POSTER

ELIMINATING BIAS IN CEM SYSTEMS

—

A CHECKLIST

U.S. Environmental Protection Agency

Acid Rain Division

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How to Use this Checklist

Step 1: Identify the type of components in your monitoring system.

Step 2: For each component in your system, find the potential causes of bias as shown in the Checklist. Refer to the indicated pages in the "Operator's Guide" for additional information.

Step 3: Diagnose the components in your system using the list of possible causes shown in the Checklist. Narrow in on the source of the measurement bias.

Step 4: Take corrective action.

Step 5: Re-test for bias. If necessary, take further corrective action until the source of bias is eliminated or brought within acceptable limits.

Chapter 2 Highlights

Probe Location and Stratification Problems

Problem: Name	Problem: Description	Corrective Actions	Page Refs
Stratification — All Types	Gas stratification and flow stratification produce unrepresentative sampling and bias measurements during Relative Accuracy Test Audit.	Find unstratified locations if at all possible. Use fans or gas reinjection to solve gas stratification problems. Use straightening vanes or baffles to solve flow problems.	2-9
Stable Stratification Patterns	Stratification is present but pattern does not vary over time, i.e., with load or process changes.	Sample at a point representative of the area of measurement. Monitor on a path representative of the area of measurement.	2-9, 2-10
Varying Stratification Patterns	Stratification is present and pattern varies as plant's operating conditions change.	Calibrate the monitored values to the reference values determined over the range of variation (e.g., different load/process conditions). <u>For point sampling systems</u>: Extract or monitor at multiple points. <u>For path sampling systems</u>: Monitor on paths less sensitive to variation. Monitor on multiple paths on the cross-section.	2-10, 2-11

Chapter 3 Highlights

Sampling System Problems — Extractive CEMS

Problem: Name	Problem: Description	Corrective Actions	Page Refs
Probe Problems — Source Level Systems			
Plugging	Particulate matter clogs sampling probe.	Blowback. Increase filter surface area.	3-3, 3-4
Scrubbing	Precipitates on probe "scrub" SO_2 from sample gas.	Blowback. Redesign.	3-3, 3-4
Probe Problems — Dilution Extractive Systems			
Pressure Effects	Pressure changes affect dilution ratio causing measurement errors.	Calculate correction.	3-5, 3-6
Temperature Effects	Temperature changes affect dilution ratio causing measurement errors.	Calculate correction. Add probe heater. Replace with ex-situ probe.	3-5, 3-6
Droplet Scrubbing	Evaporation of droplets in sonic probe can plug probe or cause pre-diluting and inconsistent measurements.	Attach demister. Replace with ex-situ probe.	3-5
Multi-Component Cal Gas Effect	Mixtures of cal gases may alter the expected gas velocity through the sonic orifice, biasing measurements.	Calculate correction. Use gas mixtures consistently.	3-6–3-8
Contaminated Dilution Air	Trace amounts of measured gas in dilution air cause errors.	Check zero baseline with high quality zero air.	3-9
Varying Dilution Air Pressure	Poor quality dilution air regulator adversely affects dilution ratio.	Install flow controllers or better quality pressure regulators.	3-9
Other Sampling System Problems - Source-Level Extractive Systems			
Water Entrainment	Collected liquid can scrub soluble gases, dilute sample gas, or cause leaks through corrosion.	Redesign.	3-9, 3-10
Leaks	In negative pressure systems, leaks may dilute sample gas.	Find and remove leaks.	3-10, 3-11
Adsorption	Gas adsorbs on walls of tubing causing measurement errors, particularly at low emissions concentrations.	Increase flow rate.	3-11, 3-12
Absorption	Gas is absorbed in moisture condensed in the H_2O conditioning system.	Remove moisture. Acidify condensate. Change system design.	3-12, 3-13
Moisture Monitor Errors	Systematic error in moisture monitor may produce bias.	Factor in error from moisture monitoring in test calculations.	3-13

Chapter 4 Highlights

Sampling System Problems — In-Situ Gas CEMS and Opacity Monitors

Problem		Corrective Actions	Page Refs
Name	Description		
Point Monitors			
Blinding	Precipitate on the filter seals the probe tip from the flue gas.	Clean or replace filter.	4-4
Faulty Audit Gas Injection	Improper flow rate of calibration gases results in biased concentrations in probe cavity.	Adjust flow, carefully following calibration procedures.	4-4
Temperature Distortions	If temperature sensors are not working properly, errors can result in emission values.	Calculate correction. Adjust or replace sensor.	4-5
Path Monitors			
Internal Calibration Cell Defects	Errors are introduced when internal calibration cell leaks or its gas decomposes.	Check daily cal chart for jumps or drift. Replace cell.	4-5–4-7
Gas Cell Temperature Problem	Bias results if the temperature of the gas cell and flue gas differ greatly.	Correct mathematically. Install cell in "zero pipe" or outside stack in heated area.	4-9
Flow-Through Calibration Gas Availability	Protocol 1 gases often not available at required concentrations.	Use only if certified gases are available. Redesign system - use longer cell.	4-7–4-10
Transmissometers (Opacity Monitors)			
Improper System Design	Poor design produces both bias and inconsistencies with visual observations.	Redesign.	4-10
Dirty Windows	Build-up on windows produces bias.	Auto-correct.	4-10
Interferences	Water droplets and high NO_2 distort measurements.	Calculate correction.	4-10

Chapter 5 Highlights

Flow (Velocity) Monitoring System Problems

Problem: Name	Problem: Description	Corrective Actions	Page Refs
General			
Stack Area Miscalculation	Use of incorrect cross-sectional area in calculating volumetric flow can produce measurement error.	Directly measure and re-calculate.	5-2
Gas Density and Temperature Distortions	Bias can be introduced if the temperature profile is different from the velocity profile.	Verify temperature profile and use new assumptions if there is a disparity with velocity profile.	5-2
Differential Pressure Sensing Monitors			
Improper Angle of Probe Tube to Gas Flow	Measurement error can result if probe tube is not oriented perpendicular to flue gas flow.	Rectify improper orientation. Avoid using where cyclonic flow is present.	5-3
Plugging	Probe plugging can prevent accurate pressure measurements.	Increase frequency and/or pressure of blowback.	5-3, 5-4
Thermal Sensing Monitors			
Particulate Build-Up on Sensors	Particulate build-up can slow instrument response by forming an insulating layer on the probe's temperature sensors.	Remove by flash heating or blowing off deposits. Avoid by employing aerodynamic cavity design.	5-4, 5-5
Water Droplets and Acid Corrosion	Heat lost to evaporation can bias measurements. Acid droplets can eat into the metal junctions of probe arrays.	Repair and change probe design.	5-4
Ultrasonic Monitors			
Improper angle of transducers	Measurement errors can result under pitched or cyclonic flow conditions.	Orient measurement path perpendicular to the flow pitch. Where pitched flow is variable, consider using two sets of transducers in X-pattern.	5-5, 5-6
Particulate build-up on sensors.	Build-up on sensors can introduce measurement error.	Use blowers to keep transducer sensors clean.	5-6

Chapter 6 Highlights

Gas Analyzer Problems

Problem: Name	Problem: Description	Corrective Actions	Page Refs
General			
Interference Effects	The presence of other gas species throws off the measurement of the gas being monitored.	Change analysis technique. Measure concentration of interferent and correct for its presence. Scrub out the interfering species before analysis.	6-2–6-5
Analyzer Design	Features inherent in an analyzer's physical construction, electronic design, and analytical technique can be prone to producing measurement bias.	Choose analyzers wisely, considering bias-prone features. In QA/QC program, tailor preventative maintenance to design features that are bias prone.	6-7
Ambient Effects			
Temperature	If exposed to extreme temperatures, the analyzer may produce erroneous readings.	Temperature stabilize the analyzer. Measure temperature and compensate.	6-5, 6-6
Pressure	Changes in barometric pressure can introduce systematic error in spectroscopic systems where measurements are made from a sample cell.	Monitor pressure and mathematically compensate for pressure effects.	6-6, 6-7
Polluted/ Corrosive Atmosphere	Situations like plume downwash or flue gas exhausting into CEM shelter can produce systematic error or system failure.	Shelter or otherwise protect system. Filter ambient air.	6-6
Calibration			
Incorrect Gas Values	If the presumed and actual calibration gas concentrations differ significantly, biased measurements will result.	Replace or recertify gas. Find actual concentration. Recalculate effluent concentrations.	6-8
Inadequate/ Inconsistent Response Time	Bias can develop if operator or operating system does not allow adequate time for monitor to reach its asymptotic value.	Establish procedures that ensure consistently adequate time for monitor response.	6-9–6-11
System Calibration Obscuring Local Bias	Routine analyzer adjustments during full system calibration can mask local sources of bias.	Perform probe and local analyzer calibration checks in addition to system checks.	6-11, 6-12

Chapter 7 Highlights

Data Acquisition and Handling System (DAHS) Problems

Problem		Corrective Actions	Page Refs
Name	**Description**		
Improper Interfacing			
Distorted Inputs from Analyzer	Input signals to the DAHS from the analyzer, process controller, or sensors are distorted.	To detect problem, compare DAHS readings to strip chart recorder's. Replace or repair faulty components.	7-2
Synchronization Problems	Errors will result if system control and DAHS clocks are out of synchronization.	Prior to certification testing, fix any mismatch between system and DAHS clocks.	7-2, 7-3
Calculation Problems			
Round-Off Problems	Incorrect rounding methods can produce biased results.	Change math to meet accepted professional practices and the conventions in regulations.	7-3
Incorrect Parameters	Entering incorrect values for user-configurable parameters will produce recurring errors.	Re-enter correct values.	7-4
Incorrect Equations	Programming incorrect equations will produce recurring calculation errors.	Require DAHS developers to document and validate all equations and correct code.	7-4
Improper Correction Routines			
Automated Zero/Span "Corrections"	Such adjustments may not be warranted and, at times, can introduce errors.	Do not allow automated corrections, OR Require vendor to precisely define and print out each adjustment. Include definitions in QC plan.	7-5, 7-6
Flow Monitor Correction Factors	If not correlated with actual conditions, these factors can produce systematic error.	Re-test under all prevailing conditions. Then, re-calculate the factors.	7-6, 7-7
Faulty Dilution System P/T Corrections	Pressure and temperature corrections can produce errors if incorrectly derived.	Require vendor to specify factors used and how derived. Correct if wrong.	7-7
Bias Adjustment Factor (BAF)	The BAF is a regulatory remedy, not a technical correction for systematic error.	Avoid having to apply a BAF by eliminating the sources of bias. The lower the BAF, the higher the confidence in the CEM's accuracy.	7-7, 7-8