
ACHIEVING UNIFORM COMBUSTION USING REAL TIME COAL FLOW AND GASEOUS EMISSIONS MEASUREMENT EQUIPMENT

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EVIDENCE OF NON-UNIFORM COMBUSTION

Symptoms Of Non-Uniform Combustion Often Include:

- **Uneven Excess Oxygen Readings (Side-To-Side)**
- **Inconsistent Flyash Loss On Ignition (LOI) Values And Localized High Carbon Monoxide (CO)**
- **Uneven Waterwall Deposition Patterns**
- **Side-To-Side O₂, CO And NO_x Data Change With Firing Pattern**
- **Uneven Flue Gas And Steam Temperatures**

WHY BALANCE THE STEAM GENERATOR'S COMBUSTION?

Non-Uniform Combustion Can Lead To:

- **Poor Equipment Performance**
- **Increased Flyash Loss On Ignition (LOI) And Increased Carbon Monoxide (CO) Resulting In Lower Boiler Efficiency**
- **Waterwall Corrosion And Fouling In The Convective Section**
- **Elevated NO_x Emissions Caused By Air Rich Burners**
- **Elevated CO Emissions Caused by Fuel Rich Burners**

STEP ONE:

Address Pipe-to-Pipe Fuel Flow Distributions

MEASURING AND OPTIMIZING COMBUSTION – COAL FLOW DISTRIBUTION TESTING

- **Extractive Sampling (RotorProbe™) Versus Real Time Coal Flow Measurements**
- **RotorProbe™ :**
 - ISO Approved
 - Performed Well Under Most Test Conditions In FERCo's Evaluations And At The EPRI Coal Flow Test Loop
 - Sequential, “Snapshot” Testing
- **MIC:**
 - Real-Time Coal Flow Distributions
 - Data Logged Constantly For All Burner Lines Of A Pulverizer
 - Field Testing Confirmed Accuracy With RotorProbe™ Results
 - Data From The EPRI Test Loop Indicated Very Good Agreement

MIC REAL TIME COAL FLOW DISTRIBUTION TESTING

- **Two (Vertical Piping) or Three (Horizontal Piping) Sensors Required Per Burner Line**
- **Attach To Burner Line Using Existing Sample Ports (Valves)**
- **Data Logged And Displayed Simultaneously For All Burner Lines**
- **Distribution Changes Due To Operating Conditions, Such As Feedrate, Or To Equipment Settings, Such As Adjustable Orifices, Can Be Seen Immediately**

TYPICAL MIC SENSOR SET-UP



STEP TWO:

**Address Flue Gas Distributions for
O₂, CO and NO_x (Side-to-Side)**

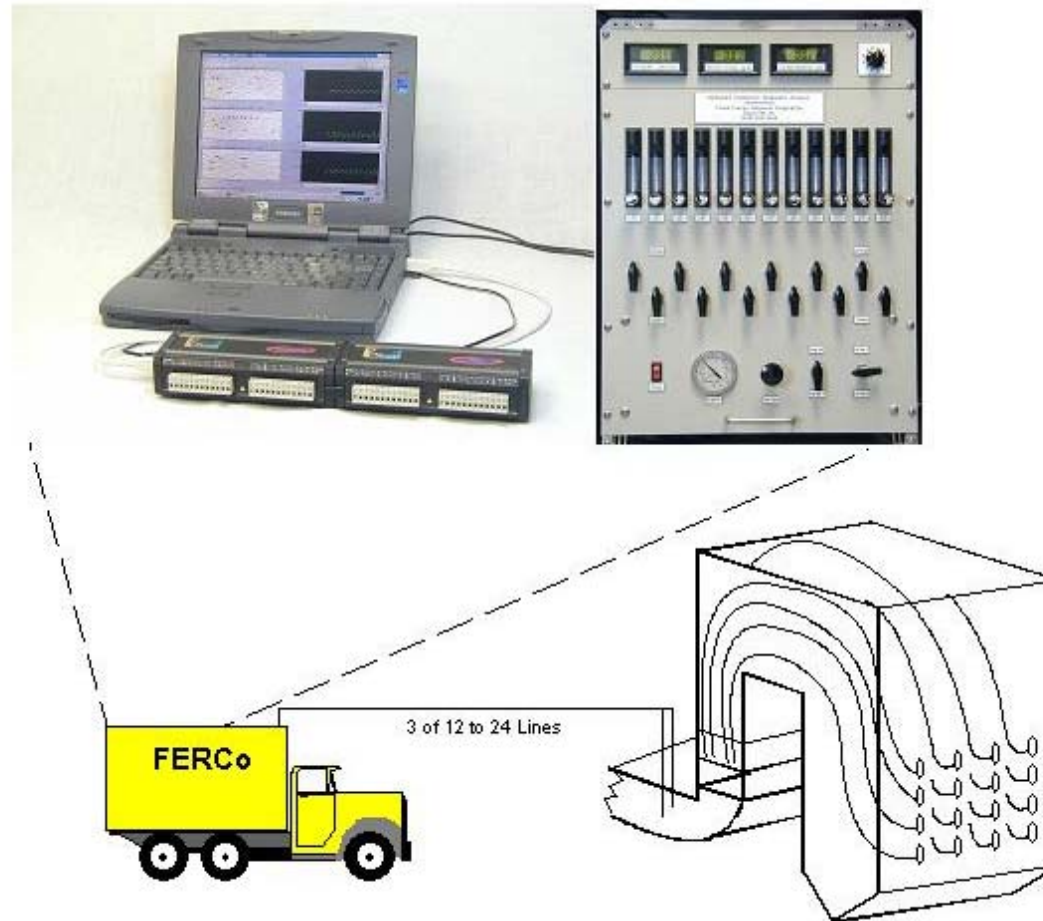
MEASURING AND OPTIMIZING COMBUSTION – GASEOUS EMISSIONS DISTRIBUTION TESTING

- **Traditional (Point-To-Point) or Real Time Using the FERCo Multipoint Combustion Diagnostic Analyzer (MCDA)**
- **Traditional Sampling:**
 - **Perform Flue Gas Analysis Sequentially, Requiring Approximately 3-5 Minutes Per Point (24 Points = 72-90 Minutes)**
 - **Boiler May Change, Thus Initial Data May Not Be Representative**

MEASURING AND OPTIMIZING COMBUSTION – GASEOUS EMISSIONS DISTRIBUTION TESTING (Cont'd)

- **MCDA:**
 - Perform Flue Gas Sampling Of Points In Parallel; 12 Points Can Be Sampled Simultaneously; 24 Points = 10-13 Minutes
 - Data Logged Automatically Every 10-20 Seconds And Can Be Replayed For Additional Analyses
 - Data Can Be Monitored In Real Time To See The Cause And Effect Relationships Of Operating Parameter And Equipment Changes, Such As Mill Loadings Or Air Register Settings
 - MCDA Data Compared With Traditional CEM Instruments For Increased Confidence

TYPICAL MULTIPOINT NO, O₂, CO ANALYZER (MCDA) INSTALLATION



CASE HISTORY:

Combustion Diagnostics Using Real Time Instrumentation

UNIT DESCRIPTION

- **Allegheny Energy Supply's Harrison Unit 2**
- **640 MWg**
- **Foster-Wheeler Supercritical Boiler**
- **Opposed Wall Fired**
- **Six D9 Ball Tube Mills With Four Burner Lines Per Mill**
- **Firing Pattern: Three Elevations With Four Burners Across For Both Walls**

NON-UNIFORM COMBUSTION SYMPTOMS ON HARRISON UNIT 2

- **High CO And LOI On One Side Only**
- **Increased LOI Forced Operators To Increase Excess Air**
- **Higher Excess Air And High LOI Caused Decreased Electrostatic Precipitator (ESP) Performance**
- **The Increased Ash In The Flue Gas Leaving The ESP Was Eroding An Induced Draft Fan**

DIAGNOSTIC METHODOLOGY

- **Perform Fuel Distribution Testing**
- **Evaluate PC Samples For Fineness**
- **Measure Concentrations of O₂, CO and NO_x At Economizer Exit**
- **Establish Cause And Effect Relationships By Varying O₂ Level, Firing Pattern, Mill Loading And Burner Register Settings**
- **Program Completed Within Seven Test Days**

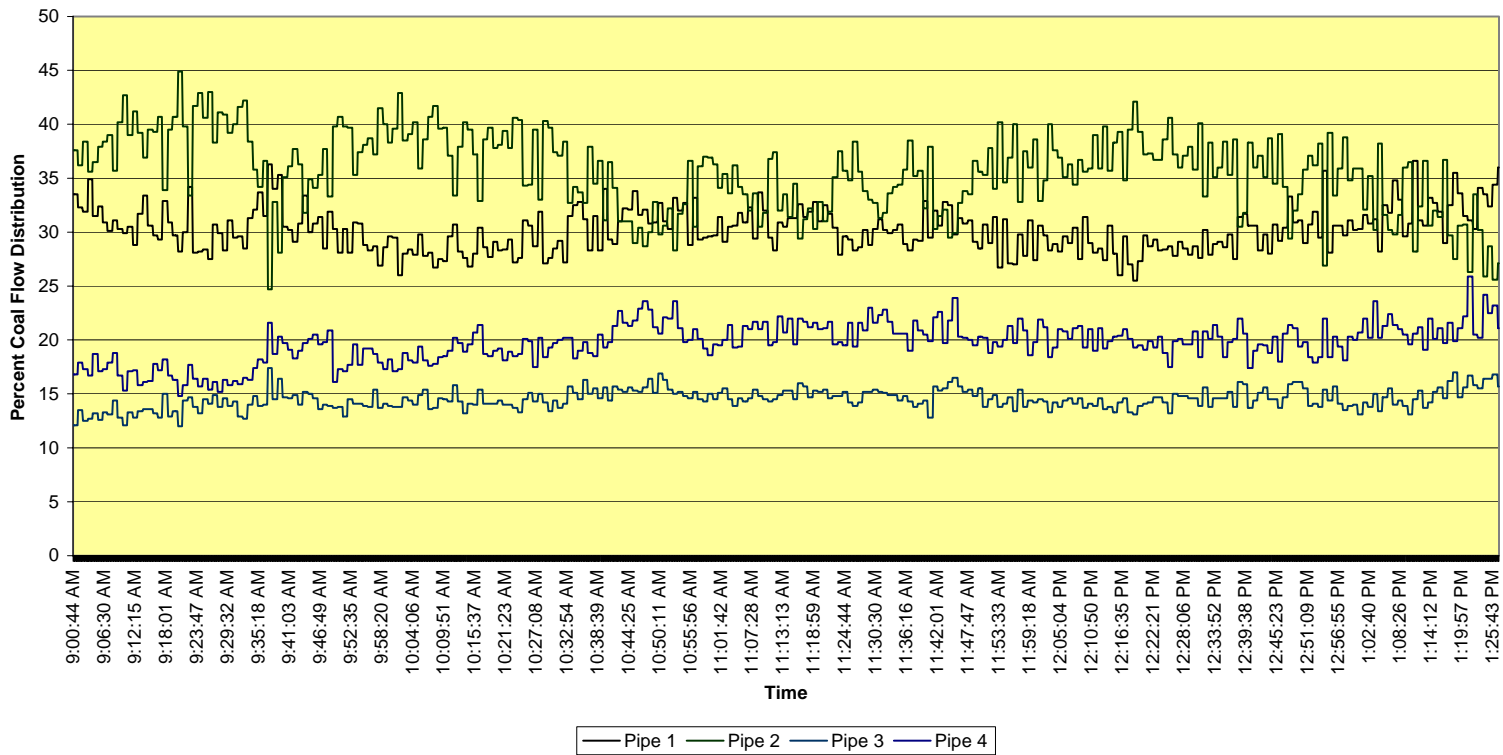
HARRISON 2E MILL COAL FLOW DISTRIBUTION DATA

- **F-W BALL TUBE MILLS WITH 4 – 15¼” BURNER LINES**

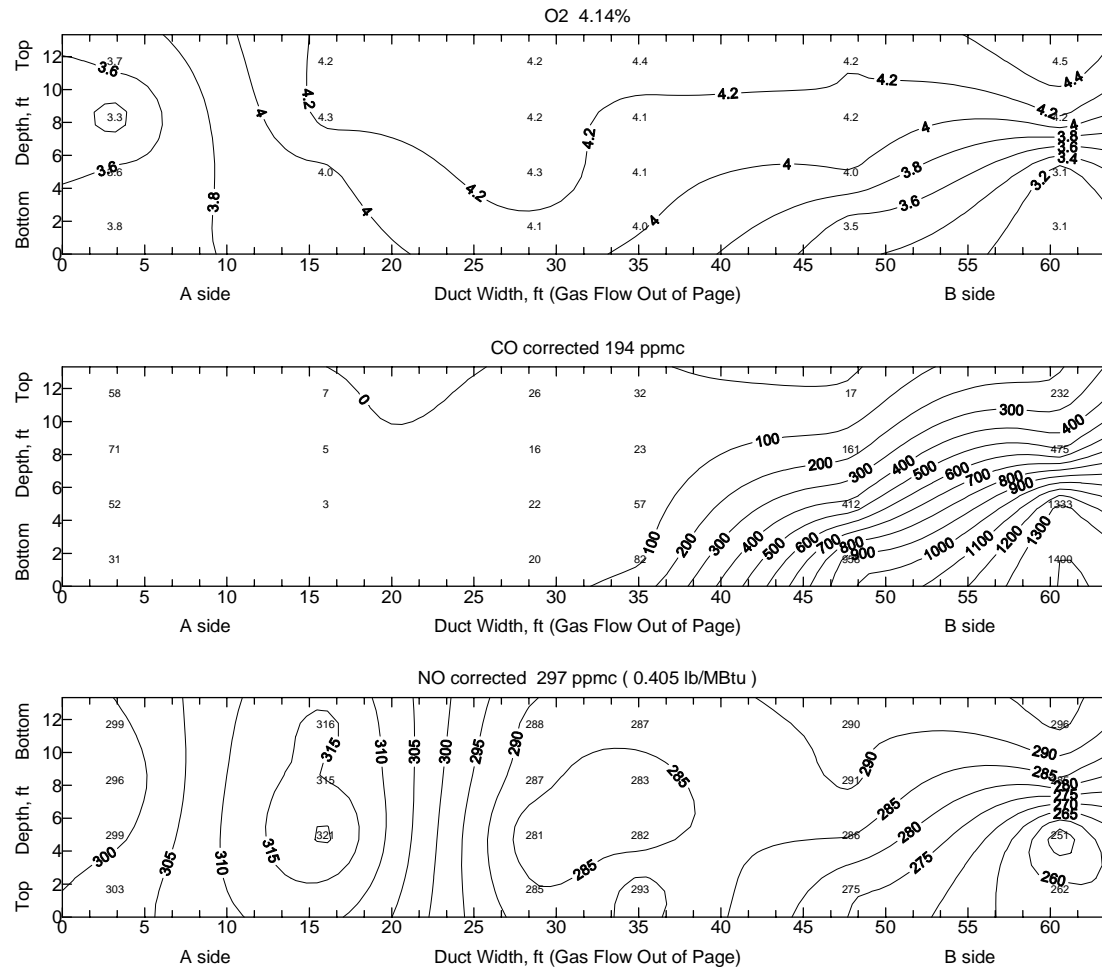
ROTORPROBE™ RECOVERED MASSES: (Four Minute Collection Period)		Pipe 1	Pipe 2	Pipe 3	Pipe 4
	Run 1	235gm	230gm	93gm	117gm
	Run 2	186gm	217gm	125gm	221gm
	Run 3	277gm	208gm	71gm	176gm
CALCULATED % DEVIATION PIPE TO PIPE		20.0%	24.2%	-39.4%	-4.8%
• MIC % DEVIATIONS PIPE TO PIPE (MIC Data Recorded Over 4 ½ Hours)		20.8%	42.5%	-42.0	-21.3%

MIC PLOT OF COAL FLOW DISTRIBUTIONS OVER TIME FOR 2E PULVERIZER

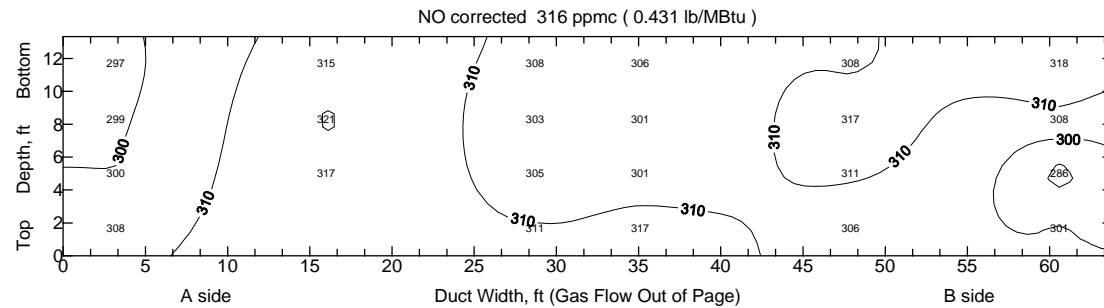
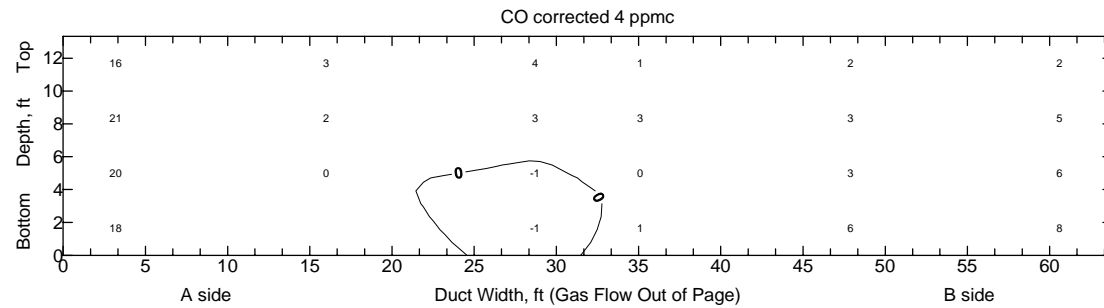
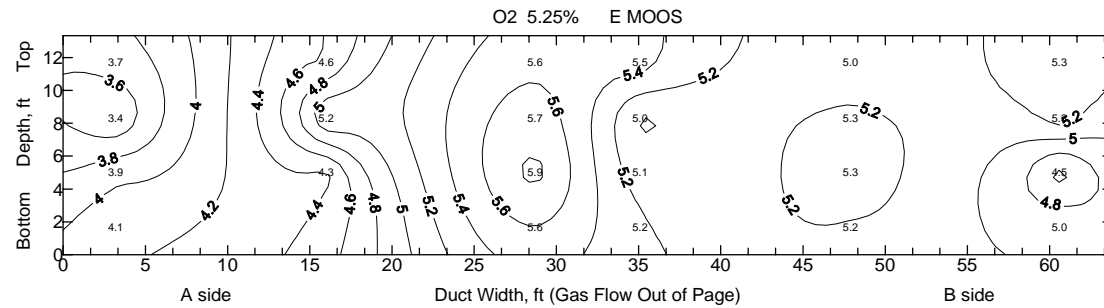
Mill 2E Burner Line Coal Flow Distributions



THE EFFECT OF 2E MILL ON COMBUSTION UNIFORMITY WITH ALL MILLS IN-SERVICE



THE EFFECT OF 2E MILL ON COMBUSTION UNIFORMITY WITH 2E MILL OUT OF SERVICE



COMBUSTION IMPROVEMENTS

The Results Of Removing 2E Mill Were:

- **CO Was Reduced From 194 ppm_c To 4 ppm_c**
- **O₂ Increased From 4.14% To 5.25% (Dry Basis)**
- **NO_x Increased From 0.405 To 0.413 lb/MBtu**
- **Flyash LOI Reduced From 6.0% to 3.2%**
- **Improvements Realized With No Changes In Fuel Flow, Total Airflow, Steam Flow Or Any Burner Settings**

COMBUSTION IMPROVEMENTS

The Results Of Removing 2E Mill Were:

- **Additional Tuning Reduced NO_x Emissions From 0.413 lb/MBtu To 0.372 lb/MBtu With Minimal Impact On CO (4ppmc to 90ppmc) At A Reduced Excess Oxygen Level (5.3% to 3.7%)**
- **ESP Performance Restored To Expected levels**
- **2E Mill Fineness Was Found To Be 98.15% Passing 50 Mesh And 74.47% Passing 200 Mesh**

CONCLUSIONS

THE KEY POINTS OF THIS CASE HISTORY ARE:

- 1. The Unsteadiness Of The Combustion Could Easily Be Misinterpreted By Conventional, “Snapshot-Style” Extractive Coal Flow Sampling.**
- 2. Real Time Coal Flow And Emissions Sampling Allows A Much Quicker And More Accurate Analysis Of Combustion Variability.**
- 3. Real Time Pulverizer Fuel Distribution Data Can Be Monitored Over Time And Compared To The Unit’s DCS Data For Impact-Based Analysis Of Combustion, Emissions And Efficiency.**
- 4. Real Time Gaseous Emissions Monitoring Allows The Effects Of System Changes To Be Readily Evaluated In Terms Of The Unit’s Combustion, Emissions And Efficiency.**

CONCLUSIONS (Continued)

- 5. The Performance Of Only One Pulverizer Can Have A Very Pronounced Impact On Combustion Uniformity And Equipment Performance.**
- 6. The Combustion Impacts Were Reducing Unit Availability And Key Equipment Life.**
- 7. These Combustion Impacts Were Quickly And Accurately Identified Using The FERCo Proprietary Real Time Combustion Diagnostic Technologies.**
- 8. These Same Diagnostic Technologies Were Used To Make Corrections To Key Operating Parameters, Which Were Proven To Improve The Unit's Combustion And Reduce The Associated Impacts On Key Equipment Performance.**

ACKNOWLEDGEMENTS

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