Air Pollution Control Devices - continued

CE 326 Principles of Environmental Engineering
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Air Pollution Control Devices

A b s o r p t i o n tower
B a g h o u s e
C y c l o n e Separator
A d s o r p t i o n Bed
E l e c t r o s t a t i c precipitator
V e n t u r i scrubber
Electrostatic Precipitator

- Wire in tube or wire and plate configurations
- Wet or dry, wet cleaned by water spray, dry by rapping, can be cleaned while in service
- Charging wire imparts an electrical charge (neg), particles are attracted to charged (pos) collecting plates
- High particulate removal efficiencies possible
Figure 9. Conventional Electrostatic Precipitator

**Electrostatic precipitator**
- Transformer-Rectifier Sets
- Rappers
- Collection Plates
- Flue Gas In
- Flue Gas Out
- Discharge Electrodes
- Hoppers
- Clean Gas Out
- Rapper for collecting surfaces
- high-voltage transformer/rectifier access panel
- rapper for discharge electrodes
- insulated high-voltage wire support
- grounded collecting surface (collection electrode)
- inspection door
- perforated airflow-distribution baffle
- high-voltage discharge electrode
- clean air
- wire weight
- collection hopper

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Venturi Scrubber

- velocity of gas is accelerated by a factor of four in the throat section where nozzles inject water or solution
- high velocity causes atomization of liquid
- pressure drop following the throat section creates a lot of turbulence resulting in good intermixing
- requires separator (e.g., cyclone) following venturi to collect particles and liquid
Thermal Incineration

VOC's, haz wastes, CO, odor

An Inside Look at the Compact UNITHERM

1. The UNITHERM's Energy Recovery Chambers contain shop-installed ceramic stoneware that captures and recycles heat energy.

2. Final combustion of pollutants takes place in the Main Purification Chamber. The housing is fully insulated and capable of withstanding continuously high operating temperatures and acid compounds.

3. The main purification and energy recovery chambers are lined with modular ceramic Refractory Insulation, which is shop-installed by REECO. Stainless steel anchoring attaches the insulation to the base.

4. REECO's high quality Burners are equipped with IRI- or FM-approved fuel train components, independent combustion blowers, and safety controls. A sight port and UV-type scanner are provided for each burner for an unobstructed view of the main flame and pilot.

5. The Inlet Manifold and Plenum area utilizes a unique crossover design whereby process gas enters the recovery chamber from both sides of the chamber. This allows for more efficient use of the stoneware media and the elimination of the metal support grid typical of most incinerators.

6. Our proprietary cast iron Valves utilize an integral step seat design to ensure minimal leakage. Since there are no O-ring seals or fabricated seats to replace, they require little or no maintenance. The tight-seated design, especially when combined with the valve sealing feature, offers unsurpassed efficiency and leakage control. The REECO patented valve sealing feature eliminates valve leakage at the seat with pressurized air. We give particular attention to the critical operation of valve seating. Close quality control of all components associated with our valve installation ensures long valve life and

7. The Chamber Flushing Duct increases the destruction efficiency of the system. This feature captures and destroys all amounts of solvent laden air (commonly referred to as "slug volume") that can be trapped in the transition manifold at the bottom of the heat recovery chambers. This feature purges the system clean air as the UNITHERM cycles between inlet and outlet modes.

8. A Variable Frequency Drive (VFD) keeps operating costs in check during process fluctuations by varying the speed of the exhaust blower as needed.
Air Pollution Control Devices: Mobile Sources
Automotive Emissions

Mobile sources contribute approximately 60% of total air pollution (78% of CO, 47% of NO\textsubscript{X}, 44% of total hydrocarbons, 5% of particulates, and 2% of SO\textsubscript{X}).

20 to 40% of the automobile's total hydrocarbon emissions are from the crankcase. This emission is called blowby.

- function of speed
- after 1963 all vehicles are required to have a positive crankcase ventilation (PCV) valve
- the PCV valve opens up more at higher speeds to allow more crankcase fumes to be sucked into the intake manifold.
Fuel tank evaporation

As the fuel tank warms, the vapors in the headspace are exhausted through the vent line.
- activated carbon canister
- vent the fuel tank to the crankcase
Carburetor Losses

After the engine is shut off, the gas in the float valve evaporates to the atmosphere.

This is called hot soak:
- activated carbon canister
- vent to the crankcase
Engine Exhaust.

**Engine** modifications → Air/Fuel Ratio

**Fuel** system modifications → type of fuel

**Exhaust** system modifications:
- catalytic converter for NO\textsubscript{X} and HC control
- platinum-rhodium or platinum-palladium catalyst - requires temp of 350°C (660°F)

\[
\text{NO} + \text{CO} + \text{HC} \rightarrow \text{N}_2 + \text{CO}_2 + \text{H}_2\text{O}
\]
Diagnosing a Damaged Converter

Shell or Air Tube Damage

1. Scratched or Dented Shell
2. Cracked Neck or Shell
3. Broken Air Tube

Check for:
1. Physical Damage - Installation Errors, Metal Fatigue, Low Hanging Exhaust System, Broken Hanger, Brackets, Engine Mounts, Transmission Mounts, Manifold Studs, Spring Bolts, Poor Manufacturing or Inferior Materials
3. Excessive Heat - Diverter Valve, Air Injection System, Vehicle or Trailer Overload, Exhaust System Restrictions
4. Mechanical/Electrical Failures - Head Gasket, Intake Gasket, Oil in Exhaust or Fuel, Transmission Modular Failure, Piston Rings, Valve Guides, Air Injection Tube
5. Fuel Contamination - Non-Sensor-Safe Gas Additives, Non-Sensor-Safe RTV used in engine repairs, Anti-Freeze, Poor Quality Gasoline, Fuels with High Sulfur Content

Shell Discoloration

2345 Overall Shell Discoloration
2345 Shell Discoloration at Outlet (with Air)

Substrate Damage

64 Carbon Deposits
245 Clogged
12345 Cracked/Broken
12345 Melted/Disintegrated
1990 Clean Air Act Amendments had two performance targets for reformulated gasoline:

- 15% reduction in VOCs
- 15% reduction in air toxics (e.g., benzene)
Reformulated Gasoline

- one third of U.S. uses reformulated gasoline
- Congress mandated that reformulated fuel contains 2% oxygenates
Federal Reformulated Gasoline Areas

April, 2002

The following California counties will become part of the Federal RFG program as of 12/1/02:
San Joaquin, Kern, Fresno, Kings, Madera, Merced, Stanislaus & Tulare
Common Oxygenates

- **ME**thanol
- **EE**thanol – fermented from **corn**
- MTBE (methyl tertiary butyl ether) derived from natural gas and **coal**
- ETBE (ethyl tertiary butyl ether) derived from _______
Announcements

If you missed part of last week’s field trip, the video from last year is posted on the course website.

First exam is scheduled for 2/13/09

Lab class this week will be in the lab classroom (230 TEB section 1 and 250 TEB section 2)

Tuesday, Feb 10 @ 7 pm in 280 TEB?
Atmospheric Engine

- atmospheric stability (and weather) is a function of temperature and pressure
- wind flows from high pressure areas to low pressure areas
- in absence of earth’s rotation, wind would be perpendicular to constant pressure lines (i.e., isobaric)
- earth’s rotation creates Coriolis effect
Atmospheric stability

tendency of atmosphere to **resist** or **enhance** vertical air movement is termed **stability**

there are three categories of stability depending on the **lapse rate**
- rate of temperature change as a function of elevation
  - neutral - **dry adiabatic lapse rate**
  - unstable - **superadiabatic lapse rate**
  - stable - **subadiabatic lapse rate**
    - isothermal - no change in temperature with elevation
    - inversion - temperature increases with elevation
Atmospheric stability

Looping

Coning

Fanning

Lofting

Fumigation
Terrain Effects

Heat Island Effect

- mass of material that absorbs and emits heat at a greater rate than surrounding area
- stability over heat islands is less
  - good for ground level sources
  - bad for tall stack
Land/Sea Breeze

land c_____ more rapidly at night than sea
- land_____ breeze

land h_____ faster during day
- sea_____ breeze
Valleys

- valleys at an angle to the prevailing wind will direct a portion of wind into the valley
- valleys oriented in the north-south direction are more susceptible to inversions than east-west direction
- during daytime sun heats valley floor
  - valley breeze
- during night
  - hill breeze
- early day
  - inversion possible
How do we predict the dispersion of air pollutants?

- stack height
- prevailing winds
- terrain
- temperature (air)
- temperature (stack gas)
- elevation (pressure)
- emission rate - how much of the pollutant are we emitting
- atmospheric stability