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COMBUSTION & FIRED HEATER OPTIMIZATION

AN ANALYTICAL APPROACH TO IMPROVING SAFE & EFFICIENT OPERATIONS

AGENDA

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INTRODUCTION
COMBUSTION & FIRED HEATERS

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COMBUSTION & FIRED HEATERS

Combustion sources such as furnaces and fired heaters play a critical role in the process industry. Unfortunately, combustion requires large amounts of fuel (gas, fuel oil). As a result, combustion efficiency directly influences the performance and operational costs of production facilities. However, efficiency is not the only concern. Compliance and safety are major challenges as well.

Incomplete combustion and the use of excess air can lead to higher levels of toxic emissions. Also, variation in fuel quality, low emission burners, aging heaters and boilers, and the desire to increase production through the unit would seem to push the limits of proper control and safety. What happens if limits are crossed?

SOME FACTS

Fired heaters are the largest energy consumer in all of the manufacturing sector, and represent a tremendous opportunity for energy savings. Refineries in the US alone spent a staggering 2,5 billion dollars on fuel consumption from natural gas in 2010. (EIA 2010)

Fired heaters pose a series of problems from safety risks to poor energy efficiency

The largest risk in fired heater operation is during the startup and shutdown sequencing

Anything involving a combustion process represents an opportunity for improved safety, control, energy efficiency and environmental compliance

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COMBUSTION & FIRED HEATERS

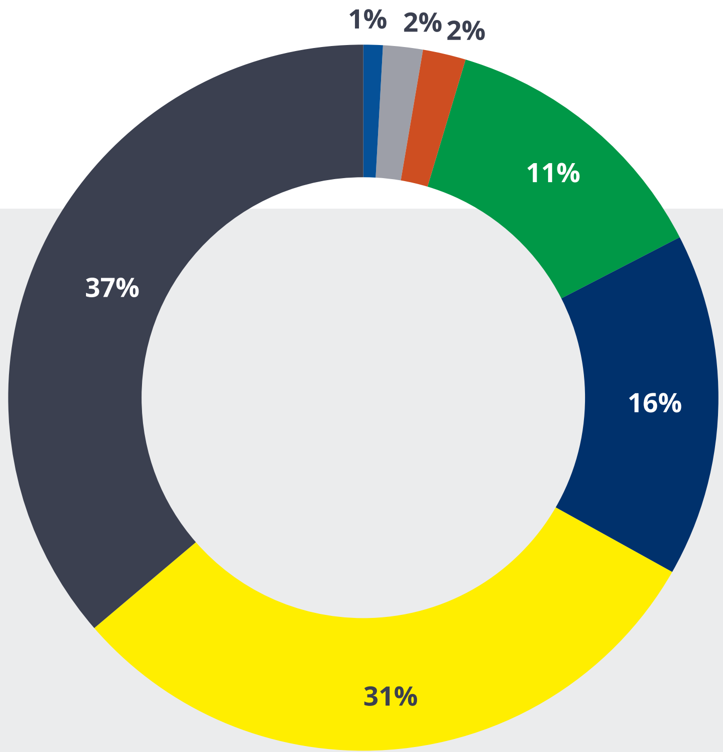
Fired heaters account for **37%** of the U.S. manufacturing energy end use (DOE/MECS 2002). Based on 2010 U.S. Energy Information Administration (EIA) data, that means the total energy end use in fired heaters is over **7 quadrillion BTU** (excluding offsite and in-plant distribution losses).

** This number includes approximately 3,000 refinery heaters*

U.S. MANUFACTURING ENERGY END USE

(excludes offsite and distribution losses)
Source: DOE/MECS 2002

- **Fired Heaters**
- **Steam**
- **Machine Drive**
- **Non-Process Energy Use**
- **Electrochemical**
- **Process Cooling**
- **Other**



COMBUSTION & FIRED HEATERS

Most refiners today recognize the need to run process heaters at their lowest level of excess oxygen (O_2). This ensures a complete burn of fuel for efficiency, and a reduction in NOx without sacrificing safety.

The combustion analyzer has been a necessary component of fired heater control for many years. In its simplest form, the combustion analyzer provides an excess oxygen reading so that an air to fuel ratio can be maintained throughout the firing range of the process heater.

However, reliable measurements of O_2 and CO at high temperatures have only recently become viable with the introduction of Tunable Diode Laser Spectrometer (TDLS) technology.

eBOOK

This eBook explains how to improve safety & efficiency by controlling combustion using TDLS technology. Simultaneously control air and fuel supply by measuring average gas concentrations across the high temperature radiant section.

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CHAPTER 01
INDUSTRY CONCERNS

TOP 4 CONCERNS RELATED TO FIRED HEATERS

TOP 4 CONCERNS RELATED TO FIRED HEATERS

ASSET SUSTAINABILITY

- Low ranking CAPEX projects for improvements for years have resulted in antiquated diagnostics and controls, leaving the majority of the burden to operator response
- False low incident rate has been created by lack of reporting near misses, such as contained over pressuring of equipment
- Traditional PHA/LOPA does not fully provide coverage of the myriad of potential hazards associated with fired equipment

TOP 4 CONCERNS RELATED TO FIRED HEATERS

INEFFICIENT OPERATIONS

- Different parts of facilities are faced with different goals, and operations are not always aligned appropriately
- Control schemes for firing rates have changed very little over 40 years
- Air-Fuel ratio-control is only used on a few systems, and fewer still compensate for changing fuel composition
- Feedback measurements are minimal and often not leveraged or trusted
- Emissions are higher than design
- Thermal efficiency is lower than design
- Chemical duty cycle is shorter than design
- Traditional ESD (Emergency Shutdown System), commonly referred to as burner management system, is not proactive and is not designed to prevent tripping the asset
- Typically only one control loop governs normal operation, where the process outlet temperature controls the fuel pressure to the burners, with no override or cross-limiting functions to maintain operation in a safe envelope

TOP 4 CONCERNS RELATED TO FIRED HEATERS

OPERATOR SKILLSET

- Operator lacks a clear understanding of fired heaters design which has operational consequences
- Engineering principles of heat transfer are not part of the education
- Fired system design for air flow is another aspect where operators are not fully educated
- Aging workforce: skilled operators are close to retirement

TOP 4 CONCERNS RELATED TO FIRED HEATERS

SAFETY & COMPLIANCE

- To address safety concerns, industry standards are upgrading their recommended practices for instrumentation, control & protective systems for fired heaters & steam generators.
- Plants not meeting the best industry practice guidelines will be at risk in the event of an incident on a fired heater.
- Many natural draft fired heaters do not meet this guideline with existing instrumentation and control systems.
- Most natural draft fired heaters have only automated control of the fuel supply and not the air, excess air is often applied to the combustion process, thereby increasing carbon and NOx emissions as a result of over firing or overcome loss of thermal efficiency.

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CASE STUDY | EXPLOSIVE EVENTS

Explosive events attributed to heated analyzers have occurred in the past, but usually anecdotally. One event occurred at a large chemical plant in the US in 2005 for which there is good investigative information, so it is instructive to review this data.

Source: Hazardous Flue Gas Mixtures in Furnaces Due to Fuel-Rich Combustion', Andrew Hawryluk, NOVA Chemicals Corp. Ethylene Producers Conference, 8 Apr 2008

SAFETY & INCIDENTS

Although most fired heater incidents occur at light-off, it is possible to create hazardous gas mixtures in an operating heater. Fuel-rich combustion produces hot flue gases with residual combustibles that can burn or explode if mixed with fresh air too quickly. This is most likely to occur when a heater transitions suddenly from rich combustion to lean combustion.

Unfortunately, sometimes the safety risks that can appear during heater operation are underestimated. It is tempting to believe, for example, that a heater cannot accumulate hazardous gases above auto ignition temperatures, but this is not the case if there is insufficient air to consume all the fuel.

WHAT HAPPENED

During this incident, the heater was offline due to a plant outage caused by a power failure. The investigation determined that this mixture was ignited by an *in situ zirconium oxide oxygen probe* in the heater stack. The probe was equipped with a heater to achieve the 700 C operating temperature of the element and with a flame arrestor. The probe had been placed in service in the 1990's and had functioned well with only routine preventive maintenance. When removed from the field and inspected, it was discovered that the threaded housing holding the flame arrestor to the probe body was loose. It was conjectured that the loose threads formed a path for flame propagation, bypassing the flame arrestor. In addition there was evidence of flame impingement on the probe body just outside the thread area. These facts led to the conclusion that the flame arrestor function was disabled by the loose threads.

LESSONS LEARNED?

- An oxygen analyzer with heated ZrO_2 sensor is a **potential ignition cause during purge cycle**. Mitigation options include a purge interlock to disconnect sensor power, reverse flow of close-coupled extractive systems or flame arrestors.
- During combustibles breakthrough - at low oxygen levels - it is possible for a high concentrations of Hydrogen and CO to **mask** (malfunction low) the **true oxygen concentration at the sensor.**
- Upon complete loss of flame - in a fuel rich environment - it is possible for a high concentration of methane to **mask** (malfunction low) **the true oxygen concentration at the sensor.**
- Nitrogen backup to the instrument air system has the potential to create an **oxygen analyzer malfunction** high.

CHAPTER 02
MANAGING COMBUSTION

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THE FIRED HEATER

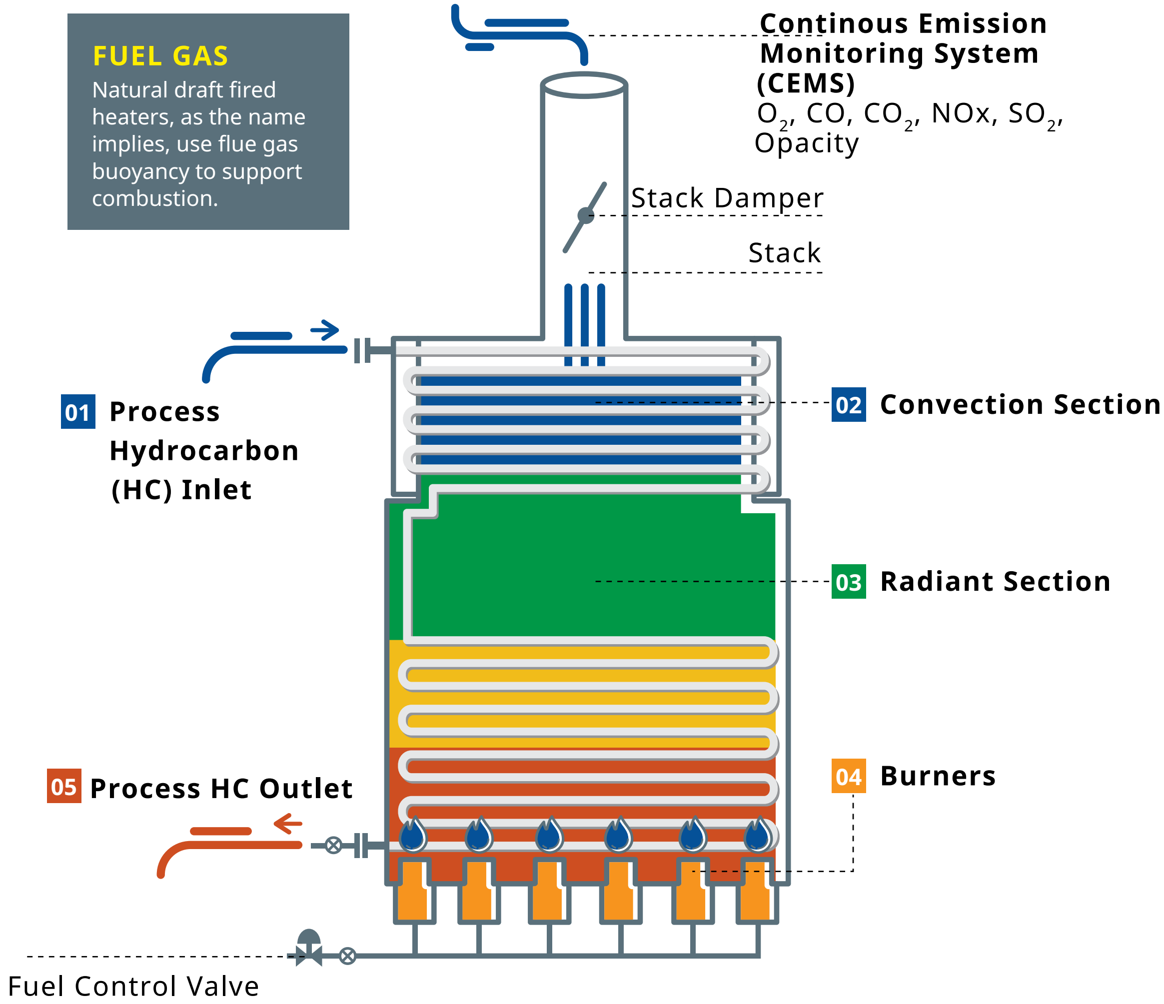
The air supply for many fired heaters is natural draft, not forced air, and these heaters typically lack the degree of automation applied to other process units in the plant. Natural draft fired heaters, as the name implies, use flue gas buoyancy to support combustion. These heaters can be either cylindrical or box type, like in the picture on the right.

The buoyancy of the flue gas (combustion product) relative to the surrounding air is determined by the product of the average density of the flue gas and the height of the heater. Furnaces are designed to run at a pressure of -0.05 to -0.15 inches of water columns at the top of the radiant section, whether a heater is natural draft, induced draft or forced draft.

A stack damper is designed to control the draft pressure at the arch, while the air registers at the burner are designed to control the amount of air flow into the system. Different damper and burner designs can have significant differences in turn-down which makes air flow changes unique to the fired system.

FUEL GAS

Natural draft fired heaters, as the name implies, use flue gas buoyancy to support combustion.



THE CONTROL STATE OF MOST FIRED HEATERS

AIR

- The value of air entering the burner is not measured
- Modulated manually via dampers, registers or louvers in front of fans
- If automated dampers are used, no automation is used on the registers
- No flow measurement to determine availability for changing fuel density

FUEL

- Volumetric flow value used to determine the amount of fuel going into the system
- Pressure is used to control the amount of fuel delivered to the burners
- BTU analysis is performed at the mixing tank but not used as a feed forward diagnostic
- No compensation for a density change

THE STATE OF MOST FIRED SYSTEMS

The low level of control on most fired heaters is due, at least in part, to the historical lack of reliable, effective instrumentation and automation technology to simultaneously measure and control the fuel, gas concentrations, and the air to fuel ratio. An O_2 sensor is typically required at the stack base for thermal efficiency calculations, which require total excess air. While operators attempt to maintain 'excess' O_2 in the furnace for safety, the amount indicated from an existing sensor may be incorrect due to tramp air. In fact, it is possible that the burners may be starved of air, despite excess oxygen at the stack base. Because of the lack of air control, in practice operators will typically allow excess air into te fired heater, reducing its thermal efficiency.

WHY IS THIS IMPORTANT?

The **optimum level of excess oxygen** minimizes both the uncombusted fuel, directly related to the CO level, and the NOx emissions. But due to boiler load changes, fouling of burners, changing humidity of the burner air, and other conditions—the optimum level of excess oxygen changes constantly.

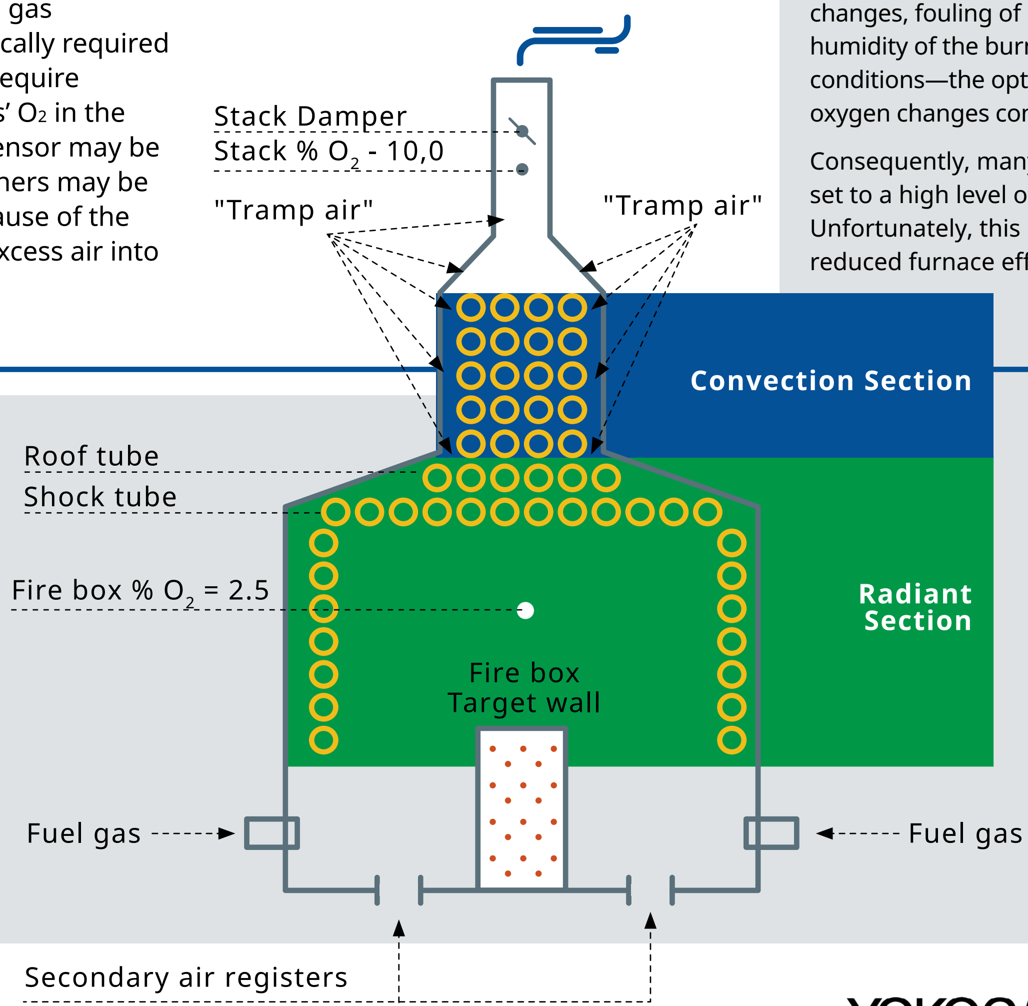
Consequently, many furnaces are set to a high level of excess oxygen. Unfortunately, this results in drastically reduced furnace efficiency.

TRAMP AIR

Tramp air is the air that is entering the heater and not taking part in combustion. It is the air entering into from peep doors, tube penetrations, header boxes, heater joints that are not sealed properly. This air does not enter the combustion process and shows up in the Oxygen analyzer at the arch and in the stack.

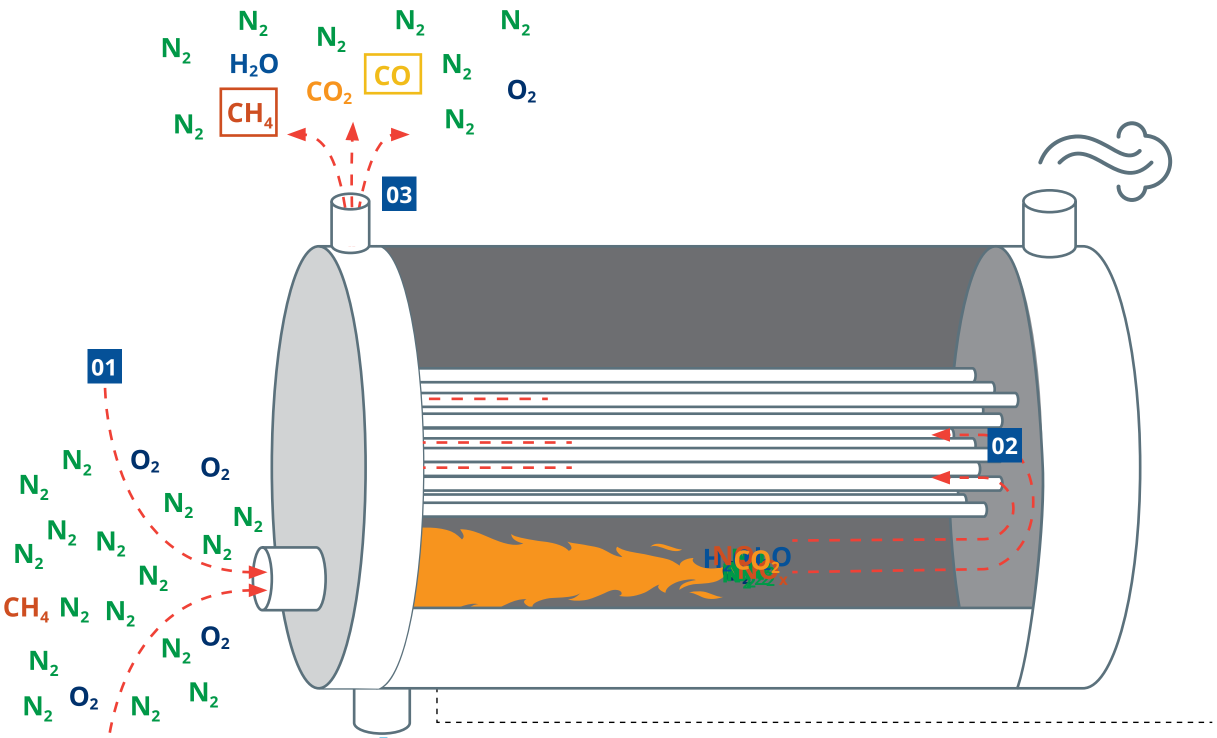
Tramp air in fired heaters is a big concern for operators, and is often seen as a cause for many fired heater ills- be it NOx emissions, thermal efficiency or heater capacity shortfall.

The biggest source of tramp air is the burners that are not lit. In most of the cases, the burner fuel gas valves are shut fully but the air registers are left in the open position.



THE STATE OF MOST FIRED SYSTEMS

The **lack of effective instrumentation** to continuously and rapidly measure O_2 and CO in the combustion chamber of the fired heater introduces considerable **safety risks**. Apart from the simultaneous control of fuel and air concentrations, it is possible for **fuel rich conditions** to arise, which increases the potential explosion risk. Note that under fuel rich conditions, temperature/fuel controllers no longer work properly.



Incomplete Combustion (Fuel Rich). Signs of incomplete combustion: CO breakthrough and high fuel usage and breakthrough in extreme cases | Consequences: Unsafe; Wasted fuel; Efficiency loss

API RECOMMENDED PRACTICE 556

As with any combustion safety system, the proper and safe operation is dependent on an effective control algorithm to monitor and identify potential harmful or catastrophic situations. Therefore, the detection of combustibles, primarily CH4, in the radiant section of the fired heater is recommended by the **American Petroleum Institute** in **API 556:** 'a recommended practice for instrumentation, control and protective systems for fired heaters and steam generators'. It specifically applies to gas fired heaters and steam generators in petroleum refinery, hydrocarbon processing, petrochemical and chemical plants.

Further, the need to reduce risk in combustion processes throughout a company's many locations dictate that each site utilize the same proven control and safety standard to eliminate rouge, patched or insufficient software. The **API standard RP556**, is currently being utilized in the United States for process heater control and SIS installations.

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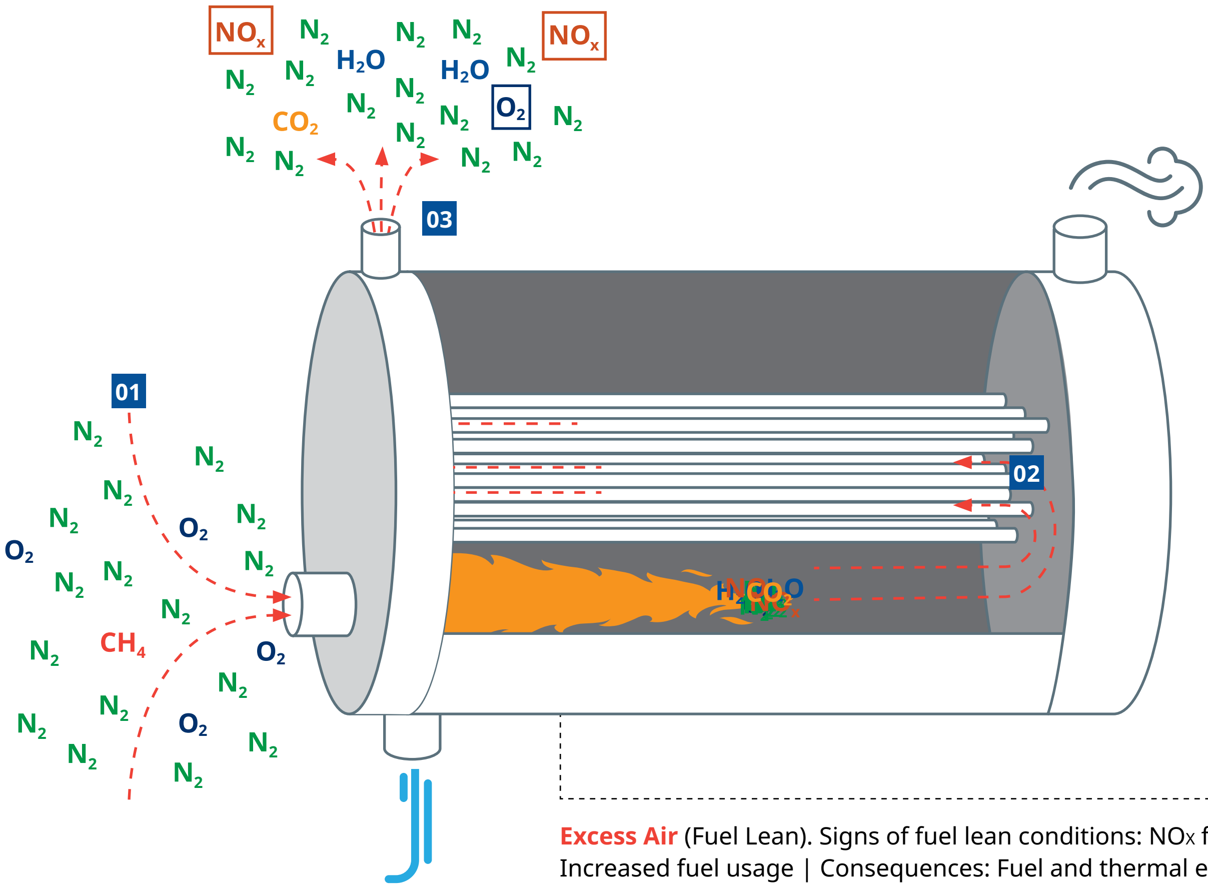
THE STATE OF MOST FIRED SYSTEMS

Detection of combustibles in the radiant section of the fired heater is recommended, but traditional analyzer technology cannot be installed in the radiant section due to the high temperatures. Without accurate measurements of CH_4, O_2 and CO concentrations, operators tend to allow more air than is necessary in the heater, reducing its thermal efficiency.



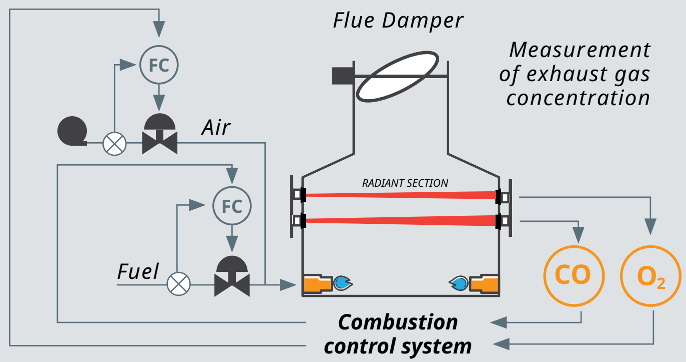
Excess Air (Fuel Lean). Signs of fuel lean conditions: NO_x formation; Increased fuel usage | Consequences: Fuel and thermal efficiency loss; Elevated NO_x emissions

COMBUSTION AIR CONTROL

To properly control the combustion air, O_2 and CO must be measured at the top of the radiant section where combustion is completed, regardless of the burner loading. Note that O_2 and CO will coexist within the flames, where the temperature may be as high as 1200˚C.

Low NO_x burners may use delayed completion of combustion through staged air to fuel mixing, or external recirculation of cooler flue gas with combustion air, reducing peak flame temperature.

In either case, to effectively control the combustion process it is essential to measure O_2 and CO at the top of the radiant section, ideally 1 ft. / 0,3 m below the roof tubes where combustion reaction is expected to complete under all heater operating loading conditions. Using a TDLS in concert with a dedicated controller, a cross sectional average O_2 and CO density rather than a localized spot measurement can be measured to determine the right air/fuel ratio. Using an average O_2 value and CO limit value produces safer burner control and greater overall heater efficiency.



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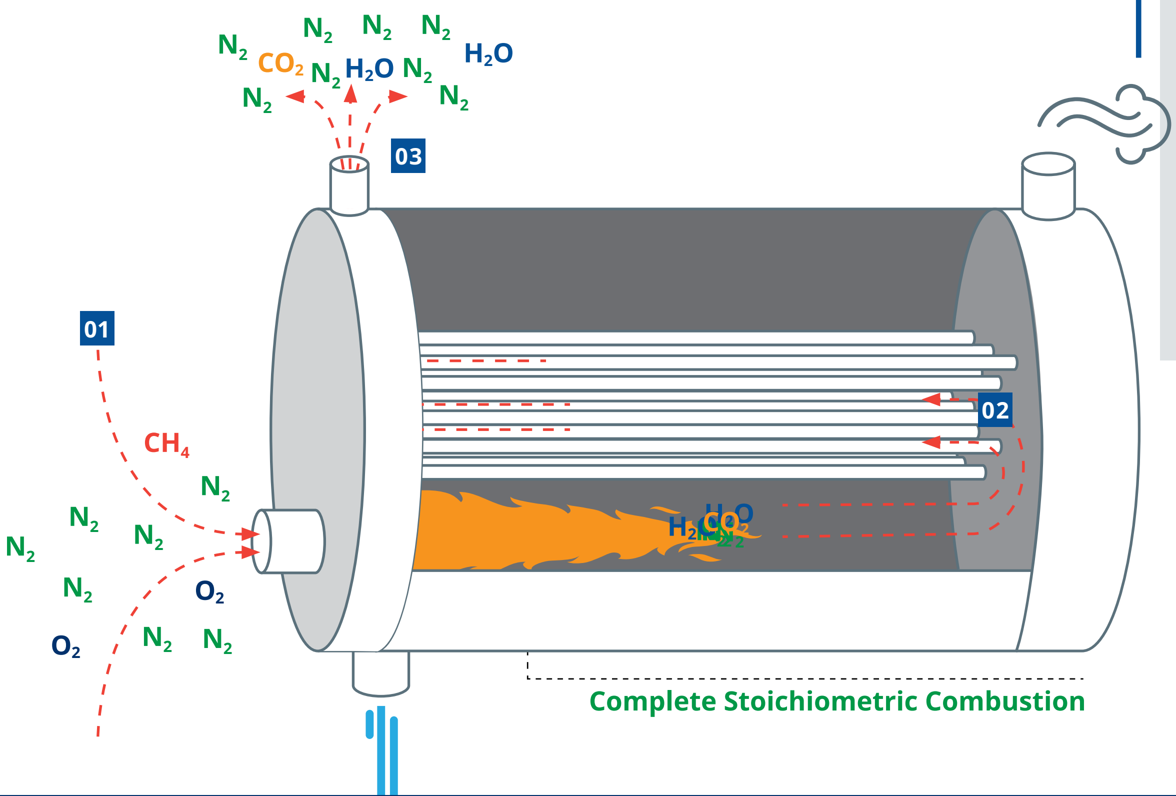
THE STATE OF MOST FIRED SYSTEMS

Continually measuring the percentage of O2 is critical to improving heater efficiency and to maintaining safe operating conditions. When firebox conditions are unacceptable, i.e. high levels of CO or combustibles exist, the effective combustion management must rapidly detect the condition and initiate the appropriate response.

In the system being described, the embedded logic controller and safety systems will ensure that these conditions are avoided or that combustion is extinguished and fuel flow is interrupted automatically if these conditions are detected. The TDLS analyzer technology will reliably respond to all ‘O2 events’ in situations where conventional sensor technology would miss most of them.



FIRED HEATERS HAVE **2 PRINCIPAL UNSAFE OPERATING CONDITIONS** THAT MUST BE AVOIDED:

Fuel rich, where air is reduced. CO will be produced by the burners and excess O2 will be lower, which results in excess fuel from the burners

Flame out, where loss of flame results in rapid loss of gas temperature. O2 levels are high as burner air is not reduced by combustion, and uncombusted fuel is present.

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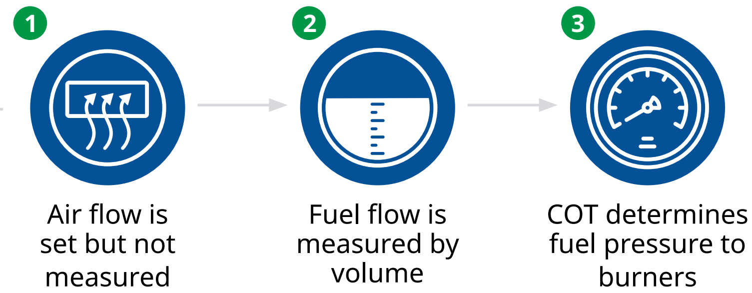
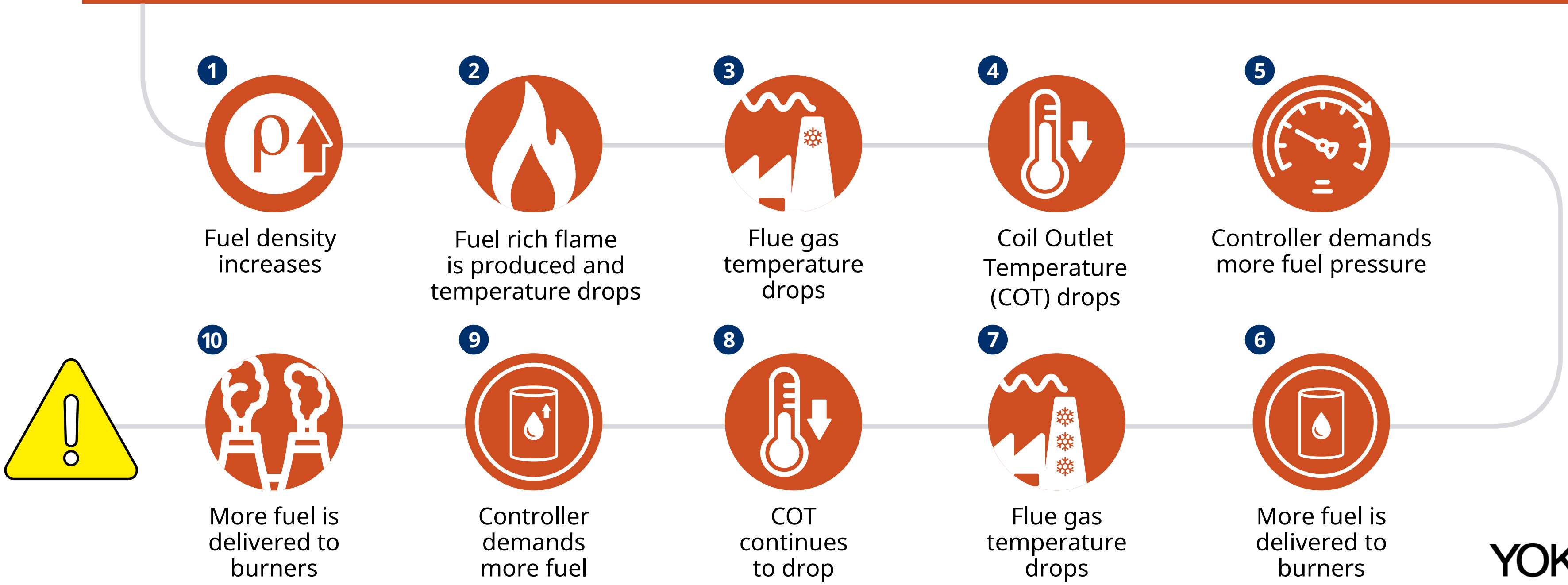
EXCESS AIR AS A FALSE SENSE OF SAFETY

Operators run heaters with high Excess Air as a false sense of safety:

1. No feedforward protection
2. The have not trusted their feedback instruments



TYPICAL CONTROL SCHEME | MURPHY'S LAW STEP-BY-STEP:



CHAPTER 03
HOW IT WORKS

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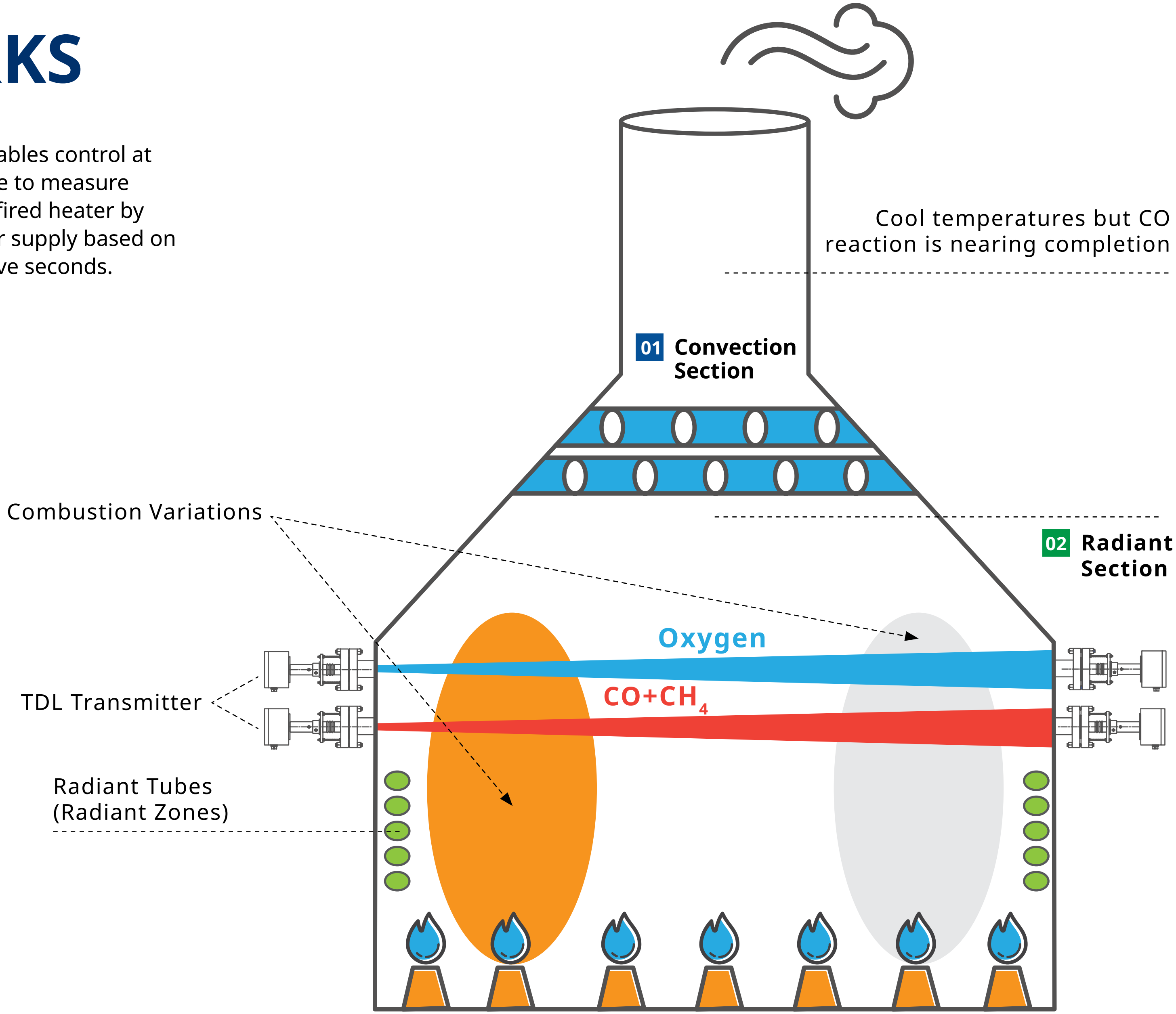
HOW IT WORKS

A properly designed system with TDLS enables control at the operational limit. Such a system is able to measure both the upper and lower conditions in a fired heater by simultaneously controlling the fuel and air supply based on fast sample intervals- typically less than five seconds.



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HOW IT WORKS

Measurements from TDLS include CO, CH_4, and O_2. Using an average gas concentration produces safer burner control and greater overall heater efficiency. By optimizing air flow control, O_2 concentration is typically **reduced from 6% to 2%**, increasing thermal efficiency of the furnace.

In order to control combustion in a fired heater, fuel flow and arch draft must be managed through the existing plant DCS or logic solver via Modbus, while combustion airflow is controlled directly with the carbon monoxide or **CO override** function.

The simplified architecture diagram in the **figure** below illustrates the **key components** comprising an integrated TDLS system.

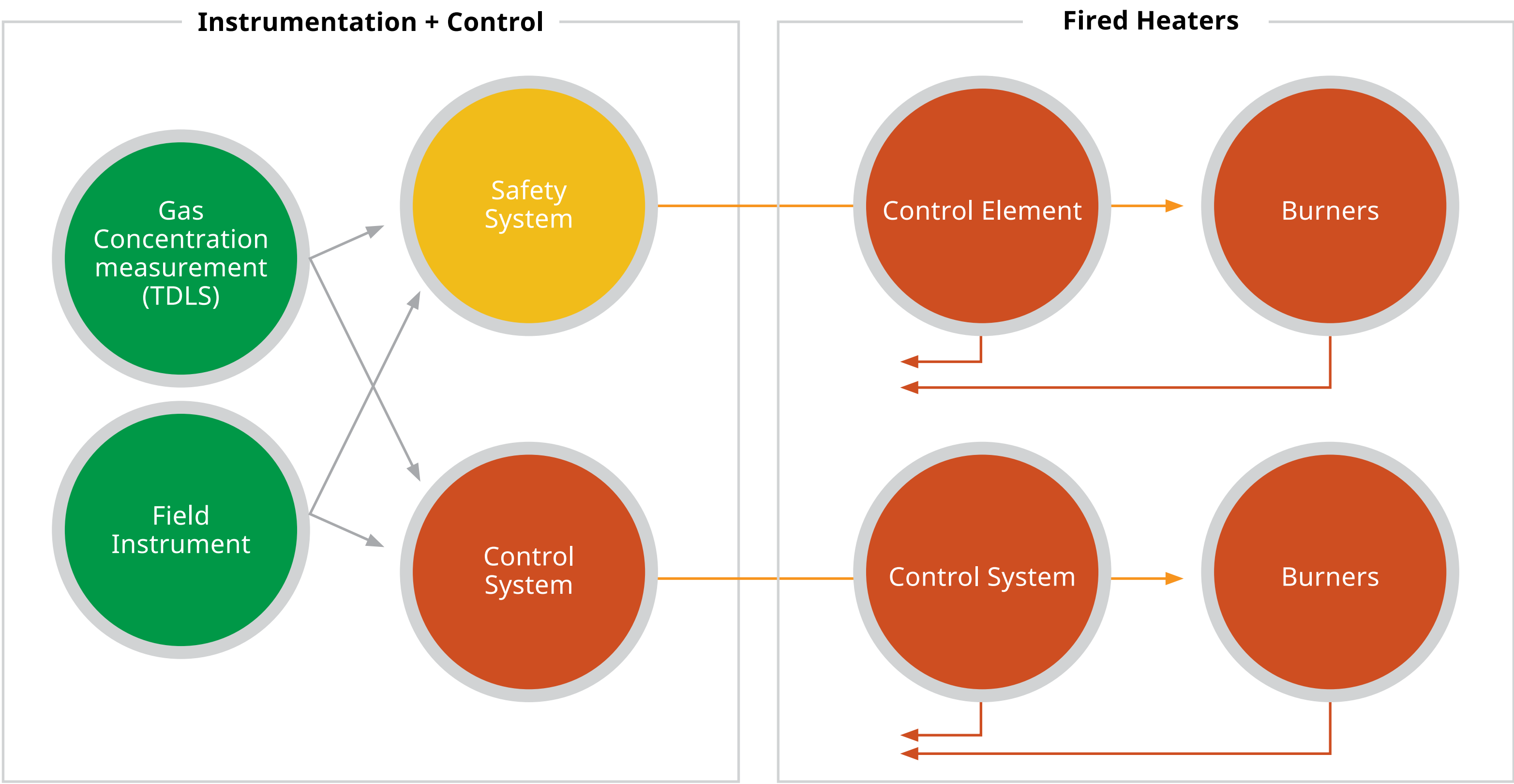

Figure – Integrated TDLS System

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HOW IT WORKS

Because the TDLS is a **non-contacting measurement**, never touching the flue gas, and has no moving parts, the whole system is very reliable. The TDLS analyzer technology has been operational on furnaces since 2003 without incidents, and most of those units have not required calibration. The analyzer has **full diagnostic capability**, and if there is an issue it will alert the operator. Moreover, the measurement signals from the **TDLS** are unaffected by the presence of other gases in the flue gas, unlike sensor based systems. The TDLS uses a path average measurement, as opposed to the traditional point measurement, making the value of concentration much more accurate.

The table on the right shows that TDLS technology has **distinct advantages over single point in situ analyzers** that may give false readings because of varying gas concentrations at different locations in the fired heater.

FEATURES & BENEFITS OF YOKOGAWA TDLS TECHNOLOGY

Features	Benefit:
In situ analysis	Sample conditioning not required
Fast response	Real time data for control
Tunable laser	Interference free analysis
Non-contact sensor	Operate in harsh environments
Optical sensor	Positive indication of operation

Source: ARC Insights, Insight# 2009 - 50MP, November 2009

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"Second only to raw materials costs, energy is the leading cost pressure currently affecting manufacturers. New analysis techniques, such as tunable diode laser spectroscopy (TDLS), can improve efficiency, maximize throughput, reduce emissions, and improve safety and reduce energy in combustion processes."

ARC INSIGHTS, INSIGHT# 2009-50MP, November 2009

"TDL analyzers can offer faster detection time in the 5 second T90 range and do provide an across duct type measurement, which can be helpful in early detection of a CO flood condition. They can be mounted in the hot, radiant section to provide measurement across the burner row and do not need flame arrestors or aspiration air."

ISA Analysis Division, 57th Annual Symposium Anaheim, California, April 2012.

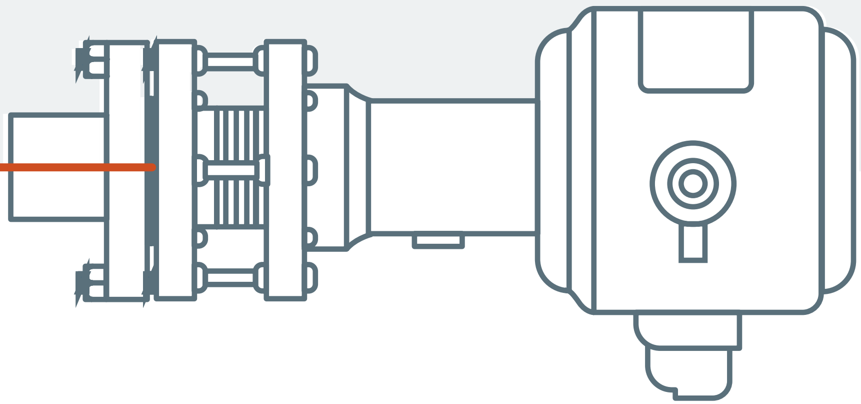
TUNABLE DIODE LASER SPECTROSCOPY

ABOUT TUNEABLE DIODE LASER SPECTROSCOPY

- **TDL:** Tunable Diode Laser
- Consists of an emitter and detector
- Laser based device that is able to measure the concentration of specific gases
- Based on absorption spectroscopy; measuring the amount of light that is absorbed as it travels through the sample being measured
- Shining across a defined path length
- Absorption equals concentration: Lambert-Beer's law

TDLS FEATURES

- Measurement of specific gases O_2,CO,CO_2,CH_4,H_2O,NH_3,HF
- In situ analysis without sample conditioning
- Fast response 2 sec
- Interference rejection (high and variable light obstruction)
- Process temperature up to 1500˚C
- Optical measurement, no sensor contact with process
- Very low maintenance



[CLICK HERE TO LEARN MORE ABOUT TDLS TECHNOLOGY]

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CHAPTER 04
APPLICATIONS

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BURNER MANAGEMENT & SAFETY

A Burner Management System (BMS) controls the burner of the combustion furnace and includes an interlock mechanism and a safety shut-off mechanism to prevent explosion.

The BMS must comply with **safety standards** based on risk assessment such as:

- The international standard: (ISO12100) and the EU, USA and Japanese standards (EU standard: EN746, USA standard: NFPA 86, NFPA, Japanese standard: JIS B9700), USA OSHA 1910.110 PHA (Hazop/LOPA), USA: ANSI/ISA-84.00.01-2004 (IEC 61511-Mod), and many other international requirements for Burner Systems.

With regards to critical safety, the TDLS can be implemented in the Burner Management Safety System in several ways.

The most common application for safety is to implement a ‘clear’ signal at the completion of the '**purge cycle**' to indicate the absence of combustibles in the combustion chamber after the purge cycle and before the ‘light pilot’ step. This greatly minimizes the danger of ignition in a chamber with accumulations of ignitable gas. Accumulation CO or C4 can also be implemented to initiate a time-delayed shutdown, or to alarm for operator intervention.

More frequently, the TDLS signal is allowed to operate in parallel with the safety shutdown system and allows for control of the air/gas control valve to resolve high levels of CO or C4.

In addition to the measurement of CO, TDLS technology can accurately measure **CH4 (Methane) levels** providing an extra level of safety during start up where a flame out or a failed burner ignition can cause an explosion.

The TDLS 8000 Analyzer is classified as a Type B(1) element according to IEC 16508, having a fault tolerance of 0. The Analysis shows that design of the TDLS 8000 meets the hardware requirements of IEC 61508, SIL 2 @ HFT = 0 and SIL 3 @ HFT = 1. “Exida Report No. YEC 15-01-126 R001, V1, R1, 2015”. As such, the TDLS 8000 V1 can be utilized as part of a SIF, depending on the Risk Reduction Requirements, and SRS definition.

BURNER MANAGEMENT SAFETY SYSTEM

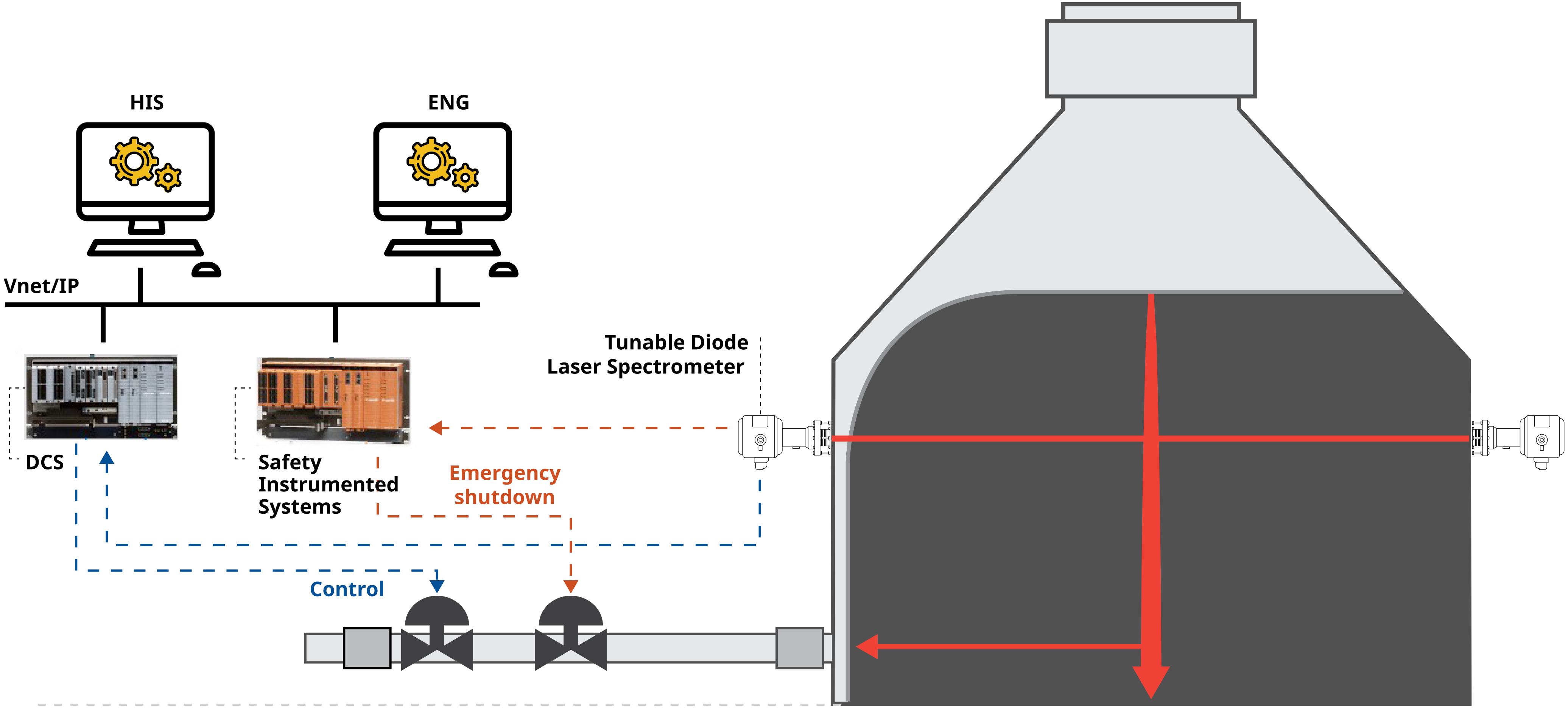

Fig. Overview of BMSS components

COMBUSTION CONTROL

The most critical times of heater operation are at **start up** and **shutdown**. Recognizing that a much faster, more reliable analyzer is required to measure O2, CO and CH4 concentrations, **a large refiner has adopted the TDLS solution for combustion management**. Since the system measures gas concentration in the radiant section of the fired heater, it improved the heater **safety** and overall operational **efficiency**.

In this application, the system is installed with two TDLS analyzers for measurement of **O2**, **CO** and **CH4** concentrations in the radiant section of the heater. A dedicated controller uses these measurements while feeding these values to an existing **DCS** for monitoring and future control of the heaters. The dedicated control hardware is equipped to receive additional signals from the heater, which will be used to control the airflow in the burners in a subsequent phase of the project. Space has also been allotted for a future safety shutdown system.

Complete combustion:

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

Incomplete (fuel-rich) combustion:

$$CH_4 + O_2 \rightarrow CO + H_2 + H_2O$$

Under perfect conditions, fuel combines with exactly the right amount of oxygen to allow complete or stoichiometric combustion; no unburned fuel and no excess oxygen. Real combustion applications are more complex. Some excess air is always needed to guarantee complete fuel combustion. If not, substantial amounts of CO are produced, reducing efficiency and increasing pollution levels.

COMBUSTION CONTROL

THE DETECTION OF COMBUSTIBLES

The most effective method to diagnose the accumulation of combustibles is by measuring the **feed forward information of the air to fuel ratio**. If you don't have that information, the most effective method is to use a TDL type device for measuring CO. With that information an operator is able to bring the system back into a safe state. Instead of 'tripping' the heater, it is recommended to use a control function to bring the heater back in to a safe state. The control algorithm on the right describes that process. It was presented in a paper during the 2008 Ethylene Producers Conference.

Control Algorithm

Reduce the fuel input into the furnace at a rate of 1% every **t** seconds.

The value of **t** would need to be selected based on the perceived risk. Based on the preceding analysis, one conservative method of selecting these values would be to:

1. assume the worst case of perfect mixing,
2. select a maximum acceptable concentration of combustibles upon the entry of excess air, and
3. find **t** from the relation

$$t = t_{res}\,(3550ppm)/C_{acceptable}$$

Example: A safe ramp can be described as a relative reduction in fuel input, rather than a change in flue gas composition. Assume tres is 8 seconds and Cacceptable is 400ppm . Then t = 8(3550)/400 = 71 seconds. So the fuel input should be reduced ar a arate of 1% every 71 secnds to achieve a safe ramp.

* *t*res = average time that a gas particle spends inside the furnace (residence time)

* *C*acceptable = maximum acceptable concentration of combustibles upon the entry of excess air

* The value 3550 ppm is used because that is the concentration of combustibles that is added by every 1% of excess fuel.

* The definition residence time is tres= ṁ, where m is the mass of flue gas within the furnace and m is the combined mass flow rate of fuel and air through the furnace.

Source: 'Hazardous Flue Gas Mixtures in Furnaces Due to Fuel-Rich Combustion', Andrew Hawryluk, NOVA Chemicals Corp | Ethylene Producers Conference, 8 Apr 2008

COMBUSTION CONTROL

The combustion management system is designed to be tested during upset conditions, with the response of **combustion gases** being analyzed to confirm the desired response to unsafe conditions. This data can then be correlated to the output from the existing stack gas analyzer to verify the results. Data collected during this testing will be incorporated into the future safety shutdown system.

A **Modular Procedural Automation** (MPA) capability will ensure safe operating conditions during start up and shutdown. Once the safety interlock system is in place, the system will be able to detect and prevent any unsafe operating conditions.

Natural draft heaters lack the capability to use air to purge the heater. Instead, steam is used. If the steam is not dry, water will accumulate on the burners or igniters, preventing ignition. The start up sequence is designed to purge the condensate from the steam line, thus **providing dry steam to purge the heater before ignition**.

Methane (CH_4) is used as a startup permissive after the purge cycle. During start-up a plant requires sufficient land independent protection layer(s) for each different part of the operation.

WHY IS TDLS A CHEAPER OPTION WHEN IT COMES TO DIFFERENT LAYERS OF PROTECTION? DOES IT REQUIRE LESS LAYERS?

One TDL applied so that it measures across the array of burners is the most effective means of ensuring that the purge cycle was successful in evacuating any potential fuel gas. No other single device has this capability. It can be proof tested through an automated function via DCS or SIS at the time of use without operator interaction which avoids the possibility of overrides or bypass.

COMBUSTION CONTROL

The combustion management system has been operational in a major refinery since June 2010, and since then:

- The TDLS analyzers continue to operate reliably with no maintenance needed.
- The operators have been able to reduce the percentage of O_2 by 1% to 1.5%, thus making the heater more efficient.
- The furnace is now near its optimum operating point, using minimum excess air.
- The TDLS measurements have been verified by the existing stack gas analyzers, but with a percentage O_2 reading of 1% to 1.5% lower than the stack gas analysis because the measurements are taken in the radiant section.
- Furnace conditions can now be controlled (or shut down) quicker since the TDLS system is taking concentration measurements at five second intervals in the radiant section. If there were to be an excess concentration of CO or CH_4 in the furnace, these gases can be detected earlier than with the conventional stack gas analyzer, enabling the heater to be shut down sooner and avoiding unsafe conditions.

SUMMARY

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COMBUSTION & FIRED HEATERS

Reliable measurements of cross sectional averages of O_2 and CO at high temperatures have only recently become viable with the introduction of TDLS technology. To show how this technology can benefit fired heater operations, we focused on a solution that has the ability to simultaneously control air and fuel supply by measuring average gas concentrations across the high temperature radiant section. The TDLS analyzer is united with a dedicated control system and a safety system certified to meet FM NFPA and SIL 2 standards.

INTRINSIC VALUE GAINED BY ADOPTING THIS NEW COMBUSTION TECHNOLOGY:

- Best industry practices which can only be satisfied with new technology.
- Increased safety because both air and fuel are continuously controlled.
- Improved thermal efficiency as excess air is always optimized.
- Longer fired heater life (asset reliability) since heat is not concentrated at the bottom of the convection section.
- Lower greenhouse gas emissions through more efficient use of fuel.

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EXTRA
INTEGRATED SOLUTION

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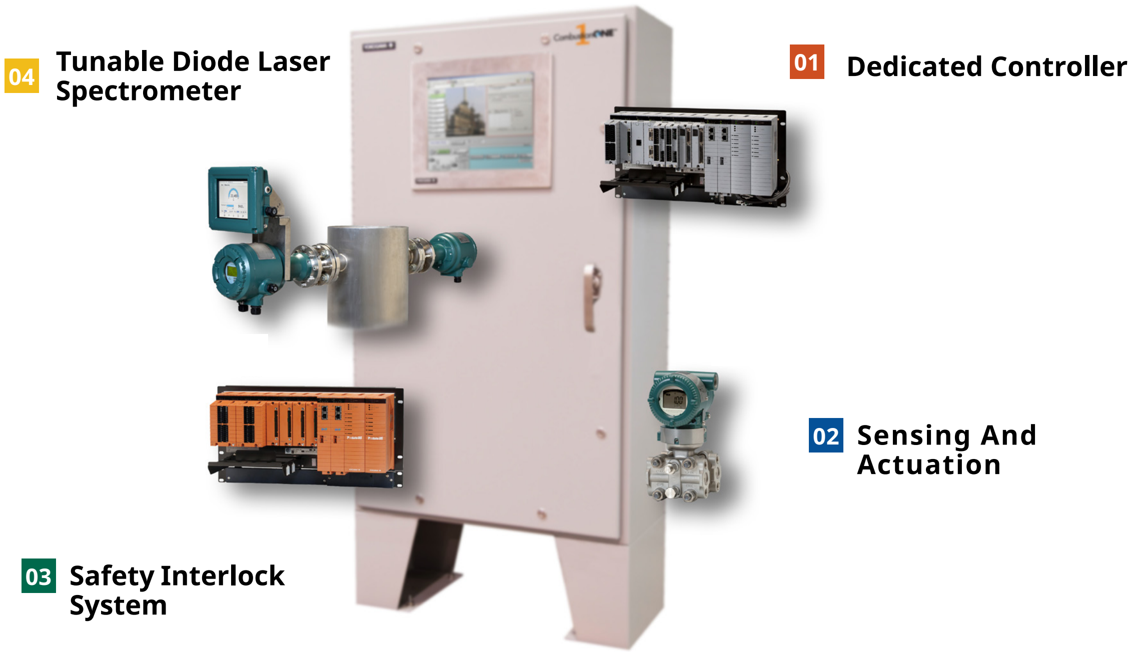
INTEGRATED SOLUTION

An integrated combustion system combines new gas combustion measurement and control technologies into one solution that improves fired heater performance and life. It simultaneously controls both the air and fuel supply to fired heaters by measuring average gas concentrations across the radiant section. This solution incorporates a TDLS analyzer with a logic solver (control system) and a safety system.

This integrated, self contained solution for fired heaters can be rapidly installed on any fired heater. It comprises four principal components:

1. A properly designed system with sufficient feed-forward and feedback diagnostics with combustibles override function
2. TDLS technology for gas concentration measurements at fast (less than five second) intervals.
3. An ISA 84 compliant safety system to prevent unsafe conditions from persisting.
4. Sensing and actuation for additional measurements and air flow control as needed.



Click here for more information about this solution.

INTEGRATED SOLUTION

Two TDLS systems (transmitters and receivers) are typically installed in the radiant section of the fired heater, which is the most accurate location for **optimum combustion** management. At minimum, one unit measures O_2 and the other CO and CH_4. Since fired heaters have differing configurations, capacities, environmental and process conditions, custom mounting brackets are built to hold and position the laser across the radiant section. This is the best location to obtain the most accurate gas concentration and temperature measurements. The **dedicated controller** is used to simultaneously control fuel and air volumes based on five second sampling measurements of average gas concentrations across the radiant section from the TDLS.

BEFORE OPTIMIZED COMBUSTION	AFTER OPTIMIZED COMBUSTION
Higher cost as operators increase O_2 flow to avoid a fuel rich atmosphere	Reduced O_2 and lower operation costs as the air-fuel mixture is controlled
Unexpected demand for fuel, leadingto unsafe combustion conditions	Fuel is limited to the available air to prevent unsafe fuel rich combustion
Greater risk during a process upset	CO and O_2 concentrations are safely controlled at the optimum levels
Risk of inadequate air control may not be assessed correctly for process upset	Unburned fuel is detected rapidly, avoiding unsafe combustion
Wet steam introduced on start up, requiring a steam purge, risking ignition failure	Process upsets are handled with controlled combustion conditions
Shorter line of the funned convection section with afterburning due to presence of combustibles	Enforced drain removal from purge steam prevents unsafe ignition attempt

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THANKS FOR READING THIS EBOOK!

Are you interested in a free consultation about how you can implement TDLS technology or combustion management? Find out how Yokogawa can help you with making Fired Heaters operate even safer and more efficient. Sign up for a free consultation!

Click Here
For a Free Consultation

Combustion & Fired Heater Optimization

An Analytical Approach To Improving Safe & Efficient Operations

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ABOUT YOKOGAWA

Yokogawa's global network of 92 companies spans 59 countries. Founded in 1915, the US$3.7 billion company engages in cutting-edge research and innovation. Yokogawa is acive in the industrial automation and control (IA), test & measurement, and other business segments.

The IA segment plays a vital role in a wide range of industries including oil, chemicals, natural gas, power, iron and steel, pulp and paper, pharmaceuticals, and food.

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