APTI Course 452

Principles and Practices of Air Pollution Control

Chapter 6:
Ambient Air Quality Monitoring

1

Chapter Overview

- Introduction to Air Quality Monitoring
- Introduction to Network Design
- Monitoring Criteria Pollutants
- Monitoring Non-Criteria Pollutants
- National Monitoring Strategy Committee

2

Introduction to Air Monitoring

- Temporal and Spatial Variations
- Complexities in the dynamics
- Uses of Air Monitoring
- Purpose of Air Monitoring

3

Introduction to Ambient Air Quality Monitoring

- Temporal and Spatial Variations
  - Changes in Pollutant Sources
  - Changes in meteorology and topography
- Complexities in the dynamics

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Introduction to Ambient Air Quality Monitoring- Uses

- Determine Compliance
- Document progress
- Establish Baselines
- Policy Development
- Establish Relationships
- AQI reporting
- Model Evaluation
- Health/Environmental Effects
- Assess Trends

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The NAAQS

- Covered in earlier sessions

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Design of Air Quality Monitoring

1. Set Objectives
2. Choose Parameters
3. Select Sites
4. Scheduling
5. Select Methods
6. Equipment Selection
7. Calibration Procedures
8. Recoding Methods
9. Data Analysis
10. Reporting Results

7

Network Design

- Network Design Objectives
- Spatial Scales
- Elements of Network Design

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Network Design Objectives

- The design should determine one of the following:
  1. Highest Concentrations
  2. Representative Concentrations
  3. Impact
  4. Background Concentration Levels
  5. Regional Pollutant Transport
  6. Welfare-related Impacts

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Spatial Scales

- The Scales
- Matching Objectives to a Scale
- Application of the Scales

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The Spatial Scales

- Microscale (1-100 meters)
- Middle scale (100m-0.5 kilometers)
- Neighborhood scale (0.5-4.0 kilometers)
- Urban scale (4-50 kilometers)
- Regional scale (tens to hundreds of kilometers)
- National and global scales (nation and globe as a whole).

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Matching Objectives to a Scale

Monitoring Objectives	Appropriate Siting Scales
Highest concentration	Micro, Middle, neighborhood or urban
Population	Neighborhood, urban
Source Impact	Micro, middle, neighborhood
General/Background	Neighborhood, urban, regional
Regional transport	Urban/regional
Welfare-related impacts	Urban/regional

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Application of the Scales

Scales Applicable for SLAMS							
	SO_2	CO	O_3	NO_2	Pb	PM_{10}	$PM_{2.5}$
Spatial Scale							
Micro	X	X			X	X	X
Middle	X	X	X	X	X	X	X
Neighborhood		X	X	X	X	X	X
Urban	X		X	X	X	X	X
Regional	X		X		X	X	X

Scales Applicable for NAMS							
	SO_2	CO	O_3	NO_2	Pb	PM_{10}	$PM_{2.5}$
Spatial Scale							
Micro	X	X			X	X	X
Middle		X			X	X	X
Neighborhood	X	X	X	X	X	X	X
Urban			X	X			
Regional							X

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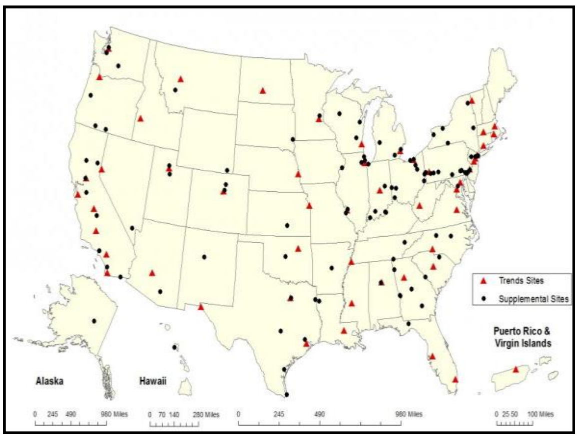

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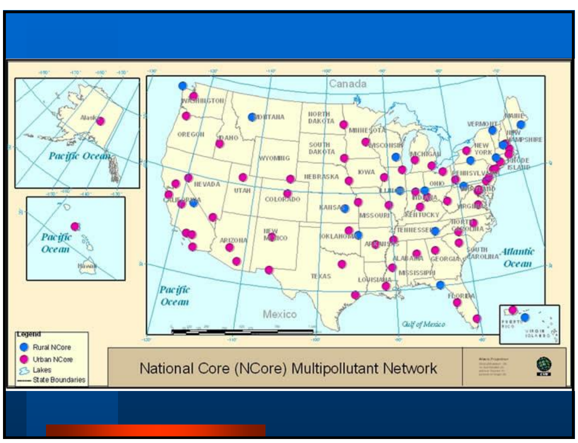

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National Air Toxics Trends Station (NATTS) Network
Last Update: 15Aug12

Location	*Operating Agency*	*AQS ID*	*Setting*
Roxbury MA	MA Department of Environmental Protection	25-025-0042	Urban
Providence RI	RI Department of Environmental Management	44-007-0022	Urban
Underhill VT	VT Department of Environmental Conservation	50-007-0007	Rural
Bronx NY	NY Department of Environmental Conservation	36-005-0110	Urban
Bronx NY	NY Department of Environmental Conservation	36-005-0080	Urban
Rochester NY	NY Department of Environmental Conservation	36-055-1007	Urban
Washington DC	DC Department of Health	11-001-0043	Urban
Richmond VA	VA Department of Environmental Quality	51-087-0014	Urban
Tampa FL	Hillsborough County Environmental Protection Commission	12-057-3002	Urban
Pinellas County FL	Pinellas County Department of Environmental Management	12-103-0026	Urban
Atlanta GA	GA Department of Natural Resources	13-089-0002	Urban
Hazard KY	KY Department of Environmental Protection	21-193-0003	Rural
Grayson Lake KY	KY Department of Environmental Protection	21-043-0500	Rural

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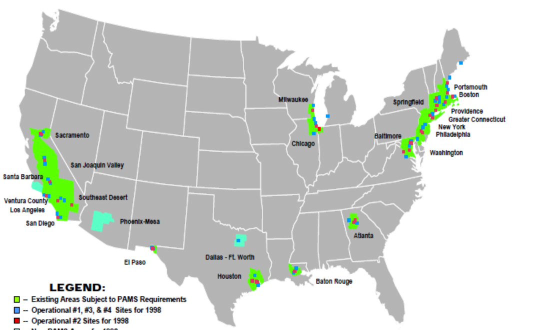
Operating PAMS Sites, 1998



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Types of Air Monitoring Networks

- SLAMS -- State and Local Monitoring Stations
- NAMS -- National Air Monitoring Stations
- PAMS -- Photochemical Assessment Monitoring Stations
- SPMS -- Special Purpose Monitoring Stations

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Elements of Network Design

- Particulate Matter Collection
- Gaseous Pollutant Collection
- Reference Methods Equivalents
- Averaging Times
- 40 CFR 58 Appendices
- Air Quality Index

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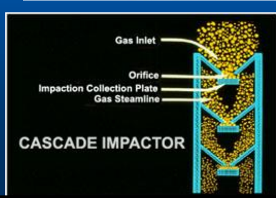
Particulate Matter Collection

- Filtration
  - Health Impact
- Impaction
  - Health Impact



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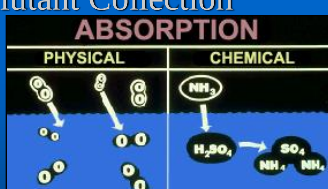
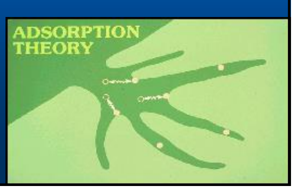
Gaseous Pollutant Collection

- Absorption
- Adsorption
- Grab Sampling





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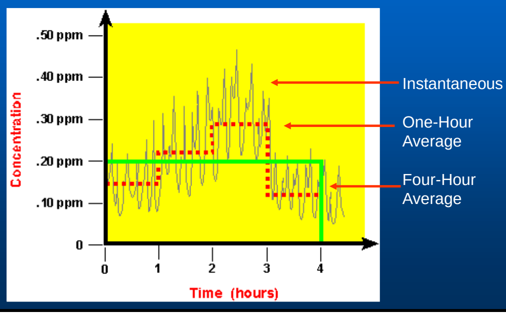
Averaging Times



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Reference Methods Equivalents

- Federal Reference Methods
  - 40 CFR part 50 Appendices A through M
- Equivalent Methods
  - 40 CFR Part 53, Subparts A through F
- http://www.epa.gov/ttn/amtic

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40 CFR 58 Appendices

- Appendix A: QA Requirements for SLAMS
- Appendix B: QA Requirements for PSD Air Monitoring
- Appendix C: Ambient Air Quality Monitoring Network
- Appendix D: Network Design for SLAMS and NAMS
- Appendix E: Probe Siting Criteria
- Appendix F: Annual SLAMS Air Quality Information
- Appendix G: AQI and Daily Reporting

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Monitoring Non-Criteria Pollutants

- Visibility
- Hazardous Air Pollutants (HAPs)

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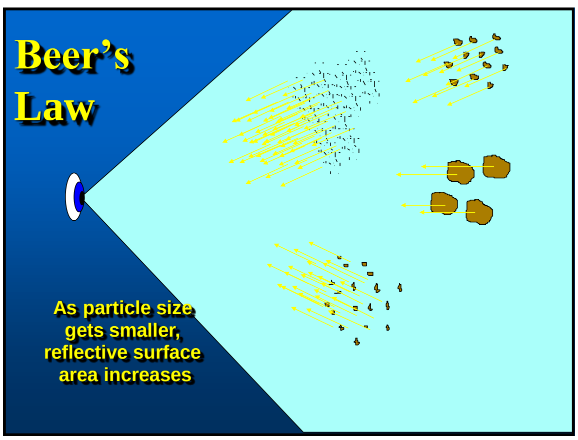

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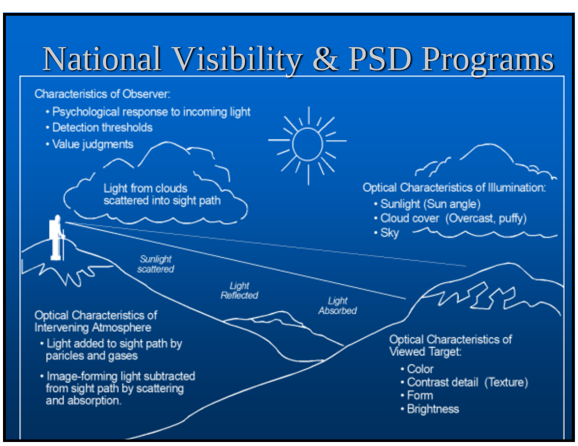

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Visibility

- IMPROVE- Interagency Monitoring of Protected Visual Environments
- CASTNET- Clean Air Status and Trends Network

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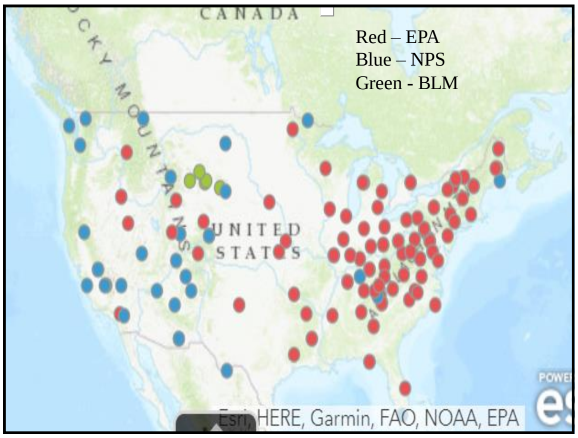

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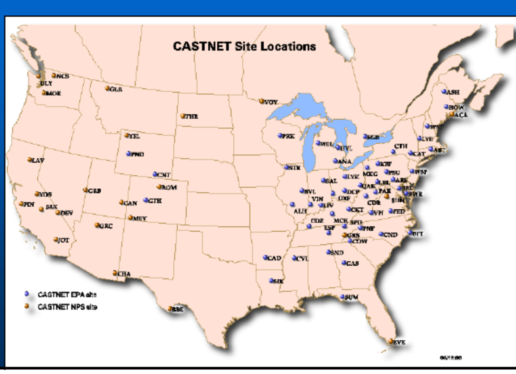
CASTNET



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Hazardous Air Pollutants (HAPs)

- Introduction
- Regulations
- Monitoring Programs

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HAPs Introduction

- What is a HAP?
- What is the Danger?
- Where do they come from?
- Does the CAA Address this?
- How Many are there?

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HAPs Regulations

- Two Phases
  - Development of technology based standards
  - Evaluate remaining issues (187)
- National Air Toxics Program
  - Quantify the impacts
- Development of a Monitoring Network

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National Air Toxics Trends Station (NATTS) Network
Last Update: June 2020

Location	Operating Agency	AQS ID	Setting	Year Established	Year Discontinued
Roxbury MA	MA Department of Environmental Protection	25-025-0042	Urban	2003	
Providence RI	RI Department of Environmental Management	44-007-0022	Urban	2003	
Underhill VT	VT Department of Environmental Conservation	50-007-0007	Rural	2004	
Bronx NY*	NY Department of Environmental Conservation	36-005-0110	Urban	2003	
Bronx NY	NY Department of Environmental Conservation	36-005-0080	Urban	2010	2012
Rochester NY	NY Department of Environmental Conservation	36-055-1007	Urban	2004	
Washington DC	DC Department of Health	11-001-0043	Urban	2004	
Richmond VA	VA Department of Environmental Quality	51-087-0014	Urban	2008	
Tampa FL	Hillsborough County Environmental Protection Commission	12-057-3002	Urban	2004	
Pinellas County FL	Pinellas County Department of Environmental Management	12-103-0026	Urban	2004	
Atlanta GA	GA Department of Natural Resources	13-089-0002	Urban	2003	
Hazard KY	KY Department of Environmental Protection	21-193-0003	Rural	2003	2008
Grayson Lake KY	KY Department of Environmental Protection	21-043-0500	Rural	2008	
Chesterfield SC	SC Department of Health and Environmental Conservation	45-025-0001	Rural	2004	
Detroit MI	MI Department of Environmental Quality	26-163-0033	Urban	2003	
Chicago IL	IL Environmental Protection Agency	17-031-4201	Urban	2003	
Mayville WI	WI Department of Natural Resources	55-027-0007	Rural	2003	2009
Horicon WI	WI Department of Natural Resources	55-027-0001	Rural	2009	
Houston TX	TX Commission on Environmental Quality	48-201-1039	Urban	2003	2018
Karnack TX	TX Commission on Environmental Quality	48-203-0002	Rural	2004	2018
St. Louis MO	MO Department of Natural Resources	29-510-0085	Urban	2003	
Bountiful UT	UT Department of Environmental Quality	49-011-0004	Urban	2003	
Grand Junction CO	CO Department of Health and Environment	08-077-0017/18	Urban	2004	
San Jose CA	Bay Area Air Quality Management District	06-085-0005	Urban	2003	2018
Phoenix AZ	AZ Department of Environmental Quality	04-013-9997	Urban	2003	

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Los Angeles CA	South Coast Air Quality Management District	06-037-1103	Urban	2007	
Rubidoux CA	South Coast Air Quality Management District	06-065-8001	Urban	2007	
Seattle WA	WA Department of Ecology	53-033-0080	Urban	2003	
La Grande OR	OR Department of Environmental Quality	41-061-0119	Rural	2004	2016
La Grande Hall OR	OR Department of Environmental Quality	41-061-0123	Rural	2016	
Portland OR	OR Department of Environmental Quality	41-051-0246	Urban	2008	2016
Portland OR	OR Department of Environmental Quality	41-051-2010	Urban	2017	
Tulsa OK	OK Department of Environmental Quality	40-143-1127	Urban	2020	
Pittsburgh PA	Allegheny County Health Department	42-003-0008	Urban	2020	

*Site discontinued in 2010, but re-established in 2012, and is currently active

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AIR QUALITY INDEX CHART

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*...air quality conditions are:*	*...as symbolized by this color:*
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

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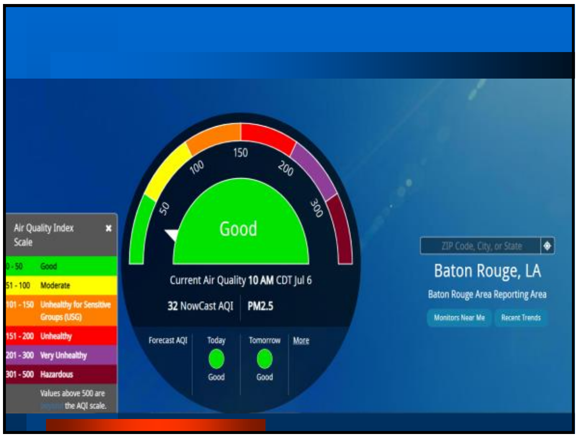

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National Monitoring Strategy Committee

- A Holistic Review of Air Monitoring
- A New Strategy
- 6 Essential Components
- Revised Strategy is on the web
  - http://www.epa.gov/tnn/amtic
- Ncore – network design proposal

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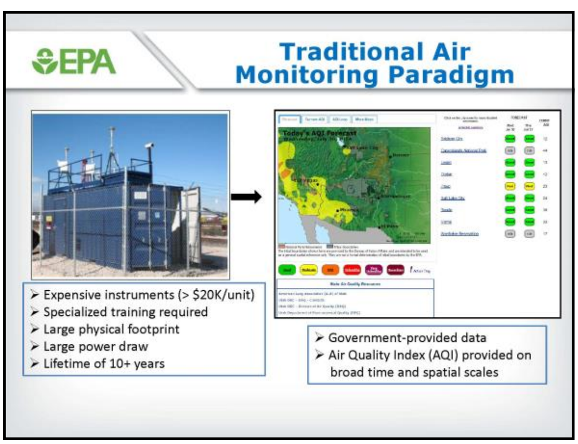

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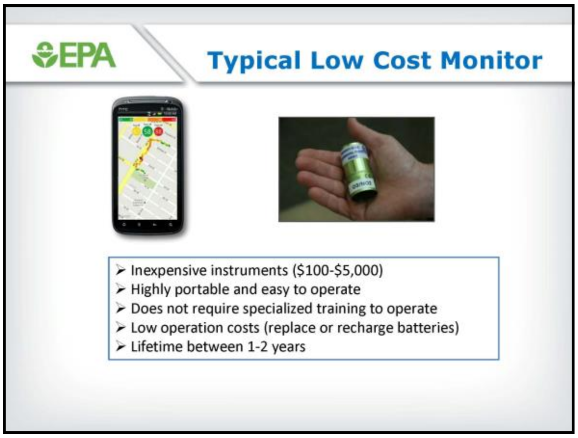

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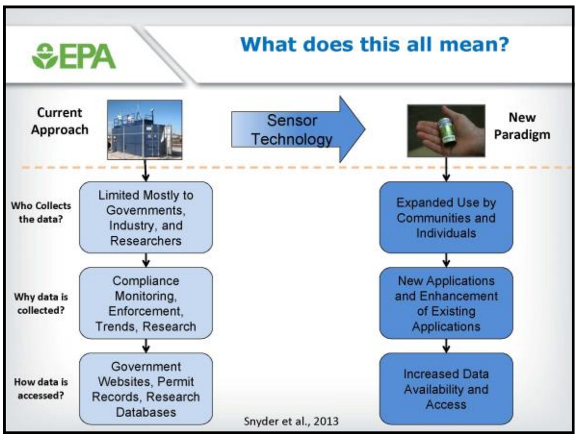

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Chapter Summary

- Introduction to Air Quality Monitoring
- Monitoring Criteria Pollutants
- Monitoring Non-Criteria Pollutants
- Network Design
- National Monitoring Strategy Committee

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Air Monitoring Technical Information Center (AMTIC)

http://www.epa.gov/ttn/amtic

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Review Questions

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APTI Course 452

Principles and Practices of Air Pollution Control

Chapter 7:
Measurement of Pollutant Emissions

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Chapter Overview

- Measurement of Pollutant Emissions
- Source Sampling Methodology
- Continuous Emission Monitoring
- Compliance Assurance Monitoring

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Testing Requirements

1. The gas being sampled should represent either the total or a known portion of the emissions from the source.
2. Samples of the emissions collected for analysis must be representative of the gas stream being sampled.
3. The volume of the gas sample withdrawn for analysis must be measured accurately in order to calculate the concentration of the analyzed constituents in the sampled gas stream.
4. The gas flow rate from the source must be determined in order to calculate emission rates for the various constituents.

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Test Methods

- U.S. EPA Reference Methods (FRM) 1-8
- Subsequent Reference Methods

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Codification of Testing

- Emission Measurement Center
  - EPA Office of Air Quality Planning and Standards (OAQPS)
- https://www3.epa.gov/ttn/emc/

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Method Numbers and the CFR

- Methods numbers or Performance Specifications between 1 and 100 are for NSPSs (40 CFR Part 60, Appendix A).
- The 100 series are for NESHAPs (40 CFR Part 61, Appendix B).
- The 200 series are example for SIPs (40 CFR Part 51, Appendix M).
- 300 series methods are for the MACT (40 CFR Part 63, Appendix A).

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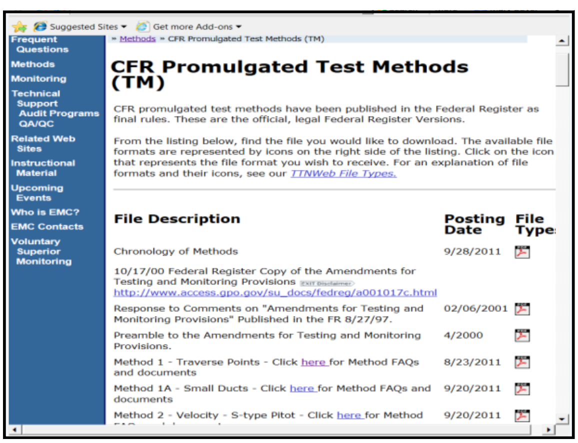

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Source Sampling Methodology

- Stationary source emissions occur primarily as either a gas or solid.
- Since no single method of measurement can accurately analyze every form of pollutant emitted from an exhaust stack, it is important to understand the properties of particulate and gaseous pollutants and the methods used to measure them.

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Test Methods Are Very Prescriptive

- Failure to adhere to the method may invalidate the test.

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Testing Issues

- Distributed Sampling Points
- Sampling Distributed Over Time
- Isokinetic Sampling
- Separation of Gas Constituents
- Sample Recovery and Analysis
- Data Recording
- Calculation of Results
- Expression of Results

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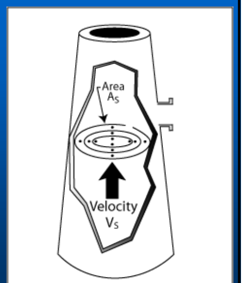
Distributed Sampling Points

A representative sample of the effluent is taken by first measuring the velocity, then extracting gas from an array of sampling points distributed over equal areas of the cross section of the stack or duct.



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Isokinetic Sampling (for particles)

- It is essential that the sample be extracted at the same rate at which the gas is flowing through the stack or duct.
- If the sample is isokinetic, the distribution of particles sizes (from small to large) entering the probe will be exactly the same as that in the stack gas itself.

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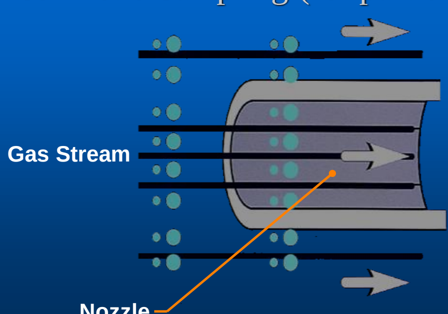
Isokinetic Sampling (for particles)



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Over-Isokinetic Sampling

When over isokinetic sampling occurs, the large particles do not follow the streamlines, but break through them to continue in the same direction.

Small particles will follow gas streamlines, and a <u>non-representative number of small particles will be present</u> in the sample gas volume.

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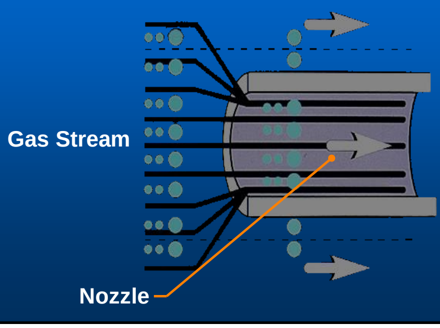
Over-Isokinetic Sampling



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Under-Isokinetic Sampling

- When the nozzle inlet velocity is less than the stack velocity, the nozzle is extracting the gas at too low a rate. The gas streamlines bunch up at the nozzle, almost as if it were an obstruction. A smaller volume of stack gas is being extracted into the nozzle.
- The large particles in the gas stream pass through the compacted streamlines near the nozzle and flow into it due to their inertia. The <u>sample is biased with large particles</u> and the particulate concentration is higher.

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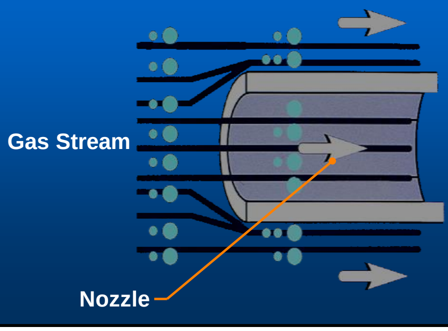
Under-Isokinetic Sampling



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Nozzles

- Sharp edged nozzle tapered from the outside inward results in the least disruption of the gas flow streamline.
- Nozzles designed without sharp and tapered edges or those that are dented should not be used for particulate sampling

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Water Vapor and Gaseous Pollutants

Capturing water vapor and gaseous pollutants is best achieved by condensation—or bubbling the sample gas through chilled impingers (sealed glass vessels), some which may contain liquid reagents to absorb gases.

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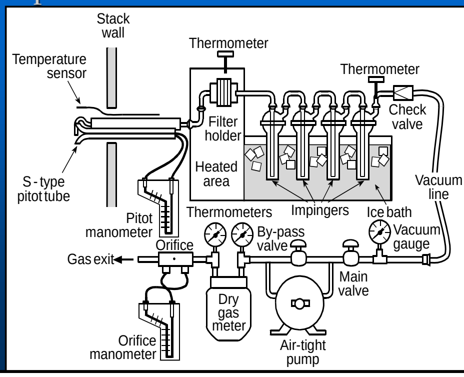
Separation of Gas Constituents



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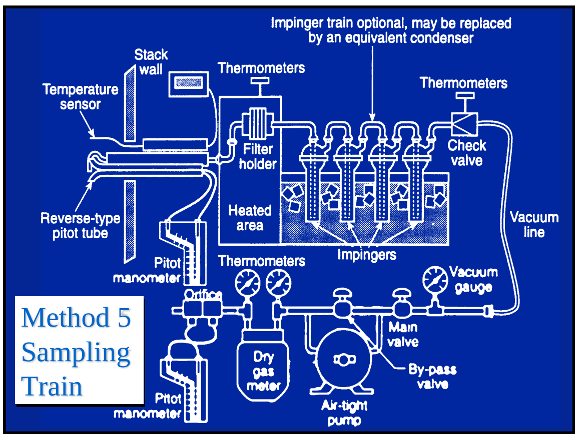

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Basic Test Methods

- Method 1 - Sampling Point Location
- Method 2 - Stack Gas Velocity
- Method 3 - Dry Molecular Weight
- Method 4 - Moisture Content of Stack Gases
- Method 5 - Particulate Emissions
- Method 6 - Sulfur Dioxide Emissions
- Method 7 - Nitrogen Oxide Emissions
- Method 8 - Sulfur Dioxide and Sulfuric Acid
- Method 9 - Opacity
- Method 10 - Carbon Monoxide Emissions
- Method 11 – H2S
- Method 12 – Pb- lead

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- Sample Recovery and Analysis
  - Filters are pre-weighed and reagent volumes pre-measured prior to use.
  - After each run, the content of each sampling train component is carefully recovered to a sealed vessel, then weighed, measured, or otherwise evaluated under laboratory conditions.
- Data Recording
  - Throughout each run, appropriate measurement data are recorded. The sampling time, sample train vacuum, differential pressures across the gas temperature, orifice meters, and dry gas meter readings are recorded.
  - Averages of these values, along with the total sample gas volume, are then used to calculate the test results.

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Results

- Calculation of Results
  - The concentration of a pollutant in the sampled gas is calculated as the proportion of captured pollutant's mass to the volume of gas sampled. These results are corrected to a standard temperature and pressure and expressed on a dry basis
- Expression of Results
  - The pollutant concentration can be used to calculate other expressions of the test result.

For instance, a gas flow rate may be used with the concentration to calculate an emission rate for the pollutant or the amount emitted per unit of time.

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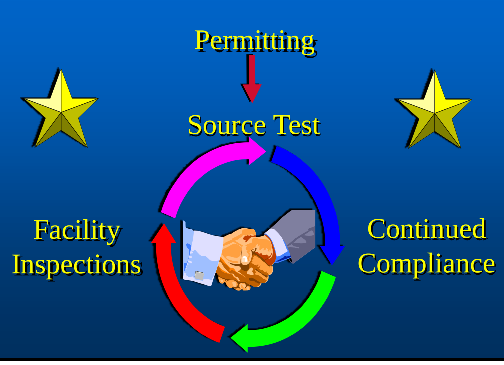
Source Test Enforcement Cycle



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Hazards

- What are the Stack Emissions?
- What Heat & Gas Hazards Exist?
- What are the Facility Health & Safety Procedures?
- Are Entry, Confined Space, or Other Permits Required?

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Continuous Emission Monitoring

CEMs are used as a means to comply with air emission standards such as the Acid Rain Program, other federal emission programs, or state permitted emission standards.

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Purpose of CEMS

Regulators View

- Determine emission compliance
- Identify periods of excess emissions
- Assess control equipment efficiency
- Monitor operating parameters
- Validate emission credits
- Public perception reports
  - Haz. Waste Incinerators
  - Municipal Waste Combustors

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Purpose of CEMS

Industry View

- Comply with regulations
- Demonstrate compliance
- Monitor control equipment
- Monitor process parameters
- Validate emission credits
- Complaint protection
- Plant safety

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Federal Guidance

- Standards Setting
- Test Methods
- Performance Specifications
  - 40 CFR 60, Appendix B
  - 40 CFR 75, Appendix A
- Quality Assurance Criteria
  - 40 CFR 60, Appendix F
- Enforcement Guidance

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Performance Specs : Gauge

- PS 1 - Opacity Monitors
- PS 2 - SO_2, NO_x Monitors
- PS 3 - CO_2, O_2, Monitors
- PS 4 - CO Monitors
- PS 5 - Total Reduced Sulfur (TRS) Monitors
- PS 6 - Rate (Velocity) Monitors
- PS 7 - Hydrogen Sulfide (H_2S) Monitors
- PS 8 - VOC Monitors
- PS 9 - Gas Chromatograph Systems

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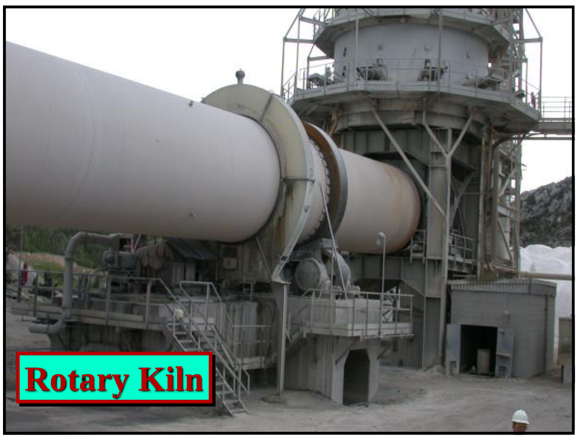

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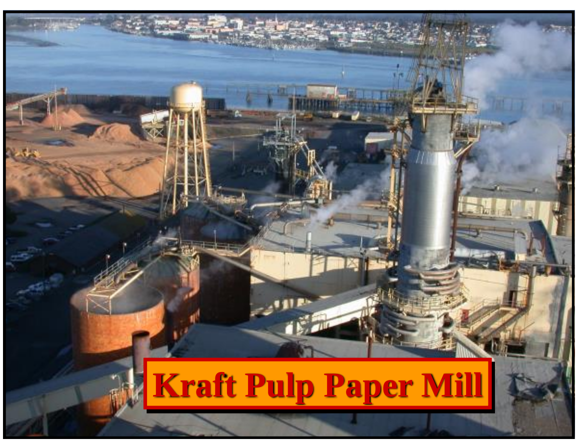

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CEMS Monitors

- Opacity
- Sulfur Dioxide
- Nitrogen Oxides
- Carbon Dioxide
- Carbon Monoxide
- Oxygen
- VOC
- Hydrogen Chloride
- Ammonia
- Total Reduced Sulfur
- Hydrogen Sulfide
- Gas Velocity
- Mercury

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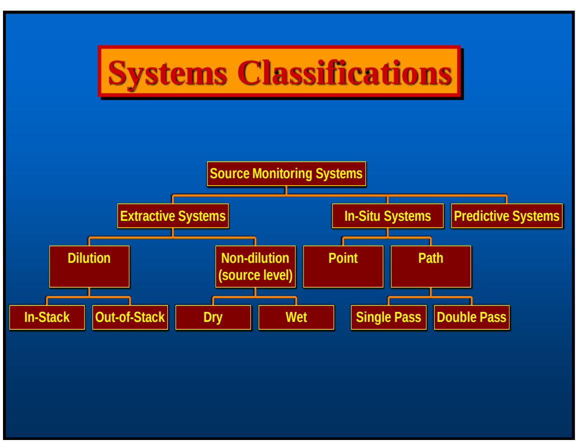

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Extractive & In-Situ Systems

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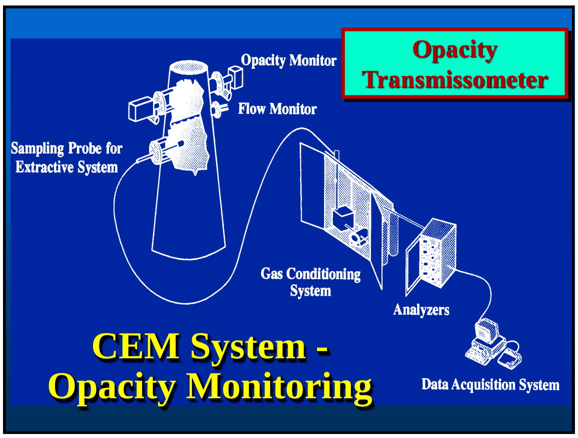
Opacity Transmissometer
Opacity Monitor
Flow Monitor
Sampling Probe for Extractive System
Gas Conditioning System
Analyzers
Data Acquisition System
CEM System - Opacity Monitoring

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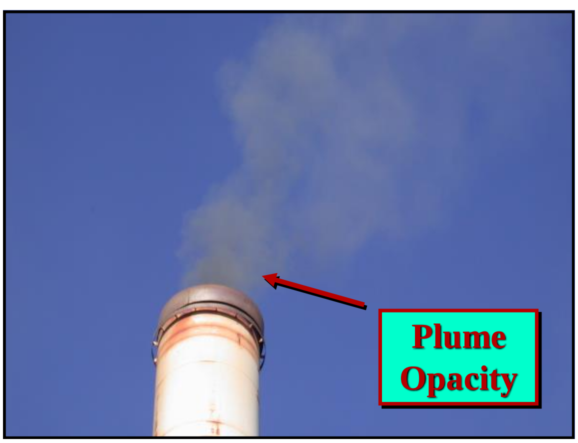
Plume Opacity

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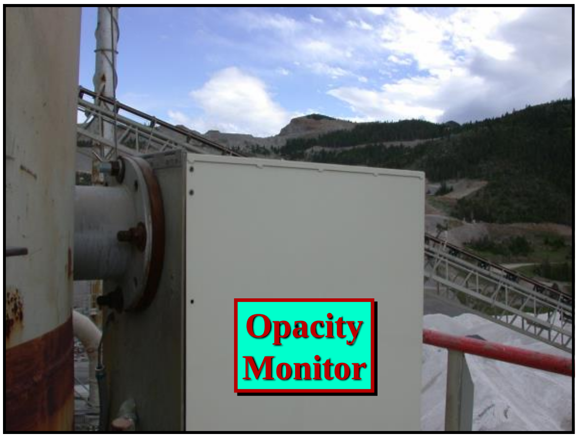

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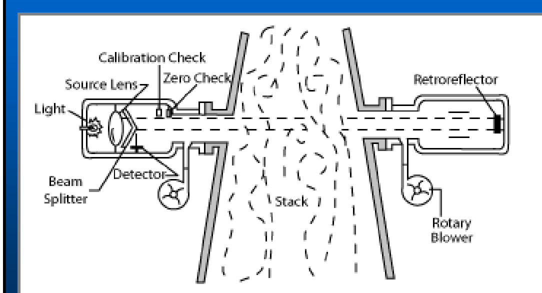
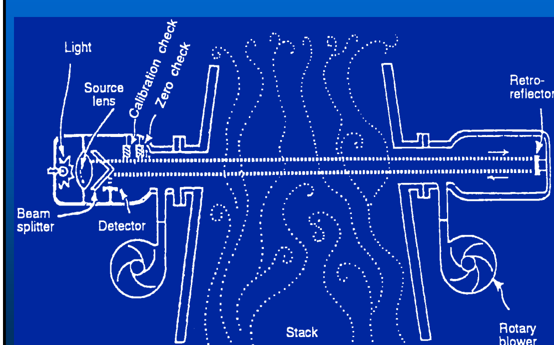
Opacity Monitors

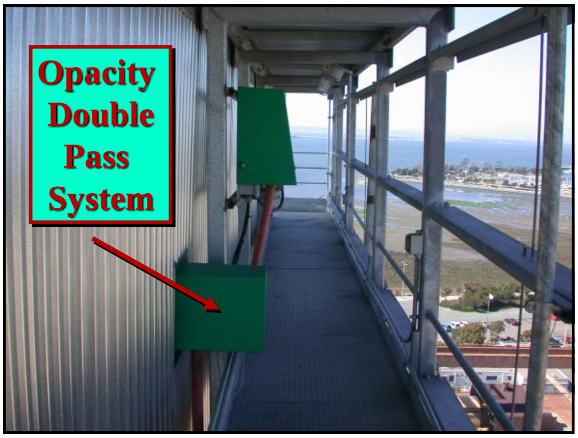


94

Double Pass Transmissometer



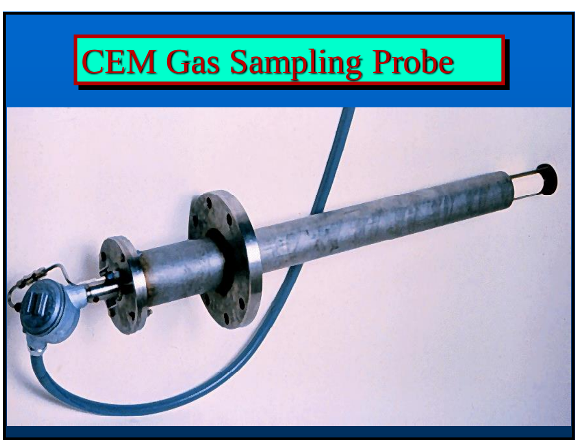
95


Opacity
Double
Pass
System

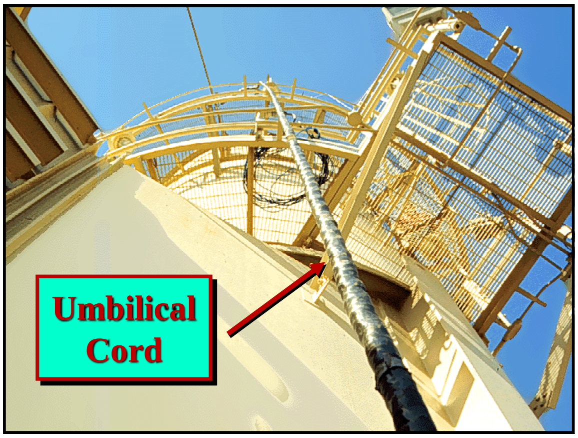
96


550 OPACITY
INST. OPACITY
0.50%
United Sciences Inc
Opacity Monitor Panel

97


CEM Gas Sampling Probe

98



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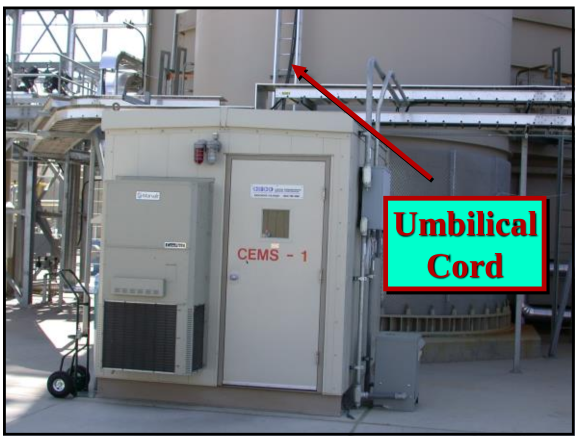
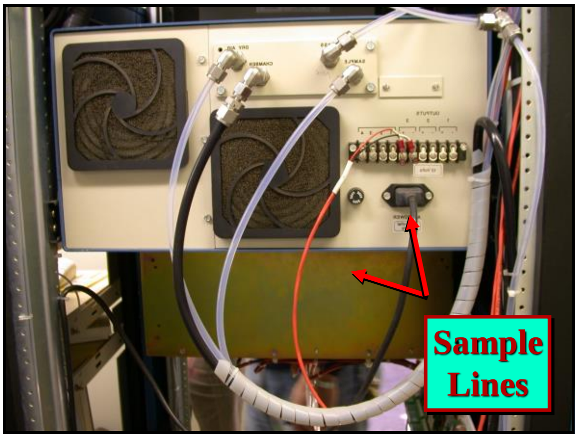


100

101



102

103

Compliance Assurance Monitoring

- Background
- Main Components

104

CAM Background

- Title V requires Operating Permits for large facilities
- Not all Title V facilities can physically accommodate CEMs and/or emit a pollutant for which there is no test method
- Title VII authorizes enhanced monitoring known as Compliance Assurance Monitoring (CAM).

105

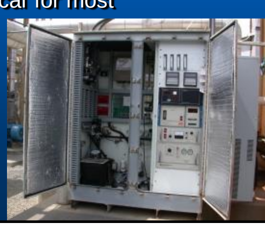
Who is affected by CAM (§64.2)

- An emission unit (except some backup utility power emission units) &
- With an emission limit or standard
- With a control device &
- With pre-control emissions greater than major source thresholds &
- At a major source subject to Title V permitting

106

Effect of Title V

- Required "continuous" monitoring of many sources
- Standard CEM is impractical for most small sources.
- CEMs do not exists for some pollutants
- This forced a new approach to monitoring



107

CONCEPTS BEHIND CAM

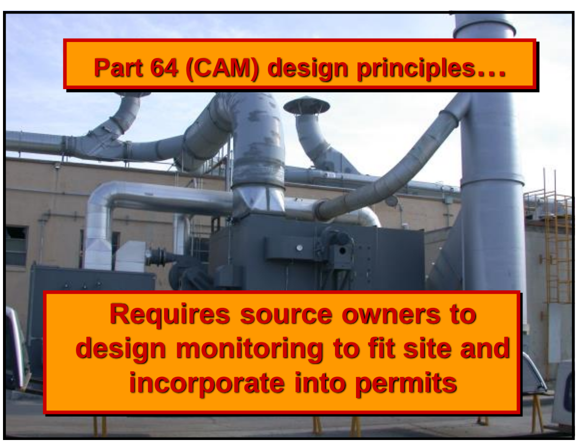
- If the emissions control system is working properly, there is "***reasonable assurance of compliance***".
- Monitoring the control system is more practical than monitoring emissions
- So - relate control system indicators to compliance.
- Many sources with no active emission controls can be monitored in other ways.

108

CAM Background

- Targets facilities with add-on control devices
- "assure that control measures...are properly operated and maintained so that they do not deteriorate to the point where the owner/operator fails to remain in compliance..."
- "long-term, significant loss of control efficiency that can occur without complete failure of a control device"

109



110

Who is exempt from CAM?

- Post-1990 NSPS and NESHAP emission limits
- CFC rules
- Acid Rain requirements
- Emissions trading programs
- Emission caps
- Title V permit requiring continuous compliance determination method (CEM)

111

CAM Rule Components

- Establishes Criteria
- Title V Compliance Certification
- Exemptions
- Monitoring Requirements
- Control Device Specifications

112

Chapter Summary

- Measurement of Pollutant Emissions
- Source Sampling Methodology
- Continuous Emission Monitoring
- Compliance Assurance Monitoring

113

- Calif. Air Resources Board - www.arb.ca.gov
- US EPA - Technology Transfer Network www.epa.gov/ttn
- Air & Waste Management Association- www.awma.org/links.htm
- US EPA - Technology Transfer Network www.epa.gov/ttn

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Review Questions

115

APTI Course 452

Principles and Practices of Air Pollution Control

Chapter 8:
Control of Stationary Sources (Gaseous Emissions)

116

Chapter Summary

- Control Devices for VOC Emissions
- Sulfur Dioxide Emission Controls
- Nitrogen Oxide Emission Controls

117

Combustion Considerations

3 T's of Combustion

- *Residence Time*
- *Temperature*
- *Turbulence (mixing)*
- Increase 3T's = more NOx
- Decrease 3T's = more CO and uncontrolled pollutant

118

Control Devices for VOC Emissions

- Thermal Incinerators
- Catalytic Incinerators
- Flares
- Boilers and Process Heaters
- Adsorbers
- Absorbers
- Condensers

119

Thermal Incinerators

- Method of Operation
- Collection Efficiency
- Advantages
- Disadvantages

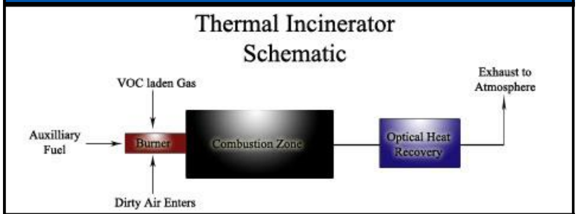
120

121

122

Thermal Incinerators: Method of Operation

- Mechanical Design
  - Time, temperature, turbulence



123

Thermal Incinerators: Collection Efficiency

- Typical Efficiency
  - 98-99.99%
- Determining Factors for Efficiency
  - Design criteria: temperature, time, VOC concentration, compound type, mixing

124

Thermal Incinerators: Advantages

- High Efficiency
- Reusable Energy and Heat Produced

125

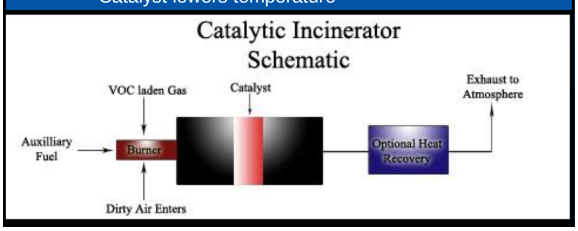
Thermal Incinerators: Disadvantages

- Not Well Suited to Streams with Highly Variable Flow
- High Operating Costs

126

Catalytic Incinerators: Method of Operation

- Mechanical Design
  - Catalyst increases oxidation reaction rate
  - Catalyst lowers temperature



128

129

Catalytic Incinerators: Collection Efficiency

- Typical Efficiency
  - 25-99%
- Determining Factors for Efficiency
  - VOC composition and concentration
  - Temperature
  - Oxygen concentration
  - Catalyst characteristics
  - velocity

130

Catalytic Incinerators: Advantages

- Lower Fuel Requirements
- Lower Operating Temperatures
- Little or No Insulation Requirements
- Reduced Fire Hazards
- Reduced Flashback Problems
- Less Volume/Size Required

131

Catalytic Incinerators: Disadvantages

- High Initial Cost
- Catalyst Poisoning is Possible
- Particulate Often Must First be Removed
- Disposal Problems for Spent Catalyst

132

Catalytic vs. Thermal for VOC Control

Catalytic	Thermal
Lower Operating Temp. & Lower Fuel Usage	Higher Operating Temp. & Higher Fuel Usage
Higher Capital & Maintenance Costs	Lower Capital & Maintenance Costs
Catalyst Fouling & Poisoning	No Catalyst Involved Here

133

134

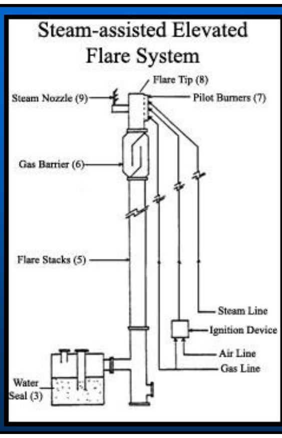
Flares

- Method of Operation
- Types of Flares
- Capacity
- Advantages
- Disadvantages

135

Flares: Method of Operation

- Mechanical Design
- Primary application in petroleum and petrochemical Industries



136

Flares: Types

- Steam-Assisted
- Air-Assisted
- Pressure-Assisted
- Non-Assisted

137

Flare at Landfill

138

Flares: Capacity

- Typical Capacity
  - 100,000 lbs/hr of hydrocarbon gases – ground flares
  - 2 million lb/hr elevated flares
- Determining Factors for Capacity
  - Type of configuration
  - Source of waste stream

139

Flares: Advantages

- Economical Way to Dispose of Gas
- Does Not Require Auxiliary Fuel
- Used to Control Intermittent or Fluctuating Waste Streams
- Can be used for almost any VOC stream
- Primary use: safety device

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Flares: Disadvantages

- Produces Undesirable Noise, Smoke, Heat Radiation, and Light
- Source of SOx, NOx, and CO
- Cannot Treat Waste Streams with Halogenated Compounds
- Released Heat from Combustion is Lost

141

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Boilers and Process Heaters

- Method of Operation
- Collection Efficiency
- Advantages
- Disadvantages

143

Boilers and Process Heaters: Method of Operation and Efficiency

- Mechanical Design
- Typical Efficiency
  - 98% or greater

144

Boilers and Process Heaters: Collection Efficiency

- Typical Efficiency
  - 98 percent plus

145

Boilers and Process Heaters: Advantages

- Little Additional Capital Cost
- Reduces Fuel Costs
- Exhaust stream be used as supplementary fuel

146

Boilers and Process Heaters: Disadvantages

- Can Only Use Pollutants for Fuel That Do Not Affect the Performance of the Burner Unit
- Gas Streams with Low Heating Values Only Work in Small Burner Units

147

148

Adsorbers

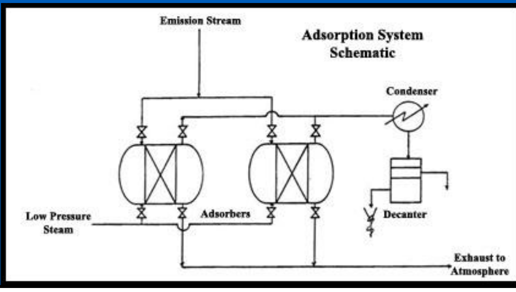
- Method of Operation
- Capacity
- Advantages
- Disadvantages

149

150

Adsorbers: Physical Process

- Physical Process (pollutant held physically)
  - Adsorbent called absorbent carbon (i.e. activated carbon)



151

Adsorbers: Mechanical Design

- Chemical Process
- Mechanical Design
- Regeneration
- Mass Transfer Zone

152

Adsorbers: Regeneration

- Chemical Process
- Mechanical Design
- Regeneration
- Mass Transfer Zone

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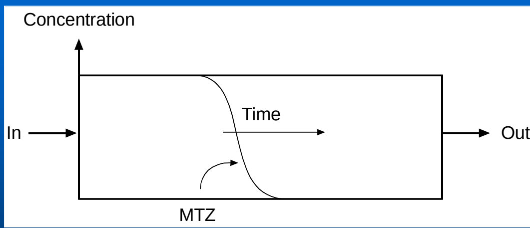
Adsorbers: Mass Transfer Zone



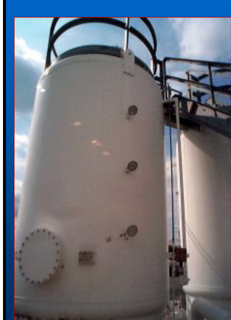
The MTZ exists in all adsorbents. In the MTZ, the concentration of VOC in air goes from 100% of the inlet vapor concentration to the lowest available vapor pressure in equilibrium with the desorbed adsorbent.

154

Carbon Adsorbers at a Soil Remediation Site

155

Adsorber Design Considerations



- Porosity of Adsorbent
- Bed Cross-Sectional Area
- Bed Length
- Multiple VOC's
- Steaming Requirements
- Fouling
- Timers/Monitors
- Channeling

156

Absorber/Condenser/Adsorber Unit at Marketing Terminal

157

Adsorbers: Capacity

- Capacity
  - Depends on adsorbent material, regeneration schedule, size of adsorbent bed

158

Adsorbers: Advantages

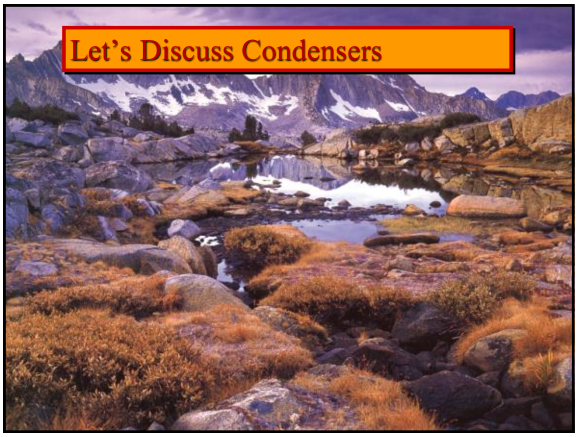
- Economical for Controlling Low Concentrations of VOCs
- Recovery of VOC possible
- Can Increase VOC Concentration to Allow the Use of Incineration or Recovery by Membrane or Condenser

159

Adsorbers: Disadvantages

- Problems with Solid Waste Disposal in Non-Regenerative Adsorbers

160



161

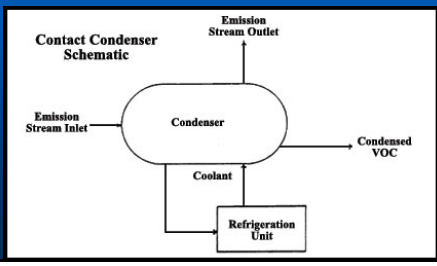
Condensers

- Method of Operation
- Collection Efficiency
- Advantages
- Disadvantages

162

Condensers: Method of Operation

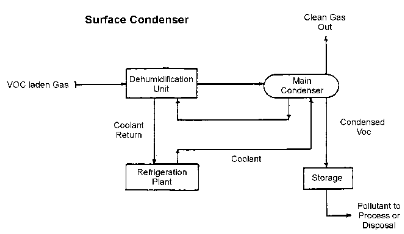
- Mechanical Design – removes gaseous pollution from air by lowering temperature such that gas condenses and become liquid



163

Condensers: Method of Operation

- Mechanical Design – removes gaseous pollution from air by lowering temperature such that gas condenses and become liquid



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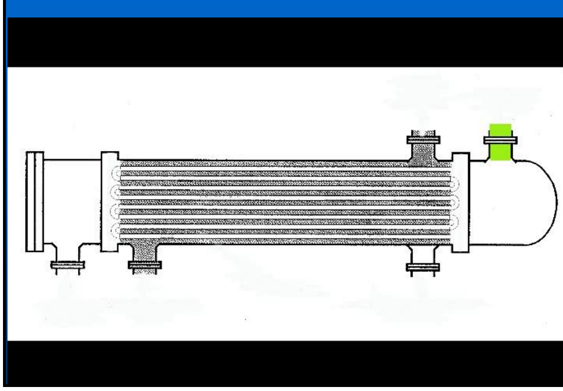

165

Condensers: Collection Efficiency

- Typical Efficiency
  - 50 – 95%
- Determining factors for efficiency
  - Design and application

166

Condensers: Advantages

- Allows Recovery of Valuable Waste Products from Gas Stream

167

Condensers: Disadvantages

- Requires Disposal of Wastewater
- Generally Used in Combination with Other Control Devices

168

169

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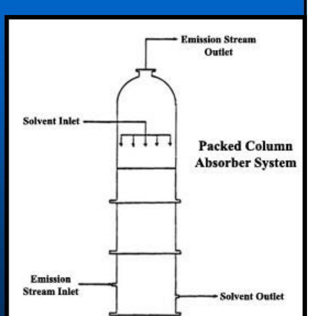
Absorbers: Method of Operation

- Mechanical Design
  - Removes gaseous Pollutant by dissolving in liquid
- Packed-bed absorber (a.k.a Scrubbers)
  - Has column filled with inert substance and absorbing liquid



172

Absorbers: Collection Efficiency

- Typical Efficiency
  - >95%
- Determining Factors for Efficiency
  - Used to control inorganic fumes, vapors, and gases, VOC's, PM,HAP's in particulate form
  - Efficiency depends on properties of gas stream and liquid absorbent
  - Process temperature dependent – lower temperature favors absorption

173

Absorbers: Advantages

- Good for recovering products or purifying gas streams that have high concentrations of organic compounds.
- More cost effective than impingement plate towers.

174

Absorbers: Disadvantages

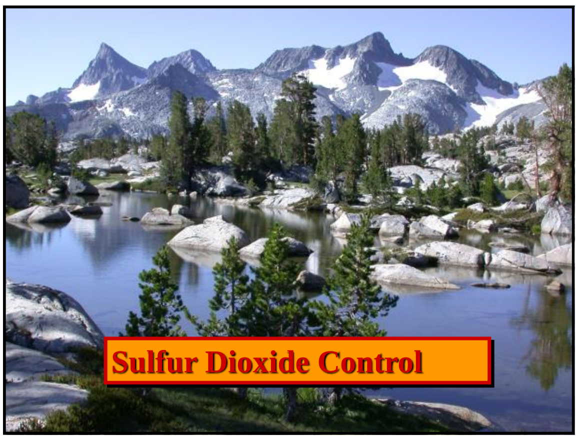
- Has Several Limiting Factors
  - Availability of suitable solvent
  - Availability of vapor/liquid equilibrium date of specific pollutant
- Requires Disposal of Wastewater
- High PM Concentrations Can Clog Bed
- Plugging

175

Inorganic Gas Control

- Solvents
  - Water is most common
- Scrubbing Liquids
  - Caustic solution
- Acid gases absorbed into scrubbing solution form neutral salts

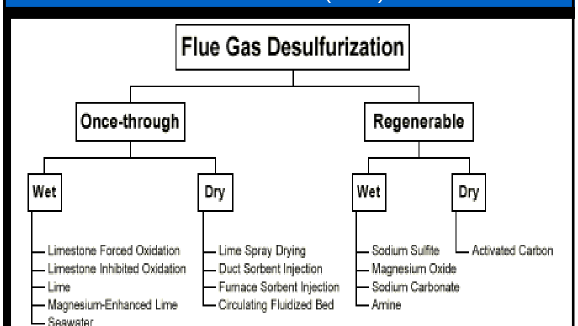
176



177

Sulfur Dioxide Emissions Controls

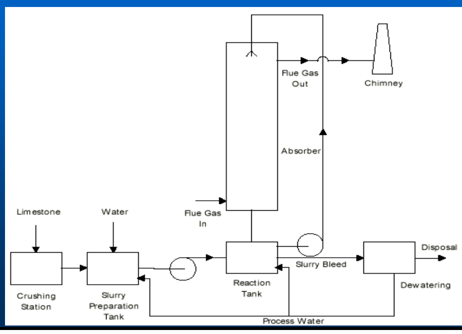
- Flue Gas Desulfurization (FGD)



178

Wet FGD Technologies

Flue gas contacts alkaline slurry in absorber



179

Wet FGD Technologies

- Limestone Forced
  Oxidation (preferred –minimizes oxidation)

180

Wet FGD Technologies

- Limestone-Inhibited Oxidation (efficient with
High sulfur coals)

181

Wet FGD Technologies

- Lime and Magnesium Lime
(more reactive than Limestone but more expensive

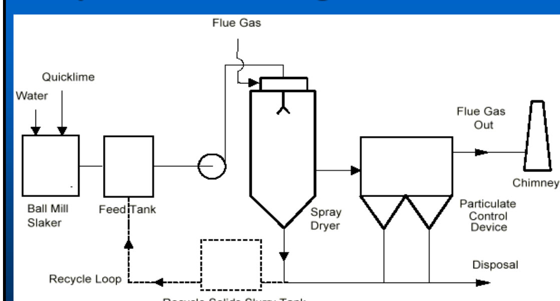
182

Dry FGD Technologies

- Hot flue gas mixes in a spray dryer vessel with a mist of finely atomized fresh lime slurry resulting in series of reactions and a drying of process waste. To increase efficiency partial recycle occurs. Lime sorbent can be delivered to flue gas in an aqueous slurry form [lime spray drying (LSD)] or as a dry powder [furnace sorbent injection (FSI), and circulating fluidized bed (CFB)].

183

Dry FGD Technologies



184

Dry FGD Technologies

- Line Spray Drying (LSD)
  - Used by sources that burn low to medium –sulfur coal
- Furnace Sorbent Injection (FSI)
  - dry sorbent injected
  - Directly into furnace w/temperature between 950-1000vC

185

Dry FGD Technologies

- Circulating Fluidized Bed (CFB)
  - Dry sorbent (hydrated lime) contacted with a humidified flue gas with long contact time provided

186

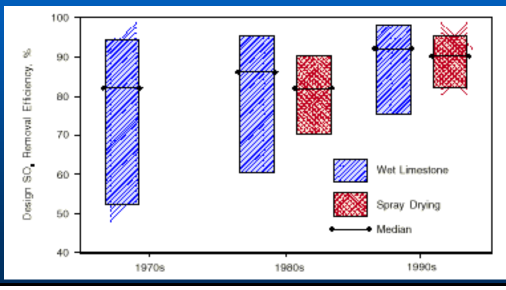
Regenerable FGD Technologies

- Only Marginal in Application
- High O&M Costs
- Five Processes in Use
  - 4 wet
  - 1 dry

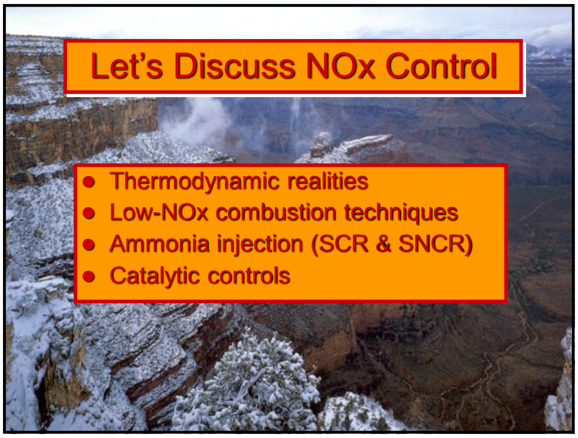
187

FGD Technology Performance

- Performance: Medium: 90%, State of Art: >95%
- Performance Improvements
  - Large capacity modules, Increase flue gas velocity, buffering



188



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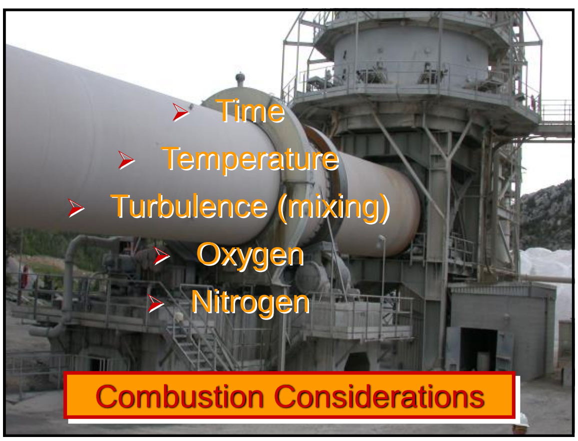

190

Nitrogen Oxides (NOx) Emissions Control

- Types of Nox
  - 7 compounds
  - NO2 only regulated as a surrogate
- NOx Control Methods

191

Types of Nitrogen Oxides (NOx)

- Thermal Nox
  - Formed by combustion
- Fuel Nox
  - Formed from fuels that contain nitrogen (i.e. coal)
- Prompt Nox
  - Formed from molecular nitrogen in air combining with fuel in fuel-rich conditions

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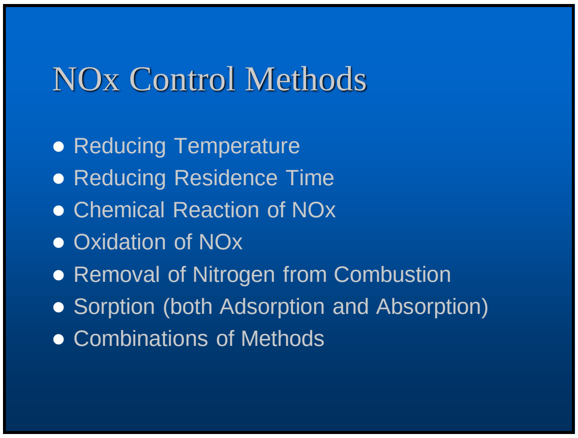
NOx is the most important reactant in Ozone formation

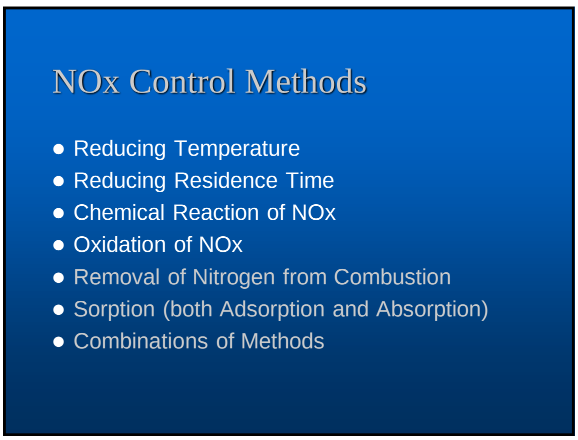
- **NOx is primarily formed from 3 different sources :**

1. **Atmospheric N2 in the combustion air : Thermal NOx >2800⁜F**
2. **N2 present in fuel : Fuel Bound Nox**
   Nox from coal burning boilers
3. **HC (in the flame) during combustion oxidize to form NOx Prompt NOx**

193


NOx Control Methods
Reducing Temperature
Reducing Residence Time
Chemical Reaction of NOx
Oxidation of NOx
Removal of Nitrogen from Combustion
Sorption (both Adsorption and Absorption)
Combinations of Methods

194


NOx Control Methods
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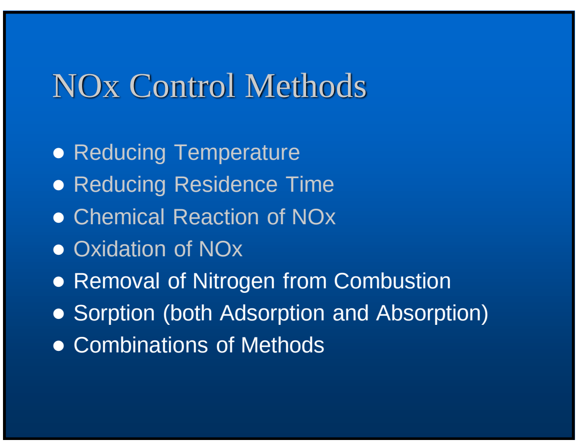
Sorption (both Adsorption and Absorption)
Combinations of Methods

195


NOx Control Methods
Reducing Temperature
Reducing Residence Time
Chemical Reaction of NOx
Oxidation of NOx
Removal of Nitrogen from Combustion
Sorption (both Adsorption and Absorption)
Combinations of Methods

196


Thermal NOx
Fuel-bound NOx
Prompt NOx
NOx Creation

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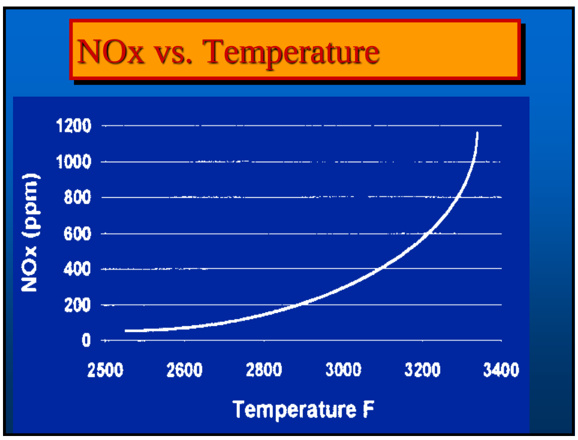
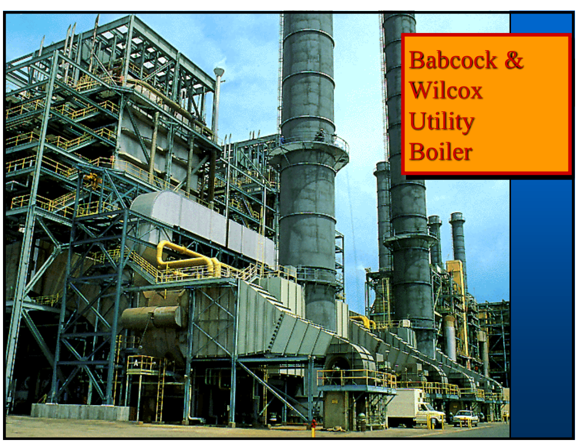
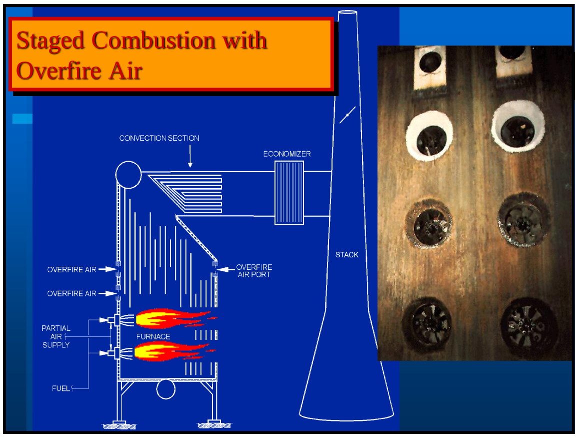

NOx vs. Temperature
1200
1000
800
600
400
200
0
NOx (ppm)
2500
2600
2800
3000
3200
3400
Temperature F

198


Babcock &
Wilcox
Utility
Boiler

199


Staged Combustion with Overfire Air
CONVECTION SECTION
ECONOMIZER
STACK
OVERFIRE AIR
OVERFIRE AIR
OVERFIRE AIR PORT
PARTIAL AIR SUPPLY
FURNACE
FUEL

200

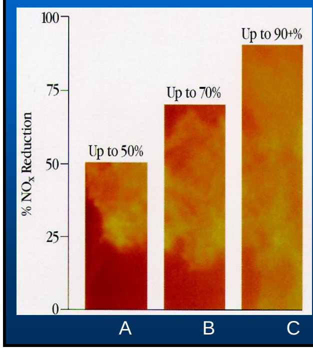

Low-NOx Burner with Staged Fuel

201


Flue Gas Recirculation

202

NOx Reduction by Boiler Configuration



A: Low-NOx burner only, no overfire air (OFA)

B: Low-NOx burner with OFA

C: Low-NOx burner with OFA and FGR

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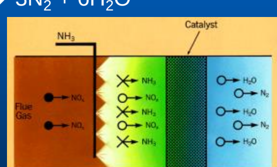
204

Selective Catalytic Reduction (SCR)

- NOx control thru ammonia (NH_3) injection
- $4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$
- $2NO_2 + 4NH_3 + O_2 \rightarrow 3N_2 + 6H_2O$
- 65-90% control
- Problems
  - Expensive
  - High maintenance
  - Ammonia "slip"
  - Catalyst replacement & disposal



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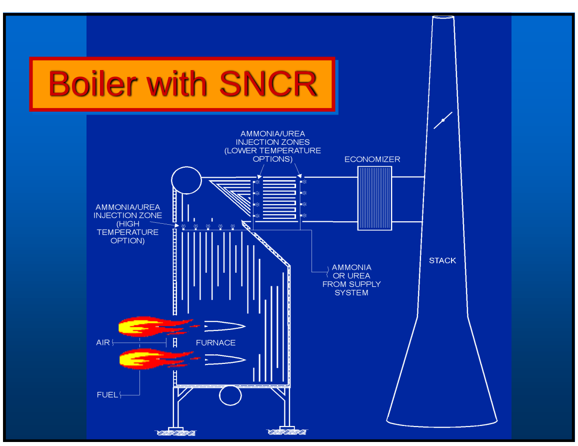
208


Small Boiler
with SCR

209


Let's Discuss SNCR

210


Boiler with SNCR
AMMONIA/UREA INJECTION ZONES (LOWER TEMPERATURE OPTIONS)
ECONOMIZER
AMMONIA/UREA INJECTION ZONE (HIGH TEMPERATURE OPTION)
AMMONIA OR UREA FROM SUPPLY SYSTEM
STACK
AIR
FURNACE
FUEL

211

Selective Non-Catalytic Reduction

- NOx control through ammonia injection
- No catalyst necessary
- Temperature range 1400 ºF – 2000 ºF
- Injected upstream of convection section
- 30% - 50% control under normal conditions
- Problems:
  - Changing flue temperatures with changing load
  - Formation of ammonium salts
  - Ammonia slip

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Comparison of NOx Control Technologies

Technology	Approx. Reduction	Approx. lbs/MMBTU	Approx. ppmv @ 3% O2
Standard burners	Base case	0.14	120
Low NOx burners	60%	0.06	45
Ultra Low NOx Burners – Ist gen.	80%	0.03	25
Ultra Low NOx Burners – 2nd gen.	*95%*	0.007	6
FGR	55%	0.025	20
Compu- NOx w/ FGR	90%	0.015	12
SNCR	40%	0.033 - 0.085	27 - 70
Catalytic Scrubbing	70%	0.017 - 0.044	14 - 36
SCR	90 – 95%	0.006 - 0.015	5 - 12

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Chapter Summary

- Control Devices for VOC Emissions
- Sulfur Dioxide Emission Controls
- Nitrogen Oxide Emission Controls

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Review Questions

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APTI Course 452

Principles and Practices of Air Pollution Control

Chapter 9:
Emissions Inventory

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Chapter Overview

- Emissions Inventory Introduction
- Purpose of Emissions Inventories
- Elements of an Emissions Inventory
- Quality Assurance and Quality Control Procedures for an Emissions Inventory

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What is an Emissions Inventory?

- Detailed listing of pollutants emitted from specific sources in a defined area.

The minimum point source reporting thresholds in tons per year of pollutant are as follows, as measured in potential to emit:

Pollutant	Annual cycle	Three-year cycle	
	(Type A sources)	Type B sources 1	NAA sources 2
(1) SOX	≥2500	≥100	≥100.
(2) VOC	≥250	≥100	O3 (moderate) ≥ 100.
(3) VOC			O3 (serious) ≥ 50.
(4) VOC			O3 (severe) ≥ 25.
(5) VOC			O3 (extreme) ≥ 10.
(6) NOX	≥ 2500	≥ 100	≥ 100.
(7) CO	≥ 2500	≥1000	O3 (all areas) ≥ 100.
(8) CO			CO (all areas) ≥ 100.
(9) Pb		≥ 5	≥ 5.
(10) PM10	≥ 250	≥ 100	PM10 (moderate) ≥ 100.
(11) PM10			PM10 (serious) ≥ 70.
(12) PM25	≥ 250	≥ 100	≥ 100.
(13) NH3	≥ 250	≥ 100	≥ 100.

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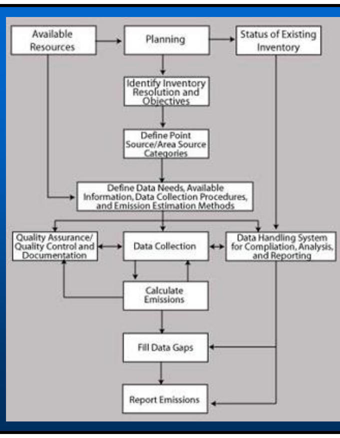
Emissions Inventory Activities



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Identification of Objectives

- Pollutants
- Emission Sources
- Source Categories
- Geographical Boundaries

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Defining Point/Area Categories

- Point Sources
- Area Sources AKA Non point source
- Mobile Sources
- Biogenic Sources

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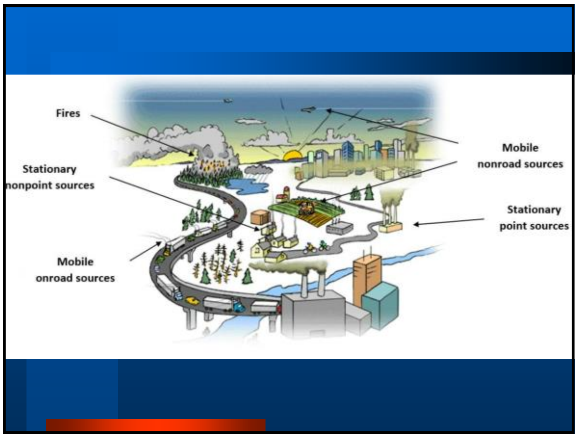

227

- **Stationary Point Sources** – Larger stationary sources that are located at a fixed, stationary location. Examples include large industrial facilities and electric power plants.
- **Stationary Nonpoint Sources** – Stationary sources which individually are too small in magnitude to report as point sources. Examples include residential heating, commercial fuel combustion, agricultural operations, and commercial and consumer solvent use. These have been previously referred to as "stationary area sources".
- **Mobile Onroad Sources** – On-road or "on-highway" vehicles that use gasoline, diesel, and other fuels. Examples include cars, trucks, and buses.
- **Mobile Nonroad Sources** – Off-road or "off-highway" mobile sources such as a nonroad engine or nonroad vehicle that uses gasoline, diesel or other fuels. Examples include aircraft, locomotives, commercial marine vessels, construction and agricultural equipment, and lawn and garden engines and equipment.
- **Fires** – This category includes wildfires, prescribed burning and agricultural field burning. The term "event" is used in the NEI for some fires (e.g., wildfires and prescribed fires in the 2017 NEI).
- **Biogenic Sources** – Emissions that come from vegetation and soils.
- **Other Natural Sources** – There are other natural sources that are responsible for emissions of criteria pollutants. Such sources include volcanic activity, lightning, dust storms, and sea spray.

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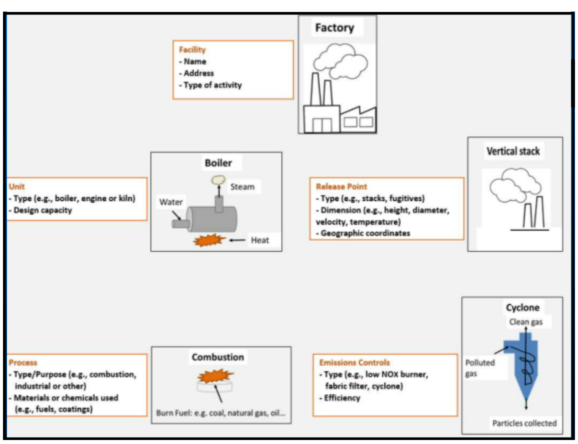

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Types of Sources

- Area sources represent numerous facilities or activities that individually release small amounts of a given pollutant, but collectively release significant amounts of a pollutant.
  - Dry cleaners, vehicle refinishing, gasoline dispensing facilities, and residential heating.
- Mobile sources can be are vehicles, airplanes, trains, combustion engines on farm and construction equipment, marine engines, and lawn mowers.
- Biogenic sources include trees, vegetation, and other microbial activity

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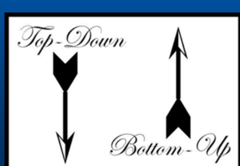
Estimation of Emissions

- Top-Down Approach
- Bottom-Up Approach



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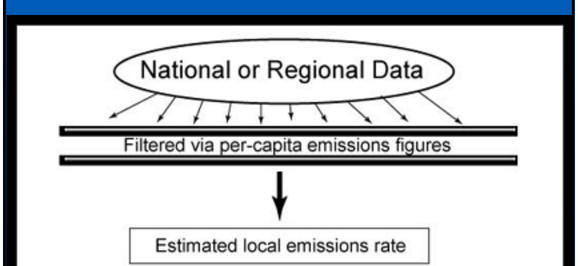
Top-Down Approach

- Definition, Benefits, Drawbacks



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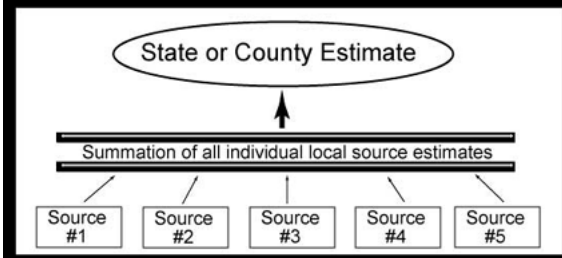
Bottom-Up Approach

- Definition, Benefits, Drawbacks



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Methods of Estimating Emissions

- Continuous Emission Monitors
- Source Testing
- Material Balance
- Emission Factors
- Fuel Analysis
- Emission Estimation Models
- Surveys and Questionnaires
- Engineering Judgment
- US EPA CHIEF
- Locating & Estimating (L&E) Documents

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CEM and Source Tests

- CEMs data can also be used to estimate emissions for different operating and longer averaging times.
- With source testing, emission rates are derived from short-term emission measurements taken at a stack or vent.
  - Emission data can then be extrapolated to estimate long-term emissions from the same or similar sources.

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Material Balance

- Emissions are determined based on the amount of material that enters a process, the amount that leaves the process, and the amount shipped as part of the product itself.

236

Emission Factors

- An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant.

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US EPA AP-42

- Provides published emission factors
- http://www.epa.gov/ttn/chief/
- Emission factors are not EPA recommended as source-specific permit limits.

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Emission Estimation Equations

$$E = A \times EF \times (1 - ER/100)$$

Where:
E = Emissions,
A = Activity Rate,
EF = Emission Factor, and
ER = overall Emission Reduction Efficiency, %.

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Fuel Analysis

- The principle that the presence of certain elements in fuels may be used to predict their presence in emission streams.
- For example, SO2 emissions from oil combustion can be calculated based on the concentration of sulfur in the oil.

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Emission Estimation Models

- Empirically developed process equations used to estimate emissions from certain source.
- An example emission estimation model is the TANKS software for estimating volatile organic compounds emissions from fixed- and floating- roof storage tan

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Surveys and Questionnaires

First Name:________ Last Name:________

Address:________

City:________ State:______ Zip:______

Telephone # (including area code) (day)________ (night)________

Type of Party: Check off

Name of Guest of Honor:________

Birthday ____ Age	Bat/Bar Mitzvah	Christening
Communion	Sweet 16	Family
Anniversary	Graduation	Office
Corporate	Fair	Carnival
Church	Temple	Other ________

Where it is to be held: Name:________

Address:________

City:________ State:______ Zip:______

Telephone #________ Time:________

What are you interested in?

Food Cart(s)	Popcorn	Cotton Candy
Hot Dog Lg Cart	Hot Dog Small Cart	Pretzel
Candy	Sno-Cone	Ice Cream
Italian Ices	Ice Cream Sundaes	Clown
Balloon Art	Face Painting	Inflatable Bouncers
Favors	Games	Bar-B-Que Cooking
Serving & Clean-Up	D.J.	Magician
Costume Characters		

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Engineering Judgment

- When the specific emission estimation techniques such as stack testing, material balance, or emission factor are not possible.

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US EPA CHIEF

- Clearing House for Inventory and Emission Factors) Web site to aid in the development of inventories and for the estimation of air emissions. https://www.epa.gov/chief

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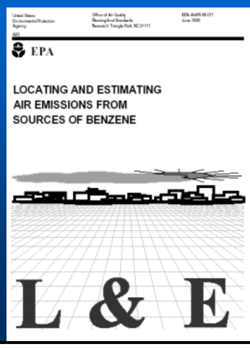
Locating & Estimating Documents



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Purpose of Emissions Inventories

- Historical Records
- Temporal and Spatial Distribution
- Emission Reactivity
- Compliance
- Policy Development
- Ambient Air Monitoring
- Agency Requirements

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Historical Records

- Before a control strategy can be effectively developed, it is essential to first quantify emissions of pollutants generated within a specific geographic area and understand past emissions patterns.
- One of the primary reasons a control agency may choose to conduct an emissions inventory is to determine the types of pollutants and in what quantities they exist.

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Tracking Past Emissions, Projecting Future Emissions

- Historical trends emissions inventories track emissions by source category over time.
- A Projection Emissions Inventory estimates future emissions by a source category.

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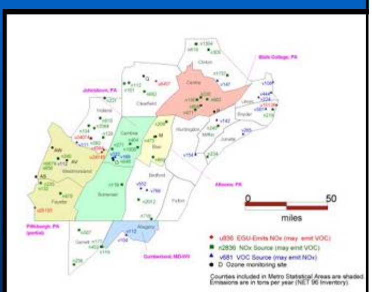
Use of Emissions Inventories: Temporal and Spatial Distribution

- To establish a temporal and spatial distribution of pollutants in a region.



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Emission Reactivity

- An emissions inventory also allows agencies to consider how pollution behaves as it interacts with other pollutants or natural elements in the surrounding environment

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Compliance

- This type of inventory effectively accounts for all known types and amounts of pollutants and better reveals excess exposure during normal monitoring period.

251

Regulatory Development

- Provides valuable information about which sources of pollution should be subject to stricter control and what effect the new emission standard might have on air quality.
- Provides a useful means for determining whether to issue or reauthorize source permits within a region.

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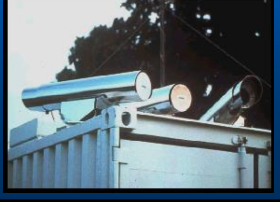
Ambient Air Monitoring

- Emissions inventory is to assist in the selection of sites for effective ambient air quality monitoring stations.



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Agency Requirements

- To meet the general information requirements of an air pollution control agency.
- Examples of such needs might include the ability to monitor and report industrial growth in a region, maintain current emission data on existing sources, and provide permit information for new source applications .

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Elements of an Emissions Inventory

- Geographical Area
- Spatial and Temporal Characteristics
- Source Specific Data
- Pre-existing Inventory Data
- Data Handling

255

Geographical Area

- Boundary Considerations

256

Spatial and Temporal Characteristics

- Spatial characteristics are those characteristics that define the location of point source.
- Temporal characteristics of a source report the type and quantity of pollutants emitted over time.

Factory Stack (Boiler)

	A	B	C
3	0	1.000	0
2	0	0	0
1	0	0	0

Factory Vent (Coating Process)

	A	B	C
3	0	1.000	0
2	0	0	0
1	0	0	0

Highway Vehicles

	A	B	C
3	.200	.200	.200
2	.200	0	0
1	.200	0	0

Gasoline Stations

	A	B	C
3	.667	0	0
2	0	0	0
1	.333	0	0

Residential Consumer Solvent Use

	A	B	C
3	0	0	0
2	.250	.250	0
1	.250	.250	0

Agricultural Pesticide Use

	A	B	C
3	0	0	0
2	0	0	.500
1	0	0	.500

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Source Specific Data

- Location
- Parameters
- Control Devices
- Other Physical Characteristics

258

Pre-existing Inventories

- Uses

259

Data Handling

- Manual Data Recovery
- Computer-assisted Data Recovery

260

QA and QC Procedures for Emission Inventories

- Quality Control
  - audits at strategic point
- Quality Assurance
  - external review and audit procedures

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Chapter Summary

- Emissions Inventory Introduction
- Purpose of Emissions Inventories
- Elements of an Emissions Inventory
- Quality Assurance and Quality Control Procedures for an Emissions Inventory

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APTI Course 452

Principles and Practices of Air Pollution Control

Chapter 10:
Control of Mobile Sources

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Chapter Overview

- Mobile Sources
- Future Alternatives

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Mobile Source Categories

1. On-road vehicles include:
- Motorcycles;
- Passenger cars and trucks; and
- Commercial trucks and buses.
2. Nonroad vehicles and engines include:
- Aircraft;
- Heavy equipment;
- Locomotives;
- Marine vessels;
- Recreation vehicles (snowmobiles, all-terrain vehicles, etc.); and
- Small engines and tools (lawnmowers, etc.).

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Mobile Sources

- Automobiles
- Diesel Engines
- Off-Road Vehicles and Equipment
- Airplanes
- Railroad Locomotives and Marine Engines

267

Mobile sources are estimated to be responsible for about half of all emissions

- 47 percent of VOC emissions
- 56 percent of NOX)emissions
- 80 percent of CO emissions and
- 50 percent of the hazardous air pollutants in urban areas.

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The transportation sector is responsible for:

- Over 55% of NOx total emissions inventory in the U.S.
- Less than 10% of VOCs emissions in the U.S.
- Less than 10% of PM2.5 and PM10 emissions in the U.S.

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Automobiles

- Air pollution and cars were first linked in 1952 by Dr. Haagen-Smit, California Institute of Technology, who determined that mobile sources were to blame for a large part of the smoggy skies over Los Angeles.
- Motor vehicles are by far the greatest mobile source of air pollution.

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Milestones in Auto Emission Control

- 1961 California requires Positive Crankcase Ventilation.
- 1966 California sets first emission standards
- 1968 EPA sets emission standards
- 1971 EPA evaporative emission standards
- 1975 EPA standards require catalytic converters

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- 1981 Sophisticated three-way catalysts with on-board computers and oxygen sensors appear in most new cars.
- 1995 Reformulated gasoline provisions take effect in the nation's smoggiest cities.
- 1996 All new cars and light trucks must meet new tailpipe and cold-temperature carbon monoxide standards.

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Automobiles and Emissions

3 sources: Evaporation, refueling and exhaust

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Evaporative Emissions

- Diurnal emissions occur due to evaporation of gasoline from the fuel tank.
- Running losses occur as the gasoline vapors are vented from the fuel tank while the automobile is operating and the fuel in the tank becomes hot.
- Hot soak emissions are released when the engine is turned off .
- Refueling emissions occur once the tank is open.

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Refueling

- The amount of gasoline vapors in the automobile fuel tank increases as the quantity of liquid gasoline in the fuel tank decreases.
- Conventional nozzles allows these vapors to escape from the automobile fuel tank through the fill pipe opening into the atmosphere.
- Stage II vapor recovery systems collect the gasoline vapors that are forced out of the automobile fill pipe opening with a vapor recovery nozzle.

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Automobile Exhaust Emissions

- 90% of automobile emissions come from the exhaust
- Nitric oxide occurs due the high temperature and pressure break down of oxygen and nitrogen atoms with the engine combustion.
- CO forms as result of the incomplete fuel combustion
- Unburned hydrocarbons

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Control of Automobile Emissions

- Federal Emission Standards
- Control Devices
- Gross Emitters
- Reformulated Gasoline
- Alternative Fuels

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Vehicle Emissions Certification

- TLEV: Transitional low emission vehicle
- LEV: Low Emission vehicle
- ULEV: ultra low emission vehicle
- SULEV: super ultra low emission vehicle
- PZEV: partial zero emission vehicle

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Tier 3

- Systems approach to reducing motor vehicle pollution: more stringent vehicle standards enabled by gasoline sulfur control
- Creates a harmonized vehicle program
  - Coordinated with California standards for model years 2017-2025
  - Enables auto industry to produce and sell one vehicle nationwide
- Part of comprehensive approach to create cleaner, more efficient vehicles

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Air Quality and Public Health

- Tier 3 standards will have immediate health and air quality benefits
- Will help attain and maintain ozone and PM NAAQS
  - Provides cost-effective national reductions that avoid more expensive local controls
- Reduces pollution near roads
  - More than 50 million people live, work, or go to school near major roads

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Why Lower Sulfur Gasoline?

- Tier 3 vehicle standards depend upon lower sulfur gasoline as Sulfur at prior levels degrades the performance of vehicle catalytic converters the primary emission control system on vehicles
- Lower sulfur also provides immediate reductions in NOx and VOC emissions from the existing fleet
- California already has lower sulfur gasoline (as do Europe, Japan, S. Korea, and several other countries)

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Tier 3 Vehicle Standards 2017-2025

- Tighter VOC and NOx tailpipe standards
  - 80% reduction from today's fleet average
- Tighter PM tailpipe standard
  - 70% reduction in per-vehicle standard
- Reduced fuel vapor emissions and improved system durability
- Added Ethanol as a certification test fuel
- Regulatory streamlining/harmonization changes in response to the President's Regulatory Review initiative

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Tier 3 Fuel Standards

- Lower the average sulfur standard from 30 to 10 ppm starting January 1, 2017
  - California is already 10 ppm sulfur on average, and Europe and Japan have a 10 ppm cap
- Maintain the current per-gallon sulfur caps (80 ppm at refinery gate, 95 ppm at retail)

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Impacts on Refiners

- Of the 111 refineries EPA estimates that:
  - 29 are either already meeting the Tier 3 standard, or could do so with operational changes alone
  - 66 could meet the Tier 3 standard by modifying their existing equipment
  - 16 will have to install new equipment to comply with Tier 3
- Refiners would invest roughly $2.1 billion

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Tier 3 Onroad Inventory Reductions

	2017		2030	
	Tons	Percent	Tons	Percent
NO_x	284,000	8	525,000	28
VOC	45,000	3	226,000	23
PM 2.5	NA	NA	7,500	10
CO	747,000	4	5,765,000	30
Benzene	1,625	4	8,581	36
Total air toxics	15,000	3	90,000	23

- Emission reductions will continue to grow beyond 2030 as more of the fleet continues to turn over to Tier 3 vehicles

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Benefits of Tier 3 by 2030

- 820-2,400 Ozone and PM-related Premature Mortality Avoided
- 3,200 Hospital admissions and asthma-related ER visits and 22,000 Asthma exacerbations
- 23,000 upper and lower respiratory symptoms in children:
- 1.8 million fewer lost school days, work days, and minor restricted activity days due to
- Total Monetized Benefits in 2030 (2010$):
  - $8 to $23 Billion

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Gross Emitters

- It is estimated that less than 10 percent of the vehicle fleet emits approximately 50 percent of the VOC emissions.
- The same vehicles, however, are not always gross emitters for all criteria pollutants - different 10 percent may be gross emitters for CO, NOX, and others.
- Additionally, 10-27 percent of the vehicles failing inspection never end up passing the State Inspection and Maintenance tests.

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Alternative Fuels

- Liquefied petroleum gas
- Natural Gas
- Methanol
- Ethanol
- Biodiesel
- Electricity
- Hydrogen

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Diesel Engines

- PM Emissions
- NOx Emissions

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New Rules for Diesel Engines and Vehicles

- Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles

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Highlights MY 2014-2018

- ☑ First ever Medium- & Heavy-Duty Standards
- ☑ Will reduce oil imports, fuel consumption, CO_2 emissions, and operating costs
- ☑ Allows manufacturers to produce a single fleet of vehicles to meet requirement

- ☑ 530 million barrels less oil
- ☑ 270 MMT lower GHGs
- ☑ $50 billion in fuel savings
- ☑ $42 billion in net savings
- ☑ $49 billion in net benefits

292

Unique Aspects of the Rule

- More complex than light-duty and regulates many entities for the first time
  - Heavy-duty truck sector is diverse, serving a wide range of functions
  - Separate procedures for truck and engine performance, new metrics to account for the work that trucks perform hauling freight
- Begins with Model Year 2014
  - typically heavy-duty rules give 4+ years lead time

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Unique Aspects of the Rule

- Gets existing technology off of the shelf and onto new trucks
  - As first-ever regulation of this sector, rule drives truck makers to apply fuel-saving technologies across all vehicles
  - Flexible enough that fleets can get the right truck for their business
- Enjoys broad support from major stakeholders
  - Truck makers wanted a national program supported by California
  - American Trucking Association wanted national fuel economy standards
  - Environmental stakeholders support early action on climate change

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Key Elements of the Final Rule

- Breaks diverse truck sector into 3 distinct categories
  - Line haul tractors “semis” (largest heavy-duty tractors used to pull trailers, ie. 18 wheelers)
  - Heavy-duty pickups and vans (3/4 and 1 ton trucks and vans made primarily by Ford, GM and Chrysler)
  - Vocational trucks (everything else, buses, refuse trucks, concrete mixers, ambulances…)
- Sets separate standards for engines and vehicles, ensures improvements in both

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Key Elements of the Final Rule

- Sets separate standards for fuel consumption, CO_2, N_2O, CH_4 and HFCs. Fuel consumption and CO_2 standards are aligned.
- Provides incentives for advanced technologies (e.g. EVs and Hybrids)
- Manufacturer flexibilities, including averaging, banking and trading
- New compliance methods for heavy-duty hybrids and innovative technologies not contemplated in existing engine and vehicle test procedures

296

SmartWay Transport Partnership

- EPA program to improve freight transportation efficiency
- Encourages key technologies such as idle reduction, improved aerodynamics, & efficient tires

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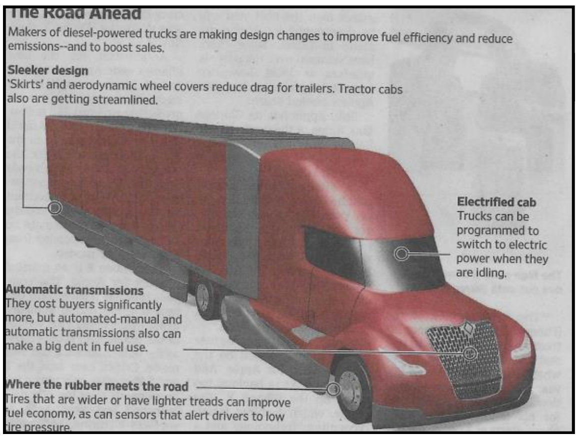

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Airplanes

- Emissions contribute only about one percent of NOx emissions and six percent of PM emissions from mobile sources.
- Commercial Aircraft Standards
- International Civil Aviation Organization

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Contrails

- Contrails are line-shaped clouds or “condensation trails” composed of ice particles that are visible behind jet aircraft engines under certain atmospheric conditions and at times can persist. EPA is not aware of any deliberate actions to release chemical or biological agents into the atmosphere. If you have a question, please see the Contact Us page or call the contrail information line at 734-214-4432 to hear a message.

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Railroad Locomotives

- Emission standards
  - Tier 2 manufactured in 2005 and later
  - Tier 3 manufactured in 2009
  - Tier 4 manufactured in 2014

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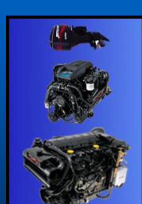
Gasoline Marine Engines

- Gasoline-Fueled Outboard Engines and Personal Watercraft
- Switch out 2 stroke with 4 stroke
- Stern Driven and Inboard Gasoline Engines



302

Diesel Marine Engines

- Tier 3 emissions standards for newly built engines that are phasing in from 2009.
- Tier 4 standards for newly built commercial marine diesel engines above 600kW, based on the application of high-efficiency catalytic aftertreatment technology, phasing in beginning in 2014.

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Future Alternatives

- Electric Cars
- https://www.epa.gov/transportation-air-pollution-and-climate-change/smog-soot-and-other-air-pollution-transportation

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Review Questions

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