“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

Combustion Efficiency

3 T's

- Time (of residence)
- Temperature
- Turbulence
Combustion

- Stoichiometric Combustion
- Excess Air Combustion
- Substoichiometric Combustion

IIA Waste Classification

TYPES 0 - 8

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

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
Single Chamber Incinerator

Controlled-Air Incinerator with Staged Hearth and Automatic Ash Removal

To Stack or Boiler

Secondary Chamber

Secondary Burner

Primary Burner

Feed Ram

Ash Transfer Rams

Ash Chute

Ash Discharge Ram

Ash Sump

Ash Quench

Stack

Combustion Chamber

Refactory

Waste

Grate

Ash Pit

Overfire Air Ports

Charge Door

Auxiliary Fuel

Underfire Air Ports

Ash Removal Door

Ash Pit

Stack

Combustion Chamber

Refactory

Waste

Grate

Ash Pit

Overfire Air Ports

Charge Door

Auxiliary Fuel

Underfire Air Ports

Ash Removal Door
AFTERBURNER

VOC WASTE STREAM

EXHAUST

AUXILIARY FUEL

AIR

REFRACTORY

In-line Multiple-Chamber Incinerator (Excess-Air)

Location of Secondary Burner

Mixing Chamber

Clean Out Doors

Grates

Curtain Wall Port

Secondary Combustion Chamber

Secondary Air Port

Flame Port

Ignition Chamber

Charging Door

Cleanout Doors

Curtain Wall
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
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
Modes of Operation

WASTE CHARGING:
- Batch
- Intermittent
- Continuous

ASH REMOVAL:
- Manual
- Automatic
Typical Incinerator Operating Procedures

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

Before Incinerator Start-up

• Manual Ash Removal
• Automatic Ash Removal
• Routine Daily Inspection
• Burner & Blower Check
Typical Incinerator Operating Procedures

<table>
<thead>
<tr>
<th>Operating Step</th>
<th>Typical Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ash Cleanout</td>
<td>15 to 30 minutes</td>
</tr>
<tr>
<td>2. Pre-Heat</td>
<td>15 to 60 minutes</td>
</tr>
<tr>
<td>3. Charging &amp; Burning</td>
<td>Up to 14 hours</td>
</tr>
<tr>
<td>4. Burndown</td>
<td>2 to 4 hours</td>
</tr>
<tr>
<td>5. Cool down</td>
<td>5 to 8 hours</td>
</tr>
</tbody>
</table>

Incinerator Operation

- Waste Logging
- Pre-Heating
- Charging

Shutdown

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

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

Incinerator Emissions & Control

Emissions

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

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

Incinerator Emissions Control

• Source Separation
• Combustion Control
• Flue Gas Controls
  • (APC equipment)

Particulate Matter Formation

• Suspension of Inorganic Substances
• Incomplete Combustion of Fuel Materials
• Condensation of Vaporous Metals
**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

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"POSITIVE" CONDITION - SMOKE LEAKING

- Malfunction in Stack Damper or Fan
- Adjust Ash Ram Discharge Cycle
- Too Much Underfire Primary Air
- Burner Overfired
- Temp. Too High

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BLACK SMOKE

(Incomplete Burning - Soot Formation)

- Too Much Highly Volatile Waste
- Burner Failure, Temperature too Low
- Not Enough Secondary Air
- Poor Mixing
- Too Much Underfire Air
**Carbon Monoxide Formation**

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

## 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

### Wet Scrubber Acid Gas Removal

- Sodium Hydroxide (NaOH - Caustic Soda) or Sodium Carbonate (Na$_2$CO$_3$)
- Alkali Added to Re-circulation Tank Water (pH of 8-9).
Common Spray Tower Scrubber Problems

- Liquor Spray Nozzles Plugged
- Erosion of Spray Nozzles
- Corrosion of Shell
- Mist Re-entrainment
- pH too low or high
Countercurrent-Flow Packed-Bed Scrubber

Liquor inlet

Packed-Bed Operating Problems

• Accumulation of Solids
• Settling of Packing Material
• Liquor pH (between 5.5-10)
SPRAY VENTURI WITH RECTANGULAR THROAT

Particle Behavior in Venturi-Scrubber Section

- Flue-Gas Inlet from Quench
- Converging Region
- Particles Accelerate
- Particles collide with droplets
- Droplets have no axial velocity
- Throat
- Spray Nozzle
- Particles Decelerate
- Droplets Accelerate
- Diverging Region
- Flue-Gas Outlet to Separator Tower Section

Exhaust Gas Flow

Liquor Flow
State and Local Regulatory Requirements

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

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

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
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

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

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
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

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

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
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

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

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
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

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

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
Hazardous Waste Incinerators

- 40 CFR 63 Subpart EEE

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, CI 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

Incinerator Inspection
Inspector Safety Equipment

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

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

Common Potential Safety Problems

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

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

Air Pollution Control Points of Inspection

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

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

Transport

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

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

• Are the proper instruments present?
• Do these instruments appear to be functioning?
• Are the instruments showing the appropriate units?
Control Device

- Is it On?
- Visible Emissions?
Subsystem

* What is the Ultimate Fate of the Captured Emissions?
What about Violations?

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

What about Violations?

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