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COMBUSTIÓN INDUSTRIAL Y CONTROL S.A. DE C.V.

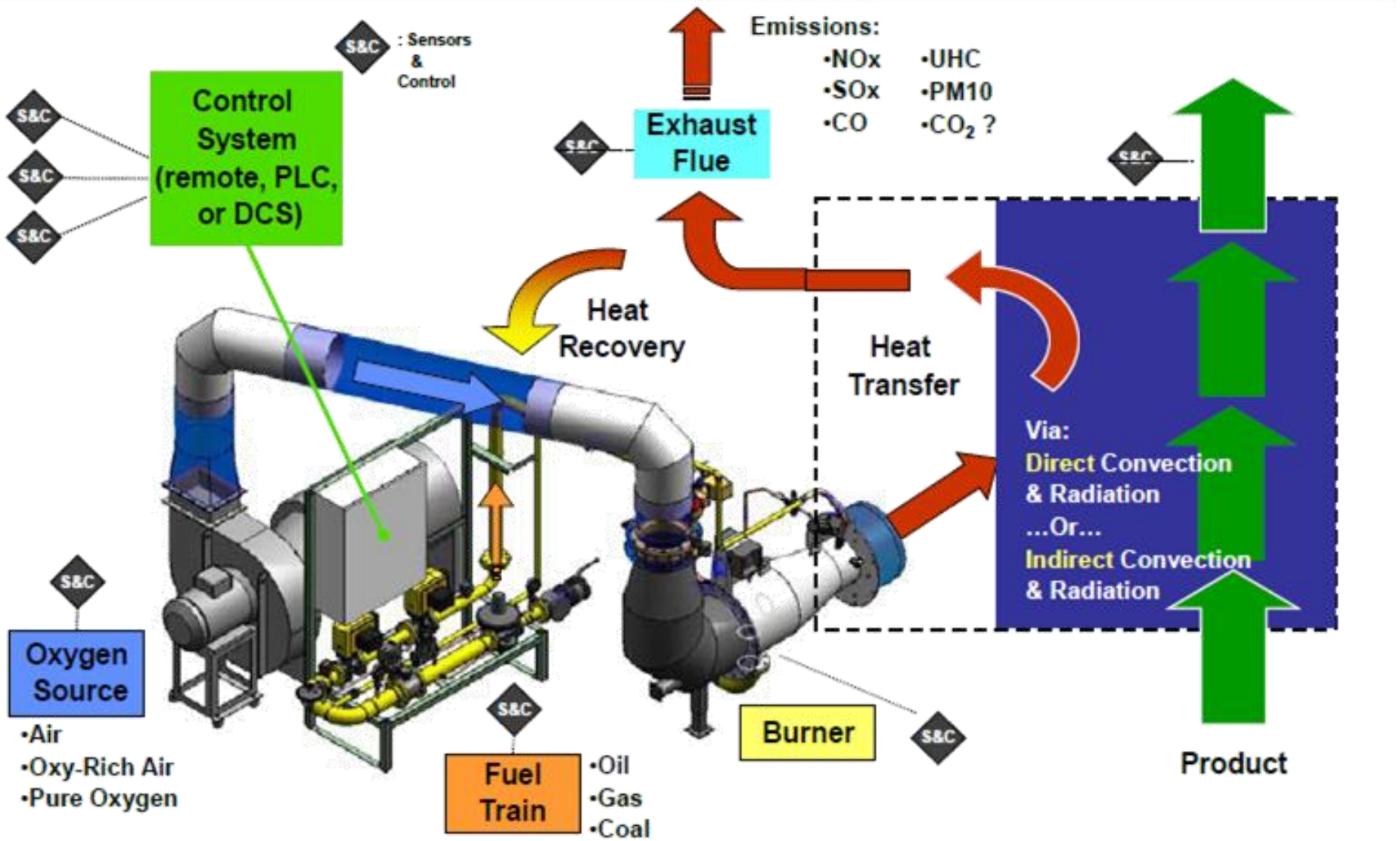
# Basic Combustion

LAR Training

May 2015

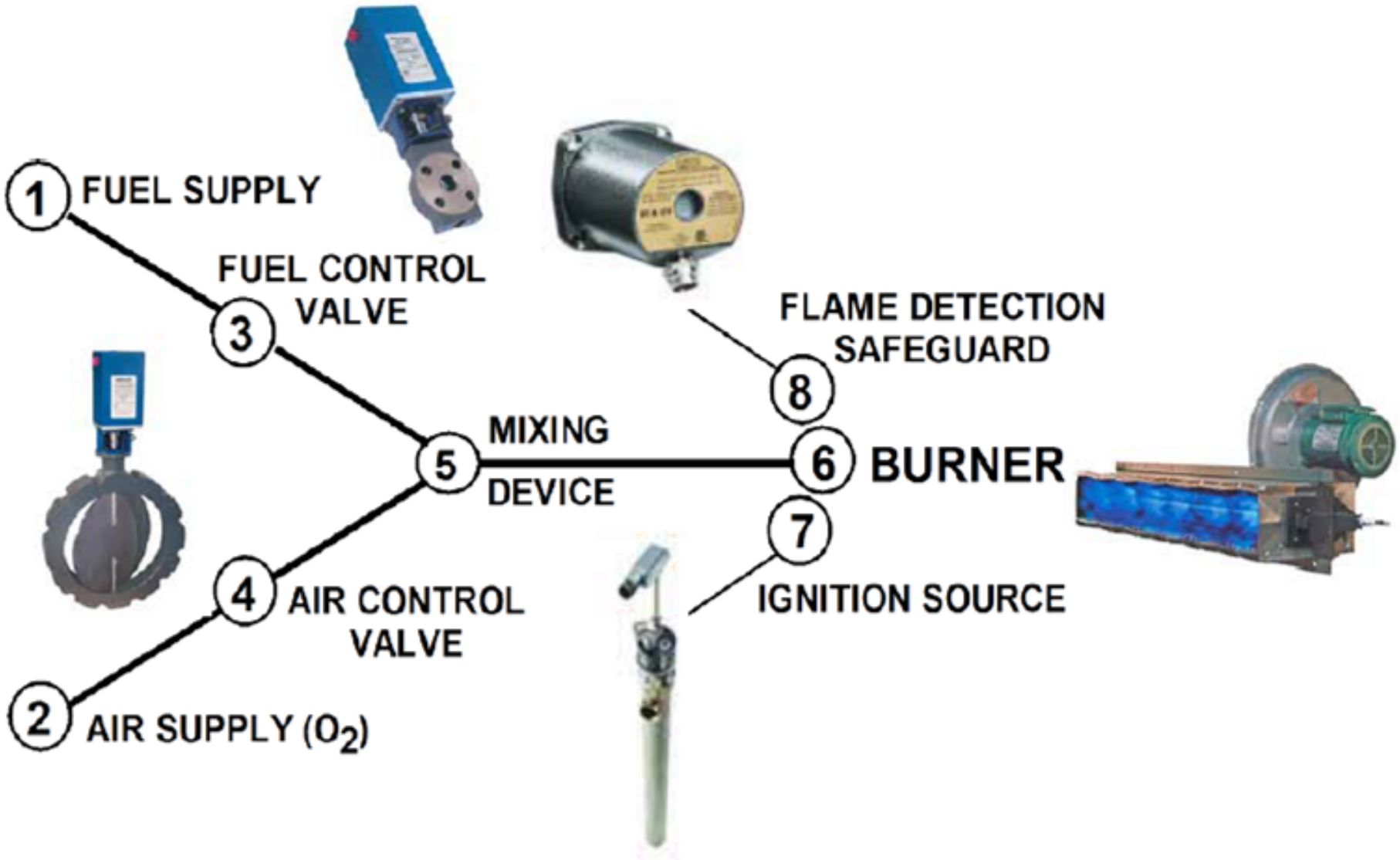
Honeywell

# Typical Industrial Combustion System




- **Combustion is liberation of energy from fuel to create usable heat**

# Combustion System



# Chemistry of Combustion

## Requirements for Combustion:

- fuel
- oxygen
- flammable ratio
- ignition source

# Chemistry of Combustion

Air consists of approx.

21% O2 and 79% N2…

or approx.

1 part O2 for every 4 parts N2

# Chemistry of Combustion

## For Natural Gas:

$$CH_4 + 2\,O_2 + 8\,N_2 \text{ Þ}$$

$$CO_2 + 2\,H_2O + 8\,N_2$$

+ 1,000 Btu Heat

# Chemistry of Combustion

**For Propane:**

**1 cubic foot of propane**

**+ 25 cubic feet of air**

**produces 2,500 Btu heat**

# Chemistry of Combustion

**For Butane:**

**1 cubic foot of butane**

**+ 32 cubic feet of air**

**produces 3,200 Btu heat**

## Air-Gas Ratios

| GAS | RATIO |
| --- | --- |
| Natural Gas | 10 : 1 |
| Propane | 25 : 1 |
| Butane | 32 : 1 |

# Properties of Fuels

## Heating Values of Fuels (Btu/ft3)

| Fuel | HHV | LHV |
|---|---|---|
| Methane (CH4) | 1014 | 911 |
| Ethane (C2H6) | 1773 | 1622 |
| Propame (C3H8) | 2524 | 2322 |
| Butane (C4H10) | 3271 | 3018 |

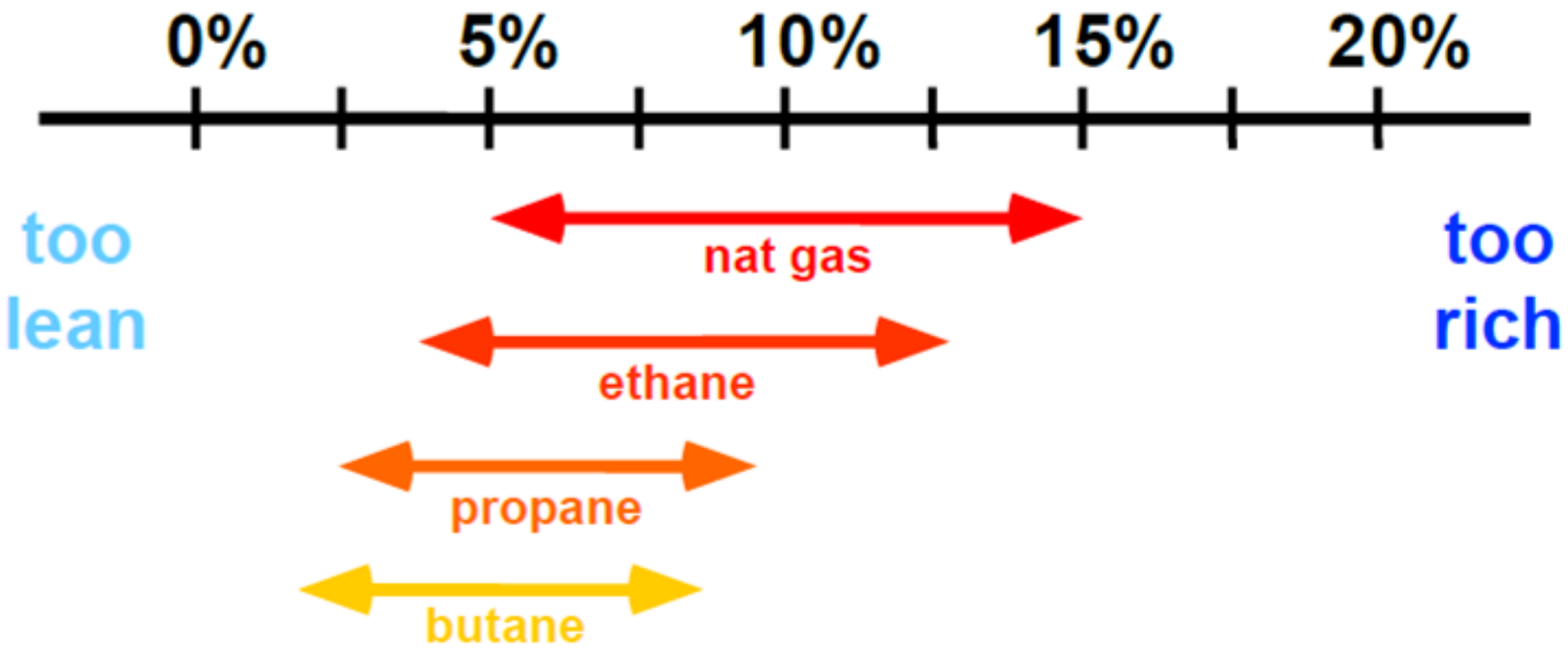
## Higher (Gross) Heating Value

**When a perfect mixture of fuel and air, originally at 60°F, is ignited and then cooled to 60°F, the total heat released is the HHV. This value is seldom attained.**

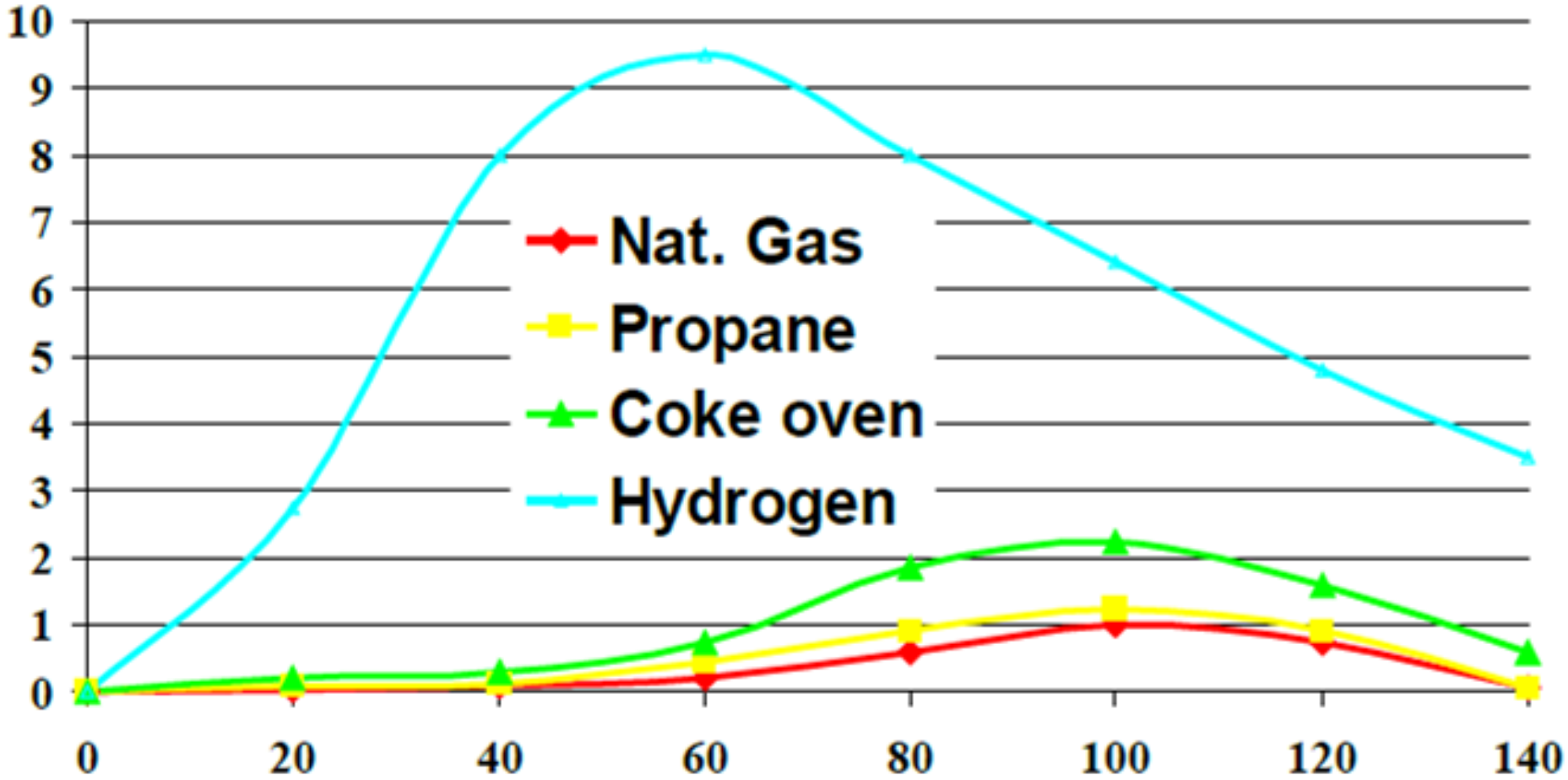
## Lower (Net) Heating Value

**LHV equals the HHV minus the heat released by the condensation of water vapor in the combustion products.**

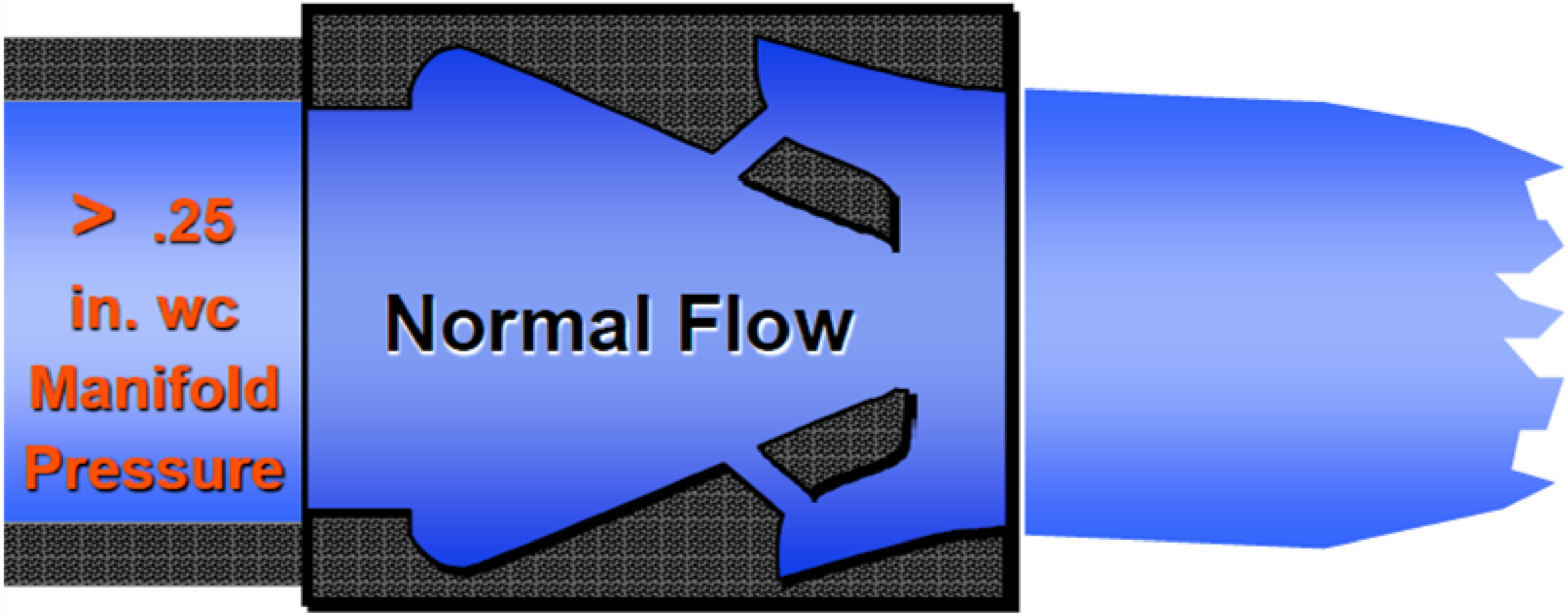
# Properties of Fuels



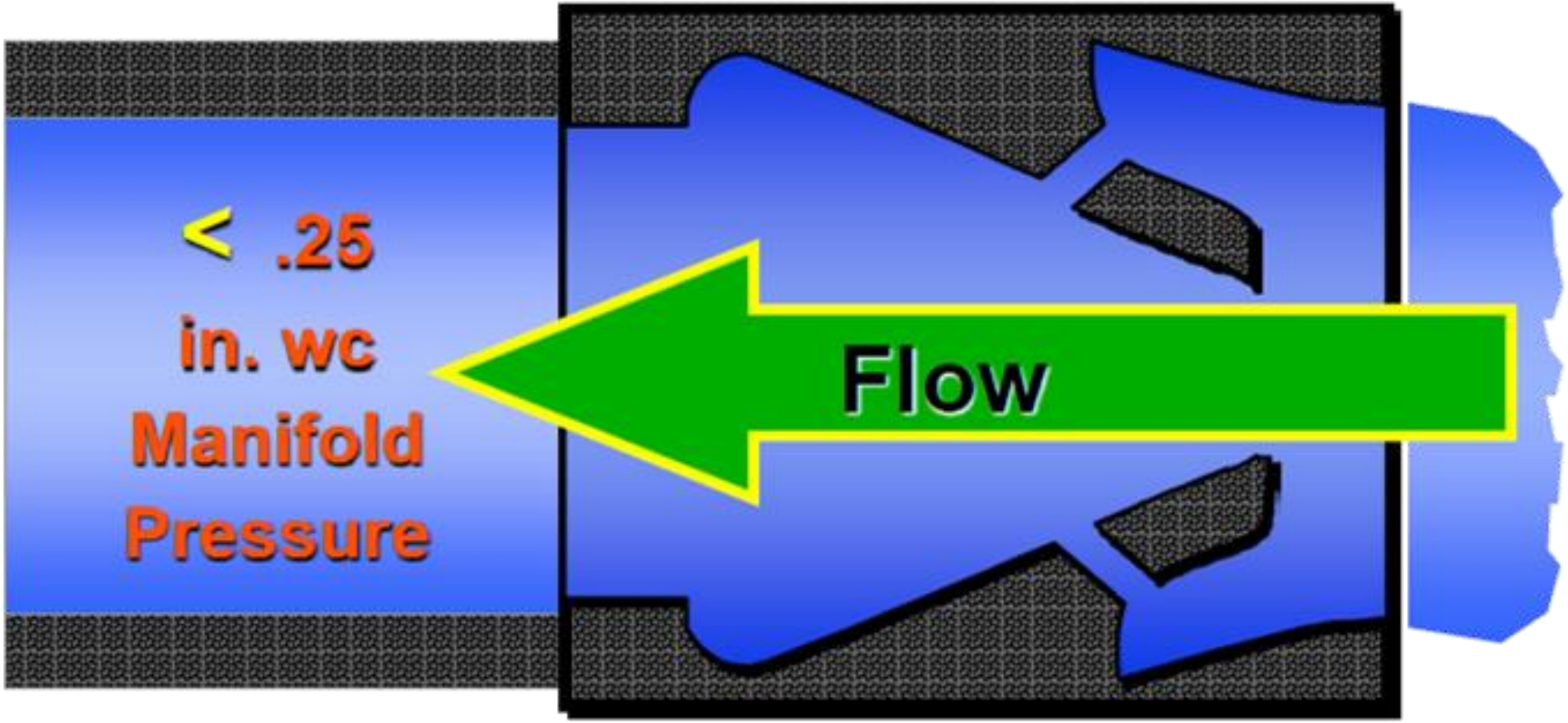
# Flame Speed in FT/S vs % Theoretical Primary Air



# Normal forward moving flames



# Flashback conditions



# Properties of Fuels

**Average fuel oil composition (by weight):**

- 85.6% Carbon
- 12.0% hydrogen
- 35% sulfur
- 6% oxygen
- 5% nitrogen
- traces of ash & moisture

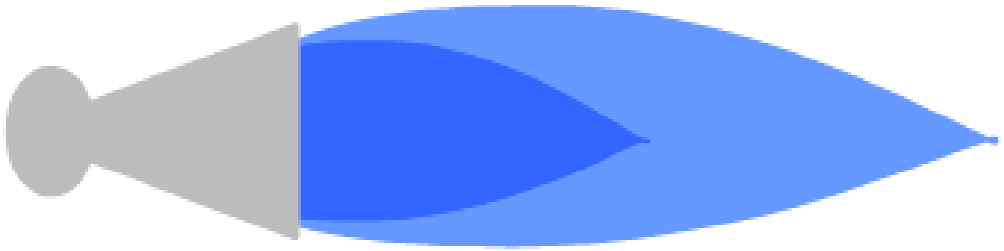
# Terminology

## STOICHIOMETRIC or ON-RATIO

**Recall for natural gas:**

**an on-ratio or stoichiometric mixture contains**

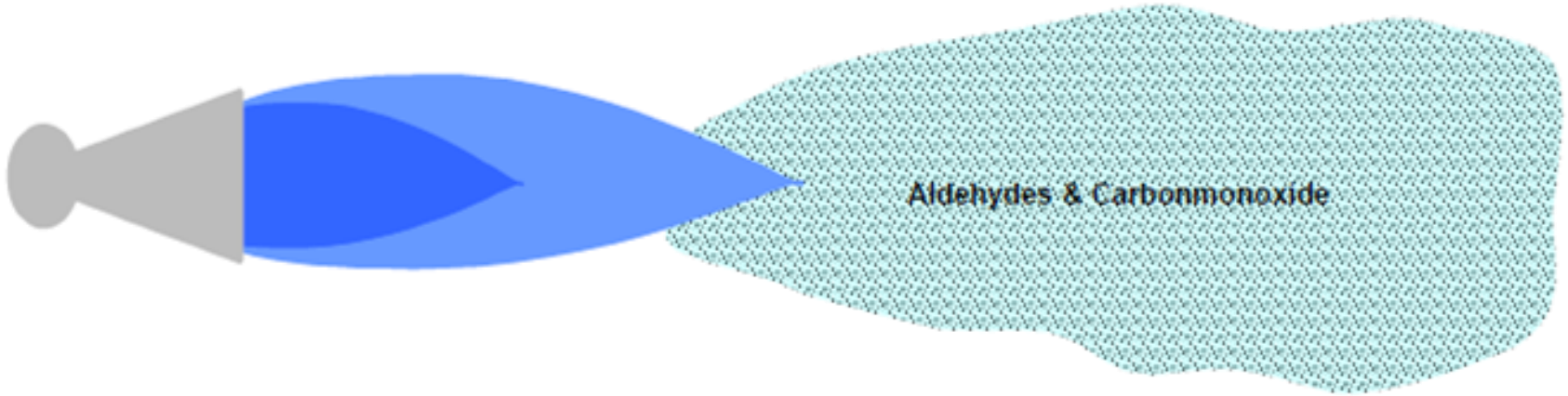
**10 parts air for each part fuel.**



# INCOMPLETE COMBUSTION

**Not all of the fuel is converted into the ultimate products of combustion.**

**Aldehydes and carbon monoxide (CO) are produced.**



# EXCESS AIR

**Excess air is usually expressed as a percentage of air greater than on ratio.**

**Thus, 10% excess air is 110% of the air required for complete combustion.**