Furnatek™ Presentation

Agenda

1. Short Introduction
2. Steam Reforming Challenges
3. Furnatek™
   - Core Technology
   - Benefits
   - Economics
   - Implementation
   - Project Timeline and Close

Visible Future

CATMASTERS™

We are a **Specialized Technology Company,** concentrated on improvements in the oil & gas, chemical and petrochemical industries globally.

- Started in 2019 - recognized an overlooked segment of the industry that was ready for innovation. Automation and ML/AI was possible but not being utilized or fully attempted yet.
- Original focus was on catalyst loading/unloading improvements, has since grown to include furnace optimization and automation
- Always striving to keep innovations as simple as possible
- Located in Houston, Amsterdam and Copenhagen

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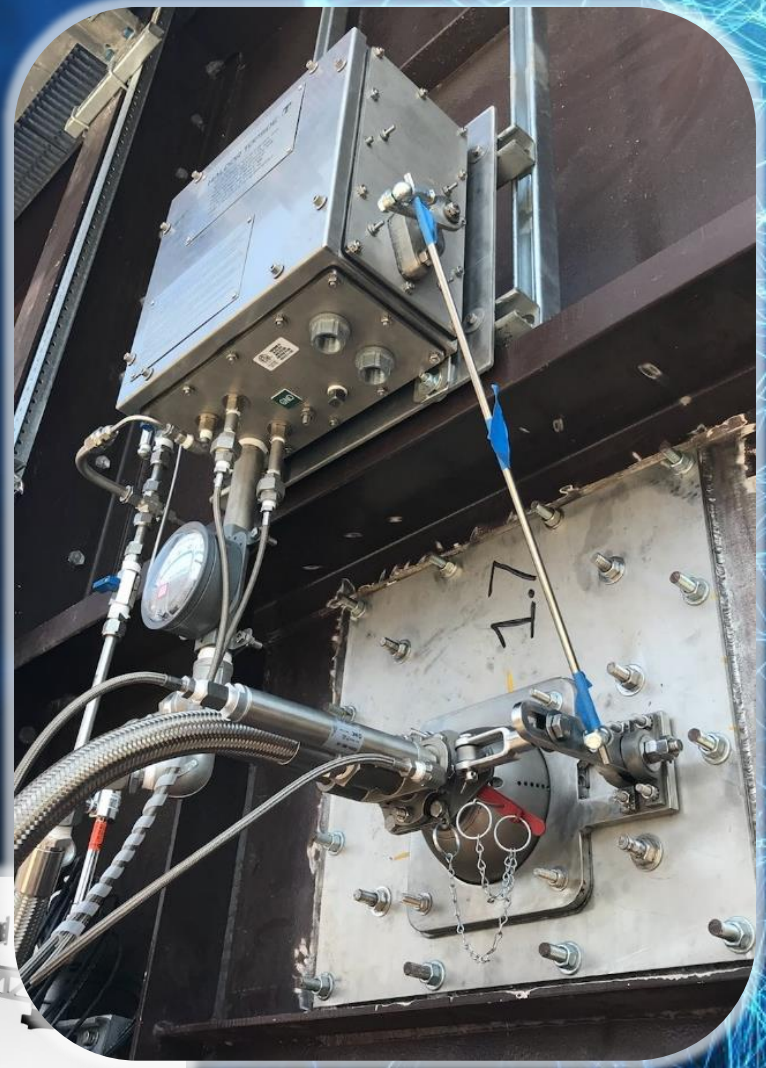
We deliver **practical yet high-impact technologies** and **field services** that improve *safety, reliability, productivity, and on-stream factor* worldwide

- Multidisciplinary engineering team with decades of hands-on experience in process, mechanical, and catalyst-handling challenges across reformers, converters and reactors
- Extensive global network of process and mechanical specialists that we can mobilize immediately for complex technical support
- World-class in-house test facility, capable of full-scale pilot testing, performance validation, and rapid fabrication of demonstration models and prototypes (we can build most equipment ourselves with few outside needs)

Introduction – Catmasters, LLC

Current innovative technologies include:

- **Furnatek™** (TRL 9) - continuous live furnace monitoring system
- **Hyperloader™** (TRL 9) - latest catalyst dense loading device on the market
- **Robotics** (TRL 6) – currently in full scale model / operational environment testing and certification
- Specialized reactor grading and distribution technologies (TRL 2-3)
- Catalyst loading and tray inspection services
- …. more planned each year



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Industry is increasingly data-driven, with decisions guided by information from critical production equipment. Furnace operations are no different, but capturing high-quality data is challenging due to extreme firebox temperatures. Several technologies address this need; today, we appreciate the opportunity to present our approach.

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Let ‘s take a moment and think about the current and past challenges on your Unit.
(SMR’s, Furnaces/Heaters)

If you had immediate 24/7 visibility inside the furnace, complete temperature insight by region and a continuous record of operational data, how would that have influenced how you operate your furnace?

In short, this is what Furnatek™ **empowers** you and your team to do.

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"Hydrogen networks rely heavily on real-time balancing between production and consumption. Control philosophies are built around predictable reformer behavior, slow dynamic response, and high mechanical availability. Any disturbance in hydrogen supply can quickly cascade into process unit instability, making **hydrogen system reliability** a **dominant design and operating constraint**."

- Bansal, PTQ Magazine, March 2026

Furnatek™

Furnatek™ offers real-time, continuous visibility into your furnace - reading tube wall temperatures, burner flame profiles and overall internal furnace conditions. It eliminates the need for human interaction with the firebox and maximize information flow!

At the same time, clients can take full advantage of the data acquisition during furnace operation, allowing them to assess and optimize furnace performance effectively while protecting one of the largest plant assets.

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CHALLENGES

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Steam Reformers – Monitoring Challenges

How vital data is usually gathered

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Steam Reformers – Monitoring Challenges

There are several sources of error in firebox temperature measurement with non-contact devices

Furnace Errors

- Tube Scale
- Gases
- Angles and Views

Data Errors

- Data Handoffs
- Specific Point Comparison
- Repeatability

Device Errors

- Infrequent Calibration
- Emissivity Correction

Human Errors

- Lack of Training
- Personnel Differences

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Steam Reformers – Monitoring Challenges

Furnatek™ eliminates human and data errors, and greatly reduces device errors

Data Errors

- Data Handoffs
- Specific Point Comparison
- Repeatability

Human Errors

- Lack of Training
- Personnel Differences

Device Errors

- Infrequent Calibration
- Emissivity Correction

Data Accuracy

- No Handoffs, automatic
- High-res grey scale imaging
- Digitally Consistent

Human Oversight

- Trained superusers, historical data is transferred seamlessly and universally accessible

Consistent Equipment

- One system, calibrated by Catmasters. Technology eliminates emissivity errors

CORE TECH

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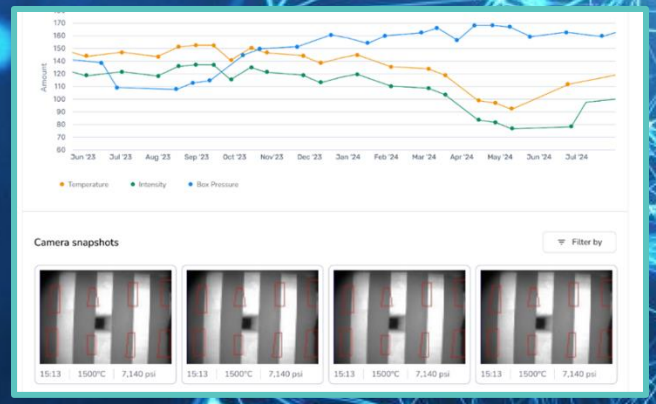
What is Furnatek™?

Furnatek™ =  + 

ThermoLens™ *ThermoProfiler™*

- ***ThermoLens™*** – compact imaging unit installed on the furnace shell
- ***ThermoProfiler™*** – computer & software for temperature analysis & historical trending
- Seamless data flow for real-time and post-process evaluation
- Accessible remotely through secure interface
- 70-100% visibility of all tubes, 100% burners (depending on scope)

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Enabling online reformer monitoring 24 -7

Control Box

Data Acquisition Unit

- Controller
- Switches
- Data transfer
- Actuation assembly

ThermoLens™

Image Acquisition Unit

- Optics
- Sensor
- Communications cabling
- Pivoting mount assembly

Furnatek™

Enabling online reformer monitoring 24 -7

Furnatek™

Enabling online reformer monitoring 24 -7

What Separates Furnatek™

Imaging Method: High-res greyscale imaging

Automated Movement: Unprecedented views from a single point

Core Tech: ThermoLens™

Feature	Detail
Sensor	325,546 greyscale pixels (400 - 1000nm VIS-SWNIR)
Filters	Configurable for tubes or burners (436nm, 710nm)
Coverage	**Full row: 100s tubes + burners**
TWT Method	Intensity → **Calibrated mapping** (vs. gold cup/IR)

- Imaging: High-res greyscale intensity (flame-penetrating bands)
- Smart Features: Air-cooled housing (~20 SCFM per unit), auto-shutdown, direct wire to ThermoProfiler™ communication (at OPS control room) & automatically adjustable angle views

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Tube Filter (650-710 nm)

Spectrum Region: Deep red to near-infrared (NIR)

Purpose:

- At this wavelength, SMR tubes emit strong radiant intensity

It is used to detect:

- Hot surfaces and tube metal radiation/glow
- Radiant heat distribution
- Flame impingement
- Tube wall cracks

Design Basis:

- Offers a strong balance between high signal strength from the tubes and low interference from the flames.

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Burner Filter (436 nm)

Spectrum Region: Blue / violet light

Purpose:

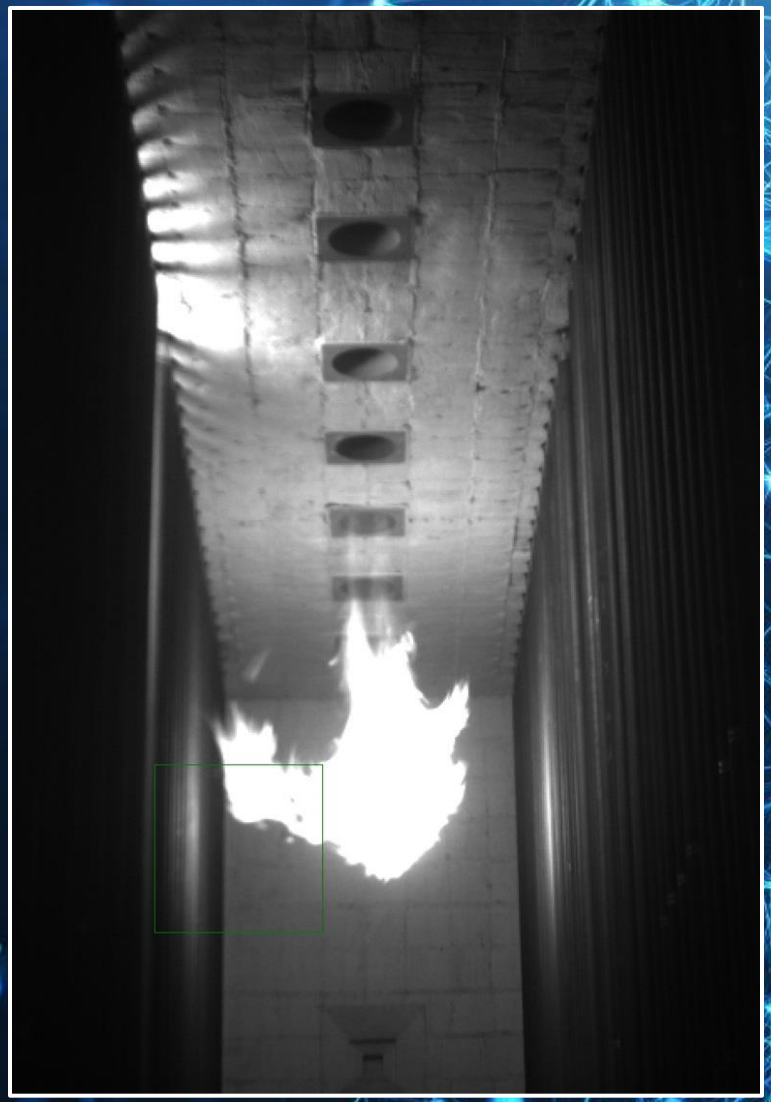
- Isolates the strong emission line of CH+ radicals from incomplete combustion

It is used to detect:

- Incomplete combustion
- CH* and OH* chemiluminescence in flames
- Flame instability and impingement

Design Basis:

- Allows Furnatek to clearly visualize the flame front, flame root, and combustion intensity with high contrast



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Core Tech: ThermoProfiler™

Live Monitoring & Control

- Real-time 24/7 greyscale imaging with programmable remote motion (vertical or horizontal) and automated scanning profiles.

Temperature Measurement & Alarms

- Live tube wall temperature mapping with configurable low/high alarms and direct hardwired outputs to DCS.

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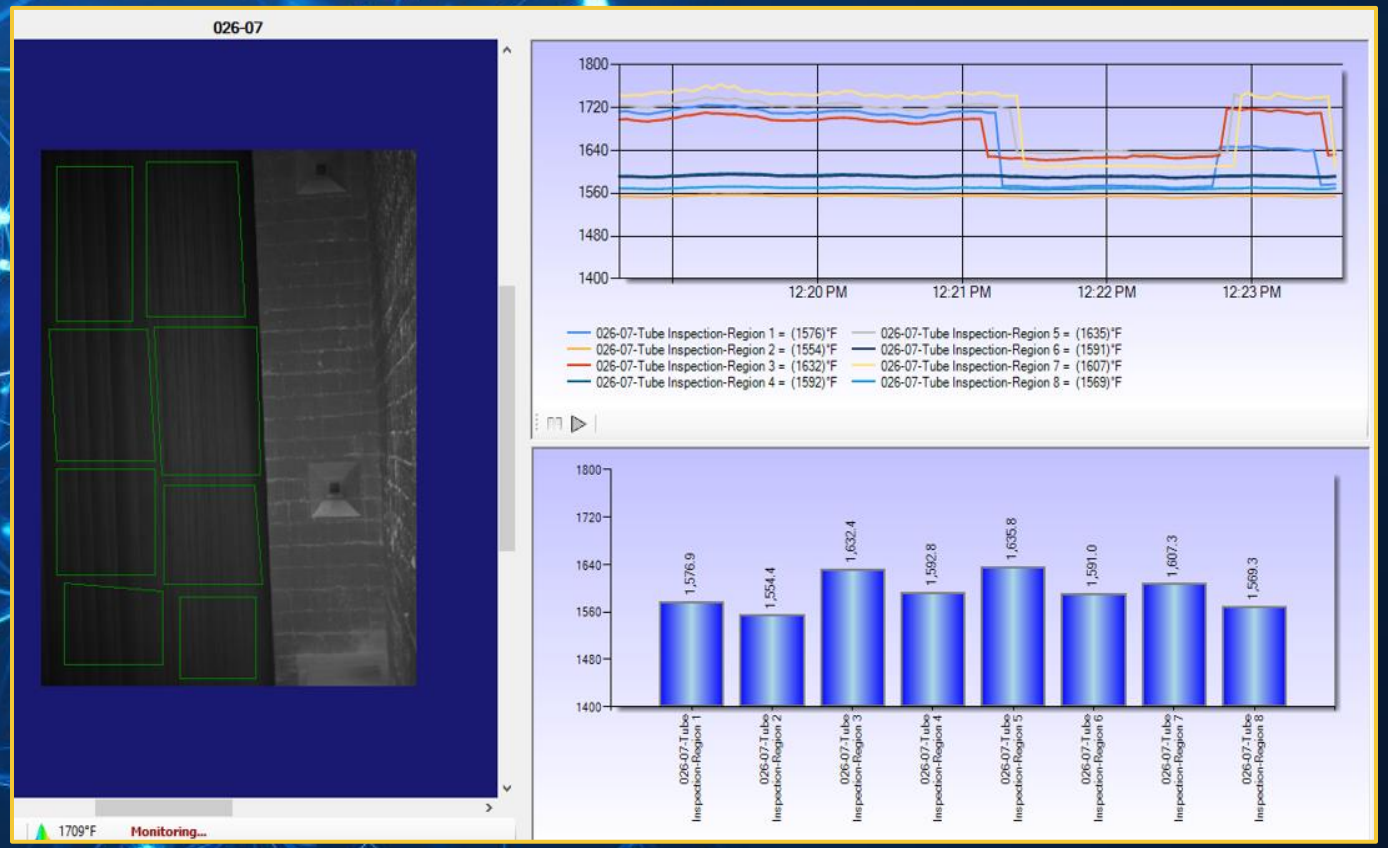
Core Tech: ThermoProfiler™



Advanced Analysis

- Unlimited custom Areas of Interest (AOIs) with per-AOI temperature tracking, trending, and cumulative time-above-temperature threshold calculations.

Data Historian & Reporting

- Full historical data storage, degradation analysis, and easy export to PDF, CSV, PI System, Seeq, and other platforms.

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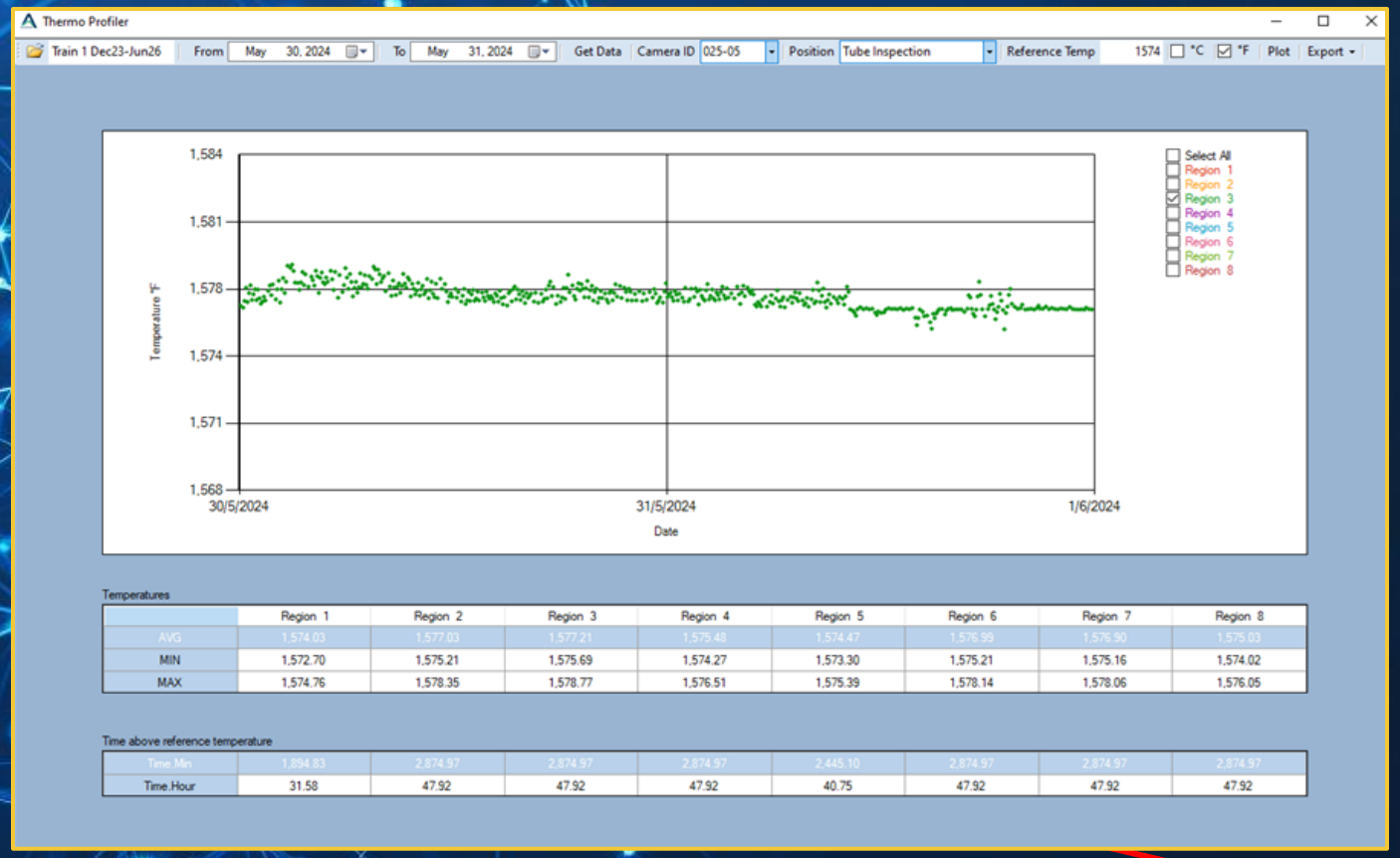
Core Tech: ThermoProfiler™



System Safety & Diagnostics

- Continuous self-diagnostics, pressure monitoring, and automatic camera retraction on over-temperature

Digital Tool for Furnace Optimization

- Analytics accessible from control room.
- Data transported via one-way data diode

Time above reference temperature

Time.Min	1,894.83	2,874.97	2,874.97	2,874.97	2,445.10	2,874.97	2,874.97	2,874.97
Time.Hour	31.58	47.92	47.92	47.92	40.75	47.92	47.92	47.92

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BENEFITS

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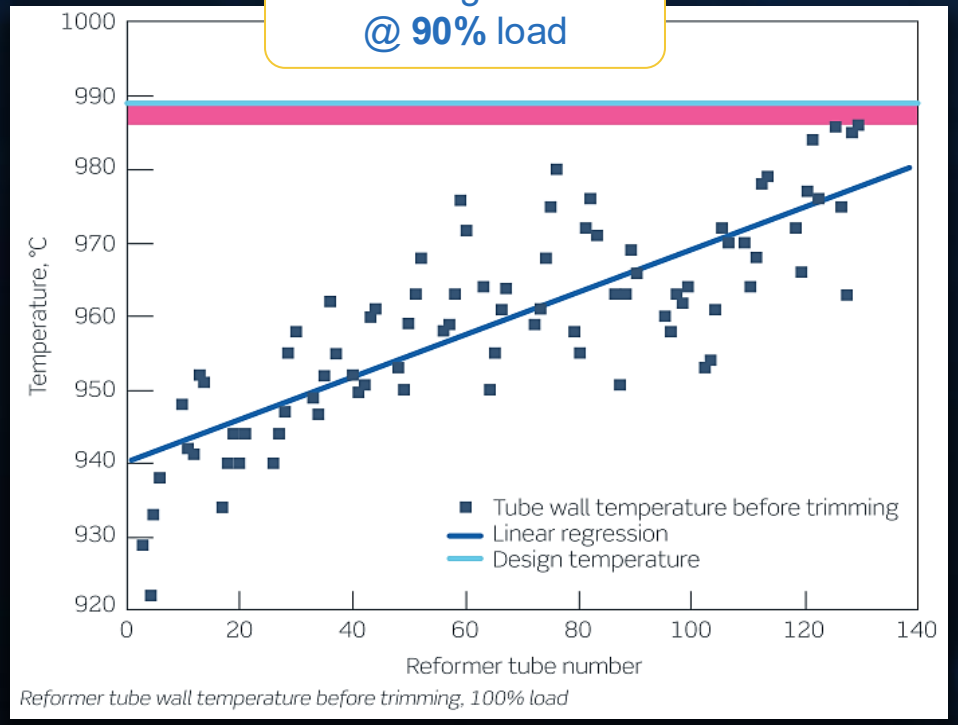
Furnatek™ Benefits Comparison

Specification / Feature	Furnatek™	Others
Eliminates operator exposure	✓	✓
Continuous 24/7 operation	✓	✓
Hazardous area certification	✓	varies
Real-time alarms to DCS	✓	varies
Historical trending & degradation analysis	✓	varies
SMR-specific design & tube life support	✓	varies
Superior small crack / surface detail visibility (greyscale SWIR advantage)	✓	No
Better flame penetration & less obscuration	✓	No
Programmable motion	✓	No
Fewer cameras required	✓	No
Automated motion profiles	✓	No
Unlimited custom AOIs / sub-regions	✓	No
Centralized control for many lenses	✓	No
Scalable across multiple furnaces/sites	✓	No

What can Furnatek™ help you achieve?

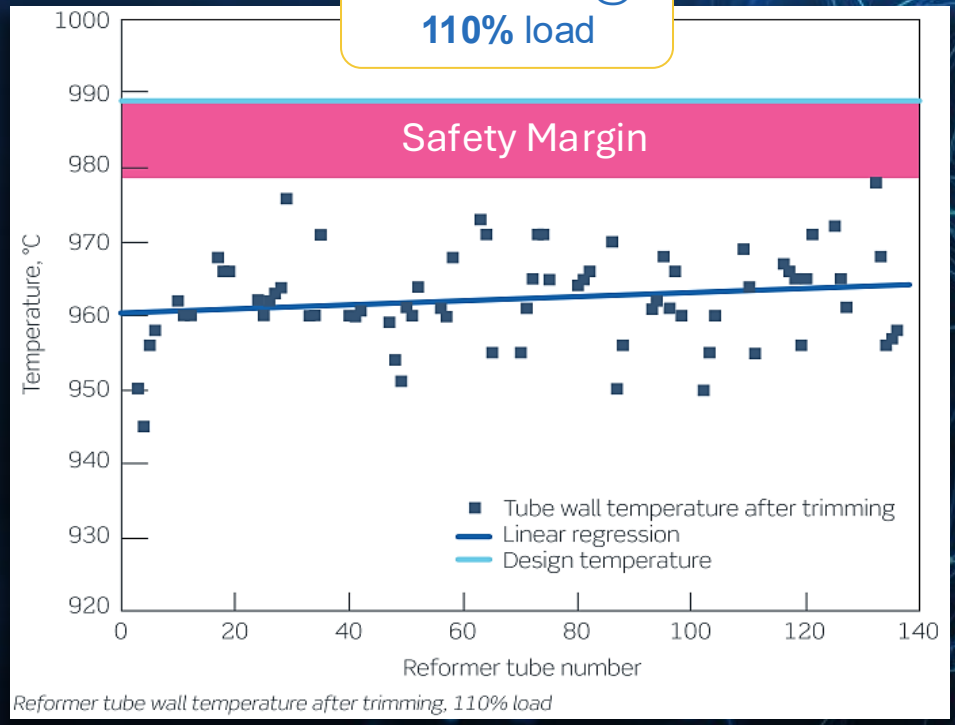
Before and after furnace balancing

Wider range of TWT @ **90%** load



Reformer tube wall temperature before trimming, 100% load

Flatter TWT @ **110%** load



Reformer tube wall temperature after trimming, 110% load

	Min TWT	Max TWT	Avg TWT	Deviation	Capacity
Before	922°C	986°C	955°C	-33°C/+31°C	90%
After	945°C	978°C	962°C	-17°C/+16°C	>105%

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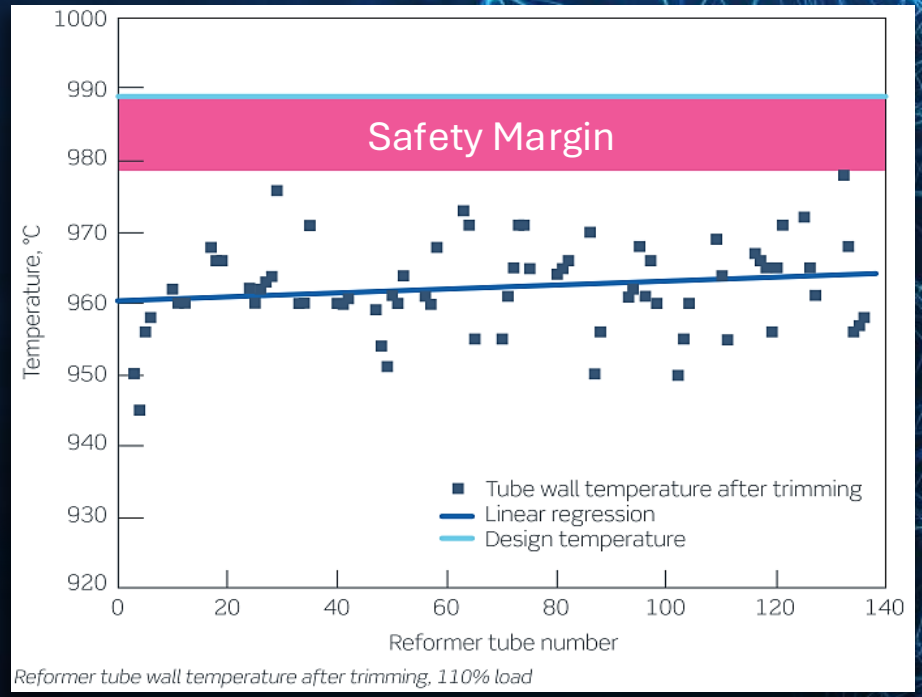
What can Furnatek™ help you achieve?

Before and after furnace balancing

- Increased efficiency & capacity while maintaining safety margins
- Transitioning to Digital Operations with Furnatek™ eliminates repetitive manual IR gun readings, reduces operator trips to the furnace, and provides continuous real-time visibility, enabling faster adjustments based on accurate data for optimized furnace balance.

Flatter TWT @ **110%** load



Reformer tube wall temperature after trimming, 110% load

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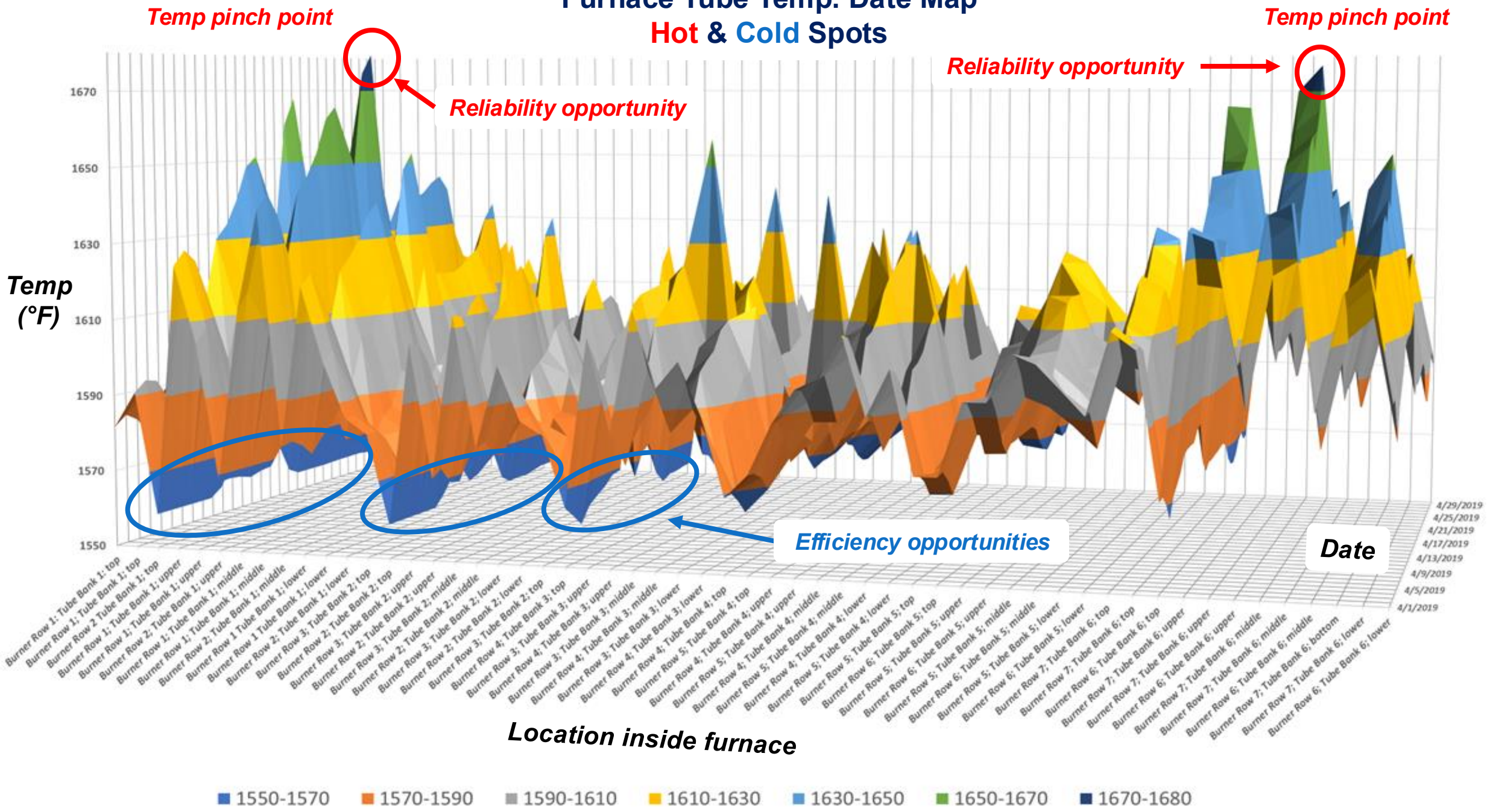
Furnace Tube Temp. Date Map
Hot & Cold Spots



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Will provide you with the critical data for Operational decisions and this will lead to the best operating temperature & predictive maintenance

~ 2% lost production, resulting in up to $3-4MM USD lost per year, due to:

- Lower production
- Lower energy efficiency

°F = $

<50% tube lifetime

- Tube rupture (+$20K USD ea)
- Unplanned shutdowns
- Safety risk

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IMPLEMENTATION

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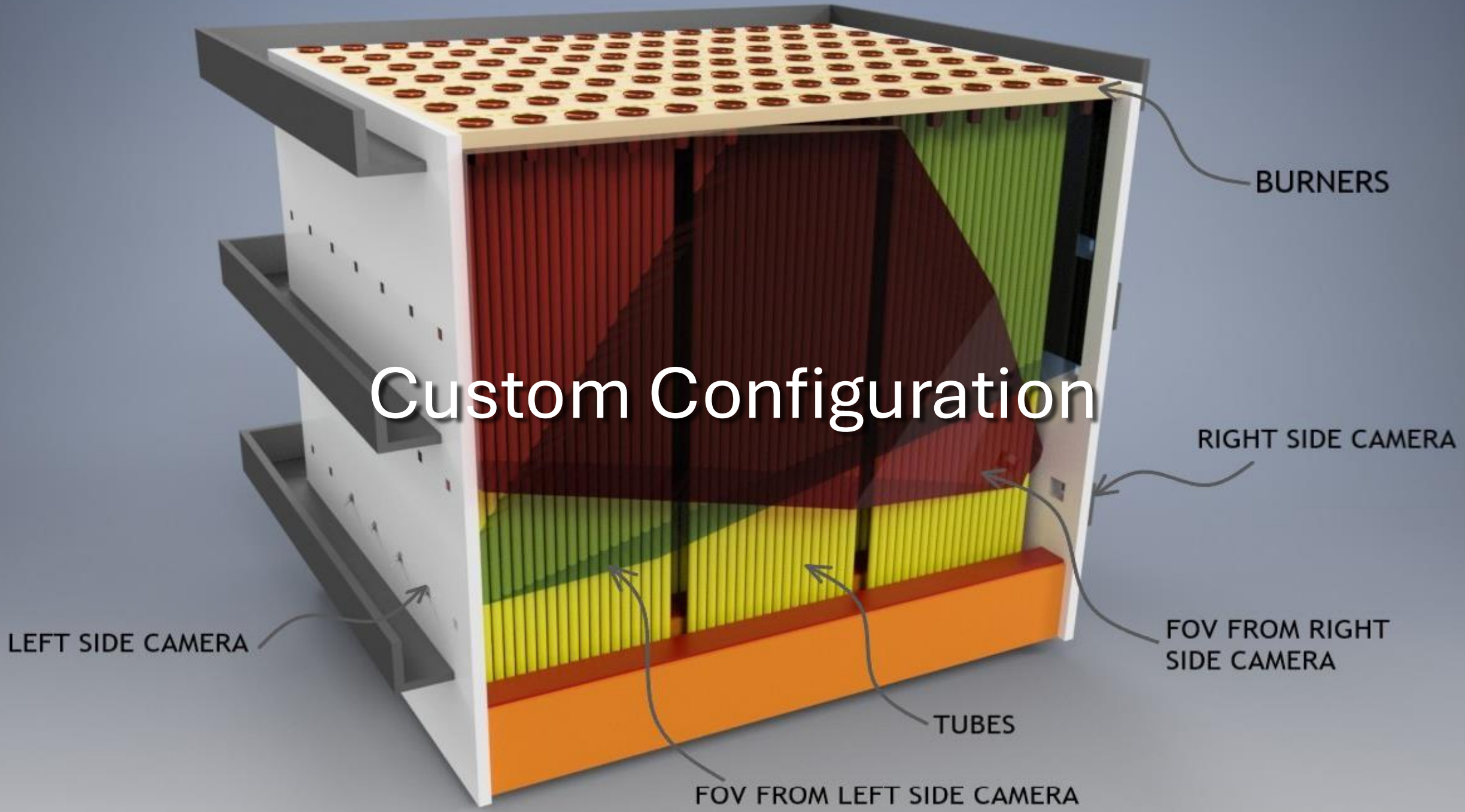
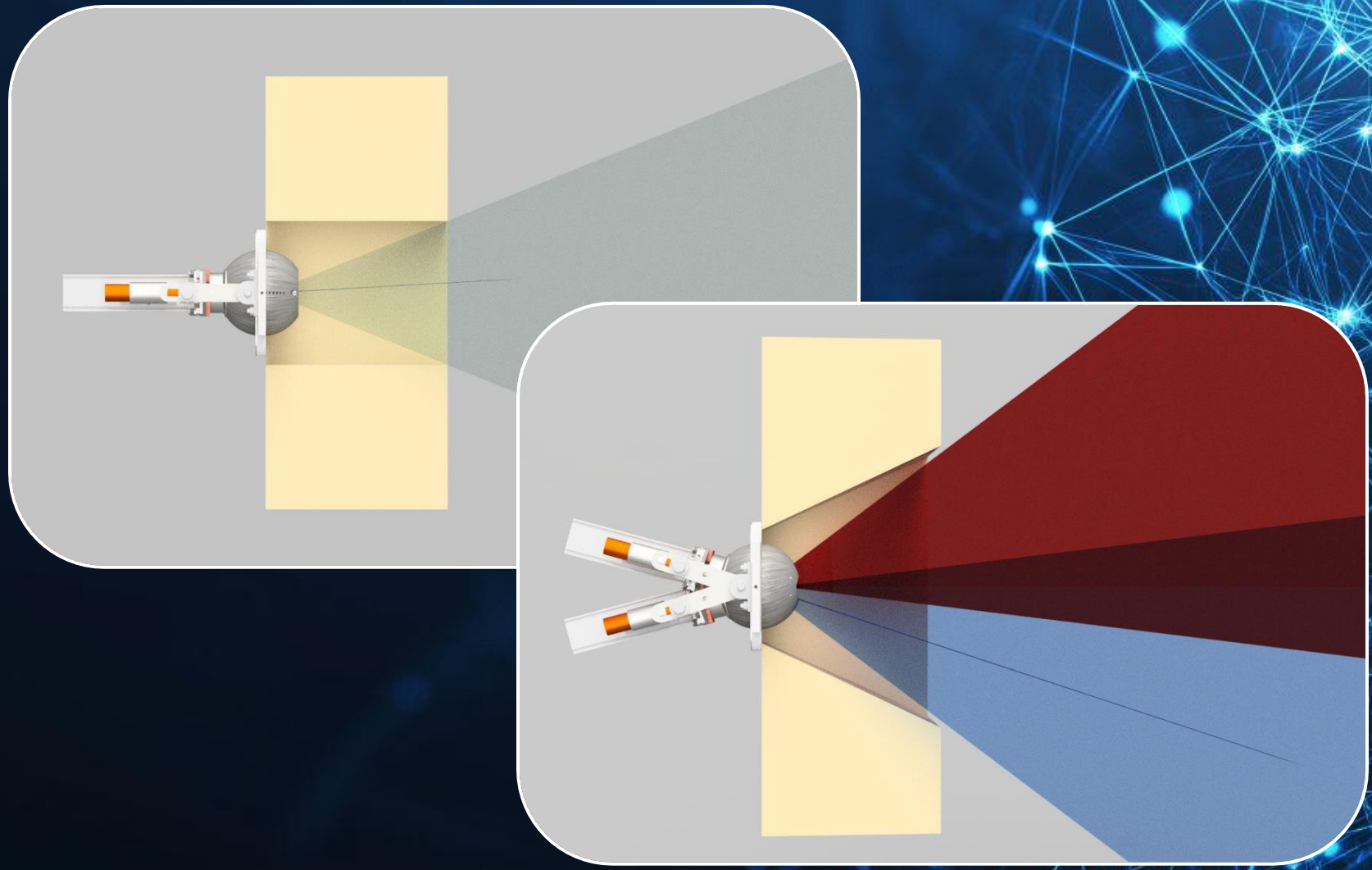
Custom Configuration



Installation and Views – Existing Peep Doors

- Little to no modification of furnace walls and refractory
- Depending on existing refractory, views can sometimes be limiting
- Installation can occur during operation



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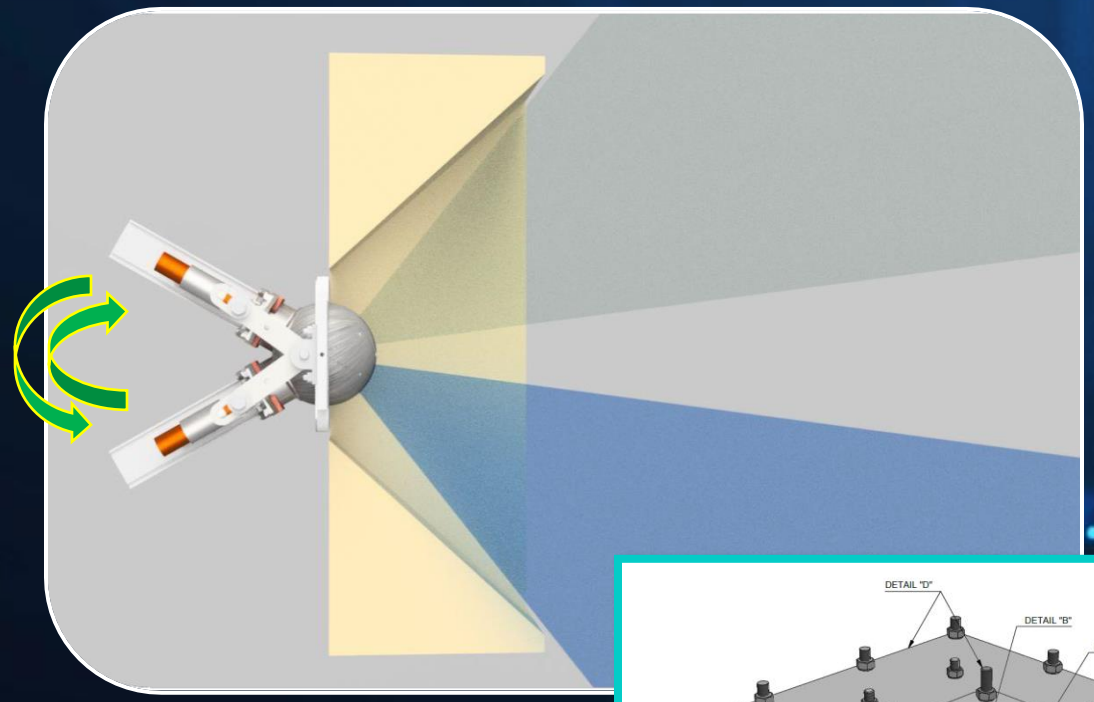
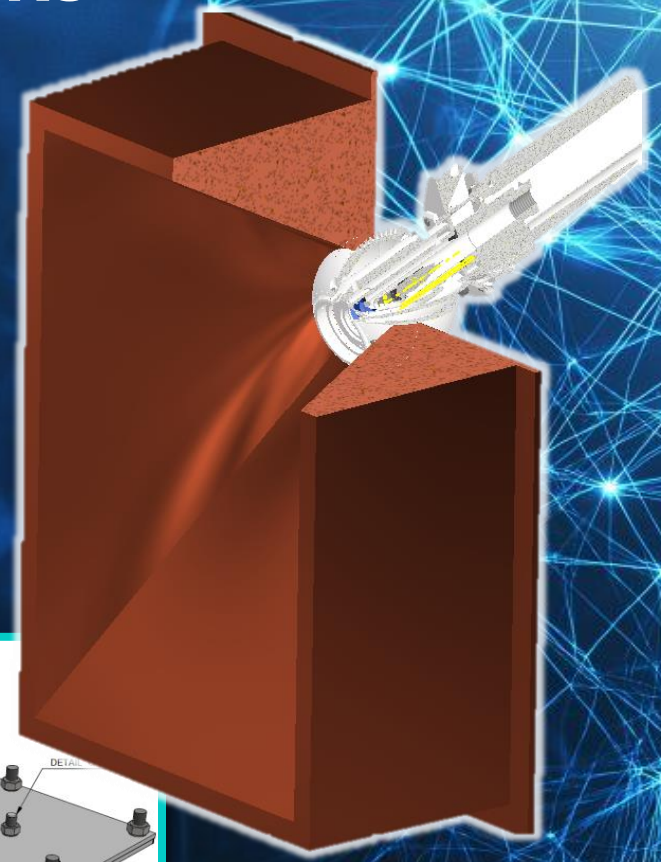
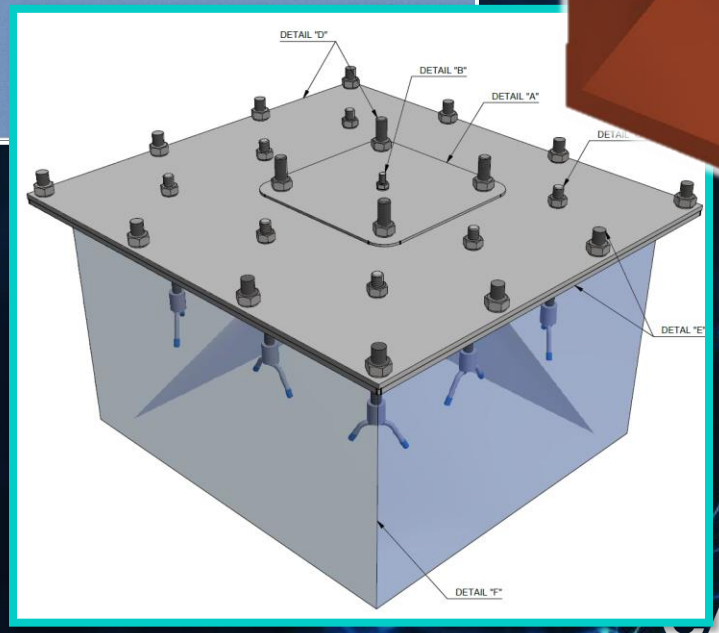
Installation and Views – Custom Refractor Blocks

- Slight modification of furnace walls and refractory
- Maximum viewing angles and positions
- Fast installation during normal TAR







Furnatek™ Project Schedule

Week -3

Week -1

Review
- Furnace 3D model
- Viewing Angles
- Total number of ThermoLenses
- Pricing & delivering options

Week 0

Upon award of project & signed contract
Catmasters will start final designs and build outs
Following the project milestones outlined in the proposal

Week 6-10

Catmasters will start providing first set
Of design document for review

Week 11-18

Trips to site & Fabrication facilities

Week 18-26

Delivery of hardware
In stages as per milestones

Week 27+

On site testing
& commissioning

Furnatek™ & Environment

With Furnatek™, operators gain actionable data to optimize combustion, fuel-air ratio, and thermal balance.

This approach helps with efforts on minimizing energy intensity resulting in significant cost savings, helping SMR’s and Heaters to lower their environmental impact.

Total Legacy Furnatek™ Units

20

Total ThermoLenses™ Installed

254

APPENDIX

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General System Specifications

Design Conditions	Ambient temperature	-37°C to 48°C (-35°F to 118°F)
	Maximum case temperature	82°C (180°F)
	Area classification	Class 1 Div 2, ATEX, IeCUx
	Maximum reformer chamber temperature	1200°C (2200°F)
ThermoLens™ (with enclosure)	Enclosure Size (WxHxD)	355.6 x 355.6 x 177.8 mm (14x14x7 in)
	Adjustments - axis	Primary – programmable (actuator) 105° rotation Secondary – Manually adjusted ± 30° with 5° steps
	Over temperature protection	Yes
	Detect low line pressure	Yes
	Monitor positive box pressure	Yes
	ThermoLens™ tile material	Vacuum Formed or KAO Lite 2300
	Cutout size in furnace side wall (if necessary)	min ~ 400 x 400, max ~ 750 x 500 mm (15x15 - 30x20 in)
Air requirements	Air consumption	Operating - 25-33 Nm3/h (15-20 SCFM) per ThermoLens™ Peak - 52 Nm3/h (25 SCFM) per ThermoLens™
	Air type	Instrument air
	Air pressure	6.9 Barg (100 psig)
Electrical Requirements	Supply voltage	90-260VAC, 50/60Hz
	Power (50 ThermoLens™s' system)	Peak - 5.88 kW Nominal – 5.56 kW
	Power (1 ThermoLens™ with box)	Peak – 32 W Nominal – 28 W
Communications	Communication control box	Single enclosure with redundant power supply
	Enclosure Size (WxHxD)	1066.8 x 355.6 x 254.8 mm (24"x14"x10") per 25 grouped ThermoLens™s
	Connection to ThermoLens™s	Armored Cat5e, shielded, solid core, UV protected
	Connection to Core PC	Multimode fiber optic
Interfaces	Furnatek™ Control Panel	Optional, multiple access, multiple panels
	Discrete outputs	Communication fault, general fault, ready

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Comparing Technology Options

Contact vs. Non-Contact: Choose Your Precision Level

Method	Type	Coverage	Frequency	Accuracy
Gold Cup	Contact	Single spot	Manual (daily/weekly)	± 0.5% +1°C (Absolute)
Handheld IR Pyrometer	Non-Contact Spot	Single spot	Manual	± 1-2% (w/ corrections)
Furnatek™	Non-Contact Imaging	100s of tubes + burners	Continuous 24/7	± 0.5% + 2°C calibrated maps

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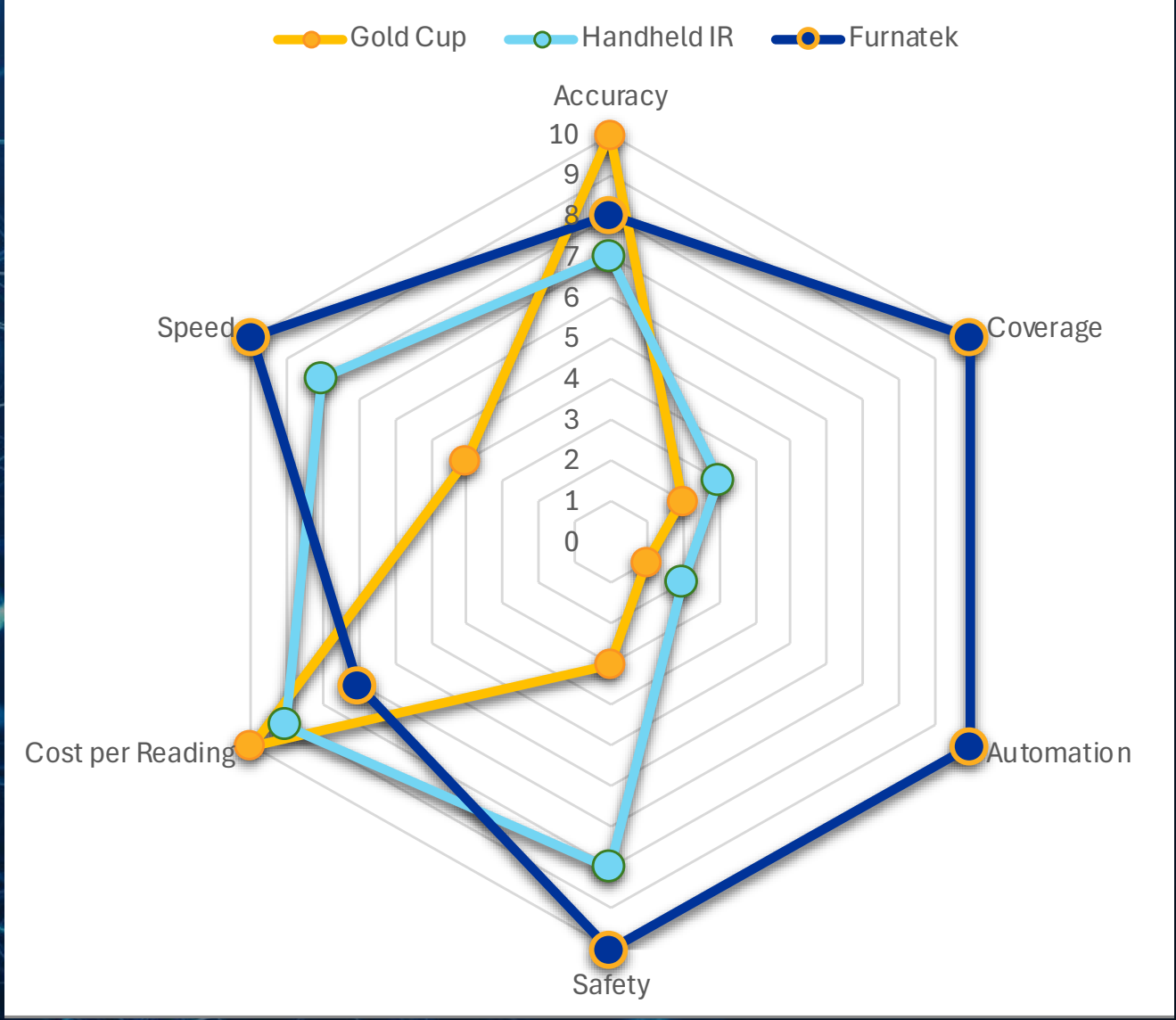
Head-to-Head Comparison



Why Furnatek™ ?

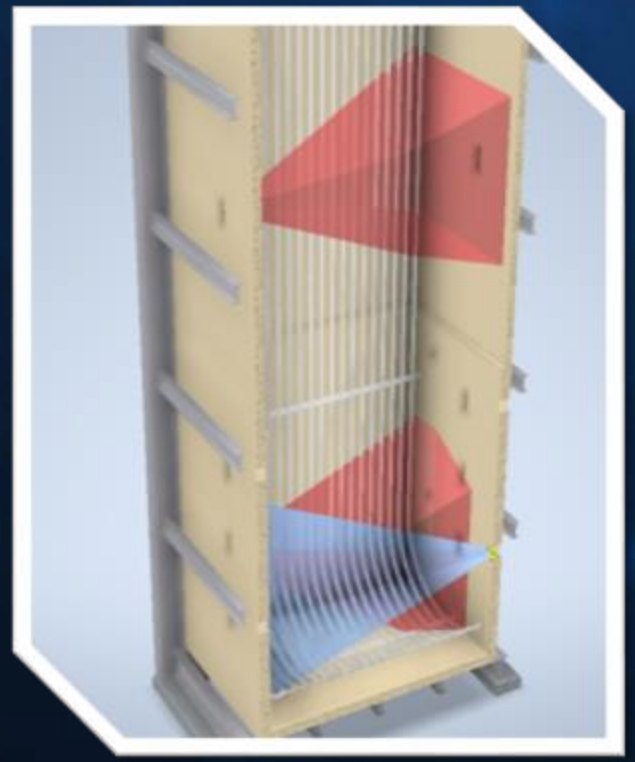
- Maximum Coverage
- Safest Operation
- Continuous and Traceable Data

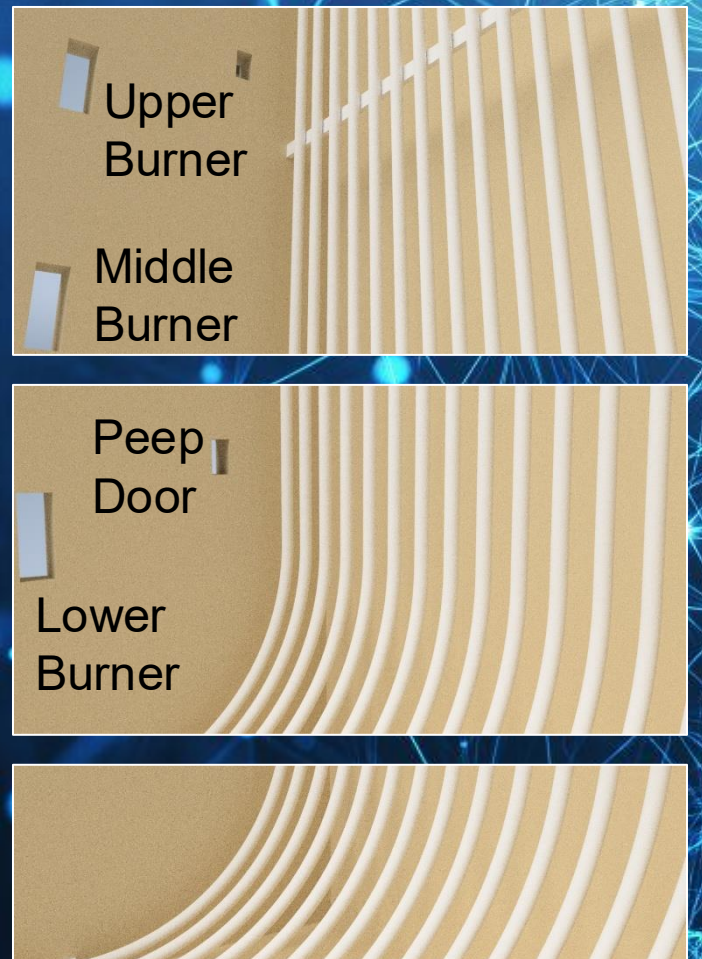
Refinery Heater : Example

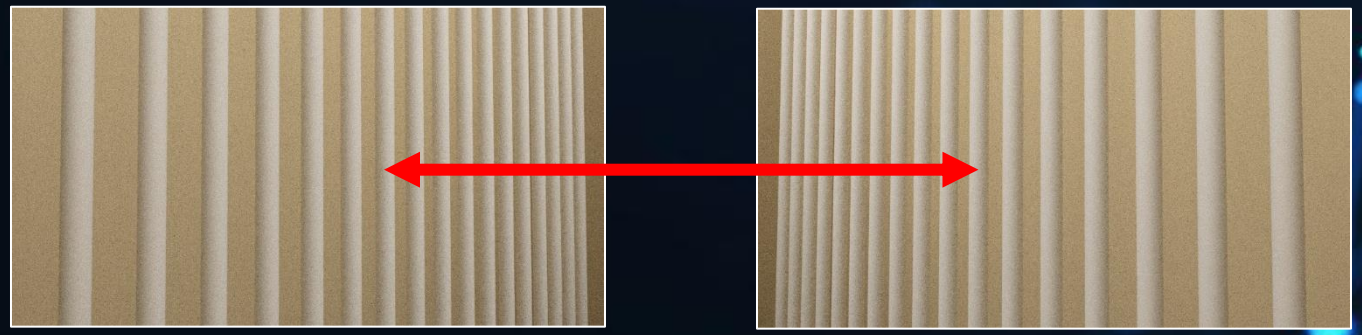
Scope:

Three (3) Total Furnatek ThermoLens™

- 2 on Bottom, opposite sides, next to peep doors, movement up/down:
  - ✓ Able see floor U-bends and all burners
- 1 at highest possible location, above top peep door:
  - ✓ Able to see most or all the tubes at location of highest temperatures







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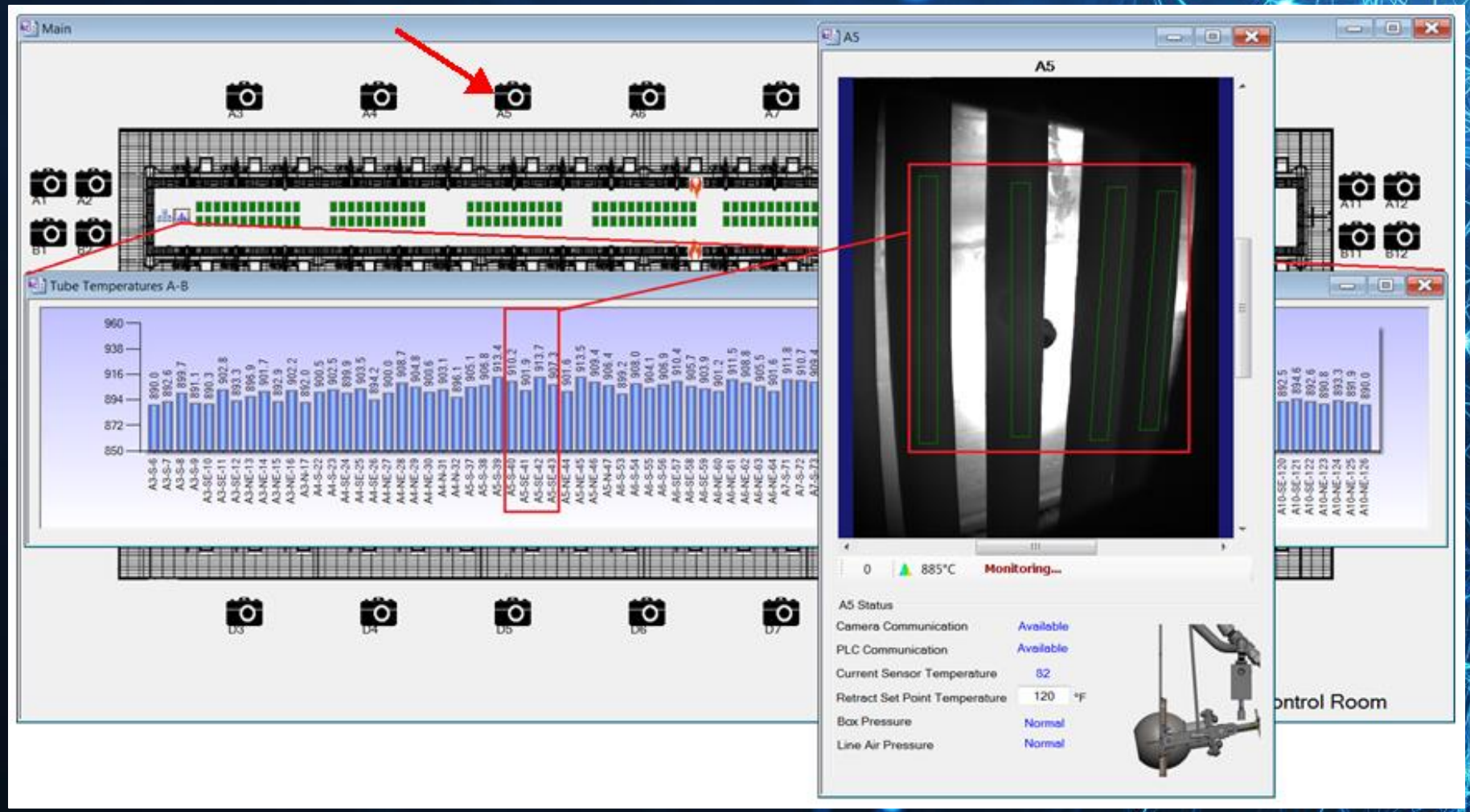
Tube Details

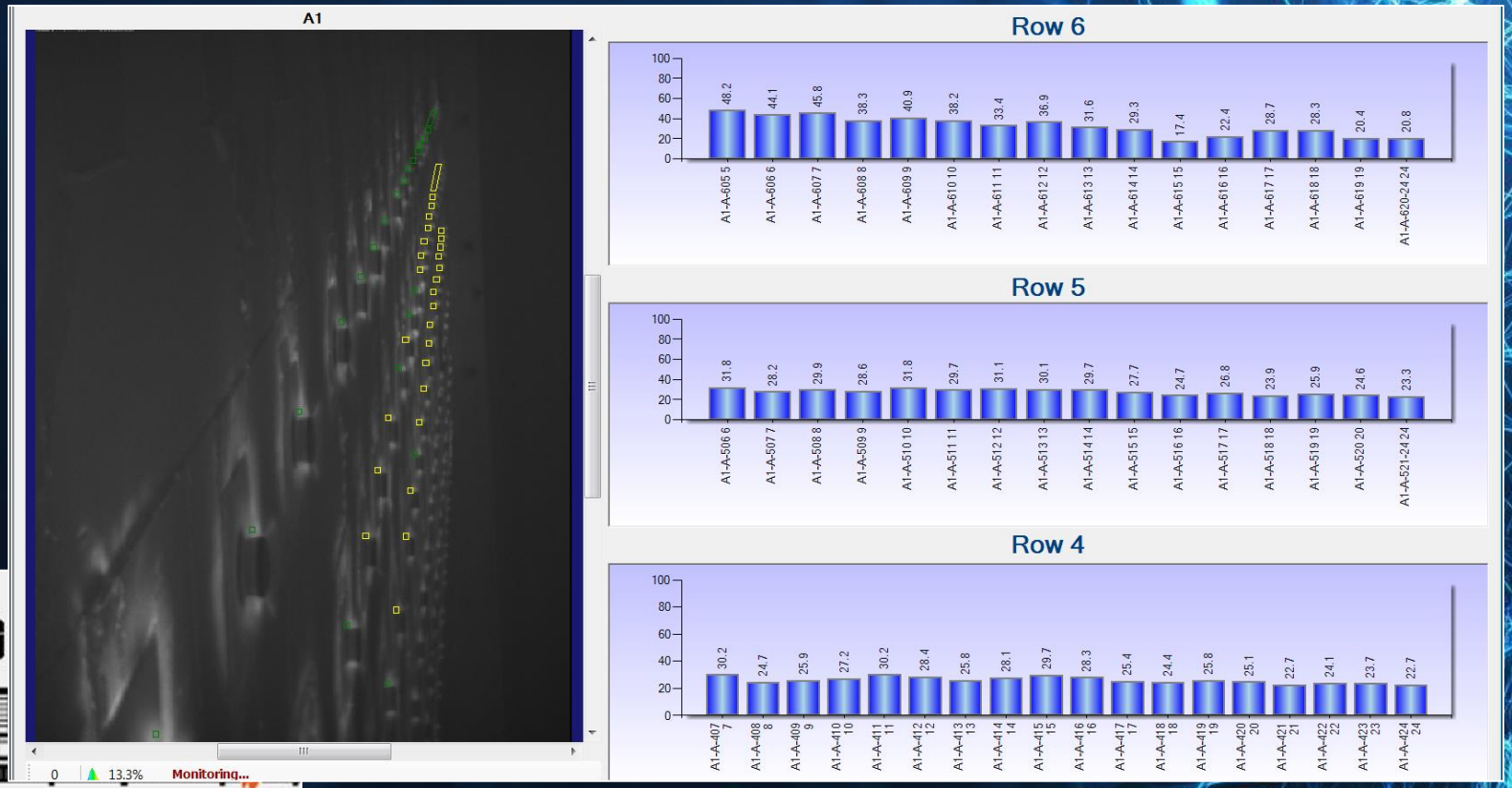
- Selecting imager icons displays the view from that imager
- Tube images correlated to temperature data

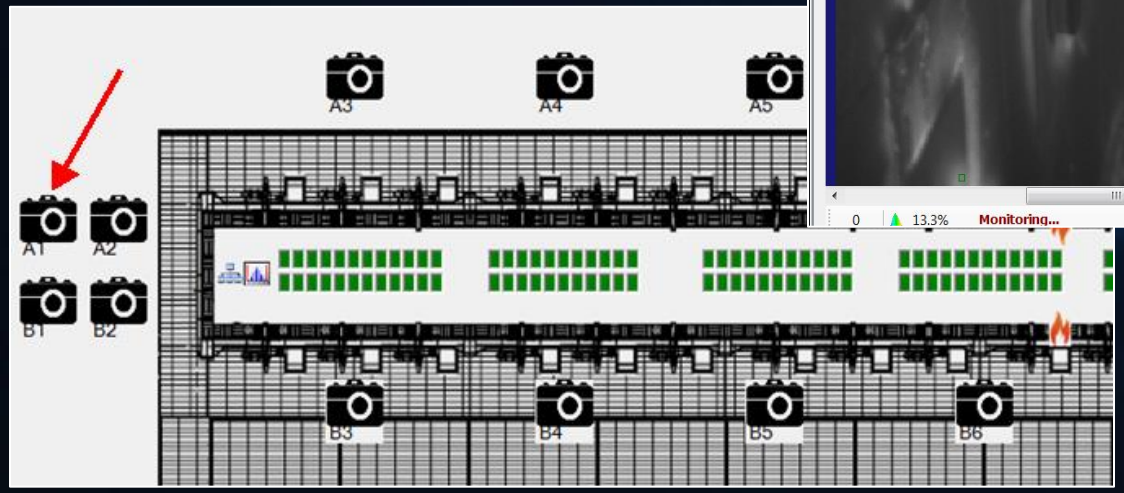


Correlation of image to data

Burner Performance

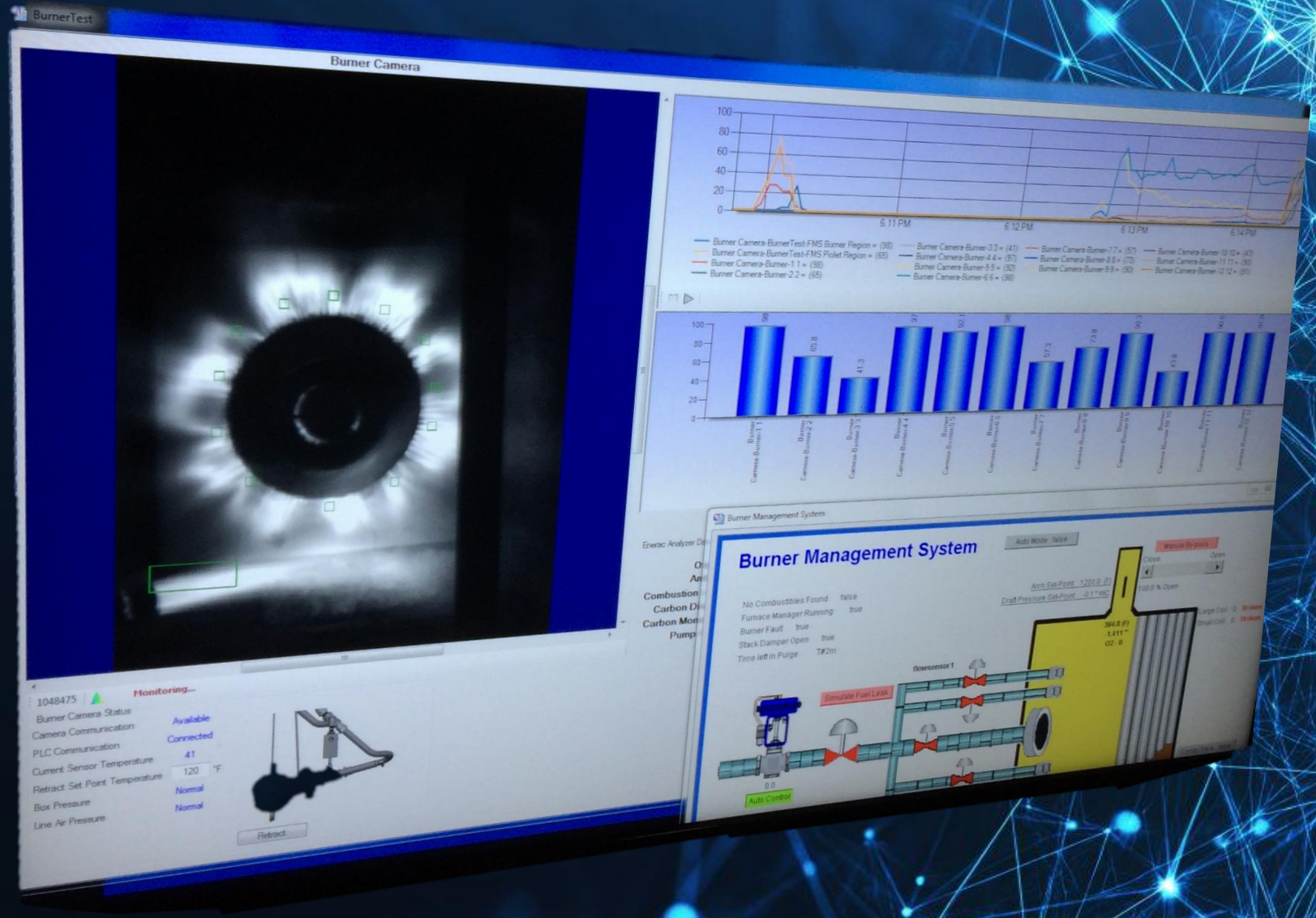
- View multiple burner rows
- Chart burner intensities for each of the rows monitored





Burner Performance

- Unlimited ROI allows for the ability to view pilot light status, burner profile and performance.



Software Interface - Historian

- Historian provides detailed view with data concerning archive time, etc.
- Tube camera on left and burner camera on right
- Detailed locational & time stamp data

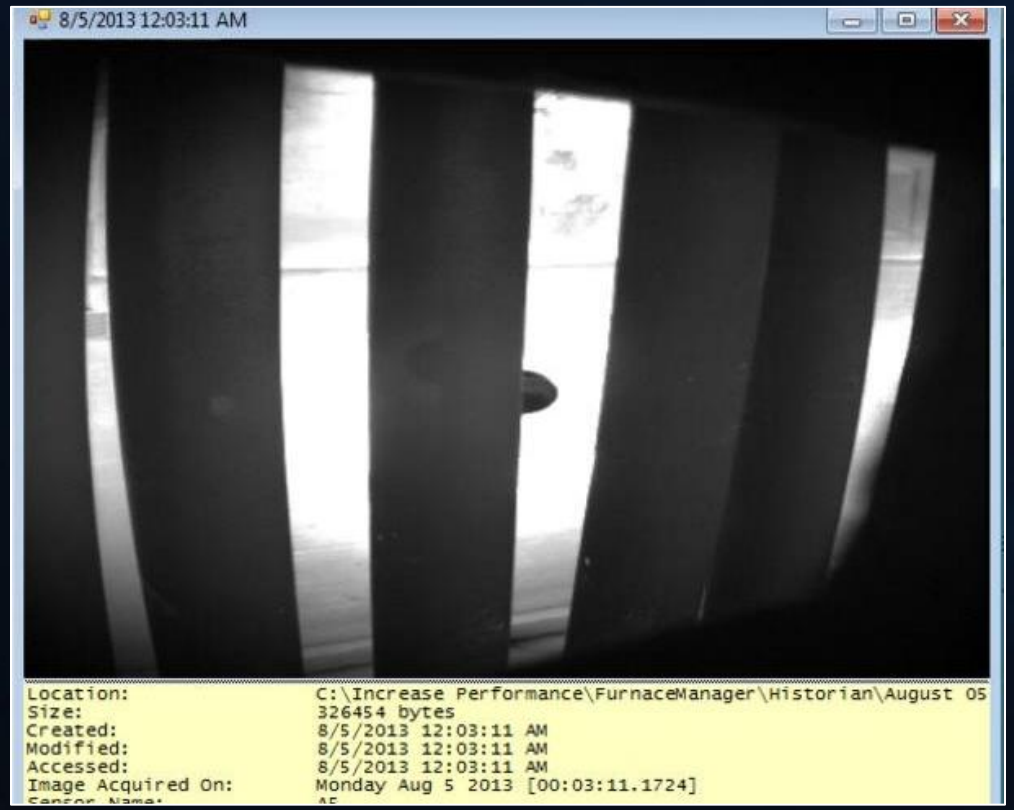
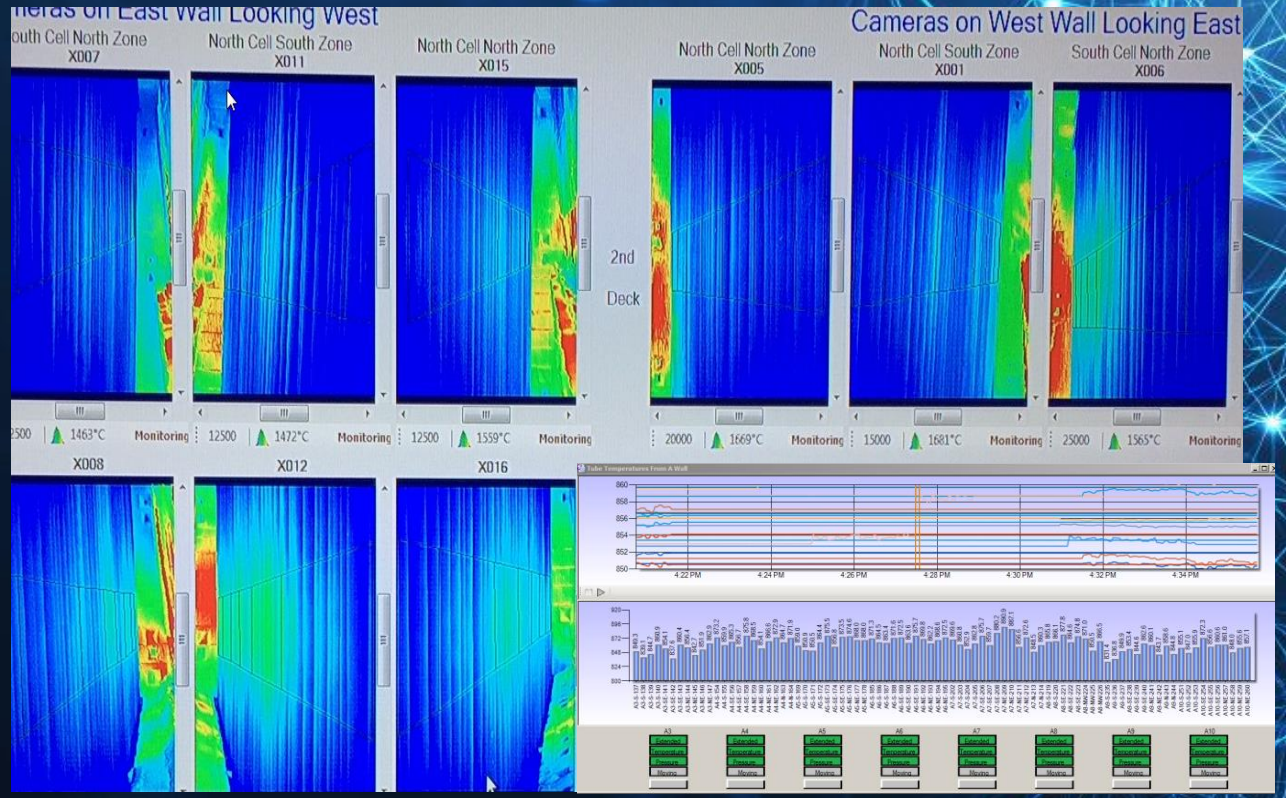
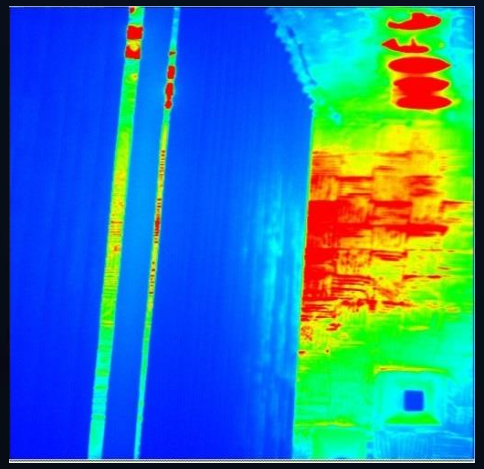
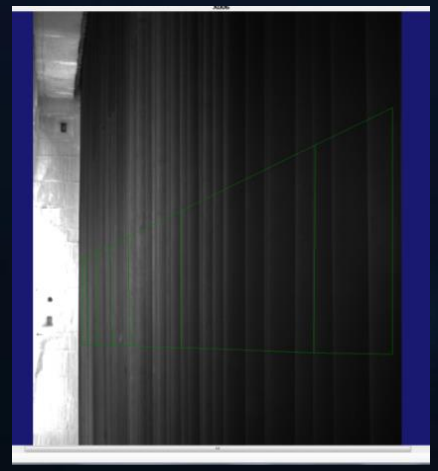


Image Color Coding

- Color-coded surface temps
- Easy identification of abnormalities
- Quick view of furnace health
- Images provide context of overall furnace condition
- Images correlated with data



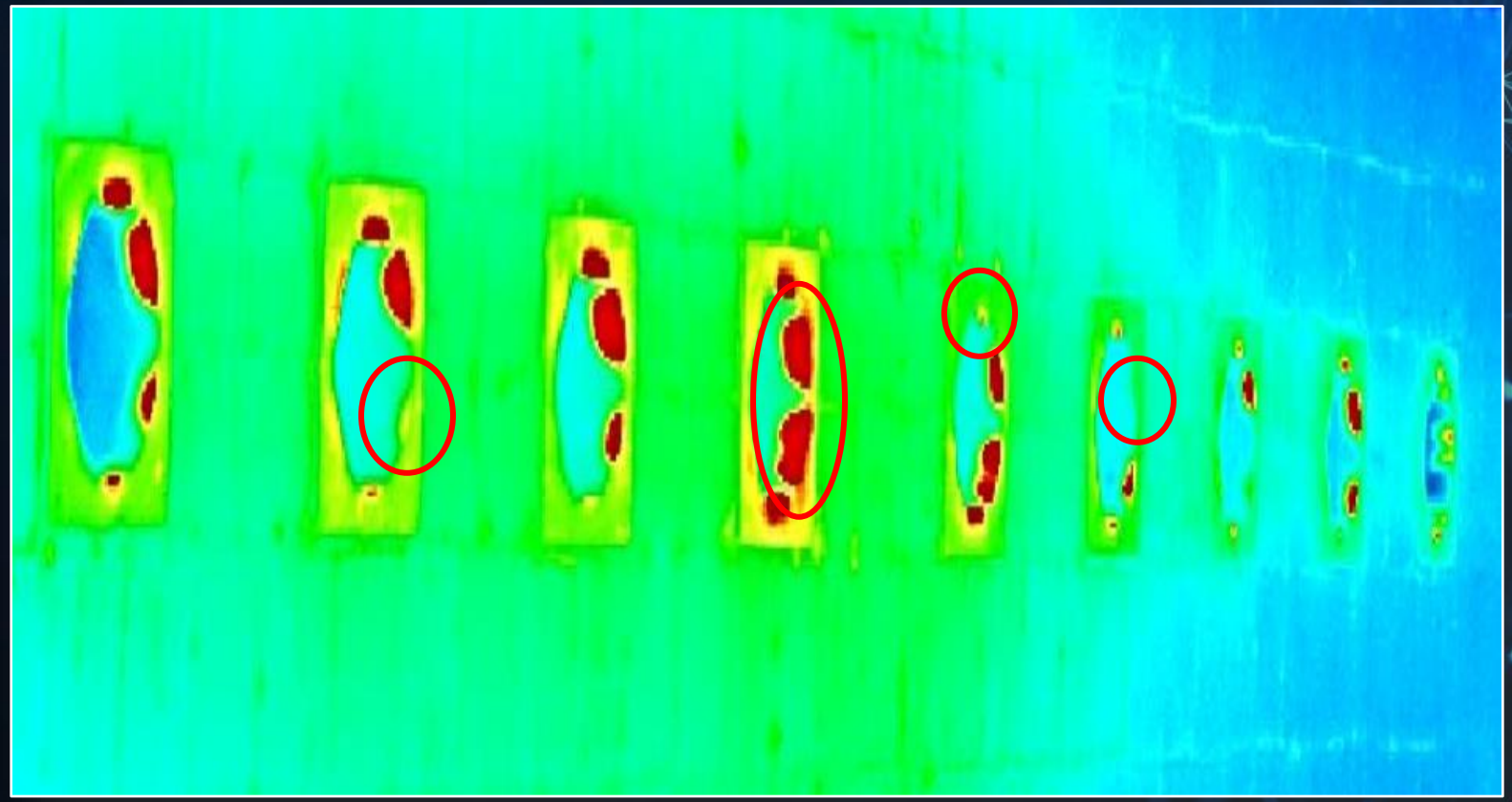




Color images, data, & raw images

Furnace and Plant Optimization

Burner thermal profiles



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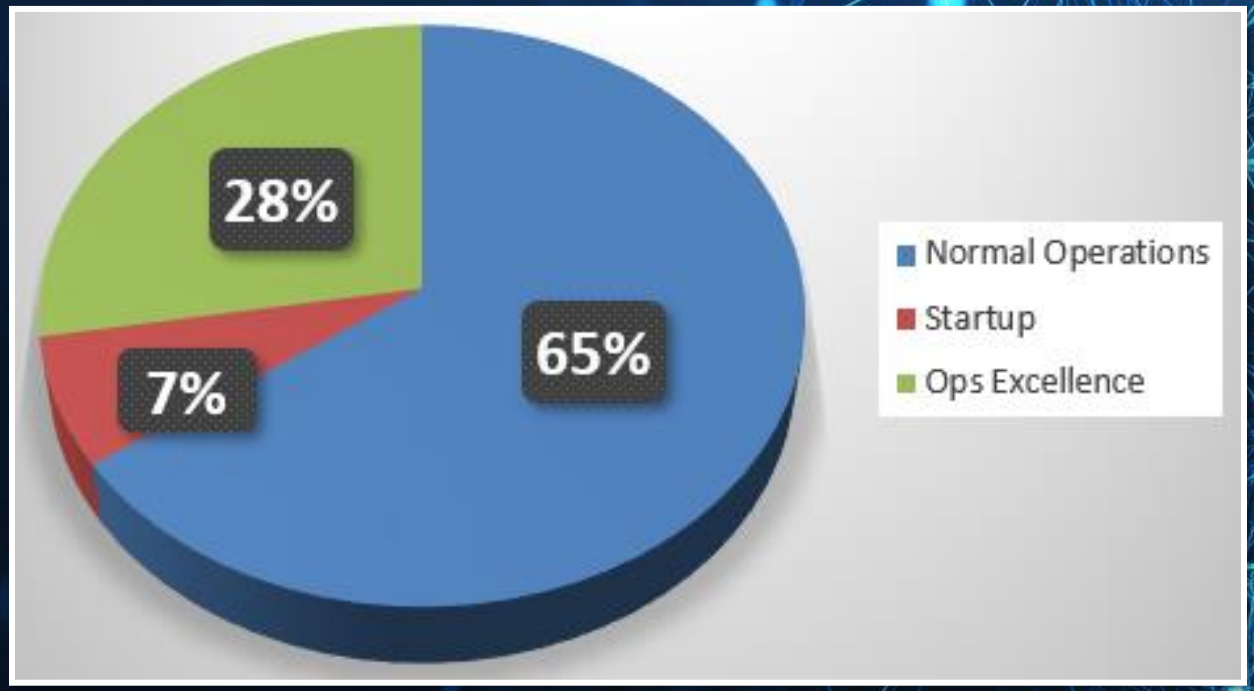
Asset Protection and Cost Savings

Delivering significant cost savings through:

- Optimizing fuel usage
- Furnace tubes protection
- Savings for normal operations



Payback period can be as fast as three months.

Typically, within 1-2 years.

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Case Stories

- **Reliability:** Successfully used to manage catalyst tube temperatures and burner adjustments so that after about 45,000 fired hours of operation, all catalyst tube creep measurements were less than 1%.
- **Operational Excellence:** Used successfully to share best firebox operating practices via remote access to Furnatek™, and to leverage furnace start-up engineers for monitoring start-ups at several SMR's remotely.
- **Process Safety (PSM):** An installation of Furnatek™ after a significant incident involving the total loss of over 300 catalyst tubes in a large SMR during start-up. Management asked, "Is there any technology that would have helped to prevent this loss?" Furnatek™ was available and installed. There have been no further major PSM firebox incidents since.
- **Incident Avoidance:** Several clients installed Furnatek™ when necessity required operation of their SMR with older, end-of-life, catalyst tubes. In one case, operation with a small process leak in the firebox was managed for over 2 years without direct personnel interaction with the burner deck or peep holes on the firebox.

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Current and Future Developments

ThermoProfiler™

Catmasters latest software update

- Simpler interface, with ability to look quickly at key areas and historical data from the furnace historian.
- Generate graphs for selected dates to show min-max-average temperatures for selected regions.
- Also calculates time above user defined reference temperature for each region.
- Easily exported to MS Excel

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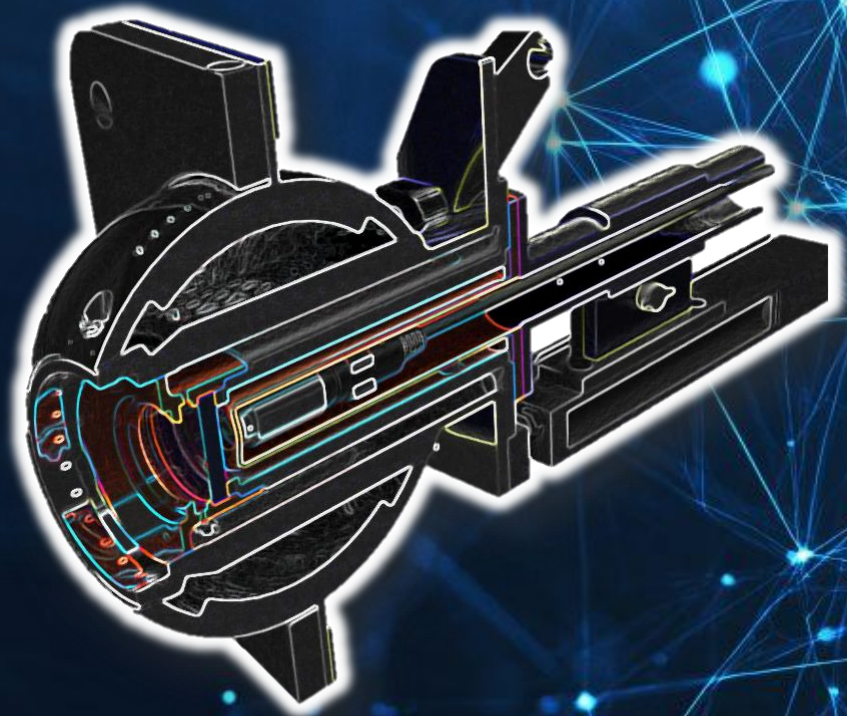
Unlocking Precision

Gold Cup, IR Pyrometers & Furnatek for SMR Tube Wall Temps

Deep dive into the 3 industry-standard methods and why Furnatek™ dominates non-contact



CATMASTERS™

Why Measure Tube Wall Temperature (TWT)?

Critical for SMR Safety, Efficiency & Longevity

- **Operating Conditions:** 740–950°C, 50 bar; tubes last 100,000+ hrs. if managed right

Issue	Risks of Poor Monitoring
Issue	**Consequence**
Hotspots (>950°C)	Tube creep, rupture, catalyst degradation
Imbalance	Coking, inefficiency (+5-10% fuel use), NOx/CO_2 emissions
Flame-out	Unburnt fuel, explosions

- Benefits: 2-10% energy savings, extended life, blue H_2 readiness

CATMASTERS™

ThermoProfiler™

Select ThermoLens™ and stored position