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A TRULY INTEGRATED CONTINUOUS EMISSION MONITORING SYSTEM (CEMS) OPTIMIZED FOR THE WASTE-TO-ENERGY (WTE) APPLICATIONS

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ABSTRACT

In a previous paper presented to the NAWTEC 12 Conference [1] we described the use of Multicomponent Infrared Gas Analyzers at Waste-to-Energy Facilities. In the subsequent eight years since the paper was presented, the state-of-the-art for the technology has advanced significantly. In addition, the user base has significantly expanded leading to more widespread use of the hot-wet multicomponent technology. Experience in dealing with recurring issues has helped develop best-practice approaches for rapid startup and minimal downtime during maintenance periods. This paper describes these technological advances and best practices incorporated into this competitively priced integrated CEM system design.

MULTICOMPONENT ANALYZER ADVANCES

The hot-wet MC3 multicomponent analyzer used by these CEMS has been enhanced significantly:

- The sample cell was completely re-designed keeping in mind maintenance related tasks and reliability
- Improved sealing O-rings on the sample cell
- Easier to access the new lid & securing latches
- Handles added to lift easier
- Outer analyzer cover – easier to open
- Thicker cell walls – more durable fittings

In addition, a purge air option has been added to minimize ambient dust effects on the internal optics. This leads to even greater analyzer stability and further reduces downtime by extending the period between Preventative Maintenance (PM) cycles.

- Most applications – 30-36 month interval between optics and cell window cleaning
- Purge system requires 0.1 LPM purge air

SYSTEM RE-CONFIGURATION

The standard MC3 analyzer and hot-wet sample system (maintained at 185 °C) is offered in a traditional self-standing cabinet (3'x3'x6') which is generally located in a CEM building at ground level. However, certain cost-saving optional configurations are also available to meet site specific needs:

- Panel-mount system with increased thermal stability and sample path length leading to improved sensitivity. Hydrogen chloride measurements of 1-5 PPM range are possible.
- Panel mount system can be located closer to probe location to avoid excessive sample line lengths.
- System interconnection via Ethernet allows not only for more modular design but provides the opportunity to interface with the system from remote access points

HEATED SAMPLE PROBE ENHANCEMENTS

The heated sample probe has been further optimized. The entire probe can be removed without pulling out the 3" or 4" ANSI 150 lb mounting flange. The probe can be operated with or without an air-operated isolation valve. The probe tube heater can be replaced at lower cost. The design facilitates easy filter cartridge maintenance or exchange. The heater temperature control can be local or at a remote site. All wetted surfaces are constructed of 316SS or proven durable alloys (for example, Hastelloy) if necessary upon request

- Used in conjunction with a heated sample line umbilical
- Not vulnerable to gasket leak as with prior two section hot-wet probes
- Using Gortex vs. composite gaskets – triples the life cycle and extends replacement cycle

- Future capability to do "wet" calibrations from the probe location – utilizing water/steam injection to further eliminate water interference accuracy

MAN-MACHINE INTERFACE REDESIGN

The CEMS interface has been redesigned for efficient data presentation to operations and EH&S personnel via touch screen interface, network and VPN connection.

- Easy historical color graphic recall of data in time-stamped graphic or tabular formats (10 sec to 24 hr)
- Charting of digital/relay events such as calibration, purge, alarms, over range
- Expandable time scale of plotted data
- System drawings, operations manuals, maintenance history all within finger touches of the Cabinets 10" x 7" color touch screen
- Available optional feature: Data review each quarter of such comparisons as:
    - Inlet vs. outlet Oxygen signal with reference historical averages
    - Oxygen and Carbon Dioxide additive values to audit 2nd tier data credibility
    - Convenient access to long term analyzer performance parameters: IR energies, calibration drift, equipment ambient temperatures

INTEGRATED REGULATORY COMPLIANCE SOFTWARE

A Data Acquisition and Handling System (DAHS) has been produced to integrate with the CEMS in order to assist with regulatory compliance. The system interfaces to the CEMS and plant parameter inputs through a Programmable Logic Controller (PLC) using the industry standard MODBUS communications protocol. This eliminates the use of proprietary data-loggers and results in a very cost-effective, reliable and flexible system architecture. Use of industry-standard software like Microsoft SQL Server database and Microsoft Excel also ensure that customers have an easy transition into the software and corporate IT staff can assist in the maintenance. The DAHS includes capabilities of displaying real-time strip charts, alarms, and calibration results. In addition, extensive reporting capabilities enable the user to generate Query reports, Quarterly Downtime and Excess Emission (EPA format) reports, Daily Calibration results, Monthly data and Alarm summaries. All reports are generated in Microsoft Excel format and can be easily customized. The DAHS is designed to handle data from one or more CEMS and hence integration of data (inlet and outlet signals) required for specific reports is an inherent part of the software.

QA-QC PLANS AND BEST PRACTICE GUIDELINES

Over the past 30 years, QA-QC plans and best practice guidelines have matured to ensure accurate system documentation and drawings. A most tangible benefit of these best practice guidelines is the reduced time and smoother startup associated with new projects. All project related documents are maintained electronically at an FTP site or more recently at a Microsoft Sharepoint Portal. Giving the user a common, easy-to-access location with all documents ensures dissemination of the information to the project participants.

As part of the best practices guidelines, an optimization of spare parts inventory is carried out. This plant-specific plan is phased in over 5 years based upon application and life expectancy

- Overnight shipping of all critical parts
- Photo illustrated manual sections for easy part identification
- Operating systems over 5 years with only 5 non-consumable parts changed
- Parts offered in component and assembly configurations for minimizing downtime and technical level of experience
- Support for optimizing inventories within regions

CONCLUSIONS

The combination of growing demand for ever more dependable and cost-effective CEMs within the WTE industry has driven the evolution of all CEM system components to be increasingly more durable and manageable. The design improvements described in this article are offered at competitive prices compared to traditional systems. This substantiates where this market has trended in the last two decades as an increasing number of earlier vintage CEMs are being replaced or upgraded to manage obsolescence and or new regulations. These design improvements and efficiencies are made primarily with the CEMs utilizing advancements in component technologies and through intelligent integration to take full advantage of these improved technologies. The savings to the plant in not only initial cost, but reduced maintenance, supervision hours, and spare parts inventory continues to fuel demand for higher value CEMs equipment.

ACKNOWLEDGMENTS

The authors are grateful to Wolfgang Berkhahn, Ph.D. and David L. Dillehay for the many discussions and valuable input regarding the subject of CEMS.

REFERENCES

[1] Baker, R, 2004, R. Peters and E. Chikhliwala, Use of Multicomponent Infrared Gas Analyzers at Waste-to-Energy Facilities, 2004, Paper presented at the 12th Annual North American Waste-to-Energy Conference (NAWTEC12), Savannah, Georgia.

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Overview

- At NAWTEC 12 Conference, we described the **use of Multicomponent Infrared Gas Analyzers at Waste-to-Energy Facilities.**
- Since that time, the state-of-the-art for the **technology has advanced significantly**
- The **use of the hot-wet multicomponent technology** has significantly expanded
- Application experience has helped develop best-practice approaches for rapid startup and **minimal downtime during maintenance periods.**
- This paper describes these **technological advances** and best practices incorporated into this **competitively priced integrated CEM system design.**

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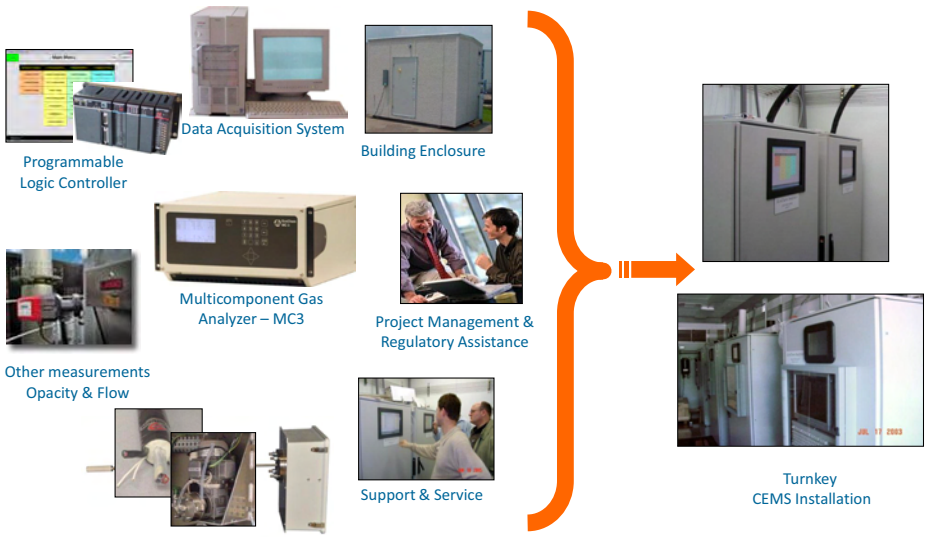
A Current CEMs–Putting it All Together Components & System Integration



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Typical Older Continuous Emission Monitor (CEM)

- Separate analyzers
- Lots of wires & tubes
- Retrofits
- Technician living with the CEM

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CEMs circa 1995- present

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After 15 years of retrofits, it starts to become a blur…and difficult to keep working

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State-of-the-art CEMs – 2012

- Fully Digital
- Touch Screen Interface
- No Chiller
- One Analyzer

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Delivered Features of Current Production CEMs

- Capable of running <u>3 months</u> without being touched
- Touchscreen interface
- Remote control & diagnostics
- One analyzer instead of 4 or 5
- 99+ % availability
- Full Regulatory compliance
- <u>Semi-annual</u> PM cycle
- Cost of hardware- $65-75K

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MC3 Measurement Capability

Single MC3 analyzer can measure 8 gases plus Oxygen

Dual ranges can be selected for same gas

* All components at 185°C or above; standard sample cell path 6 meters

Gas	Range Interval**
CO	0-50 PPM to 0-10,000 PPM
SO_2	0-10 PPM to 0-1,000 PPM
NO	0-10 PPM to 0-500 PPM
NO_2	0-10 PPM to 0-500 PPM
CO_2	0-1,000PPM to 0-40%
NH_3	0-10 PPM to 0-500 PPM
HCl	0-10 PPM to 0-100 PPM
H_2O	0-2% to 0-50%
O_2	0-25%
N_2O	0-10 PPM to 0-1,500 PPM
CH4	0-10 PPM to 0-1,000 PPM

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Multicomponent Analyzer Advances

- The sample cell was completely re-designed keeping in mind maintenance related tasks and reliability.
- Improved sealing O-rings on the sample cell
- Easier to access – new lid – latches
- Handles added to lift cell easier
- Outer analyzer cover redesigned– easier to open
- Thicker cell walls – better port seal

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Multicomponent Analyzer

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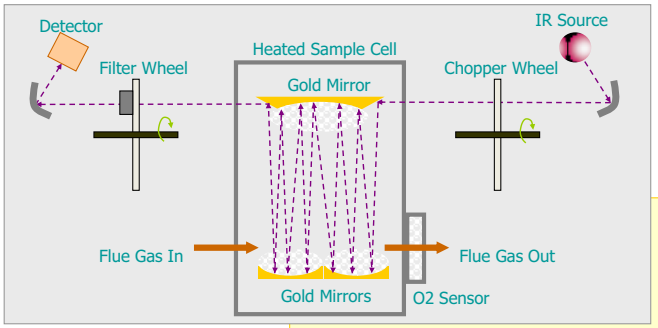
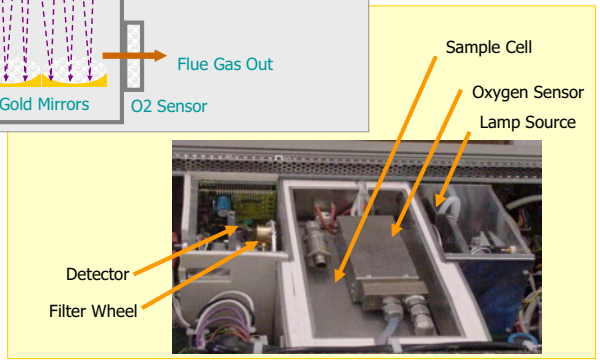
Analyzer Components





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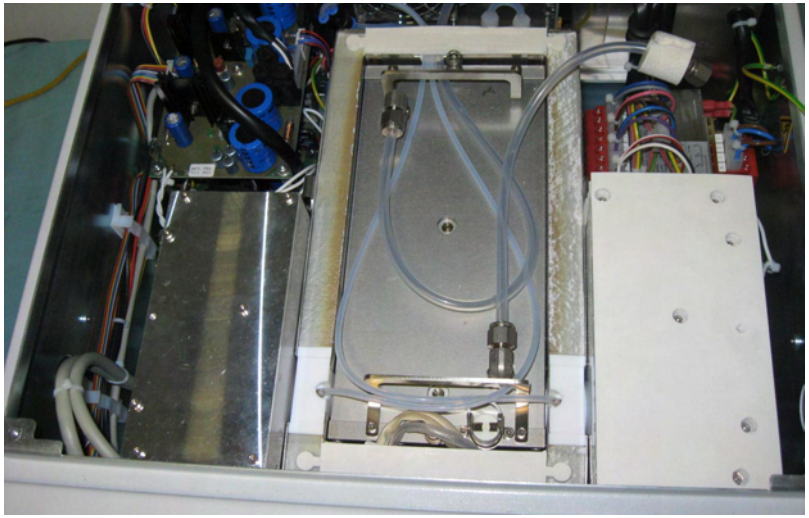
Heated Sample Cell



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Improved Optics

- A purge air option has been added to minimize dust effects on the internal optics - greater analyzer stability - 0.1 LPM instrument air
- Reduces downtime by extending the period between Preventative Maintenance (PM) cycles.
- Most applications – 30-36 month interval between cleaning – audited by daily energy readings taken automatically

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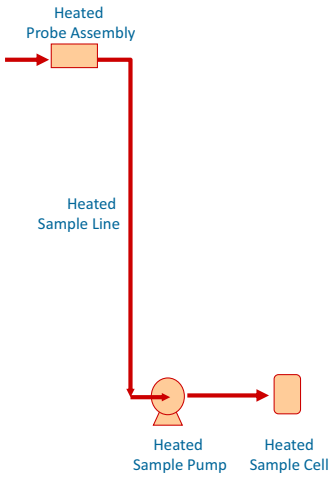
Key Attributes of Sampling Approach



- **Hot-Wet Sampling**
  - Relative simplicity of sample system
  - Reliable, eliminates troublesome gas coolers
  - Reactive gases such as HCl, SO_2, and Ammonia can be measured
  - Entire sampling system greater than 185°C (~365°F)
  - Direct measurement of water
- **Extractive Multicomponent**
  - For a Hot and Wet sample, a Multicomponent analyzer will measure all gases simultaneously while taking into account interfering compounds
  - All measurements are made at ground level (ease of maintenance for analyzer)

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System Reconfiguration

- The standard MC3 analyzer and **hot-wet sample system (maintained at 185 °C) is offered in a traditional self-standing cabinet** which is generally located in a CEM building at ground level.
- Also now available, **a panel-mount system with increased thermal stability and sample path length**
- Panel mount system can **be located closer to probe** location to avoid excessive sample line lengths.
- System interconnection via Ethernet provides the opportunity to **interface with the system from remote access points**

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Standard System Cabinet

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Standard MC3 System

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Panel Mount Configuration

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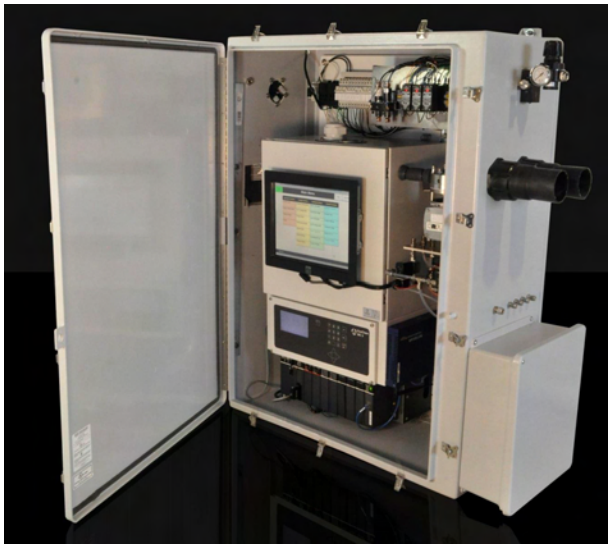
Panel Mount System



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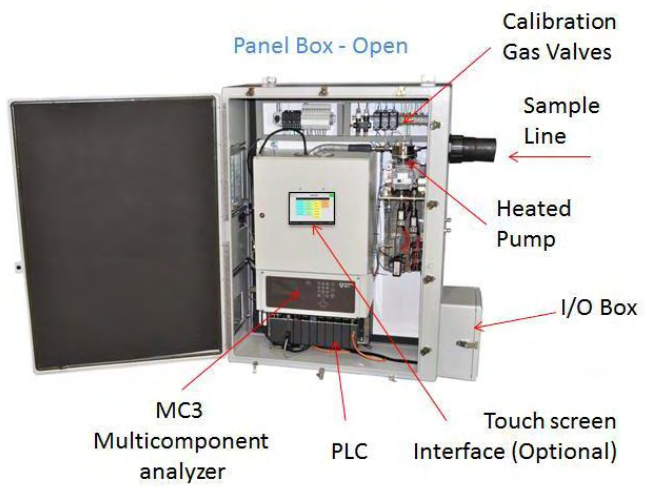
Panel Mount – Open Cabinet



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Heated Sample Probe Enhancements

- The entire probe **can be removed without unbolting the mounting flange.**
- The probe tube heater can be replaced at low cost. The heater temperature control can be local or at a remote site.
- All wetted surfaces are constructed of 316SS or proven durable alloys – Hastelloy available
- Used in conjunction with a heated sample line umbilical
- Not vulnerable to gasket leak as with prior hot-wet probes
- It can be operated with or without an air-operated isolation valve.
- Future capability to do “wet” calibrations from the probe location – utilizing water/steam

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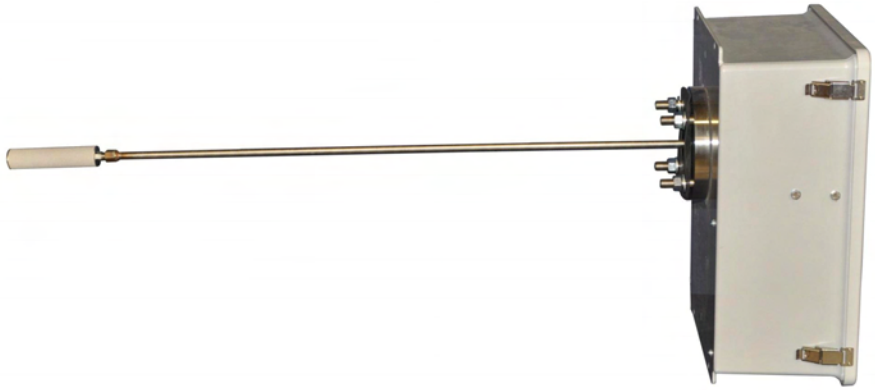
HW5 Heated Probe



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HW5 Heated Probe

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Man- Machine Interface Refinements

- Redesigned for efficient data presentation to operations and EH&S personnel via touch screen interface, network and VPN connection.
- Easy historical color graphic recall of data in time-stamped graphic or tabular formats
- Charting of digital/relay events (calibration, purge, alarms)
- Expandable time scale of plotted data
- Drawings, manuals, maintenance history all within finger touches of the Cabinets 10” x 7” color touch screen

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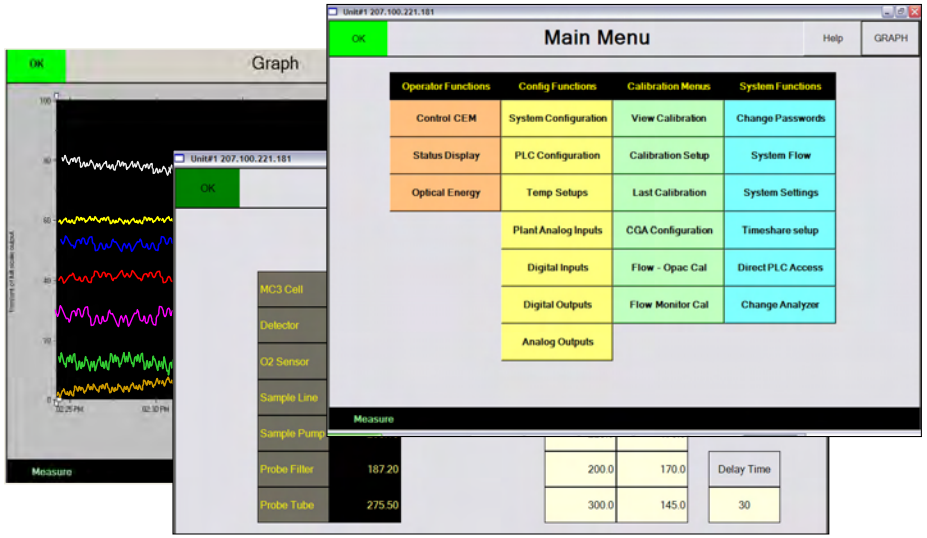
Effective Interface to System



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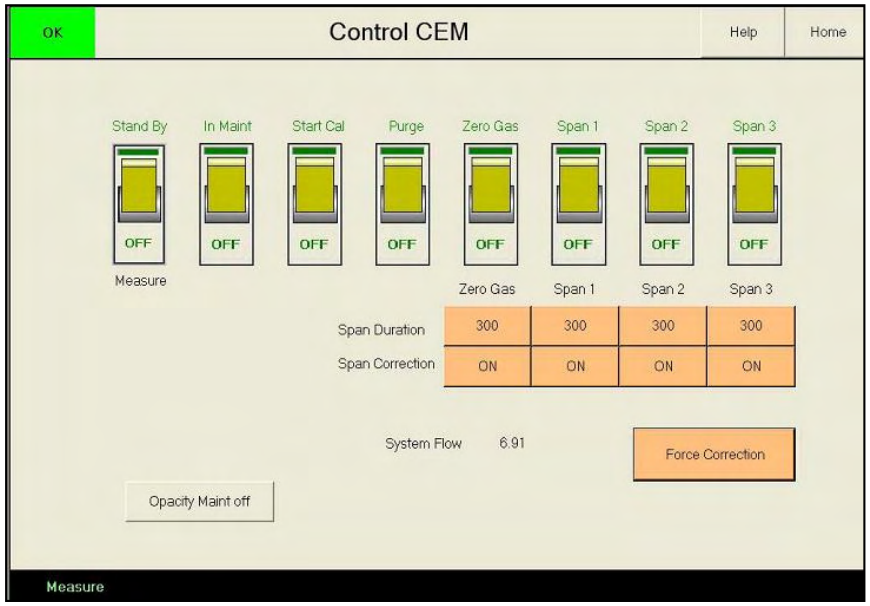
Control CEM



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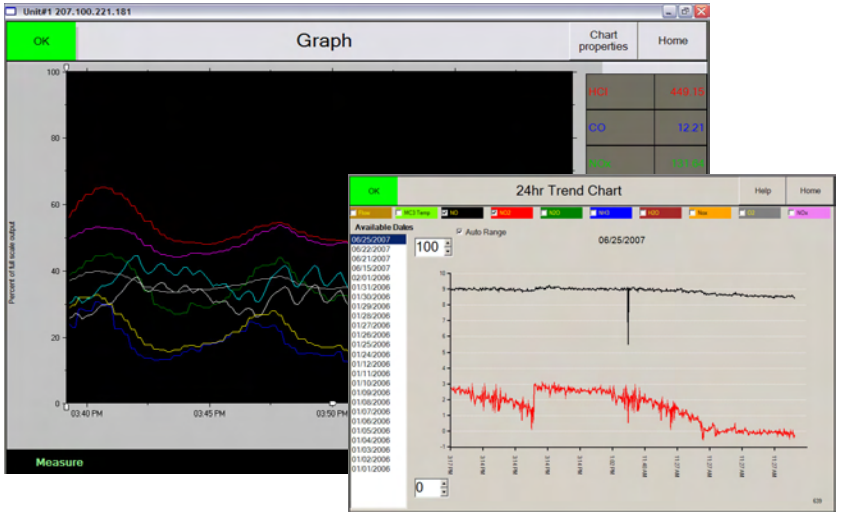
Graphics Displays



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Man-Machine Interface Refinements – cont'd

- Available optional feature: Data review each quarter of such comparisons as:
  - Inlet vs. outlet Oxygen signal with reference historical averages
  - Oxygen and Carbon Dioxide additive values to audit 2nd tier data credibility
  - Convenient access to long term analyzer performance parameters: IR energies, calibration drift, equipment ambient temperatures

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Integrated Regulatory Compliance Software

- A Data Acquisition and Handling System (DAHS) has been built to integrate with the CEMS in order to assist with regulatory compliance - Programmable Logic Controllers (PLC) using the industry standard MODBUS communications protocol
- Reliable and flexible system architecture. Use of industry-standard software - Microsoft SQL Server database and Microsoft
- The DAHS includes capabilities of displaying real-time strip charts, alarms, extensive Query reports, Quarterly Downtime and Excess Emission (EPA format) report, Daily Calibration results, Monthly data and Alarm summary.
- All reports are generated in Microsoft Excel format and can be easily customized. The DAHS is designed to handle data from one or more CEMS and hence integration of data (inlet and outlet signals) required for specific reports is an inherent part of the software.

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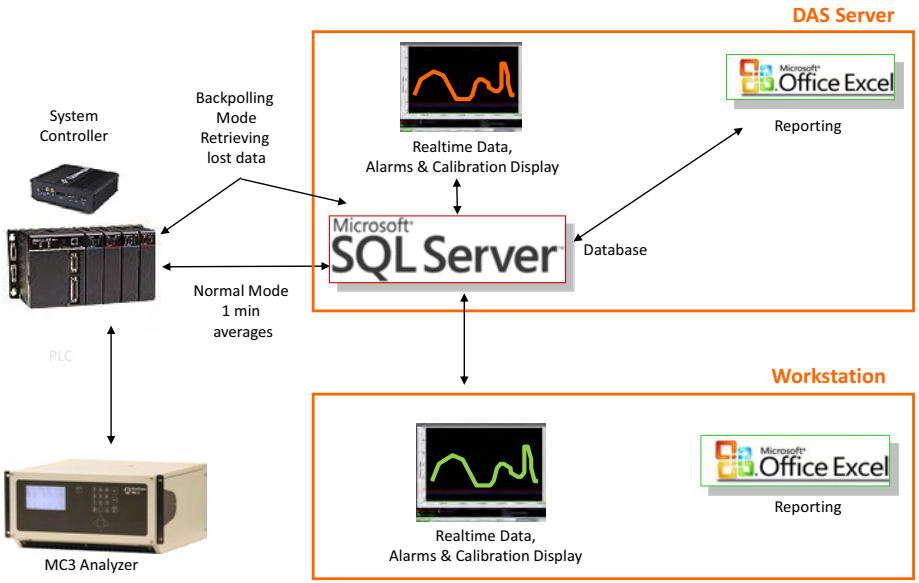
System Design



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DAS Server Hardware

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QA-QC Plans & Best Practice Guideleines

- The most tangible benefit of these best practice guidelines is the reduced downtime and smoother startup associated with new projects.
- Engineering drawings and manuals right on touch screen - one button touch away
- All project related documents are maintained electronically at an FTP site or more recently at a Microsoft Sharepoint Portal -ensures dissemination of the information to the project participants.
- An optimization of spare parts inventory is carried out. Inventory is phased in over 5 years based upon application and life expectancy
- Overnight shipping of all critical parts is available when necessary
- Photo illustrated manual sections are provided for easy part identification
- Systems in service >5 years with only 5 parts changed is not uncommon
- Parts offered in component and assembly configurations for minimizing downtime and technical level of experience
- Support for optimizing plant's QAQC procedures to lower operating costs

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Are New CEMs THAT much better? Why Upgrade? Why Now?

- Purchase price of new CEM may be equal to your annual maintenance cost savings over 24-36 months
- Data credibility with operations and regulators an ongoing issue
- Can't get replacement parts for analyzers
- Full compliance with PADEP Rev 8 and EPA Part 75
- Can do wonders for target community relations

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Conclusions

- The growing demand for ever more dependable and cost-effective CEMs within the WTE industry has driven the evolution of all **CEM system components to be increasingly more durable and manageable**.
- The systems with these design improvements described in this article are offered at **competitive prices compared to traditional systems**.
- These design improvements and **efficiencies are made primarily with the CEMs utilizing advancements in component technologies and through intelligent integration.**
- The **savings to the plant is realized not only initial cost, but reduced maintenance, supervision hours, and reduced spare parts inventory** continues to fuel demand for these higher value CEMs.

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Acknowledgements

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- NAWTEC Committees & Staff for this opportunity to present this material.

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Thank You

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