NACT 270

Incinerators

1

2

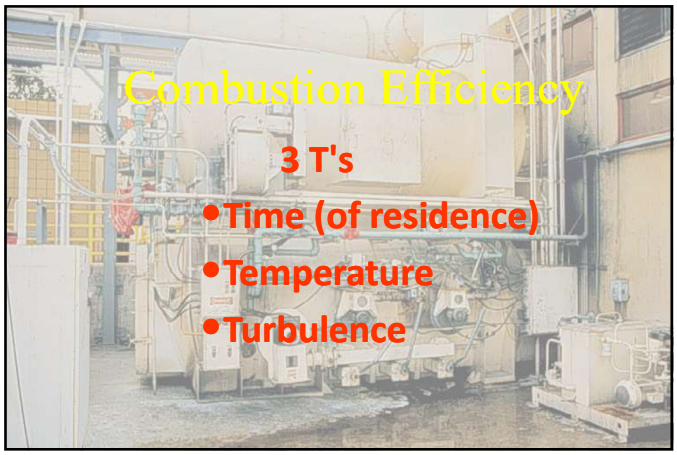
3

4

INCINERATION

- "A combustion process, in which the primary purpose is to destroy combustible material."
- Biomedical Incinerators: Hospital, Pathological and Crematory Incinerators.
- Heat Stripping Ovens (Burn off ovens)
- MSW incinerators
- Sewage Sludge incinerators
- Hazardous Waste incinerators
- Commercial and Industrial Incinerators
- Air Curtain Incinerators

5



6

Combustion

- Stoichiometric Combustion
- Excess Air Combustion
- Substoichiometric Combustion

7

IIA Waste Classification

TYPES 0 - 8

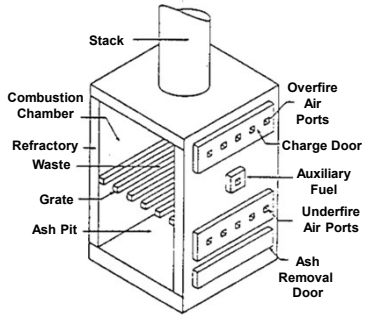
- Vary by Composition
- Vary by Moisture Content
- Vary by Btu value per pound fired

8

Solid Waste Incinerators

- Open Burning
- Open-Pit Incinerators
- Teepee Burners
- Single Chamber Incinerators
- Multiple Chamber Incinerators
- Controlled Air Incinerators
- Rotary Kiln Incinerators
- Fluidized Bed Incinerators
- Multiple Hearth Incinerators
- Air Curtain Incinerators

9

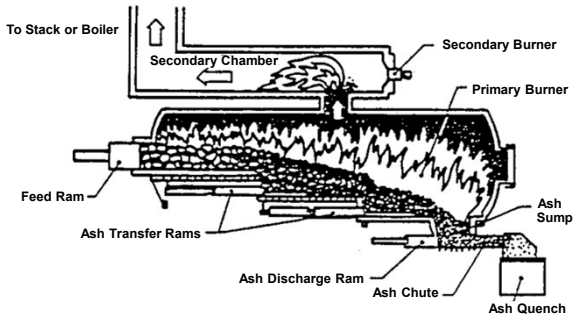


Single Chamber Incinerator

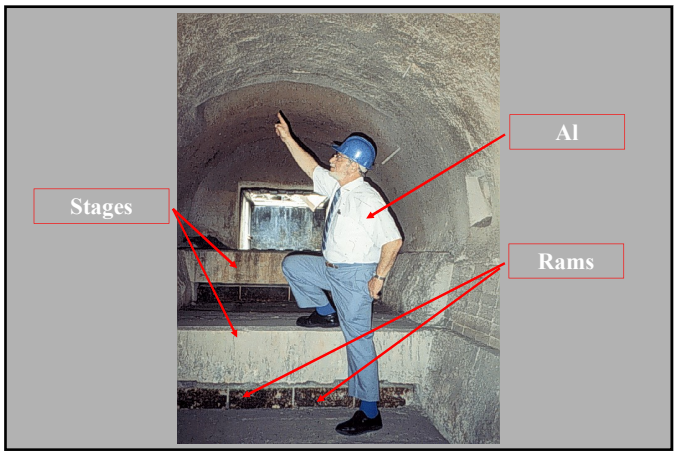
10

11

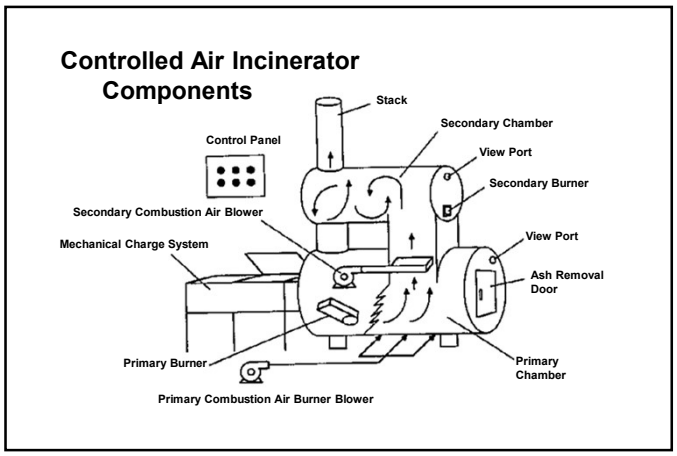
Controlled-Air Incinerator with Staged Hearth and Automatic Ash Removal



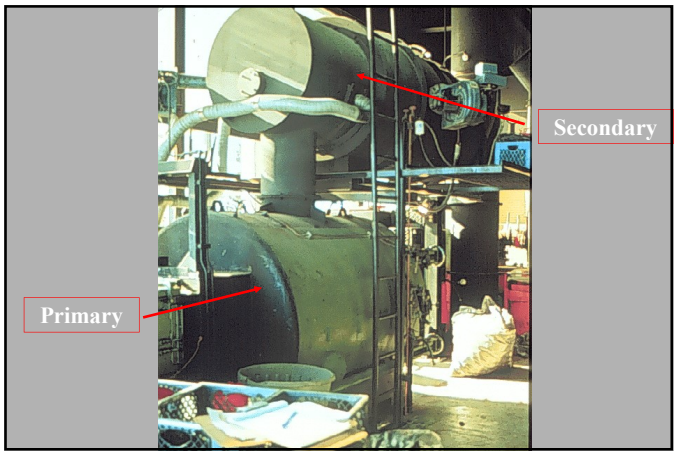
12


Al
Stages
Rams

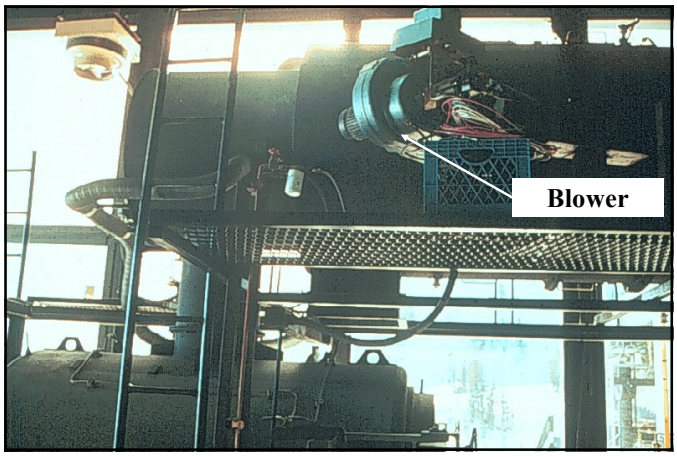
13


Controlled Air Incinerator Components
Stack
Secondary Chamber
Control Panel
View Port
Secondary Burner
Secondary Combustion Air Blower
View Port
Mechanical Charge System
Ash Removal Door
Primary Burner
Primary Chamber
Primary Combustion Air Burner Blower

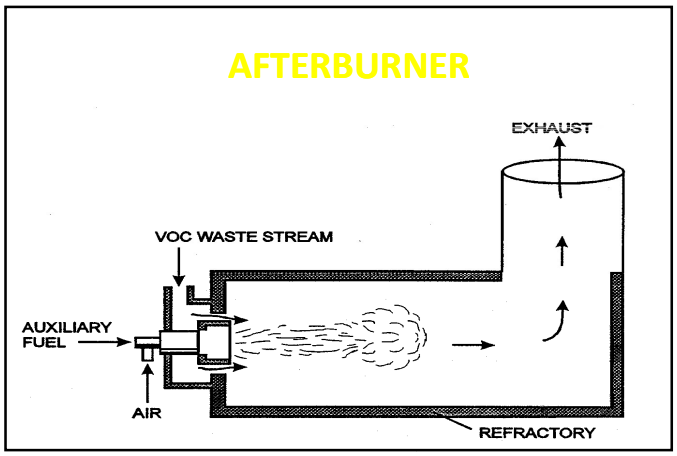
14


Secondary
Primary

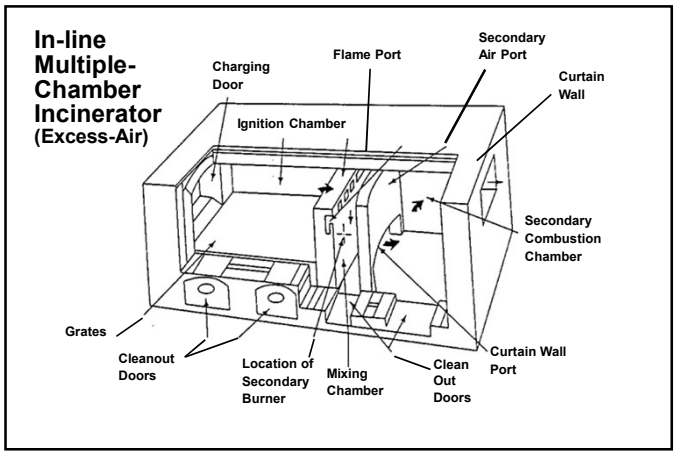
15


Blower

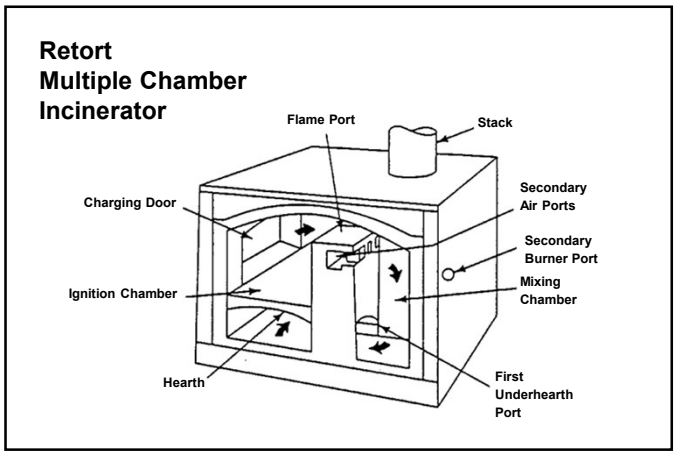
16


AFTERBURNER
EXHAUST
VOC WASTE STREAM
AUXILIARY FUEL
AIR
REFRACTORY

17

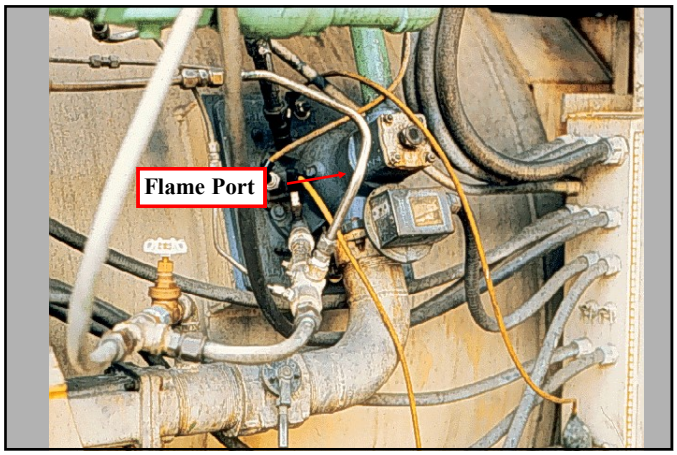

In-line Multiple-Chamber Incinerator (Excess-Air)
Charging Door
Flame Port
Secondary Air Port
Curtain Wall
Ignition Chamber
Secondary Combustion Chamber
Grates
Cleanout Doors
Location of Secondary Burner
Mixing Chamber
Clean Out Doors
Curtain Wall Port

18


Retort
Multiple Chamber
Incinerator
Flame Port
Stack
Charging Door
Secondary
Air Ports
Secondary
Burner Port
Ignition Chamber
Mixing
Chamber
Hearth
First
Underhearth
Port

19

20

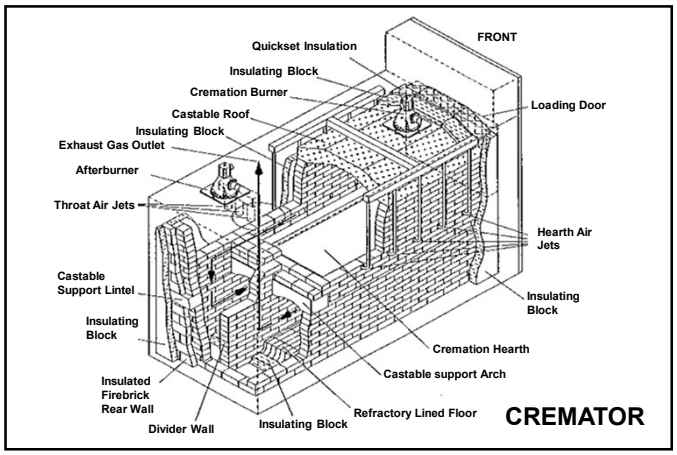

Flame Port

21

22

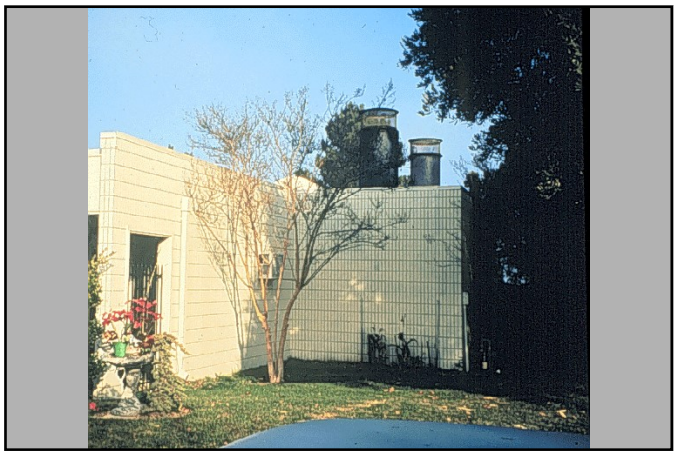
LEAVE
OPEN

23


FRONT
Quickset Insulation
Insulating Block
Cremation Burner
Castable Roof
Insulating Block
Exhaust Gas Outlet
Afterburner
Throat Air Jets
Loading Door
Hearth Air Jets
Castable Support Lintel
Insulating Block
Insulating Block
Cremation Hearth
Castable support Arch
Insulated Firebrick Rear Wall
Divider Wall
Insulating Block
Refractory Lined Floor
CREMATOR

24

NACT



25

26

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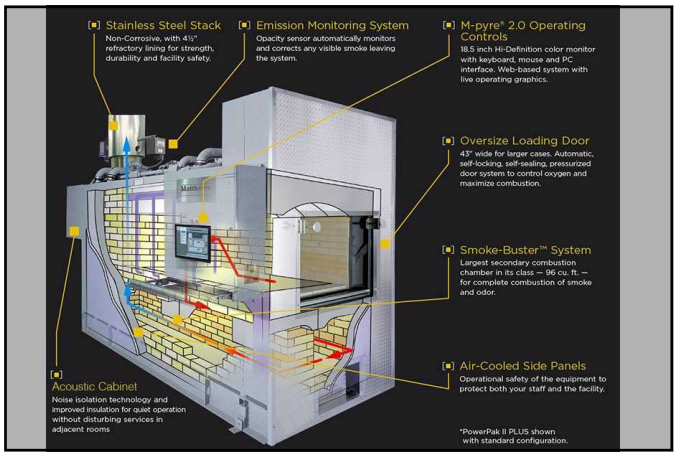
28



29

Categories of Industrial Incinerators

- Volume Reduction (trash, wood, solid waste streams)
- Toxicity Reduction (any toxic waste stream)
- Resource Recovery (copper wire, steel drums, electric motors)
- Energy Recovery

30

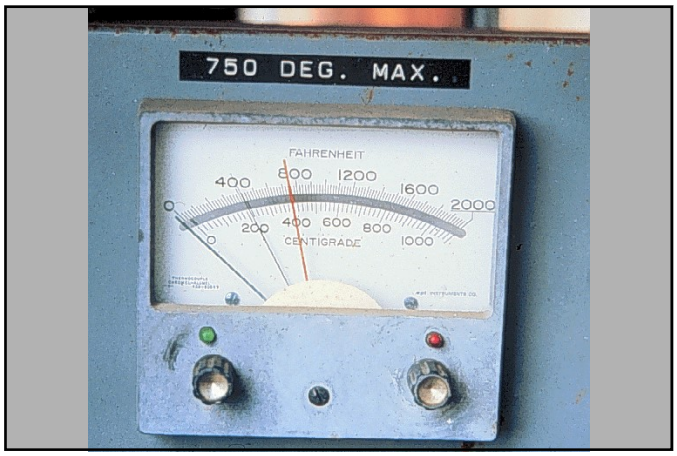
Industrial Heat Cleaning (Burnout) Ovens

- Primary Chamber 700 - 750 F
- Secondary Chamber 1200 -1400 F
- Roasting Condition in Primary
- Low Oxygen Environment
- Volatiles & Smoke go to Afterburner
- Water Mist Injection in Primary

31

32

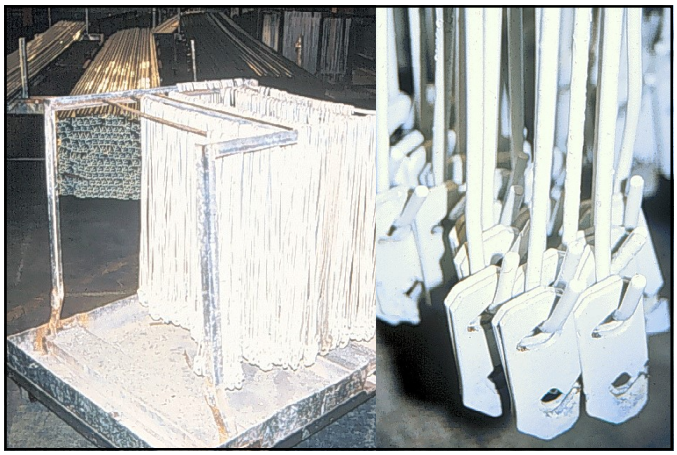
33


750 DEG. MAX.
FAHRENHEIT
400
800
1200
1600
2000
0
200
400
600
800
1000
CENTIGRADE

34

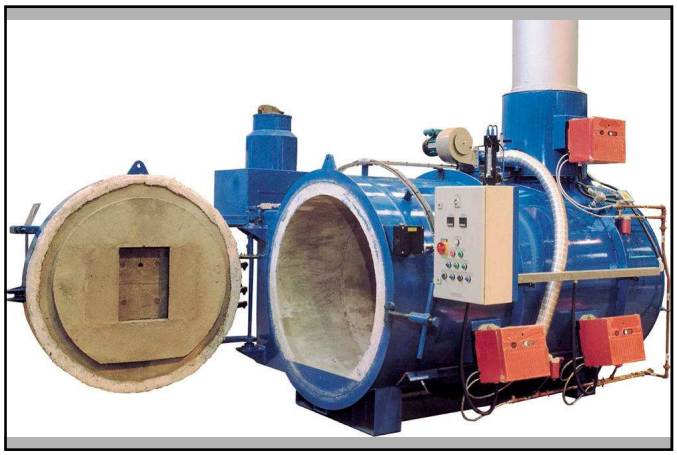
BRYCO

35



36

NACT



37

38

39

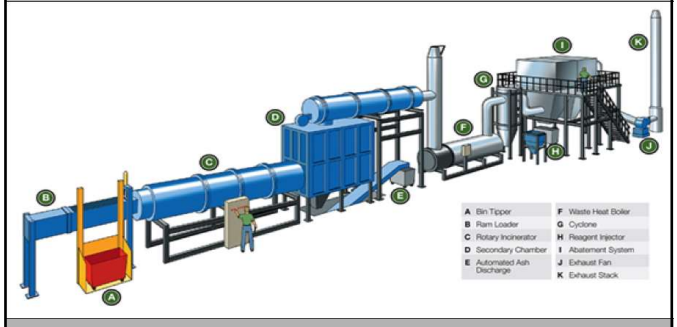
Air Burners LLC

40

Rotary kiln

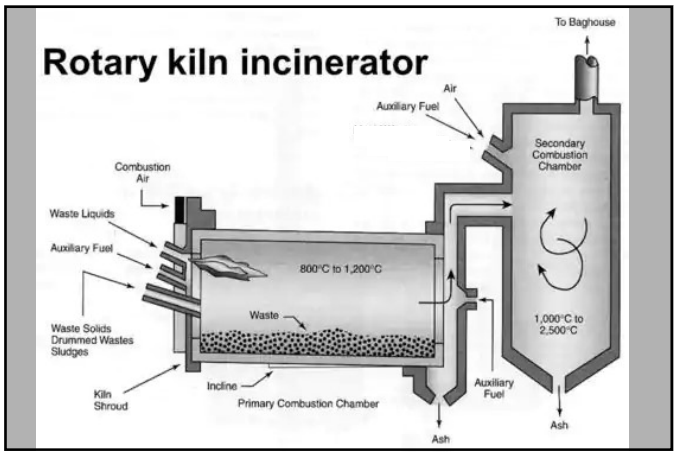
37

41

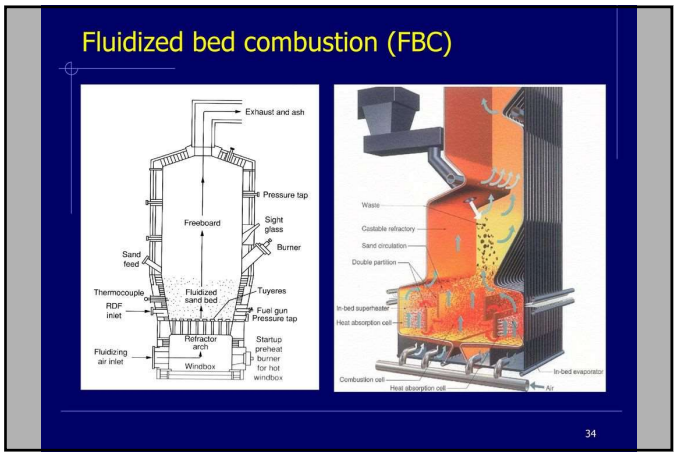


42

NACT


Rotary kiln incinerator
To Baghouse
Air
Auxiliary Fuel
Secondary Combustion Chamber
Combustion Air
Waste Liquids
Auxiliary Fuel
800°C to 1,200°C
Waste
1,000°C to 2,500°C
Waste Solids Drummed Wastes Sludges
Kiln Shroud
Incline
Primary Combustion Chamber
Auxiliary Fuel
Ash
Ash

43

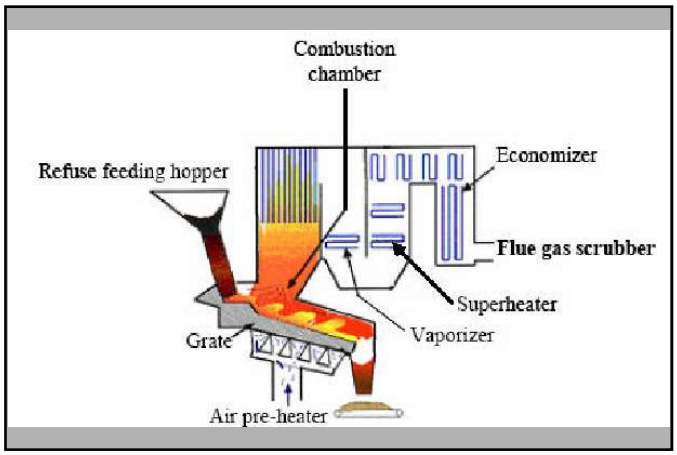

Fluidized bed combustion (FBC)
Exhaust and ash
Pressure tap
Freeboard
Sight glass
Burner
Sand feed
Thermocouple
Fluidized sand bed
Tuyeres
RDF inlet
Fuel gun Pressure tap
Refractor arch
Startup preheat burner for hot windbox
Fluidizing air inlet
Windbox
Waste
Castable refractory
Sand circulation
Double partition
In-bed superheater
Heat absorption cell
In-bed evaporator
Combustion cell
Heat absorption cell
Air
34

44

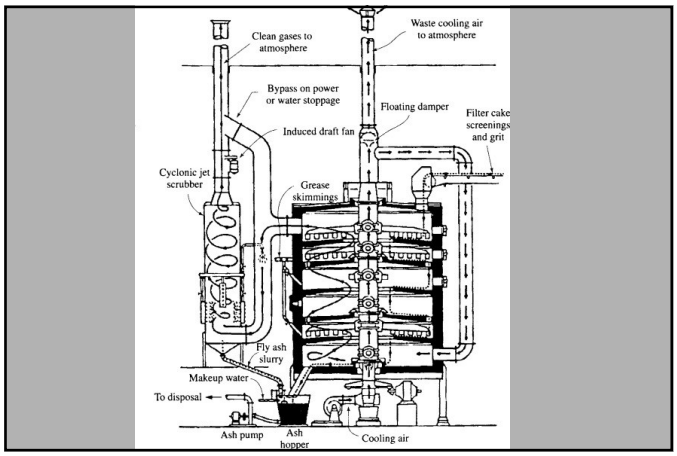
This is an excerpt from our Fluidized Bed Boilers training module.
Our EHS videos can be found at www.convergencetraining.com

45

NACT


Combustion chamber
Refuse feeding hopper
Economizer
Flue gas scrubber
Superheater
Vaporizer
Grate
Air pre-heater

46


Clean gases to atmosphere
Waste cooling air to atmosphere
Bypass on power or water stoppage
Floating damper
Filter cake screenings and grit
Induced draft fan
Cyclonic jet scrubber
Grease skimmings
Fly ash slurry
Makeup water
To disposal
Ash pump
Ash hopper
Cooling air

47

48

Modes of Operation

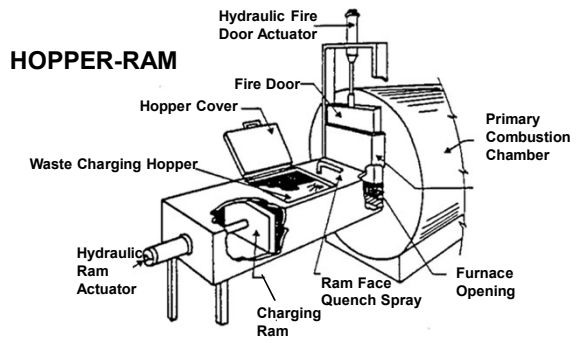
WASTE CHARGING:

- Batch
- Intermittent
- Continuous

ASH REMOVAL:

- Manual
- Automatic

49



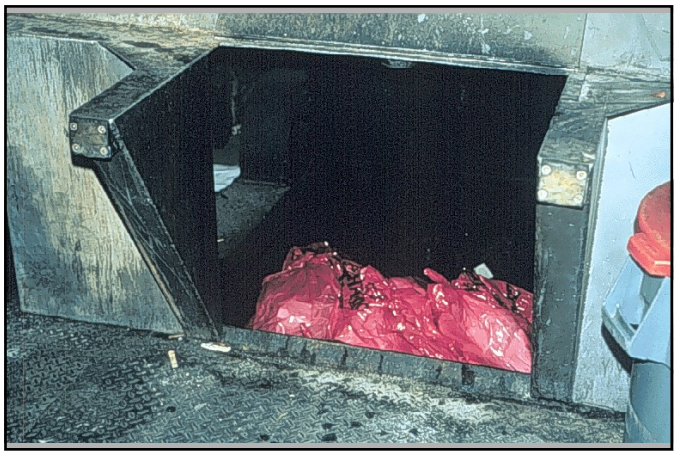
50

51

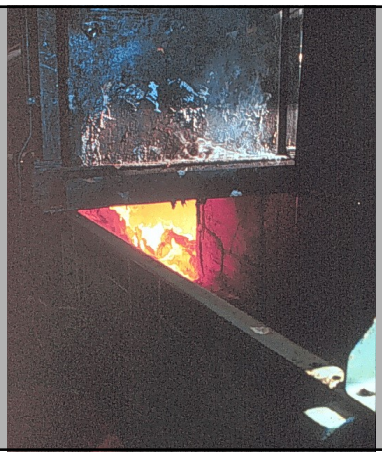
NACT

52

53



54



55

Typical Incinerator Operating Procedures

- Before Start-up
- Start-up
- Charging/Burning
- Burn Down
- Shutdown (batch & intermittent)

56

Before Incinerator Start-up

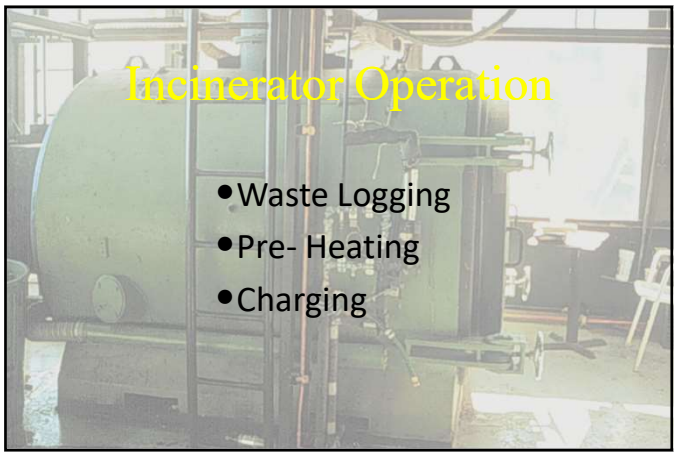
- Manual Ash Removal
- Automatic Ash Removal
- Routine Daily Inspection
- Burner & Blower Check

57

Typical Incinerator Operating Procedures

Operating Step	Typical Duration
1. Ash Cleanout	15 to 30 minutes
2. Pre-Heat	15 to 60 minutes
3. Charging & Burning	Up to 14 hours
4. Burndown	2 to 4 hours
5. Cooldown	5 to 8 hours

58



59

Shutdown

- Batch or Intermittent Duty:
  - Combustion Blowers left on to cool
  - Typically lasts 5 to 8 hours
  - Ash removed and inspected

60

Typical Operational Errors

- Charging before Operating Temps. Are Achieved (failure to Pre-heat)
- Overcharging
- Waste with Excessive Moisture

BMWNC medical waste incinerator (smoke from stacks 2)

61

Incinerator Emissions & Control

62

Emissions

- Visible Emissions (Stack or Fugitive)
- Particulate Matter (Concentration/Weight)
- Acid Gases (NOx, SOx, HCl)
- Toxics (Dioxins, Furans, Heavy Metals)

63

Pollutant Formation Factors

- Fuel Composition
- Charging Method and Rate
- Incinerator Type and Design
- Combustion Conditions (3 T's)
- Excess Air

64

65

Particulate Matter Formation

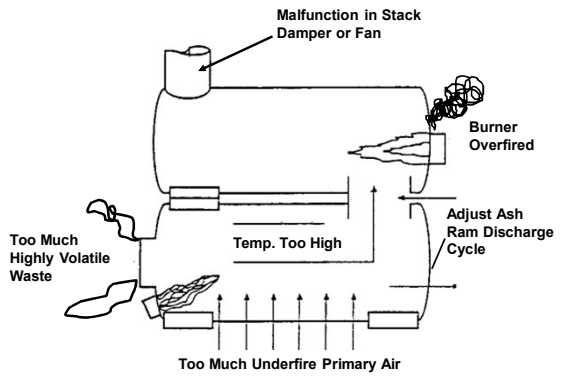
- Suspension of Inorganic Substances
- Incomplete Combustion of Fuel Materials
- Condensation of Vaporous Metals

66

Smoke Formation

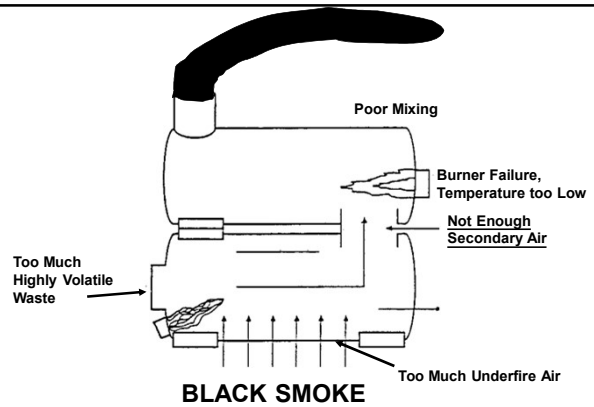
- Black Smoke
  - Too Little Oxygen Relative to Fuel
  - Usually Caused by Overcharging
- White Smoke
  - Premature Cooling of Flue Gas
  - Excessive Air
  - Inorganic Particles

67



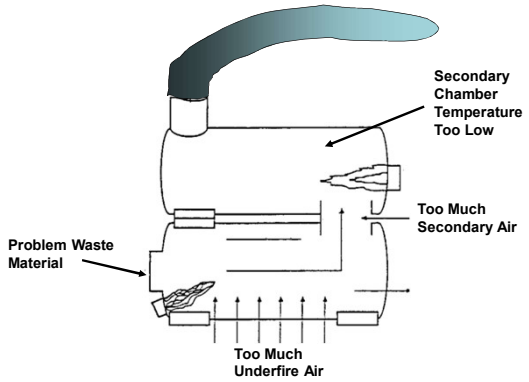
"POSITIVE" CONDITION - SMOKE LEAKING

68



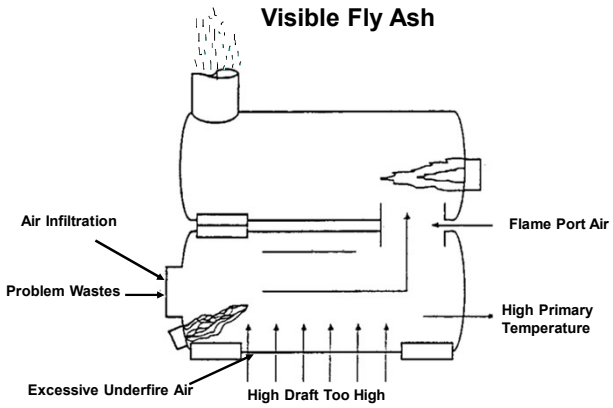
BLACK SMOKE
(Incomplete Burning - Soot Formation)

69



WHITE/BLUE SMOKE

70



71

Carbon Monoxide Formation

- Insufficient Oxygen for Complete Combustion
- Indicator of Inadequate Combustion Air Turbulence
- Indicator of Combustion Efficiency

72

Products of Incomplete Combustion (PIC's)

- Greater Combustion Efficiency = Lower Dioxins
- Can occur when charging PVC plastics
- Dioxins are some of the most toxic man-made substances
- Polycyclic Aromatic Hydrocarbons (PAH's)
- Polychlorinated Biphenyls (PCB's)

73

Wet Scrubbers

- Remove both Particulates & Acid Gases
- Rely on Flue Gas Pressure Drop for Particulate Removal with Alkali Reagent for Acid Gas Removal.
- Categories of scrubbers:
  - Spray Chambers
  - Packed Towers (Beds)
  - Venturi

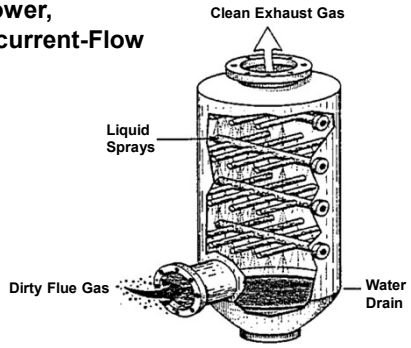
74

Wet Scrubber Acid Gas Removal

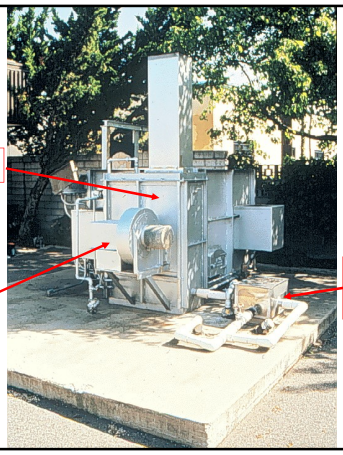
- Sodium Hydroxide (NaOH - Caustic Soda) or Sodium Carbonate (Na_2CO_3)
- Alkali Added to Re-circulation Tank Water (pH of 8-9).

75

Spray Tower, Countercurrent-Flow Type



76

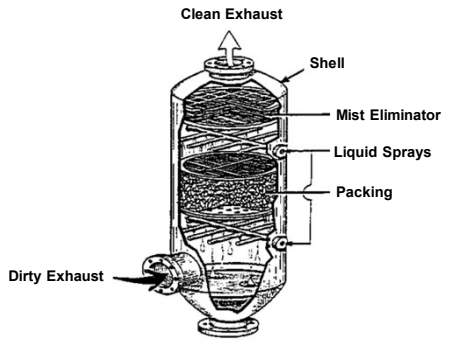


77

Common Spray Tower Scrubber Problems

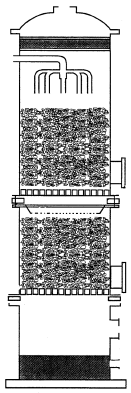
- Liquor Spray Nozzles Plugged
- Erosion of Spray Nozzles
- Corrosion of Shell
- Mist Re-entrainment
- pH too low or high

78



Countercurrent- Flow Packed-Bed Scrubber

79

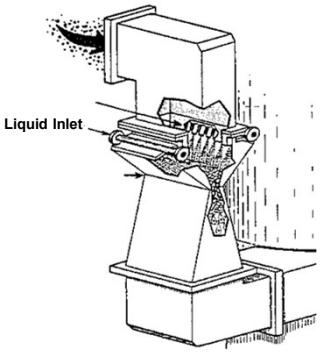


80

Packed-Bed Operating Problems

- Accumulation of Solids
- Settling of Packing Material
- Liquor pH (between 5.5-10)

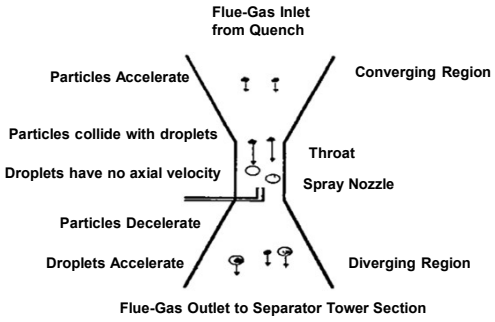
81



SPRAY VENTURI WITH RECTANGULAR THROAT

82

Particle Behavior in Venturi-Scrubber Section



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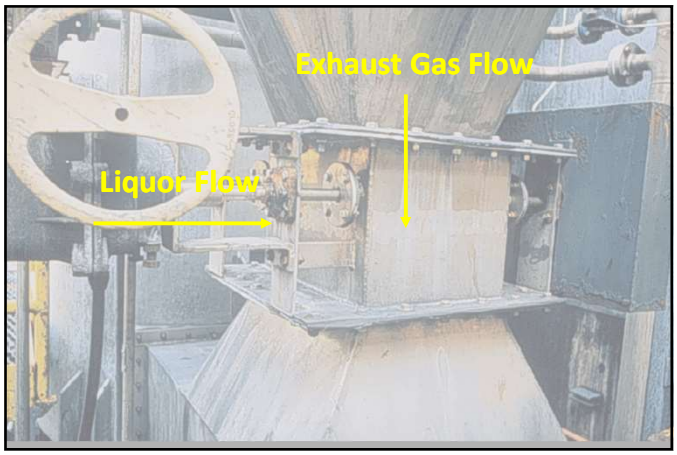

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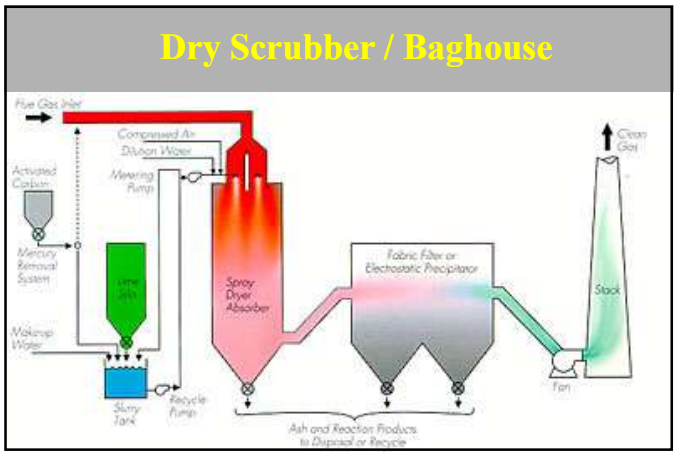
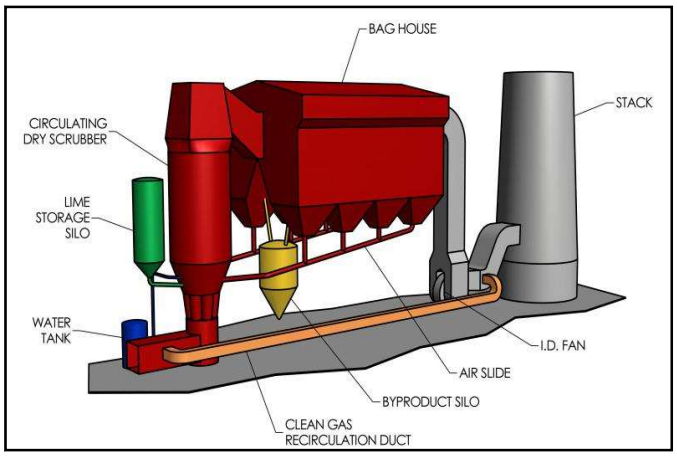
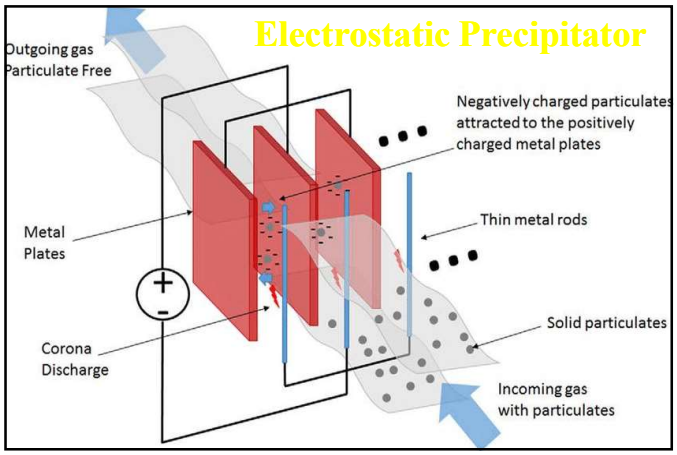

Dry Scrubber / Baghouse
Flue Gas Inlet
Compressed Air
Dilution Water
Activated Carbon
Metering Pumps
Mercury Removal System
Lime Silo
Spray Dryer Absorber
Fabric Filter or Electrostatic Precipitator
Clean Gas
Stack
Makeup Water
Slurry Tank
Recycle Pumps
Fan
Ash and Reaction Products to Disposal or Recycle

85

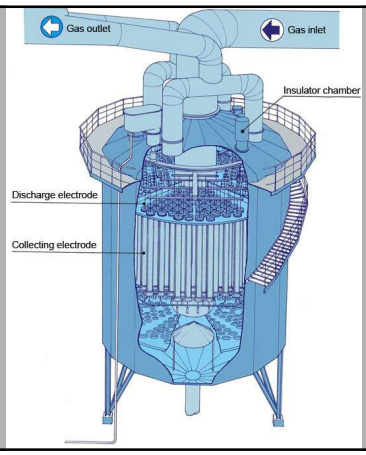

BAG HOUSE
STACK
CIRCULATING DRY SCRUBBER
LIME STORAGE SILO
WATER TANK
I.D. FAN
AIR SLIDE
BYPRODUCT SILO
CLEAN GAS RECIRCULATION DUCT

86

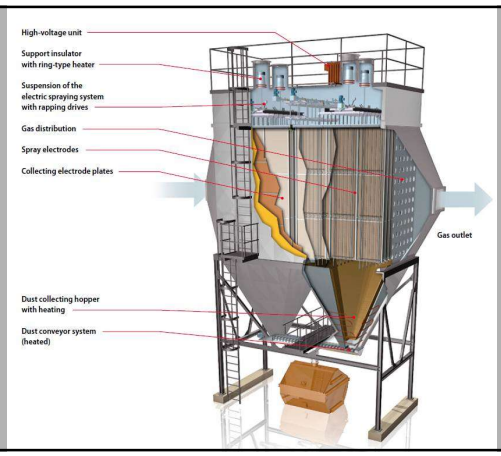

Electrostatic Precipitator
Outgoing gas
Particulate Free
Negatively charged particulates attracted to the positively charged metal plates
Thin metal rods
Metal Plates
Solid particulates
Corona Discharge
Incoming gas with particulates

87

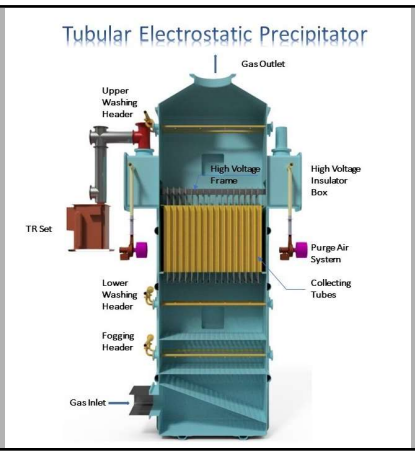
NACT


Gas outlet
Gas inlet
Insulator chamber
Discharge electrode
Collecting electrode

88

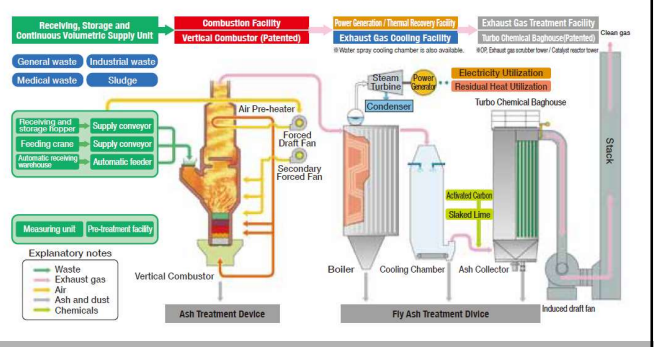

High-voltage unit
Support insulator with ring-type heater
Suspension of the electric spraying system with rapping drives
Gas distribution
Spray electrodes
Collecting electrode plates
Gas outlet
Dust collecting hopper with heating
Dust conveyor system (heated)

89


Tubular Electrostatic Precipitator
Gas Outlet
Upper Washing Header
High Voltage Frame
High Voltage Insulator Box
TR Set
Purge Air System
Collecting Tubes
Lower Washing Header
Fogging Header
Gas Inlet

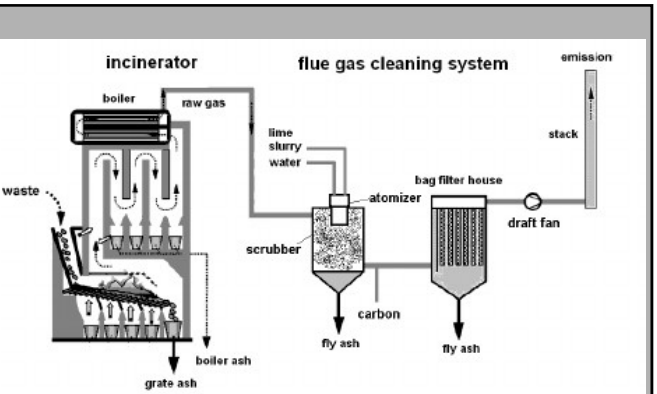
90

NACT


Receiving, Storage and Continuous Volumetric Supply Unit
Combustion Facility
Vertical Combustor (Patented)
Power Generation / Thermal Recovery Facility
Exhaust Gas Cooling Facility
Exhaust Gas Treatment Facility
Turbo Chemical Baghouse(Patented)
Clean gas
General waste
Industrial waste
Medical waste
Sludge
Steam Turbine
Power Generator
Condenser
Electricity Utilization
Residual Heat Utilization
Turbo Chemical Baghouse
Air Pre-heater
Forced Draft Fan
Secondary Forced Fan
Receiving and storage Hopper
Feeding crane
Automatic receiving warehouse
Supply conveyor
Supply conveyor
Automatic feeder
Activated Carbon
Slaked Lime
Stack
Measuring unit
Pre-treatment facility
Explanatory notes
Waste
Exhaust gas
Air
Ash and dust
Chemicals
Vertical Combustor
Boiler
Cooling Chamber
Ash Collector
Ash Treatment Device
Fly Ash Treatment Divice
Induced draft fan

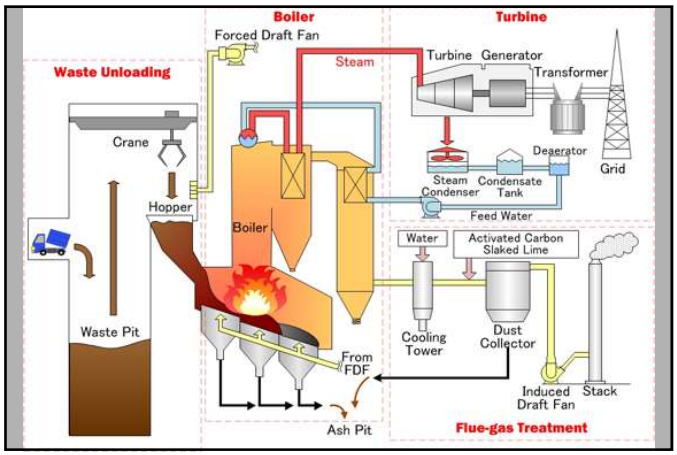
91

92

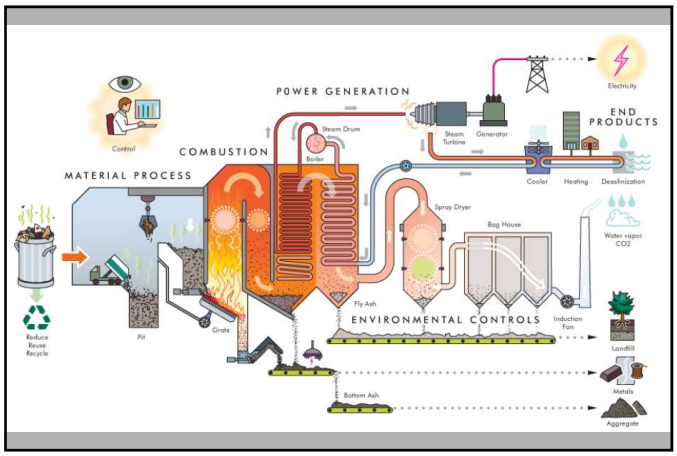

incinerator
flue gas cleaning system
emission
boiler
raw gas
lime
slurry
water
stack
bag filter house
waste
atomizer
draft fan
scrubber
carbon
fly ash
fly ash
boiler ash
grate ash

93

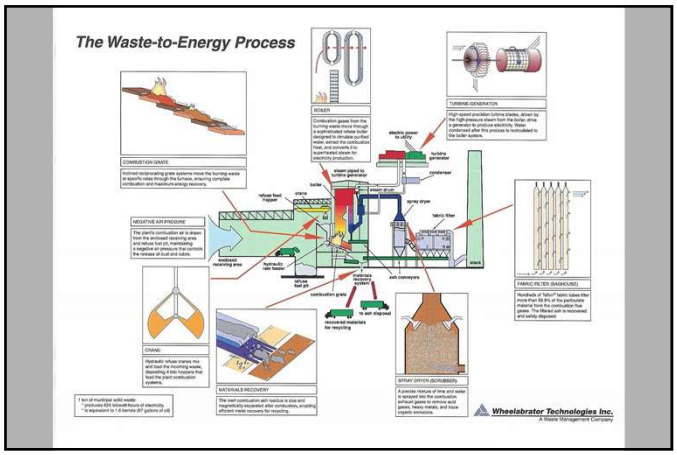
NACT


Boiler
Turbine
Forced Draft Fan
Steam
Turbine
Generator
Transformer
Waste Unloading
Crane
Deaerator
Grid
Steam Condenser
Condensate Tank
Hopper
Feed Water
Boiler
Water
Activated Carbon Slaked Lime
Waste Pit
Cooling Tower
Dust Collector
From FDF
Induced Draft Fan
Stack
Ash Pit
Flue-gas Treatment

94

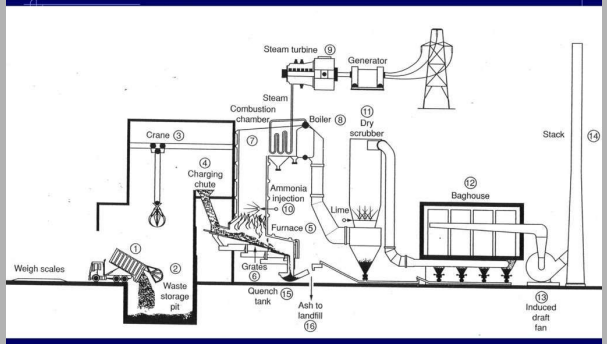

POWER GENERATION
Electricity
END PRODUCTS
Control
Steam Drum
Steam Turbine
Generator
COMBUSTION
Boiler
MATERIAL PROCESS
Cooler
Heating
Desalinization
Spray Dryer
Bag House
Water vapor CO2
Fly Ash
ENVIRONMENTAL CONTROLS
Induction Fan
Reduce Reuse Recycle
Pit
Grate
Landfill
Metals
Bottom Ash
Aggregate

95


The Waste-to-Energy Process
Wheelabrator Technologies Inc.

96

How incinerated?



18

97

98

Regulations

99

State and Local Regulatory Requirements

- General Air Emissions Limitations
  - Visible Emissions
  - Particulate Matter
  - Fugitive Dust
  - Gaseous Emissions
  - Toxic Emissions
- Public Nuisance (Odors, Noise)

100

State and Local Agency Incinerator Rules

- Crematories
  - Human
  - Animal
- Burn Off Ovens
- Pathological waste, low-level radioactive waste, and/or chemotherapeutic waste
- Acceptable Incinerators
- Regulations more stringent than Federal Regs

101

Federal Incinerator Rules

- Large Municipal Waste Combustors
- Small Municipal Waste Combustors
- Other Solid Waste Incinerators
- Hospital, Medical, Infectious Waste Incinerators
- Sewage Sludge Incinerators
- Commercial Industrial Solid Waste Incinerators
- Hazardous Waste Incinerators

102

Large Municipal Waste Combustors

- 40 CFR 60 Subpart E - Construct after 8/17/71
- 40 CFR 60 Subpart Ea – Construct 12/20/89 to 9/20/94
- 40 CFR Subpart Eb - Construct after 9/20/94, Mod or Recon after 6/19/96
- 40 CFR 60 Subpart Cb – EG - Existing on or before 9/20/94
- 40 CFR 62 Subpart FFF – FP - Existing on or before 9/20/94

103

Subpart Eb

- > 250 tpd MSW
- Siting requirements and Materials separation plan
- Operator training and certification
- Emission limits for PM, Cd, Pb, Hg, SO2, HCl, Dioxin/Furan, NOx, CO, Opacity, Fugitive ash
- CEMs – O2 or CO2, COM, SO2, NOx, CO
- Initial testing for all contaminants with limits
- Annual testing for PM, Hg, Cd, Pb, HCl, D/F (or CEMS)
- Monitoring, recordkeeping and reporting
- Limits for air curtain incinerators burning yard waste

104

Small Municipal Waste Combustors

- 40 CFR 60 Subpart AAAA - Construct after 8/30/99, Mod or Recon after 6/6/01
- 40 CFR 60 Subpart BBBB – EG - Existing on or before 8/30/99
- 40 CFR 62 Subpart JJJ – FP - Existing on or before 8/30/99

105

Subpart AAAA

- 35-250 tpd MSW
- Siting requirements and Materials separation plan
- Operator training and certification
- Good combustion practices
- Emission limits for PM, Cd, Pb, Hg, SO2, HCl, Dioxin/Furan, NOx, CO, Opacity, Fugitive ash
- CEMs – O2 or CO2, COM, SO2, CO, NOx for Class 1
- Initial and Annual testing for PM, Hg, Cd, Pb, HCl, D/F
- Class 2 may have less annual testing
- Monitoring, recordkeeping and reporting
- Limits for air curtain incinerators burning yard waste

106

Other Solid Waste Incinerators

- 40 CFR 60 Subpart EEEE - Construct after 12/9/04, Mod or Recon after 6/16/06
- 40 CFR 60 Subpart FFFF – EG - Existing on or before 12/9/04

107

Subpart EEEE

- <35 tpd MSW and Institutional units
- Siting requirements and waste management plan
- Operator training and qualification
- Good combustion practices
- Emission limits for PM, Cd, Pb, Hg, SO2, HCl, Dioxin/Furan, NOx, CO, Opacity
- CEMs – O2, CO
- Initial and Annual testing for all pollutants
- Less frequent than annual testing may be allowed
- Monitoring, recordkeeping and reporting
- Limits for air curtain incinerators

108

Hospital, Medical, and Infectious Waste Incinerators

- 40 CFR 60 Subpart Ec - Construct after 6/20/96 to 12/1/08, Mod after 3/16/98 to 4/6/10, Construct after 12/1/08, Mod after 4/6/10
- 40 CFR 60 Subpart Ce – EG – Construct on or before 6/20/96, Mod on or before 3/16/98, Construct after 6/20/96 to 12/1/08, Mod after 3/16/98 to 4/6/10
- 40 CFR 62 HHH - FP

109

Subpart Ec

- Siting requirements and waste management plan
- Operator training and qualification
- Emission limits for PM, Cd, Pb, Hg, SO2, HCl, Dioxin/Furan, NOx, CO, Opacity, Fugitive ash
- Various emission limits for different dates and size of units
- CEMs – CO
- Initial and Annual testing for all pollutants (or CEMs)
- Monitoring, recordkeeping and reporting

110

Sewage Sludge Incinerators

- 40 CFR 60 Subpart O - Construct after 6/11/73
- 40 CFR 60 Subpart LLLL – Construct after 10/14/10, Mod after 9/21/11
- 40 CFR 60 Subpart MMMM – EG – Construct before 10/14/10
- 40 CFR 62 LLL – FP - Construct before 10/14/10

111

Subpart LLLL

- Siting requirements
- Operator training and qualification
- Emission limits for PM, Cd, Pb, Hg, SO2, HCl, Dioxin/Furan, NOx, CO, Fugitive ash
- Various emission limits for different dates and size of units
- CEMs – CO
- Initial and Annual testing for all pollutants (or CEMs)
- Monitoring, recordkeeping and reporting

112

Commercial and Industrial Solid Waste Incinerators

- 40 CFR 60 Subpart CCCC - Construct after 6/4/10, Mod or Recon after 8/7/13
- 40 CFR 60 Subpart DDDD – EG – Construct on or before 11/30/99 and not modified or reconstructed after 6/1/01, Construct after 11/30/99 but no later than 6/4/10 or commenced modification or reconstruction after 6/1/01 but no later than 8/7/13, Construct on or before 6/4/10 or commenced modification or reconstruction after 6/4/10 but no later than 8/7/13
- 40 CFR 62 III – FP - Construct before 11/30/99

113

Subpart CCCC

- Incinerate solid waste as defined in 40 CFR Part 241
- Siting requirements and Waste management plan
- Operator training and qualification
- Emission limits for PM, Cd, Pb, Hg, SO2, HCl, Dioxin/Furan, NOx, CO, Fugitive ash
- Various emission limits based on dates of construction, mod or recon and type of unit
- CEMs – required based on unit type, other monitors required based on APC type
- Initial and Annual testing for all pollutants (or CEMs)
- Monitoring, recordkeeping and reporting
- Air curtain incinerator requirements

114

Hazardous Waste Incinerators

- 40 CFR 63 Subpart EEE

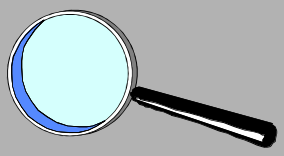
115

Subpart EEE

- HWI, Cement kilns, Lightweight Aggregate kilns, some boilers
- Operator training and qualification
- Emission limits for PM, Cd, Pb, Hg, HCl, Dioxin/Furan, CO, As, Be, Cr, hydrocarbons, Cl gas
- DRE 99.99%. But 99.9999% for dioxin listed hazardous waste
- CEMs – Hydrocarbon, COM, PM
- Extensive unit performance testing
- System interlocks (AWFCO) to stop flow of material
- Initial and Annual testing for all pollutants
- O&M plan
- Monitoring, recordkeeping and reporting

116

Incinerator Inspection



117

Inspector Safety Equipment

- Hard Hat
- Safety Glasses or Goggles
- Gloves
- Steel Tipped Safety Shoes
- Ear Protectors
- District Safety Policy

118

Identify Potential Safety Problems

- Eye Injuries:
  - Watching flames through hatches
  - Scrubber liquor
- Sharps & Infectious Wastes:
  - Avoid Skin contact
- Burns:
  - Contact with hot equipment
- Inhalation Hazards:
  - Fugitive leaks, high pressure scrubbers/ducts
  - Alkaline reagent storage/mixing equip Stacks or vents

119

Common Potential Safety Problems

- Weak or Slippery Walkways/Ladders
- Corroded Ductwork or Control Devices
- High Electrical Voltage, Control Cabinets
- Rotating Equipment: Fans/Fan Belts

120

121

Compliance with Permit Requirements

- Temperature (preheat and or operating)
- Type of Waste
- Charging Rate
- Hours of Operation
- Monitoring
- Recordkeeping
- Many Others

122

Air Pollution Control Points of Inspection

- Capture
- Transport
- Air Mover
- Instrumentation
- Control
- Subsystem

123

Capture

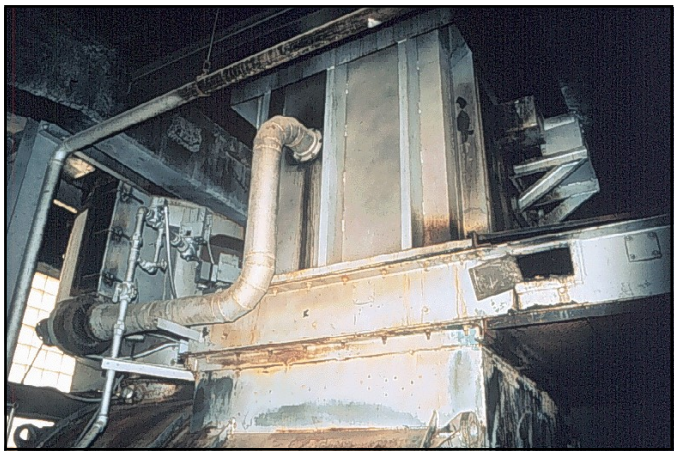
- Are Emissions immediately Drawn into a control Device?
- Collection device
  - Hoods

124

Transport

- Are Emissions Moved to the Control Device Without Loss
- Are There any Leaks

125



126

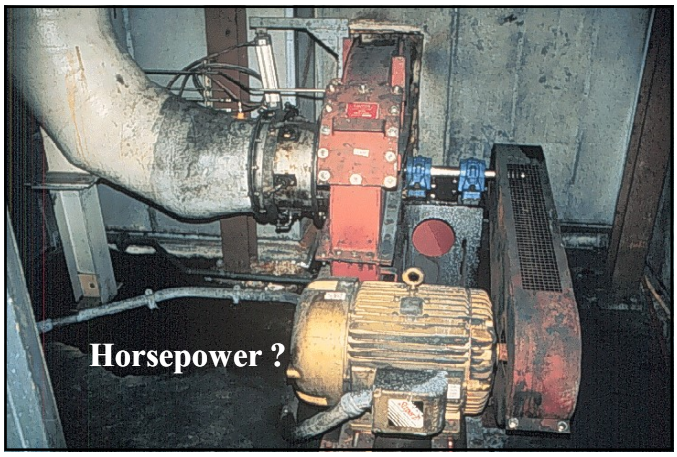
127

128

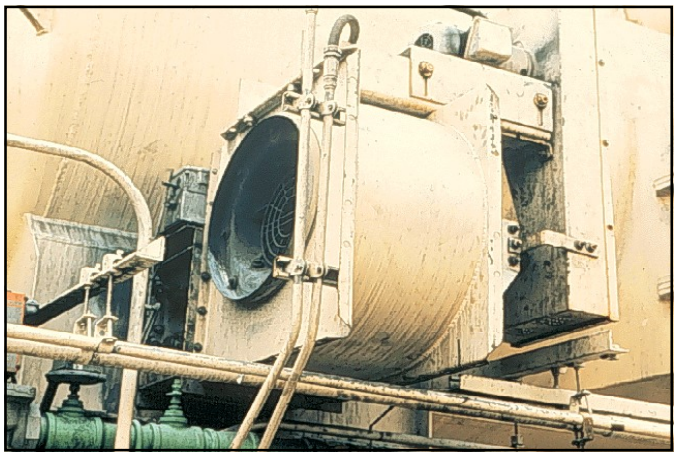
Air Mover

- Is the fan big enough for the Job?
- Is it Operating as Designed and Permitted?

129



130



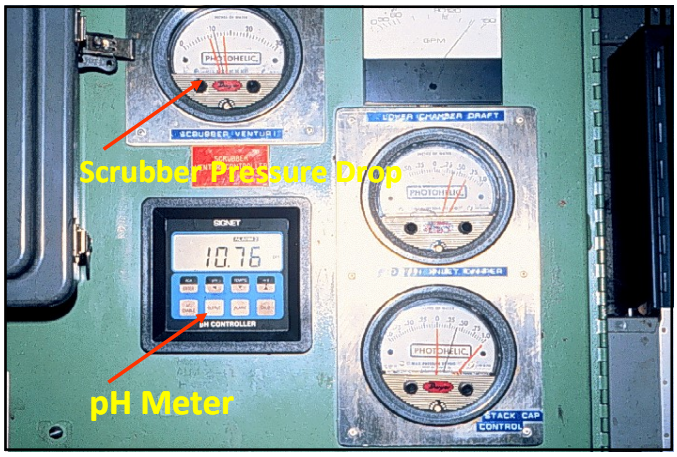
131

Instrumentation

- Are the proper instruments present?
- Do these instruments appear to be functioning?
- Are the instruments showing the appropriate units?

132

NACT



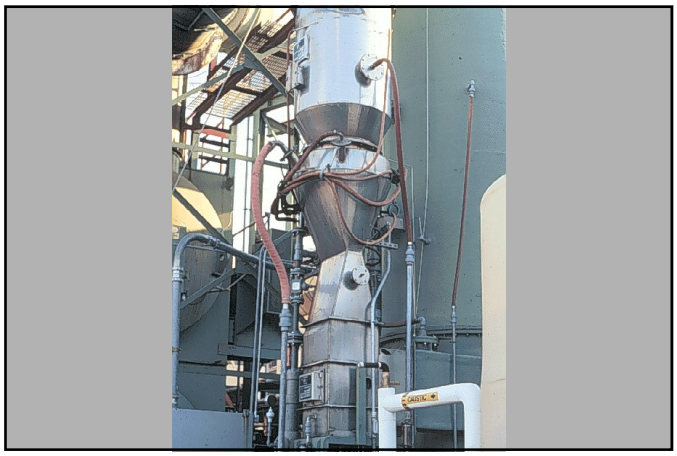
133

134

Control Device

- Is it On?
- Visible Emissions?

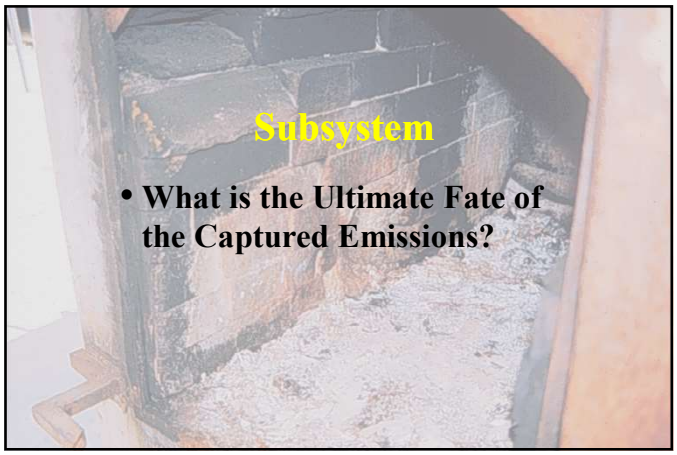
135



136

HCT

137


Subsystem
• What is the Ultimate Fate of the Captured Emissions?

138

139

What about Violations?

- Notice To Comply (NTC)
  - Minor Deficiency
  - Non-Emissions Related
  - Non-Recurring

140

What about Violations?

- Notice Of Violation (NOV)
  - Emissions Related
  - Same Problem At Last Inspection

141

Four Options After A NOV

- Continue to Operate in Violation
- Cease the Non-compliant Activity (shut down the operation)
- Correct the Problem
- Apply for a Variance

142