

WELCOME TO THE CALLIDUS COMBUSTION SCHOOL 2020

YOU ARE AT THE RIGHT PLACE, PLEASE WAIT A MOMENT
AND THE PRESENTATION WILL BEGIN AT THE APPOINTED TIME

CallidusPartsInquiries@Honeywell.com



Time	Monday, October 5, 2020	Tuesday, October 6, 2020	Wednesday, October 7, 2020	Thursday, October 8, 2020
10:00 AM CDT	Process Burner and Heater Combustion Fundamentals	Case Study: The CUBL-CF Compact Flame Burner	Process Flare Regulations and Fundamentals	Case Study: The nViro XSR Elevated Steam Flare
11:00 AM CDT	Process Burner Installation, Repair and Maintenance	Case Study: The AERO Radiant Wall Burner	Process Flare Inspection, Repair and Maintenance	Case Study: The Galaxy Multi-Point Ground Flare
3:00 PM CDT	Process Burner and Heater Combustion Fundamentals	Case Study: The CUBL-CF Compact Flame Burner	Process Flare Regulations and Fundamentals	Case Study: The nViro XSR Elevated Steam Flare
4:00 PM CDT	Process Burner Installation, Repair and Maintenance	Case Study: The AERO Radiant Wall Burner	Process Flare Inspection, Repair and Maintenance	Case Study: The Galaxy Multi-Point Ground Flare

Callidus Technologies – Leader in combustion solutions



- BURNERS
- FLARES
- FGRS
- TOs
- SCRs
- AFTERMARKET
- TURN KEY SOLUTIONS
- SOFTWARE



Callidus is the unique position to offer a complete solution for Environmental Compliance, Efficient Operation, Output Maximization





CASE STUDY: THE nViro™ XSR ELEVATED STEAM FLARE

KURT KRAUS
PRINCIPAL TECHNOLOGIST

Honeywell
UOP

Callidus
Technologies

Callidus Combustion School

October 6, 2020

Everywhere Virtual

CALLIDUS FLARE EXTREME STEAM REDUCTION XSR TECHNOLOGY

- Process Steam Control
- Drone Inspection Service
- AMEL Multipoint
Ground Flare Testing
- RSR Development

Callidus Heritage in Combustion Technology World Class Test Facility

CALLIDUS FLARE EXTREME STEAM REDUCTION XSR TECHNOLOGY



4G

4G: First Major Change in Flare Combustion Technology in Decades

ELEVATED FLARE COMBUSTION TECHNOLOGY EVOLUTION

1st

Generation | Pre 1960



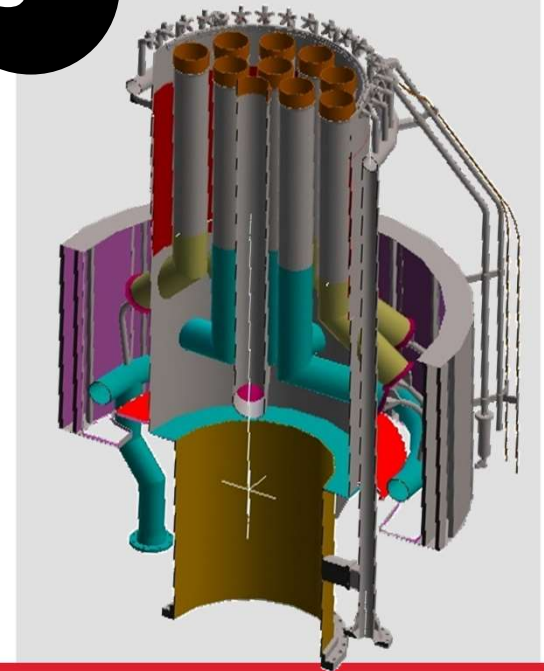
2nd

Generation | 1960



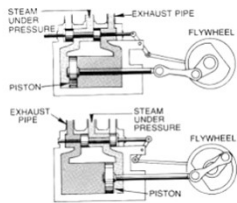
3rd

Generation | 1990's

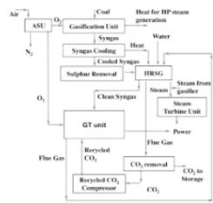


Additional Steam Used to Inspirate Air to Reduce Smoke

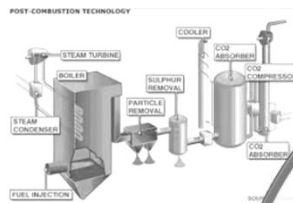
ELEVATED FLARE COMBUSTION TECHNOLOGY EVOLUTION BRAINSTORMS



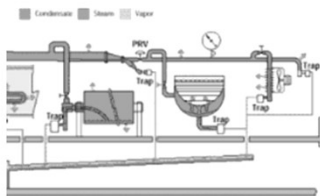
The steam engine has been a re...
pinterest.com



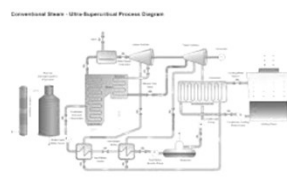
IGCC with oxy-fuel combusti...
researchgate.net



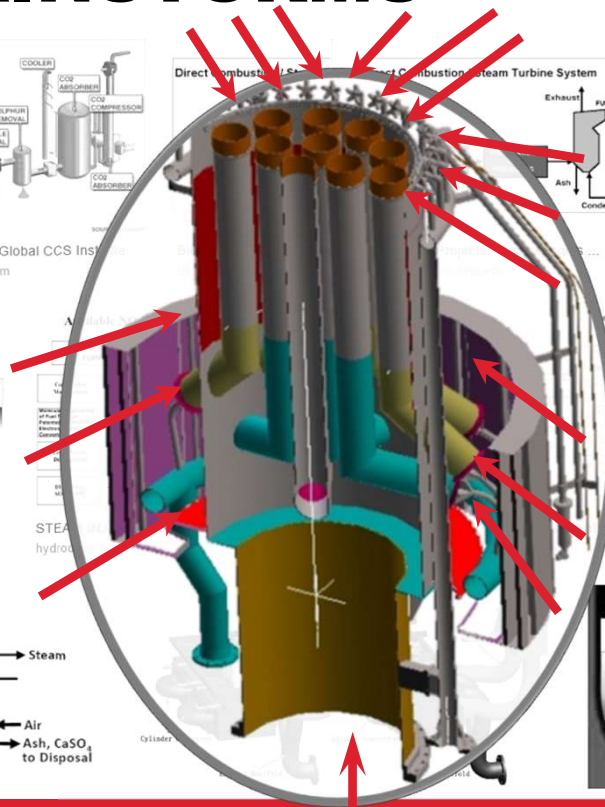
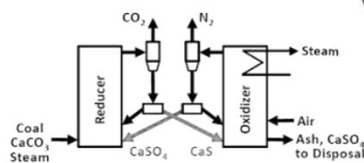
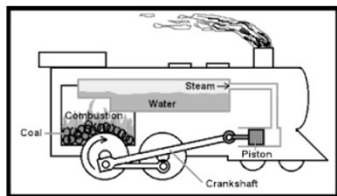
B 1 Post combustion | Global CCS Institute
hub.globalccsinstitute.com



Steam Traps, Precision Regulators ...
alignable.com



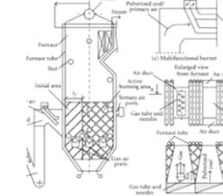
Technology Save Coal Power ...
news.thomasnet.com



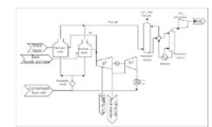
Technologies | Ex-Tar Technologies Inc.
ex-tar.com



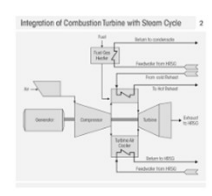
boilers and steam systems ...



PDF) Low-Temperature Com...
researchgate.net



boiler and steam turbine te...
researchgate.net



Combustion Turbines In C...
power-eng.com

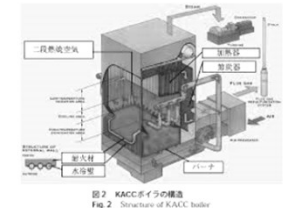
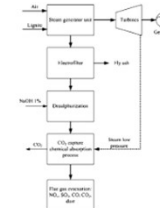
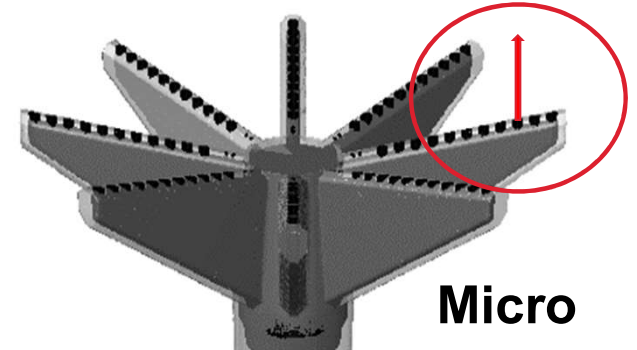
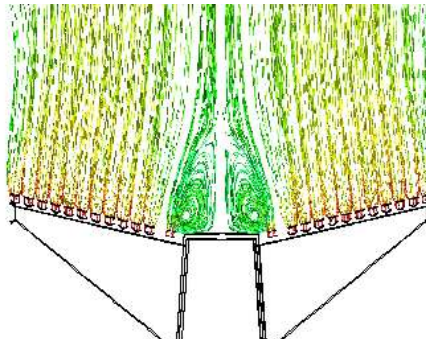
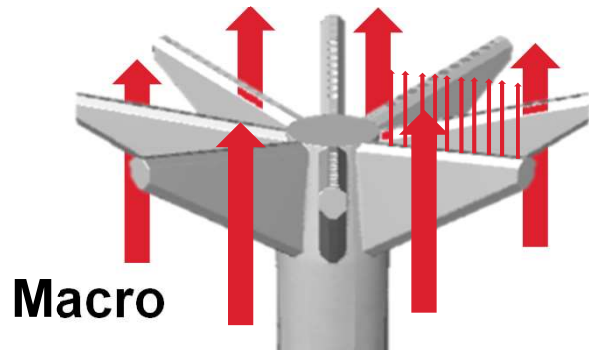


図2 KACCボイラの構造
Fig 2 Structure of KACC boiler

Concluded 4G Flare has to Be a Revolution Not and Evolution

100% SMOKELESS GROUND FLARE COMBUSTION TECHNOLOGY PATENTS APPLIED FOR



Gas Pressure Provides Mixing Energy For Smokeless Combustion

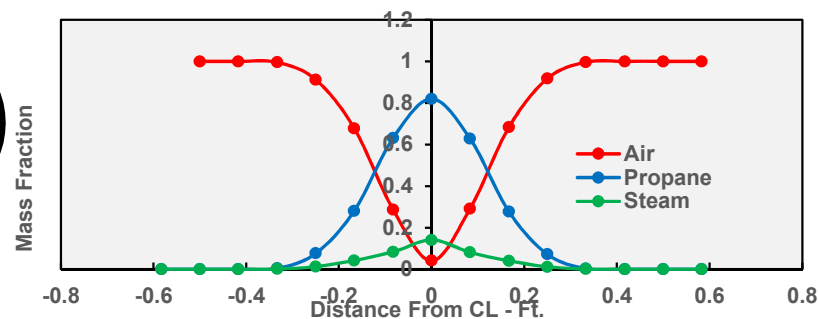
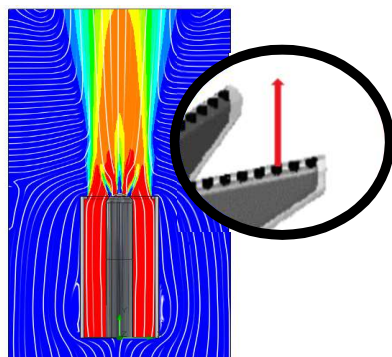
FLARE COMBUSTION PARADIGM SHIFT #1

BETTER AIR/STEAM/FUEL MIXING: MICRO STEAM JET LEVEL

4G



Steam, Gas,
Jet
Technology

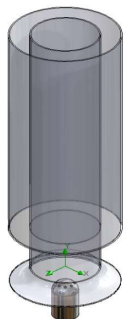


Geometry

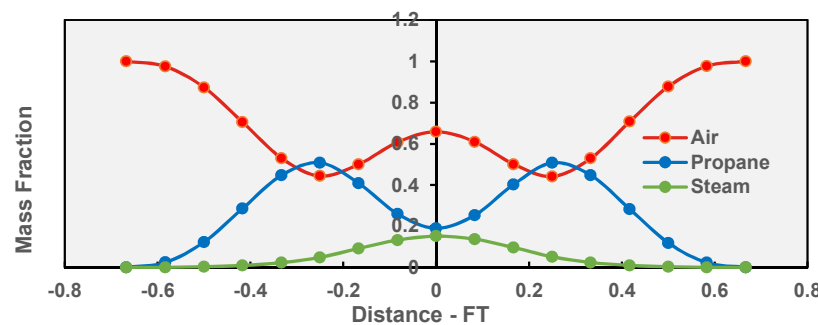
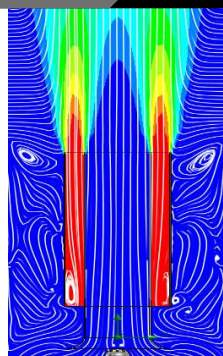
Flow

Performance

3G



Steam, Air
Mixing
Technology



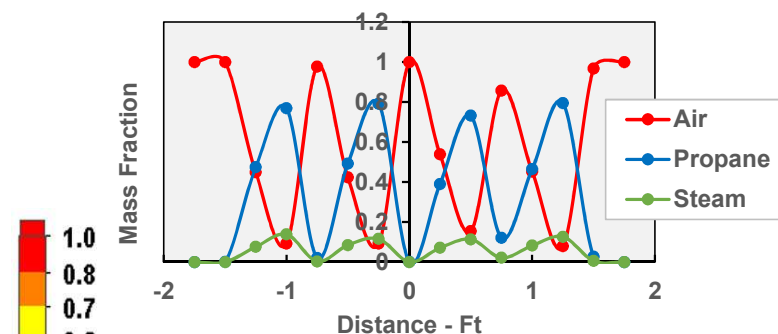
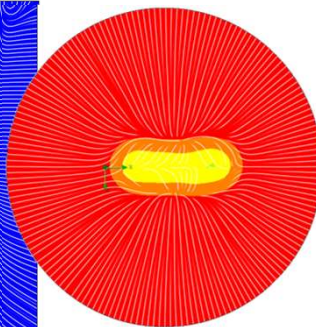
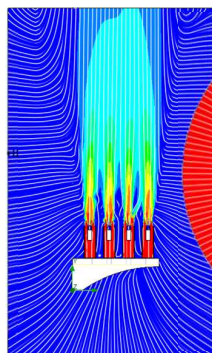
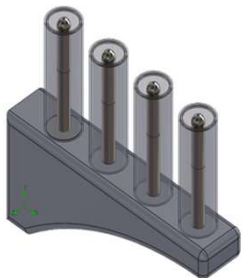
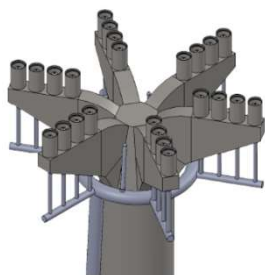
4G: Steam Used to Transfer Momentum

KK2
KK3
KK4

FLARE COMBUSTION PARADIGM SHIFT #1

BETTER AIR/STEAM/FUEL MIXING: MACRO FLARE ARM LEVEL

4G



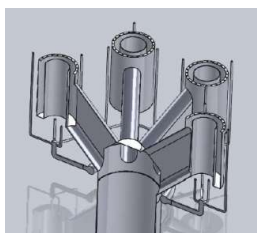
Geometry

Flow

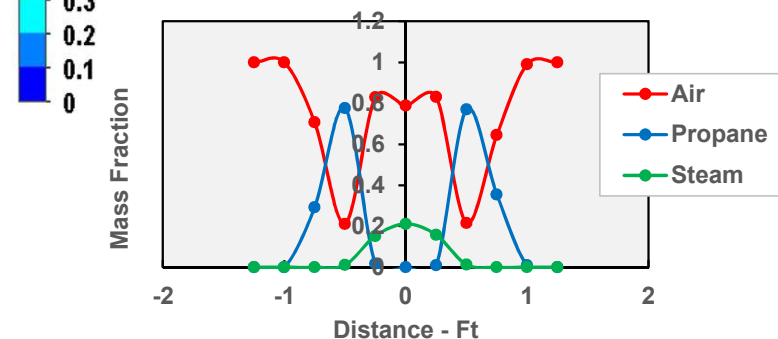
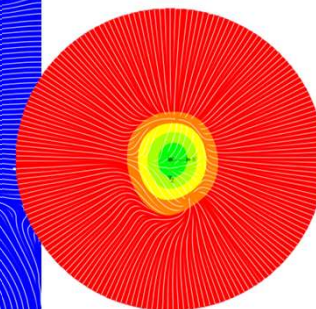
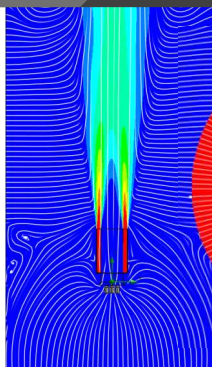
Mixing
(Mass Fraction of Air)

Performance

3G



Callidus R&D
2016



4G: Macro Level 40% Improvement in Air mixing

Slide 10

KK2 Kraus, Kurt, 9/3/2019

KK3 **Maintain Micro Mixing on a Macro level.**
Kraus, Kurt, 9/3/2019

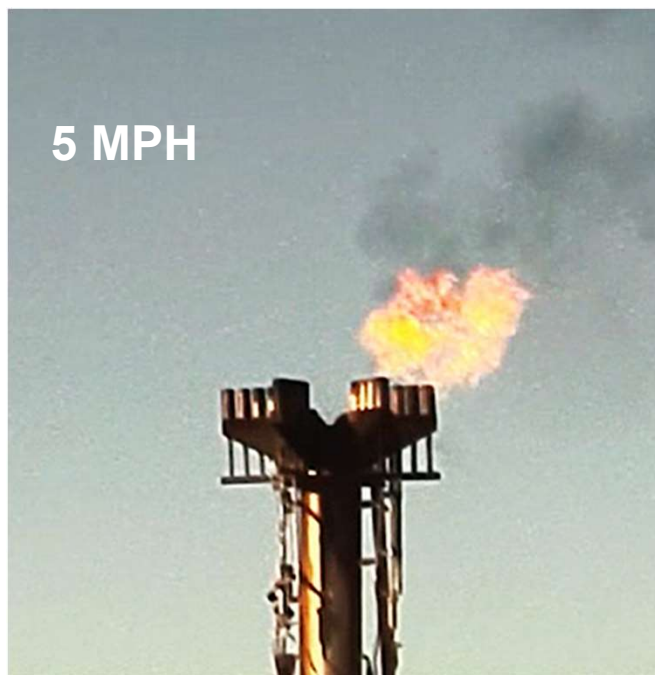
KK4 **Peaks of Steam in Sync with Peaks in Fuel, max fuel and minimum air.**
Kraus, Kurt, 9/3/2019

FLARE COMBUSTION | PARADIGM SHIFT #1:

Better Air/Steam/Fuel Mixing

**At incipient
smoke point
in low and
high wind**

**This flame is
All Burning!
Really, it is!
No Flame We
See the Steam
Plume
With**

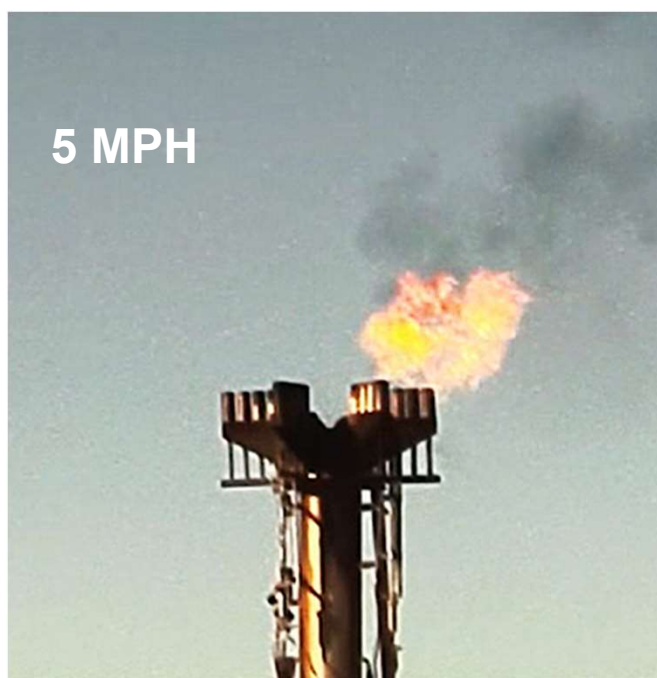


ADDED BENEFIT: No Muffler Needed, No Exposed Steam Jet, No Jet Noise

FLARE COMBUSTION | PARADIGM SHIFT #1:

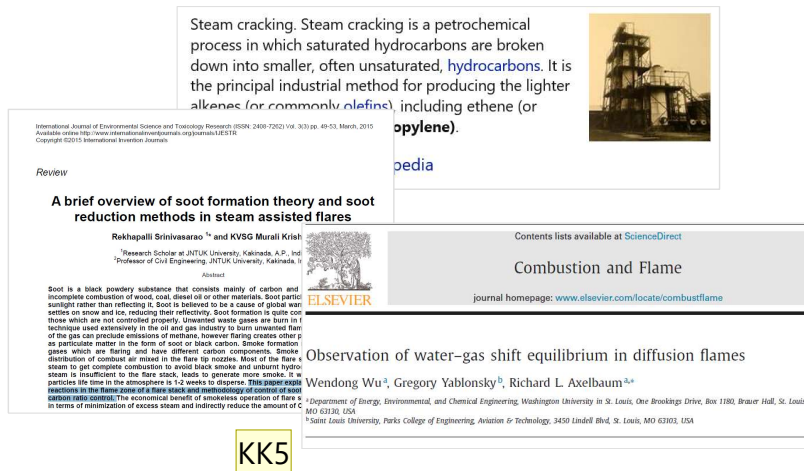
This Flame is Burning! Really, It Is!
With no flame we see the steam plume
The “invisible” flame is low emissivity blue flame

**Need to Get
Providence to
Prove Flame
is there.
Or a Flame
Scanner
Williams.**



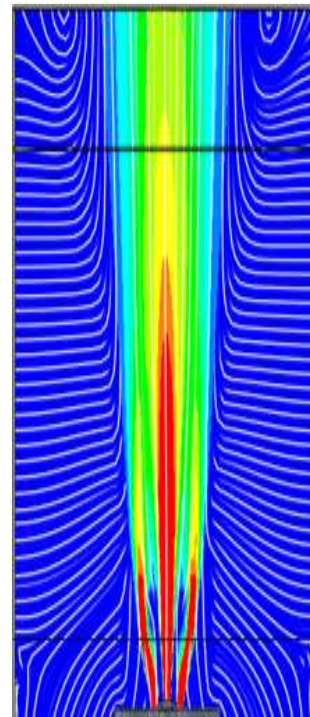
ADDED BENEFIT: No Muffler Needed, No Exposed Steam Jet, No Jet Noise

FLARE COMBUSTION | PARADIGM SHIFT #2: Water Gas Shift Reaction

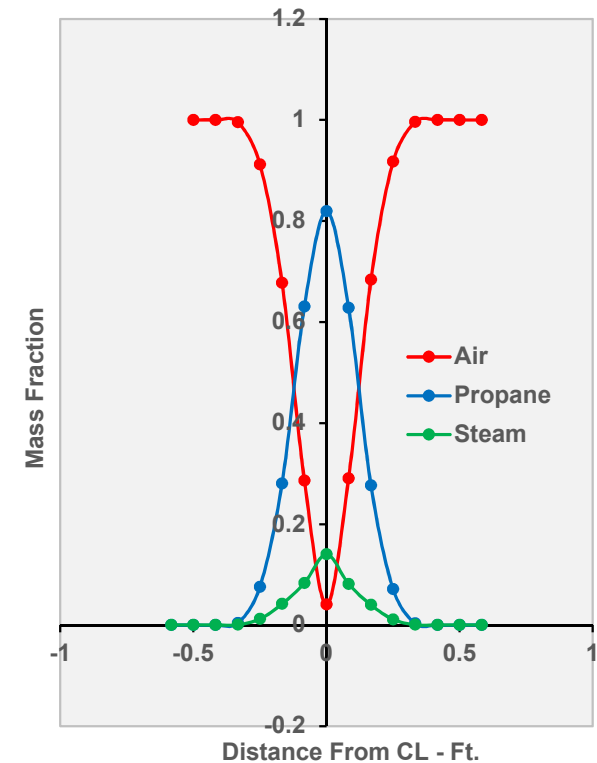


“Water Gas Shift Reaction”

Used by adjacent combustion industries: Thermal Oxidizers, Process burners, Aerospace, etc. recognize that water injection into fuel results in significant combustion improvement and NO_x reduction.



Steam



4G: Steam Used to Enhance Combustion Reactions

Slide 13

KK5 Maximize Steam and Hydrocarbon Mixing and minimize steam and air mixing
Kraus, Kurt, 9/3/2019

FLARE COMBUSTION | PARADIGM SHIFT #2:

Water Gas Shift Reaction

KK1

WGSR occurs after carbon monoxide (CO) is formed by partially combusting the hydrocarbons with the reforming reaction (R1):



This enables WGSR, which is a moderately exothermic reversible reaction expressed by:



These reactions (R1) and (R2) are intermediate reactions of the overarching hydrocarbon combustion reaction:



The reforming products are finally combusted:



But the really interesting mechanisms are happen with the partial products of the WGSR inside the double arrows ' \leftrightarrow ' of (R2). It is here where the highly reactive H⁺ and OH-free radicals are joining the already present and highly reactive CO.

4G: Steam Used to Enhance Combustion Reactions

KK1 WGSR works within the hydrocarbon combustion process by reducing activation energies, solvating, and catalysing, thereby accelerating the disassociation of carbon-carbon and carbon-hydrogen bonds. Hydrocarbons, particularly unsaturated hydrocarbons, are burned more easily, fully and rapidly with intimately present and thoroughly mixed water. Further, it is much more effective to mix water with the fuel at elevated temperatures than it is to mix steam with air before entering the hydrocarbon stream.

Kraus, Kurt, 8/31/2019

4G VS 3G | PRODUCT COMPARISON MATRIX

Feature: Steam Consumption	4G nViro-XSR	3G API 521 Average		Reduction
Steam-to-Hydrocarbon Ratio (Propane)	0.12	0.3	↔	60%
Steam-to-Hydrocarbon Ratio (Propylene)	0.18	0.55	↔	67%
	↕	↕		
Increase Paraffin to Olefin	50%	83%		

Feature: Full Range Smokeless Capacity	4G nViro-XSR	3G API 521 Average		4G Increase
Vent Gas Flow at Smokeless Maximum/ Maximum Flow (Propane)	100%	22%	↔	354%
Vent Gas Flow at Smokeless Maximum/ Maximum Flow (Propylene)	100%	12%	↔	733%
Across Entire Operating Range: Standby to Full Load	↕	↕		
Capacity Loss Olefin to Paraffin	0%	45%		

*Publicly published S/HC ratios. Smokeless maximum is based on ratio of S/HC to the nViro-XSR.

Note: Smokeless maximum based on a 5 Psig back pressure limit.

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DIRECT EVIDENCE OF WATER GAS SHIFT REACTION WGSR AT WORK

Feature: Full Range Smokeless Capacity	4G nViro-XSR Steam	4G nViro-XSR Nitrogen		Increase
Inert-to-Hydrocarbon Ratio (Propane)	0.12	0.16	↔	33%
Inert-to-Hydrocarbon Ratio (Propylene)	0.18	0.25	↔	39%
Standby to Full Load	↕	↕		
Increase Paraffin to Olefin	50%	56%		

*Publicly published S/HC ratios. Smokeless maximum is based on ratio of S/HC to the nViro-XSR.

Note: Smokeless maximum based on a 5 Psig back pressure limit.

WGSR Works Within the Hydrocarbon Combustion Process By:

- Reducing Activation Energies
- Solvating and Catalyzing
- Thereby Accelerating the Disassociation Of Carbon-Carbon and Carbon-Hydrogen Bonds

Hydrocarbons, particularly unsaturated hydrocarbons, are burned more easily, fully and rapidly when there is intimately present and thoroughly mixed water.

HOW MUCH IS DUE TO BETTER MIXING, PARADIGM SHIFT #1 VS. WGSR, PARADIGM SHIFT #2

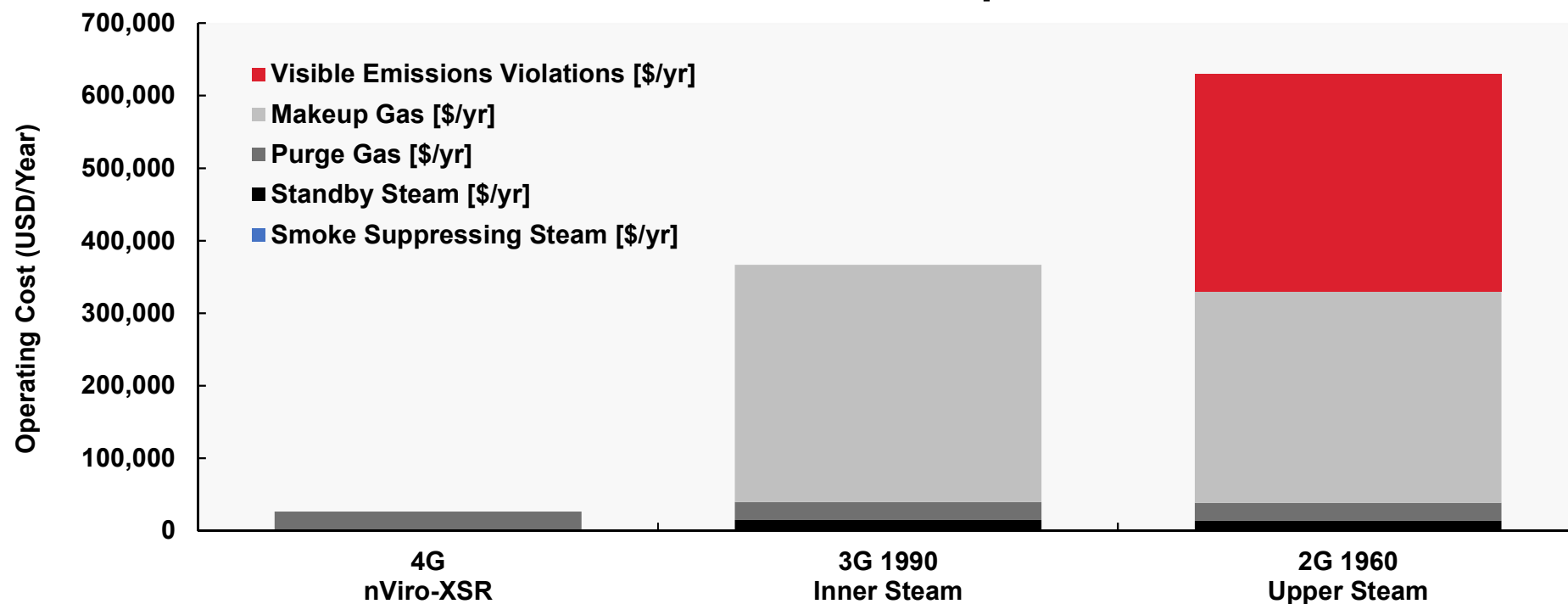
Feature	4G nViro-XSR Steam	4G nViro-XSR Nitrogen	3G API 521 Average		Due to Mixing - PS1	Due to WGSR - PS2
Inert-to-Hydrocarbon Ratio (Propane)	0.12	0.16	0.30	↔	78%	22%
Inert-to-Hydrocarbon Ratio (Propylene)	0.18	0.25	0.55	↔	81%	19%
	↑↓	↑↓	↑↓			
Increase Paraffin to Olefin	50%	56%	83%			

*Publicly published S/HC ratios. Smokeless maximum is based on ratio of S/HC to the nViro-XSR.

Note: Smokeless maximum based on a 5 Psig back pressure limit.

4G XSR TECHNOLOGY OPERATING COST

One Year OPEX Comparison



Note: Based on average flaring behavior of 2005-2015 SCAQMD refineries with 2 flares assumed and optimal flare selection. OPEX is per flare. Standby steam rate for 'Competitor' is assumed based on general practice. Price of Purge Gas [\$/MMBtu] \$2.93. Steam \$0.0033 / 1000lb

EXCELLENT COLD WEATHER OPERATION: NO ICE BUILDUP ON FLARE TIP | PARADIGM SHIFT #3

- Steam is Never Mixed with Cold Air Being Pushed Into Flare Tip
- Steam Piping Is Inside the Flare tip, Heating Up Inside the Flare Tip
- No Center Steam
- All Steam Exits the Flare Tip
- Here the steam was run overnight in zero degree weather
- No Assist Gas, Just Steam
- Pilot off

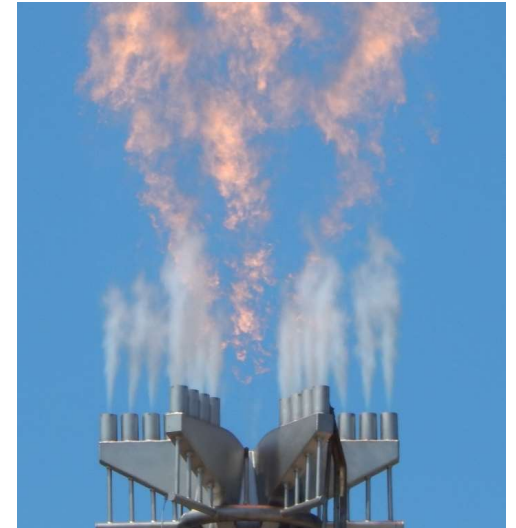
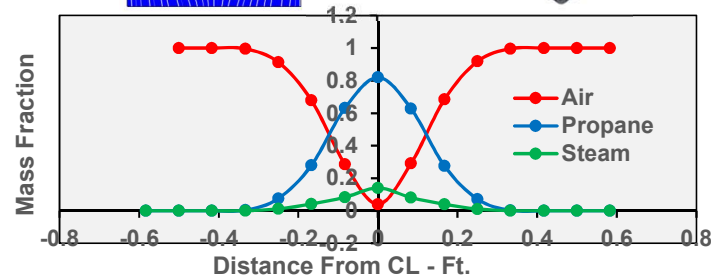
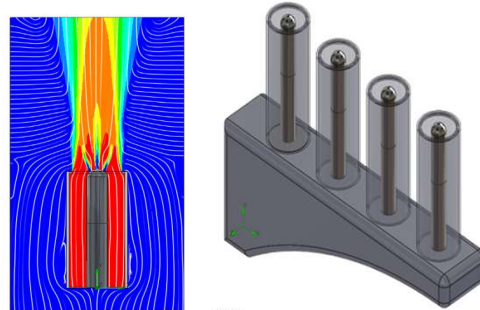


CALLIDUS NVIRO 4G COMBUSTION TECHNOLOGY REVIEW

4G
Technology

Steam, Gas,
Jet Technology

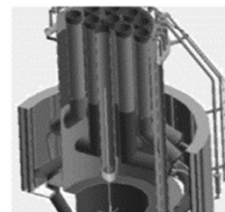
Water-Gas
Shift
Chemistry



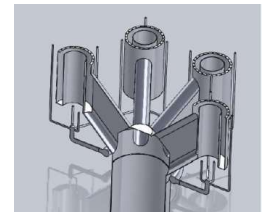
3G

Steam,
Air Mixing
Technology

Callidus
IS³
1990's



Callidus
R&D
2016



Up to 67% Less Steam and over 700% Greater Smokeless Means < 1 Year ROI

CALLIDUS FLARE TECHNOLOGY

- Process Steam Control
- Drone Inspection Service
- AMEL Multipoint
Ground Flare Testing
- RSR Development

Callidus World Class Flare Test Facility

CALLIDUS FLARE TECHNOLOGY

BURNERS

Matt McSpadden

Jesse Chambers

PARTS

Debra Wenaas

Brian Yeates

Albert Septiano

FLARES

Steve Freimuth

Kurt Kraus



Email: CallidusPartsInquiries@Honeywell.com

CALLIDUS COMBUSTION SCHOOL
October 8, 2020

EXPERION® **FLARE WATCH** **SMART FLARE** **MONITORING** **ANALYTICS**

KURT KRAUS

VIRTUAL, ONLINE, EVERYWHERE

Honeywell
UOP | Callidus
Technologies



SMART FLARE MONITORING BENEFITS

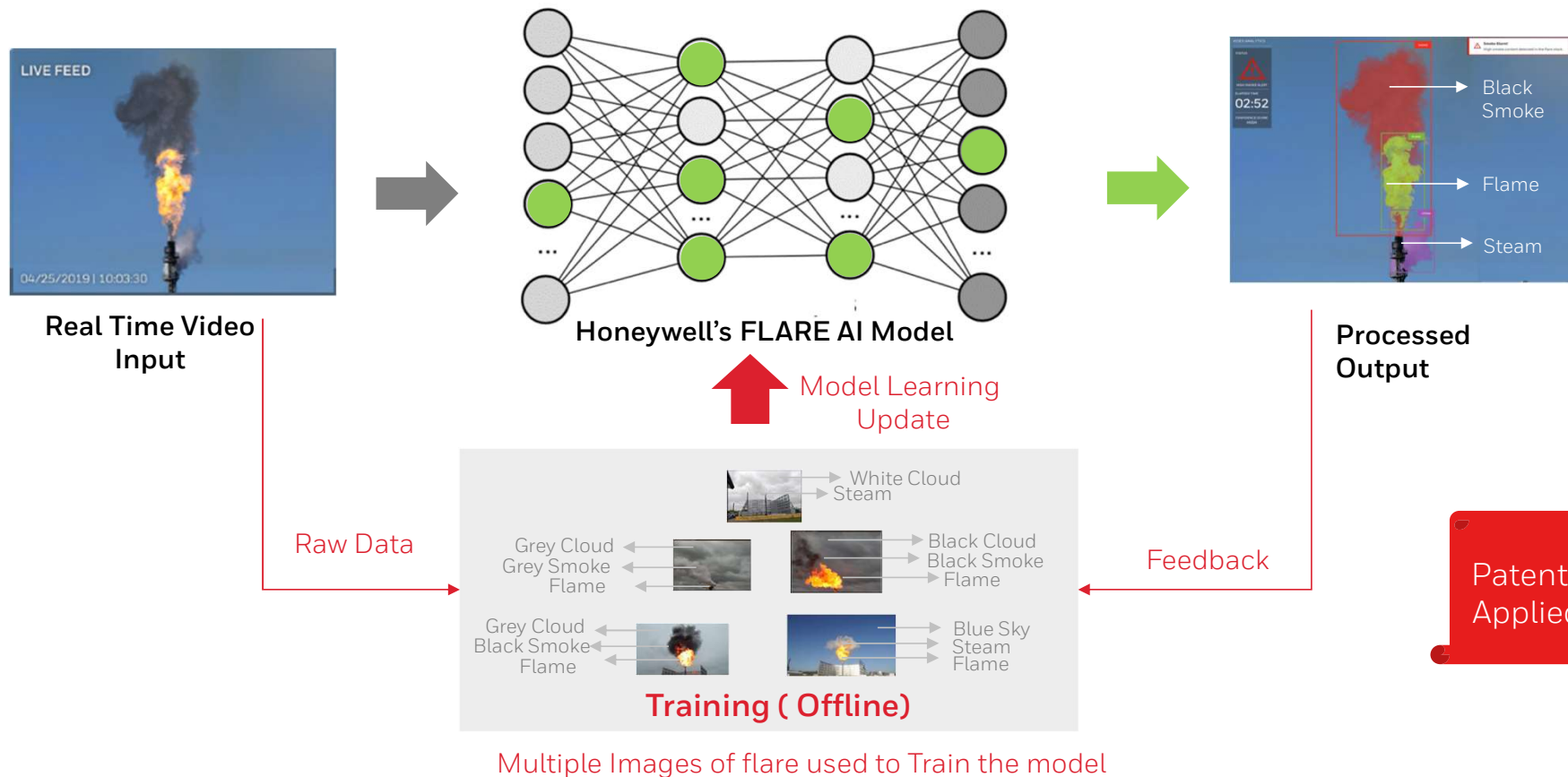
- Reduce Operator Load in continuously monitoring flare
 - Enable multi tasking while enabling efficient flare monitoring
- Help's Reduce Environmental Non-Compliance Incidents like black smoke
 - Real time alerts to operator enable faster corrective actions.
- Saves Hours of Manual Efforts in searching videos for events.
 - Recorded Event Data enable's analysis & reporting of flare events

Secure and Easy Access to multiple stake holders

- Browser based client enable easy access to multi stakeholders – Operations, HSE

Enhancing Flare Monitoring Efficiency, Compliance

HONEYWELL'S AI BASED FLARE MONITORING ANALYTICS



FLARE ANALYTICS CHALLENGES

- Complex Background (sky color and cloud cover)
- Windy conditions
- Challenging Lighting Conditions
- Low Visibility due to Weather Condition
- Continuously Changing Flare Size

Examples of Challenging Scenarios :



Traditional Video Analytics Would Not Work For Flare

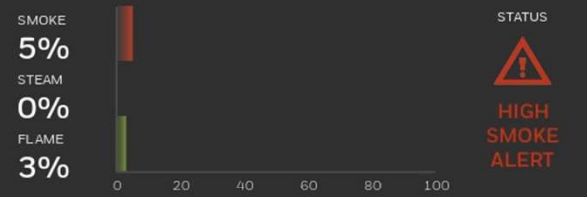
MITIGATED EVENTS

27

MISSED ALARMS

13

CONTENT STATUS/SET THRESHOLD



EVENT LOG

Day Week Month Year

SITE ENGINEER
Engineer XXXXX

ADDRESSAL TIME
2:30 pm

ACTION TAKEN
Details of action taken.



VIDEO ANALYTICS

STATUS



HIGH SMOKE ALERT

ELAPSED TIME

1:30

CONFIDENCE SCORE

HIGH

SMOKE

FLAME



Site: Demo Site (Bangalore)

90F | Sunny

NE 25 km/h

2019-06-05

16:22:47



SMART FLARE MONITORING USER INTERFACE

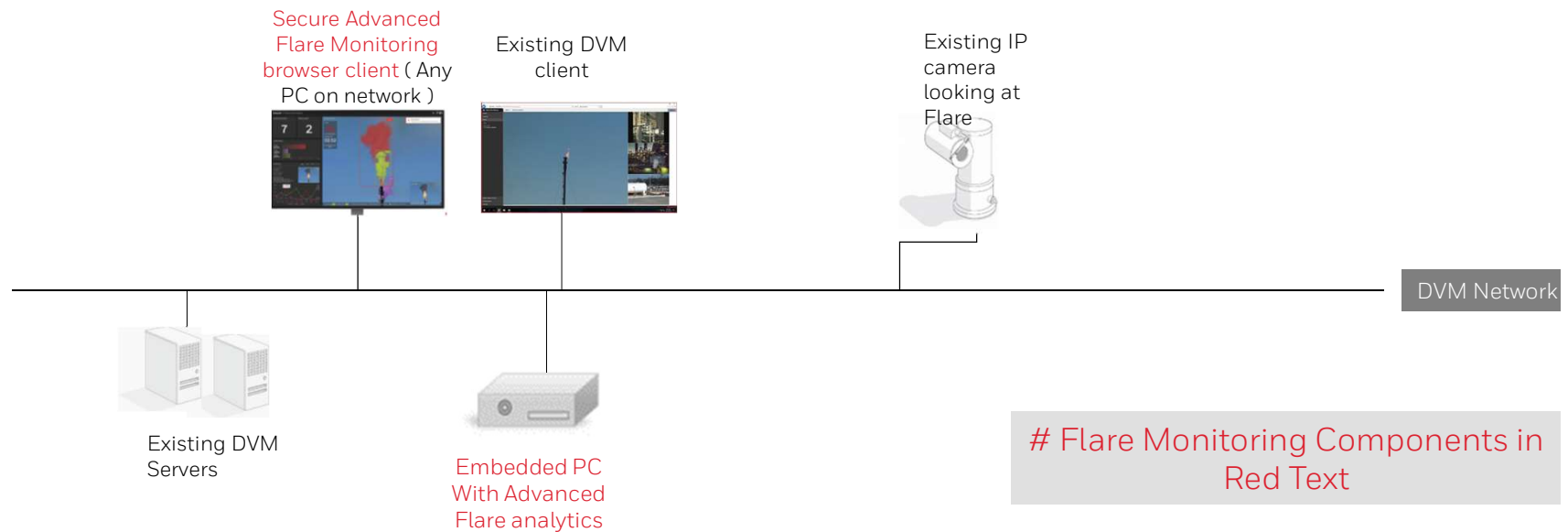


Patents
Applied

* This is early version of UI – Functionality may change in final release.

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SMART FLARE MONITORING TYPICAL SETUP



- No disturbance to existing flare monitoring setup and DVM system.
- A parallel stream from the IP camera would be configured in flare analytics box.
- Flare analytics client can be accessed via browser on any PC having access configured to the system.

Email: CallidusPartsInquiries@Honeywell.com



BURNERS	PARTS	FLARES
Matt McSpadden	Debra Wenaas	Steve Freimuth
Jesse Chambers	Brian Yeates	Kurt Kraus
	Albert Septiano	

READY TO SUPPORT YOUR OPERATIONAL NEEDS



CASE STUDY: THE **GALAXY™** MULTIPOINT GROUND FLARE BURNER

TOM RAPPSILBER
ENGINEERING MANAGER

Honeywell
UOP

October 8, 2020 | 2020 Combustion School | Virtual Presentation

GALAXY MULTIPOINT GROUND FLARE BURNER



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GALAXY MULTIPOINT FLARE BURNER

Galaxy Burner Overview:

- **Smokeless under all operating conditions**
- **Extensive destruction efficiency testing**
- **No visible flame at full load**
- **Already approved by the EPA for use in Multi-Point Ground Flares**
- **Pre-Tested for a wide variety of vent gases**



GALAXY ADVANTAGES

Shorter Flame

Higher flow rate reduces the number of burners required

Reduced Heat on Runners increases longevity

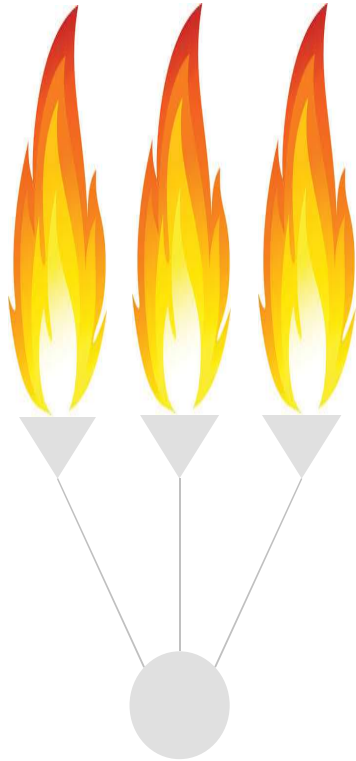
Improved Smokeless Performance

Higher Heat Density Reduces Plot Space



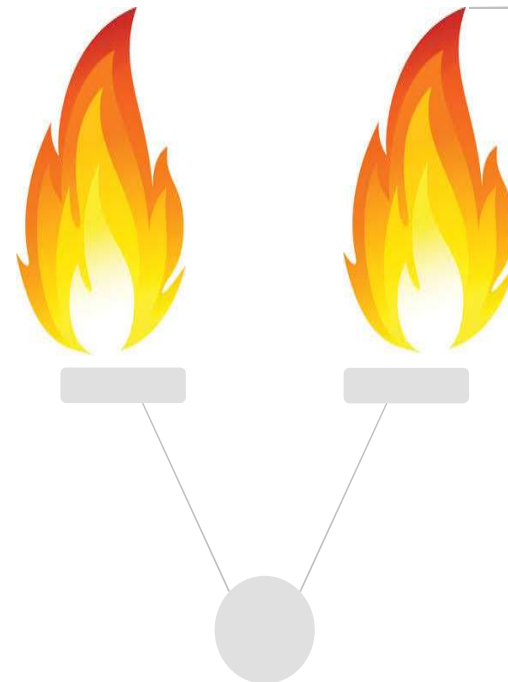
INCREASED FLOW – LOWER FLAME

60' ELEVATION



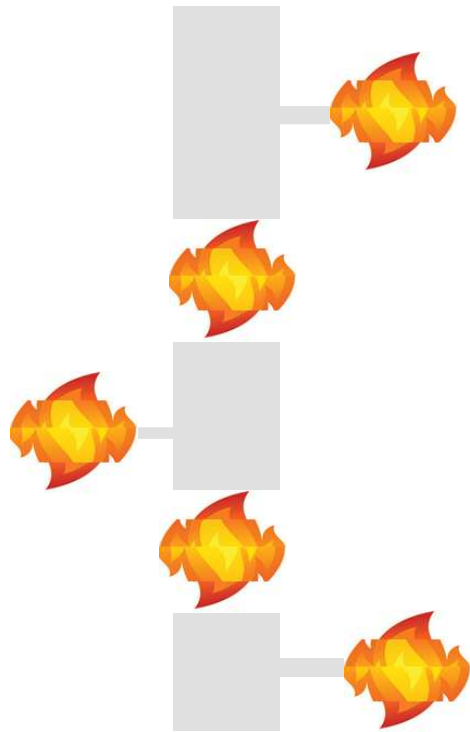
MP-4U Burner 100% Flow

45' ELEVATION

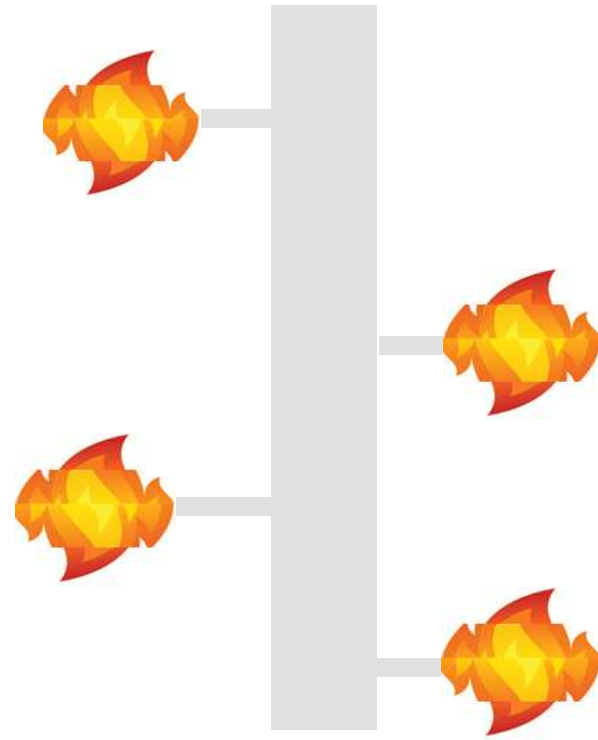


New Technology – Galaxy Burner 175% Flow

REDUCED HEAT ON RUNNER

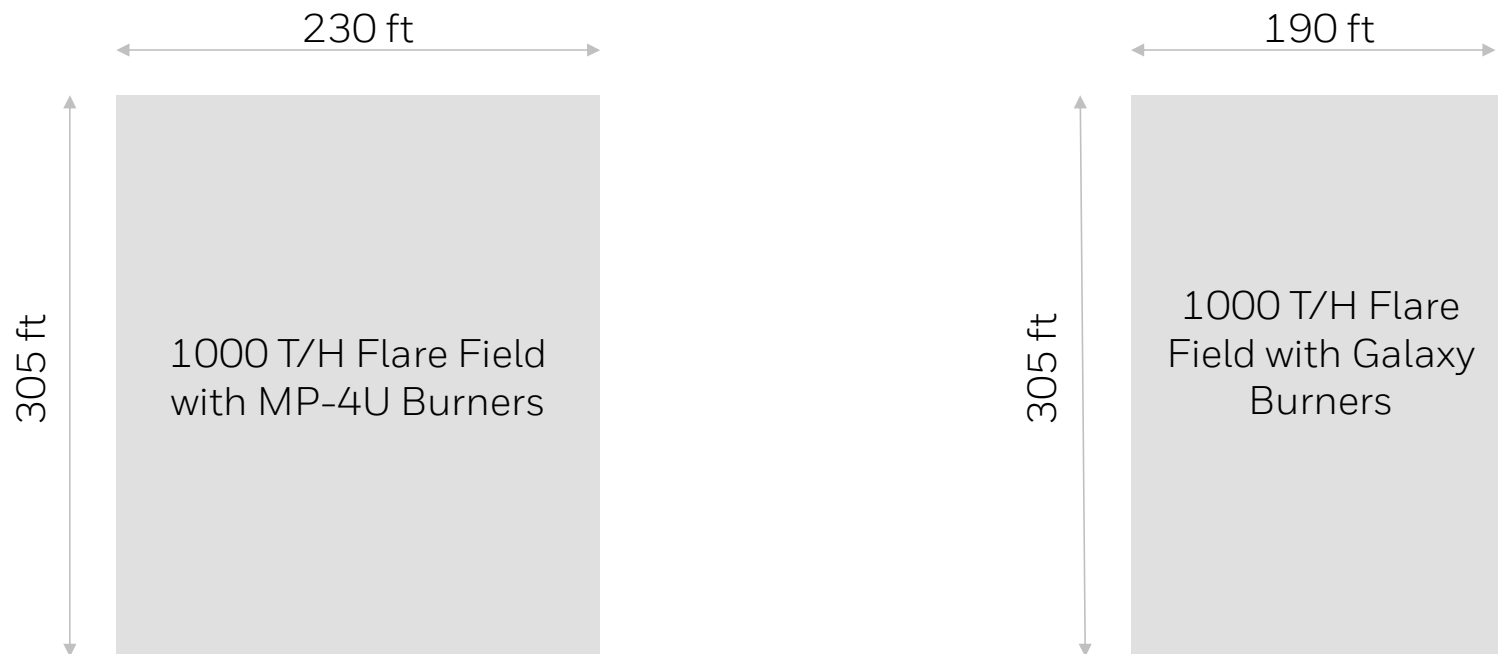


MP-4U Burner



New Technology – Galaxy Burner

REDUCED PLOT SPACE REQUIREMENTS



Galaxy Burners Reduce Plot Space by 18%

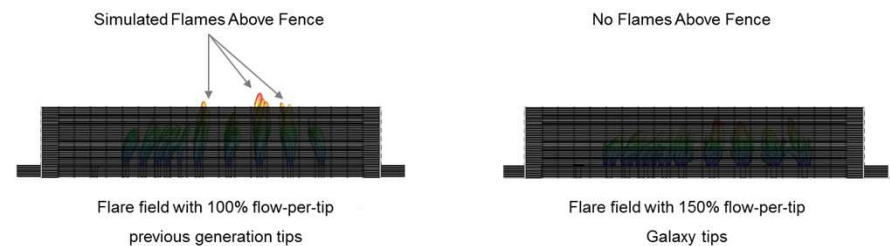
REDUCED MULTI-BURNER FLAME LENGTH

Unique patent pending design

Designed to work in conjunction with multiple flare burners as a system.

Designed to maintain flame length as more burners come online

Proven in CFD and testing



Flame Length Maintained During High Flow

REDUCED MULTI-BURNER FLAME LENGTH

Unique patent pending design

Coalesced flame length comparison of a Steam Assisted MP4-UI, and unassisted Galaxy burners in same field.

- 9 Galaxy burners operating at $>2X$ the flow rate as the 3 steam assisted burners, with significantly shorter flame length, at same operating pressure.



Flame Length Maintained During High Flow

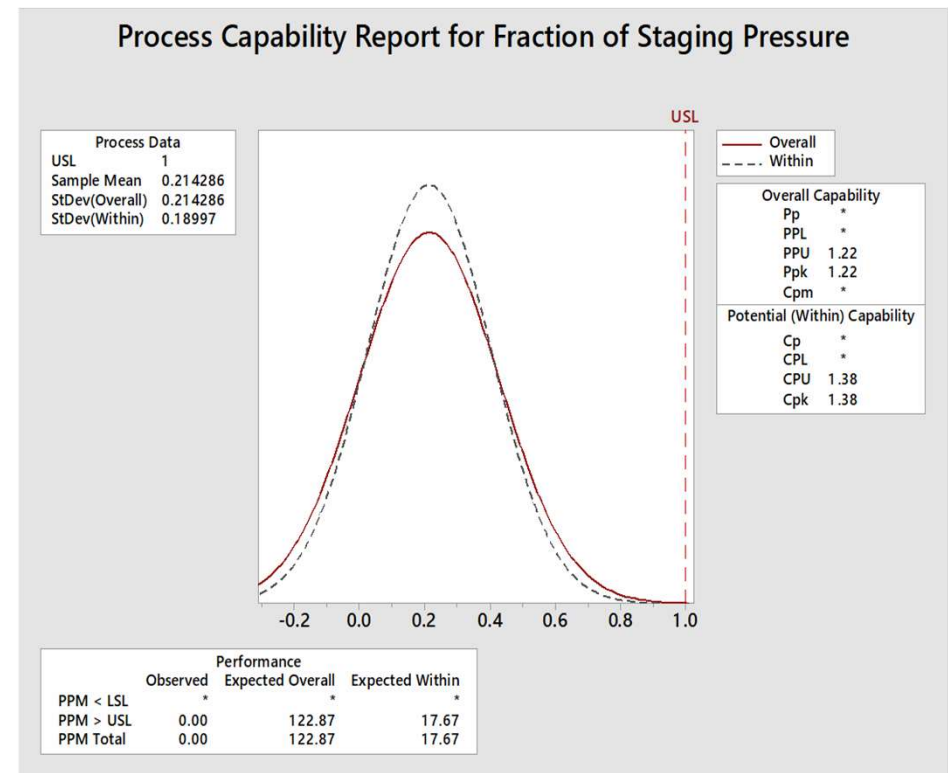
IMPROVED SMOKELESS OPERATION

Tested with no smoke at 42% of de-stage pressure on propylene

Allows for fewer burner heads

Reduced chance of smoking

Increases capacity due to wider range of operation

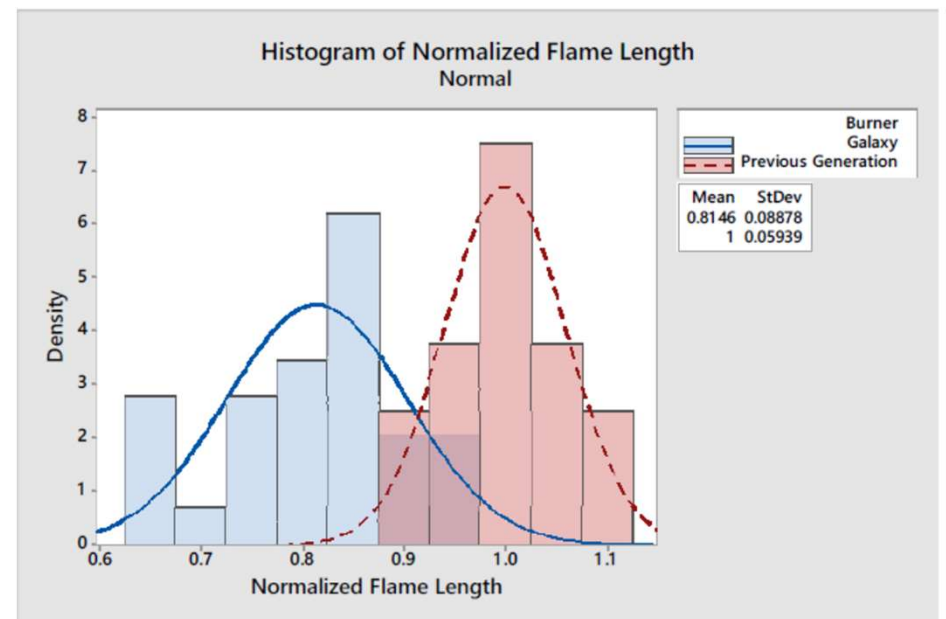


Lower Pressure Before Smoke Onset

REDUCED SINGLE BURNER FLAME LENGTH

At 150% flow rate compared to previous generation of burners the flame is 20% shorter

Tested across multiple vent gas types



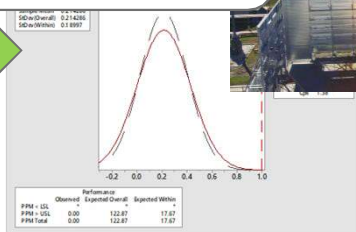
Shorter Flames Across All Operating Conditions

GALAXY PERFORMANCE

No Visible Smoke



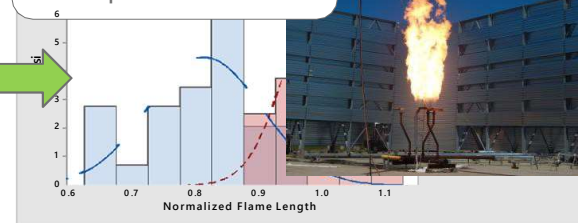
Performance Testing
< 28 kPa Smokeless
Pressure for all waste
with > 99% Confidence



No Visible Flame



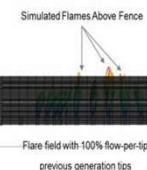
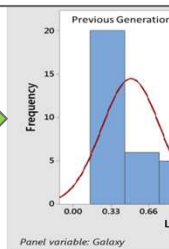
Shorter Flame
Physical Test and
Computer Simulation



Reliable Ignition with Low
Noise



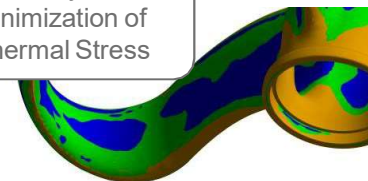
31% Improvement in Flame
Ignition Rate at < 1 Second



Reliable Design



FEA Analysis and
Minimization of
Thermal Stress



Email: CallidusPartsInquiries@Honeywell.com

BURNERS

Matt McSpadden

Jesse Chambers

PARTS

Debra Wenaas

Brian Yeates

Albert Septiano

FLARES

Steve Freimuth

Kurt Kraus

Q&A

