Inspection of Gas Control Devices and Selected Industries

Slide Manual

APTI Course 455
Fourth Edition

Authors

Jerry W. Crowder, PhD, PE
Crowder Environmental Associates, Inc.

John R. Richards, PhD, PE
Air Control Techniques, PC
Inspection of Gas Control Devices and Selected Industries

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Authors

Jerry W. Crowder, Ph.D., P.E.
Crowder Environmental Associates, Inc.
120 Cherry Circle
Dyersburg, Tennessee 38024

John R. Richards, Ph.D., P.E.
Air Control Techniques, P.C.
301 E. Durham
Cary, NC 27513
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Chapter 1: Baseline Inspection Techniques

Responsibilities of Inspectors

- Compliance evaluation
- Testing and sampling
- Litigation assistance
- Citizen complaint investigation
- Agency representation
Chapter 1: Baseline Inspection Techniques

Compliance Monitoring Activities

- Inspections
- Evaluations
  - Full compliance evaluations
  - Partial compliance evaluations
- Civil investigations
- Record reviews
- Information requests

Inspections

- Visits to a facility or site to gather information to determine compliance status
- Inspections generally include pre-inspection activities before entering the facility or site
- Inspections are usually conducted on single-media programs

Inspection Activities

- Interviewing facility or site representatives
- Reviewing records and reports
- Taking photographs
- Collecting samples
- Observing facility or site operations
Chapter 1: Baseline Inspection Techniques

Clean Air Act Evaluations

• Full Compliance Evaluation (FCE)
• Partial Compliance Evaluation (PCE)

Full Compliance Evaluation

• Comprehensive evaluation of compliance status of the facility
• Looks for all regulated pollutants at all regulated emission units
• Addresses the compliance status of each unit
• Addresses facility’s continuing ability to maintain compliance at each emission unit.

FCE Activities

• Review all reports and the underlying records
• Assess air pollution control devices and operating conditions
• Assess process parameters
• Observe visible emissions
• Review facility records and operating logs
• Stack test
Chapter 1: Baseline Inspection Techniques

Partial Compliance Evaluation

- Focused on subset of regulated pollutants, regulatory requirements, or emission units at a given facility
- More comprehensive than a cursory review of individual reports
- May combine several evaluations to satisfy the annual requirements of a FCE

Civil Investigations

- Detailed assessment of compliance status
- Potential for serious, widespread and/or continuing civil or criminal violations
- Requires significant time to complete

Record Reviews

- Review of records to evaluate compliance status
- May or may not be combined with field work
Chapter 1: Baseline Inspection Techniques

Information Requests

- Enforceable, written request for information to evaluate compliance status
- Potential for serious, widespread and/or continuing civil or criminal violations

Major Elements of Inspection

- File review
- Inspection preparation
- Pre-inspection meeting
- Plant inspection
- Post-inspection meeting
- Inspection report preparation

Inspection Analyses

- Direct comparison with promulgated standards
- Comparison of inspection units with similar units
- Evaluation of shifts from baseline operating conditions
Chapter 1: Baseline Inspection Techniques

Examples of Direct Comparison Inspections

<table>
<thead>
<tr>
<th>Regulation</th>
<th>Parameter</th>
<th>Type of Instrument or Analysis Used for Direct Comparison</th>
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<tr>
<td>Municipal Waste Incinerators</td>
<td>Incinerator operating rate</td>
<td>Steam rate gauge</td>
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<td></td>
<td>CO concentration</td>
<td>CO continuous emission monitor</td>
</tr>
<tr>
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<td>Control system inlet gas temperature</td>
<td>Thermocouple or equivalent temperature monitor</td>
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<td>Fossil Fuel Fired Boilers</td>
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<td>Sulfur dioxide continuous emission monitor</td>
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<td>Nitrogen oxides concentration</td>
<td>Nitrogen oxides continuous emission monitor</td>
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<td>Asbestos Removal</td>
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<td>Opacity monitor</td>
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<td></td>
<td>Adequately wet asbestos-containing material</td>
<td>Observation of work practices</td>
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</table>

Inspection Analyses

- Direct comparison with promulgated standards
- Comparison of inspection units with similar units
- Evaluation of shifts from baseline operating conditions

Site Specific Factors

- Particle size distribution
- Adequacy of gas distribution
- Liquid surface tension (scrubbers)
- Droplet size distribution (scrubbers)
- Gas temperature spatial differences
- Gas flow temporal variations
- Particle composition
- Particle resistivity (ESP)
- Dust cake cohesiveness (ESP and filters)
- Distribution of cleaning energy (ESP and filters)
- Mist eliminator efficiency
- Venturi throat damper condition (scrubbers)
- pH (scrubbers)
Chapter 1: Baseline Inspection Techniques

Inspection Analyses

- Direct comparison with promulgated standards
- Comparison of inspection units with similar units
- Evaluation of shifts from baseline operating conditions

Principles of Baseline Analyses

- Principle Number One

Changes over time are evaluated for individual units
Chapter 1: Baseline Inspection Techniques

Principles of Baseline Analyses

• Principle Number Two

  Sets of data are evaluated, as opposed to relying on a single measurement

Scrubber Symptoms

• Decreased pressure drop
• Increased plume opacity
• Increased outlet gas temperature
• Decrease liquid flow rate

Principles of Baseline Analyses

• Principle Number Three

  The inspection scope should include component failure information and general observations and should not be limited to operating data alone
Principles of Baseline Analyses

• Principle Number Four

Inspection data and observations must be organized in a coherent fashion and evaluated during the compliance inspection.
Chapter 1: Baseline Inspection Techniques

Principles of Baseline Analyses

• Principle Number Five

Inspectors must have the flexibility to exercise professional judgment during the inspection

Principles of Baseline Analyses

• Principle Number Six

Baseline analyses or other indirect compliance analyses are not generally used as a stand-alone basis for enforcement actions
Practical Limits to Inspections

• Time constraints
• Health and safety hazards
• Lack of plant instrumentation
Chapter 2: Adsorbers

Adsorbers

Types of Adsorption Processes

- Chemical adsorption
- Physical adsorption
Chapter 2: Adsorbers

Types of Adsorbents

<table>
<thead>
<tr>
<th></th>
<th>Polar</th>
<th>Non-Polar</th>
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<tbody>
<tr>
<td>Silica gel</td>
<td>Activated carbon</td>
<td></td>
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<tr>
<td>Activated alumina</td>
<td>Synthetic polymers</td>
<td></td>
</tr>
<tr>
<td>Molecular sieves</td>
<td>Synthetic polymers</td>
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</table>

Adsorption Steps

- Monolayer
- Multilayer
- Condensation
Chapter 2: Adsorbers

Adsorption Capacity

Retention

- Lbs of VOC adsorbed per 100 lbs of carbon
- Weight percent

![Retention vs Temperature Graph](image)

![Retention vs Pressure Graph](image)
Chapter 2: Adsorbers

Adsorption Capacity

Regeneration Methods

- Thermal swing
- Steam
- Hot gas
- Pressure swing
Chapter 2: Adsorbers

Steam Regeneration

Regeneration Methods

• Thermal swing
  • Steam
  • Hot gas
  • Pressure swing

Hot Gas Regeneration
Chapter 2: Adsorbers

Regeneration Methods

- Thermal swing
  - Steam
  - Hot gas
  - Pressure swing

Types of Adsorption Systems

- On-site regeneration
- Off-site regeneration

Off-Site Regeneration Adsorbers

Pleated thin bed Canister

Activated carbon
Chapter 2: Adsorbers

Canister Adsorber

On-Site Regeneration Fixed-Bed System

Carbon Fiber Adsorber
Compliance Inspection

General:
- Outlet VOC concentration
- Inlet gas temperature
- Adsorption/desorption cycle times
- Steam pressure and temperature
- Adsorber physical condition
Compliance Inspection

General:

- Outlet VOC concentration
- Inlet gas temperature
- Adsorption/desorption cycle times
- Steam pressure and temperature
- Adsorber physical condition
Compliance Inspection

General:
- Outlet VOC concentration
- Inlet gas temperature
- Adsorption/desorption cycle times
- Steam pressure and temperature
- Adsorber physical condition

Compliance Inspection

Follow-up:
- Inlet concentration (%LEL) and hood static pressure
- Inlet and outlet static pressures
- VOC detector calibration and maintenance
- Solvent recovery rates

Compliance Inspection

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Compliance Inspection

Follow-up:

- Inlet concentration (%LEL) and hood static pressure
- Inlet and outlet static pressures
- VOC detector calibration and maintenance
- Solvent recovery rates
Chapter 3: Thermal and Catalytic Oxidizers

Types of Oxidization Processes

- Flares
- Thermal oxidizers
  - Dedicated units
  - Process heaters and boilers
- Catalytic oxidizers
Parameters Affecting Performance

- Temperature
- Residence time
- VOC composition and concentration

Temperature

- >100°F above auto-ignition temperature
- Reaction rate increases with temperature
- >1,300°F to convert CO to CO₂
- Typically 1,300-1,800°F

Residence Time

\[ t = \frac{V}{Q} \]

Q = actual volumetric flow rate
V = effective volume

Typically 0.3-2.0 seconds
VOC Composition and Concentration

- Composition affects oxidation temperature
- Reaction rate increases with concentration
- Source of energy
  - 100% LEL vapors contain about 50 Btu/scf
  - Oxidizing 1% LEL causes about a 27°F temperature rise in the gas stream

Recuperative Thermal Oxidizer

Regenerative Thermal Oxidizer
Chapter 3: Thermal and Catalytic Oxidizers

Catalyst Materials

- Noble metal oxides
  - Platinum
  - Palladium
  - Rhodium
- Base metal oxides
  - Manganese
  - Chromium
  - Vanadium

Catalyst Configurations

- Fixed bed
  - Beaded
  - Monolithic
- Fluidized bed
Chapter 3: Thermal and Catalytic Oxidizers

Parameters Affecting Performance

- Temperature
- Space velocity
- VOC composition and concentration
- Presence of poisons or inhibitors
Temperature
- ~100°F above light-off temperature
- Reaction rate increases with temperature
- Typical inlet temperature: 500-600°F
- Typical outlet temperature: 700-900°F
- Maximum outlet temperature: 1,100-1,200°F

Generic Light-Off Curve

Space Velocity
\[ SV = \frac{Q_{\text{std}}}{BV} \]

- \( Q_{\text{std}} \) = standard volumetric flow rate
- \( BV \) = catalyst bed volume

Efficiency increases with decreasing space velocity
Typically 30,000-40,000 hr\(^{-1}\) for noble metals
10,000-15,000 hr\(^{-1}\) for base metals
VOC Composition and Concentration

- Composition affects oxidation temperature
- Reaction rate increases with concentration
- Source of energy
  - 100% LEL vapors contain about 50 Btu/scf
  - Oxidizing 1% LEL causes about a 27°F temperature rise in the gas stream

Catalyst Performance Problems

- Fouling
- Poisoning
- Masking
- Thermal aging

Catalytic Oxidizer
Chapter 3: Thermal and Catalytic Oxidizers

Compliance Inspection

General:
- Visible emissions
- Outlet VOC concentration
- Thermal oxidizer outlet temperature
- Catalytic oxidizer inlet and outlet temperature
- Oxidizer physical condition
Chapter 3: Thermal and Catalytic Oxidizers

Compliance Inspection

General:
- Visible emissions
- Outlet VOC concentration
- Thermal oxidizer outlet temperature
- Catalytic oxidizer inlet and outlet temperature
- Oxidizer physical condition
Compliance Inspection

Follow-up:
- Inlet concentration (%LEL) and hood static pressure
- Inlet and outlet static pressures
- VOC detector calibration and maintenance
- Internal inspection reports
- Catalyst activity test data
Chapter 3: Thermal and Catalytic Oxidizers

Compliance Inspection

Follow-up:
- Inlet concentration (%LEL) and hood static pressure
- Inlet and outlet static pressures
- VOC detector calibration and maintenance
- Internal inspection reports
- Catalyst activity test data
Types of Condensation Systems

- Conventional systems
- Refrigeration systems
- Cryogenic systems

Types of Condensers

- Direct contact condensers
- Surface condensers
Chapter 4: Condensers

**Tube and Fin Condenser**

- Traverse fins
- Longitudinal fins

**Refrigeration Cycle**

- Refrigeration unit
- Expansion valve
- Refrigerant condenser
- Refrigerant compressor
- Refrigerant evaporator
- Fan
- Contact chamber
- Solvent laden air
- Condensate
- Exhaust gas
- Refrigerant liquid
- Refrigerant vapor

**Refrigeration System**

- Refrigeration unit 1
- Refrigerant 1
- Pre-condenser
- Water condensate
- Fan
- Refrigeration unit 2
- Refrigerant 2
- Main chamber
- Organic condensate
- Exhaust
Chapter 4: Condensers

Compliance Inspection

General:
• Outlet gas temperature
• Coolant flow rate and temperature
• Condenser physical condition
**Compliance Inspection**

**General:**
- Outlet gas temperature
- Coolant flow rate and temperature
- Condenser physical condition

**Follow-up:**
- Inlet concentration (%LEL) and hood static pressure
- Solvent recovery rates
Chapter 4: Condensers

Compliance Inspection

Follow-up:

- Inlet concentration (%LEL) and hood static pressure
- Solvent recovery rates
### Nitrogen Oxides Control Systems

#### NO\textsubscript{X} Formation Mechanisms

- **Thermal NO\textsubscript{X}**
  Formed by oxidation of nitrogen in the combustion air

- **Fuel NO\textsubscript{X}**
  Formed by oxidation of nitrogen in the fuel

- **Prompt NO\textsubscript{X}**
  Formed by early free-radical reactions in the flame

#### Thermal NO\textsubscript{X} Formation

\[
N_2 + O_2 \leftrightarrow 2NO
\]

\[
NO + \frac{1}{2} O_2 \leftrightarrow NO_2
\]
Factors Affecting Thermal NO\textsubscript{x} Formation

- Flame Temperature
- Residence time of combustion gases in peak temperature zone of the flame
- Amount of oxygen present in peak temperature zone of the flame

Techniques for Reducing Thermal NO\textsubscript{x}

- Reduce peak flame temperature
- Reduce residence time at peak flame temperature
- Reduce oxygen concentration in maximum temperature zone
Fuel NO\textsubscript{x} Formation

- Occurs by oxidation of organically bound nitrogen contained in the fuel
  - Coal: 0.2-3.5 weight percent
  - Fuel oil: 0.01-0.5 weight percent
  - Natural gas: None
- Approximately 20-60% of the fuel nitrogen is oxidized
- Amount oxidized decreases as nitrogen content increases

Factors Affecting Fuel NO\textsubscript{x} Formation

- Combustion zone temperature
- Oxygen levels in the vicinity of the flame
- Fuel nitrogen content

Techniques for Reducing Fuel NO\textsubscript{x} Formation

- Decrease combustion temperature
- Decrease oxygen concentration
- Decrease fuel nitrogen content
Prompt NO\textsubscript{x} Formation

- Forms early in the combustion process due to free-radical reactions in the flame
- Residence time is usually too short to generate high concentrations
- Mechanism has greatest impact in fuel rich combustion zones
- Mechanism is of minor importance in large-scale combustion systems

Reducing Prompt NO\textsubscript{x}

Prompt reactions are not sensitive to peak gas temperatures. Therefore, combustion modifications do not have a strong influence on the NO\textsubscript{x} formed by this mechanism.

NO\textsubscript{x} Control Systems

- Combustion modifications
- Fuel switching
- Add-on control devices
Chapter 5: Nitrogen Oxides Control Systems

Boiler Combustion Modifications

- Low excess air combustion
- Off-stoichiometric combustion
- Flue gas recirculation
- Low NO\textsubscript{x} burners
- Gas reburning

Effect of Oxygen on NO\textsubscript{x} Formation
Chapter 5: Nitrogen Oxides Control Systems

NO\textsubscript{x} Reduction with Low Excess Air Combustion

- 16-20% for gas- and oil-fired boilers with 2-7% excess air
- ~20% for coal-fired boilers with 20% excess air

Off-Stoichiometric Combustion

- Combustion occurs in two zones
  - A primary zone with less than stoichiometric air (fuel rich)
  - A secondary zone where the remaining combustion air is added (air rich)

Use of Overfire Air (OFA)
Chapter 5: Nitrogen Oxides Control Systems

NO\textsubscript{x} Reduction with Off-Stoichiometric Combustion

• 30-40% for gas- and oil-fired boilers
• 30-50% for coal-fired boilers

Flue Gas Recirculation (FGR)

40-50% with recirculation of 20-30% of the exhaust gas in gas- and oil-fired boilers
Low NO\textsubscript{x} Burners

Control techniques
- Low excess air
- Off-stoichiometric combustion
- Combustion gas recirculation

Dual Register Burner

NO\textsubscript{x} Reduction with Low NO\textsubscript{x} Burners

Typically, 25-60%. Ultra Low NO\textsubscript{x} Burners have efficiencies approaching 80% and outlet concentrations less than 10 ppmv
Gas Reburning

Reductions of 50-70% have been demonstrated at full boiler load

**NOx Reduction with Gas Reburning**

Gas Turbine Combustion Modifications

- Lean, pre-mixed combustors
- Rich/quench/lean combustors
- Water or steam injection
Chapter 5: Nitrogen Oxides Control Systems

Fuel Switching

• Coal nitrogen content
• Fuel substitution
• Gas co-firing

Flue Gas Treatment

• Selective non-catalytic reduction (SNCR)
• Selective catalytic reduction (SCR)

Selective Non-Catalytic Reduction
SNCR Reactions

\[ 4\text{NH}_3 + 4\text{NO} + \text{O}_2 \rightarrow 4\text{N}_2 + 6\text{H}_2\text{O} \]
\[ 2\text{NO} + \text{NH}_2\text{CONH}_2 + 0.5\text{O}_2 \rightarrow 2\text{N}_2 + 2\text{H}_2\text{O} + \text{CO}_2 \]
Chapter 5: Nitrogen Oxides Control Systems

NO\textsubscript{x} Reduction with SNCR

Typical reduction efficiencies for SNCR systems are 20-60%

Selective Catalytic Reduction

SCR Reactions

\[4\text{NH}_3 + 4\text{NO} + \text{O}_2 \xrightarrow{\text{Catalyst}} 4\text{N}_2 + 6\text{H}_2\text{O}\]

\[4\text{NH}_3 + 2\text{NO}_2 + \text{O}_2 \xrightarrow{\text{Catalyst}} 3\text{N}_2 + 6\text{H}_2\text{O}\]

Temperature range: 550-750°F
Chapter 5: Nitrogen Oxides Control Systems

Catalyst Materials

- Noble metals (e.g., platinum, palladium, rhodium)
- Vanadium pentoxide
- Titanium dioxide
- Tungsten trioxide

Sulfur Dioxide Oxidation

\[2\text{SO}_2 + \text{O}_2 \xrightarrow{\text{catalyst}} 2\text{SO}_3\]
Chapter 5: Nitrogen Oxides Control Systems

Formation of Sulfate Compounds

\[
\text{SO}_3 + \text{NH}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4\text{HSO}_4
\]

\[
\text{SO}_3 + 2\text{NH}_3 + \text{H}_2\text{O} \rightarrow (\text{NH}_4)_2\text{SO}_4
\]

Common Catalyst Problems

- Poisoning
- Fouling
- Masking
- Sintering
- Erosion

\[\text{NO}_x\text{ Reduction with SCR}\]

- Typical reduction efficiencies for SCR systems are 60-90%
- Some gas turbines have outlet concentrations less than 4 ppm corrected to 15% oxygen
Chapter 5: Nitrogen Oxides Control Systems

General Range of NO$_X$ Efficiencies

<table>
<thead>
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<th>Control Technique</th>
<th>Typical Applications</th>
<th>NO$_X$ Reduction Efficiency, %</th>
</tr>
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<tr>
<td>Low Excess Air</td>
<td>Coal Fired Boilers, Municipal Waste Incinerators</td>
<td>10-30%</td>
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<tr>
<td>Off-Beddomeatic Combustion</td>
<td>Coal, Oil, Gas Fired Boilers</td>
<td>10-50%</td>
</tr>
<tr>
<td>Flex-Gas Spentatesation</td>
<td>Coal, Oil, Gas Fired Boilers</td>
<td>15-25%</td>
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<tr>
<td>Low RO, Burners</td>
<td>Coal, Oil, Gas Fired Boilers</td>
<td>20-40%</td>
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<tr>
<td>Gas Recruling</td>
<td>Coal, Oil, Gas Fired Boilers</td>
<td>30-70%</td>
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<td>Lean Combustion</td>
<td>Gas Fired Turbines</td>
<td>&gt;30%</td>
</tr>
<tr>
<td>Flue Gas Treatment</td>
<td>Gas Fired Turbines</td>
<td>60-75%</td>
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<tr>
<td>BNR</td>
<td>Coal Fired Boilers, Municipal Waste Incinerators</td>
<td>20-60%</td>
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<td>SCR</td>
<td>Coal Fired Boilers, Gas Turbines</td>
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<td>Low Nitrogen Coal</td>
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<tr>
<td>CaFiring</td>
<td>Coal Fired Boilers</td>
<td>No Data</td>
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</tbody>
</table>

Compliance Inspection

- Nitrogen oxides CEM data
- Visible emissions
- Gas temperatures
- Reagent feed rates and pressures
- SCR static pressure drop
- Gas turbine water or steam flow rates
Compliance Inspection

• Nitrogen oxides CEM data
• Visible emissions
• Gas temperatures
• Reagent feed rates and pressures
• SCR static pressure drop
• Gas turbine water or steam flow rates
Compliance Inspection

- Nitrogen oxides CEM data
- Visible emissions
- Gas temperatures
- Reagent feed rates and pressures
- SCR static pressure drop
- Gas turbine water or steam flow rates
Chapter 6: Sulfur Oxides Control Systems

Sulfur Oxides Formation Mechanisms

\[ S + O_2 \rightarrow SO_2 \]
\[ S + 1.5 O_2 \rightarrow SO_3 \]
\[ SO_3 + H_2O \rightarrow H_2SO_4 \]
SO\textsubscript{x} Control Systems

- Flue gas desulfurization
- Fuel treatment
- Low sulfur fuel firing

Flue Gas Desulfurization (FGD)

Wet FGD Systems

- Nonregenerable
- Regenerable
Chapter 6: Sulfur Oxides Control Systems

Non-Regenerative FGD Systems

Wet Systems:
- Limestone: 50%
- Lime: 20%
- Dual-Alkali: 3%

Dry Systems:
- Lime Spray Dryer: 8%

Regenerative FGD Systems

Wet Systems:
- Limestone: 4%
- Wellman-Lord: 3%

Limestone Scrubbing

\[
\text{SO}_2 + \text{CaCO}_3 \rightarrow \text{CaSO}_3 + \text{CO}_2
\]

\[
\text{CaSO}_3 + 0.5\text{O}_2 \rightarrow \text{CaSO}_4
\]
Chapter 6: Sulfur Oxides Control Systems

Lime Scrubbing

\[ \text{SO}_2 + \text{Ca(OH)}_2 \rightarrow \text{CaSO}_3 + \text{H}_2\text{O} \]
\[ \text{CaSO}_3 + 0.5\text{O}_2 \rightarrow \text{CaSO}_4 \]

Reagent Preparation

\[ \text{CaCO}_3 \xrightarrow{\Delta} \text{CaO} + \text{CO}_2 \]
\[ \text{CaO} + \text{H}_2\text{O} \rightarrow \text{Ca(OH)}_2 \]
Chapter 6: Sulfur Oxides Control Systems

Dual Alkali Scrubbing

Absorption Reactions:
\[
\begin{align*}
SO_2 + Na_2SO_3 + H_2O & \rightarrow 2NaHSO_3 \\
NaHSO_3 + 0.5O_2 & \rightarrow NaHSO_4 \\
\end{align*}
\]

Regeneration Reactions:
\[
\begin{align*}
2NaHSO_3 + Ca(OH)_2 & \rightarrow Na_2SO_3 + CaSO_3 + 2H_2O \\
NaHSO_4 + Ca(OH)_2 & \rightarrow NaOH + CaSO_3 + H_2O \\
\end{align*}
\]
**Wellman-Lord Process**

**Absorption Reaction:**

\[ \text{SO}_2 + \text{Na}_2\text{SO}_3 + \text{H}_2\text{O} \rightarrow 2\text{NaHSO}_3 \]

**Regeneration Reaction:**

\[ 2\text{NaHSO}_3 \rightarrow \text{Na}_2\text{SO}_3 + \text{H}_2\text{O} + \text{SO}_2 \]

**Spray Dryer Dry Scrubbing**
Chapter 6: Sulfur Oxides Control Systems

Types of Atomizers

- Rotary atomizers
- Compressed air assisted nozzles

Acid Gas Removal Reactions

\[
\text{SO}_2 + \text{Ca(OH)}_2 \rightarrow \text{CaSO}_3 + \text{H}_2\text{O}
\]

\[
2\text{HCl} + \text{Ca(OH)}_2 \rightarrow \text{CaCl}_2 + 2\text{H}_2\text{O}
\]
Chapter 6: Sulfur Oxides Control Systems

Dry Injection Dry Scrubbing

Fluidized Bed Combustion

Fuel Treatment

- Coal gasification
- Coal liquefaction
- Coal cleaning
  - Physical methods
  - Chemical methods
Chapter 6: Sulfur Oxides Control Systems

SO\textsubscript{x} Control Systems

- Flue gas desulfurization
- Fuel treatment
- Low sulfur fuel firing

Compliance Inspection

General:
- Sulfur oxides CEM data
- pH and alkalinity of scrubbing liquid
- Alkali feed rates
- Inlet and outlet temperatures
- Visible emissions
- Physical condition
### Compliance Inspection

**General:**

- Sulfur oxides CEM data
- pH and alkalinity of scrubbing liquid
- Alkali feed rates
- Inlet and outlet temperatures
- Visible emissions
- Physical condition
Chapter 6: Sulfur Oxides Control Systems

Compliance Inspection

General:
- Sulfur oxides CEM data
- pH and alkalinity of scrubbing liquid
- Alkali feed rates
- Inlet and outlet temperatures
- Visible emissions
- Physical condition

Compliance Inspection

General:
- Sulfur oxides CEM data
- pH and alkalinity of scrubbing liquid
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Compliance Inspection

Follow-up:
- Mist eliminator static pressure drop
- Slurry atomizer conditions
- Flue gas oxygen concentration
Compliance Inspection

Follow-up:

- Mist eliminator static pressure drop
- Slurry atomizer conditions
- Flue gas oxygen concentration
Chapter 7: Utility and Industrial Boilers

Combustion Units

- Solid-fuel combustors
  - Overfeed stoker
  - Spreader stoker
  - Pulverized coal combustor
- Liquid-fuel combustors

Overfeed Stokers

![Diagram of an overfeed stoker]

[Image of an industrial boiler]

[Image of another industrial boiler]
Characteristics of Overfeed Stokers

- 20,000-150,000 pounds of steam per hour
- Not capable of rapid load changes
- Free-swell index should be less than 5 (without tempering)
- Ash fusion temperature should be greater than 1,900°F
- Ash content should be greater than 5-6%

Characteristics of Spreader Stokers

- 40,000-400,000 pounds of steam per hour
- Capable of rapid load changes
- Free-swell index should be less than 5 (without tempering)
- Ash fusion temperature should be greater than 1,900°F
- Ash content should be greater than 5-6%
- Typical loss-on-ignition (LOI) is 10-50%
Chapter 7: Utility and Industrial Boilers

Pulverized Coal-Fired Boiler

Burner Arrangements

- Front-fired
- Opposed-fired (front and back walls)
- Tangential-fired (four corners)

Characteristics of Pulverized Coal Boilers

- Large industrial boilers and utility power stations
- Capable of rapid load changes
- Feed coal size to pulverizer not important
- Free-swelling index not important
- Ash fusion temperature determines bottom ash recovery method
- Typical loss-on-ignition (LOI) is 0.5-5%
Chapter 7: Utility and Industrial Boilers

Combustion Units
- Solid-fuel combustors
  - Overfeed stoker
  - Spreader stoker
  - Pulverized coal combustor
- Liquid-fuel combustors

Compliance Inspection
- Fuel characteristics
- Firing conditions
- Ash characteristics

Fuel Characteristics
- Type(s) of fuels
- Ultimate analysis (S, N, Cl, ash)
- Proximate analysis
- Ash composition
- Fuel sizing
- Ash fusion temperature
- Free-swell index
Compliance Inspection

Fuel Characteristics

- Type(s) of fuels
- Ultimate analysis (S, N, Cl, ash)
- Proximate analysis
- Ash composition
- Fuel sizing
- Ash fusion temperature
- Free-swell index

Types of Wood Waste

- Bark
- Dimensional lumber
- Chips
- Sawdust
- Sander dust

Compliance Inspection

Fuel Characteristics

- Type(s) of fuels
- Ultimate analysis (S, N, Cl, ash)
- Proximate analysis
- Ash composition
- Fuel sizing
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Compliance Inspection

Fuel Characteristics
- Type(s) of fuels
- Ultimate analysis (S, N, Cl, ash)
- Proximate analysis
- Ash composition
- Fuel sizing
- Ash fusion temperature
- Free-swell index

Proximate Analysis
- Heating value, Btu/pound
- Moisture content, percent
- Volatile matter content, percent
- Fixed carbon content, percent
- Ash content, percent

Compliance Inspection

Fuel Characteristics
- Type(s) of fuels
- Ultimate analysis (S, N, Cl, ash)
- Proximate analysis
- Ash composition
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Compliance Inspection

Firing Conditions
- Load
- Oxygen concentrations
- CO concentrations
- Air infiltration
- Overfire and underfire air flow rates
- Soot blowing practices
- Fuel/air distribution
- Boiler draft

Compliance Inspection

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Chapter 7: Utility and Industrial Boilers

Compliance Inspection

Firing Conditions

• Load
• Oxygen concentrations
• CO concentrations
• Air infiltration
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• Boiler draft

Causes of Higher CO Concentrations

• Overcharging of moist fuels
• Air infiltration related cooling of the combustion area
• Inadequate oxygen
• Poor air/fuel distribution
• Inadequate overfire air
• Operation at low load
Compliance Inspection

Firing Conditions

- Load
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- Boiler draft
Compliance Inspection

Ash Characteristics

• LOI and appearance
• Fugitive emissions
Chapter 8: Municipal and Medical Waste Incinerators

Combustion Units

- Reciprocating grate incinerators
- Modular incinerators
- Rotary kilns

Reciprocating Grate Incinerator
Chapter 8: Municipal and Medical Waste Incinerators

Compliance Inspection

- Waste characteristics
- Firing conditions
- Ash characteristics

Compliance Inspection

Waste Characteristics
- Type(s) of wastes burned
Undesirable Incinerator Wastes

- Hazardous chemicals
- Asbestos containing materials
- Flammable liquids (gasoline cans, solvent-based paints)
- Bulky furniture, appliances or automobile parts
- Cables and/or rolls or agricultural plastics
- Animal carcasses
- Pressurized cylinders

Compliance Inspection

Firing Conditions

- Load
- Combustion chamber temperatures
- Oxygen concentrations
- CO concentrations
- Air infiltration
- Incinerator draft
- Overfire and underfire air flow rates
Compliance Inspection

Firing Conditions

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Chapter 8: Municipal and Medical Waste Incinerators

Causes of Higher CO Concentrations

- Overcharging of moist fuels
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Compliance Inspection

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Compliance Inspection

Ash Characteristics

- LOI and appearance
- Fugitive emissions

Compliance Inspection

Ash Characteristics

- LOI and appearance
- Fugitive emissions
Chapter 8: Municipal and Medical Waste Incinerators

Compliance Inspection

Ash Characteristics

• LOI and appearance
• Fugitive emissions
Chapter 9: Iron and Steel Processes

General Inspection Items

- Process operating rates
- Quality and types of materials processed
- Fugitive emissions
Inspection Issues

- Is the process operating in accordance with the operating permit limitations and applicable regulations?
- Are fugitive emissions being adequately captured?
- Have operating conditions changed and created potential problems for the air pollution control system?

Compliance Inspection

- Operating procedures
- Emissions
- Emission capture system

Compliance Inspection

Operating Procedures

- Quality of scrap charged
- Oxygen injection
- Operating rate
Compliance Inspection

Operating Procedures

- Quality of scrap charged
- Oxygen injection
- Operating rate
Compliance Inspection

Emissions

- Fugitive emission observations
- Opacity monitoring data
Compliance Inspection

Emission Capture System

- Hood position and condition
- Gas flow rate
- Inlet gas temperature
- Hood static pressure

Hood Effectiveness Factors

- Position of the hood relative to the source of emissions
- Cross drafts or other factors interfering with capture
- Physical condition of the hood
- Capture velocities at the hood
Compliance Inspection

Emission Capture System

- Hood position and condition
- Gas flow rate
- Inlet gas temperature
- Hood static pressure
Chapter 10: Asphalt Plants

Types of Asphalt Plants

- Hot mix
- Drum mix
Minimizing Volatile Emissions

- Reduce the dryer aggregate temperature
- Shield the binder injection point from the radiant heat of the burner
- Move the binder injection pipe to a slightly cooler area within the drum
- Convert to a less volatile binder

Compliance Inspection

- Production rates
- Dryer aggregate temperature
- Binder type
- Dryer effluent gas temperature
- Fugitive emissions

Compliance Inspection

- Production rates
- Dryer aggregate temperature
- Binder type
- Dryer effluent gas temperature
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Chapter 10: Asphalt Plants

Compliance Inspection

- Production rates
- Dryer aggregate temperature
- Binder type
- Dryer effluent gas temperature
- Fugitive emissions
# Inspection of Gas Control Devices and Selected Industries

August 28-30, 2018

## AGENDA

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>MODERATOR</th>
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<tbody>
<tr>
<td>Murfreesboro, Tennessee</td>
<td>J.W. Crowder</td>
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### DAY & TIME | SUBJECT | SPEAKER

**Tuesday, August 28**

<table>
<thead>
<tr>
<th>Time</th>
<th>Subject</th>
<th>Speaker</th>
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<tbody>
<tr>
<td>9:00</td>
<td>Introduction</td>
<td>J. Crowder</td>
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<tr>
<td>9:15</td>
<td>Pre-Test</td>
<td>J. Crowder</td>
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<tr>
<td>9:45</td>
<td>Break</td>
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<tr>
<td>10:00</td>
<td>Review of the Baseline Inspection Technique</td>
<td>J. Crowder</td>
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<tr>
<td>11:00</td>
<td>Inspection of Carbon Adsorbers</td>
<td>J. Crowder</td>
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<tr>
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<td>Inspection of Carbon Adsorbers (cont’d)</td>
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<td>Inspection of Thermal and Catalytic Oxidizers</td>
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<td>Inspection of Condensers</td>
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**Wednesday, August 29**

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<tr>
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<td>Inspection of Nitrogen Oxide Control Systems</td>
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<td>Inspection of Sulfur Dioxide Control Systems</td>
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<td>1:00</td>
<td>Inspection of Utility and Industrial Boilers</td>
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<td>Inspection of Waste Incinerators</td>
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<td>Review of Pre-Test</td>
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**Thursday, August 30**

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<tr>
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<td>Course Critique</td>
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<tr>
<td>3:00</td>
<td>Adjourn</td>
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Jerry W. Crowder, Ph.D., P.E.  
Crowder Environmental Associates, Inc.  
120 Cherry Circle  
Dyersburg, TN 38024  
Tel: (731) 286-1554  
Fax: (731) 286-4910  
Cell: (731) 589-0911  
E-mail: jwcrowder@cableone.net