



Steve Gibbons, Business Development - CEMS

EUEC 2015

Experience using Cavity Enhanced
Absorption Spectroscopy (CEAS) for HCl
measurement on a coal-fired power plant

Introduction

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Agenda

- **Current status of PS-18 / Procedure 6**
- **Recap of available HCl measuring technologies**
- **Off-Axis ICOS technology**
- **Practical Demonstrations**
- **Conclusions**

PS-18 / Procedure 6

Current Status



- Proposed Rule published on May 14, 2014 (79 FR 27690)
- Commenting period extended to July 13, 2014
- Total of 17 comments submitted by various stakeholders
- Rule expected to be published in Feb/Mar 2015
- MATS compliance deadline April 16, 2015

Key Issues

- Paired reference method trains
- Accuracy of reference methods
- Impractical field certification – e.g. interference, LOD, linearity
- Availability of low level NIST traceable HCl cylinders
- Methods and frequency of system validation

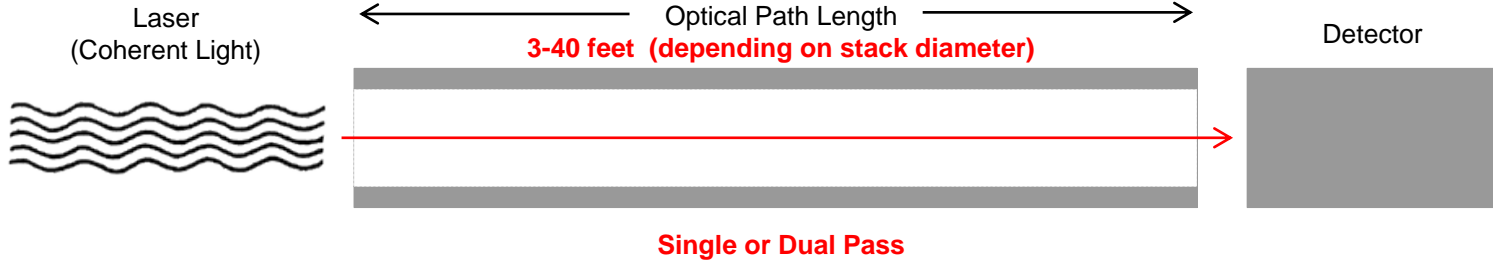
We're hanging in there...
Pioneers of HCl CEMS in
the U.S. CEMS market?!
...there's always PS-15!

(ABB also pioneered FTIR based CEMS in 1993)

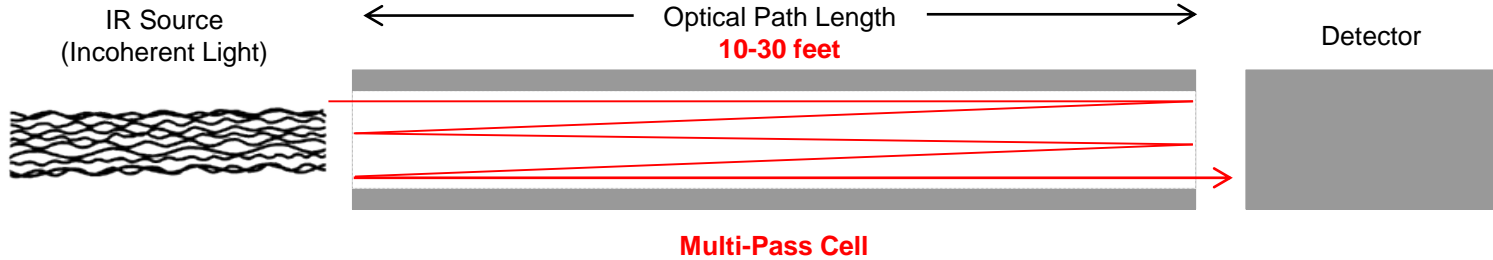
HCl Monitoring

Three Main Technologies

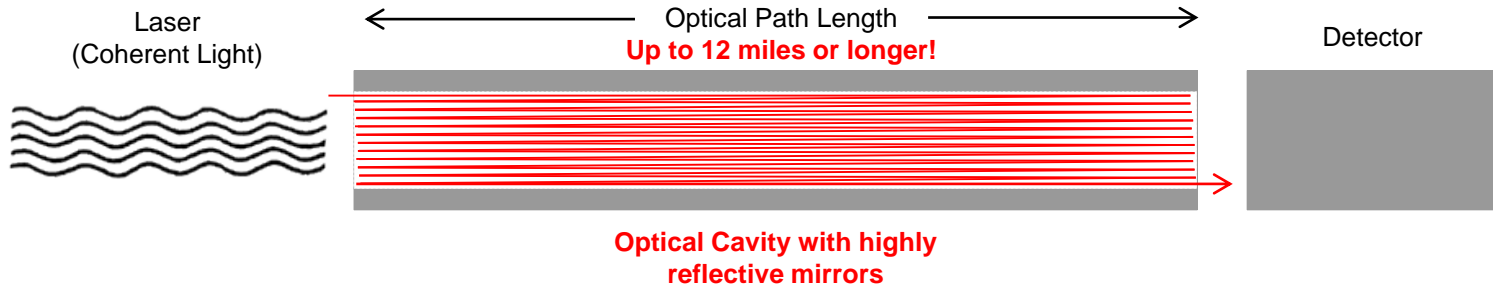
TDLAS Tunable Diode Laser Absorption Spectroscopy



FTIR Fourier Transform InfraRed



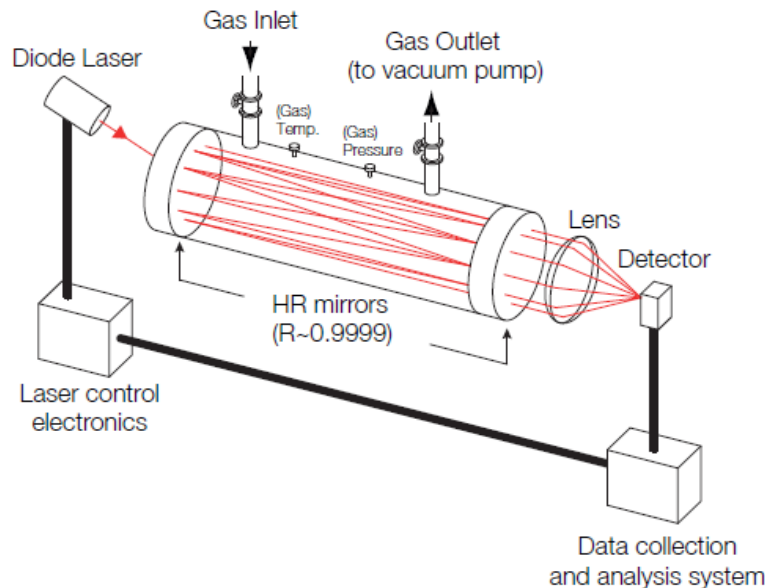
CEAS Cavity Enhanced Absorption Spectroscopy



Los Gatos Research
Pioneer and world leader
in laser-based gas sensing

ABB's solution: Off-Axis ICOS

High resolution absorption with long path lengths



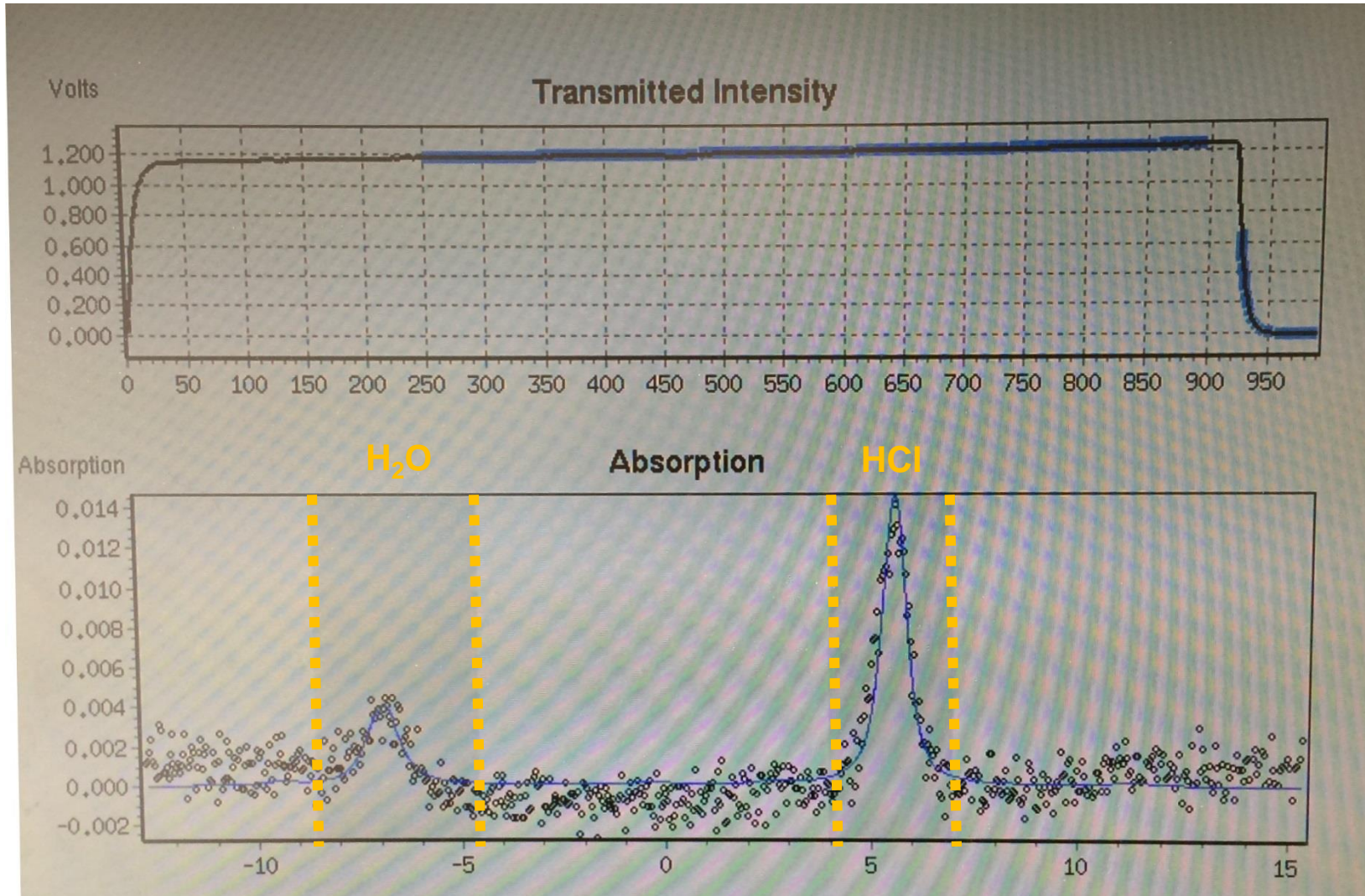
Setup for LGR's patented Off-Axis ICOS technique



- Optical cavity provides long effective pathlength (up to 20 miles or longer)
- High sensitivity allows for detection of very weak absorptions (ppb/ppt concentrations)
- Chemometrics enables quantification of multiple gases in complex mixtures
- Very robust – exact alignment, gas pressure, gas temperature are not critical
- Mirrors may be cleaned anywhere by anyone
- Off-Axis ICOS can be employed at any wavelength from UV through mid-IR
- Simple to couple multiple lasers into a single cavity for multi-species detection

Visualization of spectra real-time

Powerful diagnostics tool



Off-Axis ICOS for CEMS

Benefits that stack up

- Combination of HCl and H₂O gives added confidence
 - usually clear if H₂O values are feasible
- Possible to combine HCl, NH₃ and H₂O in one analyzer
- Potentially compatible with dilution systems up to 150:1
- Visualization of spectra very powerful diagnostic tool
- For most applications, analyzer requires no calibration
- Optical cavity can be serviced on-site with minimal training, ensuring maximum availability

Sounds nice...

Can you prove it?

Practical Demonstration - 1

Coal-fired power plant – combined with Hg CEMS



Thanks to our
partner for
managing this
trial

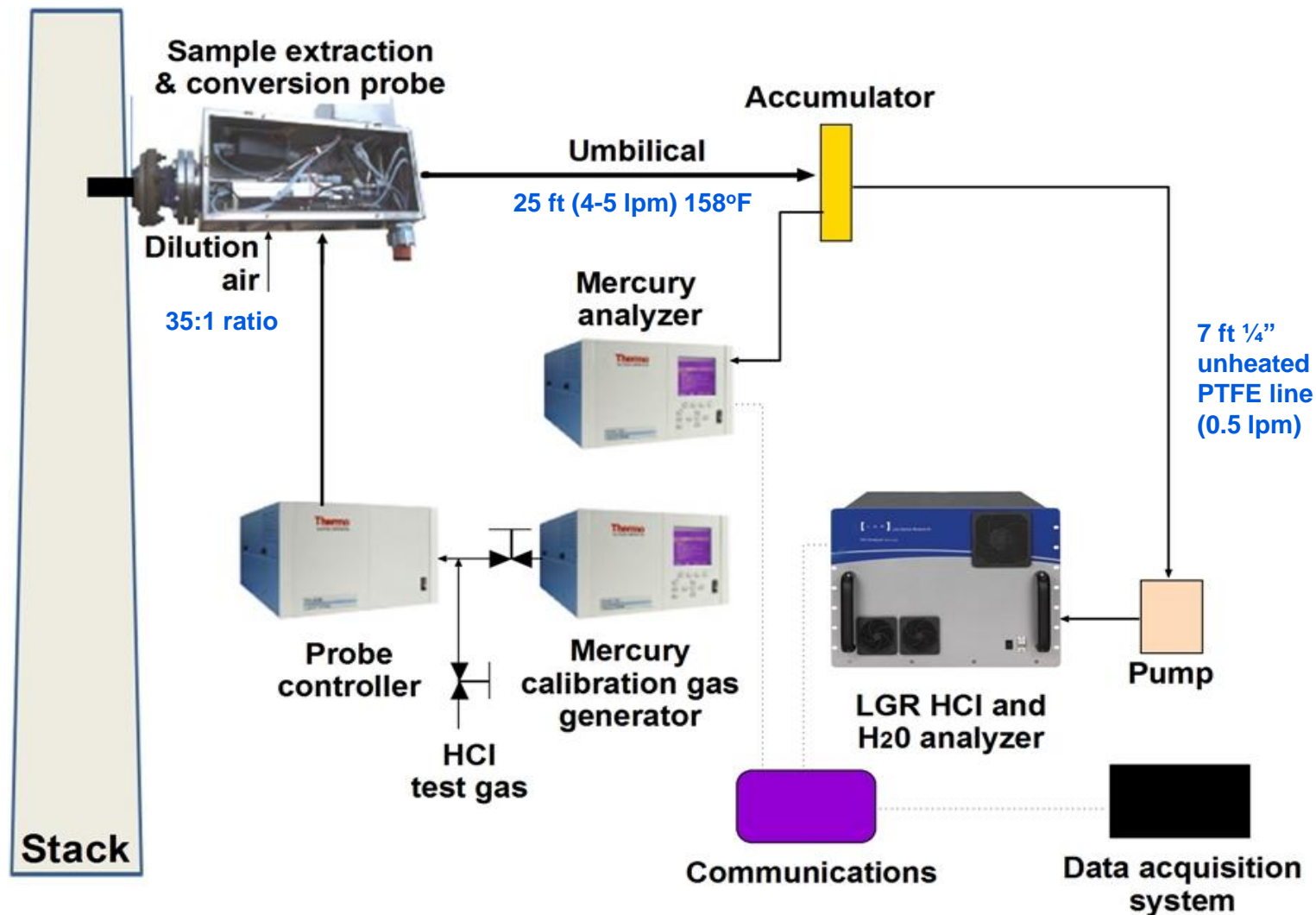


- Plant planning to switch to PRB* coal to achieve MATS limit – emissions currently around 50ppm
- Hg CEMS with 35:1 dilution
- 25ft sample line (PTFE tubing)
- Plant issues restricted opportunities to optimize system design

* Powder River Basin

Practical Demonstration - 1

Flow Diagram



What did we learn?

Not a lot, but still valuable

- Trial successfully proved compatibility with Hg CEMS
- In this case, LGR analyzer shared probe and sample line with Hg CEMS
- Trended well with plant load and returned to zero when plant offline
- No chance to demonstrate measurement ability \leq 1ppm HCl

Practical Demonstration - 2

Coal-fired power plant – dilution-extractive CEMS

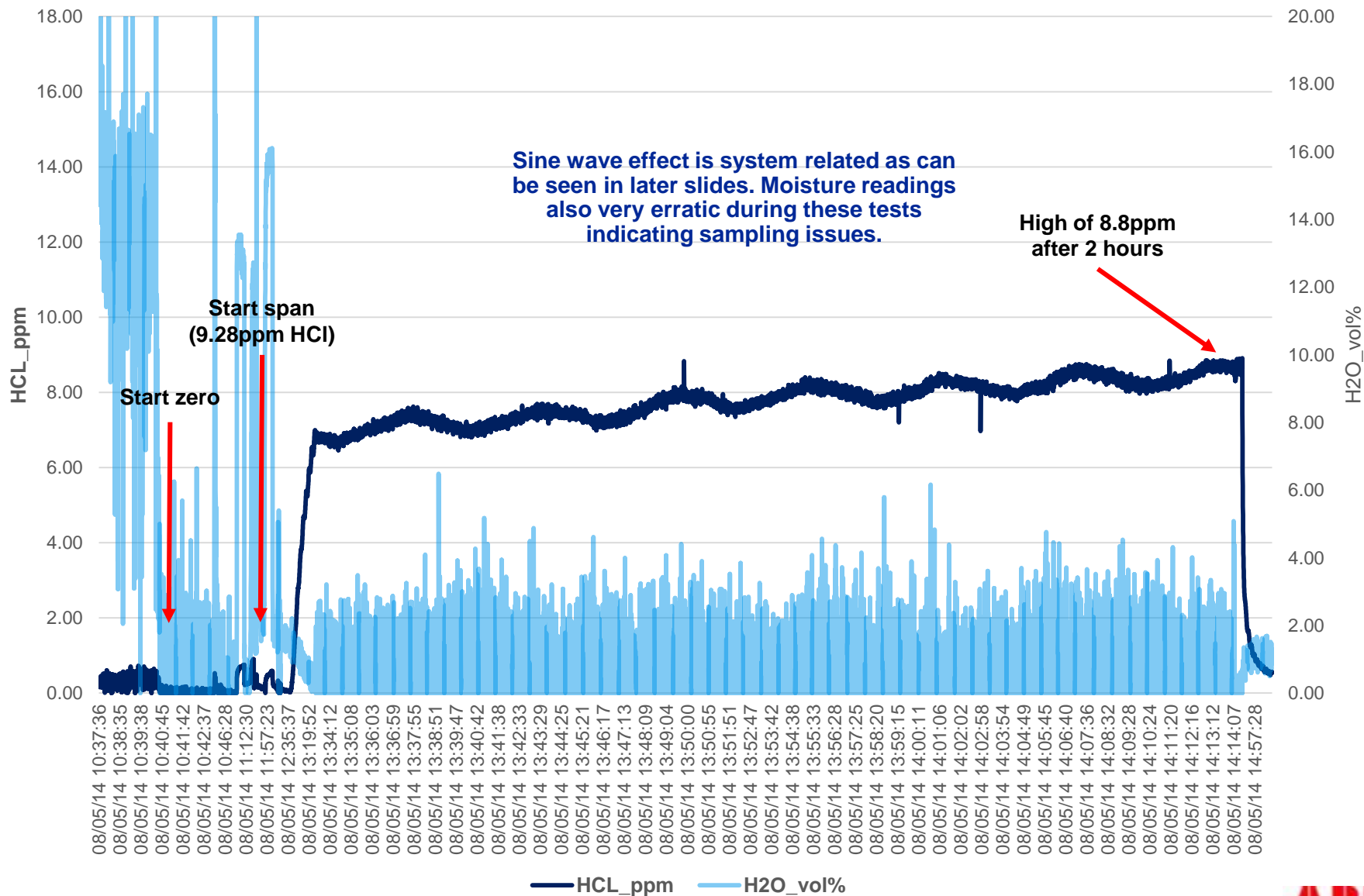
- ABB supplied analyzer for testing at one of largest U.S. coal-fired power plants over 4 weeks (completed Aug-2014)
- 100:1 dilution-extractive CEMS
- CR coated SP2000 M&C probe with ceramic filter
- 100ft sample line (frost-protected)
- Analyzer run in parallel to similar CRDS analyzer

Note: 1ppm @ 100:1 dilution = 10ppb (all field data presented in ppm/vol%)

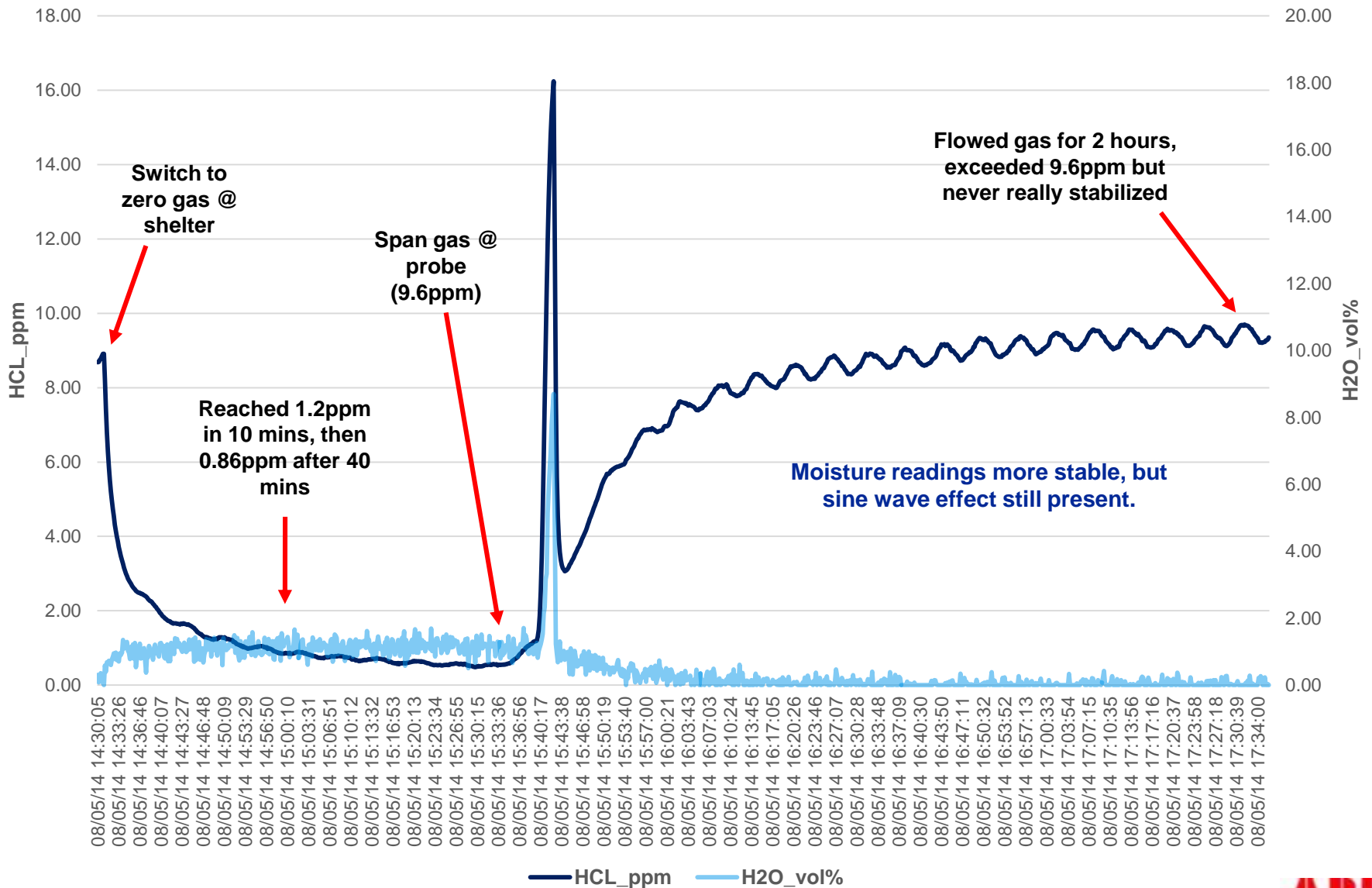
Thanks to our
partner for
managing this
trial



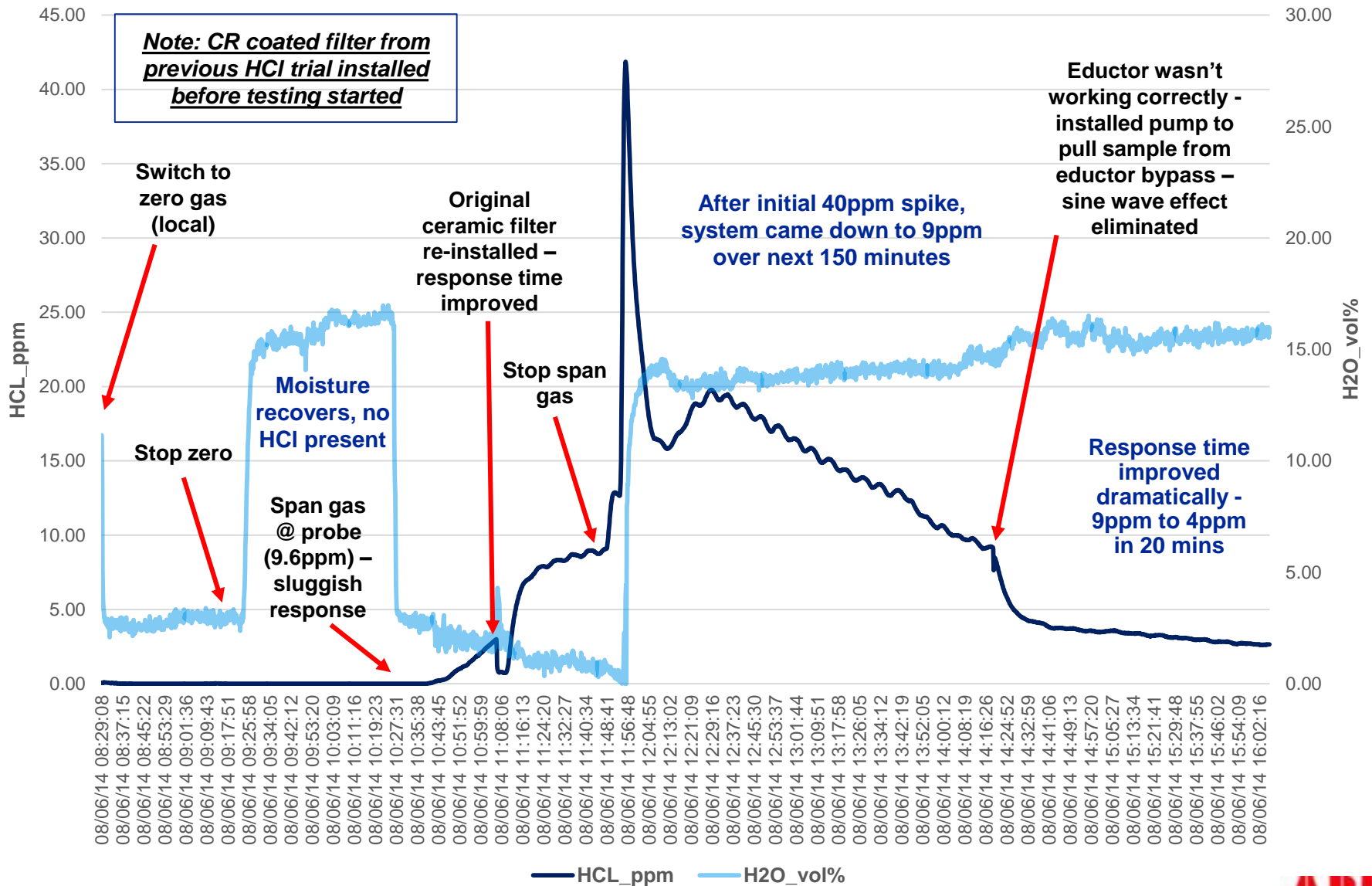
Initial zero & span (from shelter) – 4 hour time period



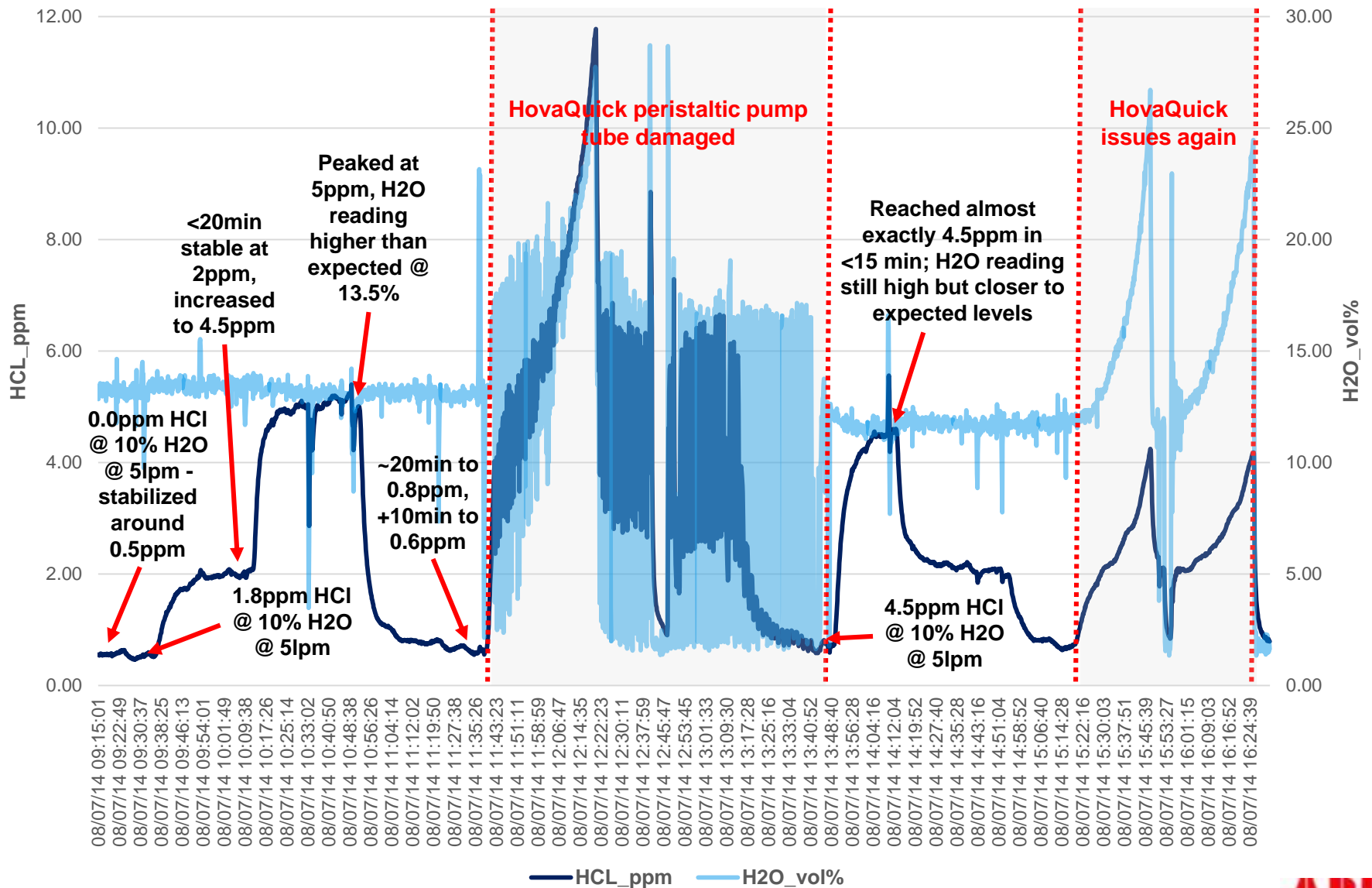
Zero & span (bottle @ probe) – 3 hour time period



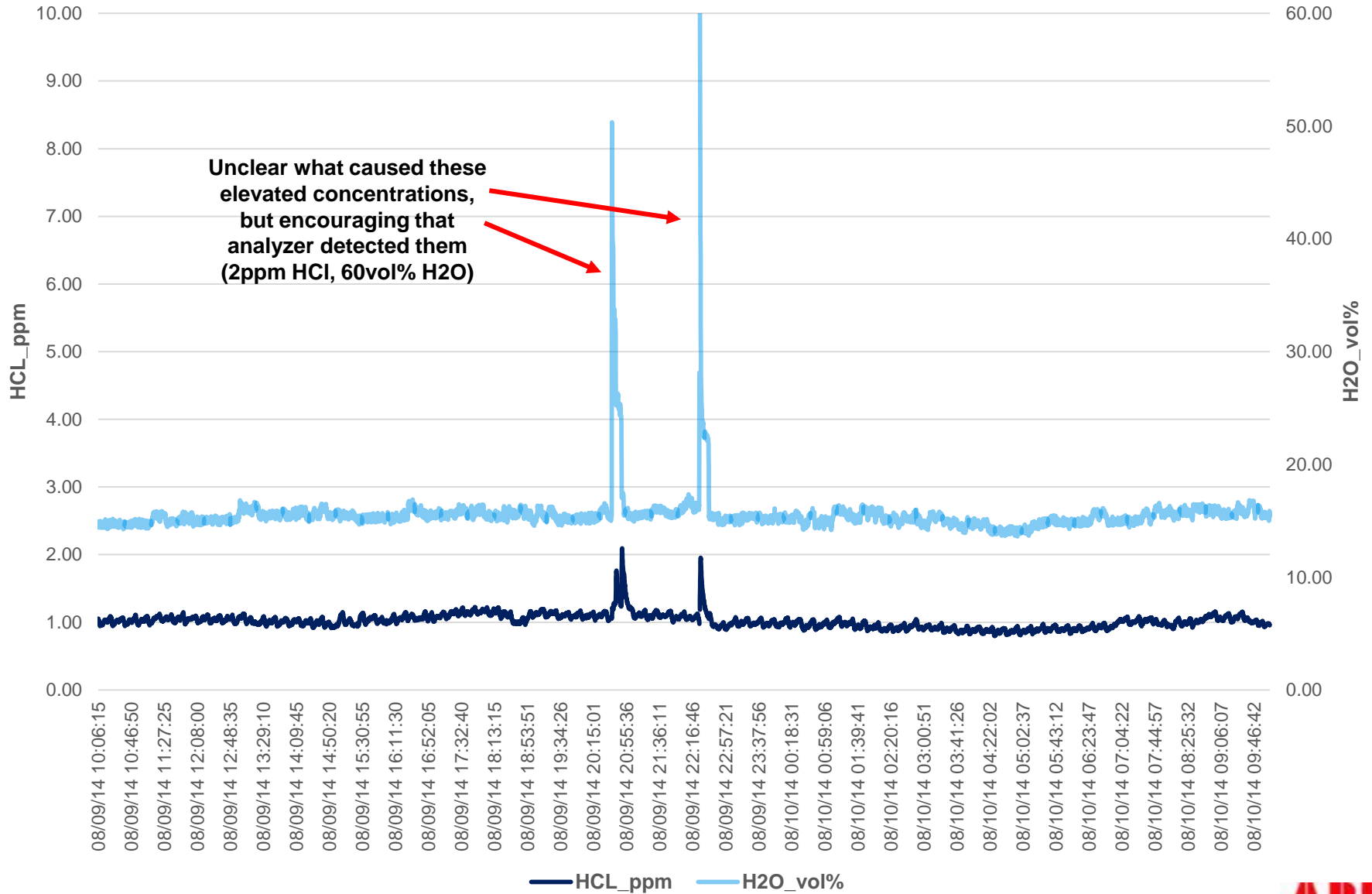
Zero & span (local) – 8 hour time period



HovaQuick calcs @ probe – 8 hour time period



Sampling stack gas throughout day – 24 hours



What did we learn from all this?

Much more than we intended, but not everything!

- Proved accurate and reliable measurement at 1ppm HCl
- Demonstrated compatibility with 100:1 dilution system
- Optimizing response time of system using glass coated or chemically treated materials makes sense, but...
- ...unless analyzer is installed close to sample probe, injecting dry test gas into the system on daily basis makes little sense
- Shown that 95% step change in under 15 min. can very likely be achieved using vaporized liquid standards (i.e. HovaCal)
- Illustrated importance of H₂O to validate HCl measurement
- Speed and accuracy of ABB Off-Axis ICOS analyzer is extraordinary considering no field calibration was performed

Some additional comments

“The sensitivity of these analyzers enabled the customer to quickly identify that there was a problem in the sample handling. Slower, less sensitive instruments (e.g. FTIR, photometers, CLD) would have greater difficulty reaching these conclusions (with a dilution setup).”

Doug Baer, PhD
President, Los Gatos Research

“He was very upbeat about how well it is doing and getting the moisture channel appears to be a huge plus. They all rave about the instrument and I have little doubt the LGR instrument will be the one they order.”

Reggie Davis
President, Spectrum Systems

Practical Demonstration - 3

In-house testing – combined with Hg CEMS



- ABB analyzer plumbed into Hg CEMS for in-house testing
- Thermo Fast Loop probe and Mercury Freedom System
- Dilution ratio 40:1
- Establish optimum system design; evaluate against PS-18

Conclusions

- <0.15ppm combined interference when challenged with other gases
- Hg CEMS probe compatible, independent sample line recommended
- Sample line material not critical when over short lengths (<30ft)
- Tested flow rate behind 80i Hg analyzer is 0.25 lpm (standard design) which is insufficient to share pump with ABB analyzer

Thanks
again to our
partner



Interference Test

Interference Gas or Gas Combination	HCl Concentration (ppmv)	HCl Concentration with Interference Gas (ppmv)	Absolute Difference (ppmv)	Average Absolute Difference (ppmv)
10.9% CO ₂ , 276 ppm SO ₂	0.16	0.17	0.01	0.01
	0.16	0.17	0.01	
	0.16	0.17	0.01	
135 ppm CO	0.16	0.17	0.01	0.01
	0.16	0.17	0.01	
	0.17	0.17	0.00	
445 ppm NO _x	0.19	0.20	0.01	0.01
	0.18	0.19	0.01	
	0.19	0.19	0.01	
89.74 ppm CH ₄	0.16	0.27	0.10	0.10
	0.17	0.27	0.10	
	0.16	0.27	0.11	
11.5 ppm NH ₃	0.13	0.12	0.01	0.01
	0.11	0.10	0.01	
	0.10	0.09	0.01	
445 ppm NO _x	0.09	0.09	0.00	0.00
	0.09	0.09	0.00	
	0.09	0.09	0.00	
18.7 ppm CH ₂ O	0.18	0.18	0.00	0.01
	0.14	0.13	0.02	
	0.10	0.09	0.01	
Sum of Responses				0.14
% of Calibration Span				1.44

Conclusions

We're getting close!



- Off-Axis ICOS demonstrated ability to measure <1ppm HCl
- Off-Axis ICOS compatible with 100:1 dilution-extractive CEMS
- Off-Axis ICOS compatible with Hg CEMS (35-45:1)
- H₂O measurement of high importance to validate HCl readings
- Off-Axis ICOS shows <0.15ppm combined interferences (PS-18)
- Recommended to install independent sample line (and pump) – Silconert coated stainless steel if sample line >30ft
- Impractical to inject dry test gas daily due to characteristics of HCl (i.e. excessive recovery time) – not at all analyzer related
- Shown that 95% step change in under 15 min. can very likely be achieved using vaporized liquid standards (i.e. HovaCal)
- Reasonable changes to PS-18 / Procedure 6 critical to successful deployment of HCl CEMS technology

ABB Measurement & Analytics

Pioneers in Continuous Emission Monitoring

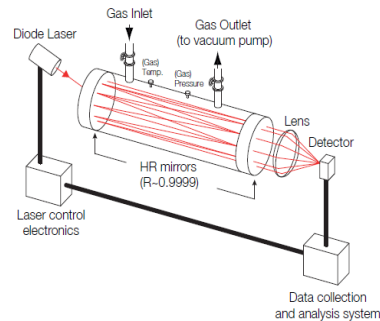


Pioneers of NDIR analyzers in 1952

URAS licensed from BASF to Hartmann & Braun



Pioneers of FTIR based CEMS in 1993
now 4th generation with >1,500 installations



Pioneers of Cavity Enhanced Absorption

Powerful and patented Off-Axis ICOS technology



Pioneers of modular analyzer systems

Simplifying system integration since 1996



Pioneers of gas-filled calibration cells

40 CFR 60 compliant
30,000 installed (20 yrs)



Thank you...

ANY
QUESTIONS
?

**Power and productivity
for a better world™**

