**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

**INCIERATION**

- Time (of residence)
- Temperature
- Turbulence

**Combustion Efficiency**

- 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
Controlled Air Incinerator
Components

- Stack
- Secondary Chamber
- View Port
- Secondary Burner
- View Port
- Ash Removal Door
- Primary Chamber
- Primary Burner
- Mechanical Charge System
- Secondary Combustion Air Blower
- Control Panel
- Primary Combustion Air Burner Blower
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. Cooldown</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

"POSITIVE" CONDITION - SMOKE LEAKING

BLACK SMOKE
(Incomplete Burning - Soot Formation)
**WHITE/BLUE SMOKE**

- Secondary Chamber Temperature Too Low
- Too Much Secondary Air
- Too Much Underfire Air
- Problem Waste Material

**Visible Fly Ash**

- Air Infiltration
- Problem Wastes
- Excessive Underfire Air
- High Draft Too High
- Flame Port Air
- High Primary Temperature

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**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 (Na₂CO₃)
- Alkali Added to Re-circulation Tank Water (pH of 8-9).
Liquid Sprays
Clean Exhaust Gas

Spray Tower, Countercurrent-Flow Type

Dirty Flue Gas
Water Drain

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

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

Exhaust Gas Flow
Liquor Flow
Regulations
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, 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

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 vent

**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?
NACT

Control Device

- Is it On?
- Visible Emissions?
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