody>
</table>
RECORDKEEPING

- Records allow trends to be tracked
- Assists with evaluating PM program
- Assists inventory decisions
### DAILY MAINTENANCE INSPECTION LOG

<table>
<thead>
<tr>
<th>Time</th>
<th>Equipment inspected</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ash removal conveyor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water quench pit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Opacity monitor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oxygen monitor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Underfire air ports</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ash pit/dropout sump</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stack</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scrubber liquid pump</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Variable throat activator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scrubber liquid lines</td>
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<tr>
<td></td>
<td>Mist eliminator pressure lines</td>
<td></td>
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<tr>
<td></td>
<td>Reagent feed system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fan</td>
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<tr>
<td></td>
<td>Fan belt</td>
<td></td>
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</tbody>
</table>
SESSION 9.

TYPICAL PROBLEMS
PROBLEMS

IT’S BETTER TO PREVENT PROBLEMS THAN TO CORRECT PROBLEMS
INCINERATOR PROBLEMS

- Black smoke
- White/blue-white smoke
- White smoke/haze
- Puffing smoke from chamber
- Excessive auxiliary fuel usage
- Poor ash quality
- Burner problems
BLACK SMOKE FROM INCINERATOR STACK

SLIDE 9-3

- Too Much Waste
- Underfire Air
- Not Enough Secondary Air
- Too Much Highly Volatile Waste
- Too Much Underfire Air
WHITE/BLUE-WHITE SMOKE FROM INCINERATOR STACK

- Secondary Chamber Temperature Too Low
- Too Much Secondary Air
Hydrochloric Acid Gas Condensing

WHITE SMOKE/HAZE APPEARING SHORT DISTANCE FROM STACK

WHITE SMOKE/HAZE A SHORT DISTANCE FROM INCINERATOR STACK
Malfunction in Stack Damper or Fan

SMOKE LEAKING FROM PRIMARY CHAMBER

Too Much Highly Volatile Waste

Too Much Primary Air

SMOKE LEAVING PRIMARY CHAMBER OF INCINERATOR
Too Much Waste/Wet Waste

Insufficient Burnout Period/ Temperature

Improper Underfire Air Distribution

Not Enough Underfire Air

INCOMPLETE BURNOUT/POOR ASH QUALITY

INCOMPLETE BURNOUT/POOR ASH QUALITY
BURNER FLAME PATTERNS

Proper Flame Pattern
Detached Flame; Too Much Burner Air

Smoking Flame; Not Enough Air

BURNER FLAME PATTERNS
Flame Impingement On Refractory

BURNER FLAME PATTERNS
PREVENT INCINERATOR PROBLEMS

- Properly charge incinerator
- Note small operating and maintenance problems and get fixed before they become big problems
SLIDE 9-13

WET SCRUBBER PROBLEMS

- Corrosion
- Plugged spray nozzles
- Fan vibration
PREVENT SCRUBBER PROBLEMS

- Maintain correct pH for scrubber liquid
- Maintain low level of solids in recirculated scrubbing liquid
- Use preventive maintenance program for inspecting/cleaning nozzles, fans, dampers
Improperly Installed Bags
Broken Bags

HIGH OPACITY FROM FABRIC FILTER
HIGH PRESSURE DROP IN FABRIC FILTER
SLIDE 9-17

PREVENT FABRIC FILTER PROBLEMS

- Maintain proper temperature range within baghouse
- Monitor ΔP
- Maintain proper cleaning cycle
- Monitor opacity
Slide 9-18

OTHER PROBLEMS

• Water cooling systems for rams
  --maintain water flow
  --maintain cooler operation

• Microswitches
  --check movement by hand
  --lubricate
WHAT PROBLEMS DO YOU HAVE?
SESSION 10.

STATE REGULATIONS
Slide 10-1

TYPES OF REQUIREMENTS IN STATE REGULATIONS

- Emission limits
- Operating practices/limits
- Continuous emission monitoring
- Recordkeeping and reporting
- Operator training
1 Grain Per Dry Standard Cubic Foot

7000 Grains = 1 pound
Contains 1 Million Cubic Meters

100 Parts Per million
Combustion Air
21% oxygen
79% nitrogen
0% carbon dioxide

Barometric Damper
Closed

1 gr/dscf
7% oxygen
12% carbon dioxide

INCINERATOR

Barometric Damper
Open

1 scf air
21% oxygen
0% carbon dioxide

1 gr/dscf
21% oxygen
7% carbon dioxide

0.5 gr/dscf
14% oxygen
6% carbon dioxide

1 gr/dscf @ 7% O₂ = 0.5 gr/dscf @ 14% O₂
1 gr/dscf @ 12% CO₂ = 0.5 gr/dscf @ 6% CO₂

CORRECTION FOR DILUTION
Ringlemann's Scale for Grading the Density of Smoke

OPACITY AND THE RINGLEMANN CHART
SESSION 11.

SAFETY: AN IMPORTANT PART OF YOUR JOB
TORN "RED" BAG
WASTE HANDLING SAFETY

HAZARDS

- Sharp objects in waste bags
- Infectious waste spillage
- Micro-organisms in air

PRECAUTIONS

- Minimize bag handling
- Do not open or crush bags
- Wear protective clothing and safety gear
- Do not eat or drink in the area
- Wash hands before eating or drinking
**PROPER SAFETY GEAR**

- Thick rubber gloves
- Hard-soled rubber shoes
- Ear protectors
- Dust mask
- Long-sleeved shirt/coveralls
- Safety glasses
INCINERATOR OPERATION--
INJURIES AND SAFETY HAZARDS

- **Burns**
  - HOT SURFACES
  - CARELESS CHARGING
  - CARELESS ASH REMOVAL
  - OPENING INSPECTION PORTS

- **Injury**
  - MOVING BELTS AND HYDRAULIC CYLINDERS
  - ELEVATED WALKWAYS

- **Exposure to Air Contaminants/Lack of Oxygen**
  - LEAK IN EQUIPMENT OR DUCTWORK
  - POOR VENTILATION OF AREA
BURNER FLAME SAFEGUARD SYSTEM

- **Controls burner ignition**

- **Purges system**

- **Pilot ignition**
  -- detector
  -- 15 seconds
  -- fuel relay

- **Main burner ignition**

- **Shutdown**
  -- flame out
  -- air supply failure
Slide 11-6

INCINERATOR OPERATION SAFETY PRECAUTIONS

Do's

- Wear protective clothing and safety gear
- Be careful around moving belts, hydraulic cylinders, and doors
- Avoid contact with hot surfaces
- Watch for fuel leaks
- Be careful on elevated walkways
- Ventilate room if there is lack of oxygen or unusual odors
- Leave area if you develop
  -- headache, drowsiness, shortness of breath, nausea
INCINERATOR OPERATION SAFETY PRECAUTIONS

Don’ts

• Do not open inspection ports during operation

• Do not place hands or feet into feed ram assembly or ash removal system

• Do not lean on guardrails of walkways

• Do not bypass burner flame safeguard system
Slide 11-8

INCINERATOR OPERATION SAFETY PRECAUTIONS: MANUAL CHARGING

Do's

- Wait for previous charge to burn down
- Turn off primary chamber burner
- Stand behind and away from door

Don'ts

- Do not look into open charge door
- Do not charge bottles of flammable liquids
INCINERATOR OPERATION SAFETY PRECAUTIONS: ASH REMOVAL

Do's

- Use proper equipment to remove ash
- Watch out for hot spots and sharp objects
- Put ash into noncombustible container
- Spray water on ash in container to cool
INCINERATOR OPERATION SAFETY PRECAUTIONS: ASH REMOVAL

**Don'ts**

- Do not enter incinerator chamber
- Do not damage incinerator refractory
- Do not spray water into chamber
- Do not handle ash directly
SLIDE 11-11

WET SCRUBBERS: HAZARDS

- Chemical burns
- Falls
- Fan/fan belts
- Hearing loss
WET SCRUBBERS: SAFETY PRECAUTIONS

Do's

- Keep scrubber liquor off skin and eyes
- Learn location of and how to use eyewash
- Get scrubber leaks repaired
- Stay away from fans, drive shafts, and fan belt assemblies
- Wear earplugs or earmuffs around noisy equipment
WET SCRUBBERS: SAFETY PRECAUTIONS

Don’ts

- Do not place hand in fan belt/pulley assembly
- Do not continue to operate if fan is vibrating severely
SLIDE 11-14

FABRIC FILTERS: HAZARDS

• Toxic chemicals in fine dusts

• Excessive heat

• Fan/fan belts

• Hearing loss

• Inside fabric filter
  -- Toxic gases and dust
  -- Hot, free flowing solids
  -- Oxygen deficiency
  -- Rotating equipment
  -- Moving mechanical parts
SLIDE 11-15

FABRIC FILTERS: SAFETY PRECAUTIONS

Do's

- Prevent inhalation of dust by wearing dust mask
- Wear earplugs or earmuffs around noisy equipment
- Stay away from fans, drive shafts, and fan belt assemblies
- Before entering a fabric filter
  -- Clean dust from bags and hopper
  -- Purge with air
  -- Be sure fan is "locked out"
  -- Have a second trained person standing by
  -- Plan to stay inside as short a time as possible
Slide 11-16

FABRIC FILTERS: SAFETY PRECAUTIONS

Don'ts

• Do not place hand in fan belt/pulley assembly

• Do not continue to operate if fan is vibrating severely

• Never enter fabric filter without proper training and equipment
EMERGENCY PROCEDURES

- Post telephone numbers for emergency services
- Security should include incinerator on rounds
- Post spill control/decontamination procedures
- Post procedures for addressing puncture wounds
REFERENCES FOR SLIDES
**TECHNICAL REPORT DATA**

Please read instructions on the reverse before completing.

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<tr>
<th>REPORT NO.</th>
<th>TITLE AND SUBTITLE</th>
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<td>Hospital Incinerator Operator Training Course: Volume II Presentation Slides</td>
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<tr>
<td>Newlicht, R. M.; Chaput, L. S.; Wallace, D. D.; Turner, M. B.; Smith, S. G.</td>
<td>Midwest Research Institute</td>
</tr>
<tr>
<td></td>
<td>401 Harrison Oaks Boulevard, Suite 350</td>
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<td></td>
<td>Cary, North Carolina 27513</td>
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<td>U. S. Environmental Protection Agency Control Technology Center Research Triangle Park, N. C. 27711</td>
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<td>James Eddinger, Office of Air Quality Planning and Standards</td>
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<td>Justice Manning, Center for Environmental Research</td>
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**ABSTRACT**

This document is Volume II of a three-volume training course for operators of hospital waste incinerators. Volume I is the Student Handbook (EPA 450/3-89-003), and Volume III is the Instructor Handbook (EPA 450/3-89-010). This training course was originally prepared by the Control Technology Center for the State of Maryland. The purpose of this course is to provide hospital waste incinerator operators with a basic understanding of the principles of incineration and air pollution control and to identify, generally, good operation and maintenance (O&M) practices. Proper O&M, in addition to reducing air emissions, improves equipment reliability and performance, prolongs equipment life, and helps to ensure proper ash burnout. The course is not intended to replace site-specific, hands-on training of operators with the specific equipment to be operated.

Volume II contains classroom materials including a copy of the presentation slides so that students can follow along during the class and worksheets that can be completed during the classroom sessions. The course includes 11 separate classroom sessions covering topics such as basic combustion principles and incinerator design; air pollution control equipment design, function, operation, and monitoring; incinerator operation; maintenance inspections; typical problems; and State regulations.

**KEY WORDS AND DOCUMENT ANALYSIS**

<table>
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<th>DESCRIPTORS</th>
<th>IDENTIFIERS/OPEN ENDED TERMS</th>
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**DISTRIBUTION STATEMENT**

Release unlimited
PART II.
STUDENT WORKSHEETS
WORKSHEET NO. 1

INCINERATOR SYSTEM INFORMATION

Can you describe the type incinerator you operate? Fill out this table. Circle the answer that best fits your system.

Operator's name ____________________________________________

Incinerator manufacturer ____________________________________

A. Incinerator type (Circle)
   1. Controlled ("starved") air
   2. Multiple chamber "excess" air
      - In-line
      - Retort
   3. Rotary kiln
   4. Other
   5. Don't know

B. My incinerator is designed especially for pathological waste:
   Yes No Don't know

C. Operating mode
   1. Single batch
   2. Intermittent duty
   3. Continuous duty
   4. Don't know

D. Waste feed charge system
   1. Manual - I do all the work
   2. Mechanical hopper/ram
      a. Manually operated
      b. Automatic timer sequence
   3. Mechanical hopper/ram with cart dumper
   4. Other
   5. Don't know

E. Ash removal system
   1. Manual - rake and hoe
   2. Continuous mechanical
   3. Don't know
F. Combustion Gas Flow

1. Natural draft
2. Induced draft
3. Balanced draft
   - Forced combustion air/natural draft stack
   - Forced combustion air/induced draft fan

G. Waste heat boiler

1. Yes
2. No
INCINERATOR SYSTEM INFORMATION

Monitoring and Control Systems

Operator's name ____________________________

Incinerator manufacturer ____________________________

A. How would you describe the operating mode of your incinerator?

1. Single batch
2. Intermittent duty
3. Continuous duty

B. How would you describe the control system used on your incinerator?

1. Manual
2. Automatic timer sequence
3. Automatic modulated control

C. What operating parameters are monitored or used as control parameters on your incinerator?

<table>
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<th>Function</th>
<th>Monitored</th>
<th>Controlled</th>
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<td>Temperature</td>
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<tr>
<td>Secondary Chamber</td>
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<tr>
<td>Temperature</td>
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<tr>
<td>Draft</td>
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<td></td>
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<tr>
<td>Charge rate</td>
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<tr>
<td>Oxygen</td>
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<tr>
<td>Carbon Monoxide</td>
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<tr>
<td>Opacity</td>
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<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
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</table>
### Operating Parameters

**Operator's name**

**Incinerator manufacturer**

**What are the key operating parameters for your incinerator. What are the setpoints or operating ranges used?**

<table>
<thead>
<tr>
<th>Key Parameter</th>
<th>Setpoints/Operating Range</th>
<th>No setpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary chamber temperature</td>
<td>upper</td>
<td>lower</td>
</tr>
<tr>
<td>Secondary chamber temperature</td>
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<td>Draft</td>
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</tr>
<tr>
<td>Charge rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxygen concentration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon monoxide concentration</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A. List the things to do when operating your incinerator that you think are the most important:

1.
2.
3.
4.
5.

B. Name the things to watch (monitor) when operating your incinerator that you think are the most important:

1.
2.
3.
4.
5.

C. Name the things not to do when operating your incinerator that you think are the most important:

1.
2.
3.
4.
5.
OPERATING PROBLEMS REVIEW

What are the most frequent problems you usually have?

A. **Problem:**

   Possible causes:

   Possible solutions:

B. **Problem:**

   Possible causes:

   Possible solutions:

C. **Problem:**

   Possible causes:

   Possible solutions:
INCINERATOR SYSTEM INFORMATION

Operator's name ____________________________________________

Incinerator manufacturer ____________________________________

What regulatory limits are you required to meet during operation of your incinerator?

A. Emission Limits:
   1. Opacity
   2. Particulate
   3. Other

B. Operating Limits
   1. Charge rate
   2. Primary chamber temp
   3. Secondary chamber temp
   4. Oxygen concentration
   5. Ash quality
   6. Other

C. Record Keeping
   1. Charge rate
   2. Primary chamber temp
   3. Secondary chamber temp
   4. Other
SAFETY REVIEW

A. What personal safety gear do you use?

1. Coveralls
2. Hard soled shoes
3. Eye protection
4. Gloves
5. Dust mask
6. Ear protection

B. List the most serious safety hazards to which you are exposed. How do you minimize your chances of injury?

1.
2.
3.
4.
5.