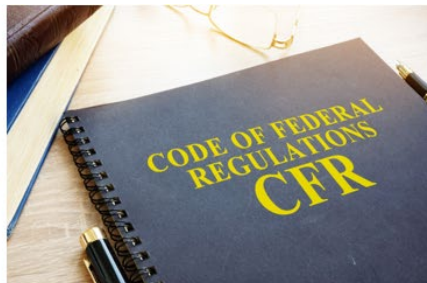




UNITED STATES  
ENVIRONMENTAL  
PROTECTION AGENCY

# INTRODUCTION TO CONTINUOUS MONITORING SYSTEMS

## PARTICIPANT GUIDE



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# Welcome!

## About this Course

The one-day classroom *Introduction to Continuous Monitoring Systems (CMS) Course* provides participants with a basic understanding of CMS. It provides an overview of key concepts and information on CMS, including purpose and uses, types, systems design and components, regulations, audits/inspections, and enforcement procedures. This course is an introductory course to CMS. For a more in-depth and comprehensive training course on CMS please refer to APTI 474, CMS.

## Course Organization

There are three modules in this course:

- Module 1: Purpose and Types of CMS
- Module 2: Regulatory Aspects for CMS
- Module 3: Audits/Inspections and Enforcement

## Target Audience

This course is intended for a fairly broad audience and could include participants with non-technical backgrounds (e.g., a basic degree in science) as well as technical backgrounds (e.g., a chemical engineering degree). This course is an introductory course for CMS, therefore, no prior knowledge of CMS is presumed. This course is intended primarily for new hires or any participants who need a basic understanding of CMS in their job responsibilities.

Staff who could benefit from the course include, but are not limited to the following:

- Staff who are inspection and/or enforcement personnel
- Staff who observe stack test and CMS certifications

- Staff who review audit reports
- Staff who work on permits

## Course Goals and Learning Objectives

Upon completing this course, learners will gain a basic understanding of Continuous Monitoring Systems (CMS). They will be able to use the knowledge gained on the following topics to assess the accuracy of CMS data and the ongoing compliance of sources monitored by CMS:

- Types and purposes of CMS
- Review of regulatory basis for CMS
- Overview of enforcement aspects for CMS

At the end of this course, learners will be able to:

- Understand the purpose of CMS and different types and uses of CMS
- Identify the regulations that contain CMS requirements
- Recognize enforcement aspects of CMS

## Prerequisites

There are no prerequisites for this course.

## Evaluation

The following types of evaluation will be conducted:

- Level 1 evaluation (reaction): accomplished through the use of the standard end-of-course evaluation
- Level 2 evaluation (learning): accomplished through the completion of post-training assessment (this could include the Post Self-Assessment, Course Exam, or both)

## Class Size

Typically, class size should be limited to 30 participants or fewer to increase engagement, pace, and interaction among the facilitator(s) and participants.

## Course Agenda

Scheduled Time	Module	Duration
8:30 am – 9:00 am	Introductions	30 minutes
9:00 am – 10:45 am	Module 1	105 minutes
10:45 am – 11:00 am	Break	15 minutes
11:00 am – 11:30 am	Module 2	30 minutes
11:30 am – 12:00 pm	Module 3	30 minutes
12 pm – 1:00 pm	Lunch	60 minutes
1:00 pm – 1:30 pm	Module 3, continued	30 minutes
1:30 pm – 4:00 pm	Site visit	150 minutes
4:00 pm – 5:00 pm	Post-Training Assessment (optional) and Exam	60 minutes
	<b>Total:</b>	<b>510 minutes (8.5 hours)</b>

# About the Participant Guide

## PowerPoint Slides

This participant guide contains a copy of the PowerPoint presentation slides that the instructor(s) will use to teach this course. This participant guide is yours to keep, so feel free to take class notes on the lines provided below each slide.

## Appendices

There are two appendices in this guide:

- **Appendix A: Pre and Post Self-Assessment** – Your instructor may direct you to complete a self-assessment prior to and after the course. These self-assessments will help you to establish a baseline of what you may already know about the information contained in this course. Then, a post self-assessment will allow you to compare how your knowledge and skills have changed as a result of completing the course.
- **Appendix B: Handouts**—Your instructor will provide you with several handouts for this course, which include a Master Glossary, as well as handouts covering General Provisions, Light Properties, Commonly Used Technologies, and General Categories of CMS.

**WELCOME!**



Introduction to Continuous Monitoring Systems

NACT 221

*Disclaimer: Any pictures herein are for educational purposes only and not intended to be an endorsement of any particular manufacturer, vendor, or product*


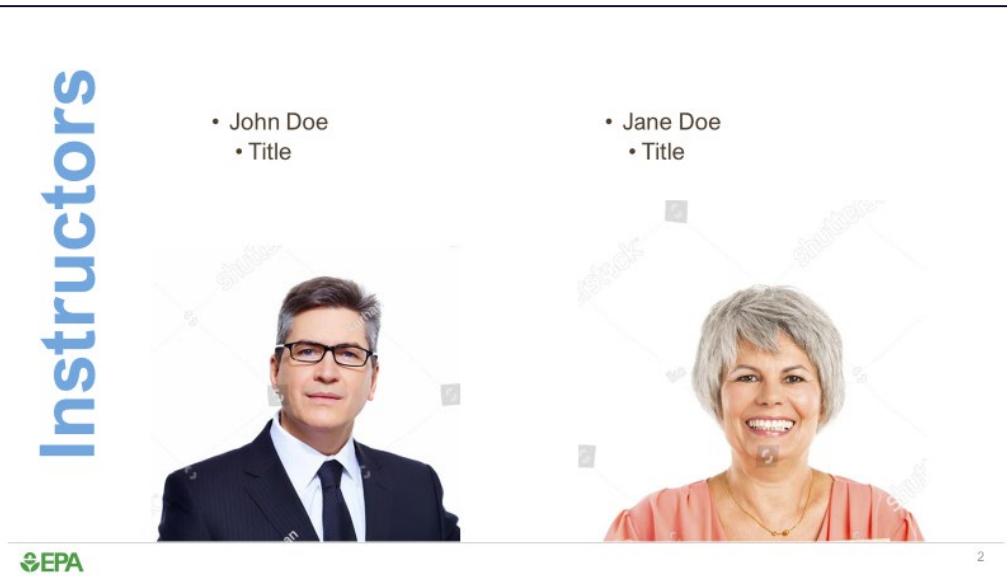
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**Instructors**

- John Doe  
• Title
- Jane Doe  
• Title



2

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## Course Introduction

- 01 Logistics
- 02 Introductions
- 03 Course Goal
- 04 Course Learning Objectives
- 05 Course Materials




## Logistical Information

- Location of the restrooms, coffee, refreshments
- Emergency evacuation information





01 Name  
02 Job Title  
03 Expectation



**INTRODUCTIONS**

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### Course Goal

Upon completing this course, you will gain a basic understanding of Continuous Monitoring Systems (CMS). You will be able to use the knowledge gained on the following topics to assess the accuracy of CMS data and the ongoing compliance of sources monitored by CMS:

- Types and purposes of CMS
- Review of regulatory basis for CMS
- Overview of enforcement aspects for CMS

These topics are covered through three separate modules.



EPA

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## Course Learning Objectives

At the end of this course, learners will be able to:

- Understand the purpose of CMS and different types and uses of CMS
- Identify the regulations that contain CMS requirements
- Recognize enforcement aspects of CMS



## Course Materials

You should have the following course materials:

- Participant Guide
- Handouts
  - Master glossary
  - General provisions
  - Properties of light
  - Commonly used technologies
  - General categories of CMS
  - Pre and post self-assessment

## Course Schedule

Scheduled Time	Module	Duration
8:30 am – 9:00 am	Introductions	30 minutes
9:00 am – 10:45 am	Module 1	105 minutes
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1:00pm-1:30pm	Module 3, continued	30 minutes
1:30pm-4:00 pm	Site visit	150 minutes
4:00pm-5:00pm	Post-Training Assessment and Exam	60 minutes
		Total: 510 minutes (8,5 hours)



# **MODULE 1: Purpose and Types of CMS**

# Module 1: Purpose and Types of CMS

## Module 1 Description:

In Module 1, participants will gain a basic understanding of continuous monitoring systems (CMS), including learning about four different types of CMS. They will learn the reasons why CMS are important, as well as their uses.

## Module 1 Learning Objectives:

- Describe different types and uses of CMS
- Define opacity and describe how continuous opacity monitoring systems (COMS) are used
- Distinguish between extractive and in-situ systems
- Describe how predictive emission monitoring systems (PEMS) function
- Describe how continuous emission rate monitoring systems (CERMS) function
- Describe CEMS location and siting considerations

Estimated Time: **105 minutes (1.75 hours)**

## Module 1: Purpose and Types of CMS



## Module 1 Outline

- What are CMS and why are they important
- Basis for CMS programs
- Types and uses of CMS
- Considerations for choosing a CEMS location

## Module 1 Learning Objectives

- Describe different types and uses of CMS
- Define opacity and describe how continuous opacity monitoring systems (COMS) are used
- Recognize the pollutant parameters measured by continuous monitoring systems (CMS)
- Describe the components of continuous emission monitoring systems (CEMS)
- Distinguish between extractive and in-situ systems
- Describe how predictive emission monitoring systems (PEMS) are used
- Describe how continuous emission rate monitoring systems (CERMS) function
- Describe CEMS location and siting considerations



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## What are CMS?

***Continuous monitoring systems (CMS)*** means “the total equipment, required under the emission monitoring sections in applicable subparts, used to sample and condition (if applicable), to analyze, and to provide a permanent record of emissions...”*40 CFR Part 60*



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## Why CMS?



CMS are required under some of the EPA regulations for either continual compliance determinations or determination of exceedances of the emissions standards.



The individual subparts of the EPA rules specify the reference methods that are used to substantiate the accuracy and precision of the CMS.

## Basis for CMS Programs



- As a result of the Clean Air Act (CAA), many pollution control devices such as baghouses, scrubbers, and electrostatic precipitators have been installed.
- After the equipment is installed and operating, an air pollution control agency needs to know if the equipment is actually reducing emissions and if the facility is meeting its emissions standards.
- CMS programs are one of the methods used to measure emissions from stationary sources.



## Basis for CMS Programs (Cont'd)

EPA established two methods to measure concentrations of pollutants from regulated sources:

- 1. EPA Reference Methods
- 2. CMS



## Reference Methods

Reference methods are beneficial, but may have disadvantages when compared to using a CMS:

- Performed infrequently and for a relatively short period of time (hours)
- Often conducted when the source is operating under optimal conditions, which may not result in producing normal, day-to-day emission values



# CMS

CMS have become an important part of a facility's compliance demonstration. The advantages of CMS are:



DATA IS CONTINUOUSLY COLLECTED, IN MOSTLY REAL-TIME

DATA IS AVAILABLE FOR ALL OPERATING CONDITIONS



ALLOW REGULATORY AGENCIES TO DETERMINE CONTINUOUS COMPLIANCE



# CMS Are Used To...

Demonstrate compliance with regulations

Generate data that can be used to develop regulations

Improve emission databases

Monitor control equipment operation

Monitor process operating parameters

Identify periods of excess emissions

Assess control equipment efficiency

Validate emission credits

Provide public assurance



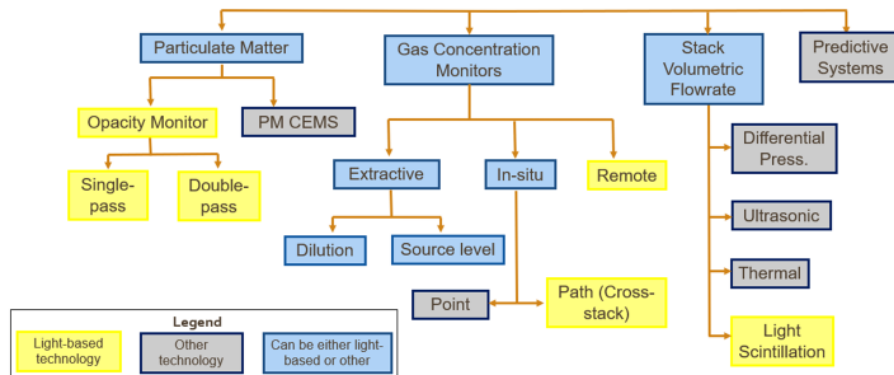
# Pollutant Parameters



Continuous Monitoring Systems (CMS) may be used to measure the following:

- Opacity
- Sulfur Dioxide
- Nitrogen Oxides
- Carbon Dioxide
- Oxygen
- Carbon Monoxide
- Total Reduced Sulfur
- Stack Flow Rate
- Hydrogen Sulfide
- Volatile Organic Compounds
- Particulate matter
- Ammonia
- Mercury
- Hydrogen Chloride
- (And other pollutants or parameters)

# General Categories of CMS



## Types of CMS



- The four types of CMS:
  - Continuous Opacity Monitoring Systems (COMS)
  - Continuous Emission Monitoring Systems (CEMS)
  - Predictive Emission Monitoring Systems (PEMS)
  - Continuous Emission Rate Monitoring Systems (CERMS)

## Continuous Opacity Monitoring Systems (COMS)

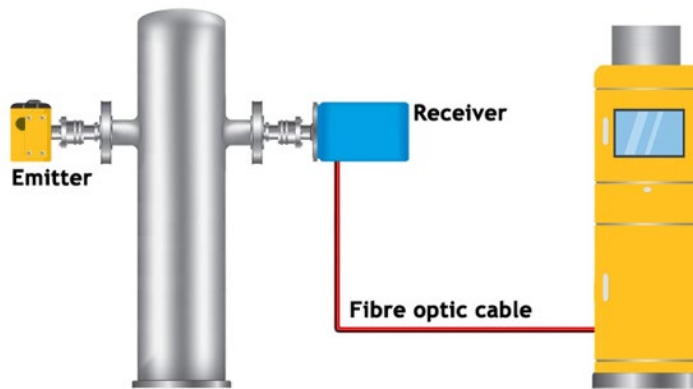


# COMS

- COMS consist of the **total equipment** used to sample, analyze, and provide a permanent record of opacity.
- COMS use light to determine opacity levels.
- Due to absorption and scattering of light by dust, smoke, and/or particulate present in the gas stream, there will be an attenuation of the transmitted light and a decrease in the light intensity that is measured.
- COMS can be "single pass" or "double pass".



# COMS: Illustrative Example

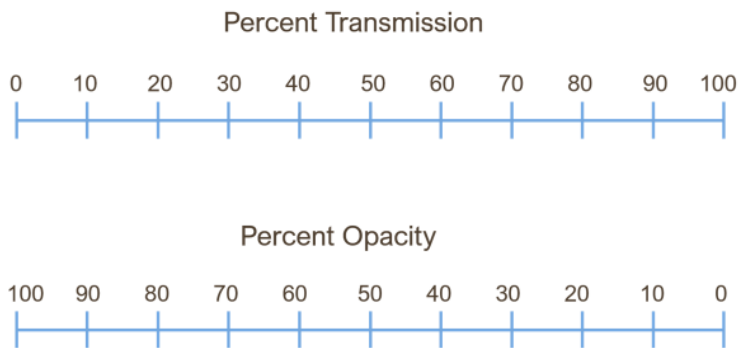


## Opacity – Setting the Stage

- **OPACITY (Op)** → The percentage of light that is attenuated by an optical medium – in our case, the effluent gas stream.
- **TRANSMITTANCE (Tr)** → The percentage of light that is transmitted through an optical medium.  
Therefore,  $Op = 100 - Tr$



## Transmittance vs. Opacity



## Single Pass and Double Pass COMS

Single Pass



Double Pass



- Can be single pass or double pass design (double pass transmissometer).
- Most COMS used for compliance determinations are double pass, which use a light path that is twice the stack diameter.
- Require a means to calibrate and periodically (usually quarterly) audit the COMS.
- Most have a remote display and control panel in the facility control room or CEMS shelter.
- Must have a means to capture, average, and store data measured by the COMS.
- Must have means (most use air blowers) to keep stack gas from impinging on and potentially damaging the lenses of the COMS.



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## Transmissometry

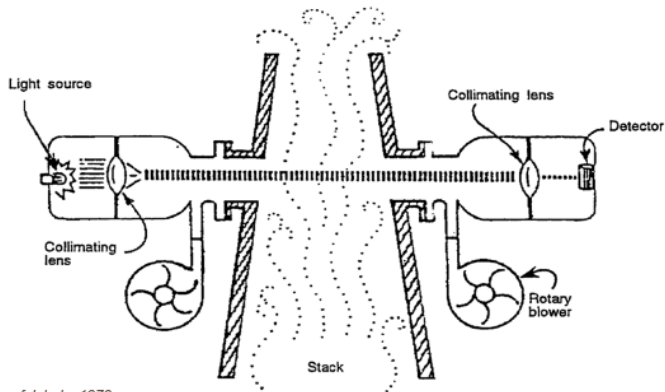
### Transmissometry

- The measurement of the amount of light that can be transmitted through a stack exhaust.
  - The intensity of the light is attenuated by scattering and absorption by PM in the stack exhaust.
  - The amount of attenuation is measured as percent opacity, and is a function of the amount, type, and distribution of PM in the stack gas.



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## Single Pass Transmissometer

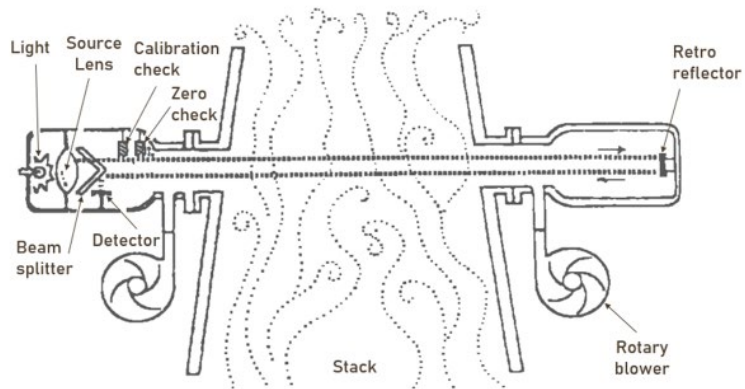


Courtesy of Jahnke 1979



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## Double Pass Transmissometer



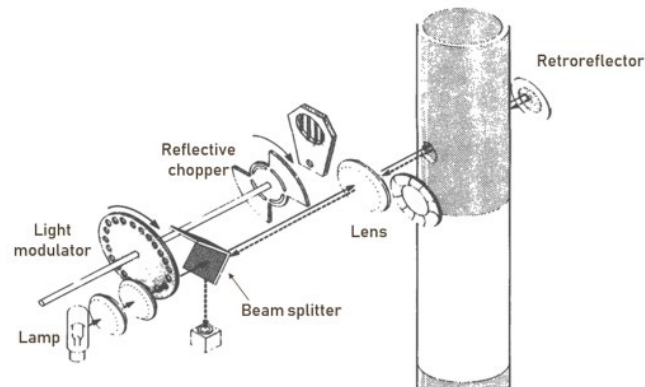
Courtesy of Jahnke 1979



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## Double Pass Transmissometer (Cont'd)



Courtesy of Jahnke 1984



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## Typical Sources with COMS Requirements

- COMS are typically used by facilities that rely on waste materials, oil, coal, wood, or other fossil fuels for combustion.
- Examples of sources are:
  - Utilities
  - Boilers
  - Flares



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## Continuous Emission Monitoring Systems (CEMS)



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## CEMS Definition

CEMS consists of the **total equipment** necessary to determine a gas or particulate matter emission concentration.



*Image courtesy of  
Thermo Fisher  
Scientific™*



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## CEMS

### CEMS:

- Continuously measures actual emissions from stationary sources by extracting a sample of gas from the emission source:
  - Sample gas may be extracted, filtered, transported, conditioned, or diluted before being presented to the analysis system.
  - Gas concentrations are measured, recorded, and stored as data.
- May also include components for measuring particulate matter, and stack gas flowrate



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## Basics of CEMS Design

CEMS can be divided into two general categories based on the means by which the sample gas is acquired (captured) and delivered to the analyzer:

### 1. Extractive systems

- Withdraw flue gas from the stack and transport the gas to analyzers.
- An extractive system may be either source-level or dilution.

### 2. In-situ systems

- Have at least some part of their analysis subsystem mounted in the stack in direct contact with the flue gas.



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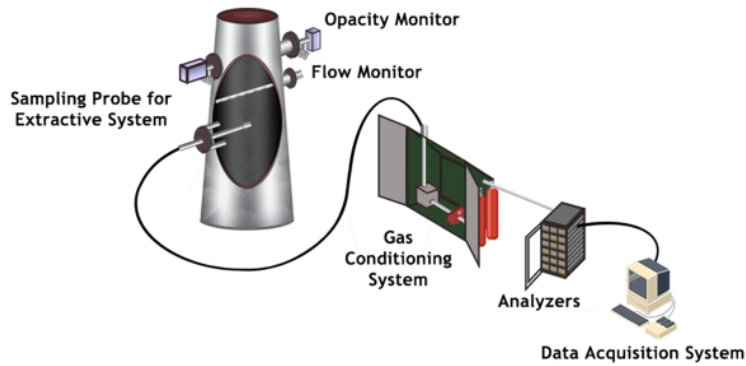
## General Extractive System – Conditioning Cabinet



## General Extractive System Components

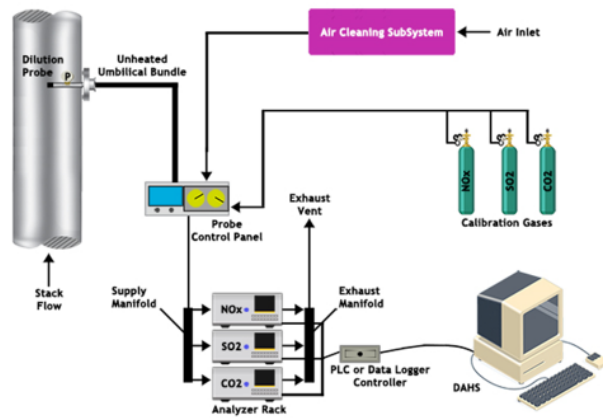
- Probe
- Particulate Filter
- Sample Conditioning or Dilution
- Sample Line
- Pump
- Controller
- Analyzer
- Data Calculation and Storage

# Source-Level Extractive System



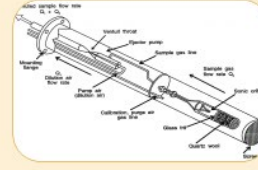
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# Dilution Extractive Systems



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## Dilution Extractive Systems (Cont'd)



The sample gas is diluted with dry, contamination-free air to a level below the dew point of the diluted sample gas to eliminate condensation in the sample line.

- The diluted sample is measured by pollutant and CO<sub>2</sub> monitors operating at or near ambient concentration ranges to provide concentration measurements on a wet basis.

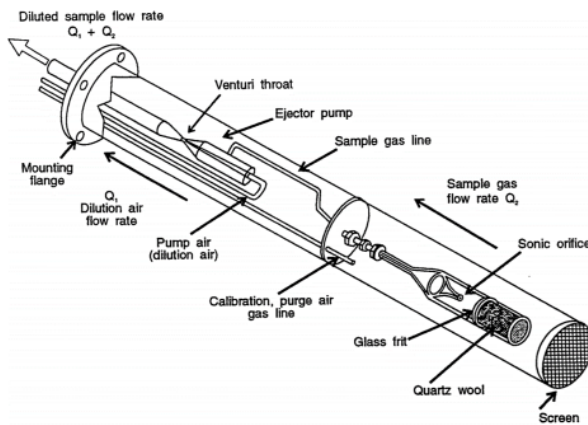
The concentrations are measured on a wet-basis. With a wet stack volume flowrate measurement, the pollutant mass emission rate can be calculated without a separate stack gas moisture measurement or assumption needed.

The most unique component of a dilution-extractive system is the dilution sampling probe.

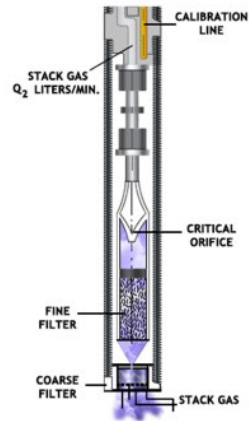
- There are two types, depending on where the dilution occurs:
- In-stack
  - Out of stack



## Dilution Probe



## Dilution Probe Orifice



## In-Situ Systems

- Perform analysis at the stack
- Lack of conditioning and transport sub-systems, hence, generally less equipment required than extractive systems
- EPA distinguishes between point and path monitors by the amount of gas stream that the probe is blocking.
  - Usually "very small" segment (point), or 1 or 2 diameters (path).

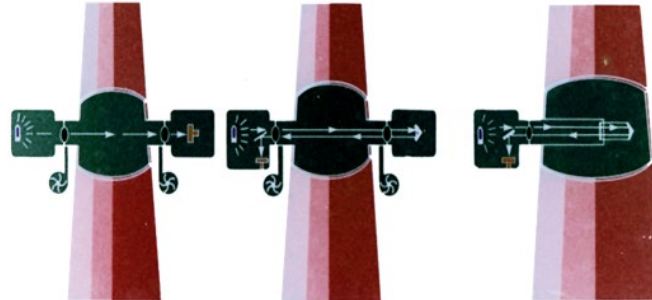
There are two types of in-situ systems:

- **Point systems** – monitor at a single point or along a very short path within the stack.
- **Path systems** (also called "cross stack") – monitor across a certain path of stack gas.

## In-Situ Monitors

### Cross-Stack (path)

### In-Stack (point)



Single Pass

Double Pass



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## Advantages of Extractive Systems

- ✓ Analyzers can be installed in an accessible, clean environment
- ✓ Ease of maintenance
- ✓ Time sharing capability
- ✓ Allows widest selection of analyzer technologies
- ✓ Can combine more than one analyzer
- ✓ Can remove interfering substances before measurement
- ✓ Gas is measured on a dry or wet basis depending on design



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## Disadvantages of Extractive Systems

Expensive to install and operate. It has high power requirements and potential for plugged lines, leaks and condensation (water and acid).	Sample gas conditioning or dilution is required	May alter sample, may inadvertently remove substances of interest from sample gas
Response time of the sampling system may be slow	Has lots of components and a complicated design	Analyzer may have time-lag with high concentrations



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## Advantages of In-Situ Systems



### Advantages

- Fast response time
- No sample transport or conditioning
- Simple, less expensive installation
- Less equipment to buy and maintain
- Has few components



### Disadvantages

- Vibration sensitive
- Access for service and maintenance can be difficult
- Limits choice of analyzer
- Does not allow for expansion
- Operates in a potentially harsh environment
- Path type may not be able to be located downstream of sorbent injection or spray dryer systems



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## Disadvantages of In-Situ Systems



### Advantages

- Fast response time
- No sample transport or conditioning
- Simple, less expensive installation
- Less equipment to buy and maintain
- Has few components

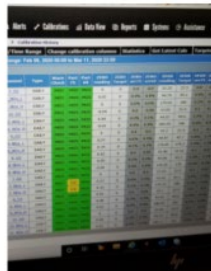


### Disadvantages

- Vibration sensitive
- Access for service and maintenance can be difficult
- Limits choice of analyzer
- Does not allow for expansion
- Operates in a potentially harsh environment
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## Major Components of CEMS

- Sample Probe
- Filter
- Sample Line (umbilical)
- Gas Conditioning System
- Calibration Gas System
- Gas Analyzers (may include more than one)
- Data Acquisition Systems (DAS)



Data Acquisition System

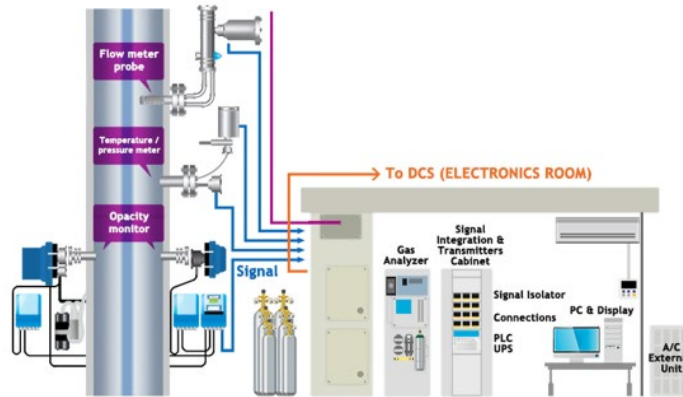


Extractive Conditioning System



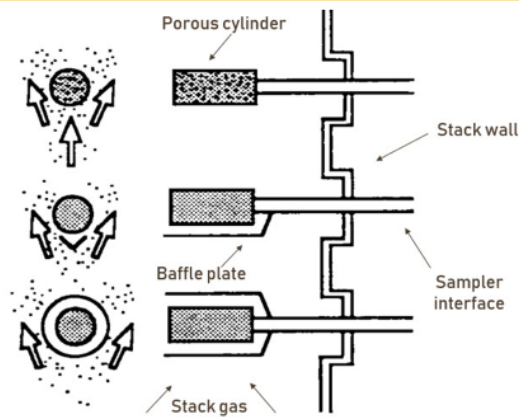
Gas Analyzers

# CEMS: Illustrative Example



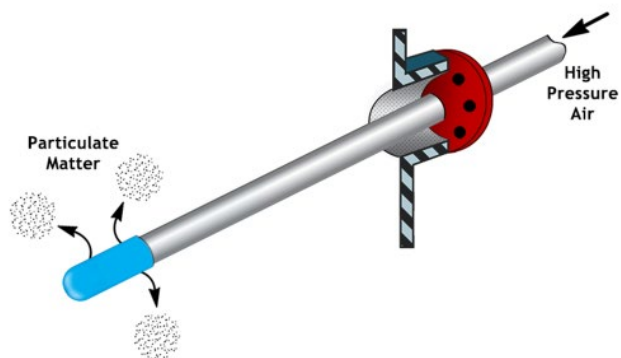
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# External Probe Filters

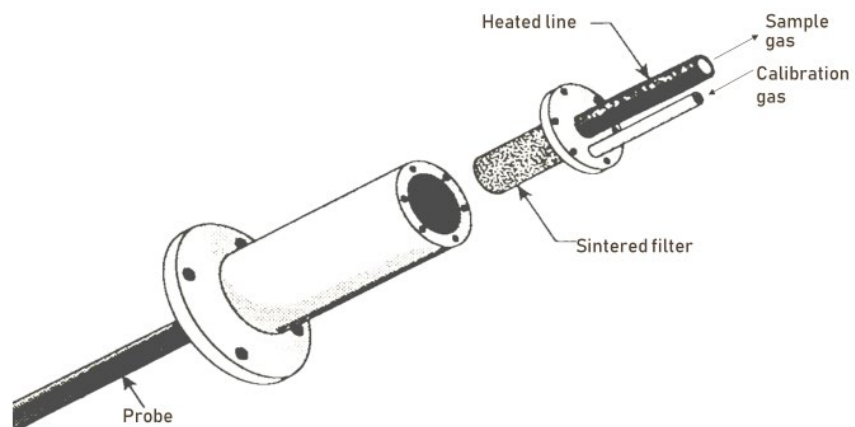


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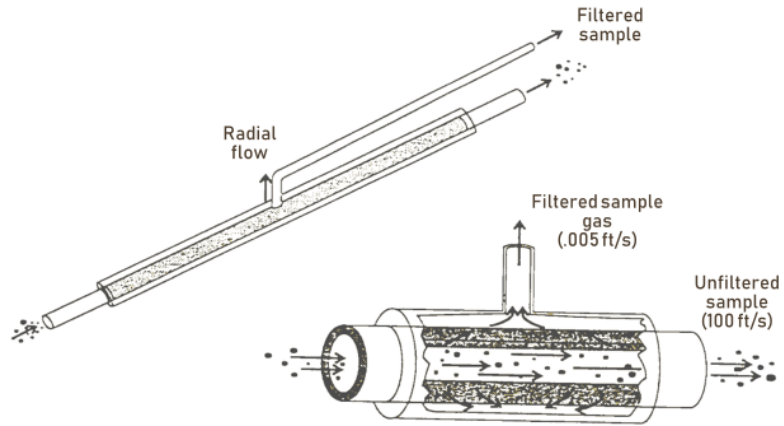
## Filter Blow Back



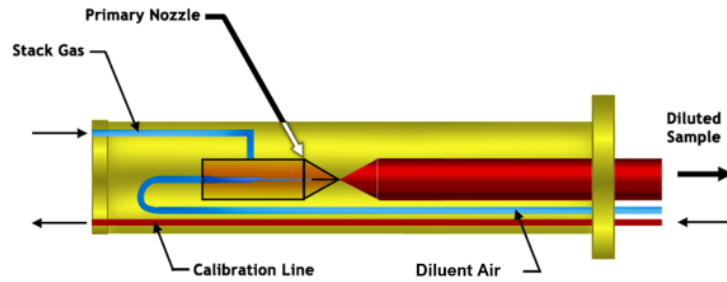
## Internal Coarse Filter



# Inertial Filter



# Example of How a Dilution Probe Works



## Cylinders of EPA Certified Gases and CEMS Cabinet



Cylinders of EPA Certified Gases



Inside a CEMS Shelter



Outside a CEMS Shelter



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## CEMS Unit Shelter



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## Commonly Used Technologies for SO<sub>2</sub> and NO<sub>x</sub>

### Pulsed Fluorescence

- Uses the property of SO<sub>2</sub> molecules to absorb ultraviolet (UV) light and become excited at one wavelength, then decay to a lower energy state emitting UV light at a different wavelength, the measured emitted light corresponding to the concentration of SO<sub>2</sub> in the sample gas.
- The pulsing of the UV source lamp allows the analyzer to use both the light and dark phases of the pulsed light to continuously detect and correct for electronic noise, and to measure lower pollutant concentrations.

### Chemiluminescence

- Uses the light-emitting chemical reaction of NO and analyzer-generated ozone to measure the concentration of the NO in a gas sample. A successive measurement of the NO, plus NO converted from the NO<sub>2</sub> in the sample, gives a total NO<sub>x</sub> measurement; the difference between the two measurements is equal to the NO<sub>2</sub> concentration in the sample.



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## SO<sub>2</sub> Analyzer

- Microprocessor control
- SO<sub>2</sub> specific
- Reflective UV filtering
- Hermetically sealed UV lamp
- No consumables



Image reprinted with permission from Thermo Fisher Scientific™



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## Chemiluminescence NO<sub>x</sub> Analyzer



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## Commonly Used Technologies for O<sub>2</sub> and CO<sub>2</sub>

### Paramagnetic O<sub>2</sub> Analyzer

- In a paramagnetic O<sub>2</sub> analyzer, a sample gas containing O<sub>2</sub> is drawn into two parallel sample paths, one passing through a magnetic field and one not. The O<sub>2</sub> is attracted into the magnetic field path, with the rest of the sample being split between the two paths, and the difference between the two measured gas flow rates is proportional to the O<sub>2</sub> content of the sample.

### Non-Dispersive Infrared

- Non-dispersive infrared (NDIR) is a type of infrared (IR) absorption spectroscopy using parallel sample and reference (non-absorbing) cells.
- It is one of the most commonly used IR methods.
- The IR light is filtered for a specific wavelength that is absorbed by CO<sub>2</sub>, and the difference in intensity of that specific IR wavelength after passing through each of the two cells is proportional to the CO<sub>2</sub> concentration in the sample gas.



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## O<sub>2</sub> & CO<sub>2</sub> Analyzer



Photo reprinted with permission from Alabama Department of Environmental Management



## Commonly Used Technologies for PM

- A light scattering PM CEMS measures the light scattered by the entrained particulate in the stack exhaust, the amount of scattering being proportional to the particulate concentration, and affected by particle size, shape, and color.
- A beta gauge PM CEMS uses a beta radiation source and an adhesive filter tape material which collects the PM material at predetermined intervals. The collected PM on the filter tape attenuates the beta radiation, the amount of attenuation being proportional to the mass of collected PM, and independent of particle characteristics.



**NOTE:** Both PM CEMS require site-specific correlation against manual gravimetric RM measurements.

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## Typical Sources with CEMS Requirements

CEMS are generally required on larger emitting stationary sources. Below are a few examples:

- Utilities
- Cement Plants
- Municipal Waste Combustors
- Nitric and Sulfuric Acid Plants
- Petroleum Refineries
- Copper, Zinc, and Lead Smelters
- Steel and Ferroalloy Plants
- Kraft Pulp Mills
- Glass Manufacturing Plants
- Magnetic Tape Production
- Phosphate Plants



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## Considerations When Choosing a Location for CEMS

Representative Emissions (well-mixed, laminar flow, and downstream of control equipment)

Accessibility for routine maintenance and repairs and performance of calibration audits and checks

Sufficient distance from flow disturbances, such as bends, changes in stack/duct diameter, and control equipment

Protection from weather and vibration

For opacity monitoring systems: no condensation inside stack near monitor and no ambient light

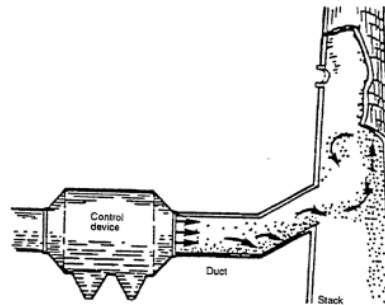
**For specific requirements, see applicable performance specification.**



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## Determining if Stratification Exists

- Calculate the mean value of all the sample points
- Find the difference between the mean value and each individual sample value
- If the mean pollutant concentration is more than 10% different from any single sample point, then stratification exists



## Access for Reference Method Testing



## Predictive Emission Monitoring Systems (PEMS)



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## What is a PEMS?

- PEMS refers to all the equipment that is required to predict an emission concentration or emission rate.
- Unlike a CEMS which uses sampling and analytical equipment to directly measure specific pollutant concentrations, a PEMS uses the continuous measurement of selected plant parameters and plant operating conditions with a software-based system of mathematical models to determine the pollutant emissions.

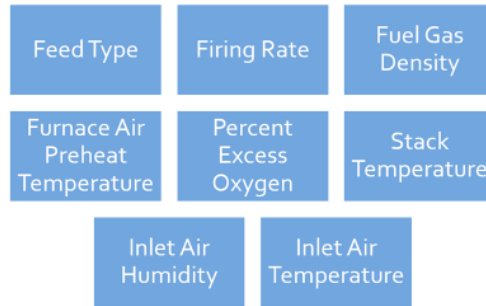


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## PEMS (Cont'd)

- **Software-based system** which uses process values as input variables to provide a real-time estimation of emissions by means of derived mathematical or statistical algorithm.
- PEMS are an acceptable regulatory alternative to CEMS for source emission compliance in some regulations.

### Example Input Variables



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## Continuous Emission Rate Monitoring Systems (CERMS)



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## CERMS

- ▶ Is the **total equipment required** for determining and recording the pollutant mass emission rate (in terms of mass per unit of time)
- ▶ Includes the use of a flow rate monitor to measure the volumetric flow rate of the emission stream and generate an output proportional to that flow rate



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## CERMS (Cont.)

CERMS are:

- Used in conjunction with gas concentration measurements, to calculate mass emission rates.
- Required for most sources subject to 40 CFR Part 75.

$$\text{Pollutant Mass Emission Rate (PMER)} = C_s A_s V_s$$

$C_s$  = Concentration

$A_s$  = Stack Area

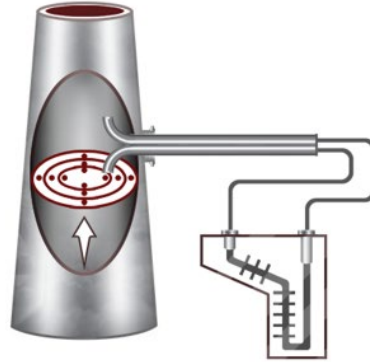
$V_s$  = Stack Gas Velocity

$$\text{lbs/hr} = (\text{lb/ft}^3) (\text{ft}^2) (\text{ft/hr})$$



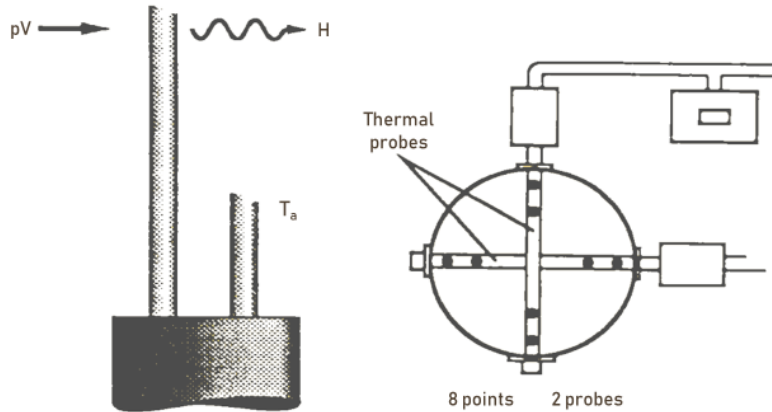
75

## Differential Pressure Measuring



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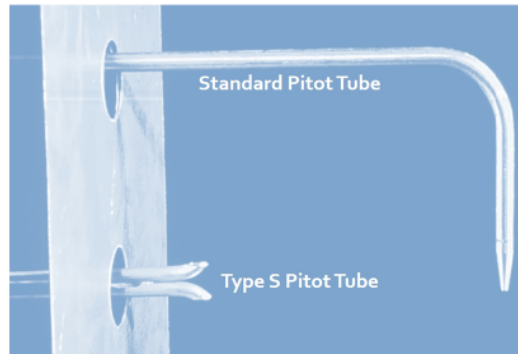
## Thermal Flow Sensor



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## Pitot Tubes

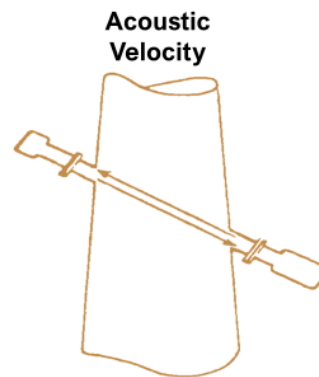
*Pitot tubes* use the differential pressure between the measurements of total pressure and the static pressure at a point in the stack to calculate the stack gas velocity and volumetric flowrate.



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## Ultrasonic Flowmeter

An *ultrasonic flowmeter* uses a pair of transmitter/receivers mounted on opposite sides of the stack, with one upstream from the other. The signal is alternated between them, sending it in the direction of stack gas flow, where it is speeded up, and then against the direction of flow, where it is slowed down. The difference in the time between the two signals is proportional to the stack gas velocity.



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## Module 1 Summary

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Now that you have completed module 1, you should be able to:

- Describe different types and uses of CMS
- Define opacity and describe how continuous opacity monitoring systems (COMS) are used
- Recognize the pollutant parameters measured by continuous monitoring systems (CMS)
- Describe the components of continuous emission monitoring systems (CEMS)
- Distinguish between extractive and in-situ systems
- Describe how predictive emission monitoring systems (PEMS) are used
- Describe how continuous emission rate monitoring systems (CERMS) function
- Describe CEMS location and siting considerations

# **MODULE 2: CMS in Federal Regulations**

# Module 2: CMS in Federal Regulations

## Module 2 Description:

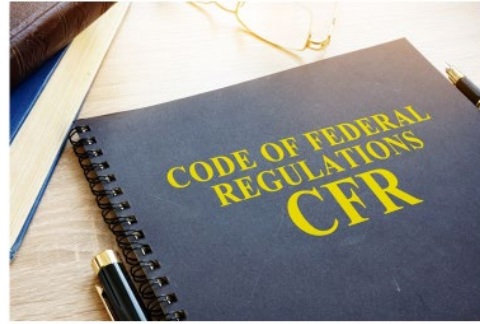
In Module 2, participants will be provided an overview of Federal regulations related to CMS. They will learn about Parts of the Code of Federal Regulations (CFR) that are related to CMS, and will be provided with an overview of Performance Specifications and Quality Assurance (QA).

## Module 2 Learning Objectives:

- Identify the regulations that contain CMS requirements
- Recognize, in general, what performance specifications are

**Estimated Time:** 30 minutes

## Module 2: CMS in Federal Regulations



## Module 2 Outline

- Overview of relevant CFR Parts pertaining to CMS
- Introduction to performance specifications and quality assurance

## Module 2 Learning Objectives

- Identify the regulations that contain CMS requirements
- Recognize, in general, what performance specifications and quality assurance are



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### 40 CFR, Part 60 - New Source Performance Standards (NSPS)




- CAA, Section 111 establishes mechanisms for controlling emissions of air pollutants from stationary sources:
  - Section 111(b) provides authority for EPA to promulgate new source performance standards (NSPS) which apply only to new and modified sources.
  - Section 111(d) requires regulation of existing sources.
- These standards limit the amount of air emissions (SO<sub>2</sub>, NO<sub>x</sub>, etc.) that may be emitted from stack sources.
- The performance specifications and quality assurance procedures for CMS are found in Appendix B and F of 40 CFR, Part 60.




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### 40 CFR Part 61 - National Emission Standards For Hazardous Air Pollutants (NESHAP)



- Established under Section 112 of the CAA
- Promulgated prior to November 15, 1990, the date of enactment of the CAA amendments of 1990
- National emission standards for hazardous air pollutants (NESHAP) contained in this part remain in effect until they are amended, and if appropriate, added to Part 63.


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### 40 CFR, Part 63 - National Emission Standards for Hazardous Air Pollutants (NESHAP) for Source Categories



- Established under Section 112 of the 1990 amendments to the CAA
- These standards regulate specific categories of stationary sources that emit (or have the potential to emit) one or more hazardous air pollutants listed in this part.
- The standards in this part are independent of the NESHAP contained in 40 CFR Part 61.


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### 40 CFR, Part 75 – Acid Rain Program



- Established under Title IV of the CAA of 1990
- First national cap and trade program in the country
- Requires major emission reductions of SO<sub>2</sub> and NO<sub>x</sub> from the power generation sector
- SO<sub>2</sub> and NO<sub>x</sub> are the primary precursors for acid rain
- Part 75 monitoring requirements are not the focus of this training



### Performance Specifications and Quality Assurance



**Performance Specifications** are used for evaluating the acceptability of the CMS at the time of, or soon after installation, or whenever specified in the regulations.



**Quality Assurance (QA)** procedures are used to evaluate the effectiveness of quality control (QC) and the quality of data produced by any CMS that is used for determining compliance with the emission standards as specified in the applicable regulation.



**Performance specifications and QA procedures** can be found in 40 CFR, Part 60 Appendices B and F, respectively.



## Performance Specifications and QA Procedures

PS	Pollutants Covered	QA Procedure
PS-1	Opacity – Continuous Opacity Monitoring Systems (COMS)	Procedure 3
PS-2	Sulfur Dioxide (SO <sub>2</sub> ) and Oxides of Nitrogen (NO <sub>x</sub> )	Procedure 1
PS-3	Oxygen (O <sub>2</sub> ) and Carbon Dioxide (CO <sub>2</sub> )	Procedure 1
PS-4, 4A, and 4B	Carbon Monoxide (CO) for PS 4 and PS-4A; and CO and O <sub>2</sub> for PS-4B	Procedure 1
PS-5	Total Reduced Sulfur (TRS)	
PS-6	Flow Rate – Continuous Emission Rate Monitoring Systems (CERMS)	
PS-7	Hydrogen Sulfide (H <sub>2</sub> S)	
PS-8	Volatile Organic Carbon (VOC)	
PS-8A	Total Hydrocarbons (THC)	
PS-9	Gas Chromatography (GC)	
PS-11	Particulate Matter (PM)	Procedure 2
PS-12A and 12B	Mercury (Hg)	Procedure 5
PS-15	Fourier Transform Infrared (FTIR)	
PS-16	PEMS	
PS-18	Hydrogen Chloride (HCl)	Procedure 6



## Module 2 Summary

Now that you have completed module 2, you should be able to:

- Identify the regulations that contain CMS requirements
- Recognize, in general, what performance specifications and quality assurance are





# **MODULE 3: Audits/Inspection and Enforcement**

# Module 3: Audits/Inspection and Enforcement

## Module 3 Description:

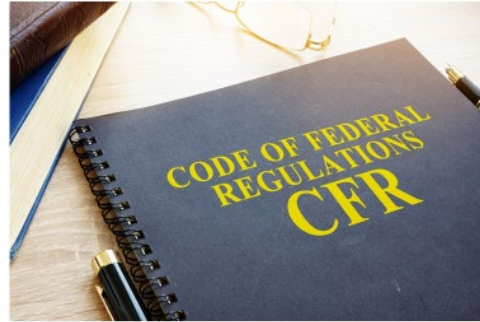
In Module 3, participants will be provided an overview of audits and inspections used for CMS. They will learn about the types of audits and what is involved in an inspection. In addition, they will learn enforcement aspects for CMS.

## Module 3 Learning Objectives:

- Distinguish the difference between performance audits and systems/field audits
- Explain the utility of performance audits and systems/field audits
- Describe the inspector's role during a Continuous Monitoring Systems (CMS) audit
- Distinguish between CMS as compliance method and CMS data as credible evidence

**Estimated Time:** 60 minutes

## Module 3: Audits/ Inspections and Enforcement



## Module 3 Outline

- Performance and system audits overview
- Quality assurance procedure audits
- Inspector's role in system/field audits
- Enforcement applications of CMS

## Module 3 Learning Objectives

- Distinguish the difference between performance audits and systems/field audits
- Explain the utility of performance audits and systems/field audits
- Describe the inspector's role during an audit
- Distinguish between CMS as compliance method and CMS data as credible evidence



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## Performance and System Audits

EPA relies on a combination of **performance** and **system/field auditing** to verify overall data integrity.

### Performance Audit Procedures

- Performance audit procedures are critical for verifying proper performance of the monitoring systems and identifying problems which may lead to inaccurate emissions accounting.

### System or Field Audits

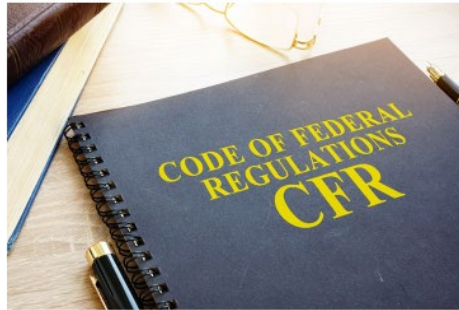
- System or field audits are an opportunity to provide information to the source on the regulatory requirements, and for the inspector to observe monitoring practices that may lead to regulatory problems.



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## Performance Audits

- Required by 40 CFR Part 60
- Found in performance specifications and QA procedures
- Include the daily, quarterly, and annual audit procedures
- Audit results usually submitted to agency for review



## Introduction to Quality Control and Quality Assurance

### 1. Quality Control

- Quality control (QC) is the procedures, policies, and corrective actions necessary to ensure product quality.

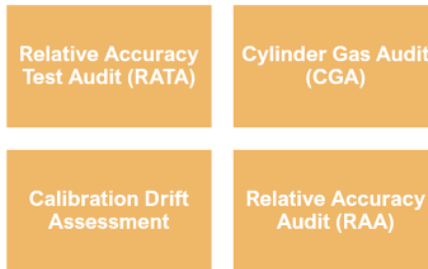
### 2. Quality Assurance

- Quality assurance (QA) procedures are used to evaluate the effectiveness of QC and the quality of data produced by any CMS that are used for determining compliance with the emission standards on a continuous basis as specified in the applicable regulation.
- These procedures are pollutant-specific and published in Appendix F of 40 CFR 60.

## Quality Assurance Procedure Audits

Audit procedures are critical for verifying proper performance of the monitoring systems and identifying problems which may lead to inaccurate emissions accounting.

There are four main types of audits discussed in QA procedures:



## What is a Relative Accuracy Test Audit?

- The **ANNUAL** comparative evaluation of the CEMS performance using a Reference Method (RM)
- Consists of:
  - 9 or more RM test runs
  - Usually 21 minutes in duration



## What is a Cylinder Gas Audit?

- Usually performed **QUARTERLY** – in three of four quarters, annually
- With RATA conducted in the fourth quarter
- Gases needed and methodology used are found in applicable QA procedure
- Audit gases must be certified by or traceable to National Institute of Standards and Technology (NIST)



## What is a Calibration Drift Assessment?

- The **DAILY** check of the difference in the CEMS readings from a known value, usually a calibration gas
- Performed to demonstrate the stability of the CEMS calibration – how does it fluctuate over time?
- Initial certification usually requires a 7-day drift test
- Daily drift test required for ongoing operation



## What is a Relative Accuracy Audit?

- An alternative **QUARTERLY** audit procedure which correlates the CEMS data to simultaneously collected RM data
- Performed like a RATA, but only requires three RM test runs
- Not used very often, but is an option



## System/Field Audit or Inspection

- May be conducted in conjunction with a performance audit such as a RATA or separately as part of a Full Compliance Evaluation
- Allows the observer to...
  - Physically inspect the CEMS,
  - Review the data collected, and
  - Review maintenance logs, etc.



**Note:** The audit procedures for Part 75 can be found here:  
<https://www.epa.gov/airmarkets/clean-air-markets-field-audit-manual>



## Inspector's Role in System/Field Audits



Every inspector should check with their agency to see exactly what their policies and procedures are before conducting an audit.



Typically, the inspector's role is not to provide technical advice or consulting on the operation of the monitoring equipment.



Usually a "hands off" approach is used when conducting the audit so that the inspector does not have any physical contact with the monitoring system hardware.



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## Inspections: Before Going Onsite

### Preparing for an inspection:

- ✓ Review any monitoring plans or test protocols, quality assurance/quality control (QA/QC) manuals, RATA records, quarterly audit records, and quarterly emission report submittals.
- ✓ Check data availability, amount and causes of downtime, significant maintenance and any reports of replacement of key components.
- ✓ Make note of multiple failed QA tests, missing data, unusual data trends (inconsistent over time, or inconsistent with other, similar facilities), and calculation errors.



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## Inspections: Before Observing a Performance Audit


**Preparing to observe any performance audit that will be conducted during the site visit:**


- ✓ Review the results of the last audits, noting any issues
- ✓ Review the necessary performance specifications and QA procedures




## The Road to Continuous Compliance: Operation of CEMS

- 

Conduct Calibration Drift (CD) at least once per operating day: Zero and Span - New Source Performance Standards (NSPS)
- 

Must be in continuous operation. Except for system breakdowns, repairs, calibration checks, and zero and span adjustments. A "continuous operation" means a minimum of one cycle of operation (sampling, analyzing, and data recording) is completed or each successive 15-minute period.
- 

Maintain and operate the CEMS in a manner consistent with good air pollution control practices and manufacturer's written specifications.
- 

Ensure the visual display or indication of operation is readily available on-site

## Inspections Process – At the Facility



**Verify:**

- Calibration and audit gas used, and
- General appearance of analyzers and sampling system



**Check:**

- Check if any alarms or warnings are indicated on DAS screen or system panels



**Review:**

- Additionally, review maintenance logs and verify regular maintenance (daily, weekly, monthly) activities.
  - Compare with description of these activities in QA/QC manual
  - Note any frequent or reoccurring problems



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## Visual Inspection of the CEMS

If possible, do a visual inspection of the CEMS from the sample probe location on the stack or duct, following the sample line to the CEMS shelter, and continuing inside the shelter through the gas conditioning system (if source-level extractive) to the analyzers.

- ✓ Does the system look to be well maintained?
- ✓ Are there low spots in the sample line where moisture might collect and scrub out pollutants? If the facility experiences cold winters, are all parts of the sampling system heated?
- ✓ Is the physical location of the CEMS probe reasonable to access for maintenance?



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## Visual Inspection of the CEMS (Cont'd)

Inside the CEMS shelter, check the condition of the sample gas conditioning system for any condensed liquid in Teflon lines.

- ✓ Where does the liquid drain?
- ✓ Could it get blocked or freeze?
- ✓ Are there signs of corrosion of valves and fittings?



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## Enforcement Applications of CMS

- CMS can provide accurate data regarding a source's compliance with the emissions limits and standards.
  - CMS data can be more representative of a source's ongoing compliance status when compared to infrequent performance testing, and
  - CMS data typically can cover a greater percentage of a source's time in operation.



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## Enforcement Applications of CMS (Cont.)

CMS data is important to enforcement, irrespective of whether the legal requirement being enforced specifies CMS as the compliance method.

- The CAA authorizes EPA to bring an administrative, civil, or criminal enforcement action “on the basis of any information available to the administrator.”
- The 1997 “Credible Evidence” revisions to 40 CFR Parts 51, 52, 60, and 61 clarified that non-reference test data, including CMS, can be used for establishing whether or not the source has violated or is in violation of any standard of that part.



## CMS is the Compliance Method



Required by some NSPS, National Emission Standards for Hazardous Air Pollutants (NESHAPS) and State Implementation Plans (SIPs)



Includes data validation requirements



Requires monitoring against emission limits with long averaging time



Data documents compliance against the emissions standard



## CMS is not the Compliance Method

CMS data is "Credible Evidence:"



Data is used for initiating and supporting enforcement cases alleging emissions violations.



CMS data may provide a basis to issue a Section 114 request for compliance method data.



CMS data may be used to enforce operation and maintenance, monitoring and recordkeeping and reporting requirements, when the regulation does not specify a compliance method or an emissions standard (e.g. General Duty Clause).

## Module 3 Summary

Now that you have completed module 3, you should be able to:

- Distinguish the difference between performance audits and systems/field audits
- Explain the utility of performance audits and systems/field audits
- Describe the inspector's role during an audit
- Distinguish between CMS as compliance method and CMS data as credible evidence

## End of Course Review

Now that you have completed this course, you should be able to:

- Recognize the purpose of CMS and different types and uses of CMS
- Identify the regulations that contain CMS requirements
- Recognize enforcement aspects of CMS

Next, you will measure how much you learned through:

- The end of course self-assessment
- The final exam



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