

HUMIDITY MEASUREMENT BENEFITS IN POWER PLANT APPLICATIONS



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Objective of Presentation

- Power Plant Applications
- “Fits” for The Sensor
- H2O Technology
- Questions / Discussion

Power Plant Applications

- **Combined Cycle**

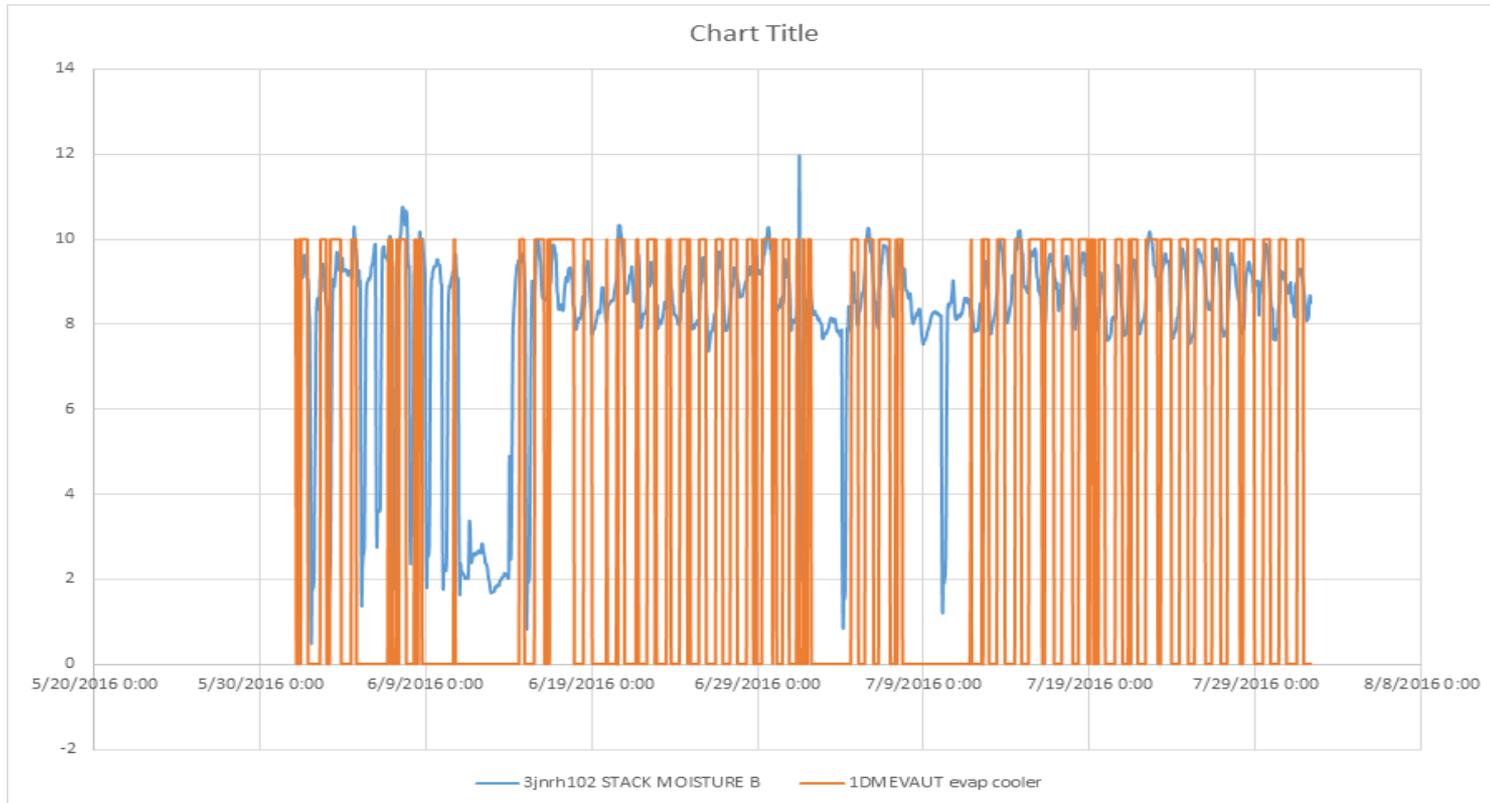
- Tube leak detection
- Dew point measurement
- Feed water temperature control
- Environmental reporting
- Power augmentation
- Optimization software input

- **Coal / Biomass Fired Boilers**

- Tube leak detection
- Soot blower feedback
- Heat rate calculations
- Air heater in-leakage
- Dry scrubber control
- Environmental reporting
- Wet scrubber stack protection
- Optimization software input
- Pulverizer control

Combined Cycle

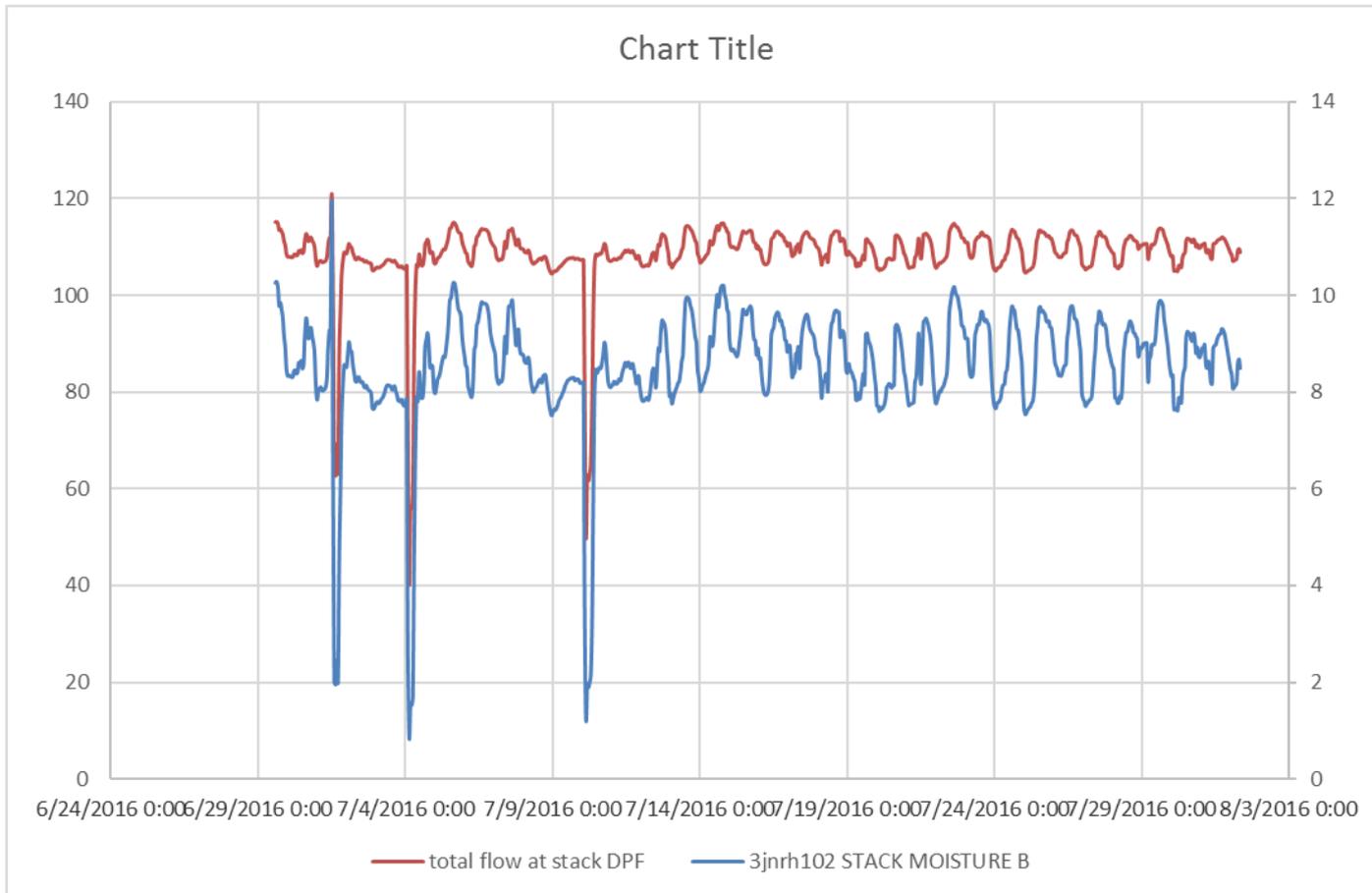
- Tube Leak Detection – HRSG Outlet
 - Evaporative Cooler Simulation
 - Advanced Pattern Recognition Software



Combined Cycle

- Dew Point Measurement – HRSG Outlet
 - Water dew point equation
 - $P_d = (1 - (0.0001 * (\text{SQRT}((0.1 * T) + 1) + 4))) * 461.51 * (T + 273.15) * F * 0.00001$
 - $D_p = (234.175 * \text{LN}(P_d / 6.1078)) / (17.08085 - \text{LN}(P_d / 6.1078))$
 - T = Temperature in C
 - F = Absolute humidity at process conditions
 - P_d = Water vapor pressure
 - D_p = Dew point temperature
 - Water dew point temperature varies 111 to 120 F
 - Corrosion prevention during outages

CC Plant Water Dew Point



Combined Cycle

- Environmental Reporting - Stack
 - Provides real time, accurate moisture concentration
 - EPA method 4 is not very accurate and data is a snapshot
 - Could hurt or help depending on humidity number used for reporting
- Power Augmentation – Turbine Inlet
 - Improved accuracy of dew point temperature
 - Reduce factor of safety so inlet temperature can be lowered without condensation

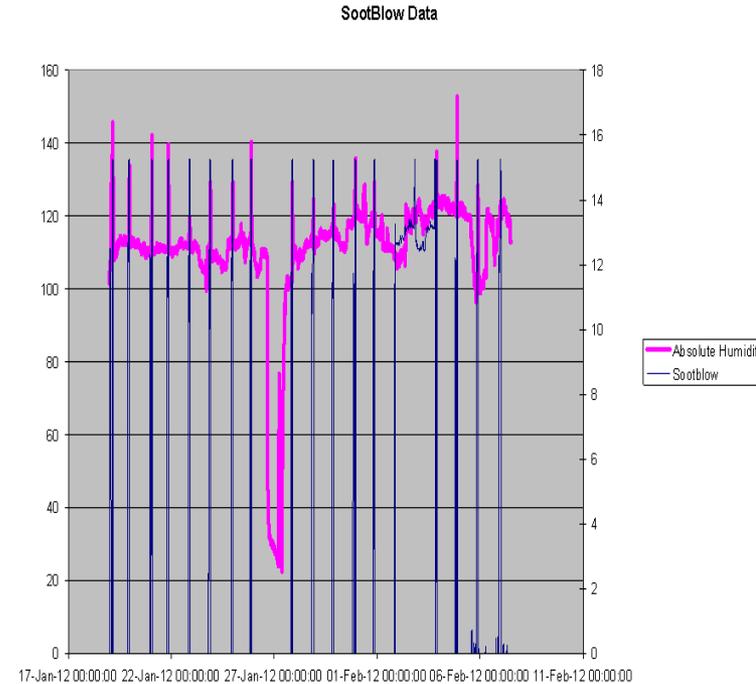
Coal / Biomass

- Tube Leak Detection – Economizer Outlet
 - Our detection limit is 0.1 g/m³ at 0C
 - Volumetric flow rate: 372,000 m³/hr.
 - Detection limit = leak / volumetric flow rate
 - Leak = .1*372,000
 - Leak = 37,200 g/hr.
 - Leak = 1.37 lbs./min or 0.17 gallons per minute
 - Process noise includes ambient humidity, soot blows and fuel moisture
 - More process noise but lower air flow
 - In conjunction with laser based units
 - APR

Coal / Biomass

EO – Soot Blower Feedback

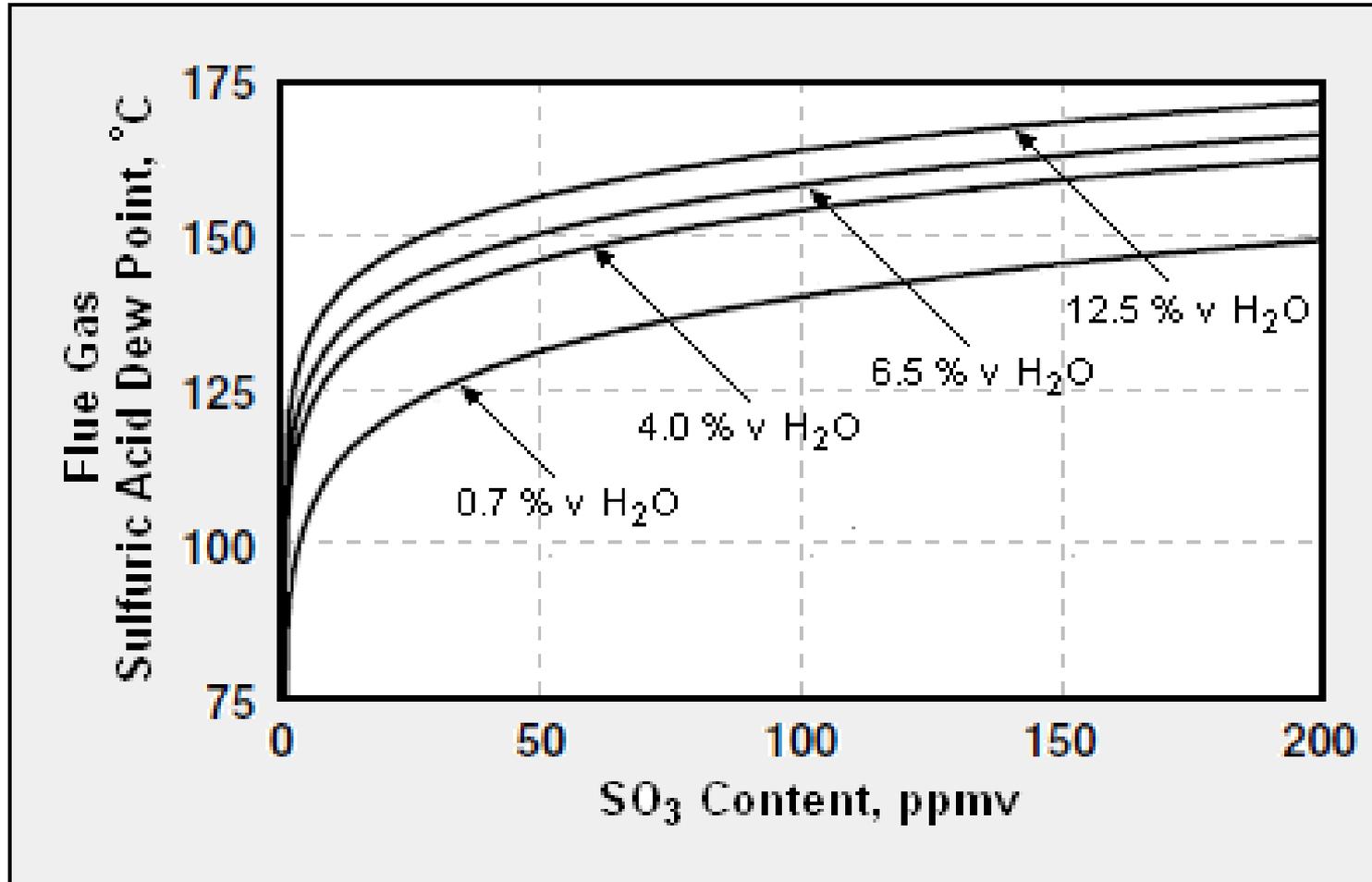
- Safety to assure steam is firing
 - Protect lances
- Heat rate calculations
- Fuel moisture variation
 - Air heater efficiency
 - Optimization software Input



Coal Biomass

- Air Heater In-Leakage Rate – Economizer Outlet and Air Heater Outlet
 - Equation
 - $AHI * y + AHA * x = AHO * F$, where $F=x+y$
 - $x = (AHI-AHO)*F/(AHI-AHA)$
 - AHI = H2O reading at air heater inlet
 - AHA = ambient humidity in g/m³ (manual or real time)
 - AHO = H2O reading at air heater outlet
 - F = flow leaving air heater
 - x = volumetric leakage rate
 - y = flow entering air heater
 - No flow measurement will still provide a relative difference

Verhoff Chart – Coal Plant



Sulfur Dew Point Data - Coal

SO3 PPM	H2O %	Tds (Celsius)	Tds (Fahrenheit)
1	9	114.6077618	238.2939712
1	10	115.7679809	240.3823657
1	12	117.8288282	244.0918907
5	9	129.5780044	265.240408
5	10	130.6603171	267.1885707
5	12	132.5811611	270.6460899
10	9	136.3876155	277.4977079
10	10	137.4314954	279.3766918
10	12	139.2834203	282.7101565

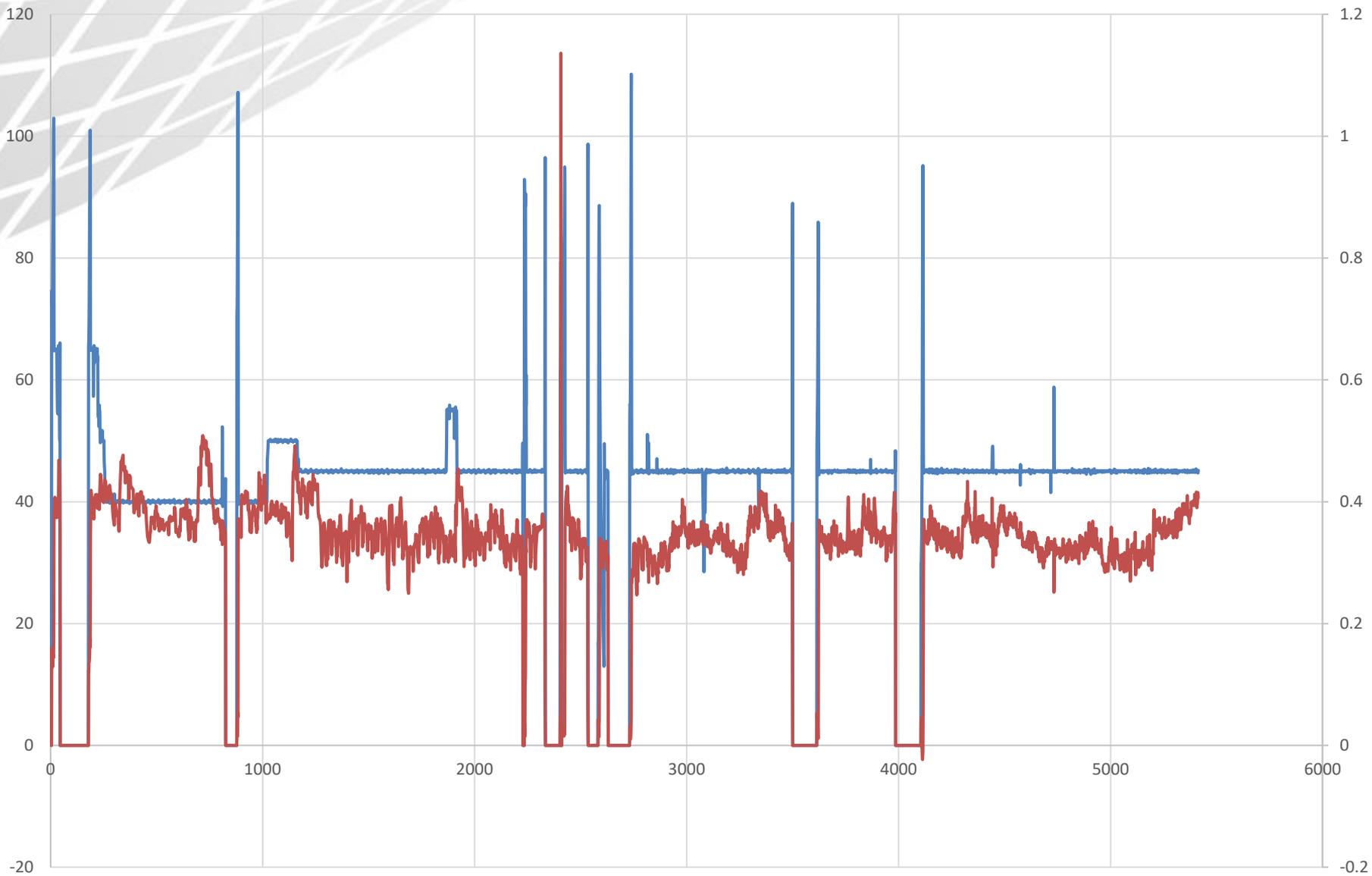
Coal / Biomass

- Dry Scrubber Control – Scrubber Outlet, Baghouse Outlet or Stack
 - Control to an approach to adiabatic saturation temperature or dew point temperature
 - Better SO₂ removal at higher relative humidity improves lime usage
 - Protects baghouse from corrosion
 - Moisture variables include soot blow, load change, fuel moisture, ambient air humidity and tube leaks
 - Dew point can vary up to 15 degrees depending upon time of year and conditions
 - GE Installations – Flint Creek and Braynton Point

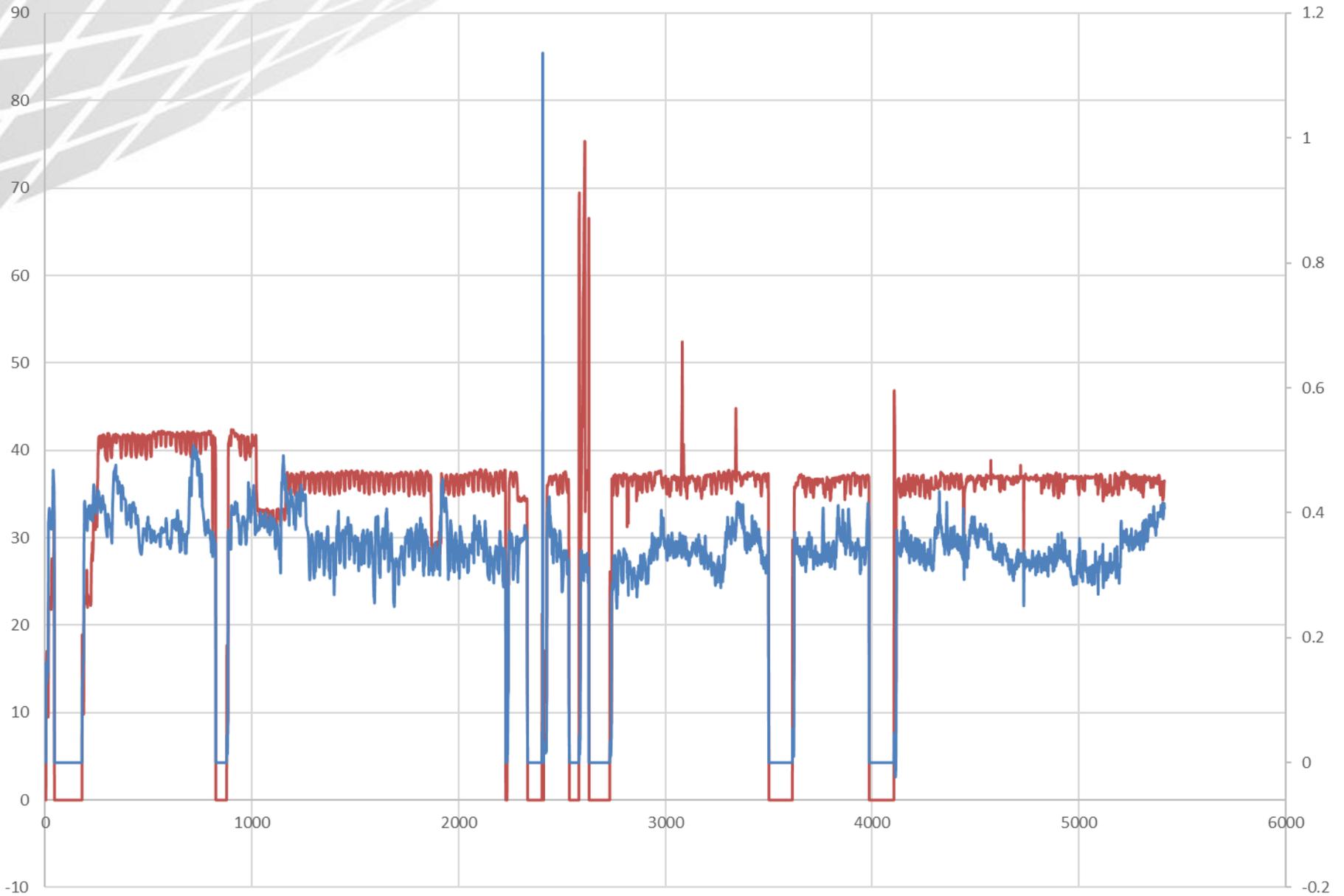
Coal Plant Load Condition Moisture

	NID M8 Dew Point Temp Avg °F	FC Gross MW
6/20/2017 13:00	118.8	277.2
6/20/2017 14:00	124.0	324.3
6/20/2017 15:00	124.8	344.3
6/20/2017 16:00	125.0	371.6
6/20/2017 17:00	125.5	432.4
6/20/2017 18:00	125.7	437.2
6/20/2017 19:00	126.0	437.9
6/20/2017 20:00	126.8	437.6
6/20/2017 21:00	127.1	438.7
6/20/2017 22:00	126.6	423.6
6/20/2017 23:00	126.3	412.1
6/21/2017 0:00	126.0	385.9
6/21/2017 1:00	125.0	312.5
6/21/2017 2:00	121.7	251.5
6/21/2017 3:00	119.8	224.7
6/21/2017 4:00	119.8	213.2
6/21/2017 5:00	119.7	213.6
6/21/2017 6:00	120.4	214.2
6/21/2017 7:00	121.1	220.7
6/21/2017 8:00	120.7	218.4
6/21/2017 9:00	121.2	251.3
6/21/2017 10:00	125.1	365.8
6/21/2017 11:00	125.8	506.5
6/21/2017 12:00	126.8	533.6
6/21/2017 13:00	126.9	527.1
6/21/2017 14:00	126.5	526.9
6/21/2017 15:00	126.8	527.1
6/21/2017 16:00	127.1	526.7
6/21/2017 17:00	127.5	530.8
6/21/2017 18:00	113.1	227.9

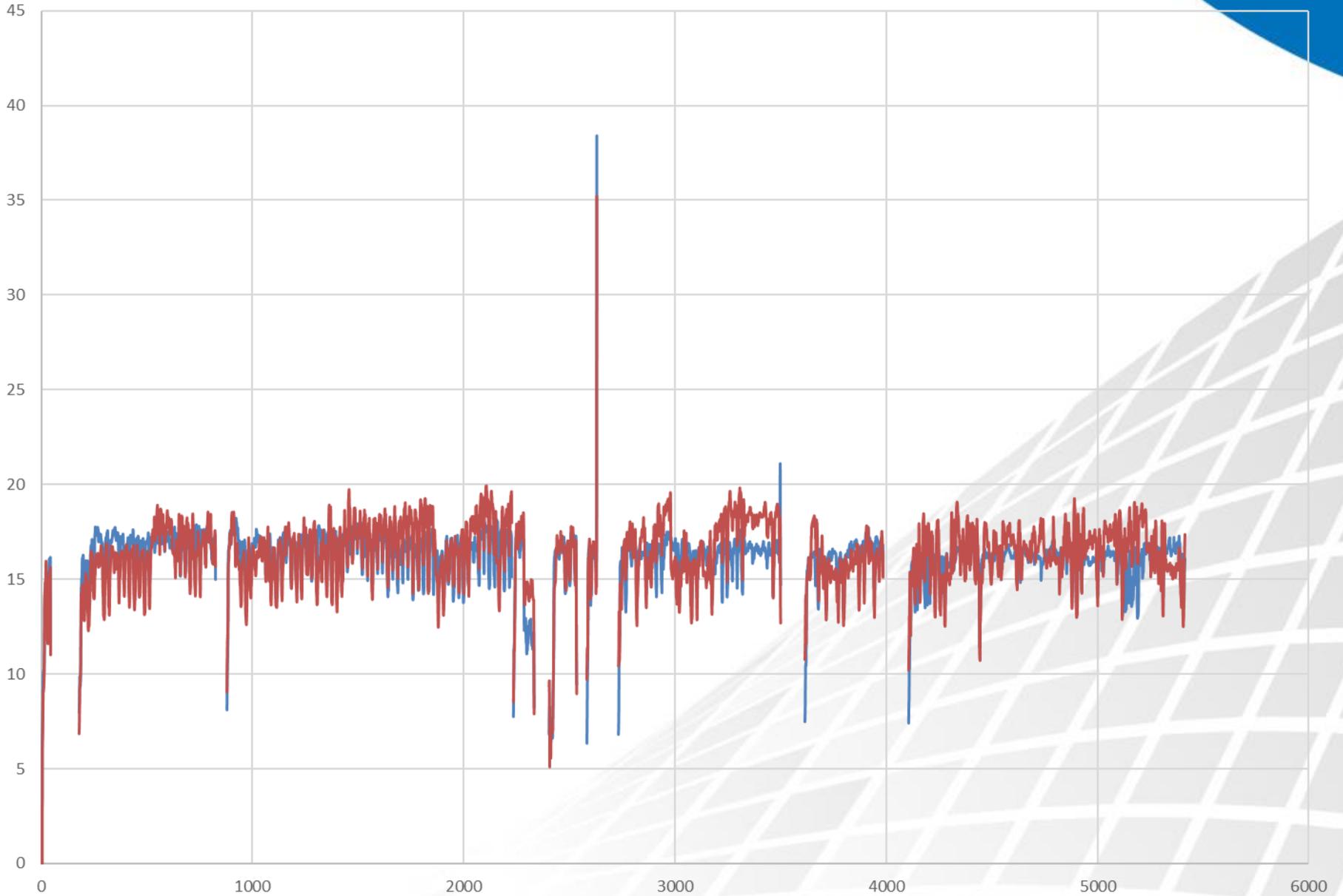
ADP (blue) vs SO2 Removal Rate (red)



RH (red) vs SO2 Removal (blue)



Sensor A (blue) vs Sensor B (Red)



Coal / Biomass

- Environmental Reporting – Stack
 - Improved accuracy of emissions
 - Wet scrubber stack protection
 - Control reheat or bi-pass after scrubber
 - Water carry over can increase moisture concentration past scrubber outlet dew point



Coal / Biomass

- Pulverizer Control – Pulverizer Outlet
 - Sensor is a real time input for mass and energy balance across the pulverizer
 - Sensor will also identify upset conditions like mill fires
 - Tests were done at GE Windsor

“Fits” for Sensor

- Operations Optimization
 - Thermal Performance
 - Outage Planning
 - Emissions Management & Reporting
- Asset Performance Management
 - Tube Leak Detection
 - Evaporative Cooling Upsets

“Fits” for Sensor

- Coal Optimization Software (Neuco, Etapro...)
 - Thermal Performance
 - Tube Leak Detection
 - Air Heater Leakage
 - Dry Scrubber Control
 - Emissions Management & Reporting
 - Pulverizer Optimization

H2O Technology

- Absolute Humidity Sensor

- Direct measurement of the water molecule
- Dipole moment measuring effect
- In-situ measurement

- Advantages

- High temperature operation – 1000 F
- High particulate operation
- Minimal maintenance
- Corrosive and condensing environments are not an issue
- Accurate
- Robust (sensor life is 10 years minimum)

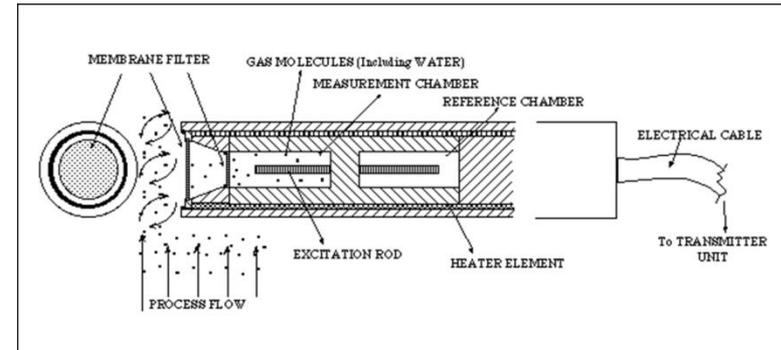
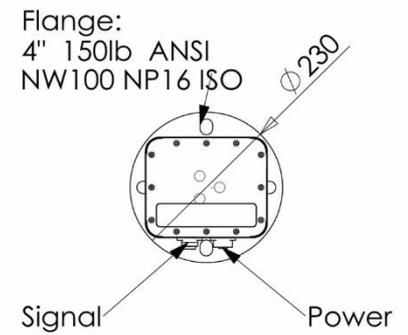
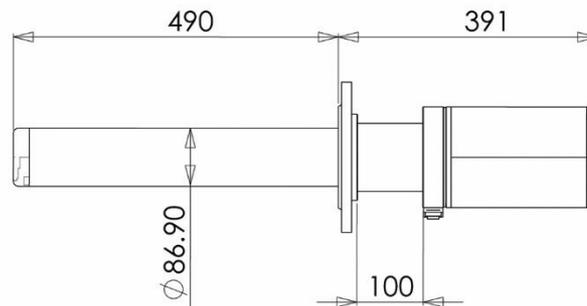
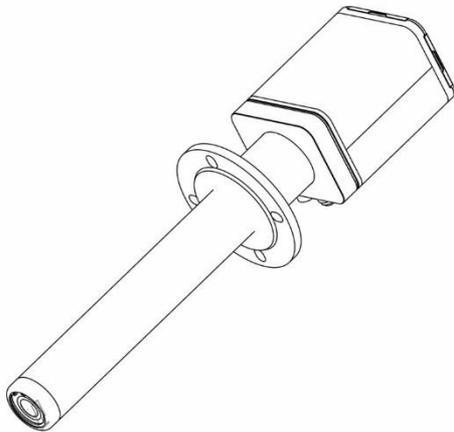


FIG. 3 - PROBE SCHEMATIC

Installation Requirements

- Probe sizes – 490 mm or 1,470 mm lengths
- Flange - 4 inch, 150 lb. ANSI
- Power – 110V, 5 Amps
- Output Signal – 4..20 mA isolated
- Measurement unit – g/m³ corrected to 0C at process pressure
- Other Units – Equations are provided (i.e., dew point, RH, humidity ratio)

Picture / Drawing

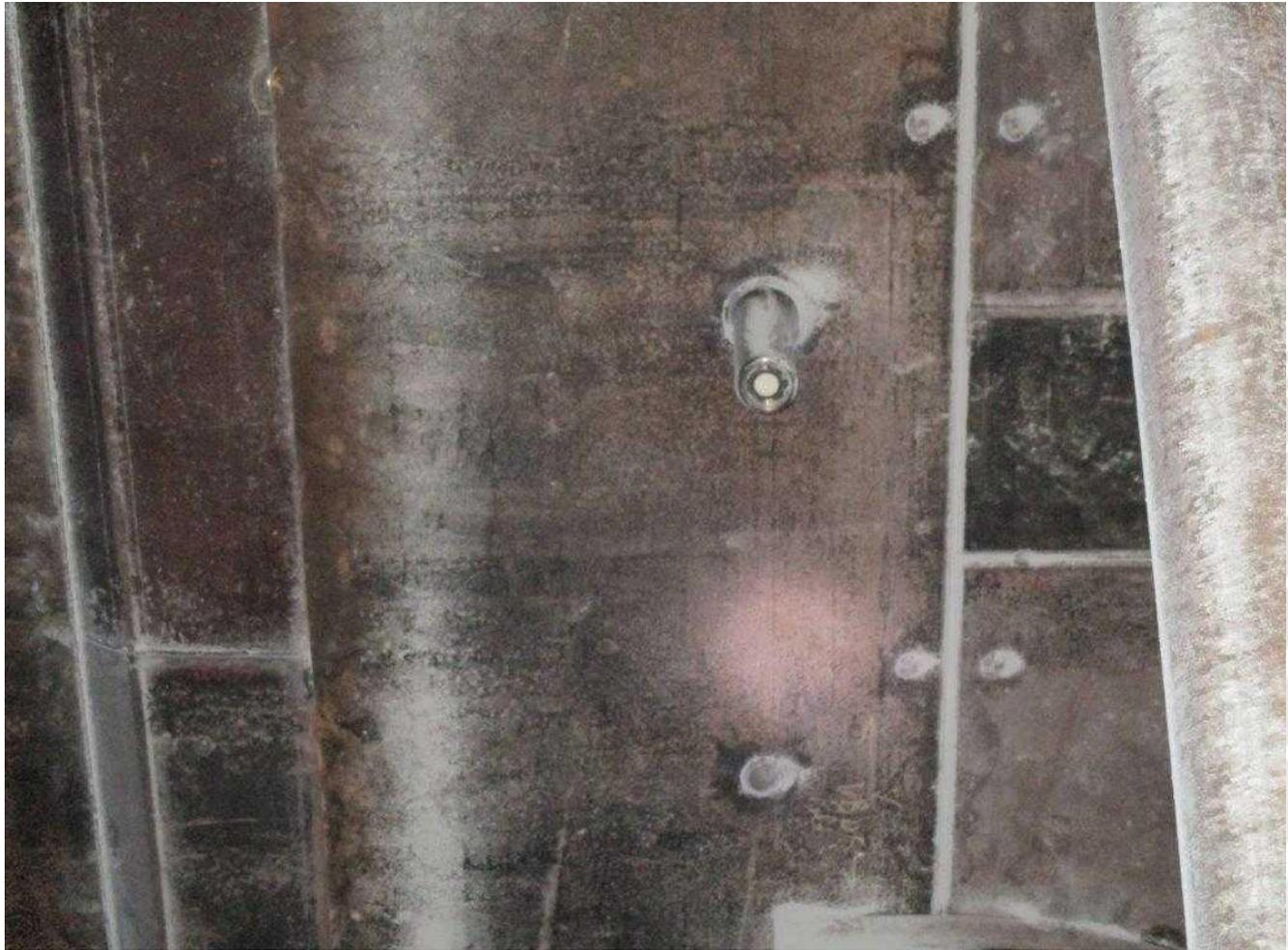


Installations









Questions / Discussion

