Mercury Control with the Advanced Hybrid Particulate Collector

(DE-FC26-01NT41184)

Stan Miller
Energy & Environmental Research Center

Mercury Control R&D Review Meeting, Pittsburgh PA
August 12–13, 2003

Project Team

U.S. Department of Energy
William Aljoe, Project Manager

Energy & Environmental Research Center
Main Contractor – Construction, Experimental Work, and Reporting
Stan Miller, Project Manager
Mike Collings, Research Engineer
Ye Zhuang, Research Engineer

W.L. Gore & Associates, Inc.
Technical and Financial Partner – Bag Supplier
Technical Advisor and Exclusive Licensee
Craig Rinschler, Associate
Rick Bucher, Associate
Rich Gebert, Associate
Dwight Davis, Associate

Big Stone Plant
Host Site for Demonstration
Jeff Endrizzi, Plant Manager
Bill Swanson, Engineering Supervisor

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Project Objective

- Demonstrate 90% total mercury control with commercially available sorbents in the *Advanced Hybrid*™ filter at a lower cost than current mercury control estimates.

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Mercury Control with the *Advanced Hybrid*™ Filter

- Approach
  - Inject powdered activated carbon upstream of the *Advanced Hybrid*™ filter
  - Achieve good mercury control at a low carbon addition rate of 24 mg/m^3 (1.5 lb/million acf)

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Mercury Control with the *Advanced Hybrid*™ Filter

Scope of work

- Bench-scale batch testing
- Small pilot-scale testing (200 acfm)
- 2.5-MW *Advanced Hybrid*™ filter field demonstration pilot testing
  - A utility power plant
  - Prove scaleup
  - Demonstration of longer-term mercury control (4 months)

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Advanced Hybrid™ Development

- **September 1994** – *Advanced Hybrid*™ filter concept proposed to DOE
- **October 1995 – September 1997**– Phase I – *Advanced Hybrid*™ filter successfully demonstrated at 200-acfm scale
- **March 1998 – February 2000** – Phase II – *Advanced Hybrid*™ filter successfully demonstrated at 2.5-MW scale at Big Stone Plant
- **September 1999 – August 2001** – Phase III – *Advanced Hybrid*™ filter commercial components tested and proven at 2.5-MW scale at Big Stone Plant
- **July 2001 – December 2003** – Mercury control with the *Advanced Hybrid*™ filter
- **Fall 2002** – First commercial *Advanced Hybrid*™ filter start-up

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What Is an *Advanced Hybrid*™ Filter?

- Best features of agglomeration, electrostatic collection, and filtration
- Different than previous concepts
- Relatively simple
- Sound theoretical basis

Concept Logic

CHALLENGE	SOLUTION
99.99% Fine Particulate Control	GORE-TEX® Membrane filter media
All Coals (chemical attack)	All ePTFE fabric
Cost	Air-to-cloth ratio 8–14 ft/min (2.4–4.3 m/min)
Pressure Drop	High-energy pulse-jet cleaning
Reentrainment	Electrostatic enhancement
Bag Life (wear)	90% electrostatic precollection
Bag Life (electrical damage)	Conductive – No Stat® bags and protective grid

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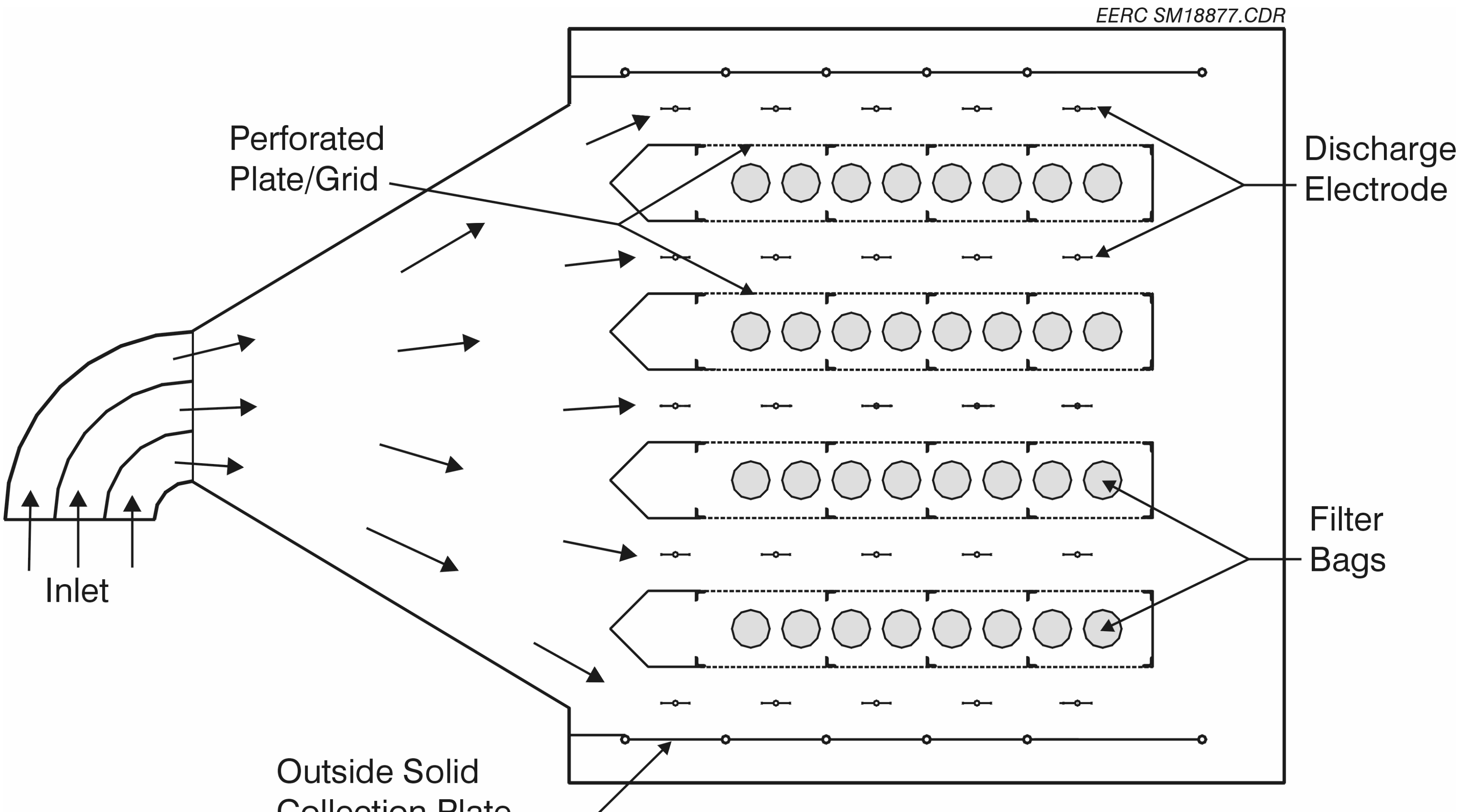
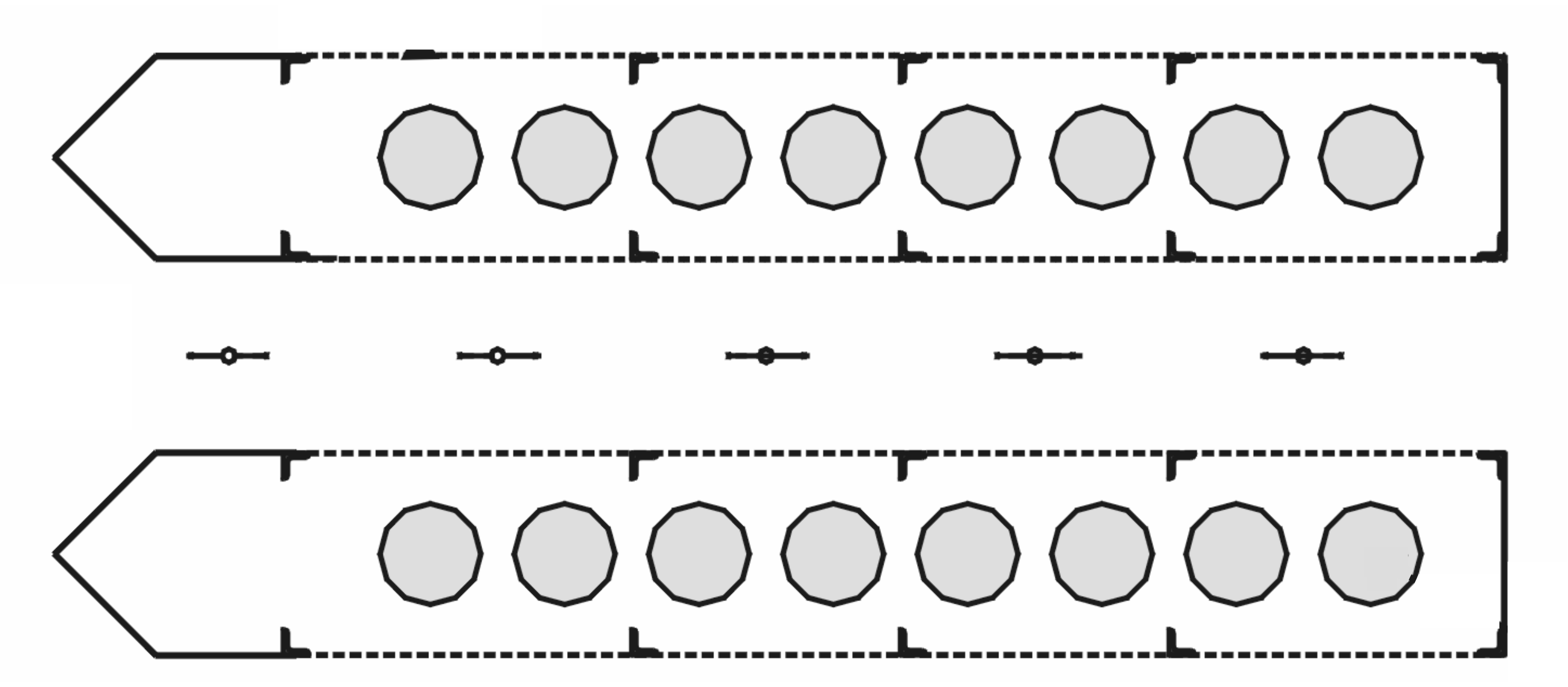
Advanced
Hybrid
Particulate
Collector

Top View of the Perforated Plate Configuration for the 2.5-MW *Advanced Hybrid*™ Filter

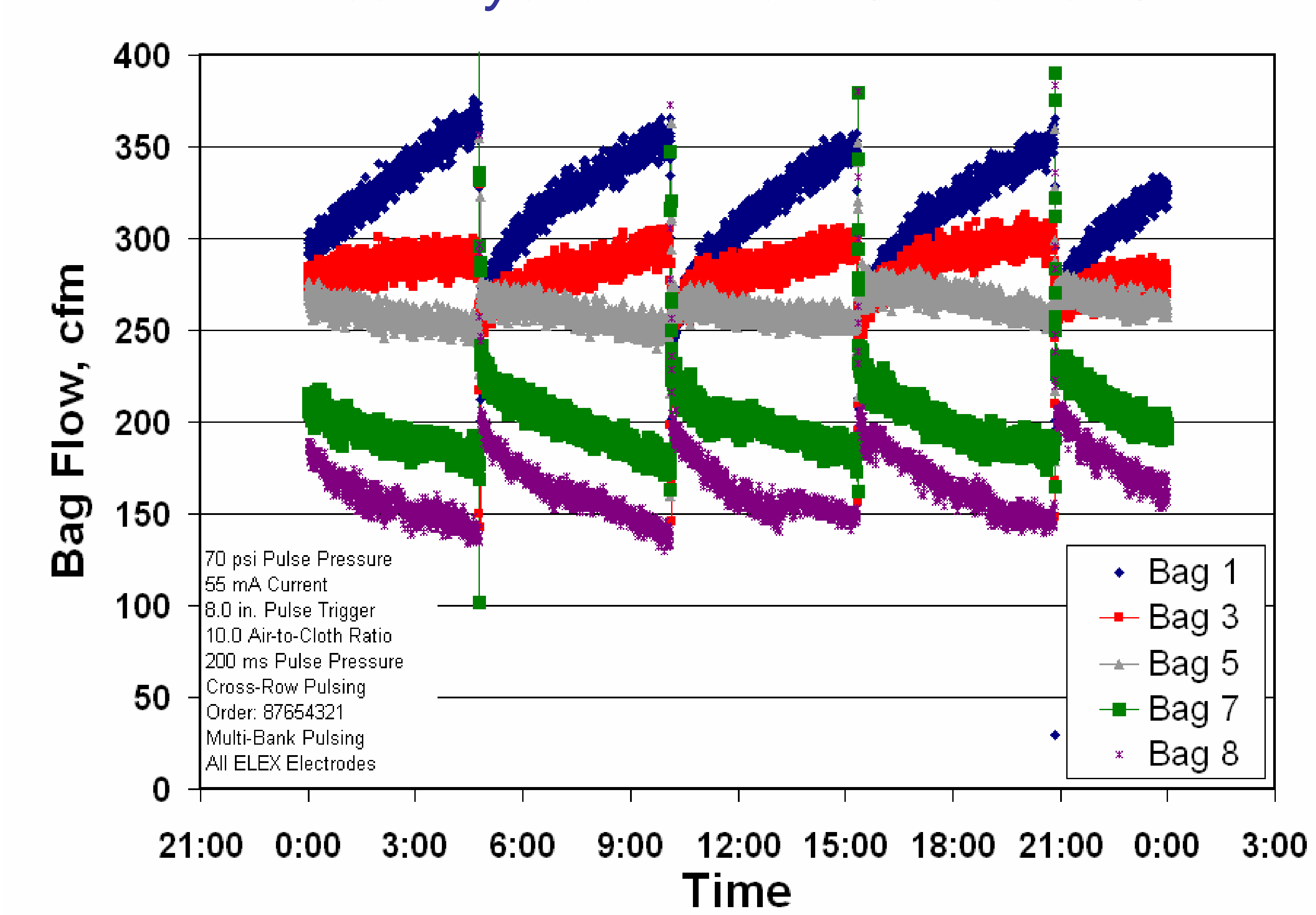


Top View of the Perforated Plate Configuration for the 2.5-MW *Advanced Hybrid*™ Filter

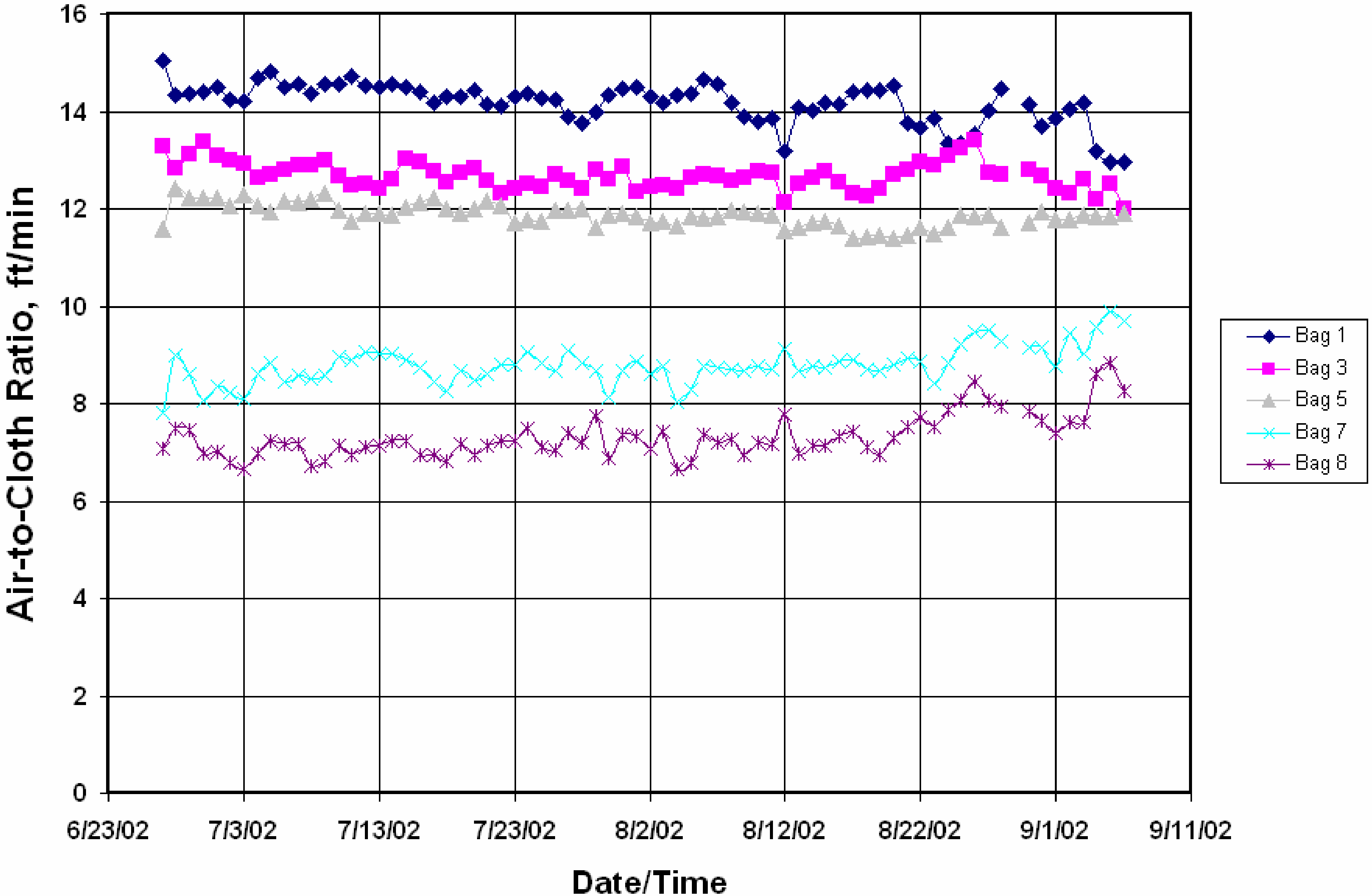


Individual Bag Flow Rates

August 16, 2002
Advanced Hybrid™ Filter ESP Power On



Daily Average Air-to-Cloth Ratio



Individual Bag Flow Rates

August 16, 2002
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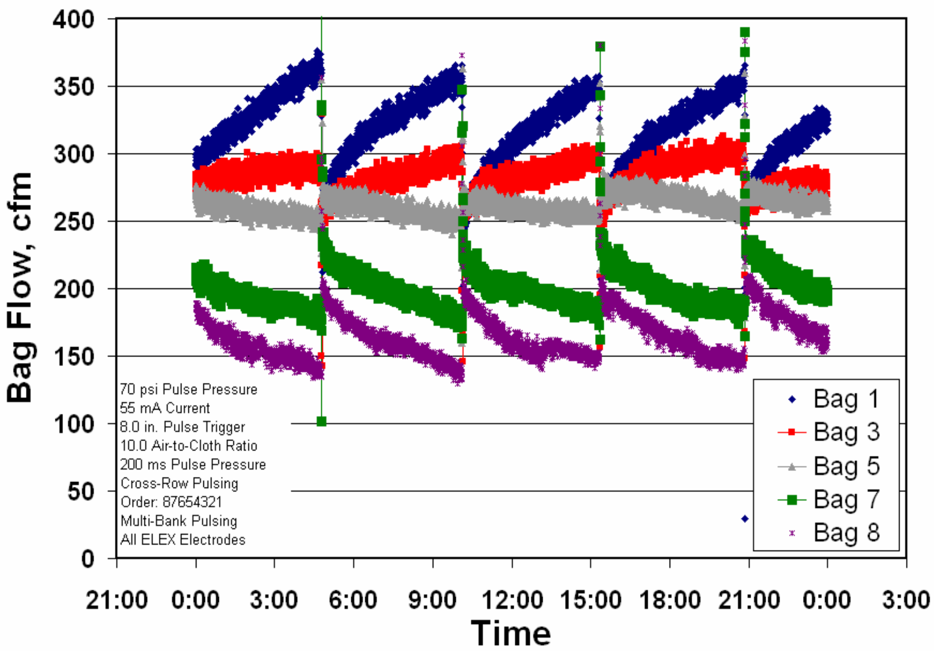
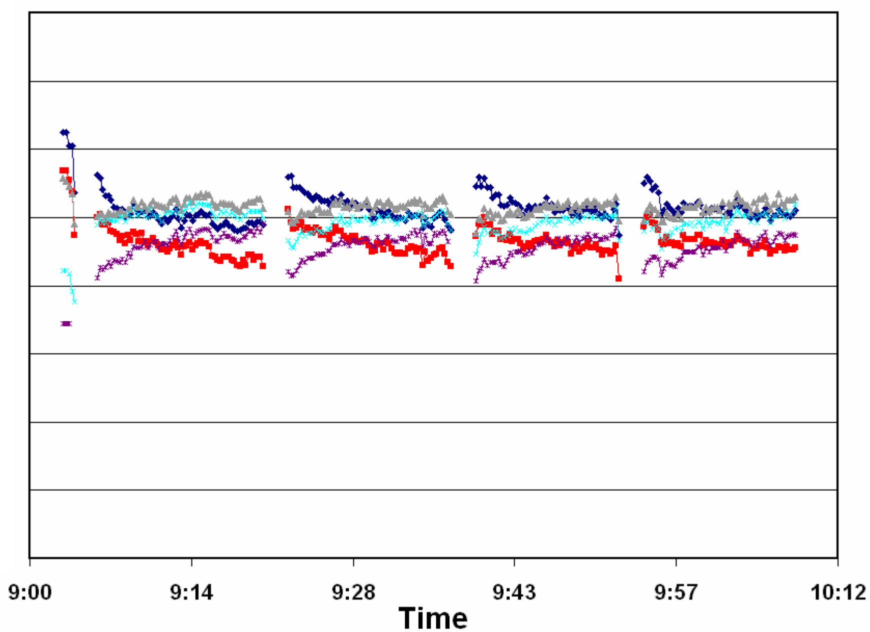


September 6, 2002
ESP Power Off



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Bench-Scale Tests

- Verify previous SO_2 and NO_2 effects
- Expand on SO_2 and NO_2 concentration effects
- Compare simulated flue gas with real flue gas results

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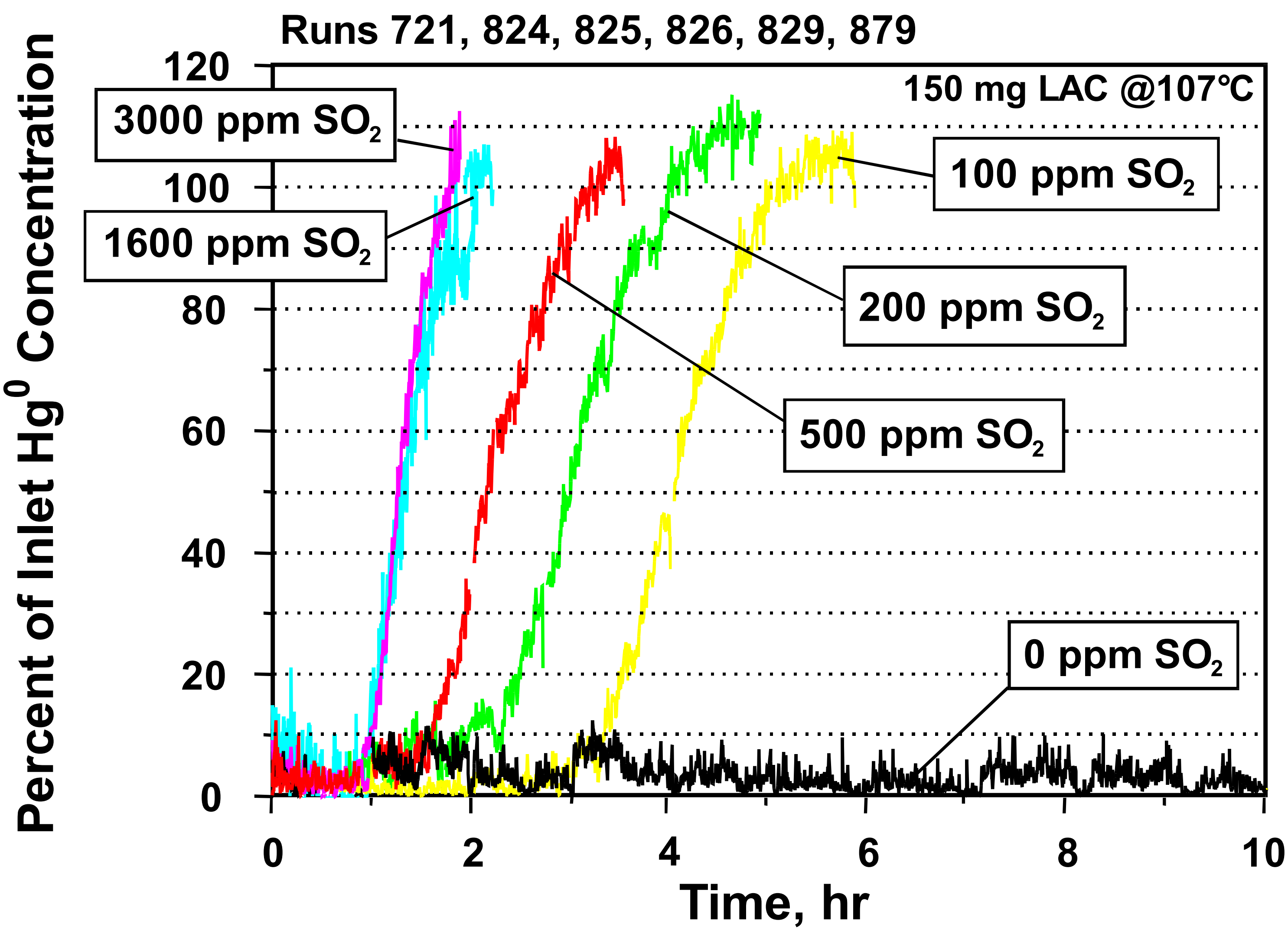
EERC Mercury Bench-Scale System

EERC SM19581.CDR

Carbon Fixed Bed

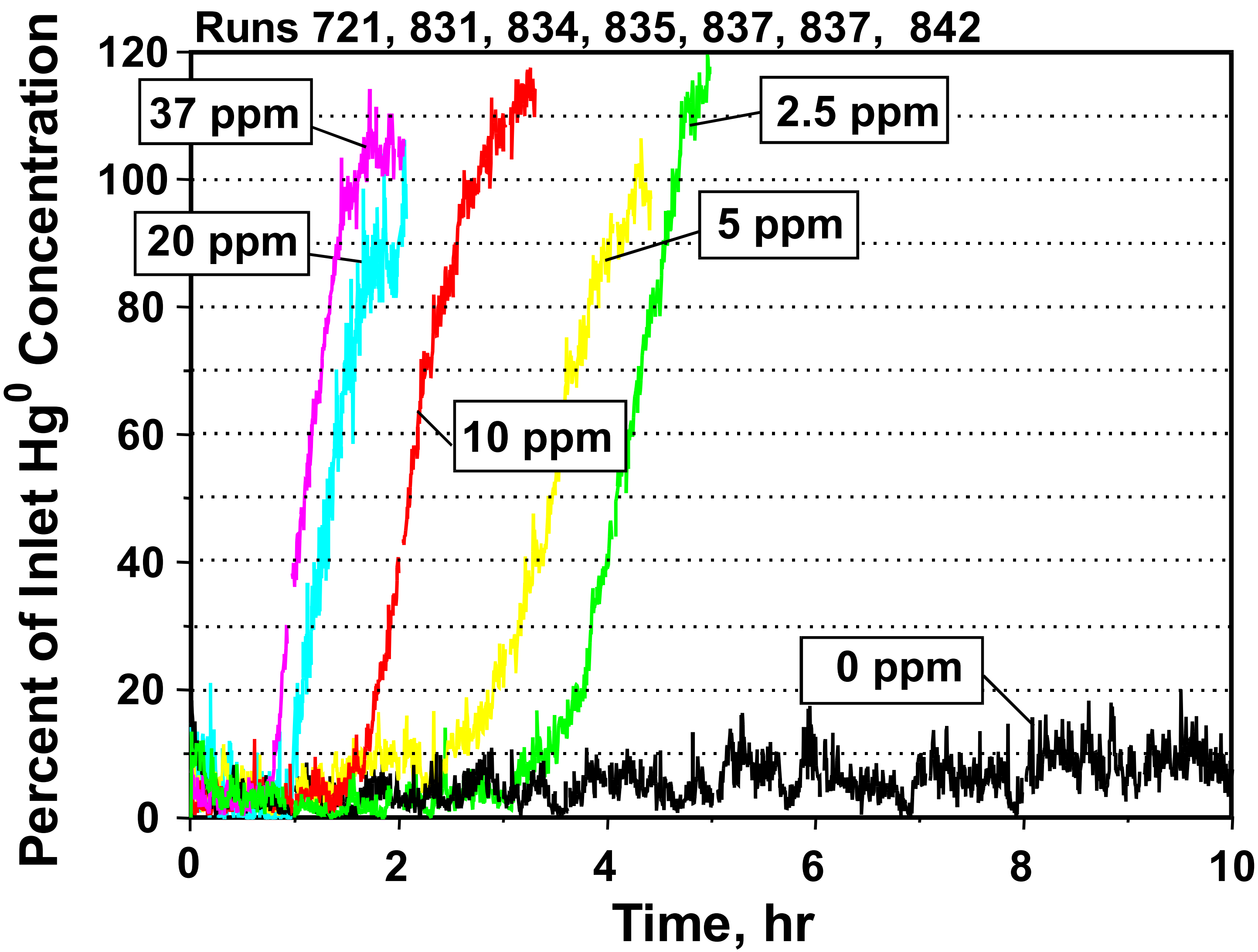
EERC SM19583.CDR

Effect of SO_2 Concentration on Hg^0 Capture with Activated Carbon



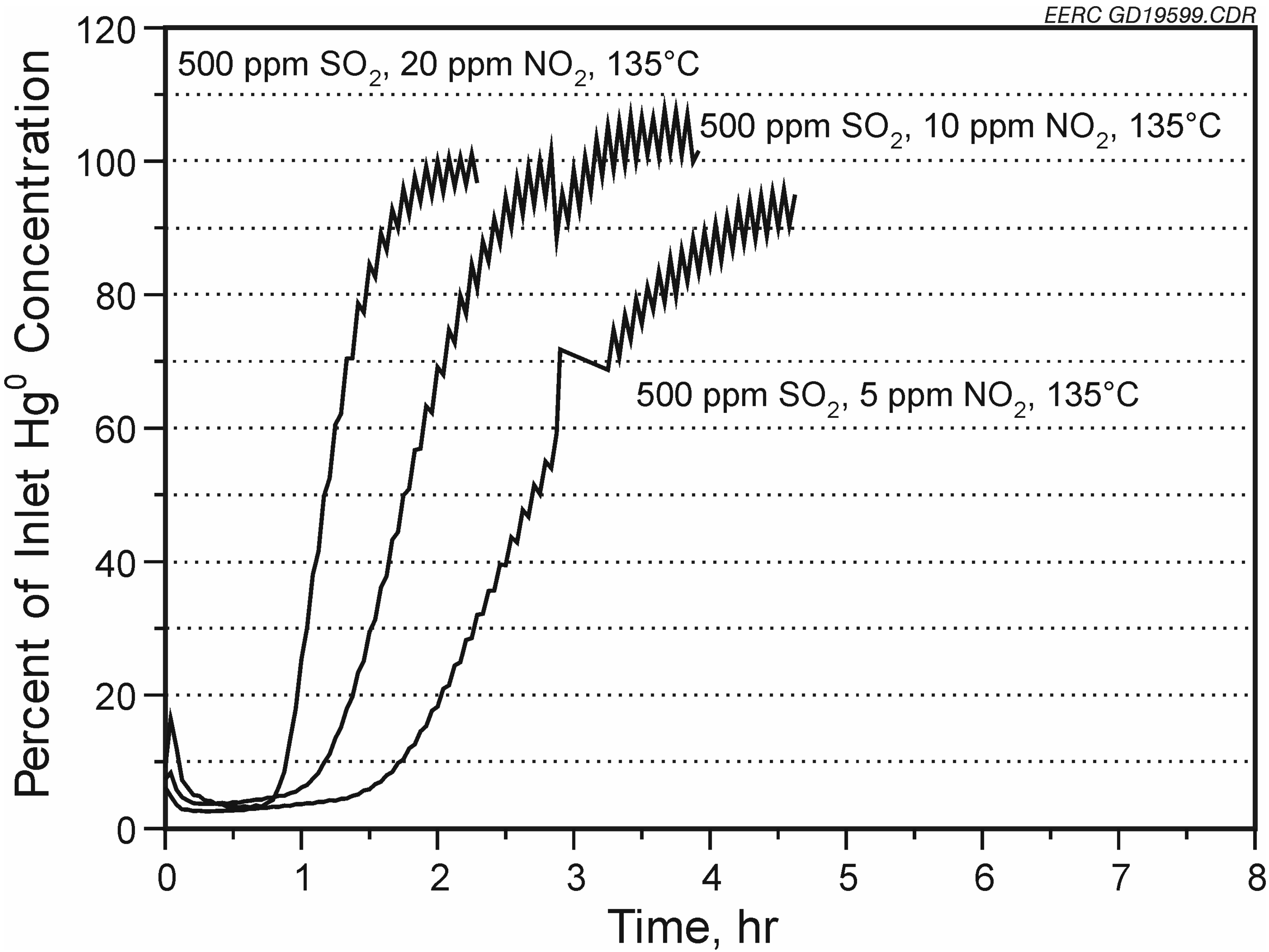
Hg^0 – 15 μg/m^3
O_2 – 6%
CO_2 – 12%
H_2O – 8%
N_2 – Balance
HCl – 50 ppm
SO_2 – 0 to 3000 ppm
NO – 400 ppm
NO_2 – 20 ppm

Effect of NO_2 Concentration on Hg^0 Capture with Activated Carbon

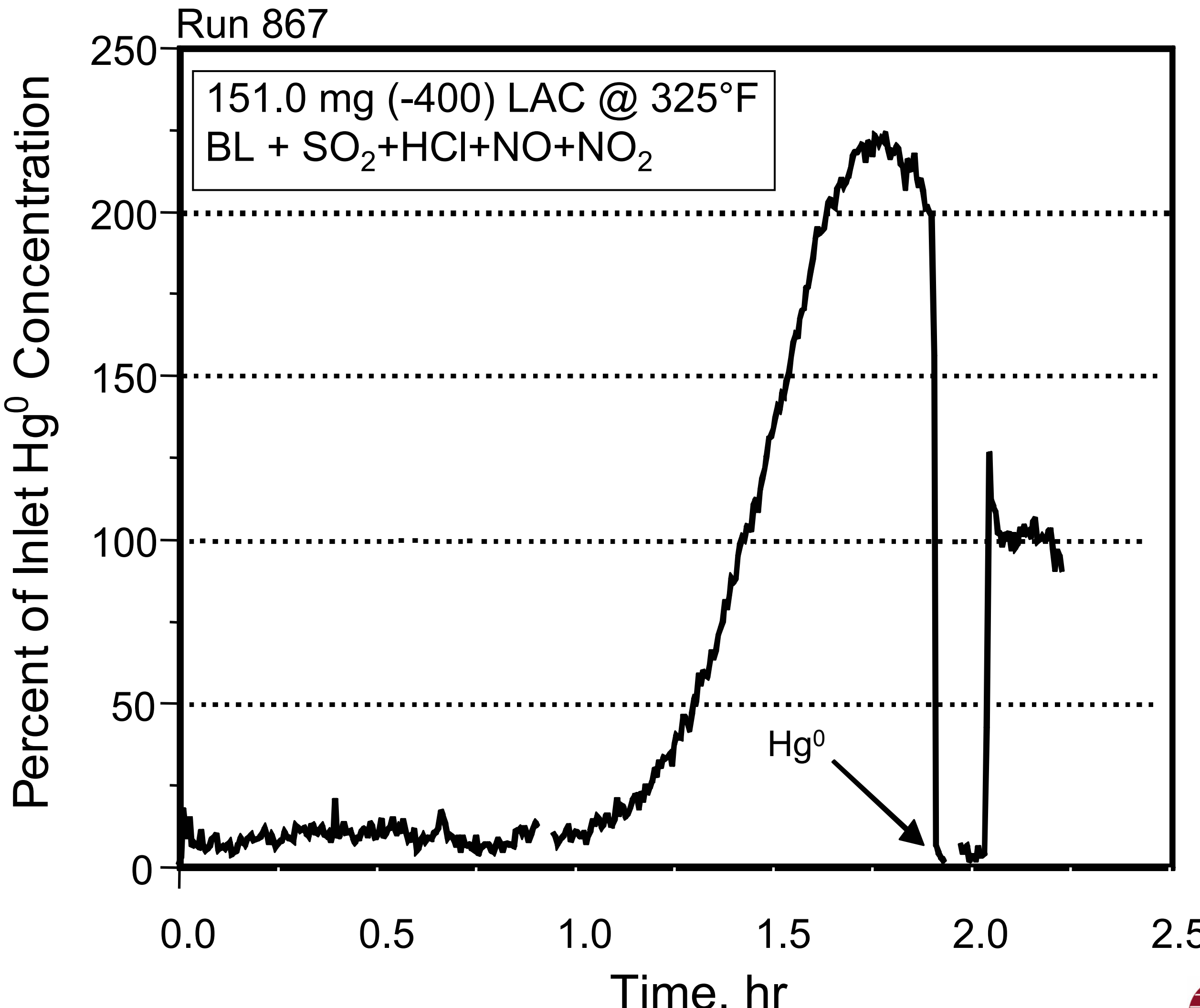


Hg^0 – 15 µg/m^3
O_2 – 6%
CO_2 – 12%
H_2O – 8%
N_2 – Balance
HCl – 50 ppm
SO_2 – 1600 ppm
NO – 400 ppm
NO_2 – 0 to 37 ppm

NO_2 Concentration Effect at 500 ppm SO_2 and 135°C



Desorption of Mercury



2.5-MW Advanced Hybrid™ Filter Field Test

- Demonstrate longer-term mercury removal.
- Determine the effect of carbon injection on the Advanced Hybrid™ filter performance.

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2.5-MW *Advanced Hybrid*™ Filter Field Tests

- November 5–9, 2001
- June 28 – September 3, 2002
- November 19–22, 2002
- May 6 – June 3, 2003

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Overview of Carbon-Injection System

EERC SM19730.CDR

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Air-Vac Eductor of Carbon-Injection System

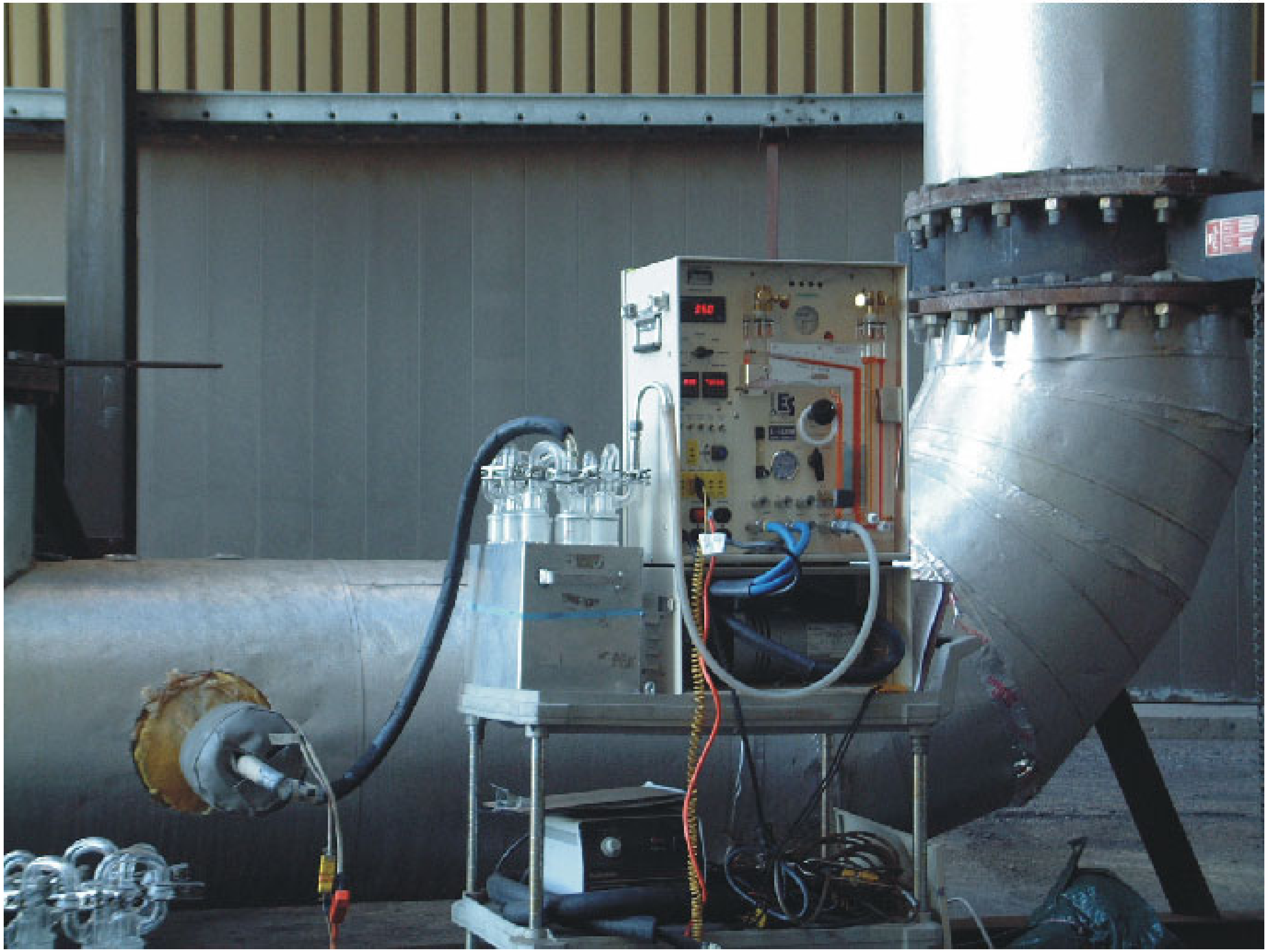
EERC SM19731.CDR

Carbon-Injection Location

EERC SM19729.CDR

Ontario Hydro Sampling Train at the *Advanced Hybrid*™ Filter Inlet

EERC SM19727.CDR



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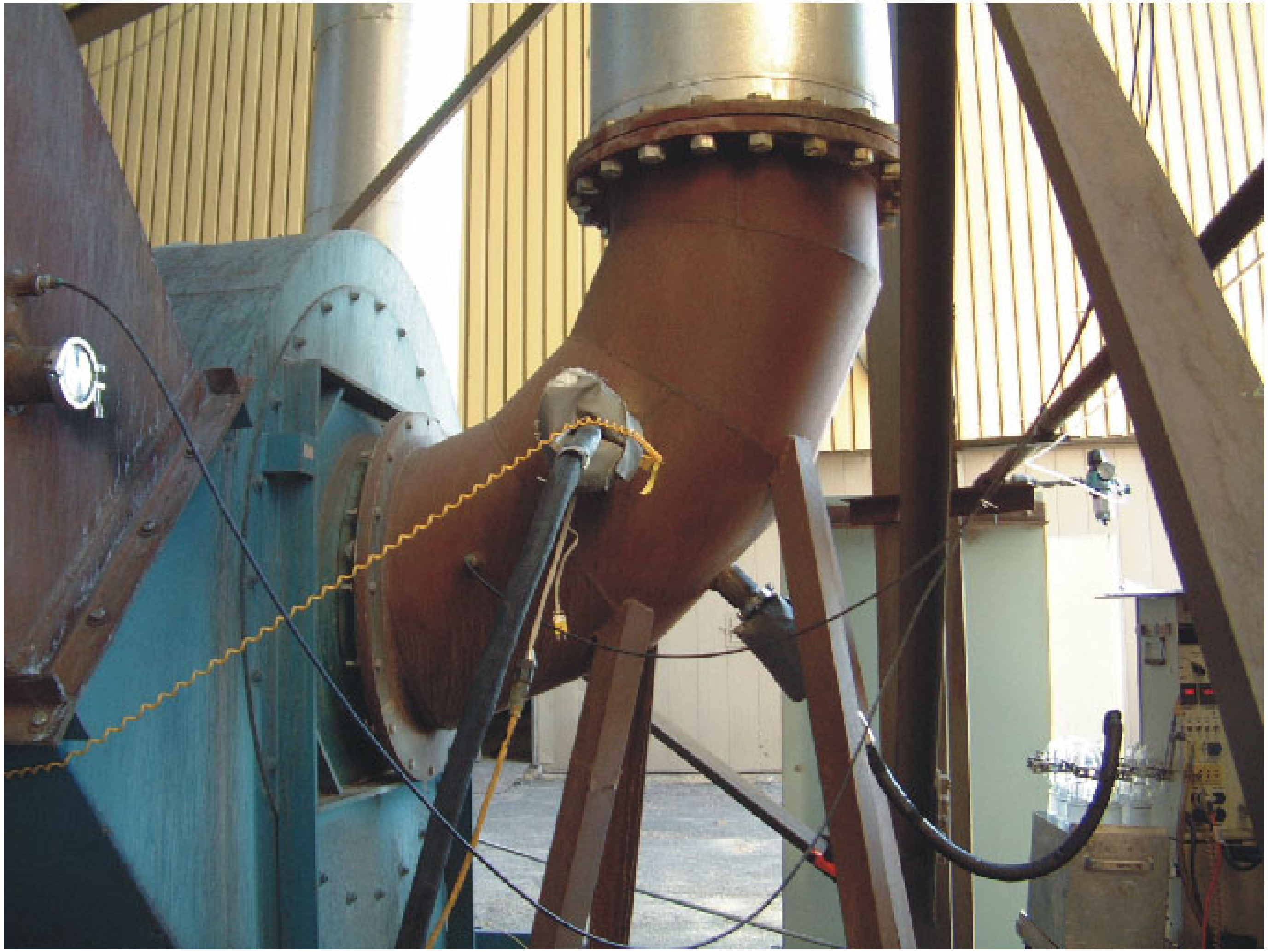
Ontario Hydro Sampling Train at the *Advanced Hybrid*™ Filter Outlet

EERC SM19726.CDR



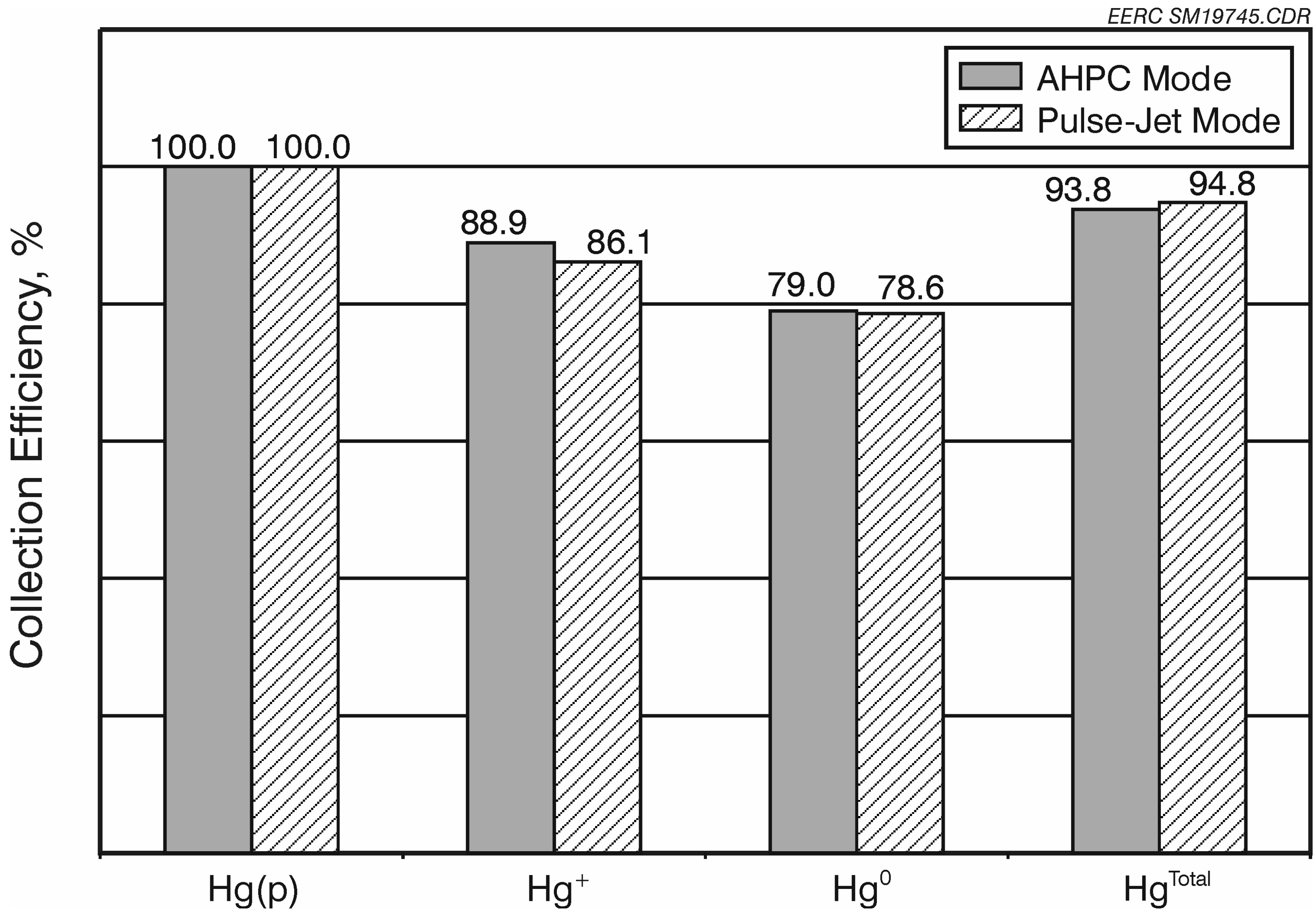
Conversion System CMM Mercury Sampling

EERC SM19728.CDR

PS Analytical Mercury Analyzer

EERC SM19725.CDR

November 2001
Day 5 – Mercury Species Collection Efficiency
Advanced Hybrid™ Filter and Pulse-Jet Modes



June 28–September 2, 2002
2.5-MW *Advanced Hybrid*™ Filter Test Parameters and Operational Summary

A/C Ratio	10 ft/min (3 m/min)
Pulse Pressure	70 psi (482 kPa)
Pulse Duration	200 ms
Pulse Sequence	87654321 (multibank)
Pulse Trigger	8.0 in. W.C. (2.0 kPa)
Pulse Interval	260–400 min
Temperature	127°–160°C (260°–320°F)
Rapping Interval	15–20 min
Voltage	58–62 kV
Current	55 mA

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June 28–September 2, 2002
2.5-MW *Advanced Hybrid*™ Filter Test
Mercury Removal Summary

Condition	Mercury Removal, %
Baseline – No TDF	5–10
1.5 lb Carbon/million acf	
No TDF	Average 63
1.5 lb Carbon/million acf	
TDF Cofiring Highest Rate	88

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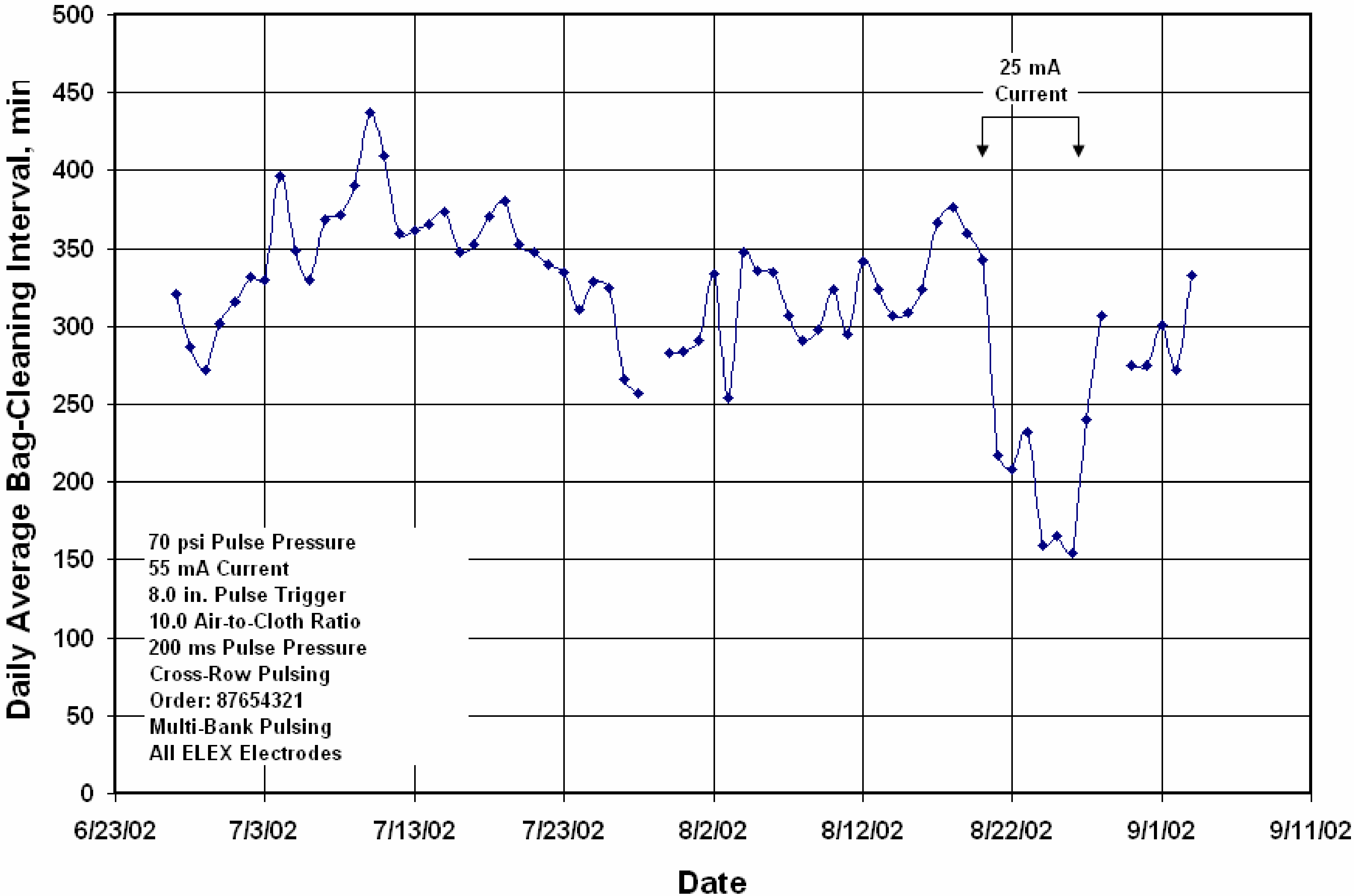
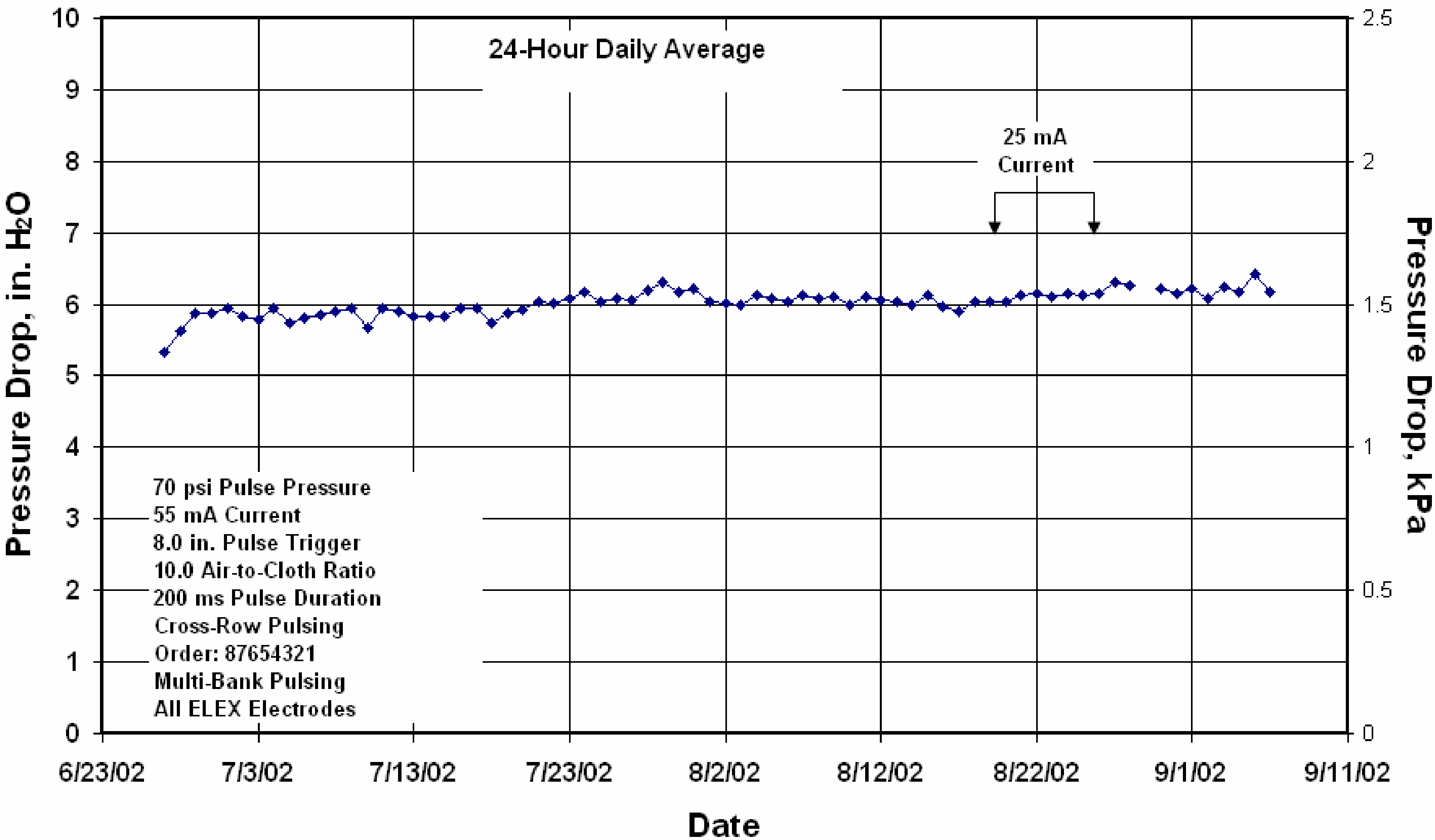
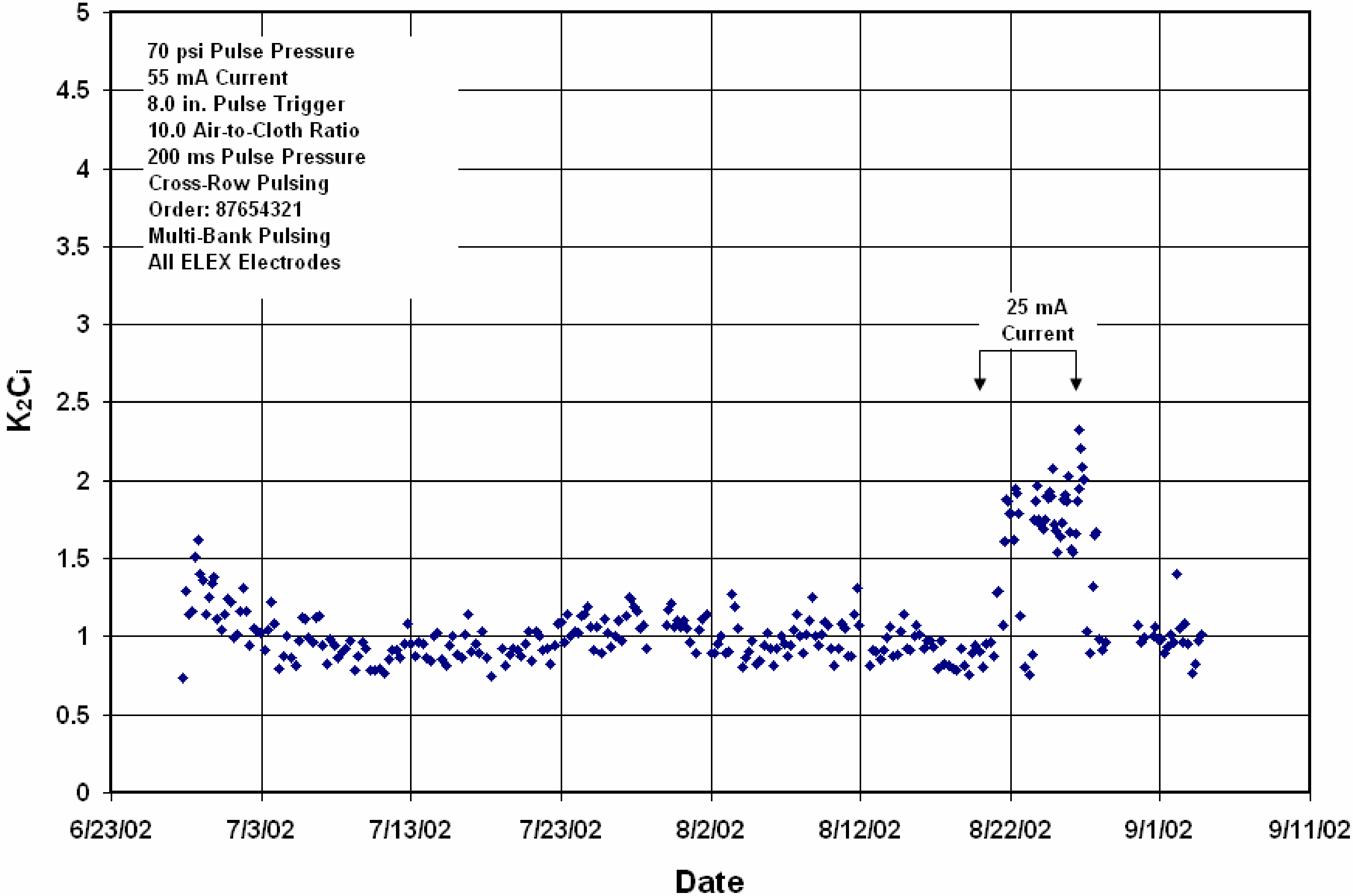
Daily Average Bag-Cleaning Interval



Daily Average Pressure Drop



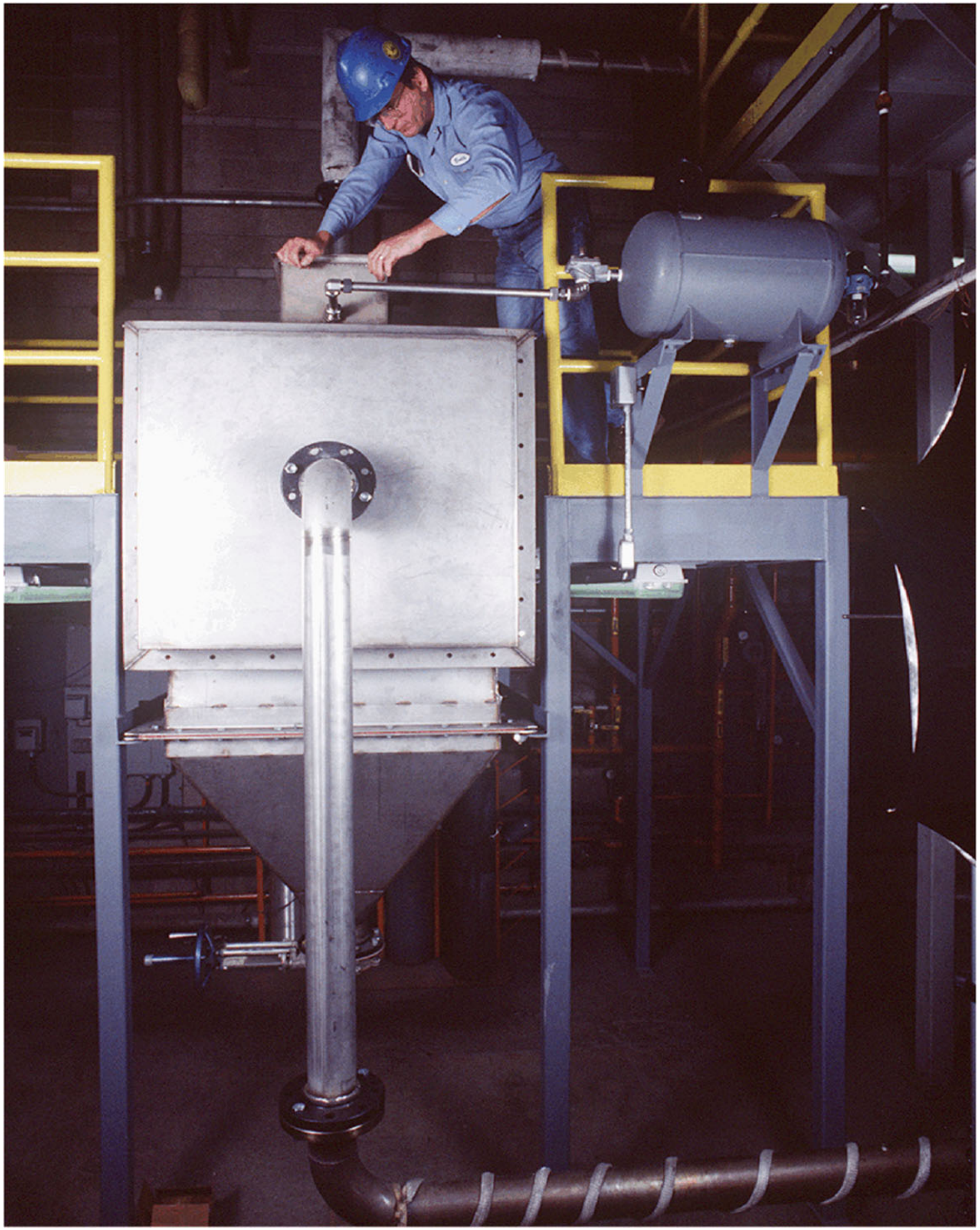
K_2C_i



70 psi Pulse Pressure
55 mA Current
8.0 in. Pulse Trigger
10.0 Air-to-Cloth Ratio
200 ms Pulse Pressure
Cross-Row Pulsing
Order: 87654321
Multi-Bank Pulsing
All ELEX Electrodes
25 mA Current
K_2C_i
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
6/23/02
7/3/02
7/13/02
7/23/02
8/2/02
8/12/02
8/22/02
9/1/02
9/11/02
Date

Small-Scale Pilot Tests

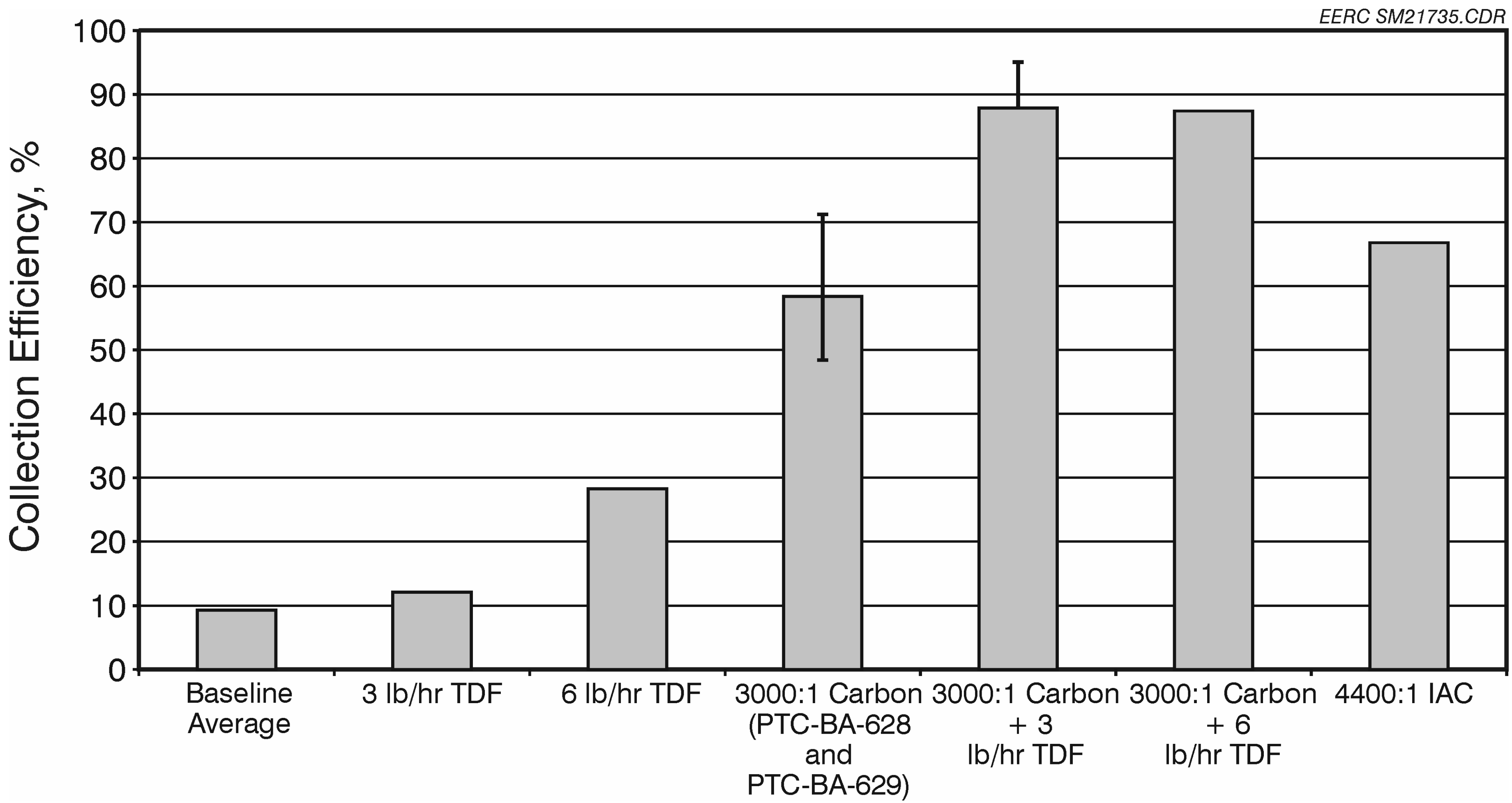
- Mercury control screening tests
- Evaluate residence time
- Compare with field test results
- Evaluate TDF cofiring



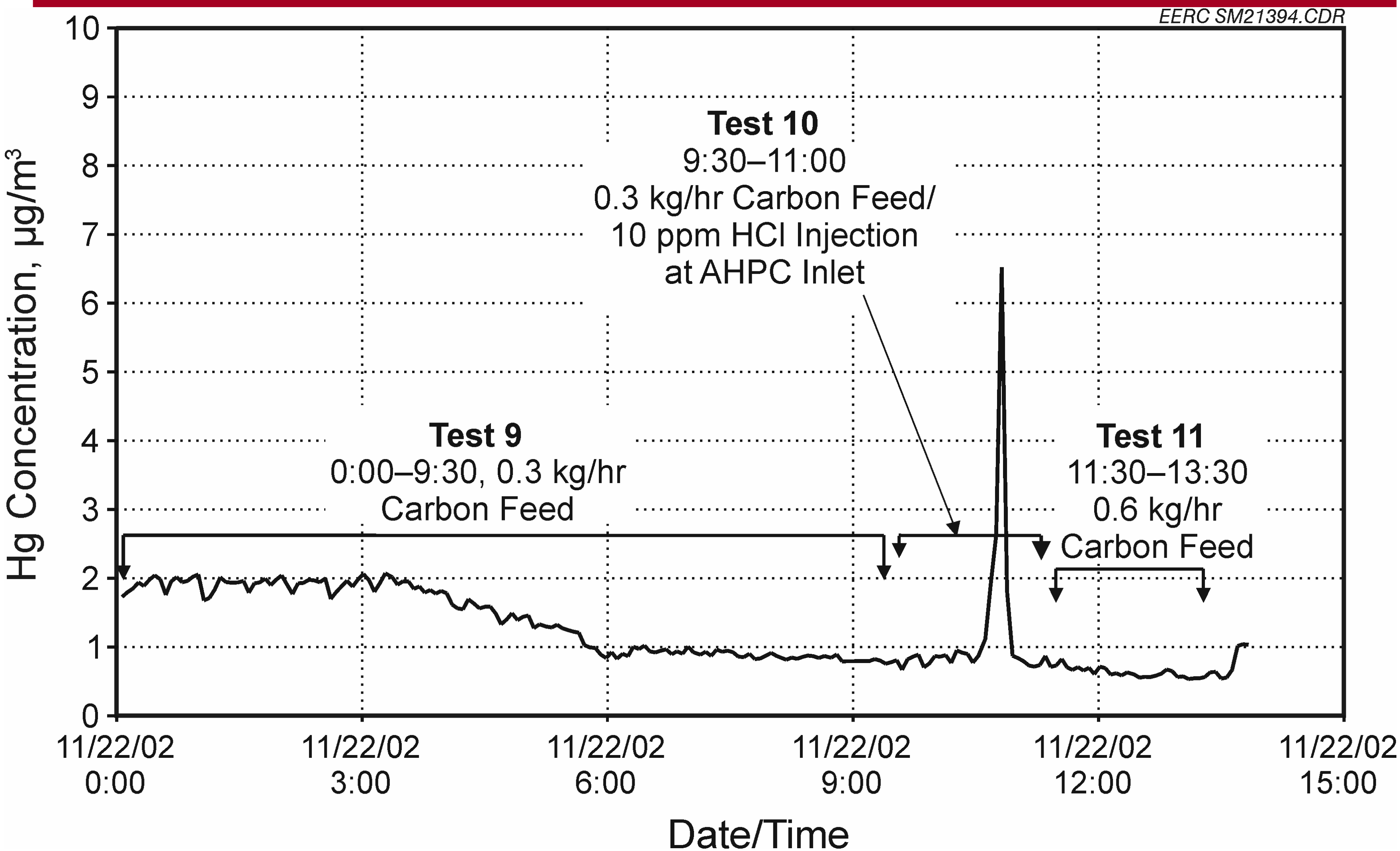
Small Pilot-Scale Tests

Effect of TDF on Mercury Capture Efficiency

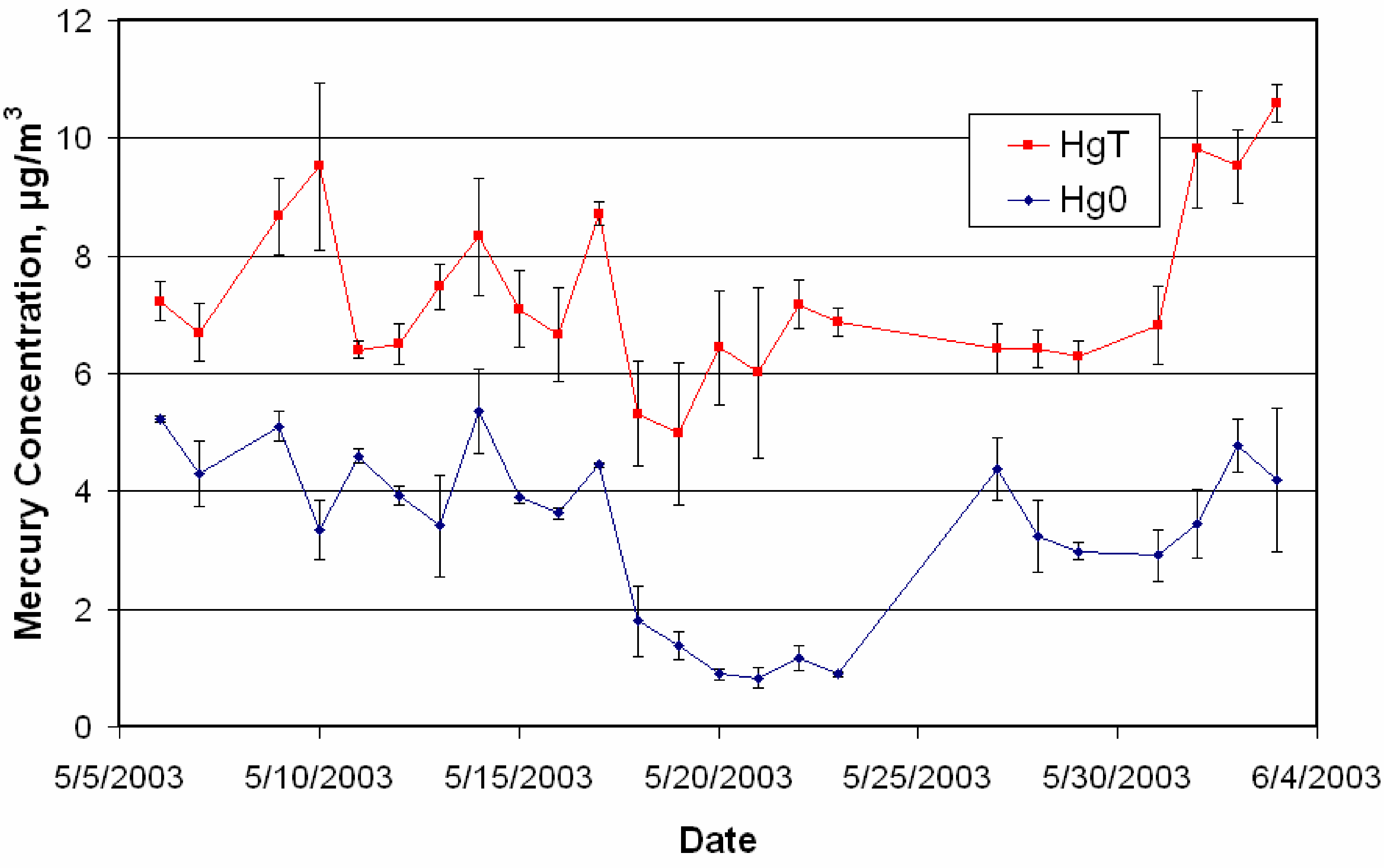
(Ontario Hydro results)



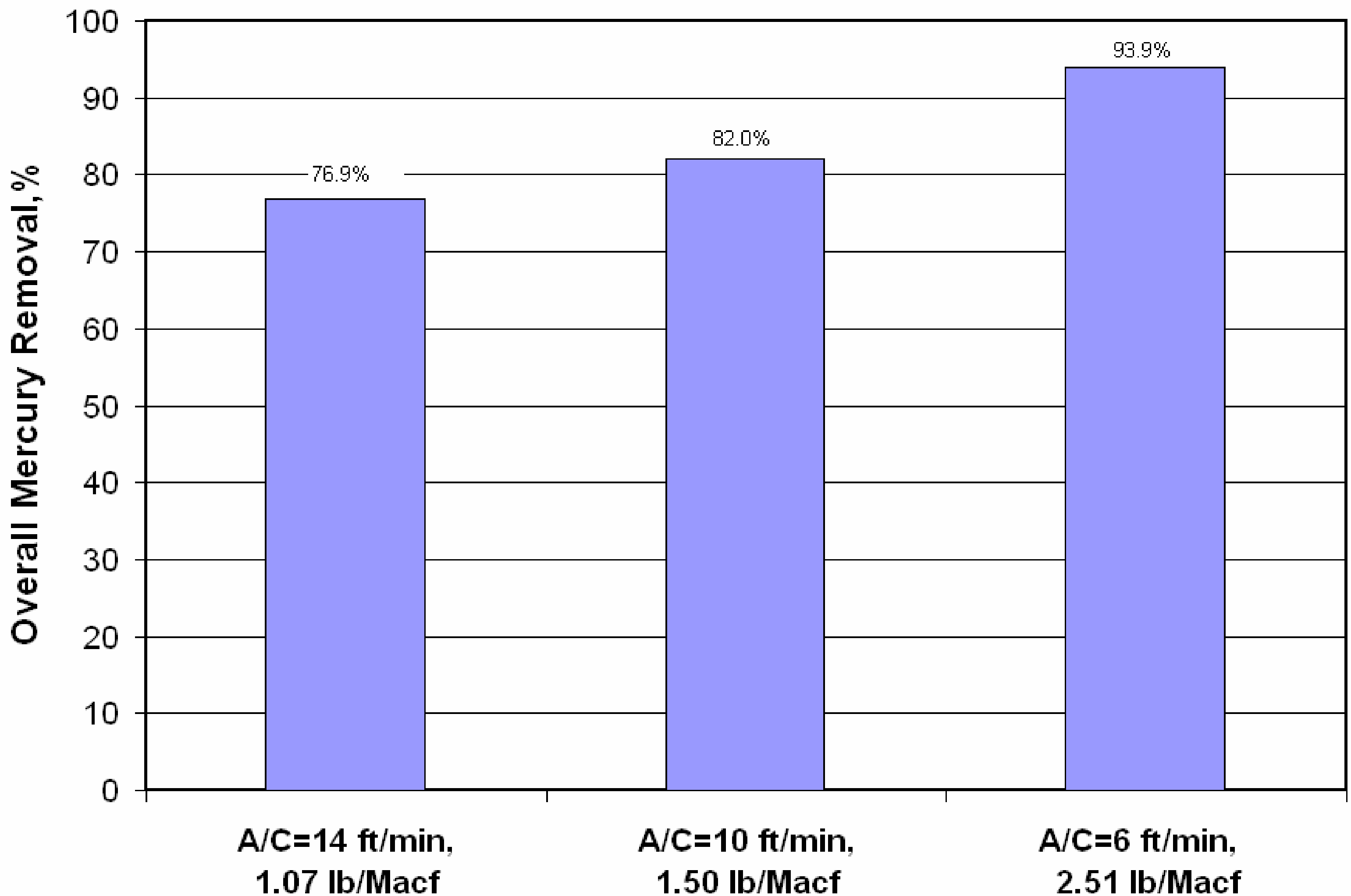
November 2002 CMM Outlet Mercury Concentration for the 2.5-MW *Advanced Hybrid*™ Filter



May 2003
2.5-MW *Advanced Hybrid*™ Filter
Inlet Mercury Speciation (CMM Data)



May 20, 2003 – 2.5-MW *Advanced Hybrid*™ Filter Effect of Filtration Velocity on Mercury Removal at Big Stone



Summary
Bench-Scale Tests

- Verified previous flue gas results
- SO_2 and NO_2 have significant effects on carbon capacity to remove mercury
- Similar results with real or simulated flue gas

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Summary
Small Pilot-Scale Tests

- Similar mercury speciation and mercury removal to field-testing results
- 50%–75% mercury removal at 1.5 lb carbon/million acf
- TDF cofiring significantly improved mercury capture
- No mercury desorption observed in longer residence time tests

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Summary
2.5-MW *Advanced Hybrid*™ Field Tests

- Total of 4-months' testing completed
- No effect of carbon on *Advanced Hybrid*™ filter pressure drop or bag-cleaning interval
- 50%–75% mercury removal at 1.5 lb carbon/million acf
- 85%–95% mercury removal at 1.5 lb carbon/million acf and the highest TDF cofiring rate
- Level of mercury removal highly dependent on other flue gas components

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