

High Temperature Sorbents and TOXECON II™ Demonstrations



DOE/NETL Mercury Control Technology Conference

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High Temperature Sorbents

- Applications
 - Hot-side ESPs
 - Warm-side ($>350^{\circ}\text{F}$) ESPs and Baghouses

MidAmerican's Council Bluff Unit 2 High Temperature Sorbent Test

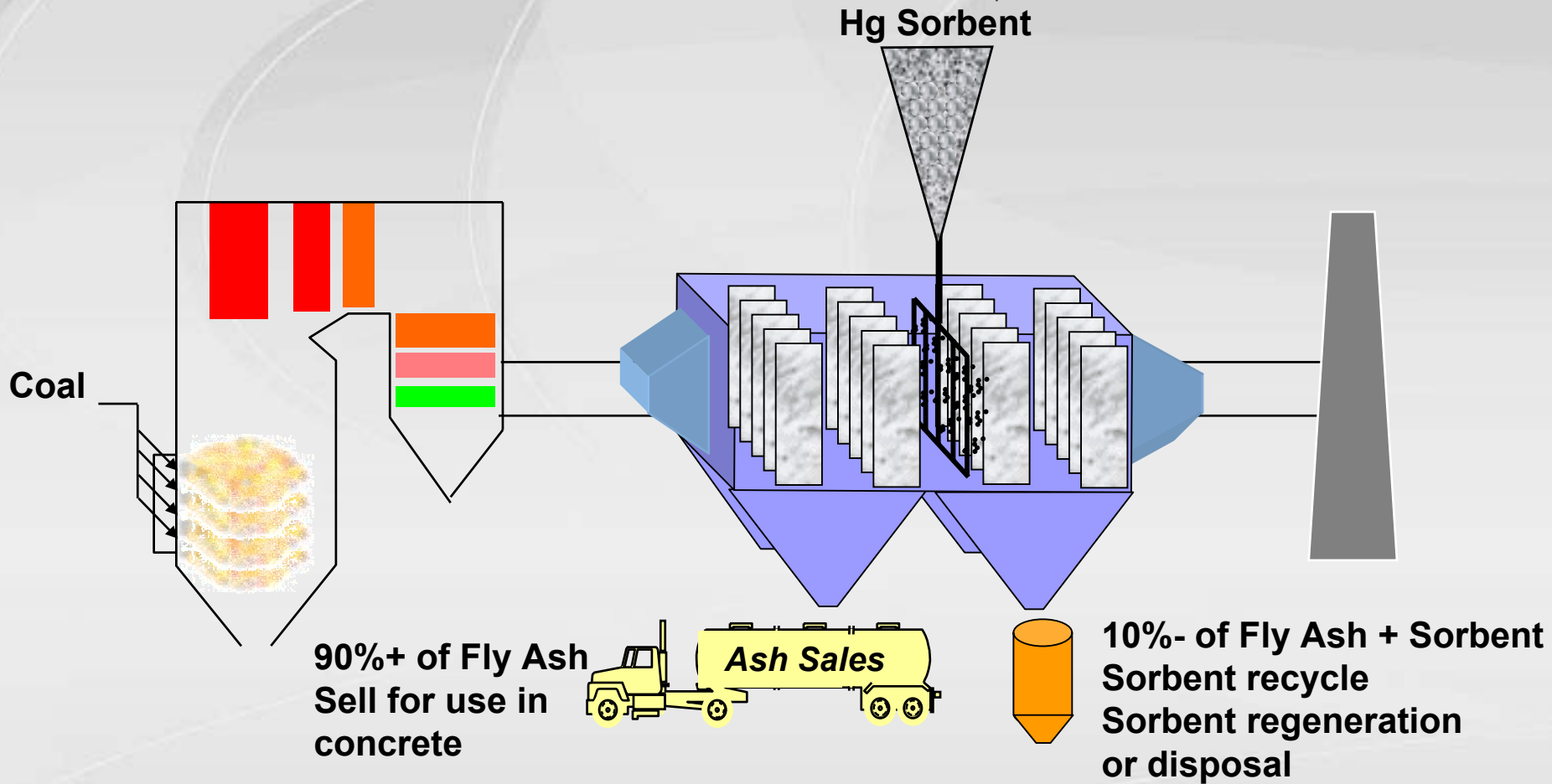
- **MidAmerican's Council Bluff Unit 2**
 - 88 MW
 - PRB Coal
 - Test full unit
- **Hot Side ESP**
 - 224 SCA
- **Project goal**
 - 50-70% Hg removal



Council Bluffs Test Plan

- Sorbent screening, carbon and non-carbon based
 - Initial tests in 2006 conducted at $>800^{\circ}\text{F}$ showed poor results from all sorbents
 - Preparing to repeat tests at a lower, more representative temperature (summer 2007)
- If results from screening tests are promising, evaluate sorbent injection upstream of hot-side ESP (Spring 2008)
- Evaluate MinPlus injected into boiler (Spring 2008)
 - REI performed CFD modeling to determine if the injection location is at the right temperature zone and if existing penetrations can be used

EPRI TOXECON II™ Configuration



TOXECON II™ Full-Scale Evaluation

- **Entergy's Independence Steam Electric Station**
 - 880 MW
 - PRB Coal from North Antelope
 - Test on 1/8 of Unit 2
- **Cold Side ESP**
 - 540 SCA
- **Project goal**
 - 50-70% Hg removal



- **Ash sold for concrete**
 - PAC/ash routed to separate silo during tests

TOXECON II™ Evaluation Co-funders

Alliant

Atco Power

DTE

Entergy*

Oglethorpe Power

Southern Company

Xcel Energy

ADA-ES

Arch Coal

EPCOR

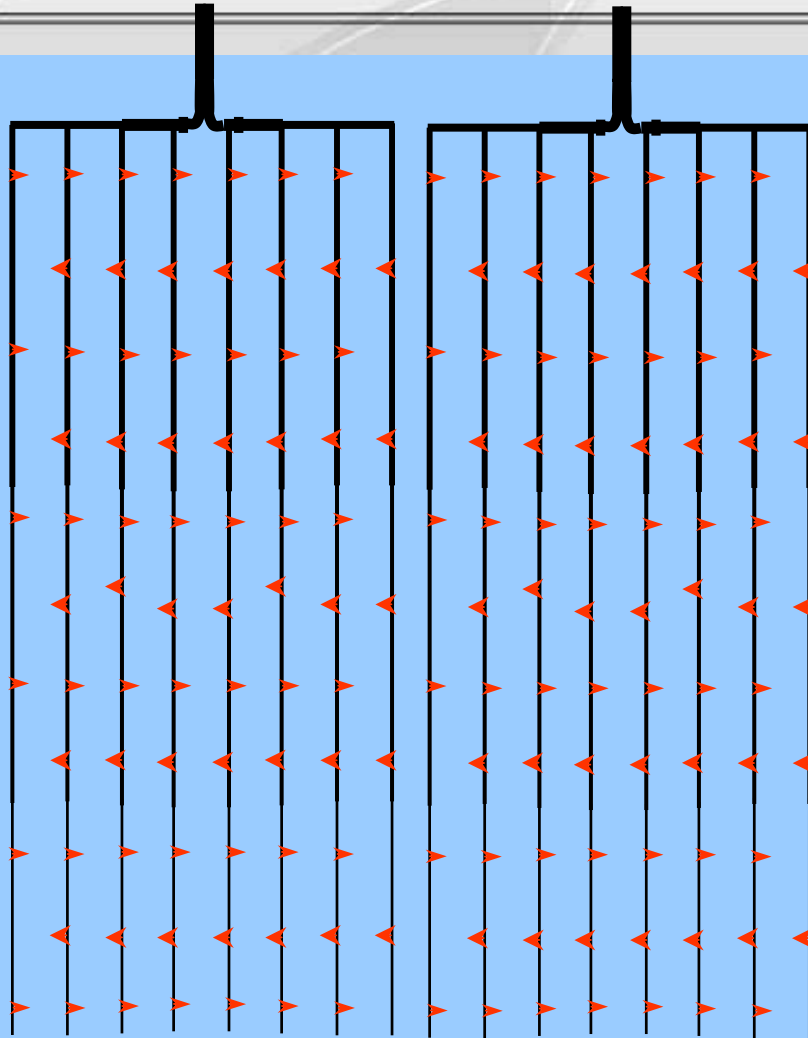
EPRI

NORIT Americas

** Host Sites*



Lance Configuration

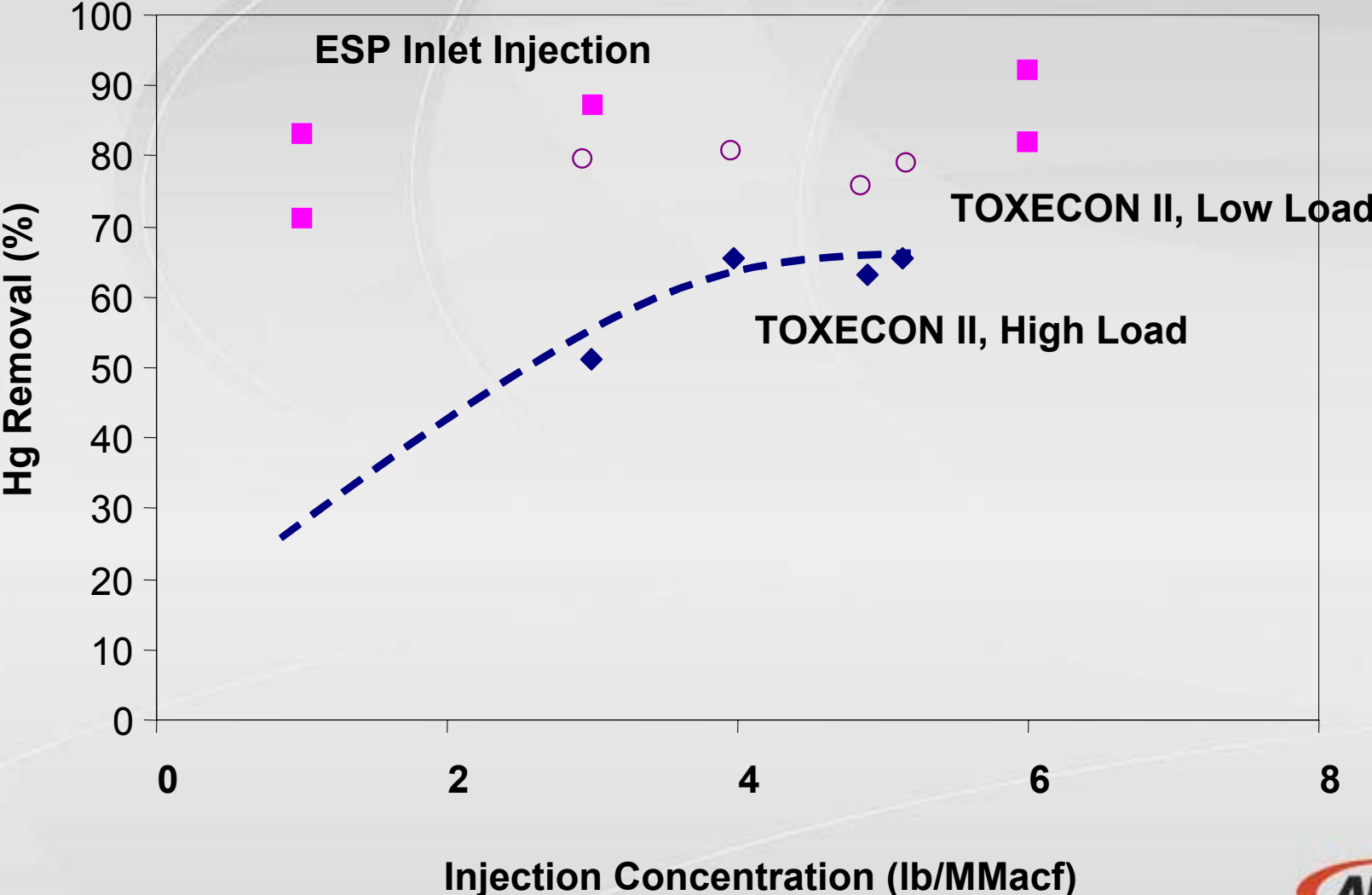


- 16 lances in $\frac{1}{2}$ of one ESP box
- $\frac{1}{8}$ of Unit 2 flow treated
- ~ 42-feet long, 34-inch spacing
- 11 nozzles per lance

Test-Side of ESP Box

Control-Side of ESP Box

Mercury Removal Results Comparisons



Test Results – Summary

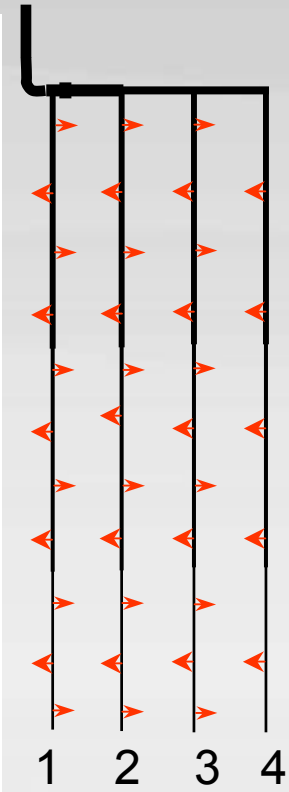
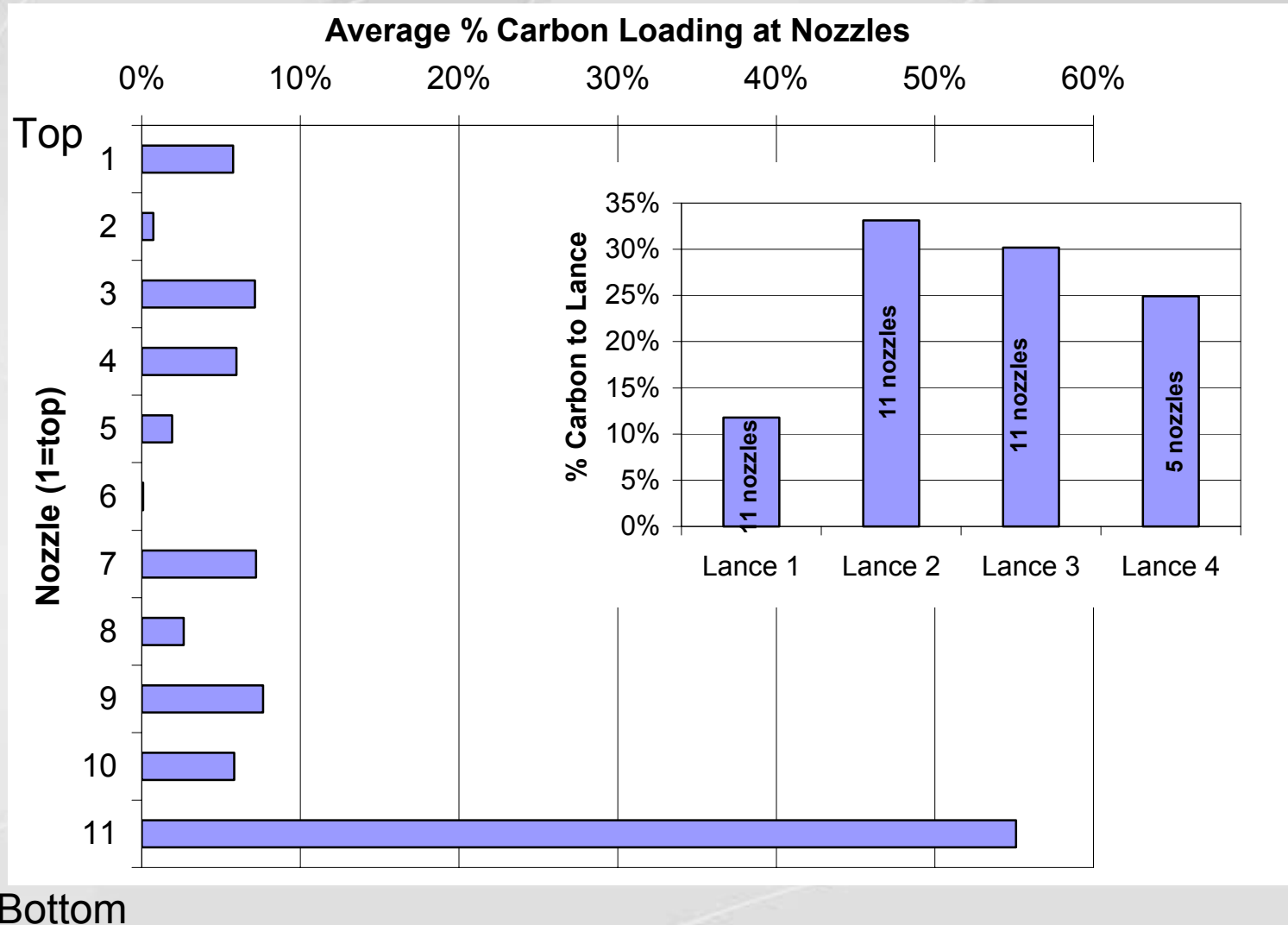
- Achieved project goal of 50 to 70% Hg removal
- TOXECON II™ Hg removal limited to < 80% at full load with up to 8 lb/MMacf DARCO® Hg-LH
- TOXECON II™ Hg removal varied significantly with load (lower removal at high load)
- Hg removal > 80% with pre-ESP injection of DARCO® Hg-LH at 1 to 2 lb/MMacf

Suspected that poor distribution contributed to conflicting results from injection upstream of ESP versus TOXECON II™ grid

TOXECON II™ Design Considerations

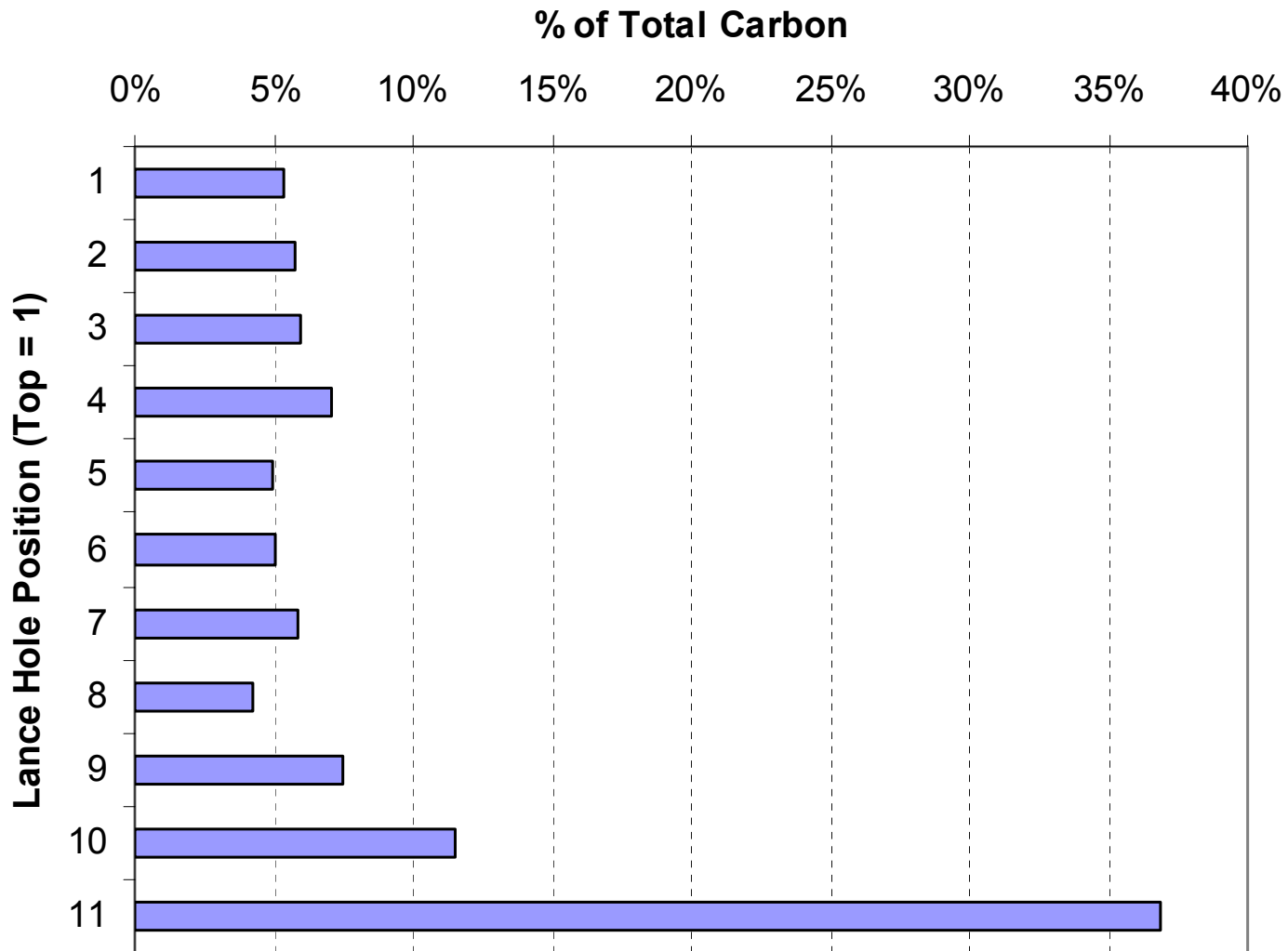
- Physical, internal dimensions of ESP
 - Spacing between fields
 - Structural support
 - Design and placement of rapping system
- ESP Control System
 - Feedback may need to be adjusted and tuned for carbon injection
- Flow
 - 4-8 ft/sec versus 40-90 ft/sec
 - Little opportunity for mixing
- Injection Grid
 - Access for lance penetration to allow on line maintenance (Penthouse layout)

Carbon Distribution – CFD Model



Carbon Distribution – Physical Model

Top

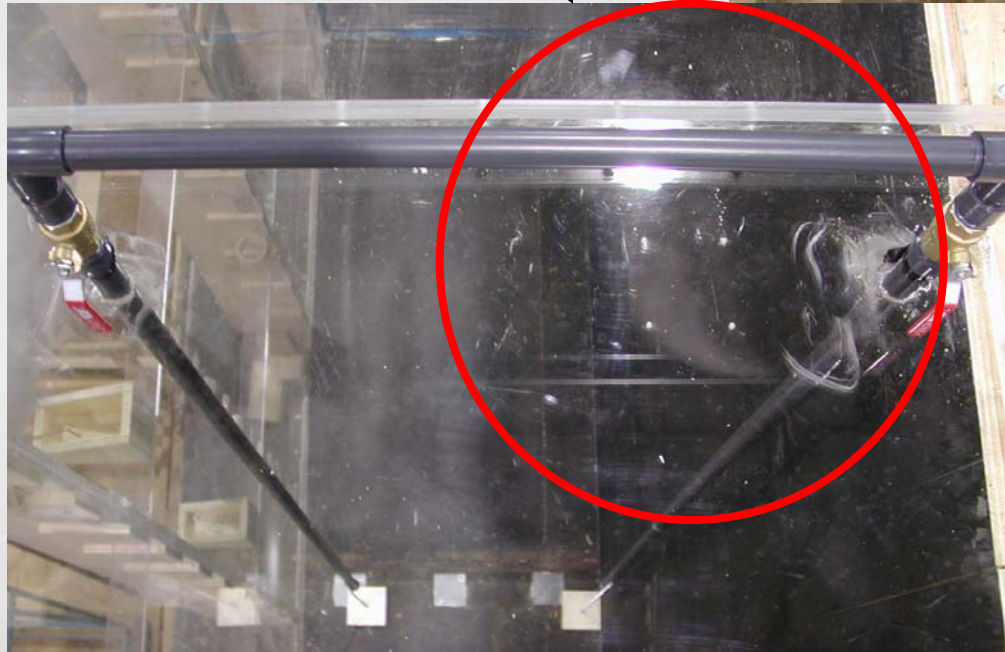


Bottom

Physical Modeling #1

Plume Penetration

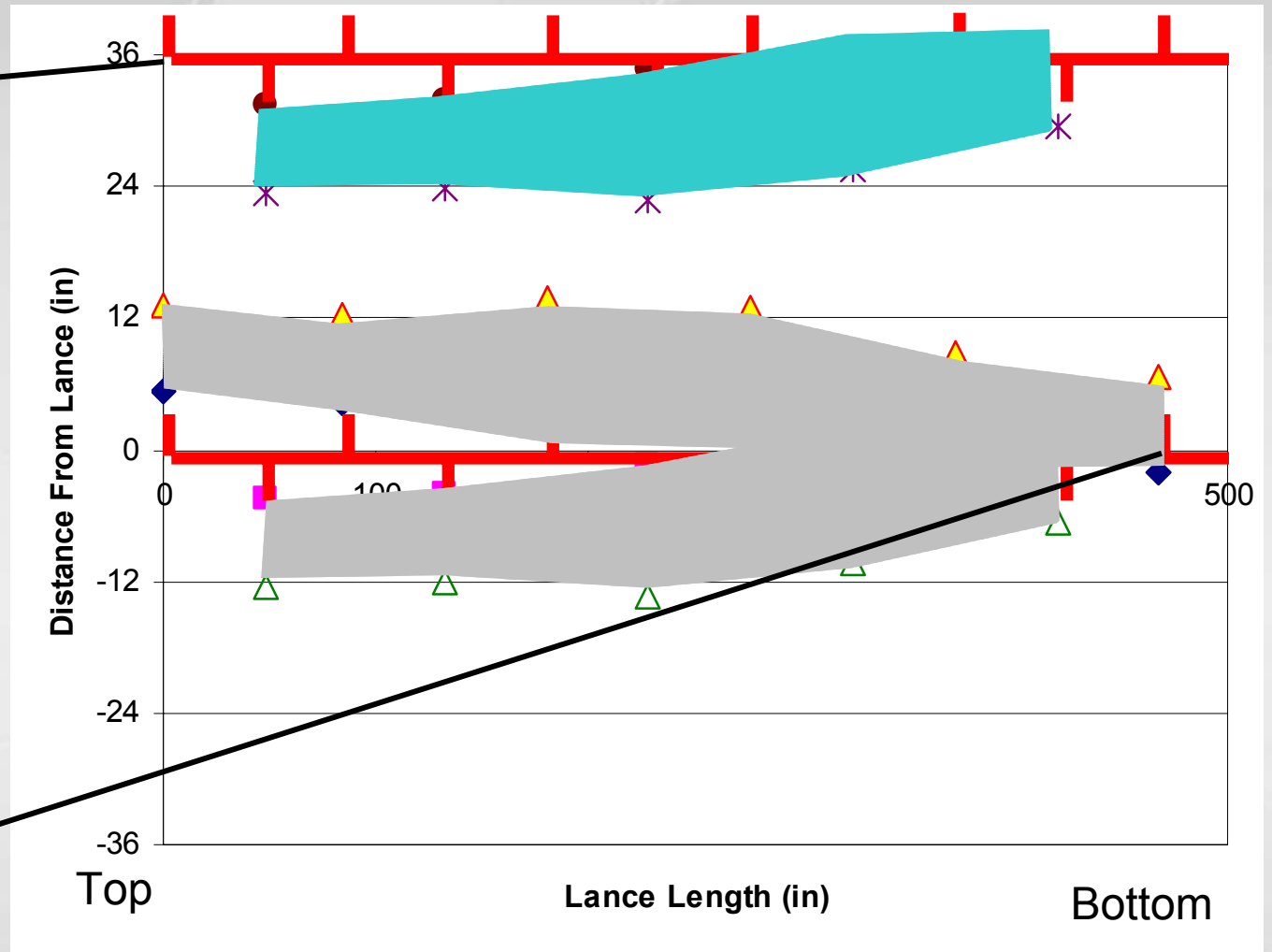
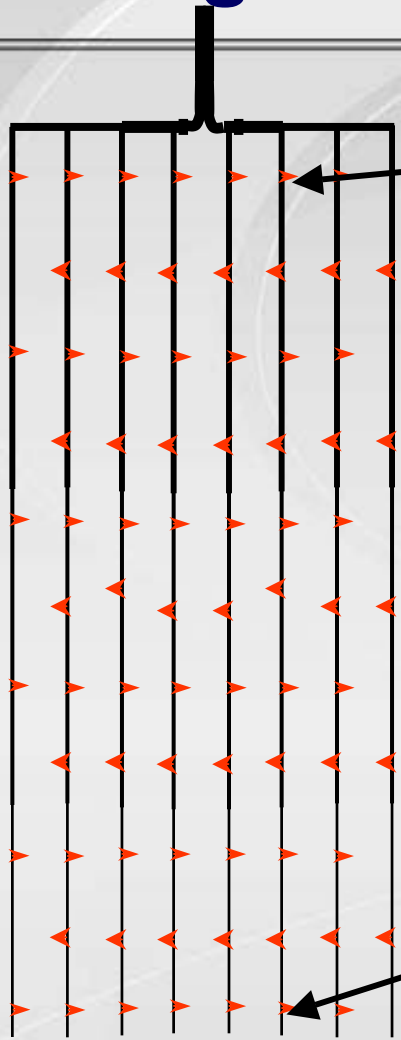
Existing blower design:
Poor coverage



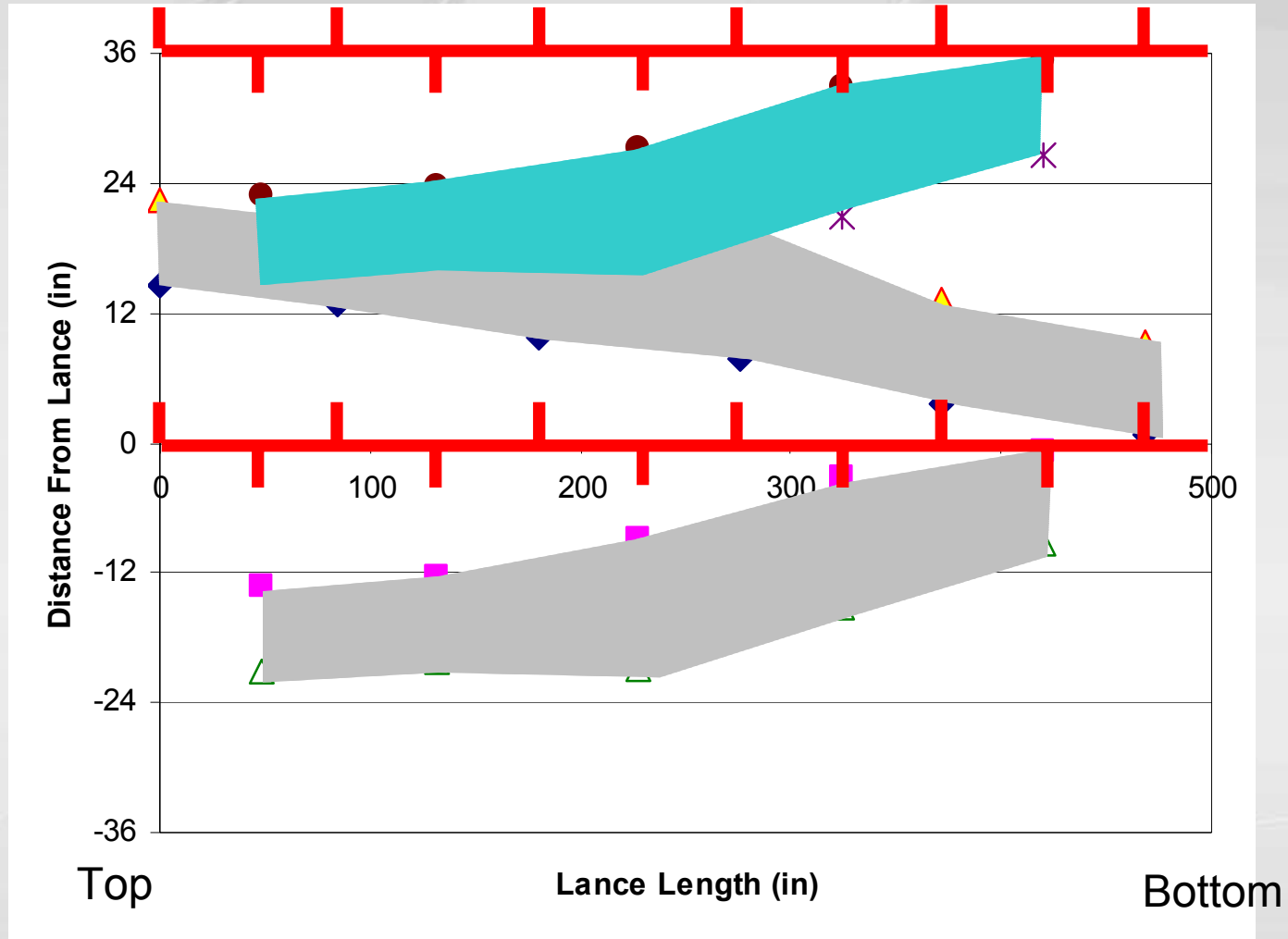
Increased air flow to
lances = increases
penetration distance



Original Lance Design – High Load



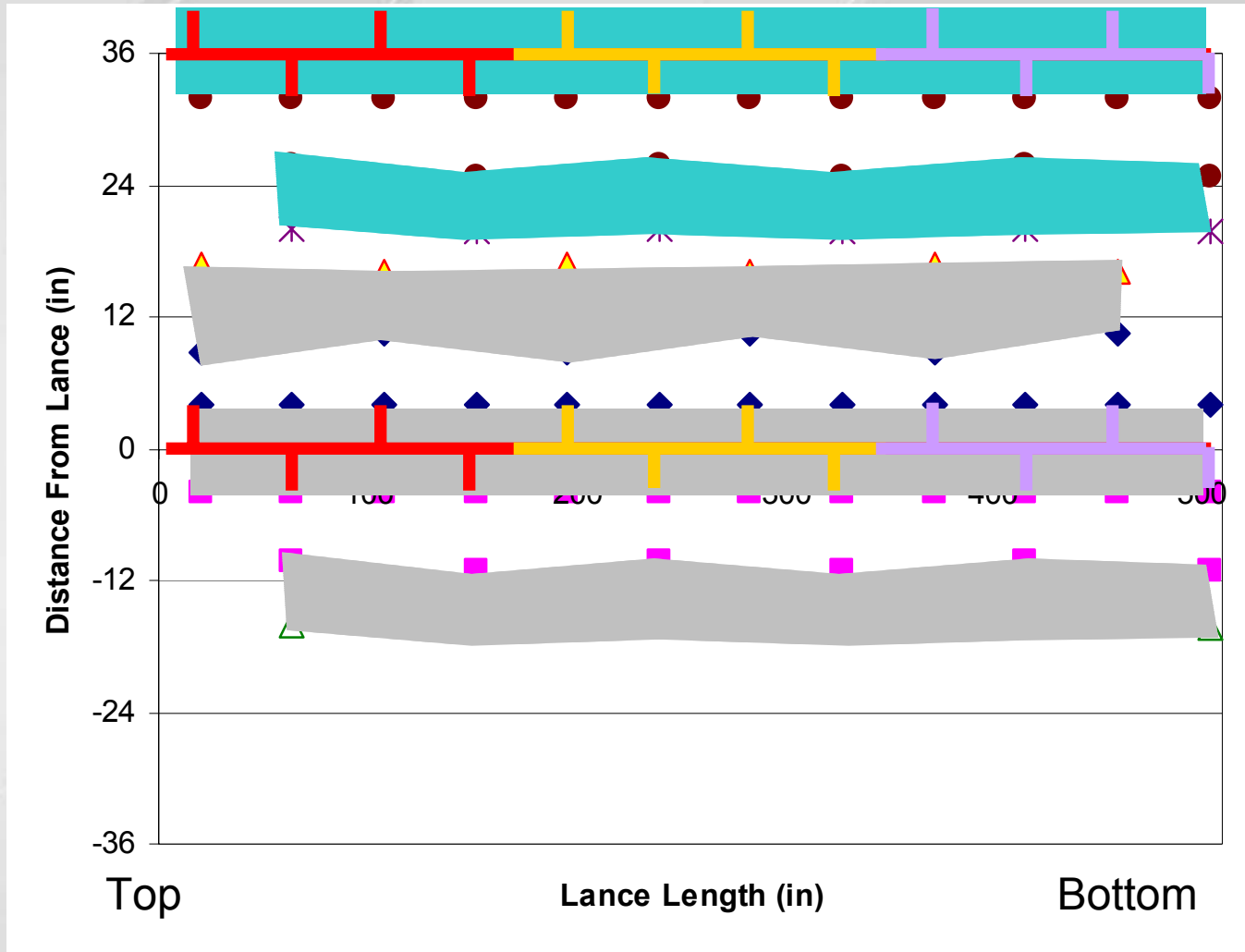
Original Lance Design – Low Load



Phase II - New Distribution Design

- Installed new penetrations to allow on-line lance insertion and maintenance
- Redesigned lances for better top to bottom carbon distribution
- Redesigned nozzles for better plume development and to better direct carbon into gas flow
- Redesigned carrier air distribution for better penetration into gas passages

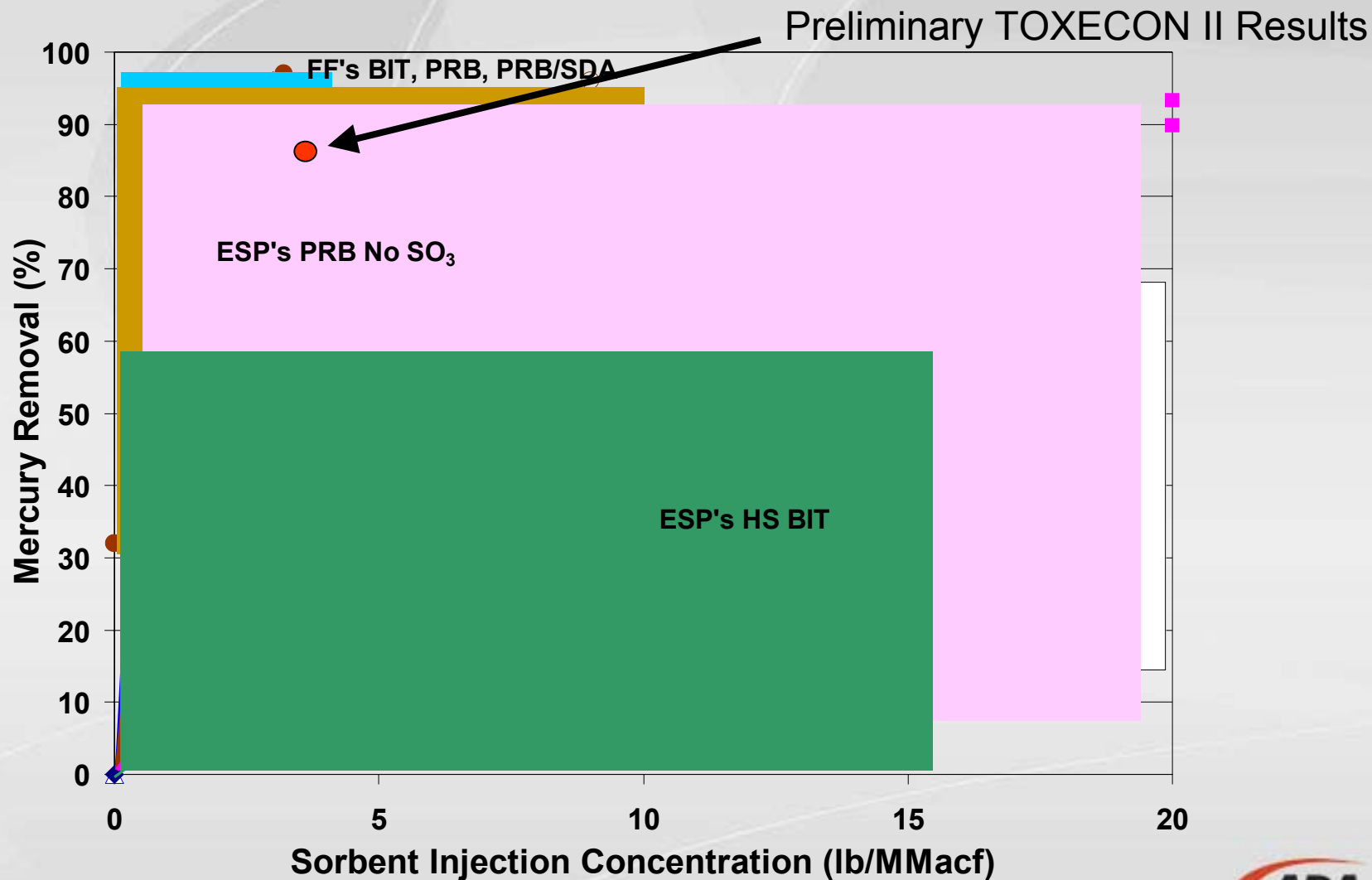
New Design – High Load



Test Schedule – New Lance Design

- Parametric testing – January 15 – 31, 2007
- Depending on results, 30-day test to start in February, 2007

Mercury Reduction Trends with ACI on FF's and ESPs



Importance of Additional Testing

- TOXECON II™ should provide a low-cost alternative for mercury control
- Goals for current Independence tests
 - Achieve >80% mercury control (goal exceeded)
 - Minimize potential of increased particulate emissions (tests underway)
 - Conduct multiple outlet particulate measurements to quantify emissions (underway through EPRI funding)

Contacts

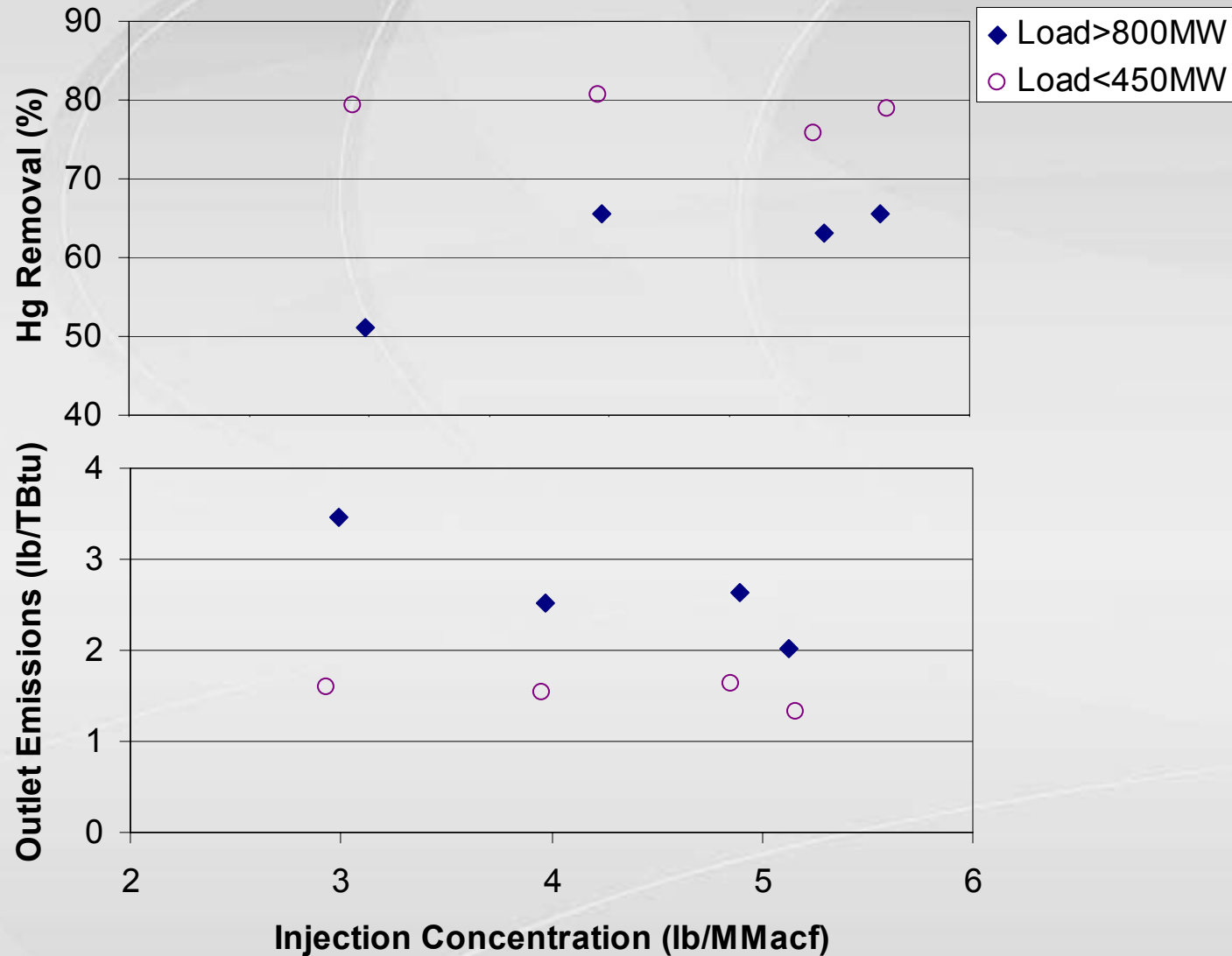
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Test Results – Balance of Plant

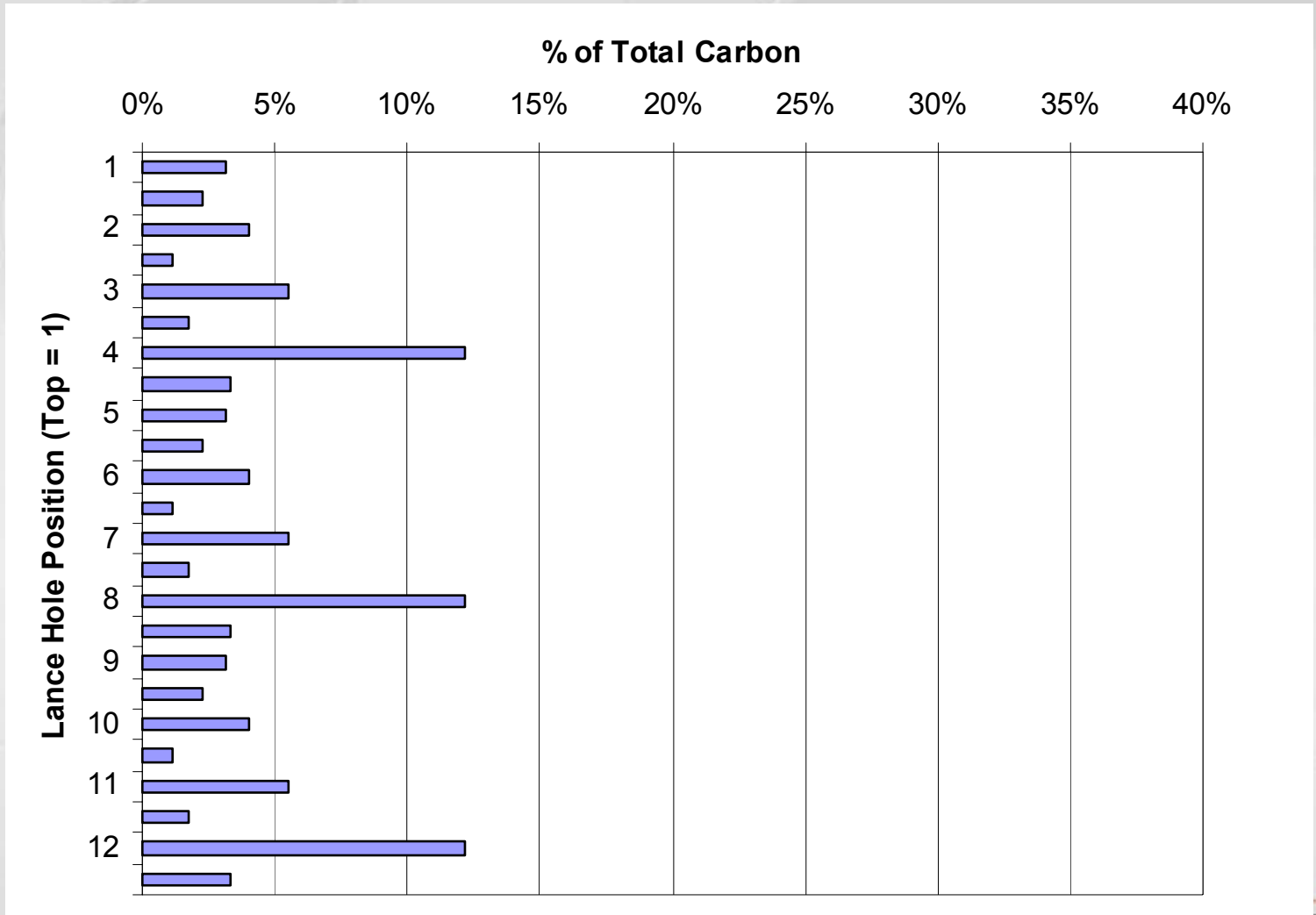
- Opacity
 - Some opacity spikes measured during last field rapping while operating at reduced ESP power
 - Testing with full ESP power and varying the rapping sequence limited the particulate and opacity spikes for all sorbents tested
- Minimal other plant impacts

Long-Term Performance Results



New Lance Design Carbon Distribution

Top



Bottom