Perma Pure LLC

Custom Dilution Probe for Increased CEMS Accuracy

EUEC Conference B8.6

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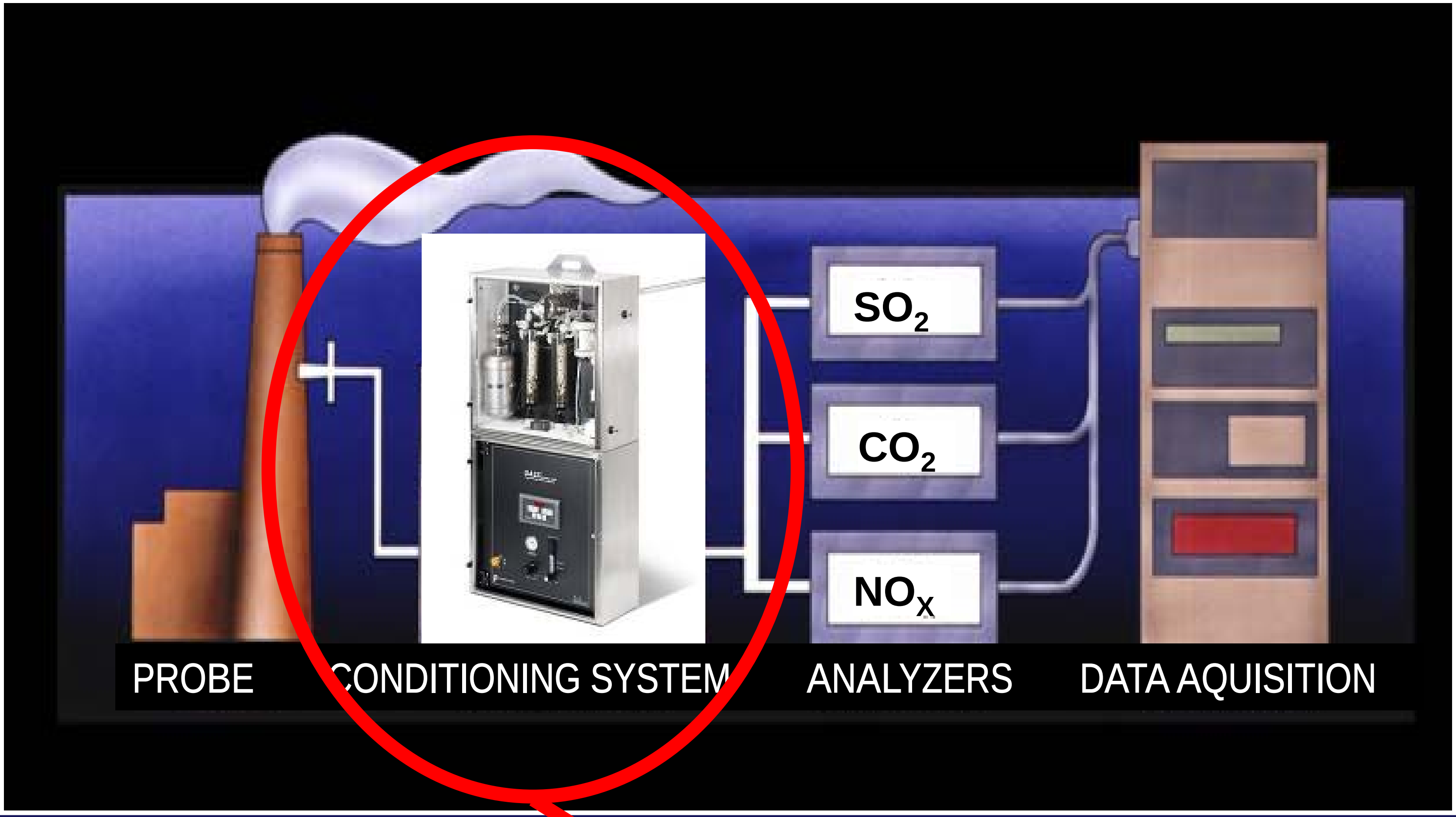
Sample Handling – Critical Path for CEMS



Perma Pure Systems

Perma Pure – Gas Sample Handling

3 Technologies:

- Dilution Probes
  - Wet measurement
- Baldwin™ brand Thermoelectric Coolers
  - Water removal through flash condensation
- Nafion® permeation dryers and systems
  - Water removal in vapor phase at the stack through unique membrane dryer (ion exchange) technology
- Plus extractive probes, filters, scrubbers, accessories

The Facility

Intermountain Power Service Corporation (IPSC)

Twin 950 MW
coal-fired steam
electric generators

Delta, UT

The Opportunity

- Help IPSC achieve more accurate CEMS reporting of CO_2. 16 million tons/year; a couple % adds up.
- Working with RMB Consulting and software provider Cartwright Associates, IPSC had developed an algorithm to compensate for high CO_2 bias.
- The algorithm required precise pressure and temperature measurements at the point of dilution, i.e. the critical orifice.
- IPSC desired a total of 3 pressure and 9 temperature measurements in each of 4 probes (2 inlet, 2 outlet).

The Design Challenges

- Temperature measurements would not be too difficult
- Could we design pressure ports near the critical orifice, on either side, without altering the flow path?
- Could we isolate the upstream pressure port during blowback?
- Could we stabilize temperature and pressure to ensure a stable dilution ratio and thus stable readings?
- How would we accommodate all the addition wiring?

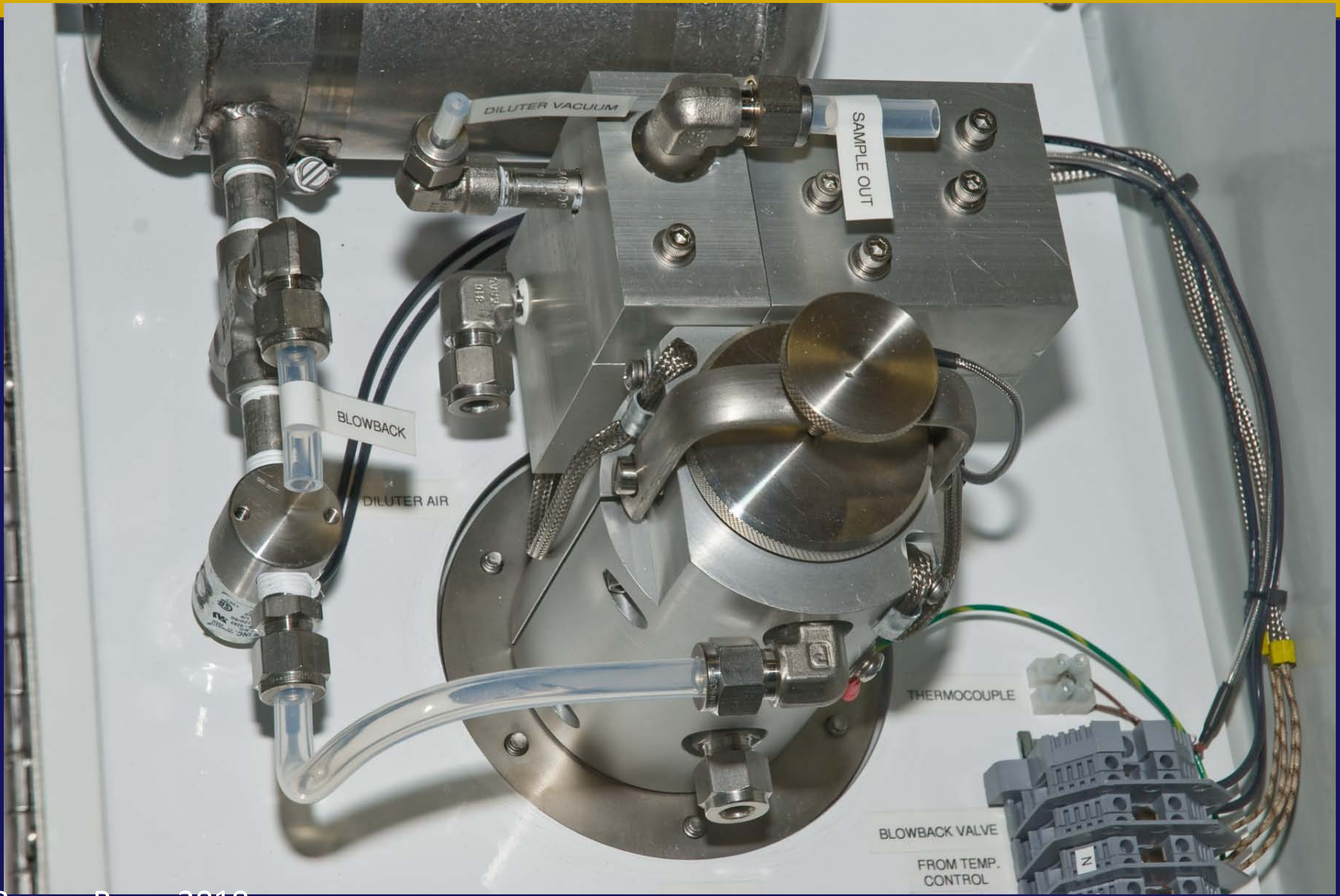
Oh, By the Way

- **Could we finalize the design and build 4 custom probes for installation 2300 miles away scheduled in less than 5 weeks?**

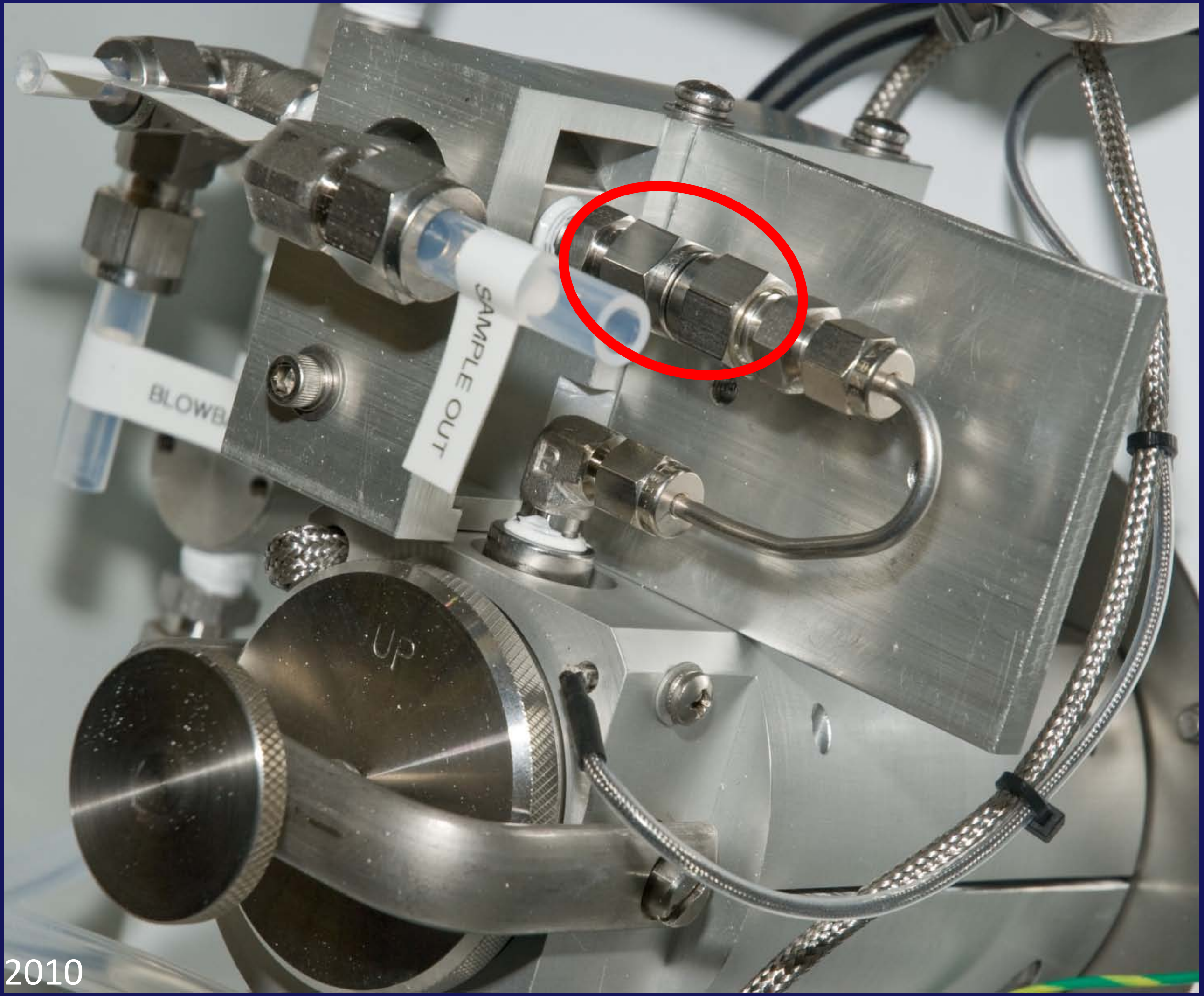
Baldwin™ Model 45 Dilution Probe

Ex-Situ

Model 45 Interior



Monel Critical Orifice – Flow Path



Pressure Measurements

1. Critical Orifice Upstream Pressure Transmitter Port
   - To verify gas density
   - At critical (sonic), speed is constant, but volumetric flow is not
2. Critical Orifice Downstream Vacuum Transmitter Port
   - To verify that flow is maintained at critical
3. Dilution Air Pressure Transmitter
   - Installed just after regulator, to ensure stable pressure

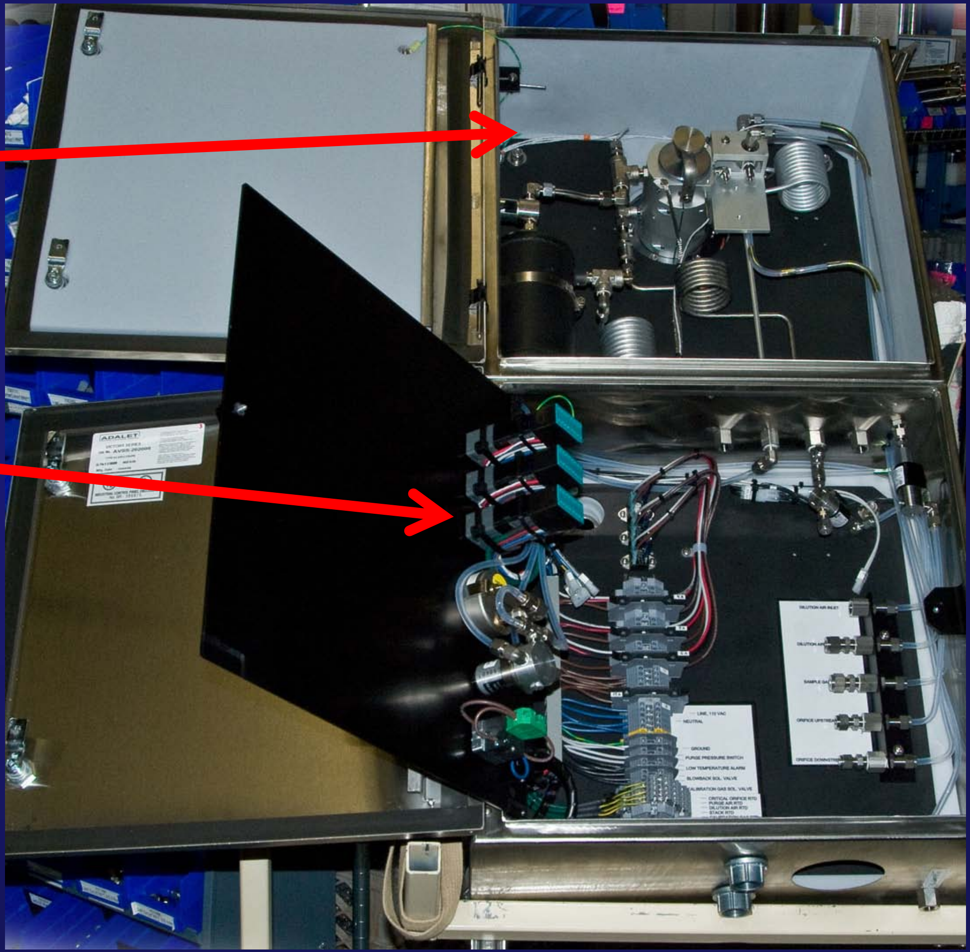
Temperature Measurements

1. Critical Orifice, Upstream
2. Dilution Air Inlet
3. Stack
4. Calibration Gas Inlet
5. Blowback/Purge Inlet
6. Filter Body Housing (Controller)
7. Enclosure Air (Controller)
8. Heated Stinger (Controller)
9. Heated Umbilical (Controller)

Dual Enclosures

Objectives:

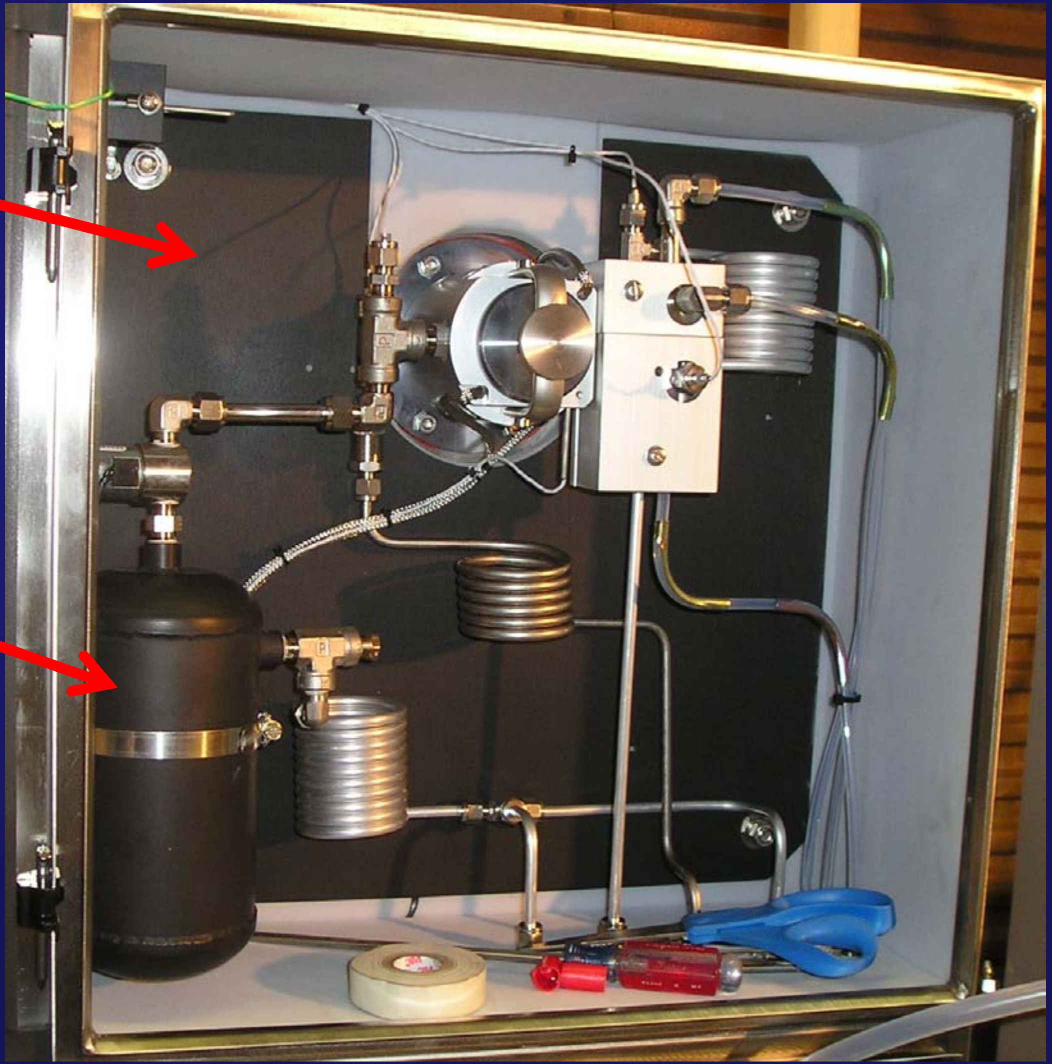
1. Maintain 290°-300°C for Filter Housing
2. Allow Ambient Temperature for all Connections
3. Plenty of room to work



Upper (Heated) Enclosure

Heated Backplate

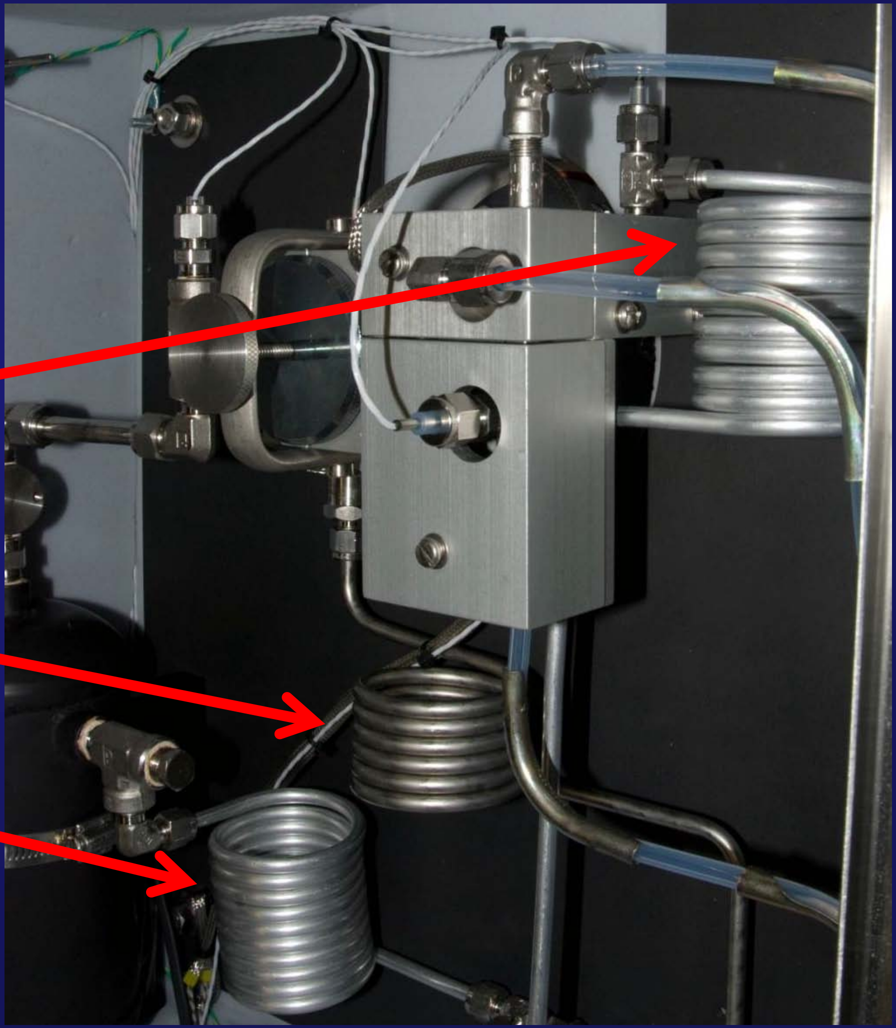
Blowback Tank – controlled by IPSC PLC



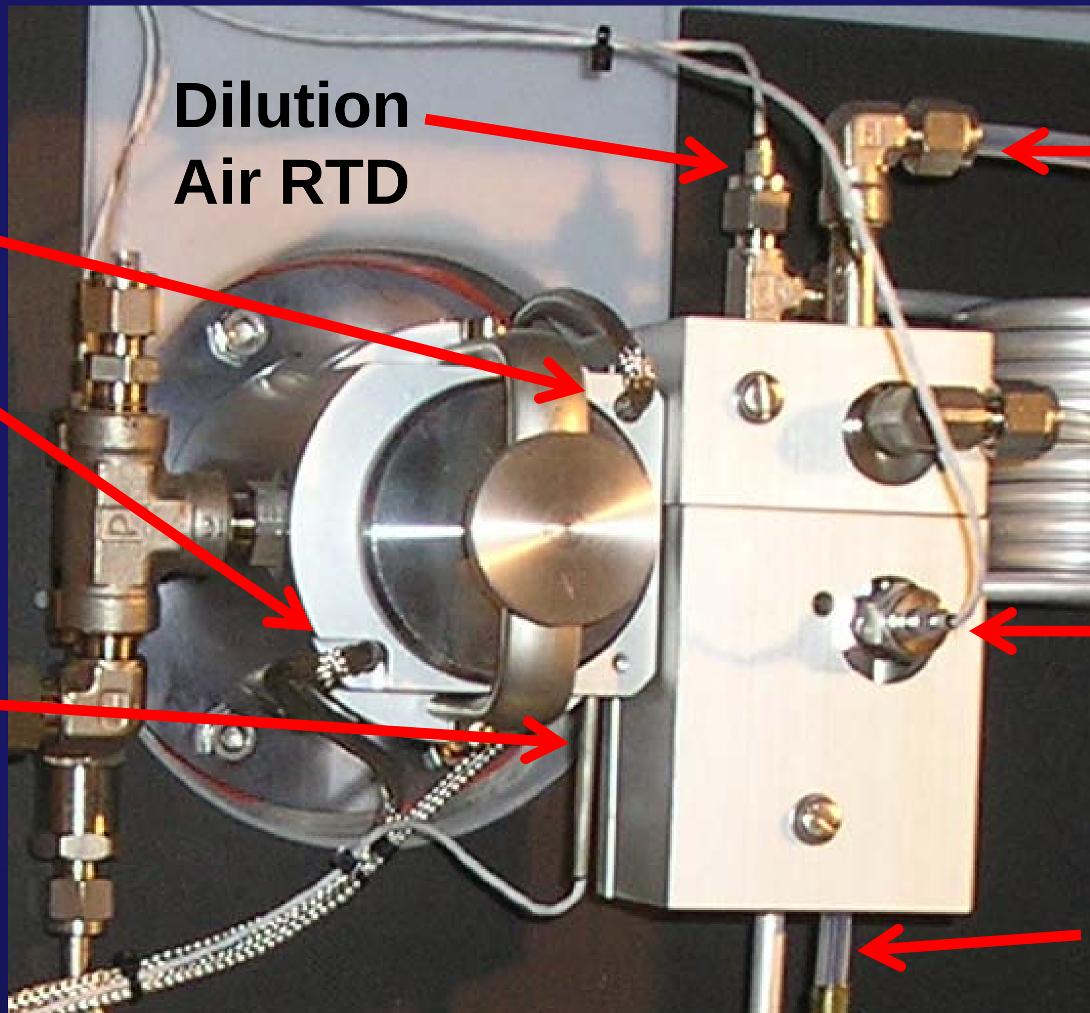
Heat Exchangers (Upper Enclosure)

Objective: Maintain Stable Temperatures

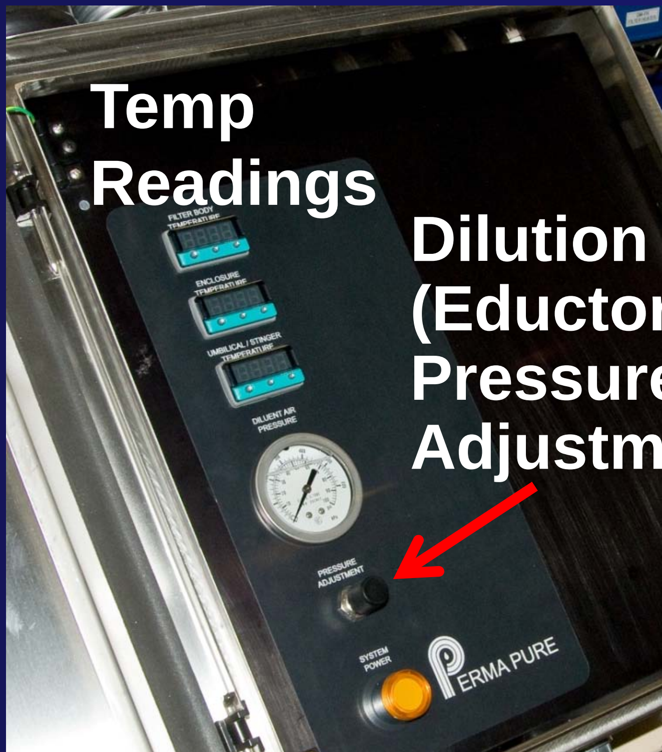
1. **Dilution Air HE (aluminum)**
2. **Cal Gas HE (SS)**
3. **Blowback Air HE (aluminum)**



Filter Housing/Critical Orifice Design



Lower (Ambient) Enclosure (Installed)



Front Panel

Heated Stinger Design

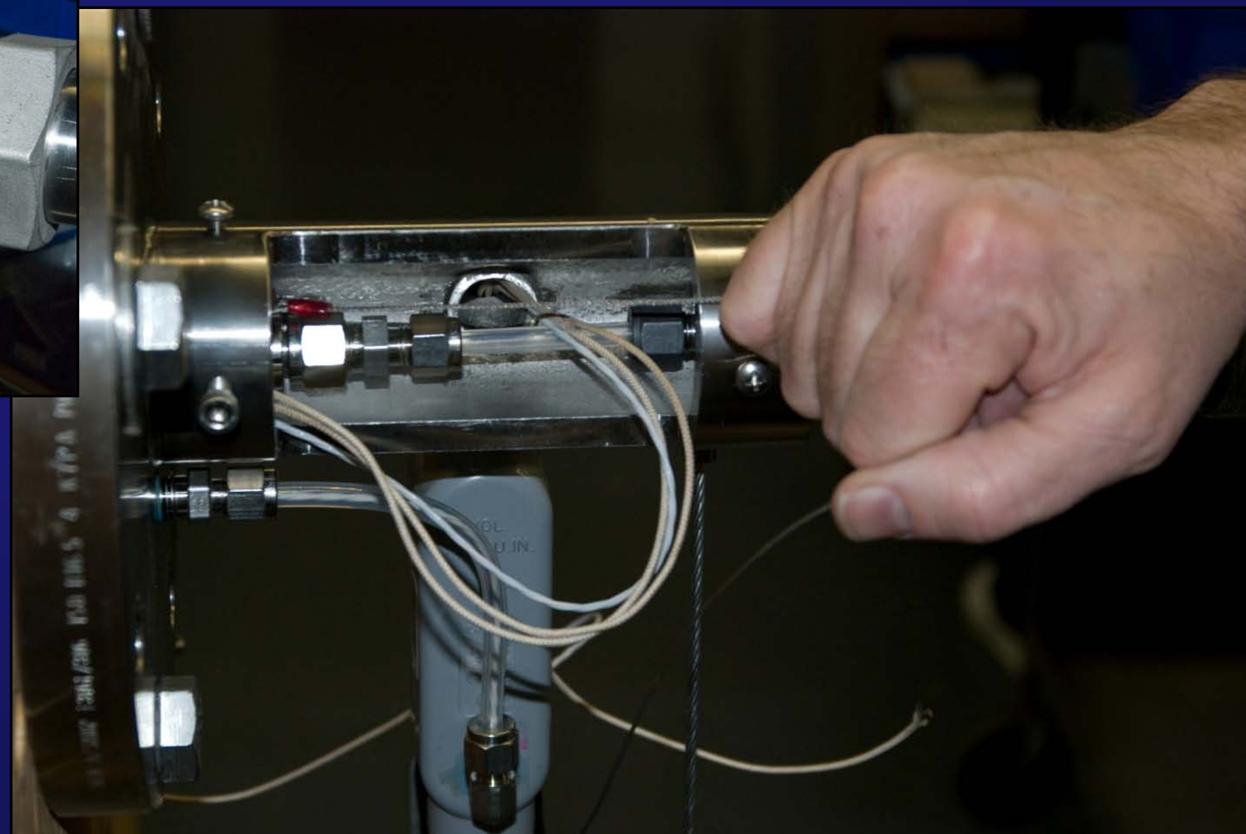
Objective: Maintain Stable Sample Gas Temperature

Requirements:

- 2 outlet stingers (Inlet stingers were reused)
- 8 feet extension into stack, plus 10” external
- C256 Hastelloy sample tube with removable PFA liner
- Accessibility chamber for changing liner without removing stinger from the stack
- 316 SS shell with fiberglass insulated heat tape (Amptek heavy AMOX insulated Duo-Tape)
- Separate 2 foot probe for stack temperature

Heated Stinger

Teflon Liner Access

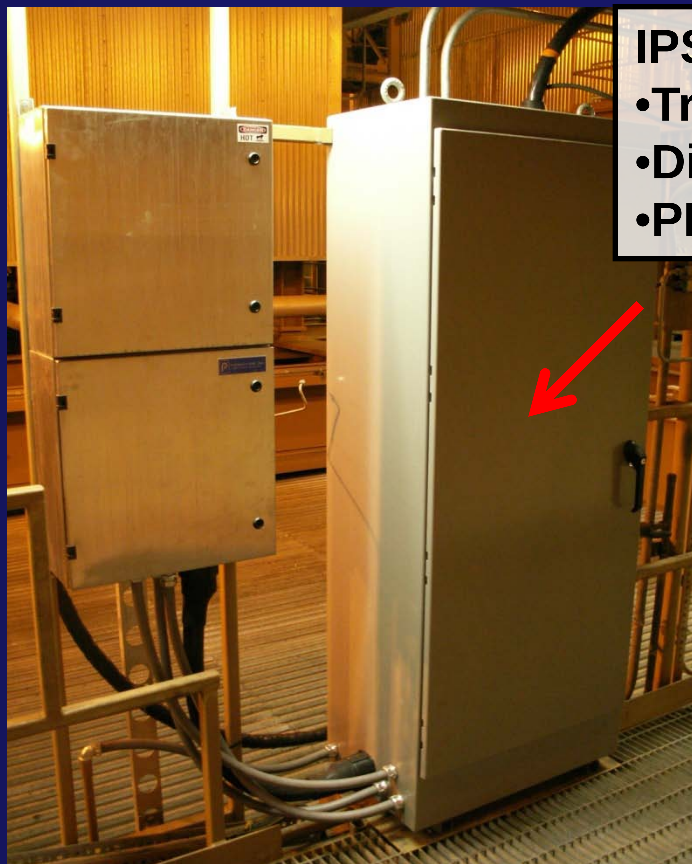


Installation

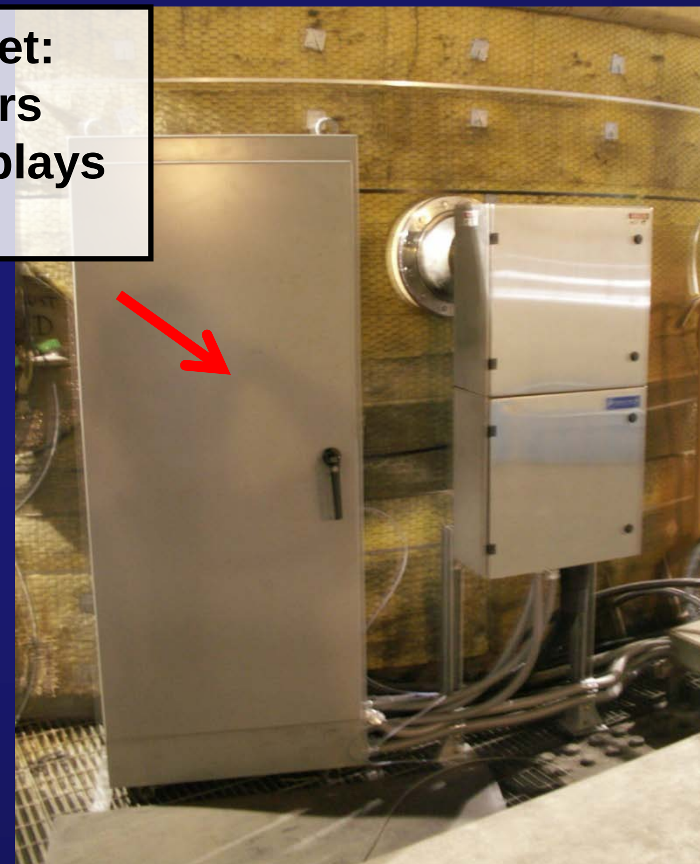
- Performed by IPSC in April, 2009
- Perma Pure provided on-site technical support
- Installation Unit 1 during Shutdown
- Installation Unit 2 during Operation
- Elapsed Time: 5 days for all 4 probes

Installed View

IPSC Cabinet:
- Transmitters
- Digital displays
- PLC



Inlet Side



Outlet Side

Probes Enables Greater Accuracy

- Probe designed to yield maximum stability of temperature and pressure
- Dilution ratio is not assumed to be constant. Instead, it is calculated dynamically for greater accuracy
- Plant uses dilution ratio correction algorithm to calculate true dilution ratio based on sensor outputs from probe
- IPSC now adjusts the dilution pressure to achieve an initial dilution ratio that yields precise cal gas measurement

Calibration Routine (Quarterly if needed)

1. CO_2 Analyzer set – zero & span at diluted level (≈1200ppm)
2. Run CO_2 cal gas (12%) through probe and adjust eductor pressure control so the diluted sample matches cal gas tag value
3. Enter remaining parameters into software
    1. Sample pressure, critical orifice temp
    2. Set other gas constituent analyzers
4. Software correction enabled
    – From this point, software will make corrections as necessary based on continuous pressure/temp/molecular weight readings

Final Results

- Each Unit passed RATA the week after installation
- Overall ≈ 2% reduction in reported CO_2 bias as a result of probe and algorithm
- Difference of ≈ 300,000 tons/year reported CO_2

Questions?