Thompson Industrial Services

PowerPlus Cleaning Systems

Off-line Heat Recovery Steam Generator (HRSG) Cleaning Utilizing Pressure Wave Technology

SAFETY QUALITY INTEGRITY

ABOUT

Thompson specializes in safe, quality Lifecycle Industrial Cleaning Service Solutions from critical path pre-commissioning & dependable on-site operations support, to productive outages, turnarounds and decommissioning.

FOUNDED
1986

EST. LLC
NC 2006

HEADQUARTERS
SUMTER, SC

William “Billy” Ford,
President & CEO

SAFETY

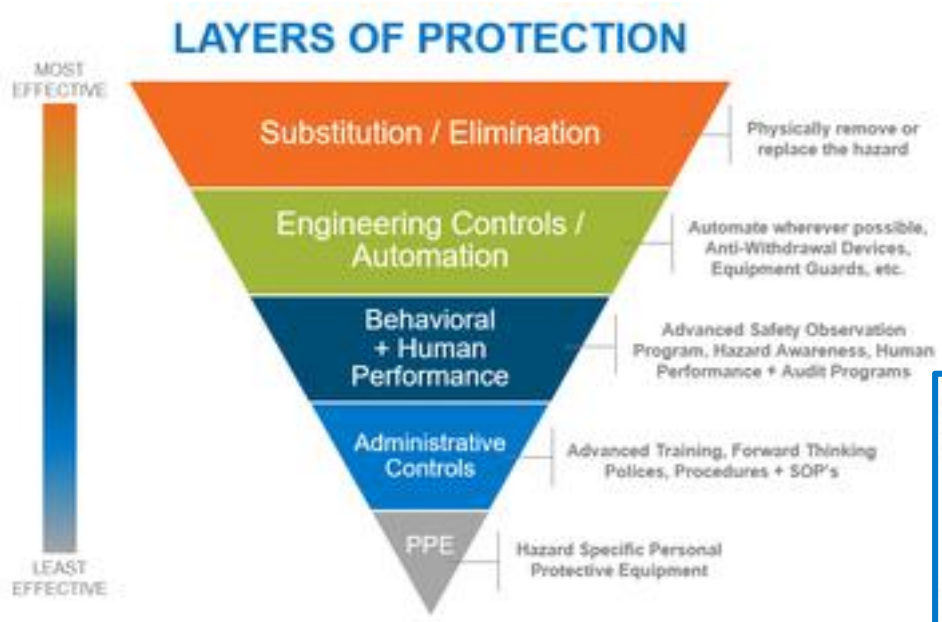
Thompson's commitment to safety radiates throughout the entire company culture through our top-to-bottom, all-in approach to safety.

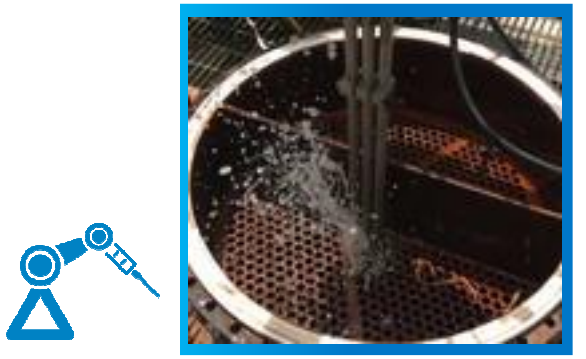
No. 1 **SIF Prevention is the top priority**

Implement as many layers of protection as possible

Use automation wherever possible to improve safety + performance

SIF PREVENTION PROGRAM





SIF PREVENTION

THOMPSON INDUSTRIAL SERVICES

35 YEARS

	EMR	TIR	LWIR
2018	0.87	0.56	0.28
2019	0.85	0.44	0.30
2020	.083	0.11	0.00

1,000+

21
SERVICE LOCATIONS

RESOURCES

80 HYDROBLAST PUMPS

116 VACUUM TRUCKS

91 AUTOMATION EQUIPMENT

LOCAL + GLOBAL

Ready to respond 24/7/365

WHAT WE DO

LIFECYCLE SERVICE SOLUTIONS

- Construction phase cleaning support
- Pre-commissioning cleaning
- On-site crews for daily operations support
- Outages, Shutdowns + Turnarounds/TARs
- Decommissioning

CHEMICAL CLEANING + FINFOAM®

- Elite chemical cleaning division w/custom-engineered methods
- Tank cleaning, vapor phase cleaning, degassing + decontamination
- FINFOAM® renews finned heat exchanger coils for maximum productivity

HYDROBLAST VACUUM + BIG PUMP

- Automated hydroblasting from 10K-40K PSI
- High-volume hydroblasting at 30x traditional volume
- Ultra-high pressure (UHP) 40K hydroblasting + cutting
- Wet + dry vacuuming
- Pneumatic + hydro-vacuum excavation
- Precision tank cleaning

SPECIALTY + CUSTOM SOLUTIONS

- Sponge media abrasive blasting
- Industrial drone inspections
- Dry ice blasting
- Pipe pigging + brushing
- Sand jetting
- In-situ SCR catalyst cleaning
- Combustible dust remediation services
- **EPIC™ Off-line HRSG Cleaning**

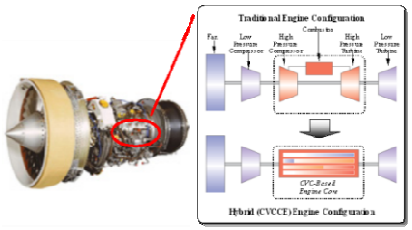
SAFETY QUALITY INTEGRITY

Background of the Core IMPULSE® Pulse Detonation Cleaning Technology

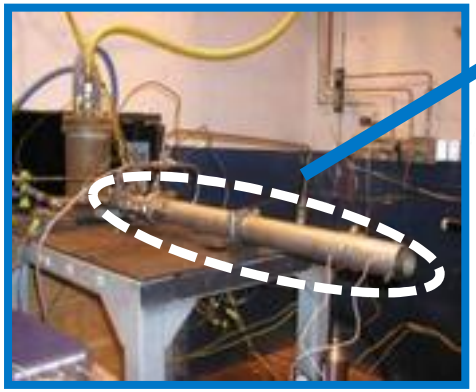
BACKGROUND OF THE TECHNOLOGY

In 2004 GE Energy began the initiative to integrate GE Aviation's prototype pulse detonation propulsion technology with GE's PowerWave acoustic cleaning product line to create a much more powerful and effective on-line boiler cleaning technology that detonates a mixture of fuel and air to create supersonic shock waves.

The system was introduced to the market by GE in 2006 as the PowerWave+



Pulse detonation engine with a series of combustion tubes



2" Combustion Tube Bench Test

Replaced acoustic driver with combustion tube

Powerwave 75 hz Acoustic Horn

Powerwave+ Pulse Detonation Cleaner

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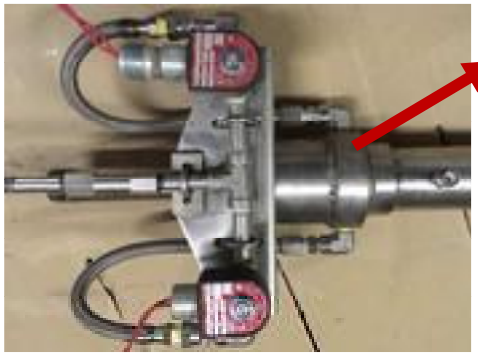
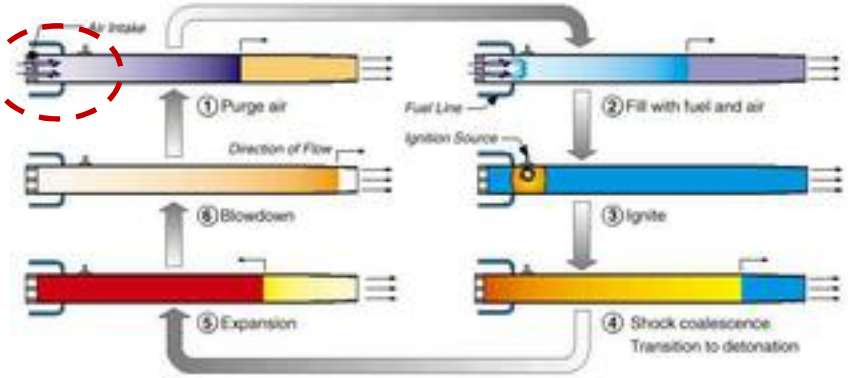
HOW THE EPIC TECHNOLOGY WORKS

FORMATION OF AN EXTRACTION PRESSURE IMPULSE WAVE

1. Cyclic combustion event creates supersonic impulses
2. Injection of fuel and air into an integral mixing chamber followed by ignition and combustion
3. Shockwave is result of the acceleration of a flame to supersonic speeds over short distance and time



Combustion Chamber Mixing Head



High Energy Impulse Wave

High Speed Video Capturing flame acceleration- 3 MS clip

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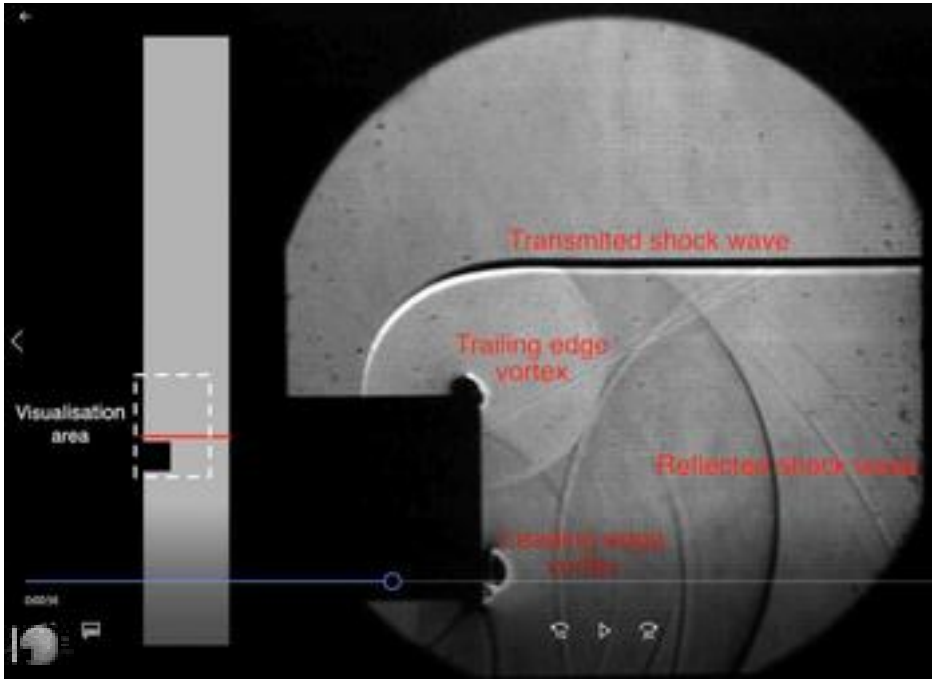
HOW IT CLEANS - VIDEO

Cleaning energy consists of compression and rarefaction waves with omni-directional vectors.

When a detonation occurs in the combustion tube, a shockwave is generated, characterized by a sharp rise in pressure and a tremendous amount of reversing airflow with it.

The IMPULSE Cleaner creates high velocities combined with a high-density front, and ultra-low pressures behind the shock, create an infinite amount of multi-directional high/low pressure vectors that serve as extremely effective cleaning energy.



PowerPlus Cleaning Systems

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PROVEN AND EFFECTIVE EXPERIENCE CLEANING A WIDE RANGE OF APPLICATIONS

EFFECTIVE EXPERIENCE ON MANY APPLICATIONS

Introduced to the market by GE in 2006

(*PowerPlus acquired the technology in 2014)

- **Coal Fired Boilers**
- **Pet Coke Fired Boilers**
- **Waste to Energy Boilers**
- **Wood Fired Boilers**
- **Industrial Heat Recovery (Reformers, Oxidizers, Recuperators, Calciners, etc.)**
- **Heat Recovery Steam Generators (HRSGs)**

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EXPERIENCE

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ONLINE CLEANING OF LARGER BOILERS

Before

After

EXPERIENCE

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Industrial Services

Pulse detonation technology adapted as an automated off-line HRSG cleaning system

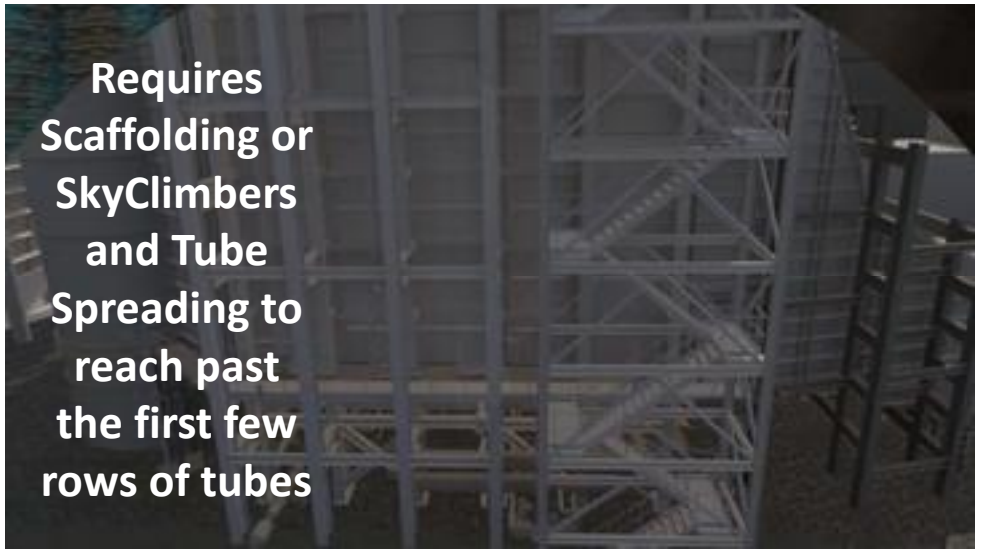
EPIC®
(Extraction Pressure Impulse Cleaner)

Comparison of HRSG Cleaning Technologies

CO^2/DRY ICE BLASTING

DRY ICE BLASTING

- Marginally effective at cleaning into depth of the tube bundle - tubes must be mechanically spread to allow for deeper access.
- May actually drive a portion of the deposits deeper into the tube bundle.
- Requires scaffolding or Sky Climbers adding time & expense.
- Pre-staging and cleaning process is time consuming increasing overall project span.
- Labor intensive + personnel risk exposure related to working at heights/enclosed spaces.
- Despite spreading the tubes to try and gain access, all circumference heat transfer surfaces are still not reached or cleaned.

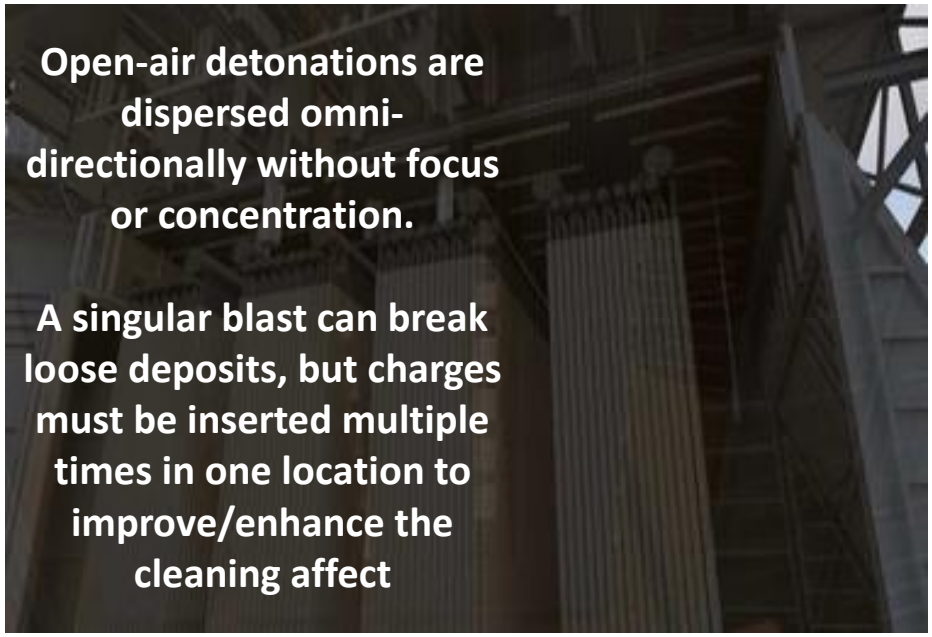


ALTERNATIVE METHODS

HRSG Open Blasting Methodology

OPEN DETONATION

- Utilizes repeated insertion of bags containing combustible gas suspended and detonated in close proximity to the face of the tube bundle.
- The open-air detonations are extensively dispersed without directional focus or concentration.
- Each gas bag inserted provides a *singular* detonation that must be inserted multiple times in one location to improve/enhance the cleaning affect.



ALTERNATIVE METHODS

The EPIC® System Difference for HRSG Cleaning

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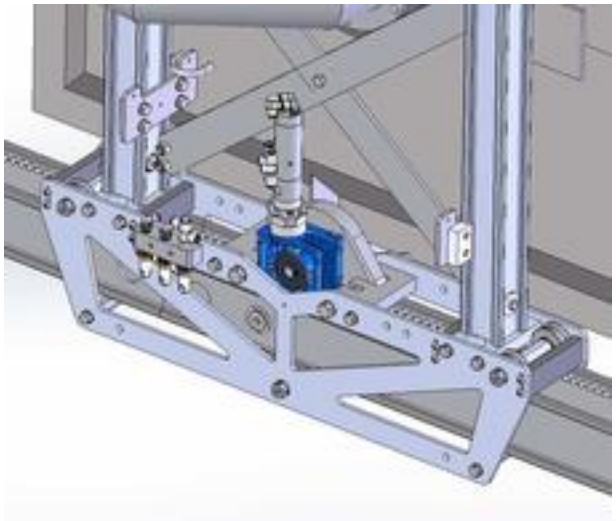
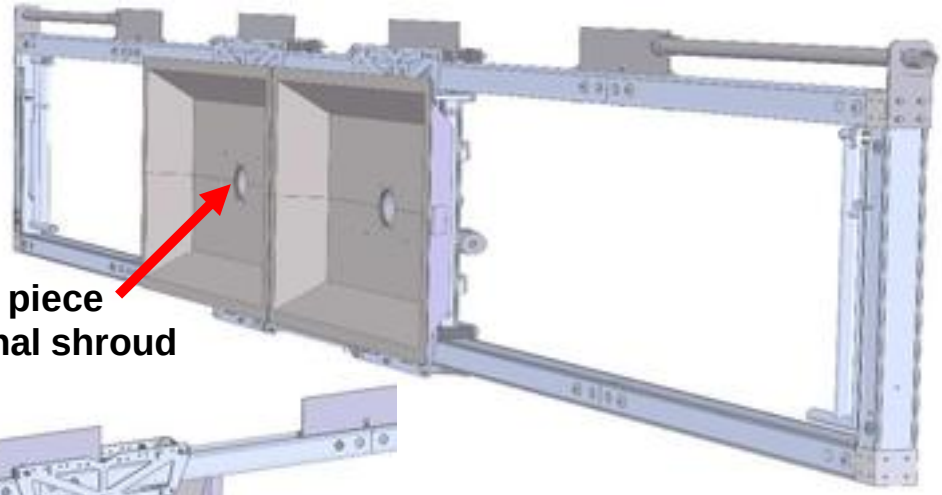
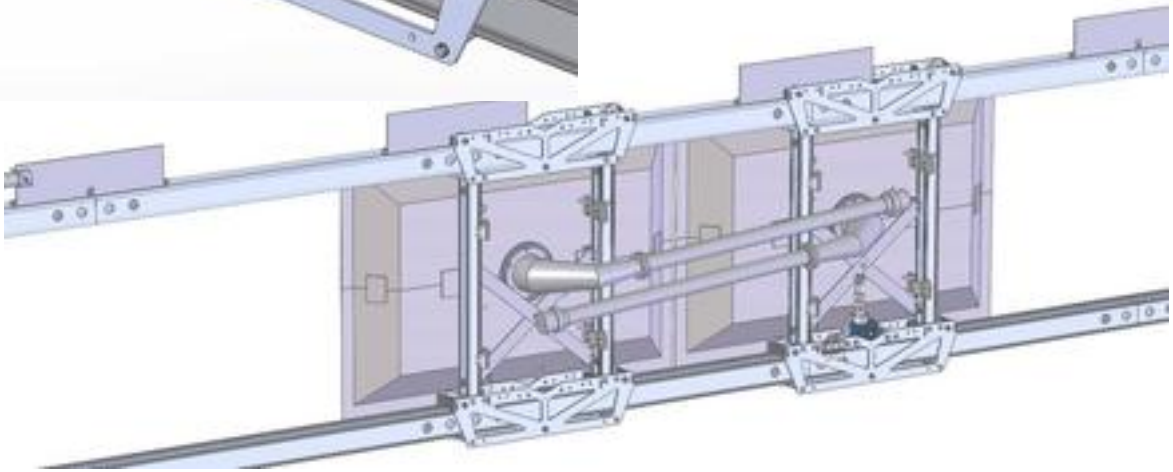
The EPIC® Difference – Modular Design





Two piece directional shroud



Modular design navigation rig inserted into the lane through access door in pieces and constructed in place

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The EPIC® Difference – Large Cleaning Pattern

DOUBLE SHROUD, NARROW CONFIGURATION

Each Shroud is 60”W X 40”H – Double Shroud Assembly = 120”W X 40”H

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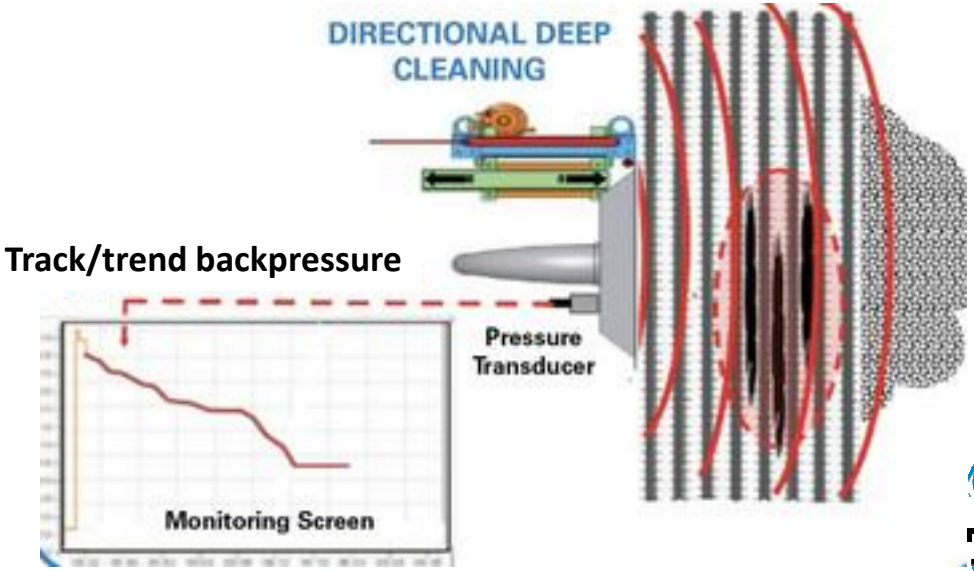
The EPIC® Difference – Deep & Directional Cleaning

CONTROLLED AND DIRECTED CLEANING

Rapidly Repeated Focused Shockwaves

Remotely controlled, fully automated, and safely contained, detonations created inside of a high-pressure combustion tube directionally focus highly effective rapidly repeated shockwaves into and through the heat transfer bundles.



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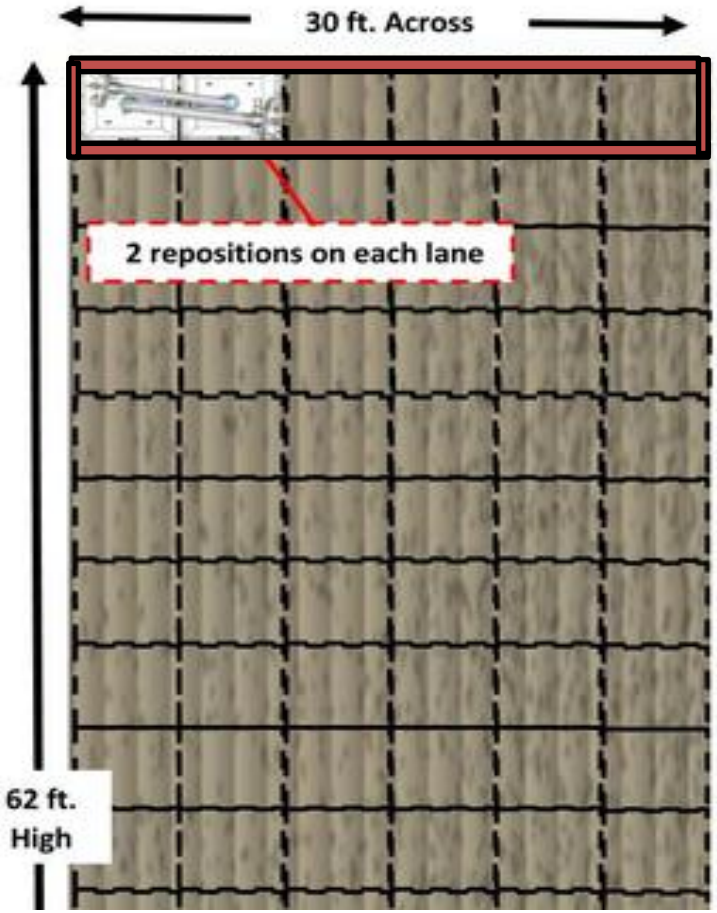
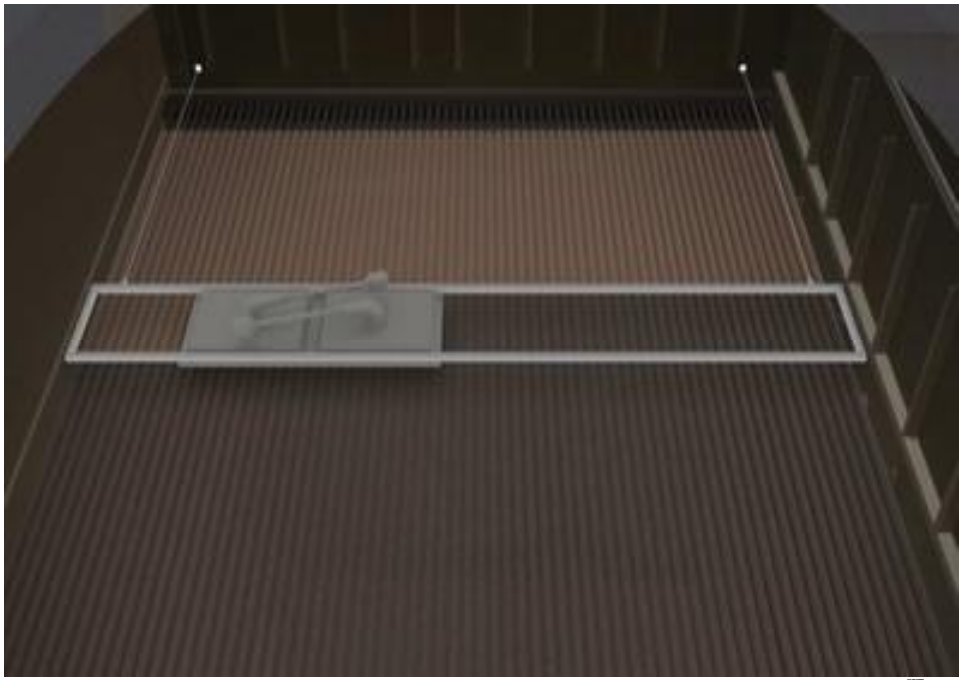
The EPIC® Difference – Deep Cleaning of the Entire Heat Transfer Module



QUICKLY AND COMPLETELY COVERS EVERY SQUARE FOOT OF THE HEAT TRANSFER SURFACE



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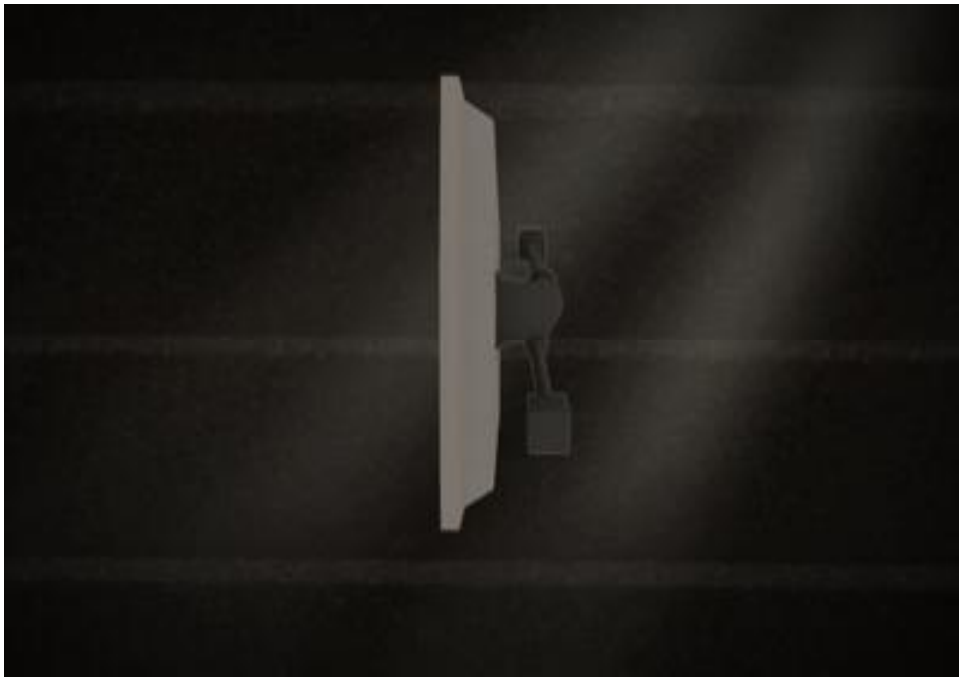
The EPIC® Difference – Very Large Number of Repetitive & Penetrating Shockwaves

EPIC- An effective, safe enhancement vs other cleaning approaches

- **Operated at 2 impulse bursts *per second* for a total of 120 repetitive, penetrating shock wave blasts at each location, from both sides of the bundle.**
- **The abundant repetition of the highly focused and directed shockwaves at each location provides an intense amount of cleaning energy, first fracturing embedded deposits, then methodically working them out and away from the tube heat transfer surfaces.**
- **The *directional* cleaning shrouds are navigated over every inch of the module surface, insuring a complete, uniform and thorough cleaning.**



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The EPIC® Difference – Remote & Safe Operation

- **Remotely operated - Personnel are never in harm's way.**
- **Cleaning cycles and/or cleaning intensity can be increased or decreased instantaneously from control panel.**

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The EPIC® Difference – Proven Cleaning Solution

KEY DIFFERENTIATORS OF THE CLEANING SYSTEM

It's a highly engineered and 15-year proven cleaning solution.

The entire cleaning process is automated and remotely controlled yielding highly competitive cleaning costs with minimal risk to personnel.

Innovative and scientific cleaning solution that incorporates additional technology features such as;

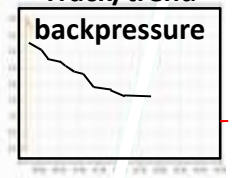
- **Back pressure monitoring tracks, trends cleaning effectiveness.**
- **Cleaning observed in real time via 2 rotating wide-angle cameras mounted on the cleaning rig, transmitted to the EPIC ground-level command center and projected to a 50" client viewing monitor.**
- **Borescope inspection to verify results.**

Patented & Proven Design

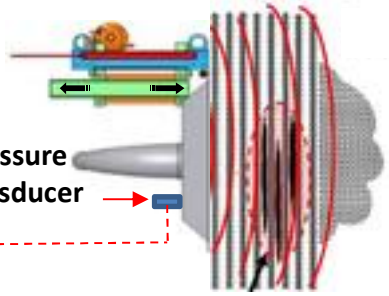
Automated and remotely controlled

Borescope Inspection

Track/trend backpressure



Pressure Transducer



Real Time Monitoring

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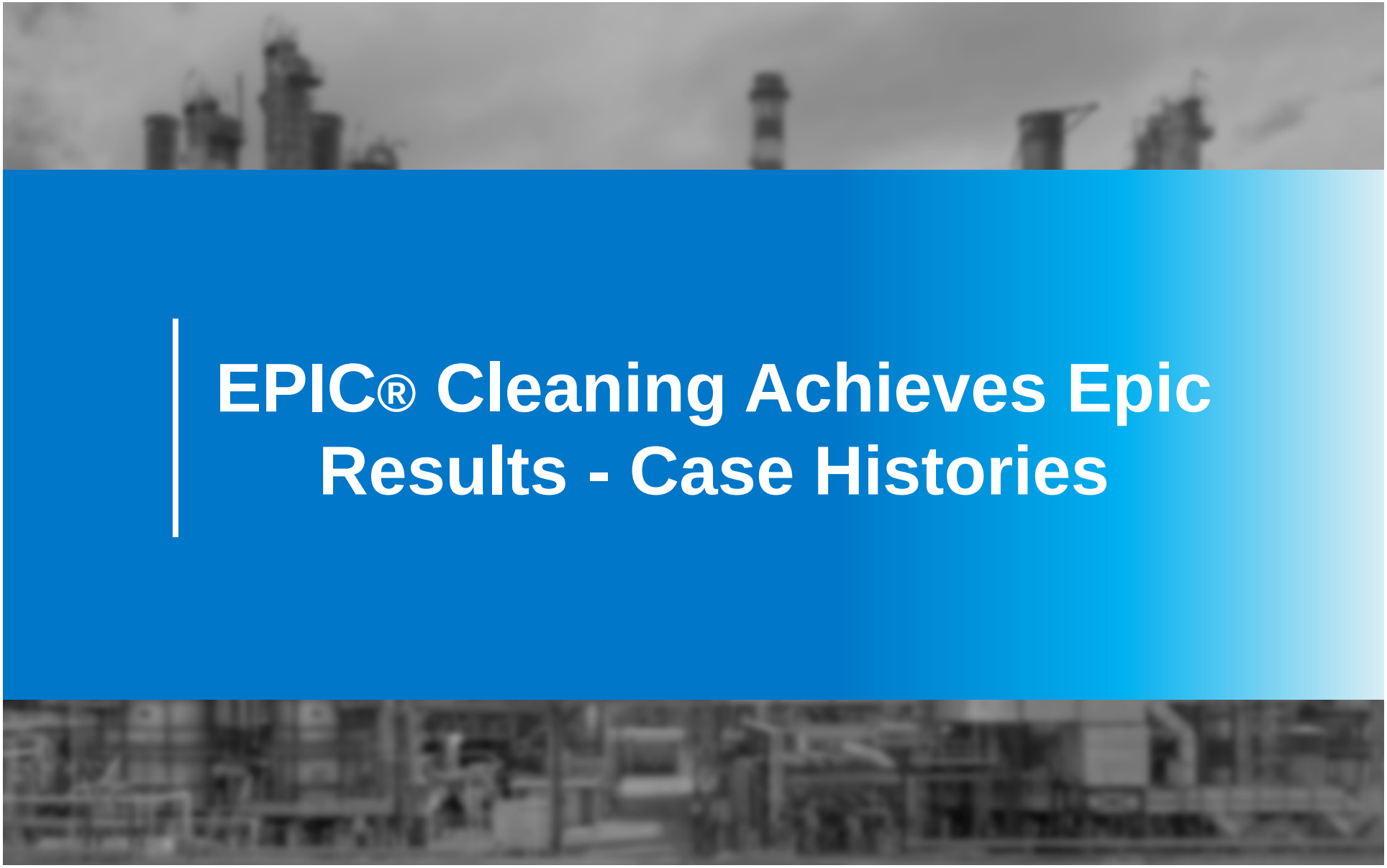
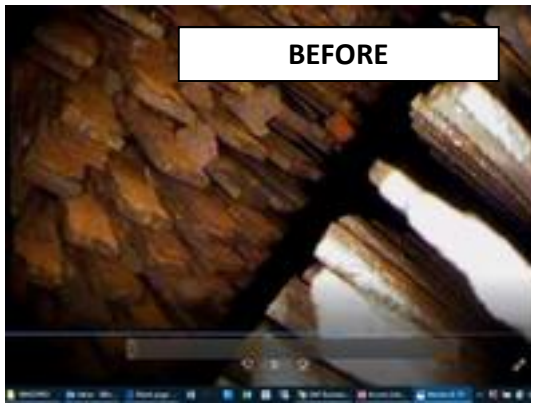
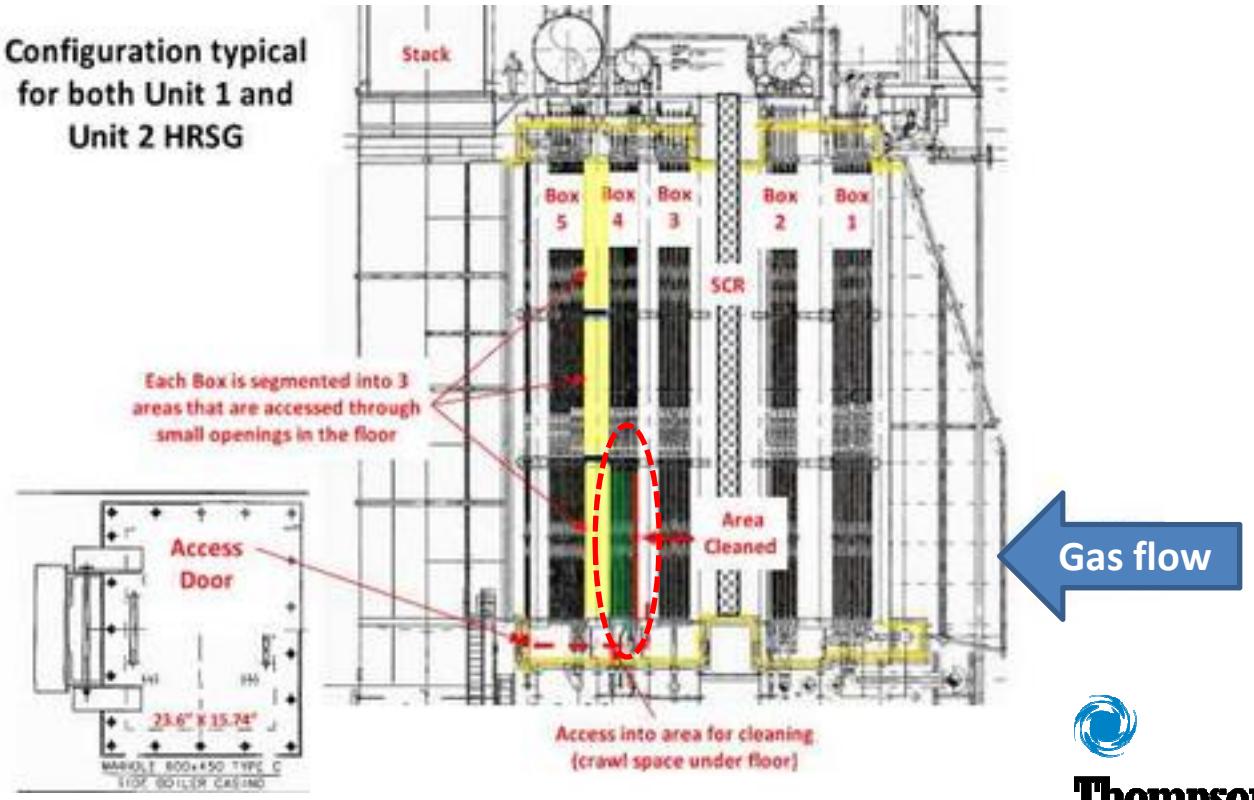


EPIC® Cleaning Achieves Epic Results - Case Histories

CLEANING RESULTS - CASE HISTORY # 1

BORESCOPE VIDEO OF CLEANING RESULTS





CLEANING RESULTS - CASE HISTORY # 2

Date: **Spring 2021**

Facility: **Xcel Energy's Riverside Plant in Minneapolis, MN**

Background: (Excerpts from Xcel's report)

Cleaning Methods Considered

Xcel Energy

- Dry Ice Blasting (with and without tube spreading)
- High Pressure Air (with tube spreading)
- PressureWave+ (aka Bang & Clean) by GE
- EPIC by Thompson Industrial [selected]

***Note: Depth of tube bundles pushed decision to EPIC**

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CLEANING RESULTS - CASE HISTORY # 2 (Cont.)

Facility: **Xcel Energy's Riverside Plant in Minneapolis, MN**

Background: (Excerpts from Xcel's report)

Post-Cleaning

Xcel Energy®

- Vacuum & disposal (Xcel scope)
  - –1 day per HRSG
  - –Plan for at least 1000 lbs per face
- Photos
- Borescope photos
- Drone photos
- Back pressure will be measured upon restart (correct for operating conditions)

- Overall = very successful. Effective deep cleaning. Safe work environment

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CLEANING RESULTS - CASE HISTORY # 2 (Cont.)

Facility: Xcel Energy's Riverside Plant in Minneapolis, MN

Overview:

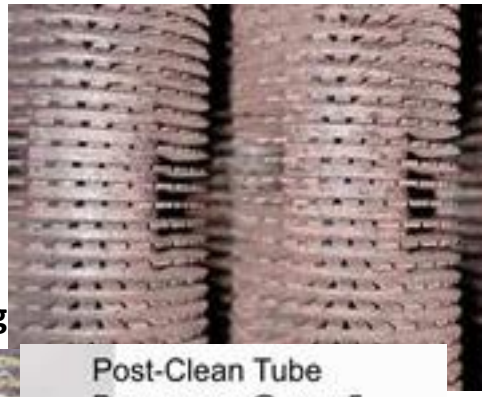
Two HRSGs were cleaned at this facility over a 4-day period.

Results:

Scott Wambeke, Xcel's Principal Engineer stated that the primary cleaning economic driver was the current CT backpressure and the Company's plan for a future 6-year run w/o a planned extended outage.

Following the EPIC cleaning, the operating backpressure for both units was reduced to 12.4" WC at base load; This was reported to be within 1" of original design, but this was on an uncorrected basis

Tubes After Cleaning



Tubes Prior to Cleaning

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CLEANING RESULTS - CASE HISTORY # 3

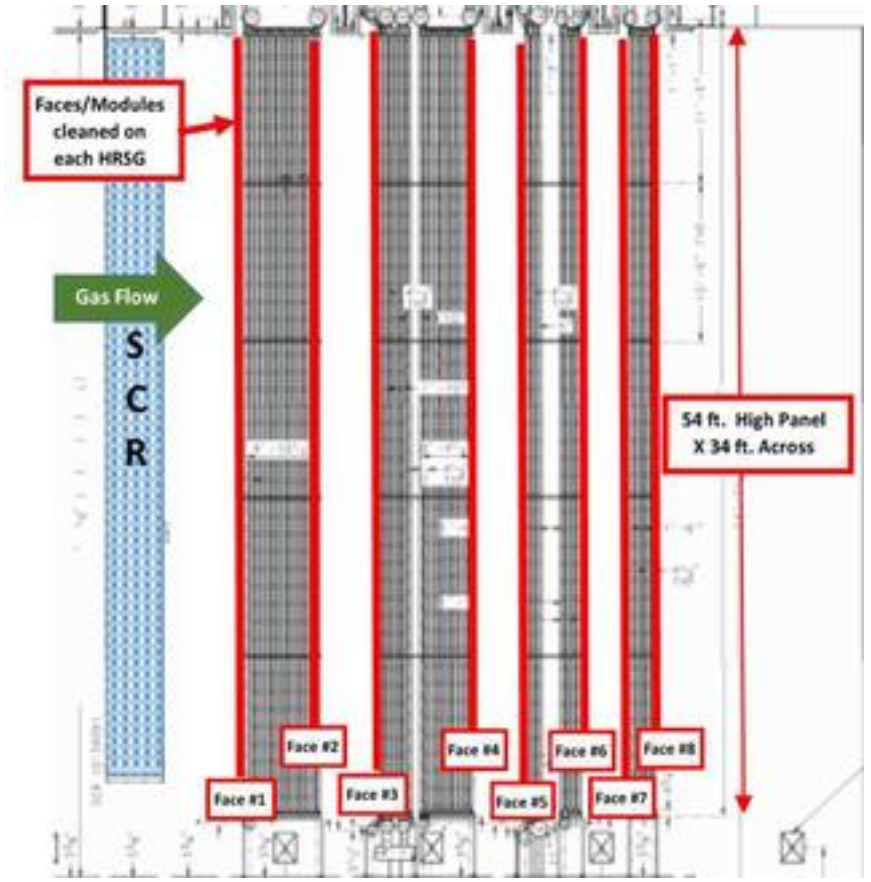
Date: **Spring 2021**

Facility: **Combined Cycle Plant in South Carolina**

Overview:

All modules downstream of the SCR were cleaned on two very large HRSGs at this facility.

A very impressive combined excess of 36 tons of debris was removed from both units.



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CLEANING RESULTS - CASE HISTORY #3 (Cont.)

Facility: Combined Cycle Plant in South Carolina

Results:

Unit 1 data indicated a 64 BTU/KW-Hr heat rate improvement that equates to average improvement of 1.33 MW increase in performance across the data range.

CT1	Ambient Temp	CT Load	Guarantee Back Pressure	Back Pressure Before Cleaning	Back Pressure After Cleaning	Back Pressure Reduction	Heat Rate Improvement	CT Output Improvement (MW)	CT Fuel Efficiency Improvement
	62°(F)	>160 MW	13.2" wc	16.57"	13.94"	2.63"	64 BTU/ KW-Hr	1.33 MW	.70%

Unit 2 data indicated a 73 BTU/KW-Hr heat rate improvement that equates to average improvement of 1.2 MW increase in performance across the data range.

CT2	Ambient Temp	CT Load	Guarantee Back Pressure	Back Pressure Before Cleaning	Back Pressure After Cleaning	Back Pressure Reduction	Heat Rate Improvement	CT Output Improvement (MW)	CT Fuel Efficiency Improvement
	62°(F)	>160 MW	13.2" wc	18.9"	14.09"	4.81"	73 BTU/ KW-Hr	1.20 MW	.78%

Plant personnel advised that the normal annual run time on these units is 7800 Hours

Assuming running both units with a CT output increase of 1.25 MW for 7800 hours per CT would generate an additional 19,500 MW-hrs per year. Utilizing a price of $32 per MW-hr, the additional revenue would be $624k in the first year.

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CLEANING RESULTS - CASE HISTORY # 4

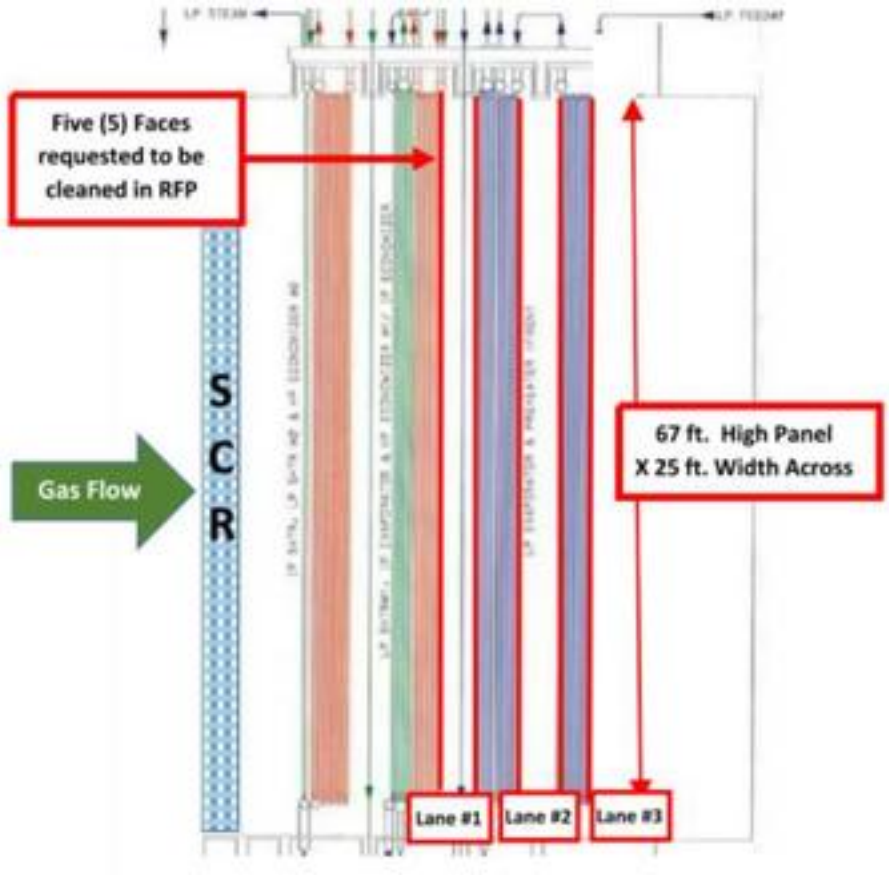
Date: **Spring 2021**

Facility: **Combined Cycle Plant in Arizona**

Overview:

Four very large N/E HRSGs were cleaned at this facility over a 9-day span in March.

Cleaning scope for all 4 units only included 5 of the 8 faces downstream of the SCR.



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CLEANING RESULTS - CASE HISTORY #4 (Cont.)

Facility: Combined Cycle Plant in Arizona

Results:

Unit 1 data indicated a 159 BTU/KW-Hr heat rate improvement that equates to average improvement of 1.74 MW increase in performance across the data range.

CT1	CT Load	Guarantee Back Pressure	Back Pressure Before Cleaning	Back Pressure After Cleaning	Back Pressure Reduction	Heat Rate Improvement	CT Output Improvement (MW)	CT Fuel Efficiency Improvement
	>155MW	17.3”	22.2” wc	19.8” wc	**2.4” wc**	**159 (BTU/KW-Hr)**	**1.74 MW**	**1.18%**

Unit 2 data indicated a 120 BTU/KW-Hr heat rate improvement that equates to average improvement of 1.78 MW increase in performance across the data range.

CT2	CT Load	Guarantee Back Pressure	Back Pressure Before Cleaning	Back Pressure After Cleaning	Back Pressure Reduction	Heat Rate Improvement	CT Output Improvement (MW)	CT Fuel Efficiency Improvement
	>155 MW	17.3”	17.8” wc	*18.5” wc	*-.7” wc	**120 (BTU/KW-Hr)**	**1.78 MW**	**1.12%**

*Note: Anomalous pressure readings attributed to a faulty sensor

Assuming running both units with a CT output increase of 1.75 MW for 7800 hours per CT would generate an additional 27,300 MW-hrs per year. Utilizing a price of $32 per MW-hr, the additional revenue would be $875k in the first year.

Note: That we were only contracted to clean 5 of the 8 faces per HRSG but the client stated afterwards when it became apparent of the effectiveness of the cleaning by our borescope videos, they would elect to clean all faces next time

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CLEANING RESULTS - CASE HISTORY # 5

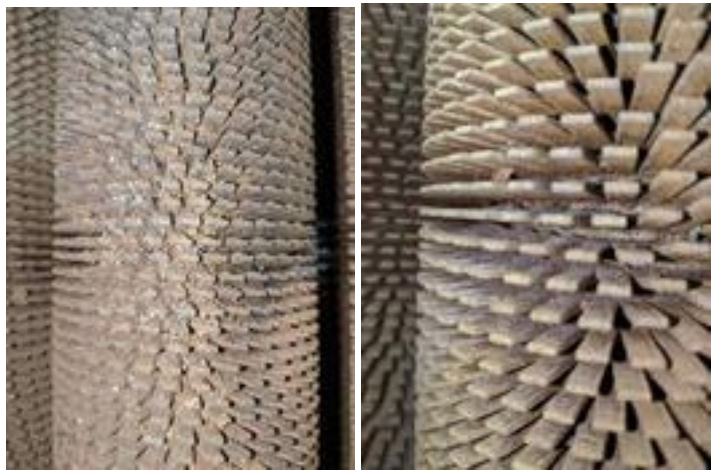
Date: **Spring 2020**

Facility: **Duke Energy-Osprey Energy Center, Auburndale, FL**

Overview:

One HRSG was cleaned over 4-day shifts of operation with a singular crew, which included setup and dismantling, coordinated off-shift vacuuming by Thompson's own personnel.

Tubes Prior to Cleaning **Tubes After Cleaning**



Results:

Based on 6-month comparative operating data, it was determined that the combustion turbine back pressure was reduced by 4 inches of water column, resulting in a heat rate decrease by roughly 0.5 MMBtu/MWh. This was computed to yield an equivalent payback in 1,018 hours (41 days) due to reduced fuel costs, based on a 100% production (MW) load.

Thompson Industrial Services

QUESTIONS?

CONTACT

For commercial or service inquiries, please contact:

Carl Wise
Thompson Industrial Services, LLC
910-612-5468

CONTACT

For inquiries related to the EPIC® or IMPULSE® cleaning technologies please contact:

Vince Barreto
PowerPlus Cleaning Systems
816-914-4782

Note: Thompson Industrial Services, with over 35 years of cleaning experience, is the exclusive service provider of the EPIC® mobile HRSG cleaning technology in the field.

EPIC® and IMPULSE®, the mobile and online versions of the impulse cleaning technology, are the property of PowerPlus Cleaning Systems, Inc.

THANK YOU!