CUBH and CUBP Process Heater Burners

Honeywell UOP Callidus

Site:
Beggs OK

Burner Test Date:
June 2022

Equipment Tested:
CUBH-8W
CUBP-8W

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Project: **Sustainable Combustion Technologies 2023 NPD**

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This burner witness test was conducted at the UOP Callidus Testing Facility located at:

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I. Burner Test for CUBH and CUBP for Process Heater Services

A. Installation

The CUBH/CUBP-8W burner was installed vertically on the floor of Test Furnace #1 and located at the center of the heater floor. (Information about Test Furnace #1 can be found in Appendix B). The test data marked “Baseline” is that data for the CUBH burner, without targeted flue gas recirculation. The test data marked “FGR” is that data for the CUBP burner with targeted flue gas recirculation.

B. Executive Summary

Testing for CUBH and CUBP burners for process heater service was successful.

- CUBP burner demonstrated the ability to cut NO_X emission in half from current generation technology such as used on the legacy CUBL and the current CUBH burners.
- Fuel gases from 100% NG to 100% H_2 to RFG were tested. Burners were stable and NO_X emission were reduced to sub-10 ppm for all fuels.
- Lowest NO_X emissions were achieved when firing 100% H_2.

II. Appendix

A. Test Data

Table 1. Test Data for 100% NG, 100% H2 & RFG Fuels

Client	CALLIDUS	Work Order	SCT 2023
Date	6/16/2022	Furnace #	F1
Burner Description	CUBP-8W		

Test Point #		Baseline	FGR	Baseline	FGR	Baseline	FGR
Time		9:01 AM	3:12 PM	9:23 AM	3:51 PM	9:56 AM	4:19 PM
Fuel Gas Composition							
Total Burner Heat Release	MMBtu/hr	7.01	7.00	6.59	6.66	6.70	6.69
Fuel Gas 2 Name		100% NG	100% NG	RFG	RFG	100% H2	100% H2
Heating Release - LHV	MMBtu/hr	7.01	7.00	6.59	6.66	6.70	6.69
Heating Value	Btu/SCF	958.0	958.0	1124.8	1119.4	274.0	274.0
Specific Gravity		0.622	0.622	0.717	0.714	0.070	0.070
NG	%	100.00%	100.00%	49.70%	49.81%	0.00%	0.00%
H2	%	0.00%	0.00%	25.27%	25.46%	100.00%	100.00%
C3H8	%	0.00%	0.00%	25.03%	24.73%	0.00%	0.00%
Pressure							
Fuel Gas 2 Tip Pressure (BURNER FUEL)	Psig	18.2	19.6	16.0	17.5	22.3	24.5
Airside Pressure Drop	in. W.C.	0.42	0.61	0.47	0.70	0.28	0.67
Damper Position		WO	WO	WO	WO	WO	WO
Temperature							
Ambient Air Temperature	F	83.4	91.5	84.4	89.5	85.8	90.9
Upper Furnace Temperature	F	1676.4	1618.0	1717.3	1651.4	1697.6	1603.9
Fuel Gas 2 Temperature	F	86.0	90.6	85.9	89.4	87.9	89.4
Emissions							
Actual O2 % (Dry)		2.98	3.12	3.03	3.09	3.08	2.96
NOx @ 3% O2	PPMV	12.49	6.34	15.13	7.69	20.28	4.12
Notes							

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B. Test Equipment

1. Test System Configuration

The general layout for any test includes test fuel gas storage, test fuel gas blending station, a furnace, a cooling water circulation system, and a flue gas sample system.

Test fuel gas is blended to adequately simulate site fuel gas by metering and measuring each component gas and mixing in a fuel header before delivery to the test burner. Each test fuel gas is calculated to simulate the site fuel gas using Wobbe number, heating value, and specific gravity. The burner is mounted in the most appropriate test furnace as close to the field mounting configuration as possible with regards to overall burner duty or combined burner duty. Water is circulated through process tubes in the furnace to remove heat. The temperature of the furnace is controlled as close to the design temperature as possible through insulation of the cooling tubes.

Various pressure, temperature, and differential pressure transmitters are placed in this system for measurement of all critical parameters. A vacuum pump draws a sample of the flue gas at the exit of the radiant section and delivers the sample to gas analyzers located in the Central Control Room (CCR).

TEST FACILITY PROCESS FLOW DIAGRAM

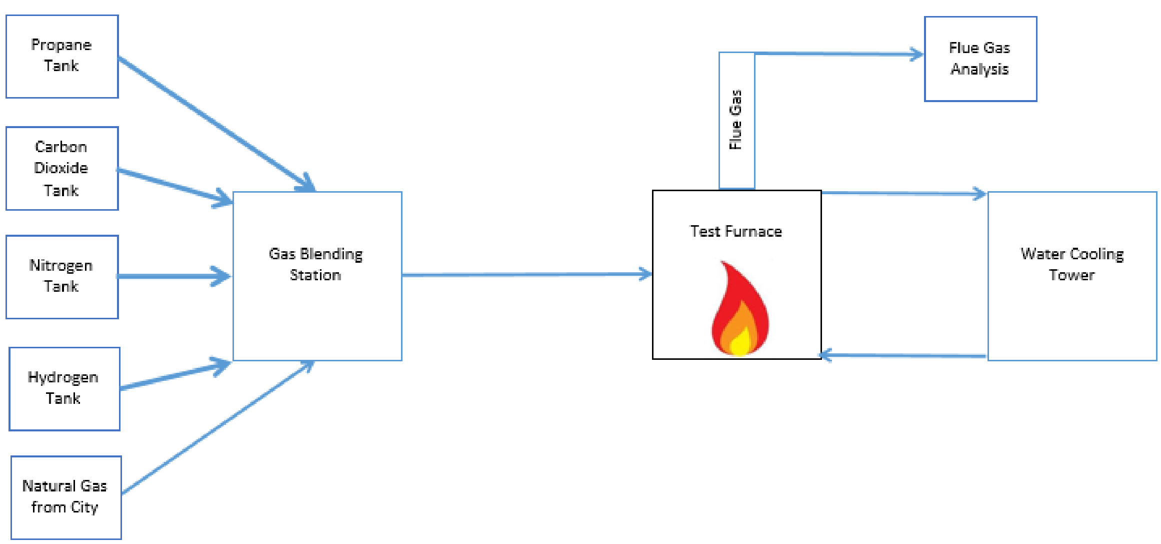

FIGURE 1

2. Test Furnace

Furnace 1: This furnace is vertically cylindrical, 9' in diameter and 34' high. It has a continuous water flow cooling system via evenly spaced process tubes situated vertically around the furnace wall. The test burner is mounted in the center of the furnace floor.

Five (5) view ports are on the furnace; two (2) at approximately 5' from the heater floor, one (1) at approximately 13' from the floor, and one (1) at approximately 21' from the floor.

The furnace wall is lined with ceramic fiber with castable refractory on the floor and roof. The stack, which is lined with castable, is 3' I.D. and has a stainless steel damper and steam sparger installed for controlling draft. Total furnace height with the stack is 61'.

A suction pyrometer is located near the exit of the radiant section. A Flue Gas Sample Port is located just after the exit of the radiant section. Note: there is no convection section on this furnace. The draft across the burner (floor draft) is measured via a differential pressure. The downstream pressure tap is located at the floor of the furnace. The upstream pressure tap is located either in the ducting upstream of the burner for forced draft applications or is open to atmosphere in natural draft applications. **See FIGURE 2 for Furnace Layout.**

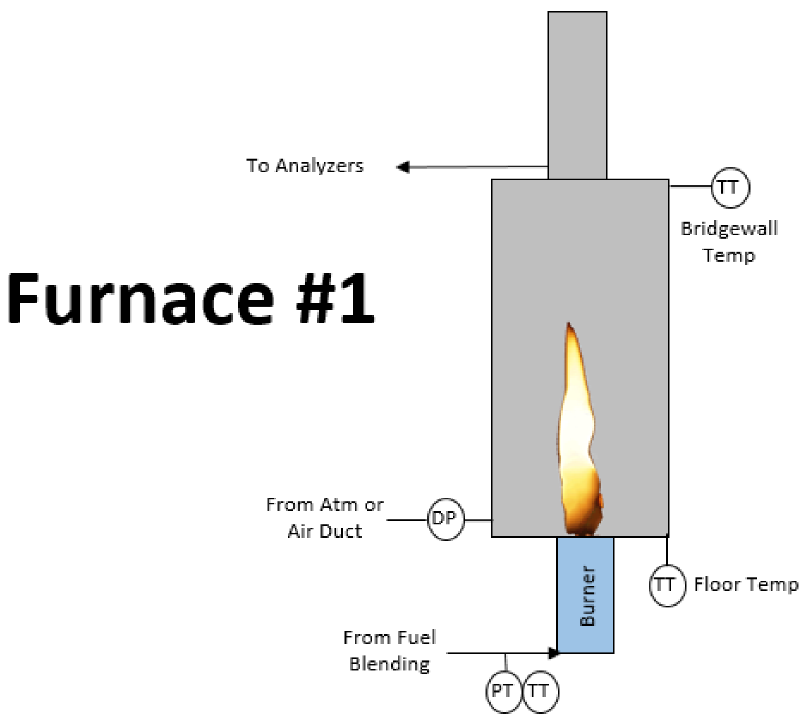

FIGURE 2

3. Instrumentation

Each component of the test fuel is controlled by automated flow control valves and measured by the use of an individual orifice run, which conforms to American Gas Association (AGA) specifications. Orifice plates are selected to provide accurate ranges of flow. Fuel temperature, orifice differential pressure, and operating pressures are transmitted to the Honeywell Distributed Control System (DCS) which calculates individual component flow rate, specific gravity, and heating value. These values are totaled up and recorded to define the overall characteristics of the Test Fuel Blend. **See FIGURE 3.**

A Suction Pyrometer, mounted at the end of the radiant section, measures the temperature of the radiant section / bridgewall temperature. Honeywell Wireless pressure, differential pressure, and temperature transmitters monitor furnace draft across the burner, fuel pressure, fuel temperature, and furnace temperature, all of which are transmitted wirelessly to the DCS. **Reference FIGURE 2.**

Flame dimensions are ascertained visually and recorded manually unless otherwise stated.

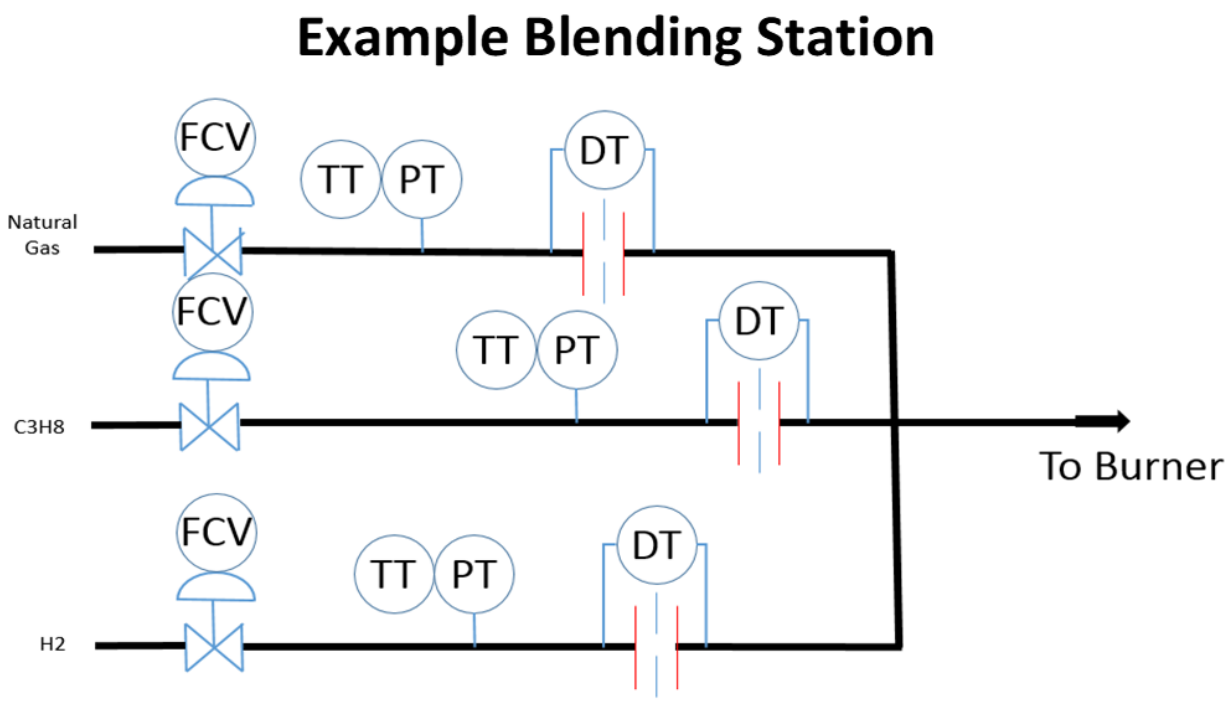

FIGURE 3

4. Flue Gas Sampling

Flue gas samples are drawn from the end of the radiant section through a heated stainless steel line by the use of a Vacuum Diaphragm Pump. Water is removed from the sample gas via a Thermoelectric Gas Cooler of make and model common in refinery Continuous Emissions Monitoring Systems (CEMS), then delivered to analyzers for analysis.

NO_X content is measured using chemiluminescence detection. Excess oxygen content is measured using paramagnetic detection. Carbon monoxide content is measured using Infrared detection. All of the instruments are calibrated using certified zero and span gases in the operating range of the test facility. Calibration of the meters is done before and after each test, and at any time that there is questionable data. **See FIGURE 4.**

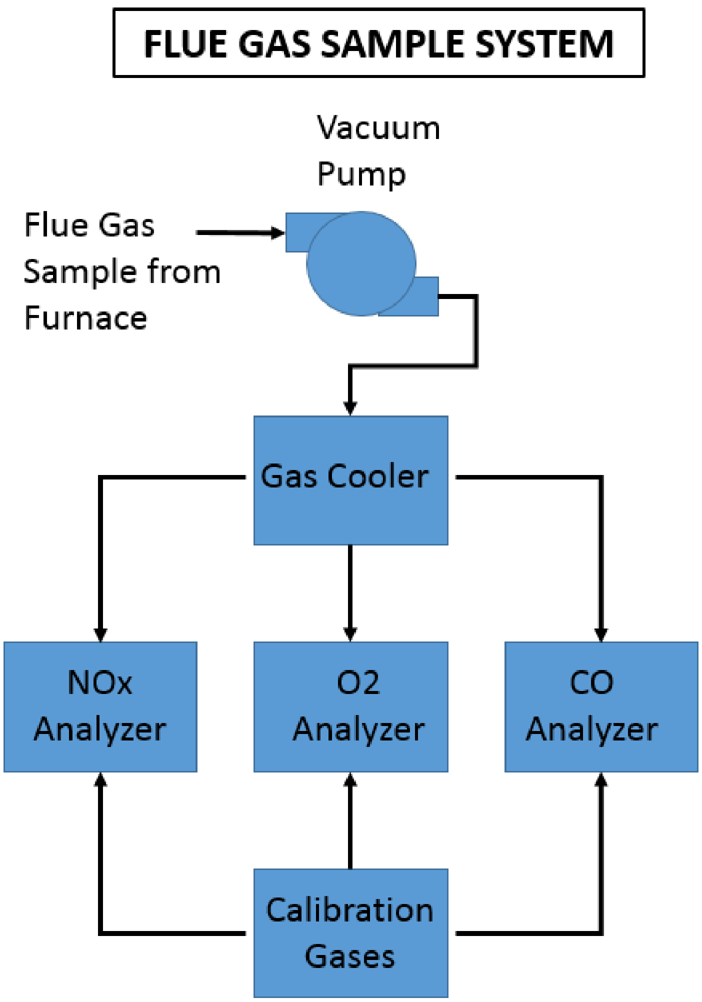

FIGURE 4

5. Data Acquisition and Reduction

All field instruments and flue gas analyzers transmit to a Honeywell DCS. These process variable signals are converted from analog to digital then to engineering units in the DCS. All flow calculations are also made by the DCS. The converted and calculated process variables then populate a spreadsheet specifically designed to calculate critical values that cannot be measured directly, such as fuel heating value, specific gravity, percentage (%) of total flow for each fuel, etc.

The spreadsheet also calculates corrected values for NO_X and CO based on deviation from design excess oxygen, site furnace temperature, and site combustion air temperature. Correction for excess oxygen is performed using EPA methods. Correction for furnace temperature and combustion air temperature are performed using empirical, proprietary curves and equations developed specifically for each type of Callidus burner through extensive testing. These curves are similar to those found in API 535.

Pressure loss (draft) across the burner is corrected for deviation from design site elevation (atmospheric pressure), site humidity, and combustion air temperature. Fuel pressure is corrected for deviation from design fuel temperature.

Data is acquired by the system every one (1) second. The DCS provides a ten (10) second rolling average to the spreadsheet. When equilibrium is attained for a particular operating condition, the data is saved.