WELCOME TO THE
CALLIDUS COMBUSTION SCHOOL 2020

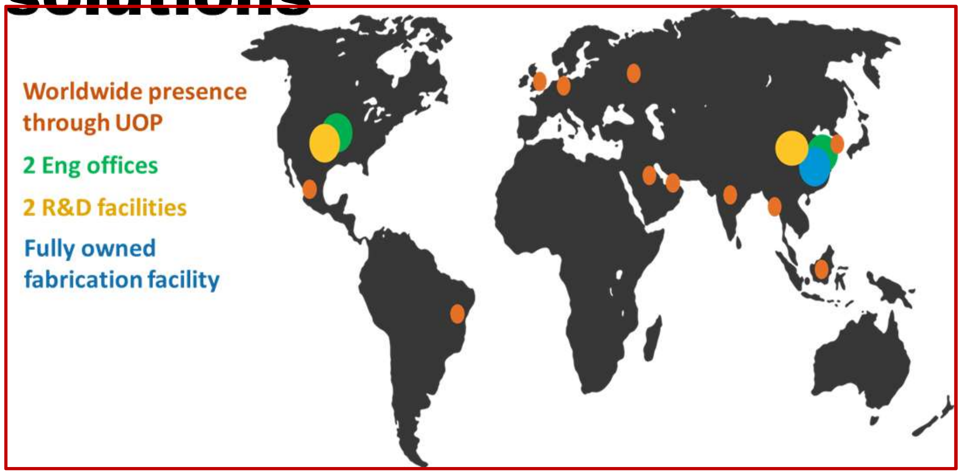
YOU ARE AT THE RIGHT PLACE, PLEASE WAIT A MOMENT AND THE PRESENTATION WILL BEGIN AT THE APPOINTED TIME

CallidusPartsInquiries@Honeywell.com

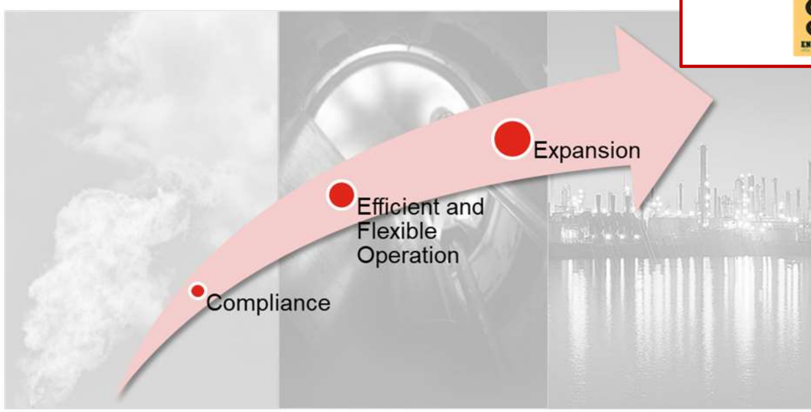
CALLIDUS
30 YEARS of INNOVATION
TECHNOLOGIES

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

CALLIDUS 30 YEARS of INNOVATION TECHNOLOGIES




BASIC COMBUSTION & GENERAL HEATER OPERATIONS

STEFANO BIETTO
SENIOR BUSINESS LEADER

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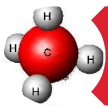
Basic Combustion



Fuels

Combustion Air

Draft

Burner Definition

Process Heaters

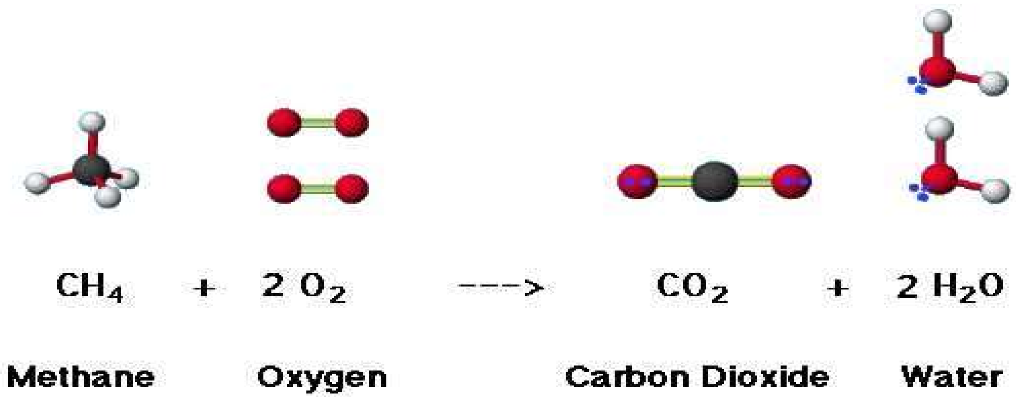
Heat Transfer

WHAT IS COMBUSTION?

A chemical reaction between fuel and oxygen producing heat.

Air is usually the source of oxygen.

The chemical reaction produces "flue products."



+ Heat

EXAMPLE: COMBUSTION OF METHANE

Heat

Fuel | Combustion Air | Products of Combustion

$$CH_4 + 2O_2 + 7.5N_2 \rightarrow CO_2 + 2H_2O + 7.5N_2$$

FUELS - TYPICAL GASEOUS FUEL COMPONENTS

- Methane – CH_4
- Ethane – C_2H_6
- Ethylene – C_2H_4
- Propane – C_3H_8
- Propylene – C_3H_6
- Butane – C_4H_{10}
- Pentane – C_5H_{12}

- Hydrogen – H_2
- Carbon Monoxide – CO
- Hydrogen Sulfide – H_2S
- Ammonia – NH_3
- Carbon Dioxide – CO_2
- Nitrogen – N_2
- Water Vapor – H_2O

FUELS - BRITISH THERMAL UNIT

The British Thermal Unit is the amount of heat required to raise the temperature of one pound of water 1°F.

1 Btu/hr = 0.29 W

1,000,000 Btu/hr = 0.29 MW

FUELS - HEATING VALUES

Higher (Gross) Heating Value (HHV)

- The total heat available from combustion of a fuel with a source of oxygen, both 60°F when combustion starts, after combustion is complete

Lower (Net) Heating Value (LHV)

- The higher heating value minus the latent heat of vaporization of the water vapor formed by the combustion of hydrogen in the fuel

Burners in Process Heaters applications are usually specified in LHV

FUELS - HEATING VALUES

Heating Value in Btu/ft^3	LHV	HHV
Methane (CH_4)	911	1012
Ethane (C_2H_6)	1622	1773
Propane (C_3H_8)	2322	2524
Butane (C_4H_{10})	3018	3271
Hydrogen (H_2)	275	325
Carbon Monoxide (CO)	321	321

COMBUSTION AIR

Dry air is primarily a mixture of oxygen and nitrogen with approximately 21% oxygen and 79% nitrogen

The other major component of air is water vapor. For high ambient temperature the water vapor content of moist air can approach 5%. Significant water vapor in combustion air will affect burner performance.

TYPES OF FUEL/AIR MIXTURES

= Stochiometric Mixture

Lean Mixture (Too Much Air) +

− Rich Mixture (Too Much Fuel)

TYPES OF FUEL / AIR MIXTURES

Stoichiometric Mixture

- What can occur if you operate with the exact amount of air?
  - If fuel conditions change may run burner out of air
  - The mixing residence time in a furnace is limited, may not get good mixing before leaving the radiant section

Lean Mixture (excess air)

- What can occur if you operate with too much excess air?
  - The furnace will operate inefficient (will take more heat input to heat up the excess volume of air

Rich Mixture (excess fuel)

- What can occur if you operate with too little excess air?
  - Will generate CO
  - Could be unsafe operating conditions

LEAN MIXTURE (EXCESS AIR)

When air is supplied in an amount that is in excess of the amount required to complete the combustion reaction with the fuel, the additional air is called excess air. The following chemical equation illustrates the burning of methane with 20% excess air.

$$CH_4 + 2.4O_2 + 9.0N_2 \rightarrow CO_2 + 2H_2O + 9.0N_2 + 0.4O_2 + \text{Heat}$$

Excess Oxygen

PROCESS BURNER (AIR REQUIREMENTS)

For a specified burner heat release, the quantity of air required is essentially the same for all hydrocarbon fuels and fuel mixtures. When a significant quantity of hydrogen is present, the required air will be less.

Rule of thumbs (hydrocarbon fuels):

- 1 MMBtu/hr requires 10,000 ft^3 of air.
- The excess air is approximately five times the measured oxygen in the dry combustion products if no inert components are present in the fuel.

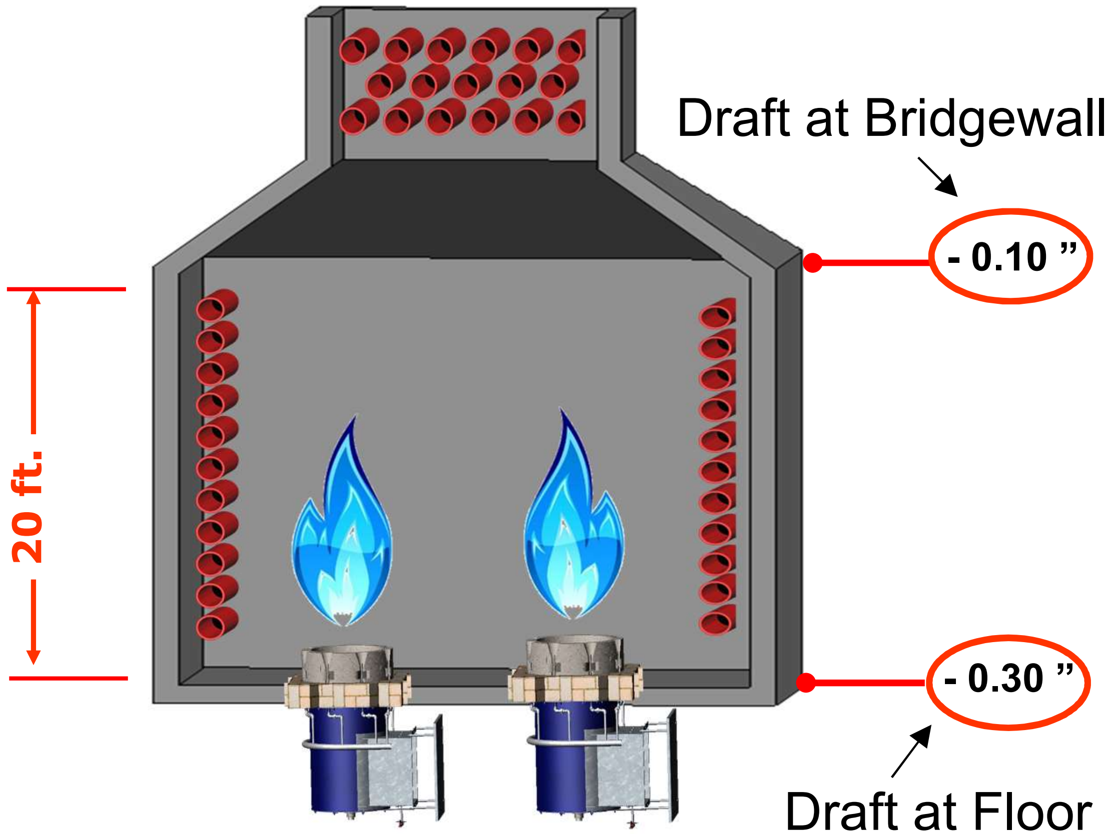
DRAFT – HEATER STACK

Two major purposes served by the stack:

1. Provide a point of discharge for combustion products

2. Provide a negative pressure inside the furnace

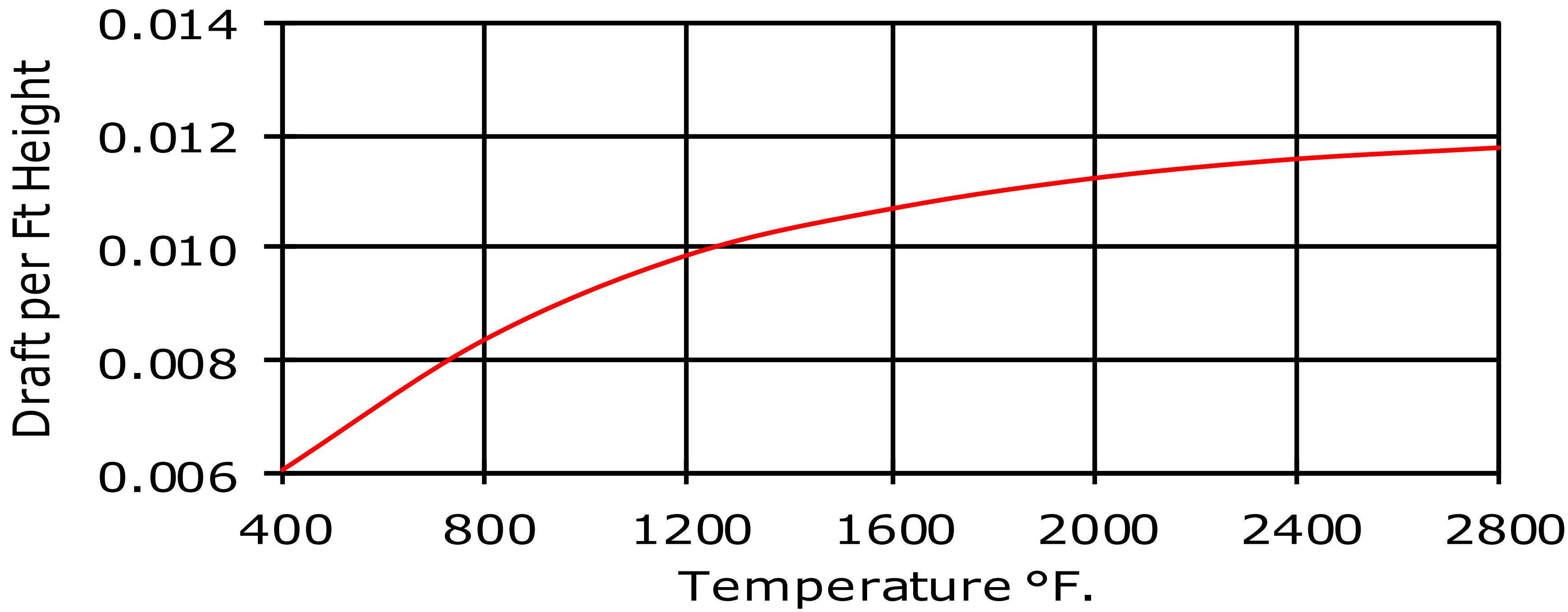
DRAFT - PROCESS HEATER



Rule of Thumb:

Draft increase 0.10” w.c. for every 10’ of radiant box height

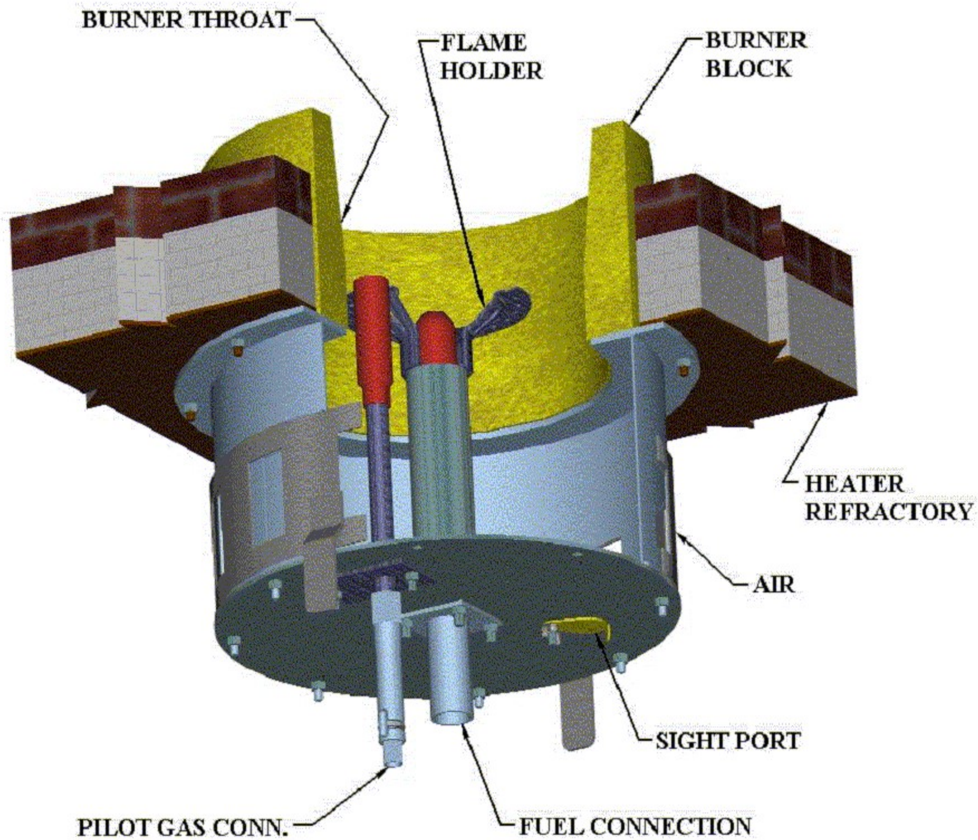
PROCESS HEATER (DRAFT)



PROCESS BURNER (DEFINITION)

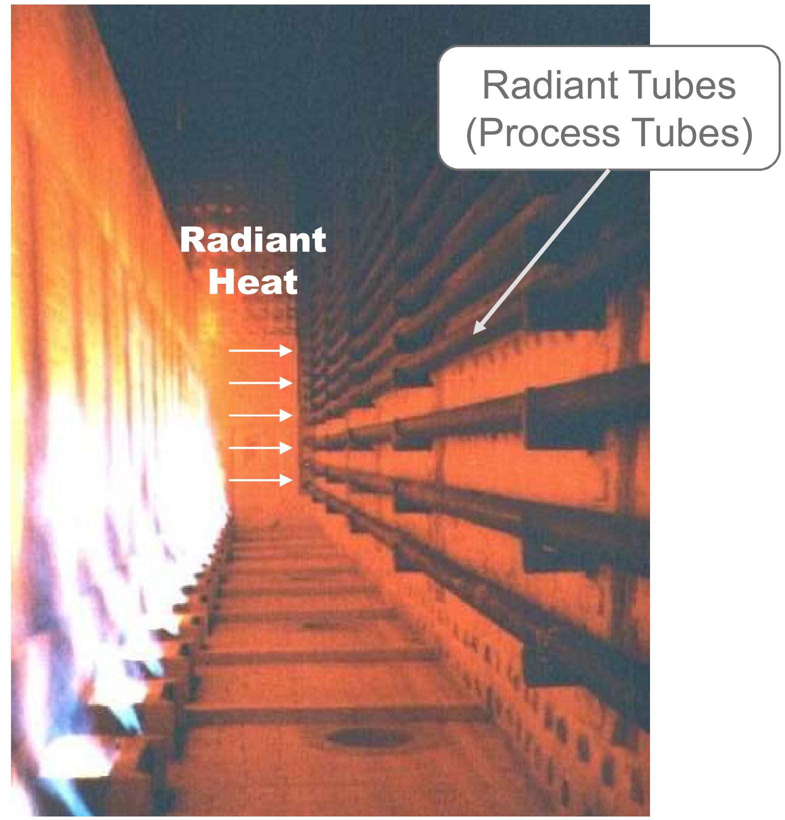
A burner is a device that delivers fuel and air in proper proportions and with sufficient mixing energy to a combustion zone where continuous ignition, complete combustion, and proper positioning of the flame is maintained.

PROCESS BURNER (TYPICAL BURNER)

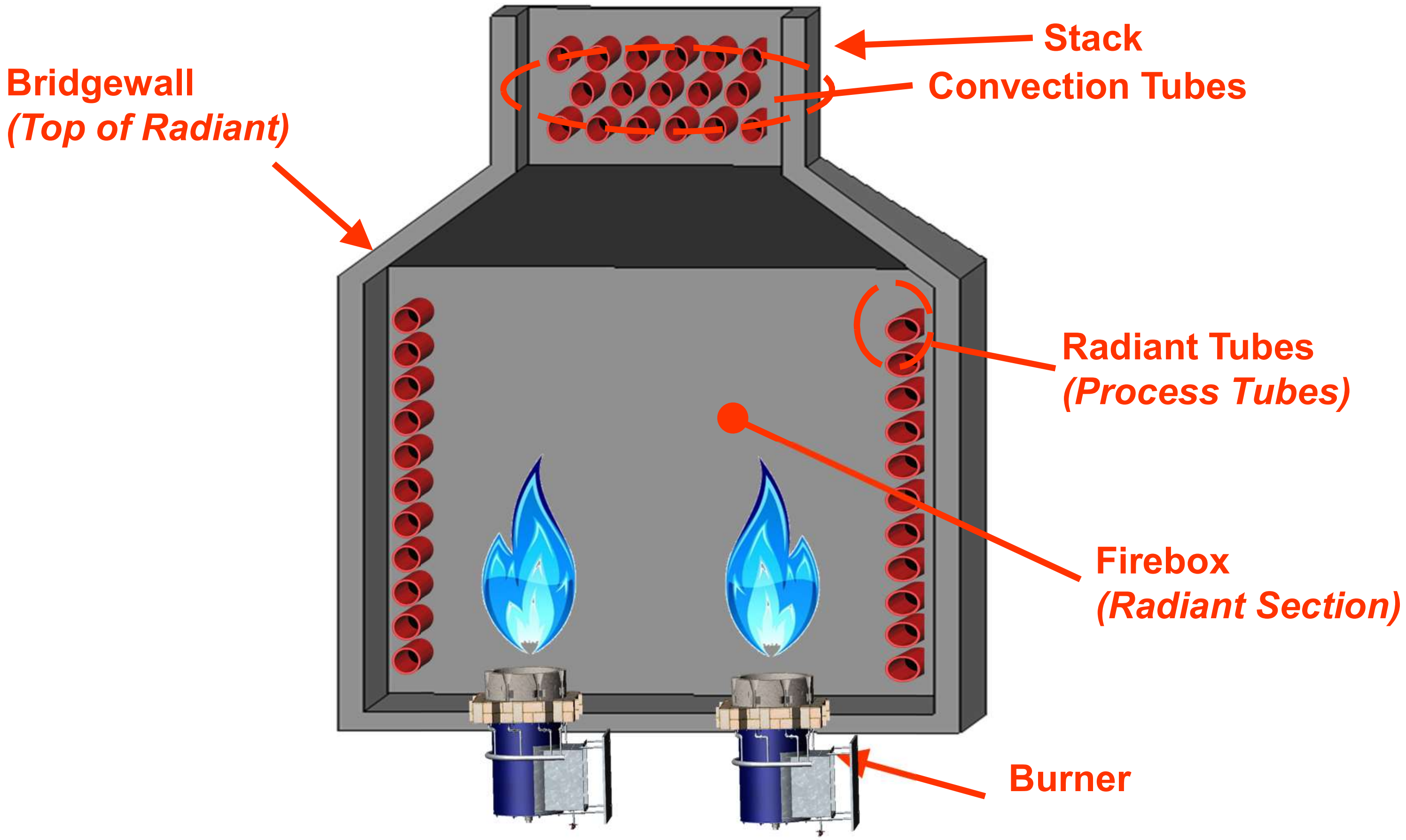


PROCESS HEATER

The purpose of a process heater is to heat the process side material by transferring heat from the hot combustion products to the process side material



PROCESS HEATER (TERMINOLOGY)



PROCESS HEATER (HEAT TRANSFER)

The purpose of a process heater is to heat the process side material by transferring heat from the hot combustion products to the process side material.

Two Types of Heat Transfer:

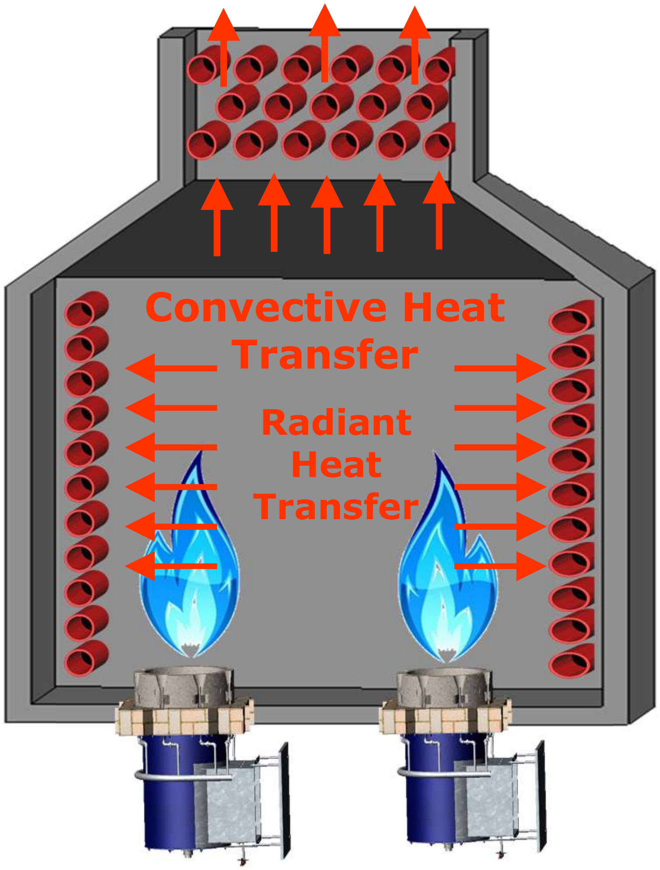
1. Radiant – Contact with the hot gases is not necessary for radiant heat transfer. Radiant heat transfer is a function of the gas temperature and the ability of the hot gases to radiate energy.

2. Convective - Contact with the hot gases is necessary for convective heat transfer. Convective heat transfer is a function of the temperature of the hot gases and the velocity of the hot gases across the tube surfaces.

PROCESS HEATER (HEAT TRANSFER)

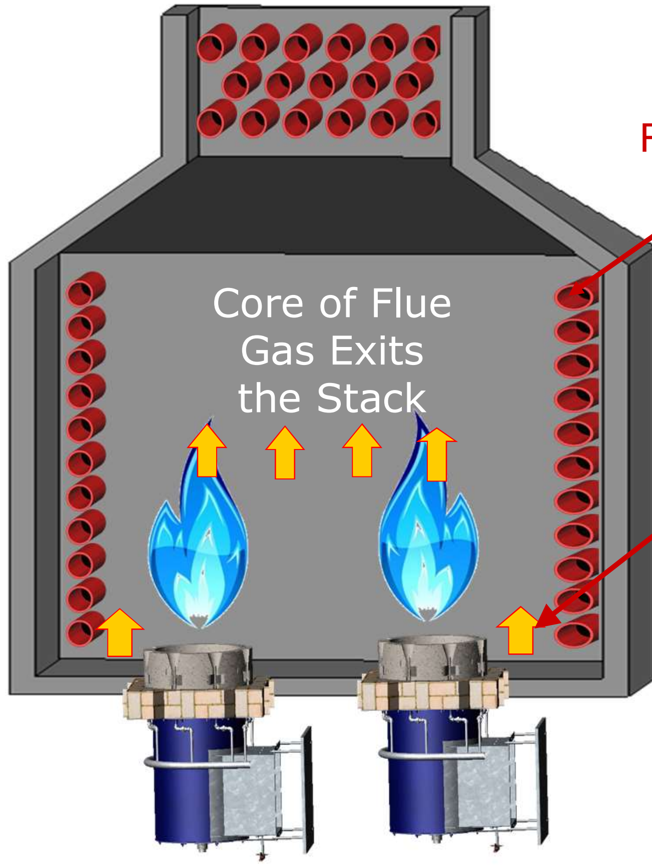
- **Convective heat**
  - *transfer* occurs to the convection tubes because of the combustion product temperature and velocity

- **Radiant heat**
  - *transfer* occurs to the radiant tubes because of the ability of the hot gases to radiate energy. Some convective transfer also occurs to the radiant tubes



PROCESS HEATER (FURNACE FLOW PATTERNS)

- A core of hot Flue Gases exit the furnace stack
- The Flue Gases along the process tube boundary are cool and dense & re-circulate to the furnace floor



TYPICAL HEATER APPLICATIONS (PROCESS BURNERS)

Refinery

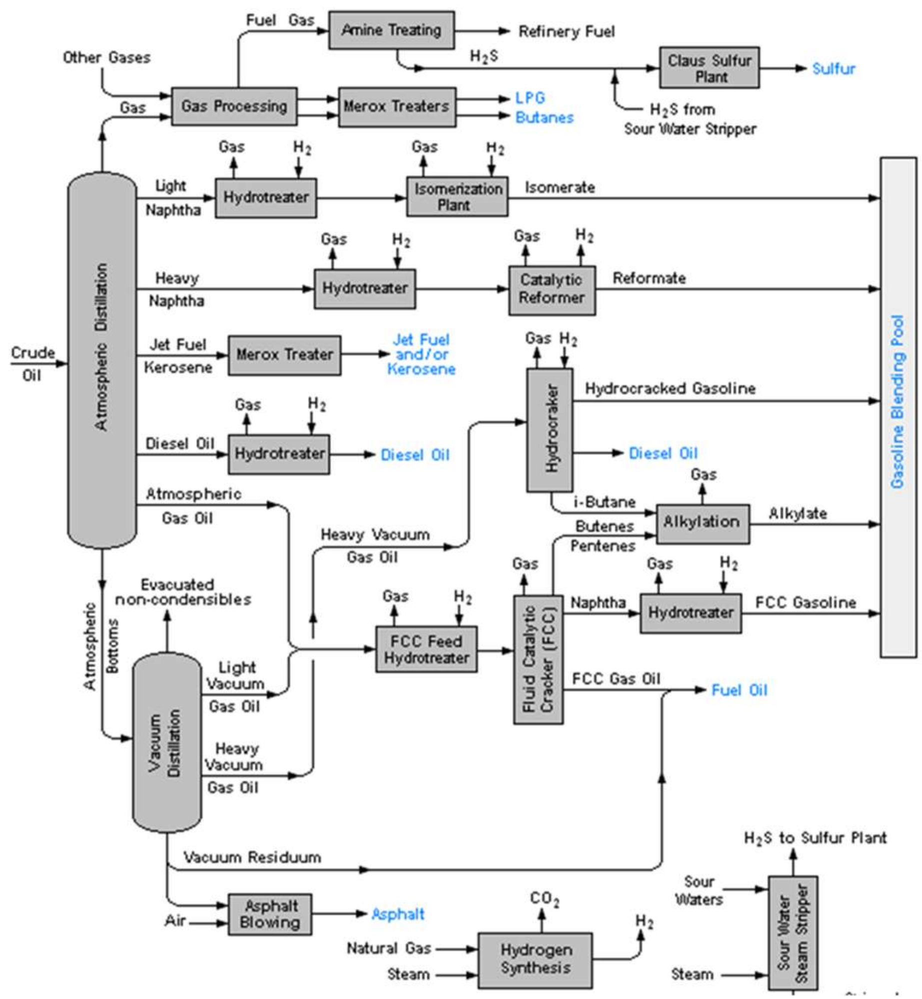
- Refining crude oil into useful products
  - Liquefied petroleum gas (LPG)
  - Gasoline or petrol
  - Kerosene
  - Jet fuel
  - Diesel oil
  - Fuel oil

Petrochemical Plant

- Converting N.G. or petroleum liquids into useful intermediate and final products
  - Fertilizers
  - Olefins
  - Adhesives
  - Detergents and Solvents
  - Rubber and Elastomers
  - Films and Fibers
  - Polymers and Resins

TYPICAL REFINERY PRODUCTION

Items in blue indicate the final product



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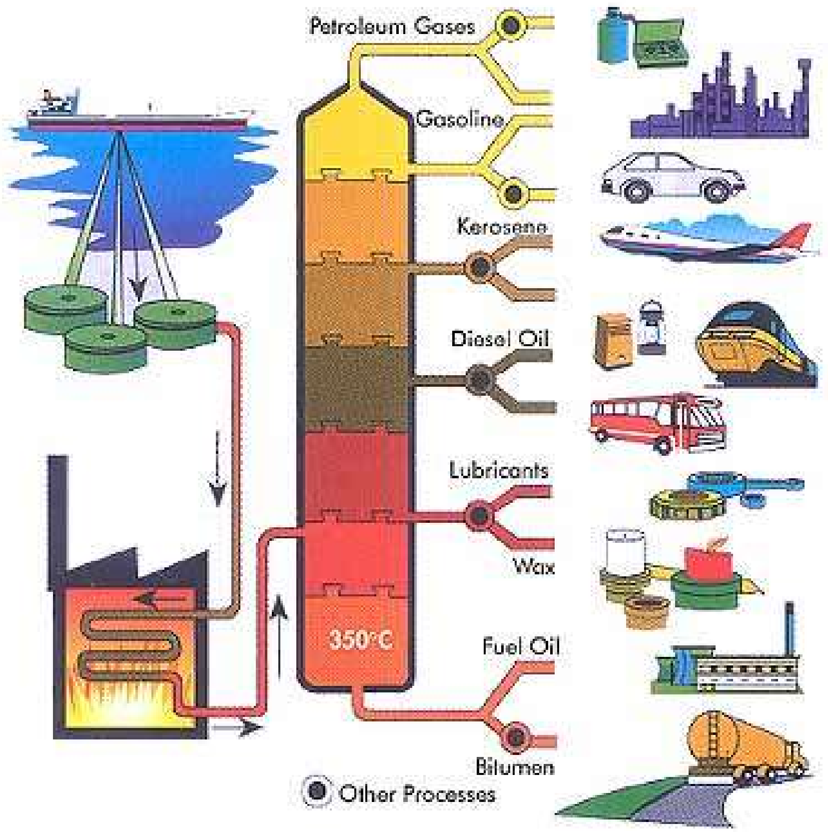
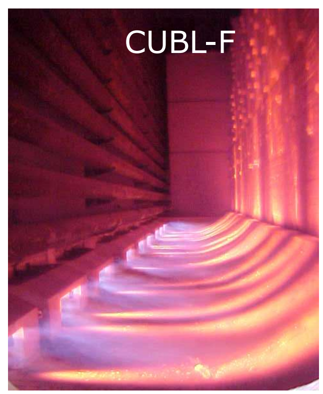
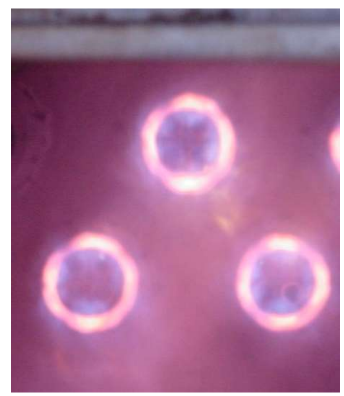
TYPICAL REFINING PRODUCTS

So what products are generated from Process Heaters?



REFINERY HEATERS (FIRING ORIENTATIONS)

Overview of Process Burner Applications

	Up fired	Floor fired	Horizontal fired
Orientation			
Burner Type			

Typical Furnace Operating Temperature 1300 to 1650 Deg. F.

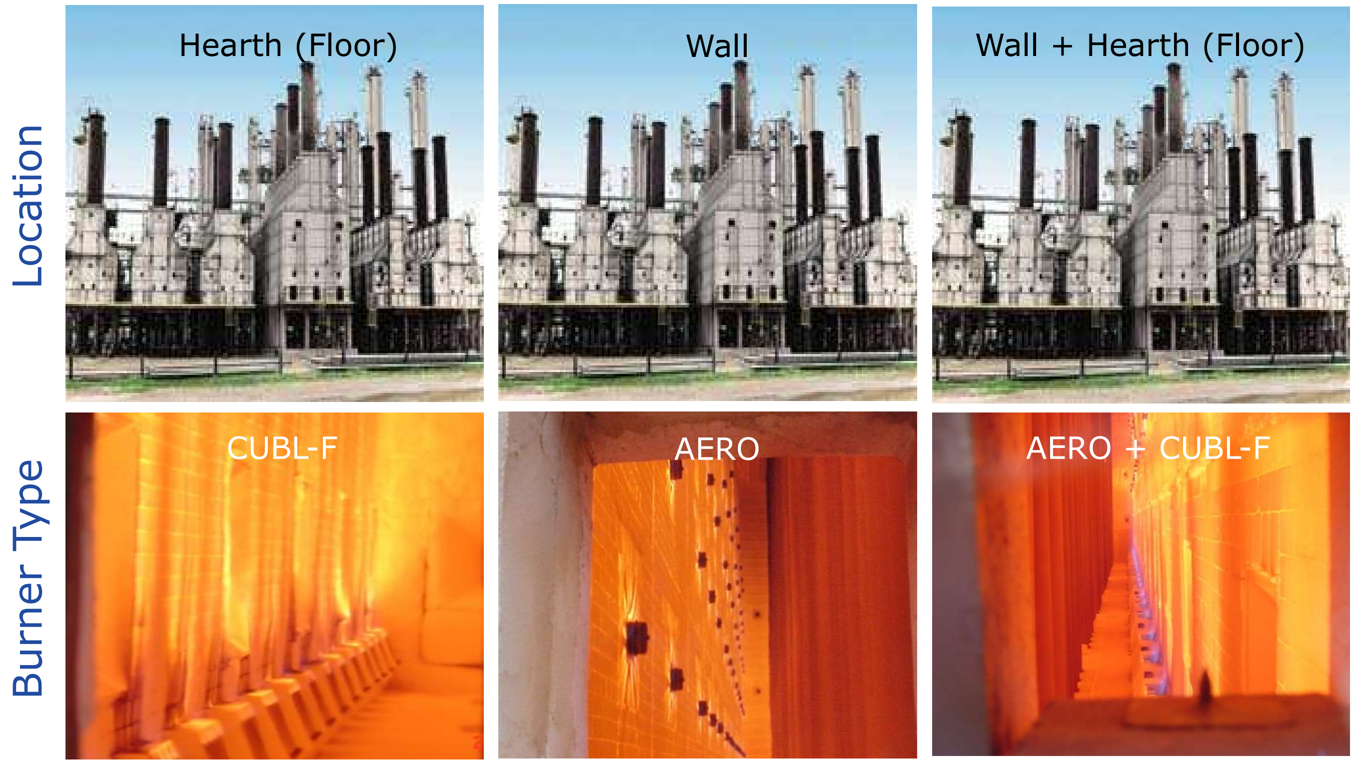
PETROCHEMICAL APPLICATIONS (REFORMERS)

Overview of Process Burner Applications

Typical Furnace Operating Temperature 1800 to 1900 Deg. F.

PETROCHEMICAL APPLICATIONS (CRACKING FURNACE)

Overview of Process Burner Applications



Typical Furnace Operating Temperature 2200 to 2300 Deg. F.

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




PROCESS BURNER TROUBLE SHOOTING

JESSE CHAMBERS
SENIOR TECHNICAL SALES ENGINEER

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AREAS OF CONCERN

1. Fouled Fuel Gas Ports
2. Improper Fuel Gas Ports
3. Poor Fuel Air Mixing
4. Improper Register Adjustment
5. Low Available Draft
6. High Fuel Pressure

PROBLEM: IRREGULAR FLAME PATTERNS

Indications

- One side of flame pattern is long, the other side is short
- Flames lean toward the tubes

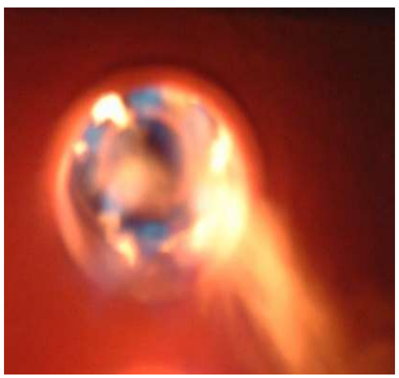
Effects

- High tube skin temperature
- Increased rate of tube coking or failure
- Hot tube hangers
- Decreased heater capacity
- High CO levels
- Increased fuel usage
- High excess air

PROBLEM: IRREGULAR FLAME PATTERNS

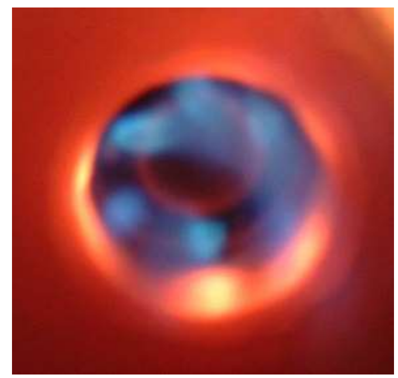
Cause

- Poor fuel
- Air distribution and fuel
- Air mixing



Solution

- Clean gas tips
- Adjust all burner air registers to same setting
- Check gas tip alignment



PROBLEM: HIGH GAS PRESSURE

Indications

- Fuel gas pressure is higher than design

Effects

- Failure to get proper outlet temperature on process side

PROBLEM: HIGH GAS PRESSURE

Cause

- Plugged fuel tip ports
- Partially closed burner block valves
- Change in fuel composition

Solution

- Clean fuel tip ports
- Open individual burner block valves
- Replace burner tips that are designed for new fuel gas composition

PROBLEM: BURNER FAILS TO LIGHT OFF

Indications

- Operator cannot ignite burner

Effects

- Failure to get unit started up

PROBLEM: BURNER FAILS TO LIGHT OFF

Cause

- Pilot flame does not "contact" flammable mixture
- No fuel flow to burner
- High air flow to burner
- Improper fuel/air mixing

Solution

- Reposition pilots to locate as specified on drawings
- Ensure all block, safety shut-off and flow control valves are open and in proper position
- Close air register to recommended ignition position (Standard practice)
- Check orientation of fuel tips and clean fuel tips

PROBLEM: PULSATING FLAME

Indications

- A “woofing” noise
- Erratic flames
- Back firing through burner register

Effects

- Damages refractory, tubes, tube supports, and other components
- Destroys burner
- Loss of flame
- Possible explosion

PROBLEM: PULSATING FLAME

Cause

- Insufficient combustion air
- Poor fuel/air mixing

Solution

- Reduce fuel flow until heater has sufficient air to burn gas within heater
- Check draft to ensure not too high
  - If yes, reduce draft so the burner damper can be opened to allow the pressure drop to be taken across the throat rather than the air register

PROBLEM: OVERHEATING IN CONVECTION SECTION

Indications

- Refractory falls from roof
- Structural steel is warping and opening up

Effects

- Reduced capacity
- Unit is shut down because of overheating

PROBLEM: OVERHEATING IN CONVECTION SECTION

Cause

- Positive pressure below the convection section
- After burning in convection

Solution

- Open stack damper to increase draft from positive to slightly negative pressure of 0.05” H_2O
- Check excess O2 at top of radiant section
- Check for leaks in furnace

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