Day 1

Course: 435
Day: 1
Lesson Time: 480 minutes
Prepared By: C2 Technologies, Inc
Date: September 26, 2008

Student Manual Coverage:

Chapter 1. An Introduction to Atmospheric Sampling
Chapter 2. Basic Gas Properties and Mathematical Manipulations
Chapter 3. Air Measuring Instruments

Learning Content:
Registration & Welcome

Pretest

BREAK

Course goal and logistic information
Chapter 1. An Introduction to Atmospheric Sampling

Chapter 2. Basic Gas Properties and Mathematical Manipulations
2.1 Temperature
- The Fahrenheit and Celsius Scales
- Absolute Temperature

2.2 Pressure
- Definition of Pressure
- Barometric Pressure
- Torricelli Barometer
- Fortin Barometer
- Aneroid Barometer
- Pressure Transducers
- Gauge Pressure
- Absolute Pressure
- The Concept of Pressure-Head
- Dalton's Law of Partial Pressure

2.3 The Ideal Gas Laws
- Boyle's Law
- Charles' Law
- The Law for Ideal Gases
- Molar Volume ( )

2.4 Gas Density
- Standard Conditions for Atmospheric Sampling
- Origin and Definition of Viscosity
- Kinematic Viscosity
- Liquid Viscosity versus Gas Viscosity
- Determination of Viscosity of Gases

2.5 Reynolds' Number

2.6 Summary of Useful Equations
- Temperature
- Pressure
- Ideal Gas Law
- Gas Density
- Viscosity,
- Reynolds' Number

2.7 Units of Measurements
- Recommended Units
- Conversion Problems
- References

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Chapter 3. Air Measuring Instruments

3.1 Introduction to Air Movers
- Relationship of Air Movers to Other Sampling System Components
- Air Mover Classification

3.2 Air Mover Selection Criteria
- Pollutant Concentration and Sampling Time
- Sampling Rate Required
- Physical and Chemical Nature of Air to be Sampled
- Portability of Air Mover
- Air Mover Noise
- Air Mover Maintenance
- Resistance
- Constant Flow Rate

3.3 Pumps
- Definition and Classification
- Positive Displacement Pumps
- Centrifugal Pumps
- "Driving Forces" for Pumps
- Characteristic Curves
- Selecting a Pump
- Pump Gauges

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3.4 Ejectors
- Principle of Operation
- Driving Forces
- Sampling Use of Ejectors

3.5 Liquid Displacers
- Principle of Operation
- Sampling by Use of Liquid Displacement

Safety Briefing & Laboratory Assignments

Laboratory Session I (Calibration of Wet test Meter)

Adjourn

Optional Content:

Class Work:

Homework:

Problem Sets:

Solution:

Day 2:

Course: 435
Day: 2
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Student Manual Coverage:

Chapter 3. Air Measuring Instruments(Cont')
Chapter 6. Gaseous Sampling
Chapter 7. Standard Methods for Criteria Pollutants
Chapter 4. Particulate Matter Sampling

Learning Content:

Chapter 3. Air Measuring Instruments(Cont')
3.6 Air Displacers
- Evacuated Flasks: Principle of Operation
- Sampling by Use of Evacuated Flasks
- "Plastic" Bags: Principle of Operation
- Sampling by Use of "Plastic" Bags

3.7 Flow Rate Control
- Control by Diversion
- Resistance Control
- Driving Force Control

3.8 Flow Rate for Sampling
- Need for Control
- Control Mechanisms

3.9 Air Measuring Instruments
- Introduction
- Types of Air Measuring Devices
- Calibration

3.10 Volume Meters
- The Spirometer (or "Bell Prover") – Primary Standard
- Displacement Bottle Technique - Primary Standard
- Frictionless Pistons - Primary Standard
- Automated Bubble Flowmeters
- Automated Dry-Piston Flowmeters
- Wet Test Meter (WTM) - Secondary Standard
- Roots Meter - Secondary Standard
- Dry Test Meter - Secondary Standard

Chapter 6. Gaseous Sampling
6.1 Principles of Absorption
- Introduction
- Types of Absorption
- Physical Absorption
- Chemical Absorption

6.2 Collection Efficiency
- Factors Affecting Collection Efficiency
- Absorber Characteristics
- Chemical Characteristics
- Physical Characteristics

6.3 Determination of Collection Efficiency
- Absorption Devices
- Fritted-glass Absorbers
- Impingers
- Summary
- Current Applications of Absorption in Atmospheric Sampling

6.4 Principles of Adsorption
- Basic Principles
- Types of Adsorption
- Physical Adsorption
- Chemical Adsorption
- Variables Affecting Gas Adsorption
- Adsorption Isotherms
- Types of Adsorption Isotherms
- Adsorbate Characteristics
- Gas Liquefaction
- Adsorbate Size
- Gas Concentration
- Presence of Other Gases
- Adsorbent Characteristics
- Surface Area
- Pore Size
- Chemical Nature
- Typical Adsorbents
- Carbon
- Molecular Sieve
- Adsorption Losses in Air Sampling
- Current Applications of Adsorption in Atmospheric Sampling
- Summary

6.5 Selection and Performance of Wet Collector Media
- Introduction
- Absorber Design/Selection Considerations
- Retention Characteristics of Absorbant (Solvent)
- Retention of Gases and Vapor by Chemical Reaction
- Retention of Particulate Matter

6.6 Principles of Grab Sampling
- Introduction
- Evacuated Containers
- Air Displacement or Purging
- Liquid Displacement
- Inflation - “Plastic Bag” Sampling
- Syringes
- Grab Sampling Techniques
- Current Applications of “Whole Air” (Grab & Integrated) Sampling in Ambient Air

6.7 Principles of Cryogenic (Freezeout) Sampling

- Introduction
- Concept
- Equipment
- Single-Stage Units
- Multistage Units
- Efficiency
- Current Applications of Cryogenic “Freezeout” Sampling in Ambient Air
- Summary

BREAK

Chapter 7. Standard Methods for Criteria Pollutants

7.1 Reference Method and Equivalent Method

- Criteria Pollutants and Measurement Methods
- Particulate Matter
- PM2.5
- PM10
- Ozone
- Carbon Monoxide
- Nitrogen Dioxide
- Sulfur Dioxide
- Lead

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Chapter 4. Particulate Matter Sampling

4.1 Introduction

- Principles of Inertial Collection

4.2 Inertial Sampling Devices

- Impaction Devices
- Impingement Devices
- Centrifugal Separation Devices
- Virtual Impactors-Dichotomous Sampler

4.3 Collection Efficiency and Penetration Efficiency of Inertial Sampling Devices

- Definition of Collection Efficiency and Penetration Efficiency
- Impactor Performance Characteristics
- Properties of Aerosols Affecting Inertial Collection Efficiency
- Properties of the Collecting Device Influencing Collection Efficiency

4.4 Limitations and Sources of Error in Inertial Collection

- Inherent Errors in Sample Collection
- Errors Associated with the Calibration of Collection Devices
- Errors in Sample Analysis
- Size-Selective Inlets and Devices for Aerosol Sampling

4.5 Filtration Sampling

- Introduction
- General Considerations
- The Theory of Filtration
- Collection Efficiency of Filters
- Characteristics of Filter Media
- Sample Problems

4.6 Gravitational Sampling
- Dustfall Bucket or Jar
- Precipitation Collectors

4.7 Electrostatic Precipitators
- Introduction
- Principles of Electrostatic Precipitation
- Collection Efficiency
- Specific Applications

4.8 Thermal Precipitators
- Introduction
- Collection Efficiency and Deposition Pattern
- Advantages and Disadvantages of Thermal Precipitators

4.9 Summary

Laboratory Session II (Gas Measuring Devices & PM Samplers)

ADJOURN

Optional Content:

Class Work:

Homework:

Problem Sets:

Solution:

Day 3

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Day: 3
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Student Manual Coverage:

Chapter 5: Methodologies and Instrumentation for Particulate Matter Sampling

Learning Content:

Review and Q&A Session

Chapter 5: Methodologies and Instrumentation for Particulate Matter Sampling

5.1 Introduction
5.2 High-Volume Sampling for Suspended Particulate Matter (SPM) and Air Toxics
5.3 High-Volume Air Sampling

- Introduction
- Development of the High-Volume Sampler
- Sampler Shelter Combination
- Filter Media for High-Volume Sampler
- Precautions in Filter Handling
- Calibration
- U.S. EPA High Volume Sampling Procedure for TSP (Appendix B of 40 CFR 50)
- Sample Problems
- Problem 1: High-Volume Sampling
- Problem 2: High-Volume Sampling
- Problem 3: High-Volume Sampling
- Analysis of High-Volume Filters
- Sampling Accuracy and Precision
- Accuracy
- Precision
- Maintenance
- Summary

5.4 FRM for the Determination of Particulate Matter as PM10

- Applicability
- Principle
- Range
- Precision
- Accuracy
- Potential Sources of Error
- PM10 Sampler Apparatus
- Filter Media
- Calculations
- Sample Problems
- Problem 1: PM10 Sampling
- Problem 2: PM10 Sampling

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5.5 FRM and FEM for the Determination of Fine Particulate Matter as PM2.5

- Reference Methods for PM2.5 (FRM)
- Designated Methods for PM2.5
- Equivalent Methods for PM2.5 (FEM)
- Limitations of PM2.5 Reference and Class I Equivalent Methods
- Approved Regional Methods (ARMs)
- Calculations
- Sample Problems
- Problem 1: PM2.5 Sampling
- Problem 2: PM2.5 Sampling

5.6 FRM and FEM for the Determination of Coarse Particles (PM10-PM2.5)

5.7 PM2.5 Speciation Sampling

5.8 Continuous in situ Monitoring for Particulate Matter

- National Core (NCore)
- State and Local Air Monitoring Stations (SLAMS)

5.9 Automated Federal Equivalent Monitors

- Beta Attenuation Monitor (BAM)
- Tapering Element Oscillating Microbalance (TEOM®)

5.10 Other Automated PM Methods

- Mass and Mass Equivalent
- Piezoelectric Microbalance
- Pressure Drop Tape Sampler (CAMMS)
- Visible Light Scattering
- Nephelometer
- Optical Particle Counter (OPC)
- Condensation Nuclei Counter (CNC)
- Aerodynamic Particle Sizer (APS)
- Light Detection And Ranging (LIDAR)
- Visible Light Absorption
- Aethalometer and Particle Soot/Absorption Photometers
- Photoacoustic Spectroscopy
- Electrical Mobility
- Electrical Aerosol Analyzer (EAA)
- Differential Mobility Particle Sizer (DMPS)
- Chemical Components
- Single Particle Mass Spectrometers
- Carbon Analyzer
- Sulfur Analyzer
- Nitrate Analyzer
- Multi-Elemental Analyzer
- Streaker
- DRUM

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Laboratory Session III (Gas Measuring Devices & PM Samplers)

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Optional Content:

Class Work:

Homework:

Problem Sets:

Solution:

Day 4

Course: 435
Day: 4
Lesson Time: 480 minutes
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Student Manual Coverage:

Appendix A. Statistical Techniques Employed in Atmospheric Sampling
Appendix G. Significant Figures and Rounding Off
Chapter 8. Introduction to Ambient Air Sampling for Air Toxics

Learning Content:

Course goal and logistic information

Review and Q&A Session

Quality Assurance/Quality Control
Appendix A. Statistical Techniques Employed in Atmospheric Sampling
A.1 Introduction
A.2 The Data Quality Objectives (DQO) Process
- The Seven Steps of the DQO Process
- Outputs of the DQO Process

A.3 Data Collection Design
- Data Plotting

A.4 Graphical Analysis
- Frequency Tables
- The Frequency Polygon
- The Histogram
- The Cumulative Frequency Distribution
- Distribution of Data
- Transformation of Data
- The Logarithmic Transformation
- Probability Graph Paper
- Least-Square Linear Regression

A.5 Measures of Central Tendency
- Arithmetic Average, or Mean
- Median
- Geometric Mean

A.6 Measures of Dispersion
- The Range
- Standard Deviation
- Coefficient of Variation
- Standard Geometric Deviation

A.7 Distribution Curves
- The Normal Distribution
- Lognormal Distributions

Quality Assurance/Quality Control (cont)
Appendix G. Significant Figures and Rounding Off
G.1 Working with Numbers
- Intro Problems

G.2 Approximate Numbers
- Rule 1 (General)
- Rule 2 (General)

G.3 Rounding Approximate Numbers
- Rule for Rounding Approximate Numbers

G.4 Adding and Subtracting Approximate Numbers
- Truncating Approximate Numbers Following Addition or Subtraction

G.5 Multiplying and Dividing Approximate Numbers
- Significant Digits
- Truncating Approximate Numbers Following Multiplication or Division

G.6 Reasonability
- Rule to Meet the Conditions of Reasonability

G.7 Practice Exercises
G.8 Answers to Intro Problems
G.9 Answers to Practice Exercises

BREAK

Chapter 8. Introduction to Ambient Air Sampling for Air Toxics
8.1 Introduction
- What are Toxic Air Pollutants?
- Clean Air Act of 1990
- Timeline for Air Toxics Monitoring

8.2 What is Risk?
- What is a Risk Assessment?
- Hazard Identification
- Weight of Evidence for Health Problems of Concern
- Exposure Assessment
- Dose-Response Assessment
- Dose-Response Relationships
- Risk Characterization

8.3 Introduction to Air Toxics Methods
- Monitoring Program Goal and Objectives
- Description of the Methods
- Compendium Method TO-11A
- Compendium Method TO-13A
- Compendium Method TO-15A
- Compendium Method IO-3.5

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Laboratory Session IV (Gas Measuring Devices & PM Samplers)

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Optional Content:

Class Work:

Homework:

Problem Sets:

Solution:

Day 5

Course: 435
Day: 5
Lesson Time: 180 minutes
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Student Manual Coverage:

Learning Content:

Course goal and logistic information

Complete Laboratory Exercises and Reports

BREAK

Review Session

Post Test

Course Critique

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Optional Content:

Class Work:

Homework:

Problem Sets:

Solution: