

REINHOLD ENVIRONMENTAL[®]



2023 Reinhold/PCUG Round Table Presentation

Cohosted by Duke Energy and Vistra in The Westin Hotel,
Cincinnati, OH on June 26-27, 2023

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Recent Experience with PressureWave Plus

June 2023

GE Gas Power



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Agenda



- Why clean your HRSG?
- PressureWave Plus cleaning method
- Frequently Asked Questions
- Case Studies

Why clean your HRSG?

Why clean your HRSG? – User Challenges



CORROSION/SPALLATION OF RUST FLAKES

- **Ambient weather** influence when out-of-service
- Operation below **dew point**



DEPOSITS

- Ammonium **salt deposits** from SCR ammonia slip
- **Sulfur** in the fuel: **Condensation** in low temperature areas creates a corrosive
- **Debris** from insulation damage or broken equipment
- Combustion by-products from **liquid fuel firing**:
Ash and contaminants

Why clean your HRSG? - Performance Impact



(1) **Increased backpressure** on the GT... leading to **additional fuel costs** and potential **load limiting** of GT

(2) **Reduced heat transfer** efficiency of HRSG... leading to loss in heat rate of combined cycle plant

\$\$\$ 1 iwg typically reduces GT load by **0.2MW** and costs **\$50,000 USD** annually in fuel

Typical debris removed between 10 – 20 Tons per unit!

PressureWave Plus cleaning method

PressureWave Plus cleaning method



- **Flexible lance** with bag positioned by rope and pulley in between the pressure part modules
- Pressure wave and tube vibrations **dislodge deposits deep** into bundle (flue gas side)
- **100 – 200 shots** per corridor
- **Offline** cleaning process
- Scaffolding **not required**
- Tube spreading **not required**

Technology proven on traditional coal-fired boilers & HRSGs

PressureWave Plus cleaning method - Equipment



EQUIPMENT

- Dosing station
- Rigid lance w. flexible hose
- Rigging and positioning cables

CONSUMABLES

- Gas bottles (32 lb. cylinders)
- Shot bags

Patented technology introduced in 2001 by Bang&Clean Technologies AG from Switzerland. PressureWave trademark belongs to Bang&Clean Technologies AG. General Electric has exclusive licensing for this technology in the **Americas**.

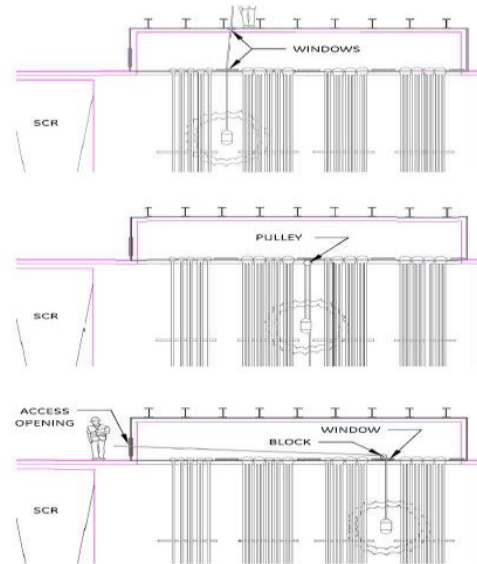
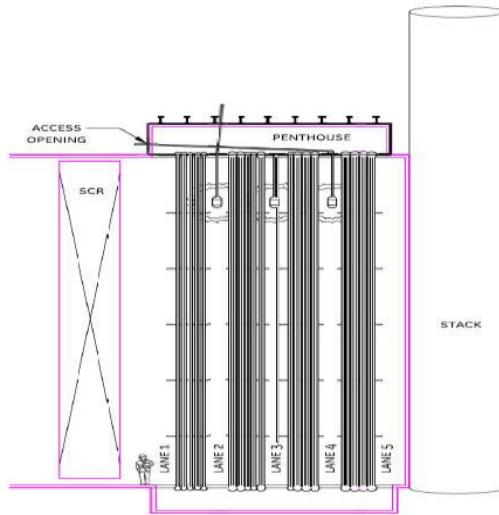


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PressureWave Plus cleaning method – Determining Access



NOTE: GENERIC CONFIGURATION SHOWN



OPTION 1

Window into penthouse roof and/or boiler roof. Work completed from **directly above** penthouse or in open space on boiler roof.

OPTION 2

Pulley installed at boiler roof. Work completed from **ground level**

OPTION 3

Window into boiler roof. Work completed **from roof**



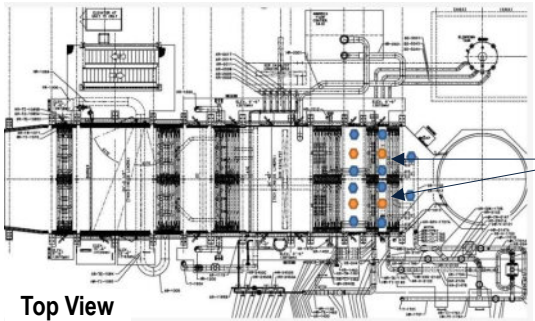
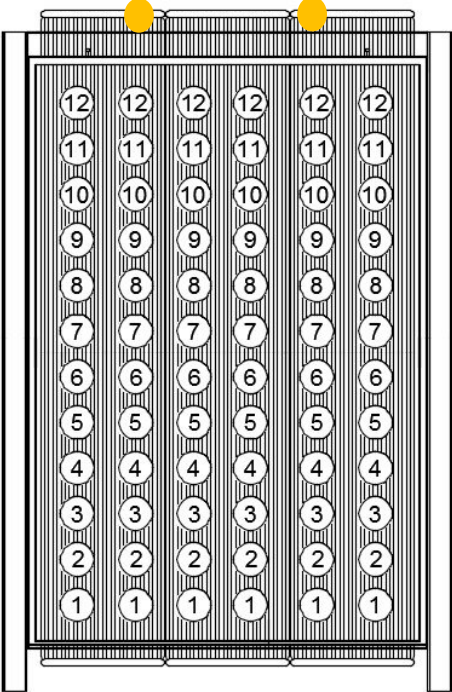
GE team determines access depending on HRSG layout

PressureWave Plus cleaning method – Determining the Grid



- Cleaning in a **methodical grid pattern**, bottom to top
- 3-7 shots every 5'-6' vert. and horiz.
- Shots every 2-4 minutes
- **100 – 200 shots** per corridor

ELEVATION VIEW IN GAS PATH



Top View

Extra ports in casing added to reduce gap between lines and ensure a more efficient cleaning

Vertical HRSG cleanings also possible


GE team determines optimal shot size for efficiency and safety

Frequently Asked Questions

Do detonations cause damage to HRSG?




- Multiple external engineering R&D studies



Zurich School of
Engineering
May 2021

ZHAW Institute of Energy Systems and Fluid Engineering
(IEFE)

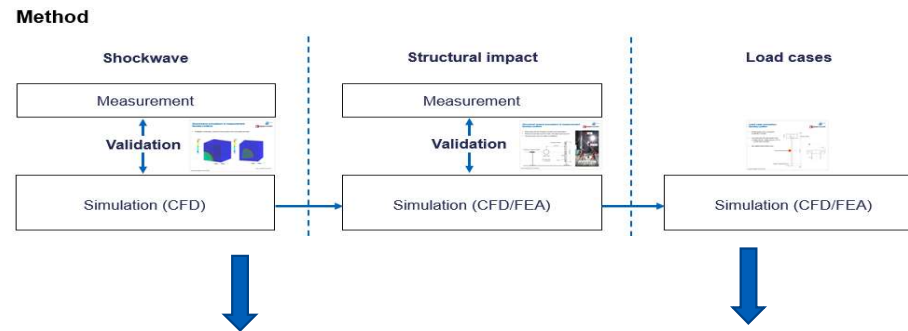


Colorado School of Mines
Explosive Research
Laboratory
April 2018

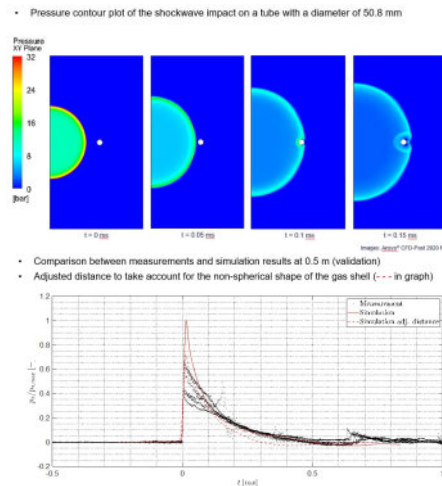
<https://www.epri.com/research/programs/056622/results/3002020140>

Do detonations cause damage to HRSG?

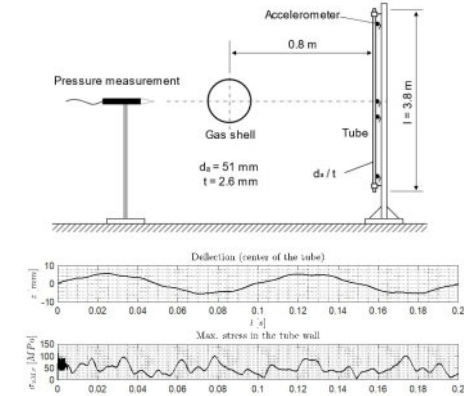
Stress in tubes & welds - Zurich School of Engineering



Part 1: Measure Pressure Wave strength



Part 2: Measure Load Case Tube welded to

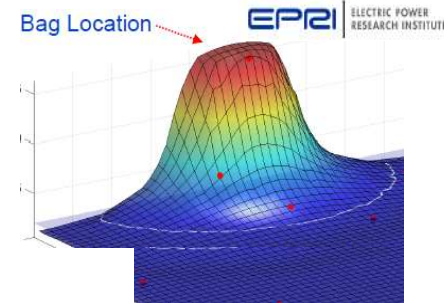
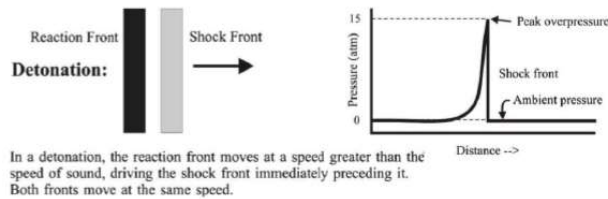
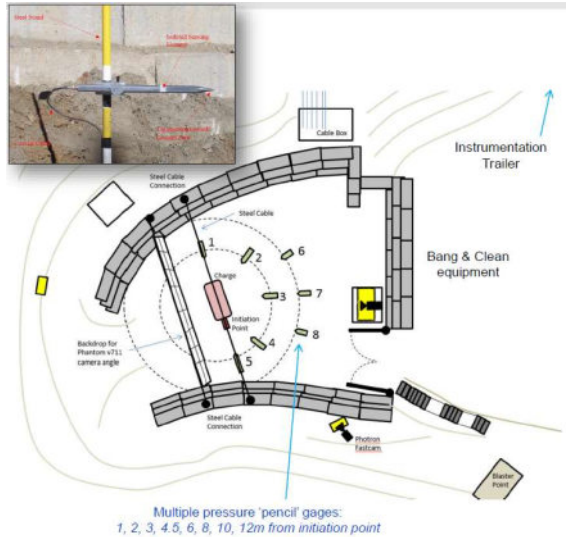


Max. stress of 110 MPa in tubes and 130 MPa in welds

Safety factor greater than 2x vs. min. yield strength of material

Do detonations cause damage to HRSG?

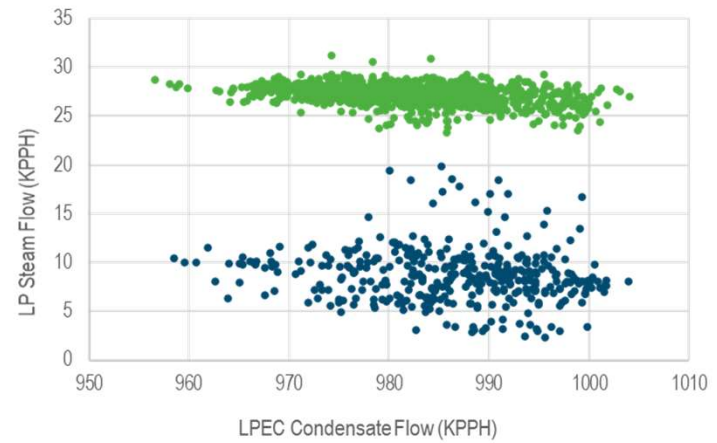
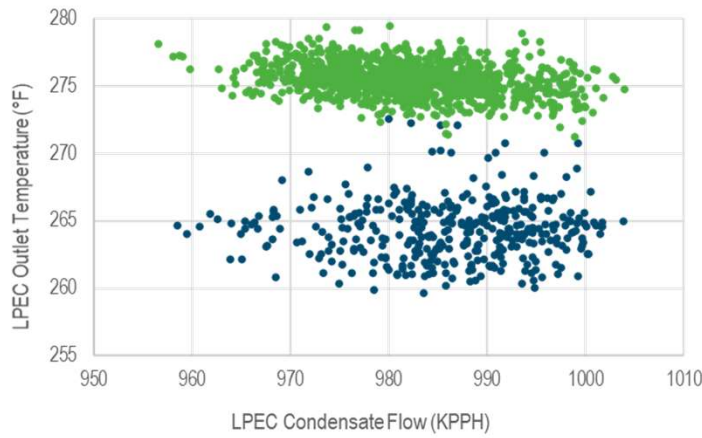
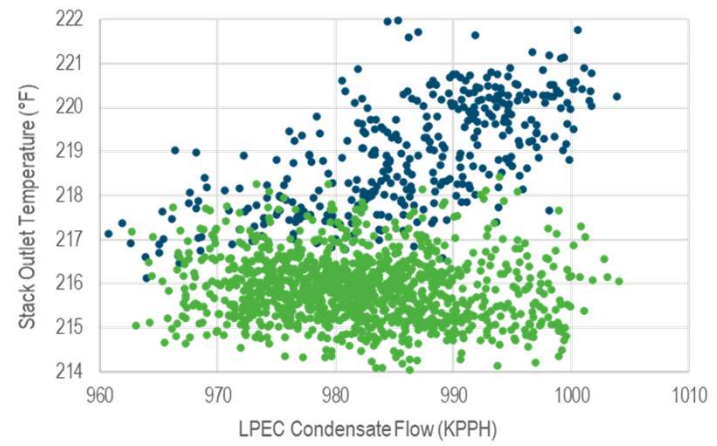
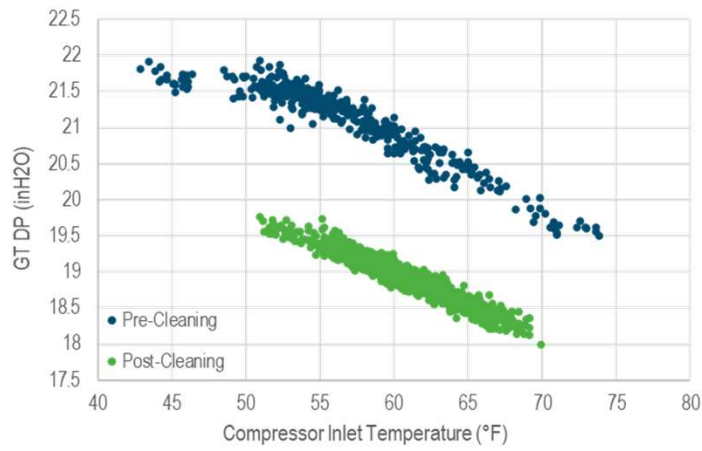
Strength of detonation - EPRI



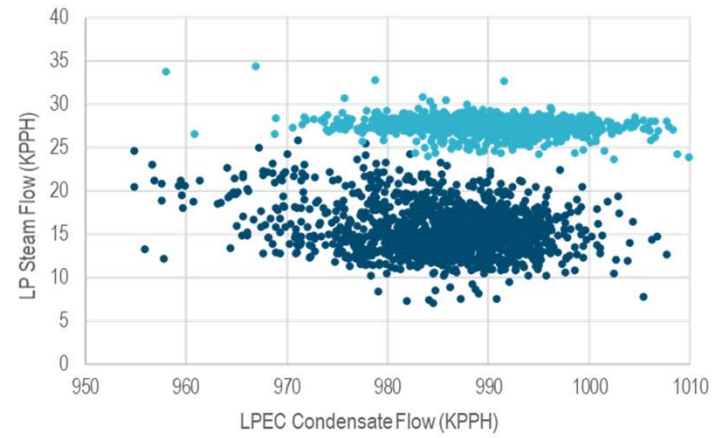
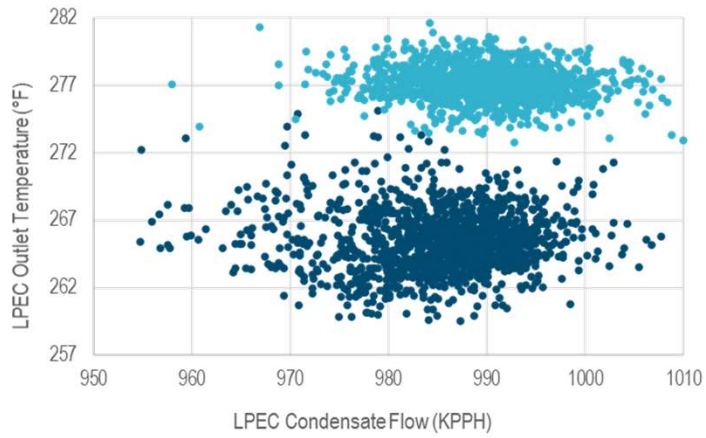
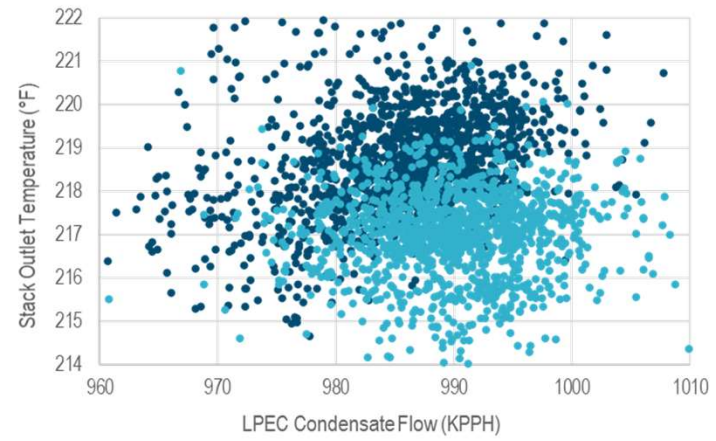
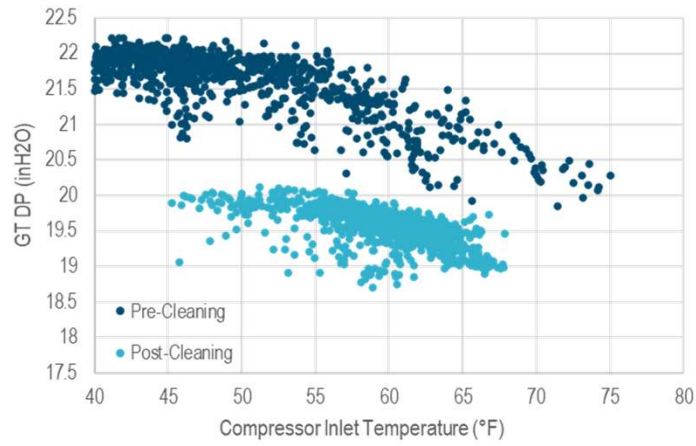
Peak overpressure comparable with or less than steam pressure in tubes during operation

Case Studies

Site A – Unit 1



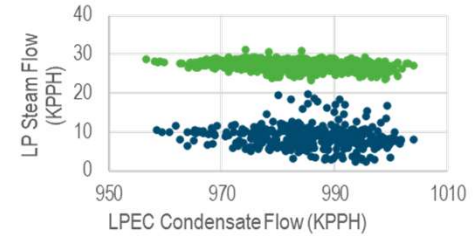
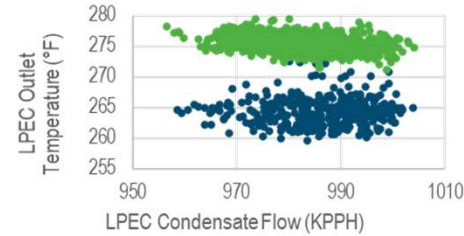
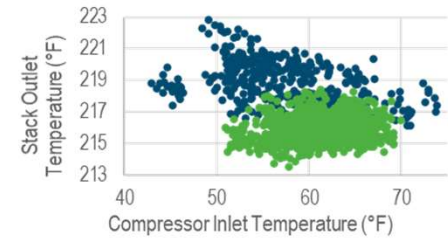
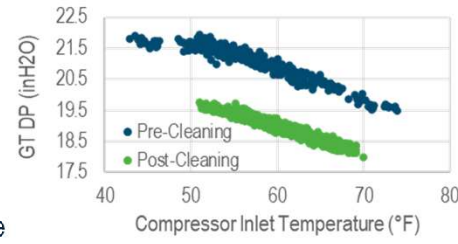
Site A – Unit 2



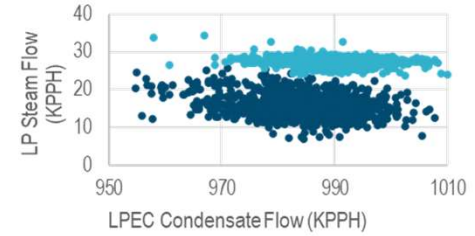
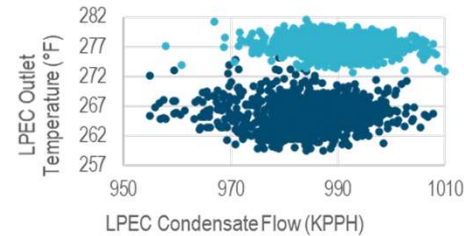
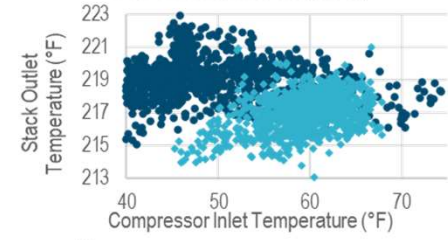
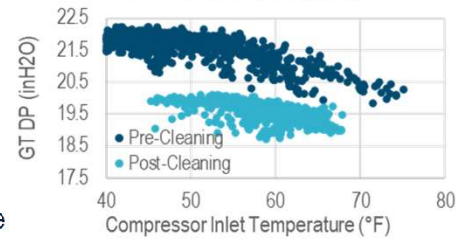
Site A



- Unit 1
 - 2inH2O ↓ DP
 - 3°F ↓ Stack Temperature
 - 10°F ↑ LPEC Outlet Temperature
 - 17KPPH ↑ LPEC Steam Flow



- Unit 2
 - 2inH2O ↓ DP
 - 2°F ↓ Stack Temperature
 - 12°F ↑ LPEC Outlet Temperature
 - 12KPPH ↑ LPEC Steam Flow

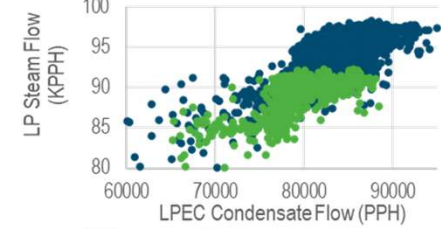
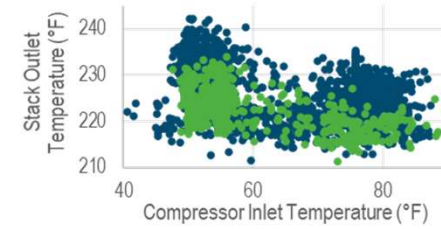
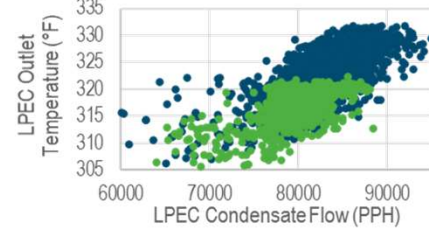
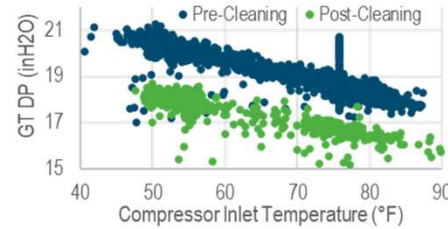


Site B – Unit 1 & 2



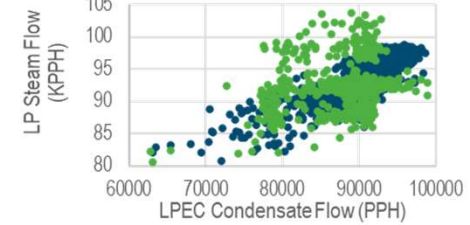
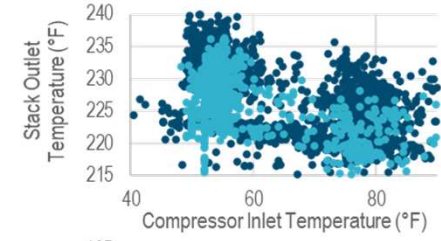
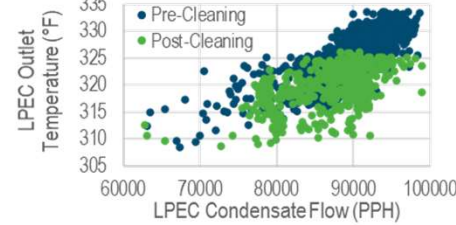
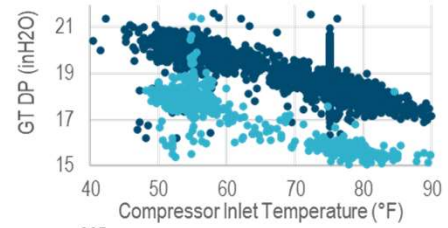
Unit 1

- 2 inH2O ↓ DP
- 5°F ↓ Stack Temperature
- 0°F ↔ LPEC Outlet Temperature
- 0KPPH ↔ LPEC Steam Flow



Unit 2

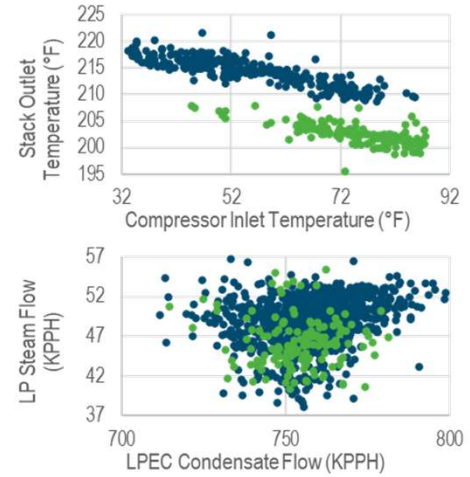
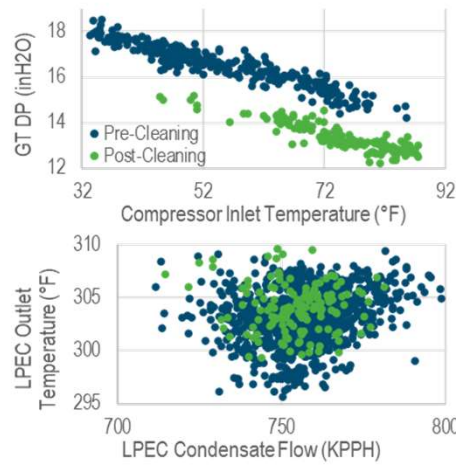
- 2.5 inH2O ↓ DP
- 2°F ↓ Stack Temperature
- 0°F ↔ LPEC Outlet Temperature
- 0KPPH ↔ LPEC Steam Flow



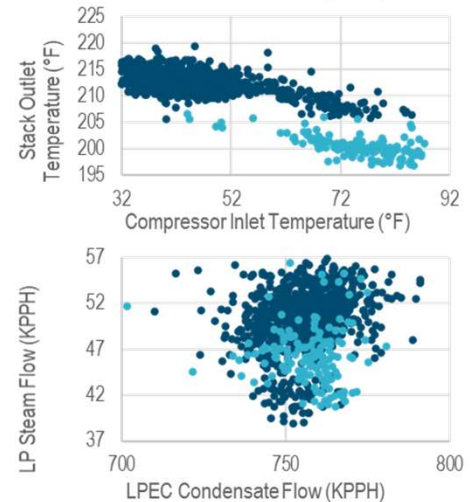
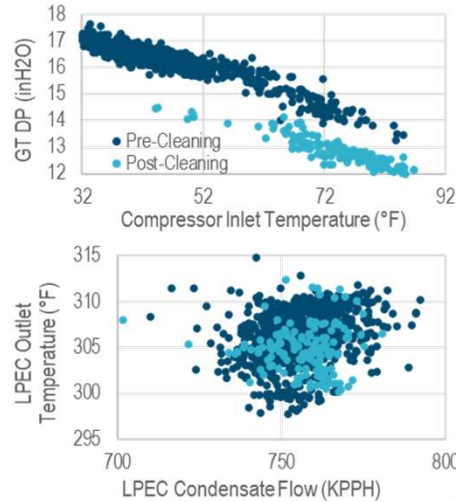
Site C



- Unit 1
 - 2 inH2O ↓ DP
 - 5°F ↓ Stack Temperature
 - 0°F ↔ LPEC Outlet Temperature
 - 5KPPH ↑ LPEC Steam Flow



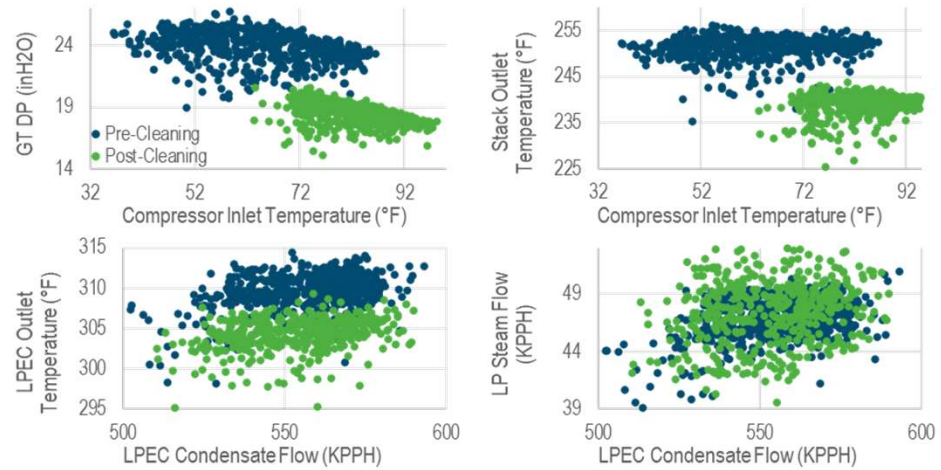
- Unit 2
 - 1.5 inH2O ↓ DP
 - 8°F ↓ Stack Temperature
 - 0°F ↔ LPEC Outlet Temperature
 - 7KPPH ↑ LPEC Steam Flow



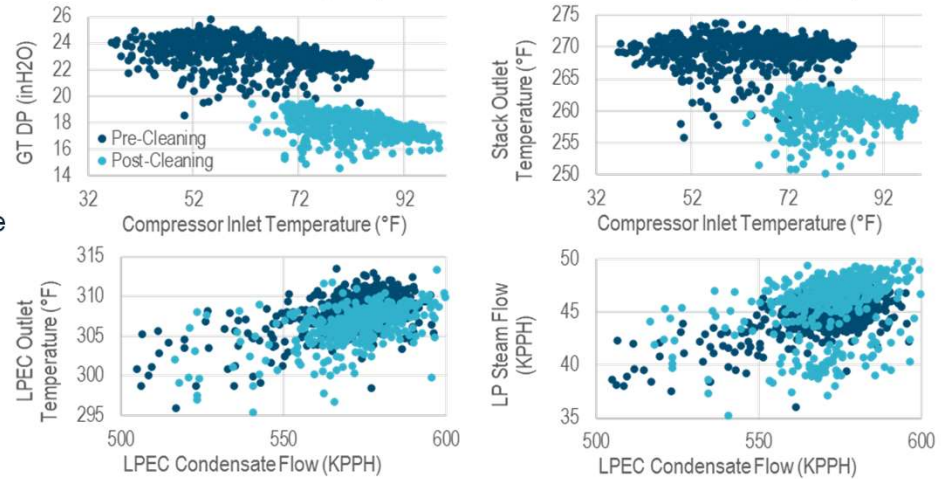
Site C



- Unit 3
 - 5 inH2O ↓ DP
 - 14°F ↓ Stack Temperature
 - 5°F ↓ LPEC Outlet Temperature
 - 0KPPH ↔ LPEC Steam Flow



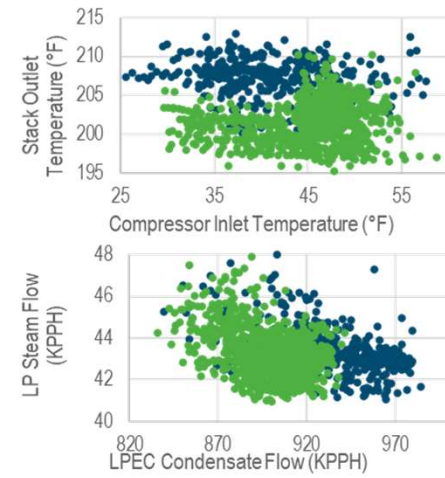
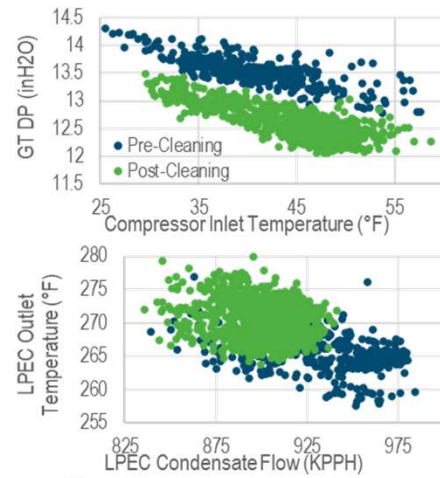
- Unit 4
 - 5 inH2O ↓ DP
 - 10°F ↓ Stack Temperature
 - 0°F ↔ LPEC Outlet Temperature
 - 1KPPH ↑ LPEC Steam Flow



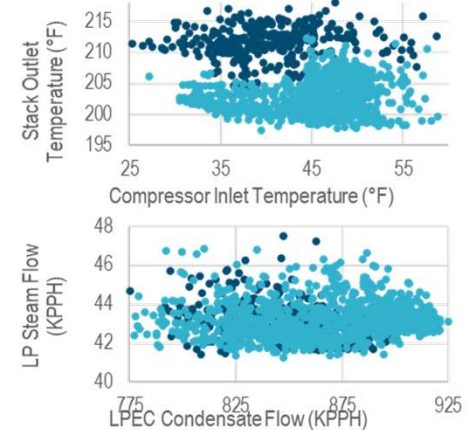
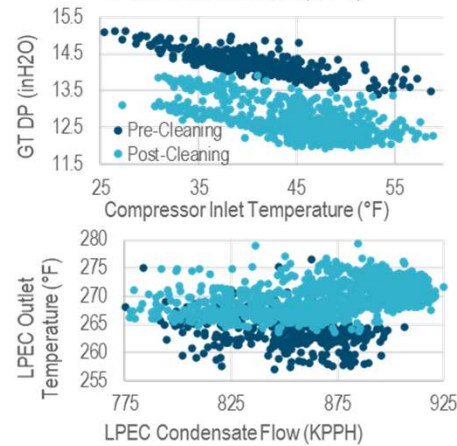
Site D



- Unit 1
 - 1inH2O ↓ DP
 - 8°F ↓ Stack Temperature
 - 3°F ↑ LPEC Outlet Temperature
 - 0KPPH ↔ LPEC Steam Flow



- Unit 2
 - 1inH2O ↓ DP
 - 10°F ↓ Stack Temperature
 - 5°F ↑ LPEC Outlet Temperature
 - 0KPPH ↔ LPEC Steam Flow



Cleaning Summary



- Generally, performance impacts can be estimated as follows:
 - 1 inH₂O of GT DP \approx 0.25MW impact on the CT
 - 10°F of stack temperature decrease \approx 1MW impact on the ST*

- For Site B Units 1 & 2, the following impacts were calculated:
 - Exhaust Gas Stack DP Decreased between 2 and 2.5 inH₂O
 - Stack Temperature Decreased by 5°F
 - MW Losses due to exhaust gas DP decreased by 0.5 MW per HRSG
 - HR Losses due to exhaust gas DP decreased by 25 Btu/KW_{hr} (i.e. 0.3%) per HRSG
 - Annual fuel cost due to exhaust gas DP decreased \$80K - \$90K per HRSG (June 2020)

Site	GT DP ↓	Estimated CT Impact (each)	HRSG Stack Temperature ↓	Estimated ST Impact	Estimated Total Impact
Site C – Units 1 & 2	1.8 inH ₂ O	0.4 MW	6.8°F	0.6 MW	1.4 MW
Site D – Units 1 & 2	1.0 inH ₂ O	0.2 MW	9.0°F	0.9 MW	1.1 MW
Site C - Units 3 & 4	5.0 inH ₂ O	1.2 MW	12°F	1.2 MW	3.6 MW
Site A – Units 1 & 2	2.0 inH ₂ O	0.5 MW	2.5°F	0.2 MW	1.2 MW



*ST MW impacts are harder to estimate, therefore these numbers should be considered carefully

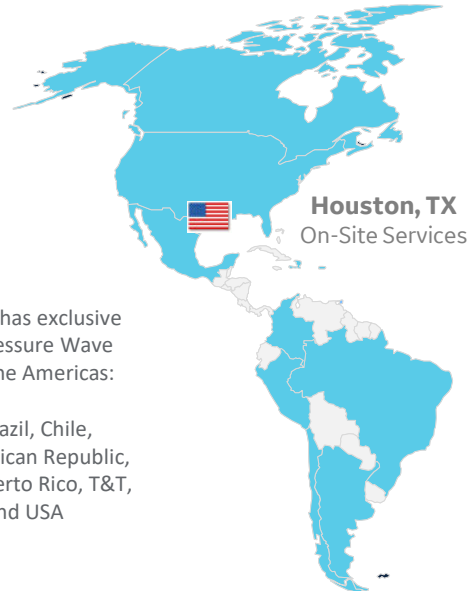
General Lessons Learned / Best Practices



- Adding additional sky-climber ports can be easy and very beneficial
- Use of the 220L “bags” are louder, but much more effective (preferred except for sensitive areas such as lines near expansion joints)
- Blasting at Night should be avoided when possible and neighbors should be notified when possible
- Not all unit should be evaluated based on DP or Stack Temp Alone



PressureWave Plus – On-site services execution



General Electric has exclusive licensing for Pressure Wave technology in the Americas:

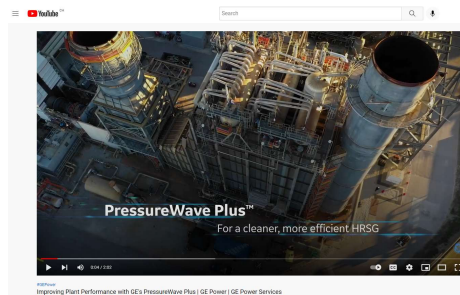
Argentina, Brazil, Chile, Colombia, Dominican Republic, Mexico, Peru, Puerto Rico, T&T, Canada, and USA



JOHN WEIMAR

Global PressureWave+ Segment Lead

- Responsible for the execution of all GE PressureWave+ projects globally.
- Directed over **200** HRSG PW+ cleanings in the Americas.
- Joined GE in 2010 with over 10 years of experience in field services.
- Part of GE's On Site Services business.
- Based in at the PW+ tooling Cassio in Houston, Texas, USA.



Scan to access
GE's
PressureWave
Plus website
(camera phone)



