Welcome

APTI 452
Principles and Practices of
Air Pollution Control

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Instructors/Facilitators

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Administrative

- Facilities
  - Rest Rooms
- Schedule/breaks
- Cell Phones
- Lunch
- Sign-In Sheet

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Administrative

To receive credit for the class you must:

1) Sign in every day
2) Take the pre test
3) Take the final exam

4

Materials

- **Registration Form**
- **Notebooks/Agenda**
- **Evaluation form - online**

5

Ground Rules

- **Ask questions**
- **Participate**
- **Provide the benefit of your experience**
- **Be on Time**
- **Feedback on Evaluations**

6

Audience Profile

1. Agency
2. No. of Years/Months/Days
3. Work unit (permitting, enforcement)
4. No. of Inspections Yearly

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Pre - Test

Make sure your name is legible

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Overview of Air Quality Management

The Heart of the Process

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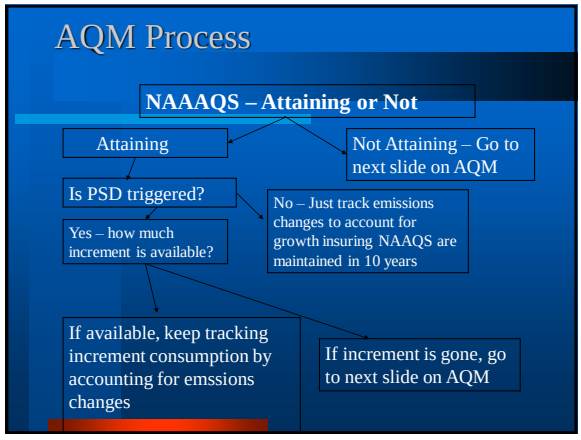
AQM Process
NAAAQS – Attaining or Not
Attaining
Not Attaining – Go to next slide on AQM
Is PSD triggered?
No – Just track emissions changes to account for growth insuring NAAQS are maintained in 10 years
Yes – how much increment is available?
If available, keep tracking increment consumption by accounting for emssions changes
If increment is gone, go to next slide on AQM

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U.S. Air Quality Management Process
National
AQ
Standards &
Goals
AQ Monitoring
Emission Inventories
AQ Modeling
FEEDBACK
FEEDBACK
Stationary & Area Sources
AQ & GHG Co-Control Strategies
Mobile Sources
Regulations & Implementation
Continued Air Quality Measurement
Health & Environmental Assessment
Compliance and Enforcement

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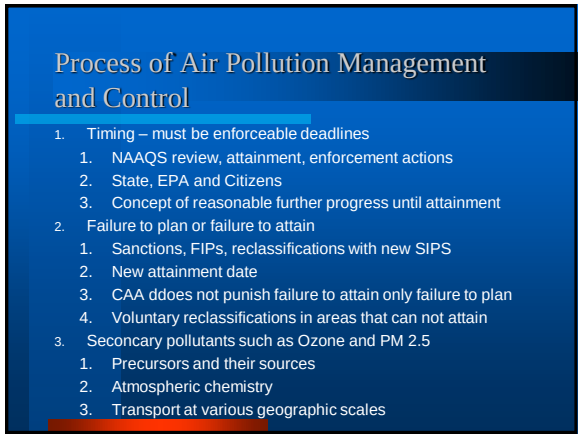
Process of Air Pollution Management and Control
1. Timing – must be enforceable deadlines
1. NAAQS review, attainment, enforcement actions
2. State, EPA and Citizens
3. Concept of reasonable further progress until attainment
2. Failure to plan or failure to attain
1. Sanctions, FIPs, reclassifications with new SIPS
2. New attainment date
3. CAA ddoes not punish failure to attain only failure to plan
4. Voluntary reclassifications in areas that can not attain
3. Seconcary pollutants such as Ozone and PM 2.5
1. Precursors and their sources
2. Atmospheric chemistry
3. Transport at various geographic scales

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Process of Air Pollution Management and Control Continued

4. Enforcement including Inspection
   1. Determination of a violation of an emission limit or work practice
   2. Notice of violation
   3. Remedies including tickets, consent decrees – how long is this process
   4. Sources of evidence – credible evidence, CEMs and record keeping
5. Mobile source program
   1. Estimating emissions for this sector
   2. Effect of FMVCP
   3. In-use testing of autos and trucks
   4. Alternative fuels, reformulated gasoline and sulfur content

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Process of Air Pollution Management and Control Continued

6. Technology Front
   1. Catalyst poisoning
   2. Control equipment maintenance
   3. Co-control from other programs including MACT, Residual risk and acid rain
   4. GHGs and any other regulatory program affecting emission of criteria pollutants
7. Increments concept including overview of baselines and triggers, increment tracking and consumption
8. Control strategy Development including concepts of reasonable available control technologies, economic feasibility and societal factors

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Federal-Regional-State Roles

FEDERAL

- **National standards, rules, and enforcement**
- **Consistency of policies and programs**
- **Technical guidance**
- **Reports on progress in reducing air pollution**
- **Ultimate authority & accountability**

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Federal-Regional-State Roles

REGIONAL

- Conduct assessment and characterization
- Help develop multi-state strategies and trading programs
- Regional planning/coordination for implementation of national programs

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Federal-Regional-State Roles

STATE

- State rules
- Source Permits
- Compliance & enforcement
- Implementation Plans
- Implement national rules & guidance
- Monitoring, modeling, emission inventories

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EPA Establishes NAAQs

	Primary Standard	Secondary Standard
Carbon Monoxide	9 ppm/10 mg/m3 (1 hr) 35 ppm/40 mg/m3 (8 hr)	None
Lead	0.5 ug/m3 (quarterly)	Same as primary
Nitrogen dioxide	0.053 ppm/100 ug/m3 (annual) 100 ppm (1 hr)	Same as primary
PM10	150 ug/m3 (24 hr)	Same as primary
PM2.5	12 ug/m3 (annual) 35 ug/m3 (24 hr)	15 ug/m3 (annua
Ozone	0.07 ppm (8 hr)	Same as primary
Sulfur Dioxide	75 ppm (1 hr)	0.5 ppm (3 hr)

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Some Major Issues

- Regional and international transport of air pollution
- Effective market-based approaches for reducing air pollution
- Evaluating, communicating, and reducing risk to public health from air toxics
- Multi-pollutant effects
- Multi-media approaches
- Balancing "carrot and stick" in our regulations & programs

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Citizen Involvement

- Public Participation
  - Hearings on Rules/Permits
  - Comment Periods on Proposed Rules
  - Workshops
- Administrative Review
  - Agency Review Boards
- Legal Review
  - State Courts
  - Federal Courts

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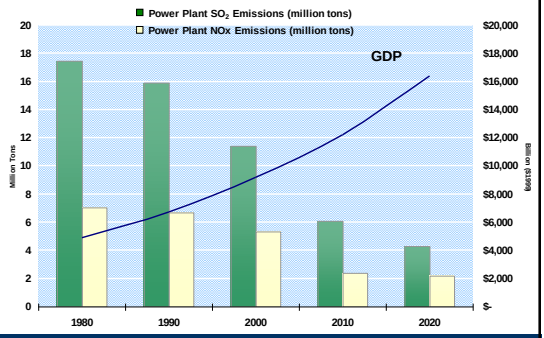
Economic Growth & Environmental Improvement



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Summary

- Air Quality Standards/Goals and Timelines are key
- Technical Tools and Information are essential
- Air Quality Management Process is iterative and adaptable
- Transparency is important to maintain credibility
- Focus on results not just process

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Principles and Practices of Air Pollution Control

Chapter 1:
Control Program History

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Chapter Overview

- Control Program History
- Air Pollution Control Programs
- Hierarchy of Government Responsibilities
- Air Pollution Management
- Future Focus of Responsibilities

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Air Pollution Control Programs

- Air Pollution Episodes
- Improvements in Science
- Changes in Society and Economy
- Environmental Activism and Public Awareness

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Air Pollution Episodes

- 1930 Meuse, Belgium, 63 people died
- 1948 Donora PA, 22 people died
- 1952 London, England, 4,000 people died
- 1953 New York City, 200 people died
- 1984 Bhopal, India 3,700-16,000
- 2008 China
- India from ? to now
- 2012- now Our Western Wildfires

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Improvements in Science

- In the 1950s, Professor A.J. Haagen-Smith showed that under ultraviolet irradiation, organic compounds and oxides of nitrogen react to produce smog
- In 1963 data indicated increased mortality with levels of high sulfur dioxide and/or smoke.
- By 1980, air pollution meteorology came of age.

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Changes in Society and Economy

- Longer Life Span
- Costs of a Higher Standard of Living

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Environmental Activism and Public Awareness

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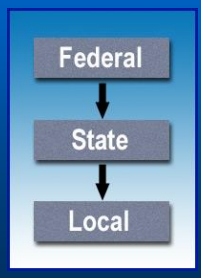
Hierarchy of Government Responsibilities



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Federal Legislative Landmarks

1955

Air Pollution Control Act of 1955

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Federal Legislative Landmarks

1955

1963

Clean Air Act of 1963

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Federal Legislative Landmarks

Motor Vehicle Air Pollution Control Act 1965

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Federal Legislative Landmarks

Air Quality Act of 1967

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Federal Legislative Landmarks

Clean Air Act Amendments of 1970

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Clean Air Act Amendments of 1970

- Goal of 90% reduction in vehicle emissions in 5 years
- National Ambient Air Quality Standards (NAAQS) and required states to produce a plans to meet NAAQS.
- National Emission Standards for Hazardous Air Pollutants (NESHAPs), to identify and regulate "hazardous air pollutants."
- Empowered EPA to establish New Source Performance Standards (NSPS) for significant sources of air pollution

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Federal Legislative Landmarks

Clean Air Act Amendments of 1977

38

Clean Air Act Amendments of 1977

- "Prevention of Significant Deterioration" (PSD) and "Nonattainment" Provisions.
- New Source Review program for construction and modification of new major sources.
- Provided a much longer and realistic time frame achieve compliance with the NAAQS.
- Strengthened auto emission standards
- Regulated chemicals that damage the stratospheric ozone layer.

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Federal Legislative Landmarks

Clean Air Act Amendments of 1990

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1990 Clean Air Act Amendments

- The air quality in several urban regions had only marginally improved.
- Overhauled the HAPs program, strengthened nonattainment provisions, and added the operating permit, acid rain and ozone depletion programs.
- Greatly expanded federal enforcement provisions; criminal penalties expanded to include felony provisions
- EPA administrative powers significantly increased via "administrative penalty orders."

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Federal Regulatory Landmarks

- 1993 Schedule to end CFC's
- 1994 New HAP standards for Chemical plants
- 1996 Lead out of Gasoline Rule
- 1999 Regional Haze Rule
- 1999 New Tailpipe Emissions Rule
- 2004 Off Road Vehicle
- 2005 Clean Air Interstate Rule

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Federal Regulatory Landmarks

2006 NAAQS For Particulates
2009 Greenhouse Gas Rule
2011 New Boiler Regs
Mercury Regs
Cross-State Air Pollution Rule
2012 Oil and Nat. Gas Rule (Fracking)
2013 Power Plant Carbon Rule
2014 New Ozone Standards (late 14)

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Air Pollution Management

- Strategies
- Implementation

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Strategies: A Comparison

Table 1-1. Comparison of Air Quality Management Strategies

Strategies	Cost	Simplicity	Enforceability	Flexibility	Adaptability
Air Quality Management	Good	Poor	Fair	Fair	Fair
Emission Standards	Terrible	Excellent	Excellent	Poor	Fair
Emission Taxes	Fair	Excellent	Excellent	Unnecessary	Good
Cost-benefit Analysis	Excellent	Terrible	Unknown	Unknown	Good

(Source: A.C. Stern, *Air Pollution* Vol. V (Academic Press: New York, 1977), p. 33.

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Implementation

- National Ambient Air Quality Standards (NAAQS)
- Air Monitoring
- Source Inventories
- Air Pollution Modeling
- Enforcement

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Future Focus of Responsibilities

- Current Situation - Control
- New Strategies - Prevention
- Other Issues

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Chapter Summary

- Control Program History
- Why Air Pollution Control Programs?
- Hierarchy of Government Responsibilities
- Air Pollution Management
- Future Focus of Responsibilities

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Review Questions

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Principles and Practices of Air Pollution Control

Chapter 2:
Human Health and Environmental Effects Of Air Pollution

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Chapter Overview

- Hazardous Effects of Air Pollutants on the Human Body Systems
- Criteria Pollutants
- Toxic Air Pollutants
- Environmental Effects of Air Pollution
- Risk Assessment

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Hazardous Effects of Air Pollutants on the Human Body Systems

- Pollutant Movement Through the Body
- Upper Respiratory System
- Lower Respiratory System

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Pollutant Movement Through the Body

- Entry Points
  - Mouth/nose
  - Skin
  - Ingestion
- Susceptible Groups
  - elderly, infants, pregnant women, and those with chronic lung or heart disease.

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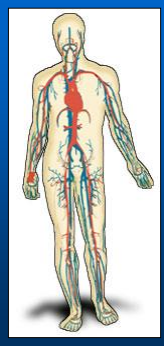
Basic Health Effects of Pollutants

- Pollutants interfere is by altering the chemical reactions that take place within individual cells.
- Manifests as either an acute (short-term) or chronic (long-term) health effect.



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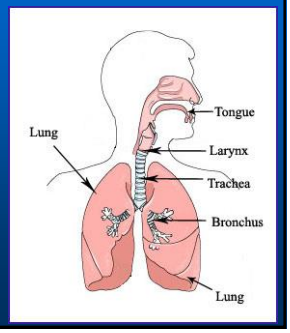
Pollutants and the Upper Respiratory System

- Entry
- Defenses
  - Cilia
  - Nasal hairs
  - Mucus membrane



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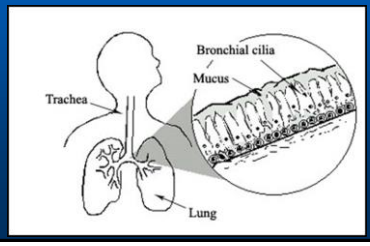
Pollutants and the Upper Respiratory System

- Smaller particles (<10 microns) can escape defense mechanisms



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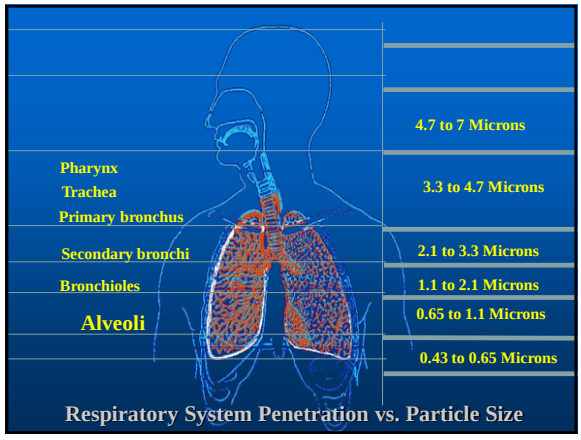

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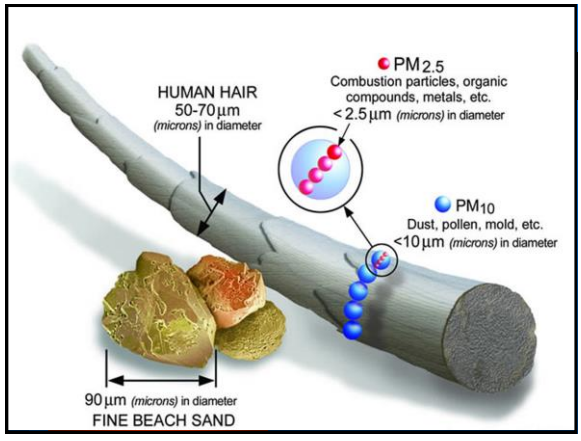

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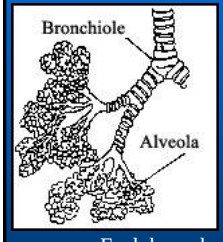
Lower Respiratory System



Each bronchus subdivides into smaller tubes called the bronchioles.
The bronchioles end in millions of tiny air sacs called alveoli.

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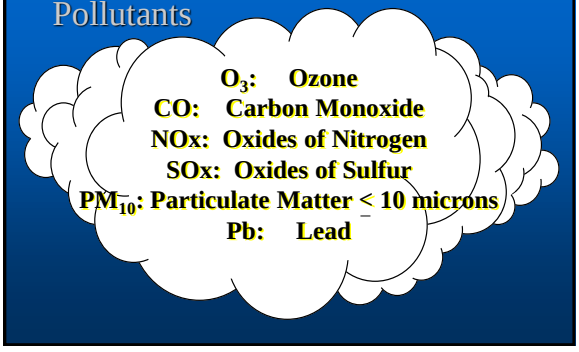
Heath Effects of Criteria Pollutants



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Criteria Pollutants

The NAAQS have “Primary” and “Secondary” categories.

Primary is based on human health and welfare

Secondary is based on property and agricultural crop dam

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Particulate Matter (PM)

- A general term used for a mixture of solid particles and liquid droplets found in the air
- Natural, mobile and industrial sources
- Impacts the respiratory system

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Lead (PB)

- Enters through ingestion and inhalation
- Bioaccumulates
- Impacts the central nervous system
- Sources are
  - Historical (leaded gasoline and paint)
  - Brakes
  - Gun ranges
  - Speedways
  - Airports

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Sulfur Dioxide (SO_2)

- Irritation and inflammation of tissue that it directly contacts.
  - Asthma
- Sources are combustion processes

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Carbon Monoxide (CO)

- Absorbed by the lungs and reacts with hemoglobin reduces the oxygen carrying capacity
- Can cause
  - Mental impairment
  - Aggravation of heart disease
  - Death
- Sources are motor vehicles, marine engines, heaters and stoves

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Nitrogen Dioxide (NO_2)

- A reddish brown, highly reactive gas that is formed in the ambient air through the oxidation of nitric oxide (NO).
- Impacts airway responsiveness and lung function
- Sources are high-temperature combustion processes

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New NASA Images Highlight U.S. Air Quality Improvement | NASA

http://www.ozonewatch.gsfc.nasa.gov

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Ozone (O3) Formation

- Reactive (non-methane) hydrocarbons and NOx accumulate in the atmosphere and are exposed to the ultraviolet component of sunlight, the formation of new compounds, including ozone.
- Absorption of ultraviolet light energy by NO2 results in its dissociation into nitric oxide and an oxygen atom. The oxygen atoms react with atmospheric molecular oxygen to form ozone.

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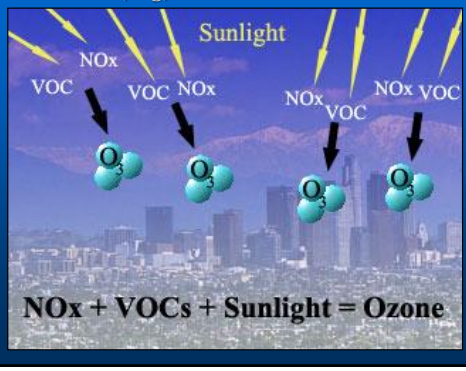
Ozone (O_3) Formation



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Ozone (O_3)

- Decreases in lung function and increased respiratory symptoms.
- At-risk groups include outdoor workers and athletes
- Ozone is formed by the reaction of VOCs and NOx in the presence of heat and sunlight.
- VOCs are emitted from motor vehicles, chemical plants, refineries, factories, and consumer products.
- Nitrogen oxides are emitted from motor vehicles, power plants, and other sources of combustion.

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Pollutant [links to historical tables of NAAQS reviews]		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide (CO)		primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb)		primary and secondary	Rolling 3 month average	0.15 μg/m³ [1]	Not to be exceeded
Nitrogen Dioxide (NO_2)		primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		primary and secondary	1 year	53 ppb [2]	Annual Mean
Ozone (O_3)		primary and secondary	8 hours	0.070 ppm [3]	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years
Particle Pollution (PM)	$PM_{2.5}$	primary	1 year	12.0 μg/m³	annual mean, averaged over 3 years
		secondary	1 year	15.0 μg/m³	annual mean, averaged over 3 years
		primary and secondary	24 hours	35 μg/m³	98th percentile, averaged over 3 years
	PM_{10}	primary and secondary	24 hours	150 μg/m³	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)		primary	1 hour	75 ppb [4]	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		secondary	3 hours	0.5 ppm	Not to be exceeded more than once per year

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Heath Effects of Criteria Pollutants

CRITERIA POLLUTANT	BODY SYSTEM	HEALTH EFFECTS	
Particulate Matter ($PM_{2.5}$ and PM_{10})	**Lower respiratory system.**	• Asthma • Bronchitis • Reduced lung function	• Cancer • Heavy metal poisoning
Lead (Pb)	**Organs and soft tissue.**	• Anemia • High blood pressure • Cancer	• Neurological disorder • Intellectual function
Carbon Monoxide (CO)	**Circulatory system.**	• CO poisoning • Angina pectoris • Neurological dysfunction	• Brain damage • Fetal abnormalities • Asphyxiation
Nitrogen Dioxide (NO_2)	**Respiratory system.**	• NO_2 poisoning • Asthma • Lowered resistance to infection	
Sulfur Dioxide (SO_2)	**Respiratory system.**	• Asthma • Bronchial constriction • SO2 poisoning	• Heart attack
Ozone (O_3)	**Respiratory system.**	• Lung inflammation • Reduced lung elasticity • Transient cough	• Chest pain • Throat irritation • Nausea

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Toxic/Hazardous Air Pollutants

- Toxic or hazardous air pollutants (HAPs) are those pollutants that may cause cancer or other serious health effects or adverse environmental and ecological effects and are not covered by NAAQs.
- There are 188 HAPs.
- NESHAPS are emission standards for HAPs.

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Toxic Air Pollutants (cont.)

- National Toxics Inventory (NTI) tries to estimate and track national emissions trends for the 188 HAPs

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Environmental Effects of Air Pollution

- Environmental Issues
- Acid Rain
- Visibility
- The Greenhouse Effect
- Stratospheric Ozone Depletion

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Environmental Issues

- Ecosystem
- Property Damage
- Quality of Life

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Acid Rain

- Nature and Source of the Problem
- Health and Environmental Effects

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Visibility

- Nature and Source of the Problem

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The Greenhouse Effect

- Nature and Source of the Problem
- Health and Environmental Effects
- International Developments

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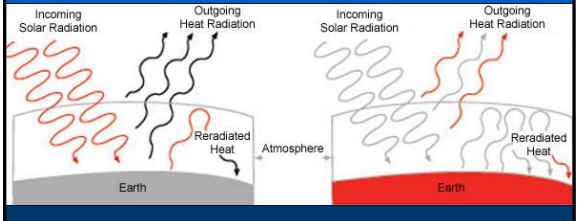
The Greenhouse Effect (cont.)



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The Greenhouse Effect (cont.)

- Climate change is likely to have wide-ranging and mostly adverse impacts on human health, with significant loss of life.

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The Greenhouse Effect (cont.)

- State of the Climate in 2016

http://www.climate.gov

- Kyoto Protocol included greenhouse gas emission targets for industrialized countries for 2008–2012.
- Paris Agreement 2015 targets a 55% reduction of ghg

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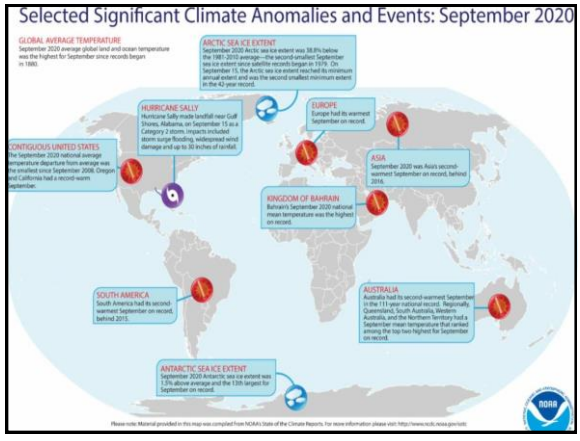
Selected Significant Climate Anomalies and Events: September 2020
GLOBAL AVERAGE TEMPERATURE
September 2020 average global land and ocean temperature was the highest for September since records began in 1880.
ARCTIC SEA ICE EXTENT
September 2020 Arctic sea ice extent was 38.8% below the 1981-2010 average—the second-smallest September sea ice extent since satellite records began in 1979. On September 15, the Arctic sea ice extent reached its minimum annual extent and was the second smallest minimum extent in the 42-year record.
HURRICANE SALLY
Hurricane Sally made landfall near Gulf Shores, Alabama, on September 15 as a Category 2 storm. Impacts included storm surge flooding, widespread wind damage and up to 30 inches of rainfall.
EUROPE
Europe had its warmest September on record.
CONTIGUOUS UNITED STATES
The September 2020 national average temperature departure from average was the smallest since September 2008. Oregon and California had a record-warm September.
ASIA
September 2020 was Asia's second-warmest September on record, behind 2016.
KINGDOM OF BAHRAIN
Bahrain's September 2020 national mean temperature was the highest on record.
SOUTH AMERICA
South America had its second-warmest September on record, behind 2015.
AUSTRALIA
Australia had its second-warmest September in the 111-year national record. Regionally, Queensland, South Australia, Western Australia, and the Northern Territory had a September mean temperature that ranked among the top two highest for September on record.
ANTARCTIC SEA ICE EXTENT
September 2020 Antarctic sea ice extent was 1.5% above average and the 13th largest for September on record.

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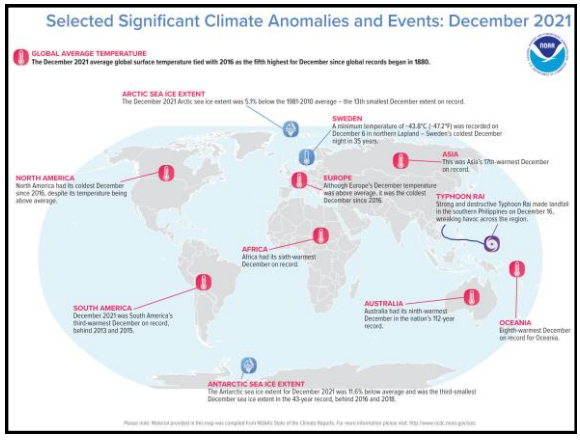
Selected Significant Climate Anomalies and Events: December 2021
GLOBAL AVERAGE TEMPERATURE
The December 2021 average global surface temperature tied with 2016 as the fifth highest for December since global records began in 1880.
ARCTIC SEA ICE EXTENT
The December 2021 Arctic sea ice extent was 5.1% below the 1981-2010 average – the 13th smallest December extent on record.
SWEDEN
A minimum temperature of -43.8°C (-47.2°F) was recorded on December 6 in northern Lapland – Sweden's coldest December night in 35 years.
ASIA
This was Asia's 17th-warmest December on record.
NORTH AMERICA
North America had its coldest December since 2016, despite its temperature being above average.
EUROPE
Although Europe's December temperature was above average, it was the coldest December since 2016.
TYPHOON RAI
Strong and destructive Typhoon Rai made landfall in the southern Philippines on December 16, wreaking havoc across the region.
AFRICA
Africa had its sixth-warmest December on record.
SOUTH AMERICA
December 2021 was South America's third-warmest December on record, behind 2013 and 2015.
AUSTRALIA
Australia had its ninth-warmest December in the nation's 112-year record.
OCEANIA
Eighth-warmest December on record for Oceania.
ANTARCTIC SEA ICE EXTENT
The Antarctic sea ice extent for December 2021 was 11.6% below average and was the third-smallest December sea ice extent in the 43-year record, behind 2016 and 2018.

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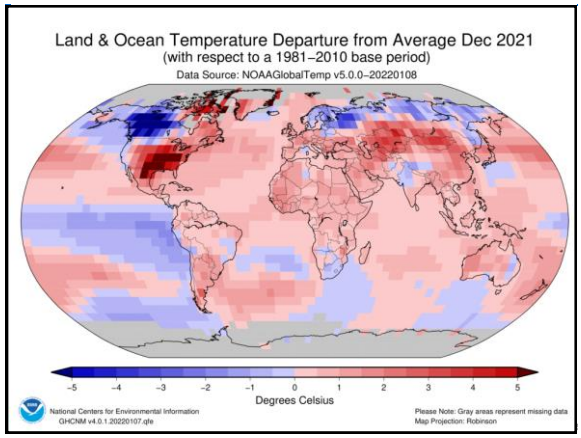

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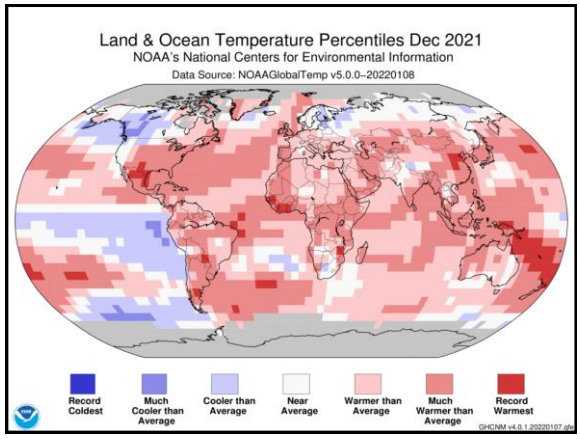

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https://www.ncei.noaa.gov/access/monitoring/monthly-report/global/202112

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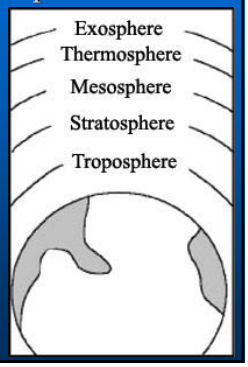
Stratospheric Ozone Depletion

- Stratosphere, 6 to 30 miles above the Earth, contains a layer of ozone gas that protects living organisms from harmful ultraviolet radiation.
- Each year, an "ozone hole" forms over the Antarctic.



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Stratospheric Ozone Depletion

- 1987 Montreal Protocol committed 170 nations to limiting the production of ozone-depleting substances.
- As a result, the hole is stabilizing and should be gone by the end of the century.

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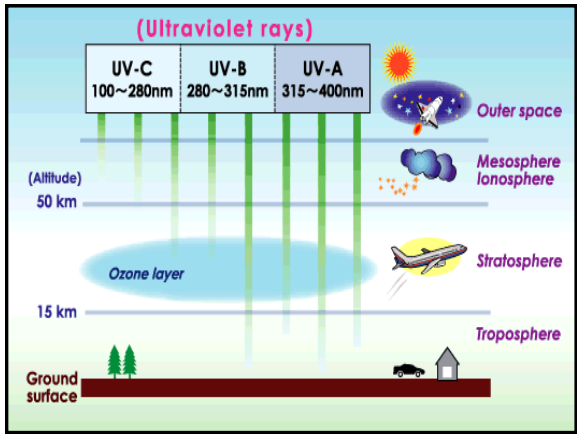

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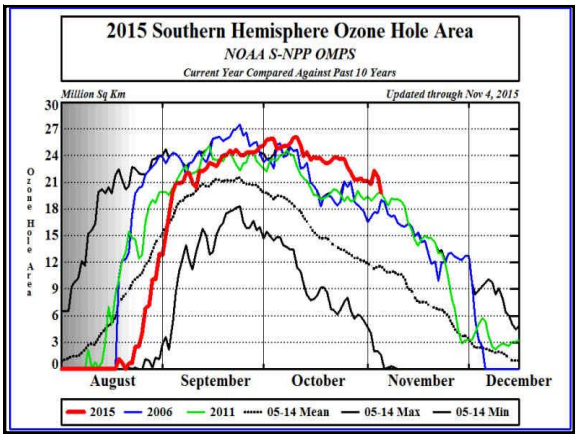

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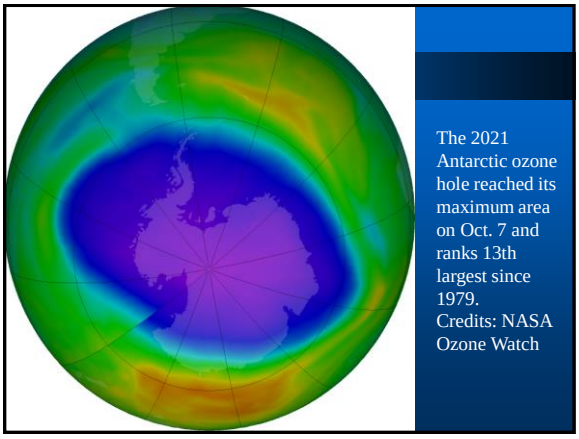
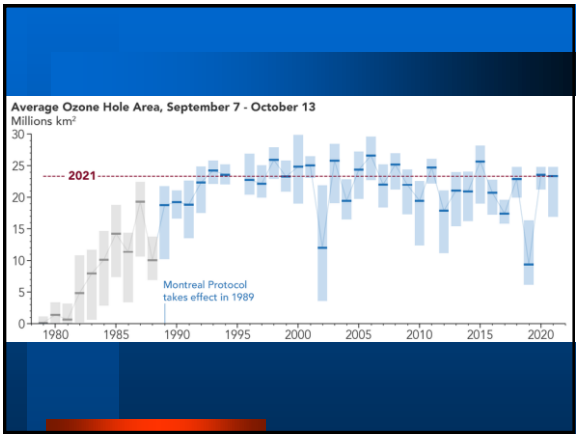


The 2021 Antarctic ozone hole reached its maximum area on Oct. 7 and ranks 13th largest since 1979.
Credits: NASA Ozone Watch

98



99

Risk Assessment

- Health risks are a measure of the chance that you will experience health problems.
- Risk management is the process the government uses to manage this health risk

100

The 4-Step Risk Assessment Process

Hazard Identification
What health problems are caused by the pollutant?

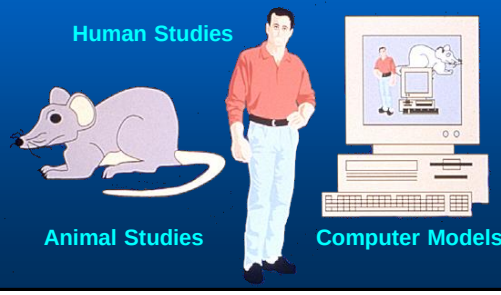
Exposure Assessment
How much of the pollutant do people inhale during a specific time period? How many people are exposed?

Dose-Response Assessment
What are the health problems at different exposures?

Risk Characterization
What is the extra risk of health problems in the exposed population?

101

Hazard Identification



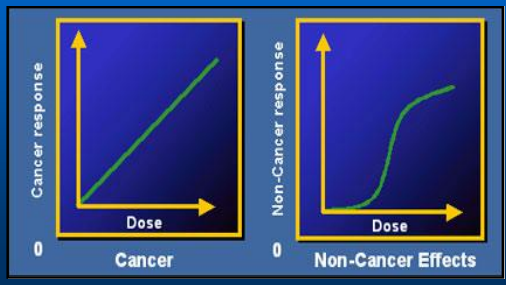
102

Exposure Assessment

- Exposure?
- Determine:
  - Sources
  - Amounts of toxins
  - Number of people
  - Pollution per person

103

Dose-Response Assessment



104

Risk Characterization: What is the extra risk to health?

Maximum Lifetime Exposure	X	Dose Relationship	=	Maximum Individual Lifetime Risk

105

Uncertainty of Risk Estimates

- Extrapolation Issues
- Inaccuracy
- Making Assumptions

106

Chapter Summary

- Hazardous Effects of Air Pollutants on the Human Body Systems
- Criteria Pollutants
- Toxic Air Pollutants
- Environmental Effects of Air Pollution
- Risk Assessment

107

Review Questions

108

APTI Course 452

Principles and Practices of Air Pollution Control

Chapter 3:
Transport and Dispersion of Air Pollution

109

Chapter Overview

- Wind Speed and Direction
- Atmospheric Stability
- Topography
- New Sources

110

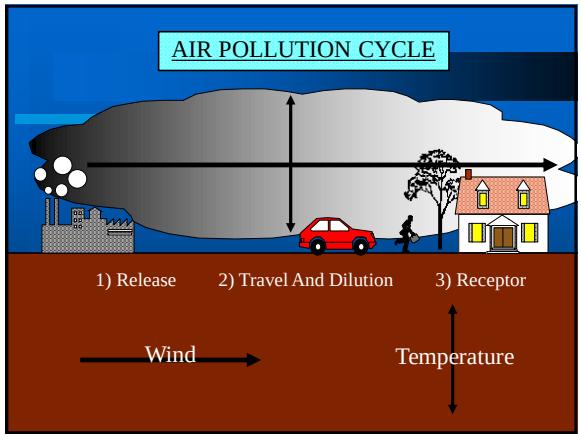
Essence of Air Pollution Meteorology

Diffusion = Expanding of Pollutant Cloud

Transport = Moving of Pollutant Cloud

111

111



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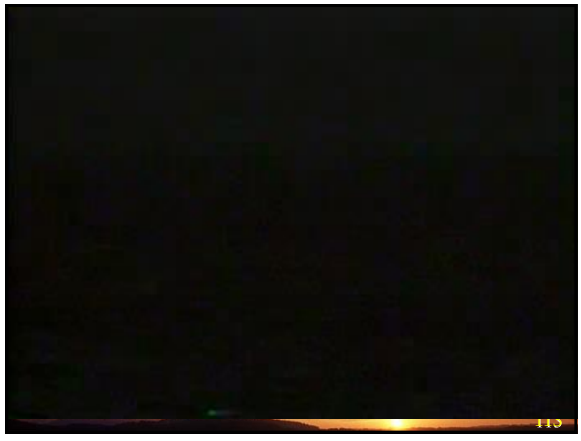
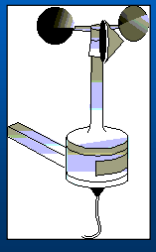


113

Wind Speed

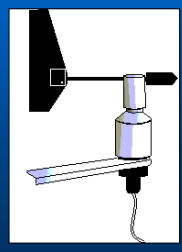
- Horizontal Motion
- Effect on Pollutant Concentration
- Measurement



114

Wind Direction

- Importance
- Tools
- Gathering Data



115

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117

Atmospheric Stability

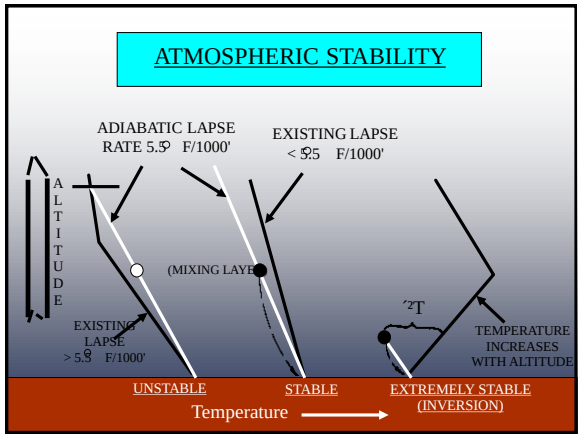
- Vertical Movement of Air
- Differential Heating
- Conduction vs. Convection
- Turbulence
  - Thermal
  - Mechanical

118

Atmospheric Stability (cont.)

- Adiabatic Lapse Rate
- Environmental Lapse Rate
- Plumes
- Plume Types

119



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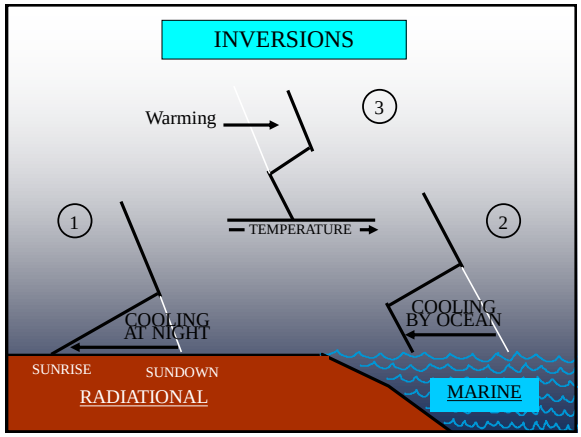

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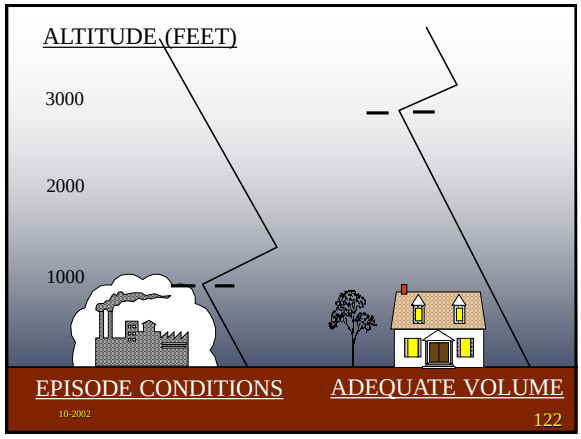
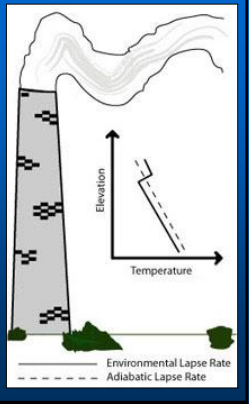


122

Looping Plumes

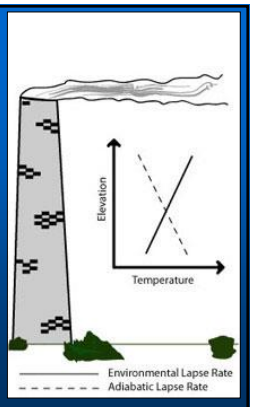
- Unstable Atmosphere
- Changing Temperature and Pressure
- Sunny Days with Wind



123

Fanning Plumes

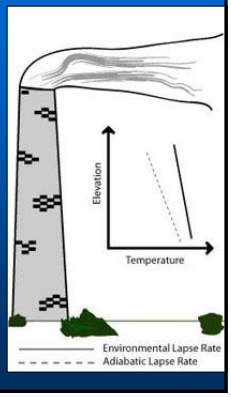
- Stable Conditions
- Wind moving horizontally
- Early Morning



124

Coning Plumes

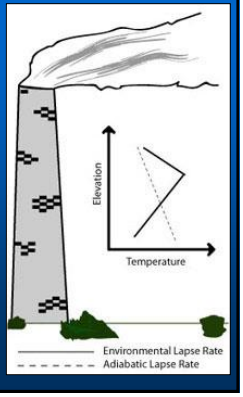
- Neutral or Slightly Unstable Conditions
- Large Billows
- Partly Cloudy Days



125

Lofting Plumes

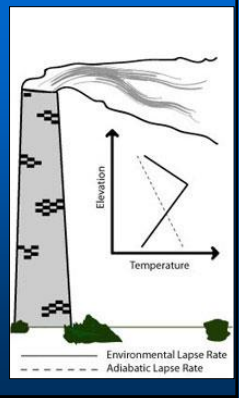
- Stable Conditions
- Above the Inversion Layer
- Smokestack Height
- Effective Dispersion



126

Fumigating Plumes

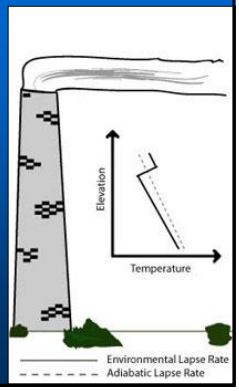
- Early Morning
- Below the Inversion Layer
- High Concentrations of Pollutants at the Surface



127

Trapping Plumes

- Clear and Sunny Days
- Inversion layer above and below
- Most Favorable Type



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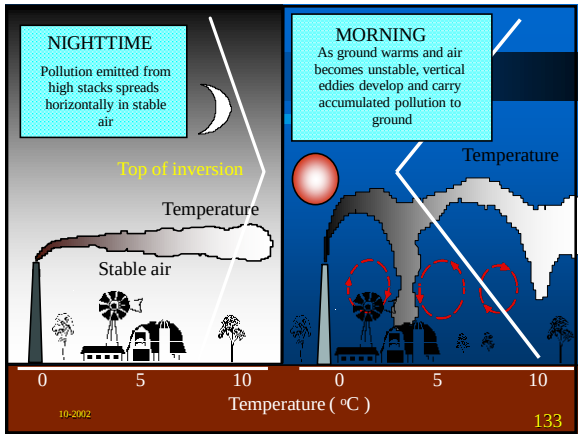
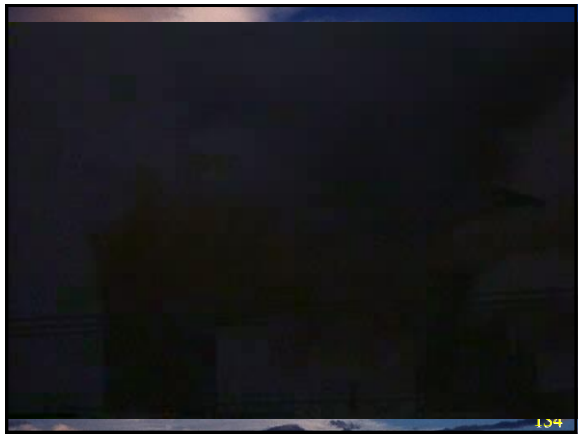

NIGHTTIME
Pollution emitted from high stacks spreads horizontally in stable air
Top of inversion
Temperature
Stable air
MORNING
As ground warms and air becomes unstable, vertical eddies develop and carry accumulated pollution to ground
Temperature
0
5
10
0
5
10
Temperature (°C)
10-2002
133

133


134

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135

135

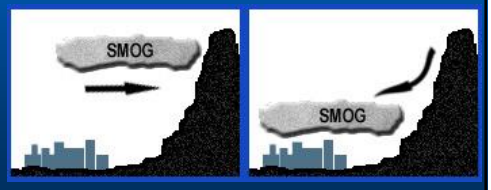
Topography

- Lakes and Oceans

136

Topography (cont.)

- Valleys
- Mountains

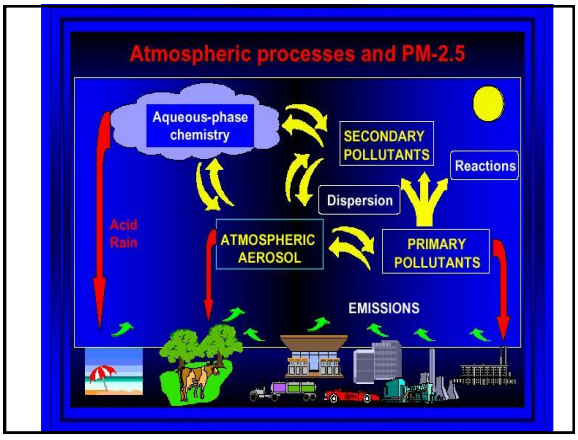


137

New Source Review (NSR)

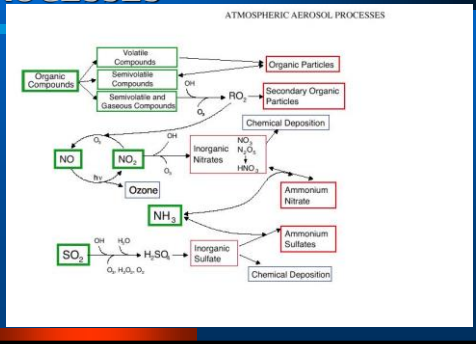
- Prevention of Significant Deterioration (PSD) uses the appropriate dispersion model to evaluate whether the proposed source will exceed its part of the allowable air increment within the sites Air Quality Management Area.
- 40 CFR Part 51 Appendix W
  - modeling

138



139

ATMOSPHERIC AEROSOL PROCESSES



140

Modeling

- Dispersion Models – use mathematical formulations to characterize the atmospheric processes that disperse a pollutant by a source
- Photochemical Models – large-scale models that simulate the changes of pollutants concentrations using mathematical equations characterizing physical and chemical processes

141

Modeling continued

- Receptor Models – mathematical and/or statistical procedures for identifying and quantifying the sources of pollutants at a receptor location
- SCRAM – Support Center for Regulatory Atmospheric Modeling
- www.epa.gov/scram/air-quality-dispersion-modeling

142

Chapter Summary

- Wind Speed and Direction
- Atmospheric Stability
- Topography
- Dispersion Modeling

143

REVIEW QUESTIONS

144

APTI Course 452

Principles and Practices of Air Pollution Control

Chapter 4:
Indoor Air Pollution

145

Chapter Overview

- Sources and Effects of Indoor Air Pollution
- Sick Building Syndrome
- Controls of Indoor Air Pollution
- EPA's Approach and Progress

146

Sources of Indoor Air Pollution

147

Levels of Indoor Pollutants

May be 25 times the outdoor level.

Many people spend 90% of their time indoors

148

Sources of Indoor Air Pollution

- Biological Contaminants
- Radon
- Environmental Tobacco Smoke
- Stoves, Heaters, Fireplaces and Chimneys
- Asbestos
- Pesticides
- Organic Chemicals
- Formaldehyde
- Lead
- Carbon Monoxide
- Nitrogen Oxide

149

Biological Contaminants

- Sources
  - Bacteria
  - Molds, mildew
  - Viruses
  - Animal dander
  - Dust mites, cockroaches
  - Pollen
  - House Dust
  - Pets
  - Poorly Maintained Air Conditioners

150

Biological Contaminants

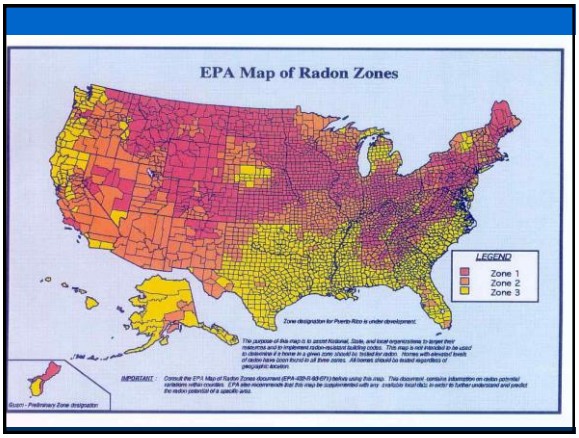
- Health Effects
  - Asthma
  - Eye, nose and throat irritation
  - Shortness of breath
  - Dizziness, lethargy
  - Fever and humidifier fever
  - Digestive problems
  - Influenza and other infections
- Ways to Reduce Exposure
  - Clean, vent, use of filters

151

Radon

- Naturally forming radioactive gas produced when uranium decays.
- Found in soil and groundwater
- Health Effects – Lung Cancer
- Ways to Reduce Exposure
  - Vents and fans

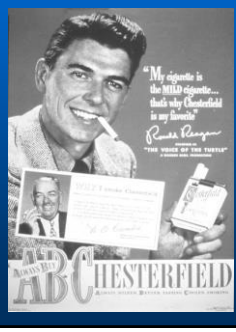
152



153

Environmental Tobacco Smoke

- A complex mixture of over 4,000 compounds, more than 40 of which are known to cause cancer in humans or animals
- Estimated there are 40,000 deaths each year in nonsmokers.



154

Stoves, Heaters, Fireplaces and Chimneys

- What is it?
- Health Effects
- Ways to Reduce Exposure

155

Asbestos

- A mineral fiber that has been commonly used in a variety of building construction materials, and brakes
- Can cause lung cancer, mesothelioma (a cancer of the chest and abdominal linings), and asbestos
- There is no danger unless fibers are released and inhaled into the lungs.

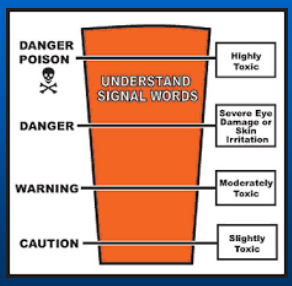
156

Asbestos

157

Pesticides

- Term includes insecticides and disinfectants
- 80 percent of most people's exposure to pesticides occurs indoors
- To reduce exposure, read the label and follow the directions



158

Organic Chemicals

- Paints, glues, solvents, cleaners, fuels
- Health effects are varied
- Reduce exposure by following the label instructions.

159

Formaldehyde

- A colorless, pungent-smelling gas that can cause watery eyes, a burning sensation in the eyes and throat, nausea, and difficulty in breathing.
- Sources include building materials, smoking, household products, and the use of unvented, fuel-burning appliances, like gas stoves or kerosene space heaters and pressed wood products.

160

Formaldehyde

- Possible health effects include increase in asthma attacks, has also been shown to cause cancer in animals.
- Ways to reduce exposure include ventilation

161

Lead

- See previous slides
- Affects the central nervous system
- Sources include old paint, soil, some types of old water pipes

162

Carbon Monoxide

- See previous slides
- To reduce exposure properly vent appliances

163

Nitrogen Oxides

- See previous slides
- To reduce exposure properly vent appliances

164

Sick Building Syndrome

- A variety of unrelated symptoms or health effects that are reported by at least twenty percent of a building's occupants.
- Estimates suggest that building-related illnesses result in direct medical costs of over $1 billion each year

165

Sick Building Syndrome

- Causes include poorly designed, maintained, or operated ventilation systems.

166

Controls of Indoor Air Pollution

- Source Control
- Ventilation
- Air Cleaners

167

EPA's Approach and Progress

- EPA Indoor Air Program
- Other Federal Agencies

168

Chapter Summary

- Sources and Effects of Indoor Air Pollution
- Sick Building Syndrome
- Controls of Indoor Air Pollution
- EPA's Approach and Progress

169

Review Questions

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APTI Course 452

Principles and Practices of Air Pollution Control

Chapter5:
Control of Stationary Sources (Particulate Matter)

171

Chapter Summary

- Introduction to Stationary Sources
- Control Procedures
- Control Devices for Particulate Emissions

172

Introduction to Stationary Sources

- Process Operations Groupings
- Air Release Emissions Points

173

Process Operations Groupings

- Process Operations
- Atmospheric Releases
- Auxiliary Losses
- Waste Emissions

174

Air Release Emissions Points

Industrial Process Operation Air Emission Points and Categories

Process Operation Reactors vents Distillation systems Vacuum systems Combustion stacks Blow molding Spray drying and booths Extrusion machines	Fugitive Sources Valves Pump seals Flanges/connectors Compressors Open ended lines Pressure relief devices Equipment cleaning/maintenance
Surface Area Sources Pond evaporation Cooling tower evaporation Wastewater treatment Land disposal	Handling, Storage, Loading Storage tank breathing losses Loading/unloading Line venting Packaging and container loading

175

Control Procedures

- Exhaust Stacks
- Plant Operations
- Control Technology

176

Exhaust Stacks

- Benefits
  - Reduce effects
  - Cheap
- Drawbacks
  - Transfer pollution to another location

177

Plant Operations

- Pre-Treating
- Cleaner Fuels
- Improved Plant Maintenance

178

Control Technology

- Exhaust Gas Characteristics
- Process or Site Characteristics
- Use of Control Devices

179

Combustion Considerations

3 T's of Combustion

- Residence *T*ime
- *T*emperature
- *T*urbulence (mixing)
- Increase 3T's = more NOx
- Decrease 3T's = more CO and uncontrolled pollutant

180

Exhaust Gas Characteristics

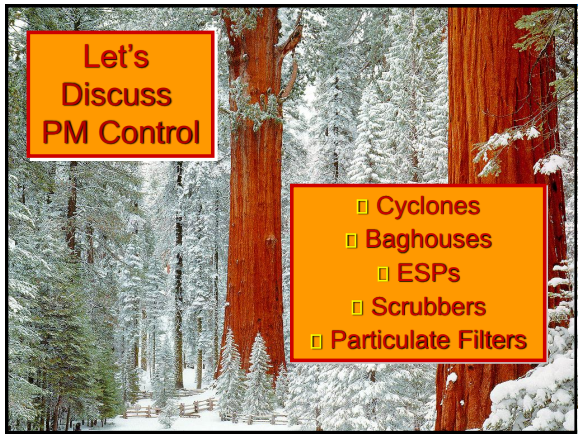
- Total Exhaust Flow Rate
- Exhaust Gas Temperature
- Required Control Efficiency
- Particle Size Distribution
- Particle Resistivity
- Composition of Emissions
- Corrosiveness of Exhaust Gas
- Moisture Content
- Stack Pressure
- Exhaust Gas Combustibility and Flammability

181

Process or Site Characteristics

- Reuse/Recycling of Collected Emissions
- Availability of Space
- Availability of Additional Electric Power
- Availability of Water
- Availability of Wastewater Treatment Facilities
- Frequency of Startup and Shutdowns
- Environmental Conditions
- Anticipated Changes in Control Regulations
- Anticipated Changes in Raw Materials
- Plant Type – Stationary or Mobile

182



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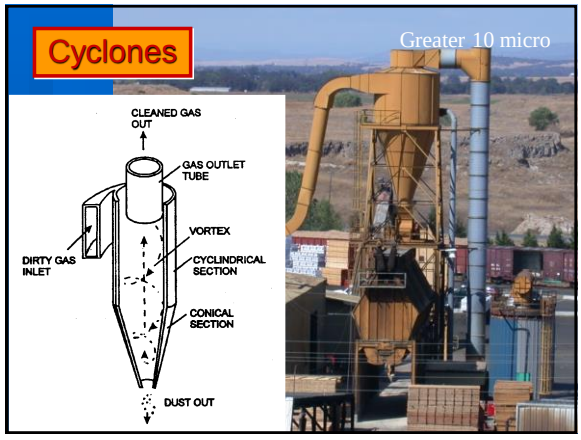
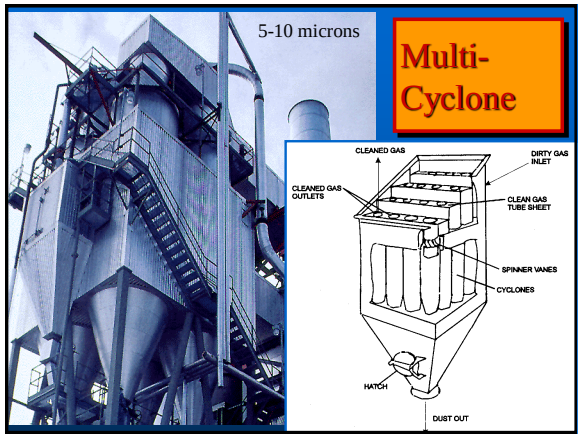

Cyclones
Greater 10 micro
CLEANED GAS OUT
GAS OUTLET TUBE
VORTEX
DIRTY GAS INLET
CYCLINDRICAL SECTION
CONICAL SECTION
DUST OUT

184

185


5-10 microns
Multi-Cyclone
CLEANED GAS
DIRTY GAS INLET
CLEANED GAS OUTLETS
CLEAN GAS TUBE SHEET
SPINNER VANES
CYCLONES
HATCH
DUST OUT

186

Cyclones: Collection Efficiency

- Typical Efficiency
  - Single cyclone: 30-95% pm10
  - Single cyclone: 0-70 pm% 2.5
  - Multiple cyclone: 80-99%
- Determining Factors for Efficiency
  - Particle size and/or density
  - Inlet duct velocity
  - Cyclone body length and design

187

Cyclones: Advantages

- Low Capital Cost
- No Moving Parts
- Few Maintenance Requirements
- Low Operating Costs
- Relatively Low Pressure Drop
- Dry Collection and Disposal
- Relatively Small Space Requirements

188

Cyclones: Disadvantages

- Relatively Low PM Collection Efficiencies
- Unable to Handle Sticky or Tacky Materials
- High Efficiency Units May Experience High Pressure Drops

189

190

191

Fabric Filters

- Method of Operation
- Cleaning
- Collection Efficiency
- Benefits / Drawbacks

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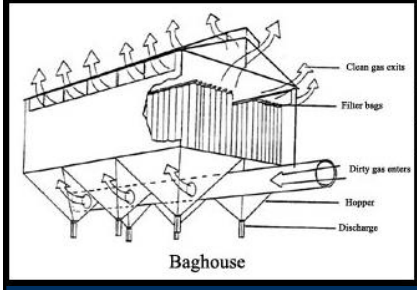
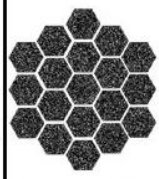
Fabric Filters: Method of Operation

- Mechanical Design



Baghouse

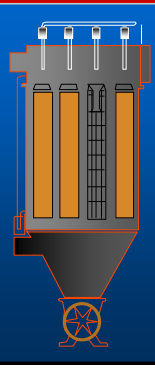


Cutaway of filter bag wall

193

Baghouse Design Considerations

- Pressure Drop
- Air-To-Cloth Ratio
- Collection Efficiency
- Fabric Type
- Cleaning
- Temperature Control
- Bag Spacing
- Compartment Design
- Space and Cost



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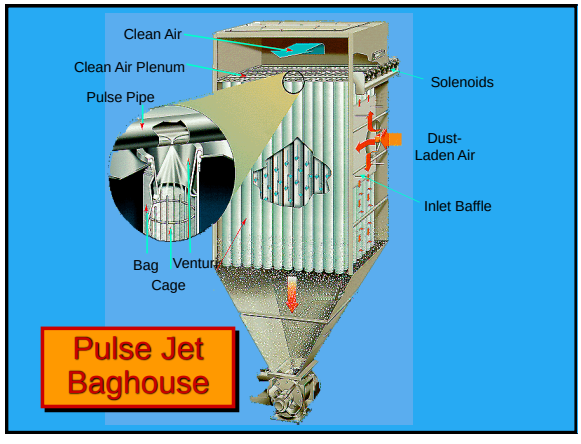
196

Fabric Filters: Cleaning

- Shaking
- Reverse-air
- Pulse-jet

197



198


Pulse Jet Baghouse

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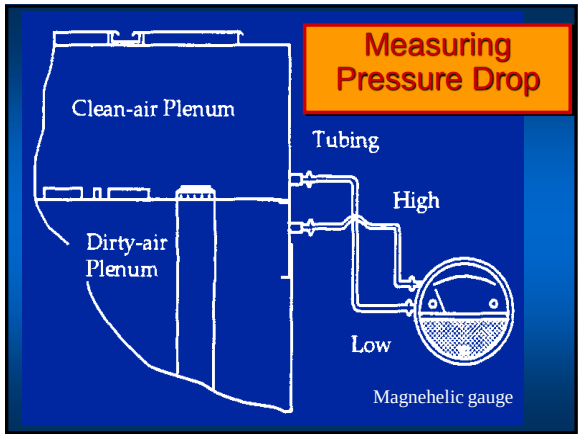
Inside a Pulse Jet Baghouse

200


Pulse Jet Bag

201



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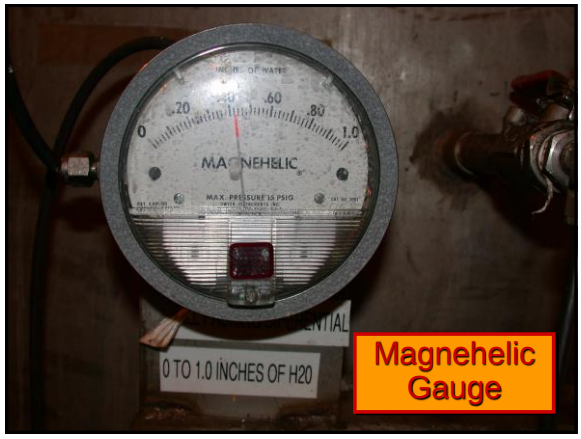

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Pulse Jet Baghouse Advantages

- Have high collection efficiency for respirable dust
- Can have high air-to-cloth ratio (6 to 10 ft/min)
- Have increased efficiency and minimal residual dust buildup due to aggressive cleaning action
- Can clean continuously
- Can use strong woven bags

204

Pulse Jet Baghouse Disadvantages

- May not be used readily in high temperatures unless special fabrics are used
-
- Cannot be used if high moisture content or humidity levels are present in the exhaust gases

205

Fabric Filters: Collection Efficiency

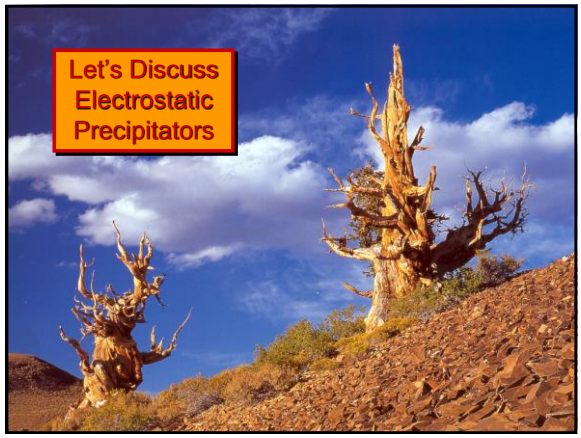
- Typical Efficiency
  - 95-99.9% (old equipment)
  - 99-99.9% (new equipment)
- Determining Factors for Efficiency
  - Gas Velocity
  - Particle characteristics
  - Fabric characteristics
  - Cleaning mechanism, intensity, frequency

206

Fabric Filters: Benefits / Drawbacks

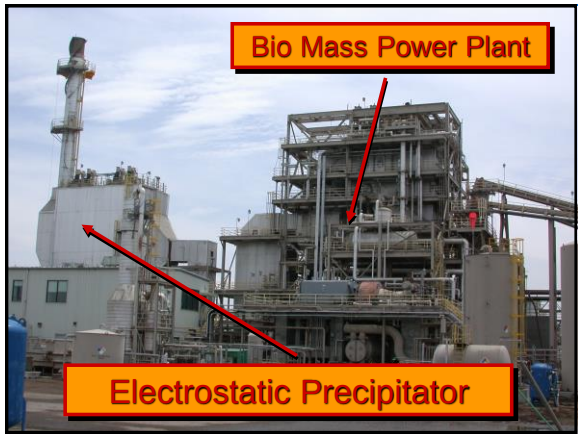
- Simplicity
- Sensitivity
- Installation
- Cleaning and Maintenance

207


Let's Discuss
Electrostatic
Precipitators

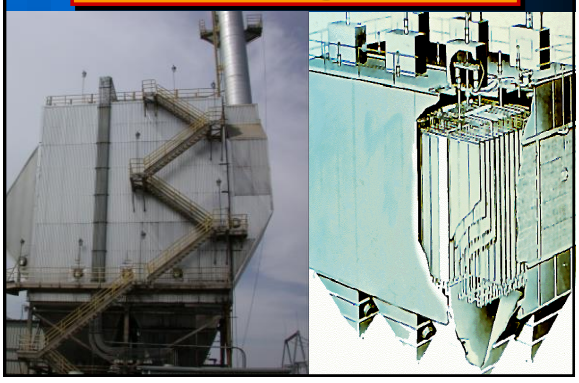
208

209


Bio Mass Power Plant
Electrostatic Precipitator

210

Electrostatic Precipitator



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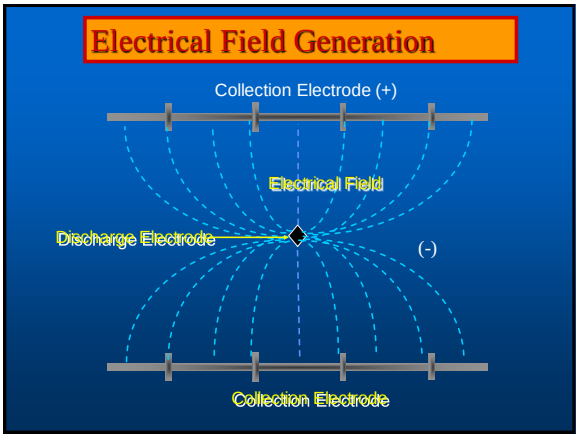
Electrical Field Generation



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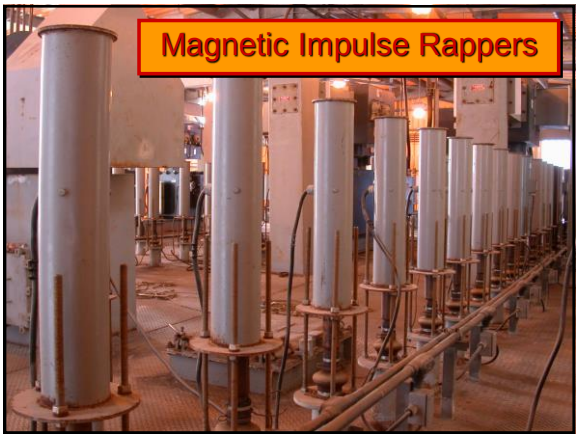
Electrostatic Precipitator

- General Description
  - Two types
    - Dry type use mechanical action to clean plates
    - Wet type use water to prequench and to rinse plates

213



214

ESPs: Design Factors Affecting Performance

- Specific Collection Area
- Aspect Ratio
- Collection Plate Spacing
- Sectionalization
- Power Requirements/Spark Rate

215

Electrostatic Precipitators: Collection Efficiency

- Typical Efficiency
  - 99% <10microns
- Determining Factors for Efficiency
  - ESP size and retention time
  - Electric field strength
  - process factors

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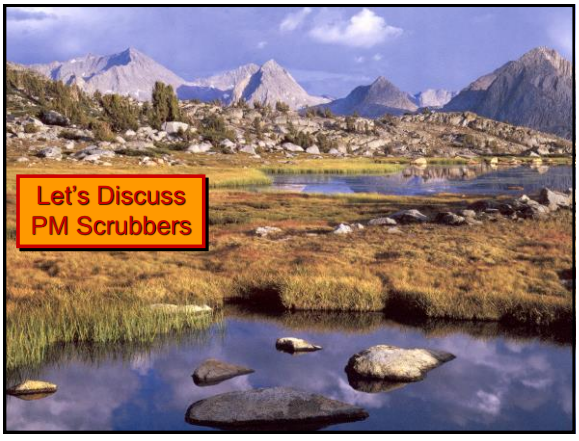
Electrostatic Precipitators: / Drawbacks

- Benefits
  - Removal efficiency
- Drawbacks
  - Cost
  - Installation
  - Operating Range
  - Treatment and Maintenance

217



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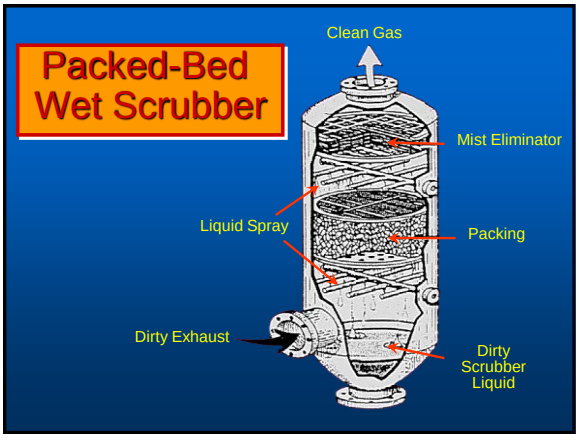

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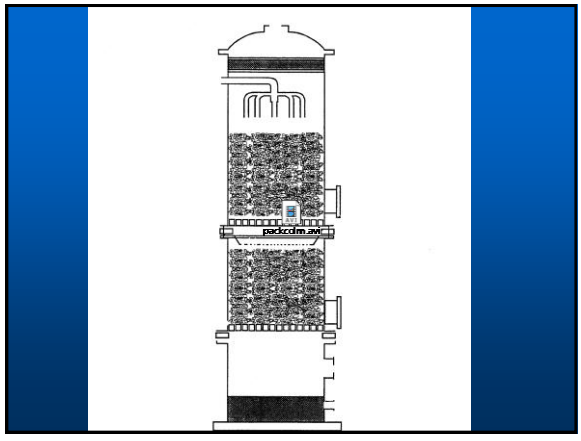
Air Pollution
Control Devices
Wet Scrubbers
for Particles

220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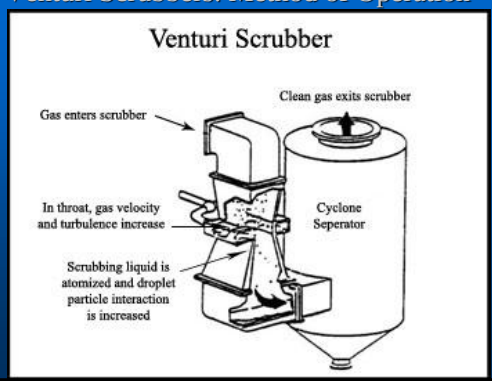
221


Packed-Bed Wet Scrubber

222

Venturi Scrubbers: Method of Operation



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Venturi Scrubbers: Collection Efficiency

- Typical Efficiency
  - 70 to 99 % removal
  - 0.5 to 5 microns
- Determining Factors for Efficiency
  - Pressure drop and energy consumption

225

Venturi Scrubbers: Advantages

- Capable of Handling Flammable and Explosive Dusts
- Can Handle Mists in Process Exhausts
- Low Maintenance
- Simple in Design and Easy to Install
- Variable Collection Efficiency
- Provides Cooling for Hot Gases
- Neutralizes Corrosive Gases and Dusts

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Venturi Scrubbers: Disadvantages

- Water Pollution
- Wet Waste Product
- High Corrosion Potential
- Requires Protection Against Freezing
- Final Exhaust Must Be Reheated
- Collected PM May be Contaminated
- Disposal of Waste Sludge is Very Expensive

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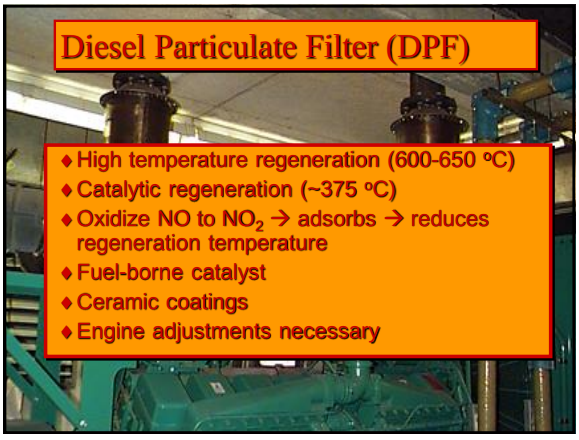

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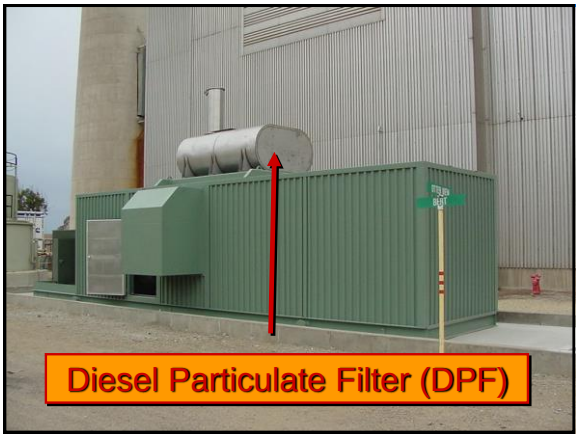

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Chapter Summary

- Introduction to Stationary Sources
- Control Procedures
- Control Devices for Particulate Emissions

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Review Questions

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