Continuous Emissions Monitoring Systems

Engineering & Design

For PetroChem Processes

a technical solution to meet every need...

Cemtek Environmental Inc.
3041 S. Orange Ave.
Santa Ana, CA 92707
800-400-0200
www.cemteks.com
Application Analysis

- Review Combustion Process and Pollution Control Equipment, Measurement Location.
- Review Permit for Compliance CEMS or the Process for a Control CEMS.
- Site Specific Requirements & Needs.
- Estimated Ranges of Constituents.
- Location of Equipment.
- Information Required and Purpose.
- Installation Requirements.
CEMS Components

- Sample extraction (sample probe)
- Sample transport (sample line)
- Sample conditioning (moisture & particulate removal with a sample cooler)
- Analysis of sample for desired constituents (gas analyzers)
- Calibration (QA/QC)
- System control (PLC)
- Data acquisition, storage and reporting (DAHS)
- Enclosure (Shelter or Cabinet)
Sample Probe

- Materials suitable for flue gas stream
- High Temperature appropriate
- Probe tube design to handle high flow velocity & vibration
- Internal Fine particulate filter
- Heated above sample dewpoint
- Blowback to lower filter maintenance
- Probe tip calibration gas injection is required for QA/QC audits
- Probe Tube Array for stratification & Multipoint
Sample Probe

Fully Extractive Heated Probe
Sample Umbilical

- Transport sample from Probe to sample conditioning system
- Maintain sample above dewpoint (heated, temperature controllers, insulation, etc)
- Tubes for cal gas injection, blowback air, control and monitoring signals for the probe
- Materials that do not absorb respective gases
- Avoid cold spots, downward sloped to grade
Sample Conditioning System

- Remove water and particulate without dissolving components, minimize water and gas sample interface & remove harmful acids
- Control flow rate of sample - bypass to vent flow for fast transport of sample.
- Sample flow to analyzer at constant flow and pressure
- Provide control of calibration gas injection
- Provide sample shutoff mechanism
- NH₃ slip control
Sample Conditioning Components

- Sample Cooler – can be compressor type or peltier. Design is important to minimize contact between water and gas – don’t dissolve gases of interest!

- Peristaltic pump to remove water from cooler

- Sample Pump – usually diaphragm type pump because this can generate flow rate required extracting sample from vacuum and is very robust

- Acid filters

- Particulate Filters
Sample System Interlocks & Alarms

- Protection in the event of a failure
  - Interlock any low sampling component temperature (HSL and Probe) with pump shutoff and alarm
  - Interlock high cooler temp with pump shutoff and alarm
  - Interlock moisture in sample with pump shutoff and alarm
  - Interlock air supply failure with pump shutoff and/or alarm (when instrument air supply critical – i.e. w/perma-pure dryer)
- Alarm sample pressure/flow low
Cabinet/Shelter

- Critical to performance of System
- Temperature Conditions
- Corrosive atmosphere
- Hazardous area Conditions
- Location
- Size & Construction
Analyzer Performance

- Different performance levels from different technologies
  - Infrared, UV, chemiluminescence and paramagnetic are most commonly used
- Legislation and quality of enforcement will affect selection of technology
- Often many background components, so analyzer should resist cross interference
Analytical Techniques

- **O₂**
  - Paramagnetic & Zirconium are most widely used, most accurate and accepted technology.

- **CO, CO₂**
  - NDIR absorption with GFC

- **NOₓ**
  - Chemiluminesence
    - EPA Reference Method
    - Excellent low range, sub ppm level capability
  - NDIR
    - Typical IR lowest range is 100-150 ppm
Analytical Techniques

- **SO₂**
  - UV Pulsed Fluorescence

- **THC/VOC**
  - Flame Ionization Detector (FID) type analyzer is used to measure unburned hydrocarbons

- **NH₃**
  - Differential NOₓ or Direct Cross Stack Tunable Diode Laser (TDL)
System Controller

- System operations controlled by PLC/data logger
- Receives other CEMS inputs and signals from plant - may also provide outputs for plant use (to DCS, etc.)
- Auto calibration sequence of CEMS
- Data Storage
- Calculations, Logic & Formulas
Data Acquisition & Handling System (DAHS)

- Data Acquisition & Handling System receives data from analyzers and other system inputs
- System Control – Daily Calibration Checks, Probe Blowback, Fault Annunciation, Alarming, Sequencing
- DAHS stores raw and calculated data
- Data Correction – Automatic correction for Drift
- Data Averaging – TWA in blocks and/or rolling (hourly, 3 hour, daily, weekly, monthly etc)
- Data Conversion – ppm to mg, accumulated masses
- Compliance Monitoring – Excursions, levels within legal boundaries
- Data Archiving and validation – Part 75 standard file structure
- Reports – Facility Data, Monitoring Data, Unit Data, Control Equipment Data, Monitoring Plans, Certification test data and results
- Missing Data Substitution – Editing
- DAHS “flags” emissions exceedances and other alarm conditions and outputs
- Some regulatory agencies require transmittal of daily data to agency ie RECLAIM

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Typical Fully Extractive CEMS in a Shelter with HVAC
Types of Analyzers

Teledyne API (TAPI)

Thermo Scientific
Analyzer Rack

Servomex & Thermo Scientific

Electrical Panel

Allen-Bradley CompactLogix PLC
Ready For a Factory Acceptance Test
Typical Fully extractive CEMS in a Cabinet, NEMA12 or NEMA 3R
Electrical Panel, Sample Conditioning Bay, and Analyzer Bay
Ready For a Factory Acceptance Test
Continuous Emissions Monitoring Systems

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Most units utilized in fractional distillation and chemical processing utilize heaters burning refinery and/or natural gas and require CEMS.

Process heaters may utilize Selective Catalytic Reduction (SCR) for NO\textsubscript{X} control.

CEMS Design Considerations

- Area classification of shelter/cabinet placement
  
  If shelter/cabinet is placed in a classified area
  - Can a positive pressure purge system be used to de-classify shelter/cabinet interior to general purpose area?
  - Site requirements for conduit, receptacle, misc. equipment whether in a classified or general purpose area.

- Space limitations including access for HVAC maintenance and I/O connections.

- Shelter ambient gas monitors for worker safety.
Fractional Distillation and Chemical Processing CEMS

CEMS Design Considerations Continued

- If SCR is utilized for NO\textsubscript{X} control
  - Dual range NO\textsubscript{X} analyzer for post-SCR measurement including associated cal gas equipment.
  - How will NH\textsubscript{3} slip be measured?
    - Tunable Diode Laser (TDL)
    - Differential NO\textsubscript{X} calculation
    - Converted NH\textsubscript{3} measured as NO\textsubscript{X}

- Calibration gas supply for startup and certification.

- Site specific boilerplate specifications required to be met.

- Data Acquisition
  - How will CEMS data be handled and stored?
    - Data Acquisition System (DAS) for data handling and storage.
    - DCS to handle CEMS data
  - Co-mingling of data issues
  - Most refinery processes subject to 40CFR Part 60 compliance. Some processes may be large enough to be subject to 40CFR Part 75, requiring data substitution routines.
Auxiliary Refinery Processes

Additional support processes are required for refinery operation to aid in refining of the crude oil and handling of the process waste:

- **power and steam production for process heat (Co-Gen Plant)**
- **hydrogen production for hydro treating processes (Hydrogen Plant)**
- **sulfur recovery for processing waste acid gases (Sulfur Recovery Unit)**

Cogeneration Plant

Cogeneration Plants are used to produce power and steam for use in the refinery processes. Steam specifically can be used for process heat and is integral in the operation of the hydrogen plant and sour water steam stripper.
Most Cogeneration Plants utilize combined cycle turbines burning natural gas and require CEMS.

The turbines typically utilize Selective Catalytic Reduction (SCR) for NO\textsubscript{X} control.

CEMS Design Considerations

- Area classification of shelter/cabinet placement is typically general purpose as the CoGen plant is remotely located from the refinery.

- If SCR is utilized for NO\textsubscript{X} control
  - Dual range NO\textsubscript{X} analyzer for post-SCR measurement including associated cal gas equipment.
  - How will NH\textsubscript{3} slip be measured?
    - Tunable Diode Laser (TDL)
    - Differential NO\textsubscript{X} calculation
    - Converted NH\textsubscript{3} measured as NO\textsubscript{X}

- Calibration gas supply for startup and certification.
CEMS Design Considerations Continued

- Site specific boilerplate specifications required to be met.
  - Cogen turbine CEMS may be required to meet site specific/classified area requirements for general purpose installation.

- Data Acquisition
  - Stand alone data acquisition system (DAS) typically utilized for data manipulation and storage.
  - System may be subject to 40CFR Part 60 or 40CFR Part 75, depending on the amount of power sold to the grid.
Additional support processes are required for refinery operation to aid in refining of the crude oil and handling of the process waste:

- power and steam production for process heat (Co-Gen Plant)
- hydrogen production for hydro treating processes (Hydrogen Plant)
- sulfur recovery for processing waste acid gases (Sulfur Recovery Unit)

Hydrogen Plant
Hydrogen plants are used to produce hydrogen gas used in the hydro treating refinery processes, particularly the hydrocracker and hydrotreater units. Natural gas is converted to hydrogen through the steam reforming process.
Most Hydrogen Plants utilize steam reformer burners burning natural gas and require CEMS.

The burners may utilize Selective Catalytic Reduction (SCR) for NO\textsubscript{X} control.

**CEMS Design Considerations**

- Area classification of shelter/cabinet placement
  - If shelter/cabinet is placed in a classified area
  - Can a positive pressure purge system be used to de-classify shelter/cabinet interior to general purpose area?
  - Site requirements for conduit, receptacle, misc. equipment whether in a classified or general purpose area.

- If SCR is utilized for NO\textsubscript{X} control
  - Dual range NO\textsubscript{X} analyzer for post-SCR measurement including associated cal gas equipment.
  - How will NH\textsubscript{3} slip be measured?
    - Tunable Diode Laser (TDL)
    - Differential NO\textsubscript{X} calculation
    - Converted NH\textsubscript{3} measured as NO\textsubscript{X}
CEMS Design Considerations Continued

- Calibration gas supply for startup and certification.
- Site specific boilerplate specifications required to be met.

Data Acquisition

- How will CEMS data be handled and stored?
  - Data Acquisition System (DAS) for data handling and storage.
  - DCS to handle CEMS data
- Co-mingling of data issues

- Most refinery processes subject to 40CFR Part 60 compliance. Some processes may be large enough to be subject to 40CFR Part 75, requiring data substitution routines.

CEMS measuring NO\textsubscript{x}, CO, wet and dry O\textsubscript{2}, ammonia and stack flow on Hydrogen Plant.
Auxiliary Refinery Processes

Additional support processes are required for refinery operation to aid in refining of the crude oil and handling of the process waste:

- **power and steam production for process heat (Co-Gen Plant)**
- **hydrogen production for hydro treating processes (Hydrogen Plant)**
- **sulfur recovery for processing waste acid gases (Sulfur Recovery Unit)**

**Sulfur Recovery Unit**

Sulfur Recovery Units remove the sulfur compounds (H₂S, SO₂) from the waste stream gases and convert them to elemental sulfur using a process developed by Carl Claus. The unit uses both thermal and catalytic reductions for removal of the sulfur compounds. Post recovery gases may be passed to a **Tail Gas Incinerator** or **Caustic Scrubber** for further cleanup.
Most Sulfur Recovery Units (SRU) exhaust waste acid gas through a Tail Gas Incinerator or Caustic Scrubber and require CEMS.

Tail Gas Incinerator and Caustic Scrubber CEMS are the most difficult refinery CEMS applications due to variable fuel compositions and wide range of expected emissions.

CEMS Design Considerations

- Area classification of shelter/cabinet placement
  - If shelter/cabinet is placed in a classified area
  - Can a positive pressure purge system be used to de-classify shelter/cabinet interior to general purpose area?
  - Site requirements for conduit, receptacle, misc. equipment whether in a classified or general purpose area.

- Space limitations including access for HVAC maintenance and I/O connections.

- Shelter ambient gas monitors for worker safety.
CEMS Design Considerations Continued

- Calibration gas supply for startup and certification.
- Site specific boilerplate specifications required to be met.

Data Acquisition
- How will CEMS data be handled and stored?
  - Data Acquisition System (DAS) for data handling and storage.
  - DCS to handle CEMS data
- Co-mingling of data issues
- Most refinery processes subject to 40CFR Part 60 compliance. Some processes may be large enough to be subject to 40CFR Part 75, requiring data substitution routines.
Sulfur Recovery Unit CEMS

CEMS Design Considerations Continued

**Tail Gas Incinerator CEMS**
- Wide range of SO₂ emissions, ~10ppm during normal operation and % level during plant upsets.
  - Separate SO₂ analyzers may be required to cover both controlled and uncontrolled plant operation.
  - Worker safety while working with % level gases.
- Stack flow measurement typically required do to variable heat input capacity of waste gas. (Mass emissions reporting)

**Caustic Scrubber CEMS**
- Measurement of SO₂ in the presence of NH₃
  - Formation of ammonia salts
  - Knockout of NH₃ at probe location to avoid loss of SO₂ sample. Critical for low level SO₂ measurements.
- Stack Flow measurement typically required.
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Refinery Projects

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SCAQMD Refinery Heater CEMS

Shelter Class 1, Div 2 HVAC

Air Cleanup System
SCAQMD Refinery Heater CEMS

Shelter Interior – Purged for General Purpose Area Rating
SCAQMD Refinery Heater CEMS

Instrument Rack  Sample Conditioning System
Since 2005, Cemtek Environmental has been responsible for the service of all 26 CEMS at a local SCAQMD Refinery. Cemtek is also performing the routine maintenance and calibration on the ambient air monitoring systems and fuel flow transmitters. To provide 7 day a week service, Cemtek has 6 full time service technicians dedicated to this site.
Cemtek provided four fully extractive NOx, CO & O2 CEMS for compliance with BAAQMD Reg 9, Rule 10 for 95% facility NOx reporting requirements. Three CEMS were provided in new Class 1, Division II exterior purged shelters while the fourth was retrofit into an existing site shelter.
SCAQMD Refinery RECLAIM CEMS Application

New CEMS for refinery heaters in seamless fiberglass shelter rated for NEC Class 1, Division II, Group C and D with stainless steel HVAC and fresh air intake stack. City of Los Angeles electrical code and inspection requirements. System utilizes Teledyne NO\textsubscript{X}, CO, and Servomex O\textsubscript{2} per CFR Part 60 and SCAQMD RECLAIM requirements.
Cemtek supplied a new CEMS for monitoring sulfur recovery unit tail gas incinerator emissions. The new CEMS was integrated into the existing Class 1, Div 2 CEMS shelter measuring NO$_X$, SO$_2$, CO, wet & dry O$_2$, and stack flow. Also provided was a custom built, 18 foot multi-point heated probe for measurement of a stratified stack.
Cemtek provided a new Siemens Maxum II gas chromatograph in a Class I, Div II interior and exterior shelter.
Supplied CEMS in a NEMA 4X Class I, Div II Stainless Steel shelter to measure NO_x, SO_2, & O_2.
Cemtek provided a new CEMS in a fiberglass Class I, Division II shelter for measuring NO$_x$, SO$_2$, CO & O$_2$ utilizing a Circor modular sampling system and a custom probe for measuring low level SO$_2$ in the presence of NH$_3$ on a caustic scrubber for SCAQMD RECLAIM reporting.
Supplied CEMS in a NEMA 4X Class I, Div II Stainless Steel cabinet to measure NO\textsubscript{X}, CO, wet and dry O\textsubscript{2}, ammonia and stack flow. Included field installation supervision services, start-up, training and certification services. Certified 2005
Cemtek provided a new SCAQMD RECLAIM CEMS in a NEMA 3R cabinet for measuring NO\textsubscript{X}, O\textsubscript{2}, & ammonia.
Cemtek provided four new NEMS (NO$_x$ Emissions Monitoring Systems) in a NEMA 3R cabinet for measuring inlet NO$_x$. These replaced 20 year old process systems.
Cemtek provided a new CEMS in a Class I, Div II shelter for measuring inlet NO$_X$ and stack NO$_X$ & O$_2$ utilizing ABB analyzers and M&C Products probes for classified areas.
Cemtek provided a new process $O_2$ monitoring analyzer panel in an open rack configuration to meet area classification.
Cemtek engineered a purged instrument enclosure to house a customer provided process O₂ monitor. The purged enclosure allowed for the general purpose monitor to operate in a Class 1, Division 2, Groups B, C & D area.
Questions?

Contact Information

Tim Kuiken
Cemtek Environmental
PetroChem Applications & Sales Manager
Ph: (714) 904-6276
tkuiken@cemteks.com