

# Burner Test Report

## CUBH-DF-PSA

Site:  
Beggs OK

Burner Test Date:  
November 2021

Equipment Tested:  
(1) CUBH-3WDF-PSA  
(1) CUBH-5WDF-PSA



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Revision: 0  
September 21, 2022

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

2499 Highway 16  
Beggs, OK 74421-9581  
Phone No.: (918) 467-4920

**Callidus Test Facility Personnel**

<b>Name</b>	<b>Title</b>
Albert Septiano	Test Engineer
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# I. Burner Test

## **A. Installation**

The burner was installed on the roof, firing downward in Test Furnace #3, and located in the center of the furnace. (Information about Test Furnace #3 can be found in Appendix B)

## **B. Executive Summary**

The burner was tested across various conditions on forced air preheat. The final burner configuration ran stable across all operating points and was optimized to meet all design criteria.

Fuel composition used during the test for both CUBH-3WDF-PSA and CUBH-5WDF-PSA burners are:

- 100%NG without PSA
- 100%H<sub>2</sub> with PSA fuel composition of 6%NG & 94%H<sub>2</sub>

## **II. Appendix**

**A. Test Data**

<b>Client</b>	CALLIDUS	<b>Work Order</b>		
<b>Date</b>	11/17/2021	<b>Furnace #</b>		F3
<b>Burner Description</b>	CUBH-3WDF-PSA			
<b>Test Point#</b>		100%NG	100H2+P SA	
<b>Time</b>		10:30 AM	4:07 PM	
<b>Fuel Gas Composition</b>				
<b>Total Burner Heat Release</b>	MMBtu/hr	2.45	5.03	
<b>Fuel Gas 1 Name</b>		NG	H2	
<b>Heating Release - LHV</b>	MMBtu/hr	2.46	0.55	
<b>Heating Value</b>	Btu/ SCF	958.0	274.0	
<b>Specific Gravity</b>		0.622	0.070	
<b>NG</b>	%	100.00%	0.00%	
<b>H2</b>	%	0.00%	100.00%	
<b>Fuel Gas 2 Name</b>				
<b>Heating Release - LHV</b>	MMBtu/hr		P SA	
<b>Heating Value</b>	Btu/ SCF		4.48	
<b>Specific Gravity</b>			314.9	
<b>NG</b>	%		0.103	
<b>H2</b>	%		5.99%	
			94.01%	
<b>Pressure</b>				
<b>Fuel Gas 1 Tip Pressure</b>	Psig	29.2	2.5	
<b>Fuel Gas 2 Tip Pressure</b>	Psig		1.1	
<b>Airside Pressure Drop</b>	in. W.C.	1.27	5.02	
<b>Damper Position</b>		WO	WO	
<b>Temperature</b>				
<b>Ambient Air Temperature</b>	F	70.3	61.8	
<b>Combustion Air Temperature</b>	F	459.9	470.5	
<b>Upper Furnace Temperature</b>	F	1618.3	2141.7	
<b>Fuel Gas 1 Temperature</b>	F	69.3	61.0	
<b>Fuel Gas 2 Temperature</b>	F	72.3	61.6	
<b>Emissions</b>				
<b>Actual O2 % (Dry)</b>		2.10	2.06	
<b>NOx @ 3% O2</b>	PPMV	28.08	31.67	
Honeywell - Confidential				

<b>Client</b>	CALLIDUS	<b>Work Order</b>	
<b>Date</b>	11/15/2021	<b>Furnace #</b>	F3
<b>Burner Description</b>	CUBH-5WDF-P SA		
<b>Test Point#</b>			
	100%NG	100H2+PSA	
<b>Time</b>	10:59 AM	3:33 PM	
<b>Fuel Gas Composition</b>			
<b>Total Burner Heat Release</b>	<b>MMBtu/hr</b>	3.55	7.14
<b>Fuel Gas 1 Name</b>	NG	H2	
<b>Heating Release - LHV</b>	<b>MMBtu/hr</b>	3.55	0.76
<b>Heating Value</b>	<b>Btu/SCF</b>	958.0	274.0
<b>Specific Gravity</b>		0.622	0.070
<b>NG</b>	%	100.00%	0.00%
<b>H2</b>	%	0.00%	100.00%
<b>Fuel Gas 2 Name</b>			
		PSA	
<b>Heating Release - LHV</b>	<b>MMBtu/hr</b>		6.38
<b>Heating Value</b>	<b>Btu/SCF</b>		315.2
<b>Specific Gravity</b>			0.103
<b>NG</b>	%		6.02%
<b>H2</b>	%		93.98%
<b>Pressure</b>			
<b>Fuel Gas 1 Tip Pressure</b>	<b>Psig</b>	28.1	2.5
<b>Fuel Gas 2 Tip Pressure</b>	<b>Psig</b>		1.0
<b>Airside Pressure Drop</b>	<b>in. W.C.</b>	1.20	4.94
<b>Damper Position</b>		WO	WO
<b>Temperature</b>			
<b>Ambient Air Temperature</b>	<b>F</b>	61.8	82.9
<b>Combustion Air Temperature</b>	<b>F</b>	405.2	483.6
<b>Upper Furnace Temperature</b>	<b>F</b>	1545.2	1852.0
<b>Fuel Gas 1 Temperature</b>	<b>F</b>	60.7	78.5
<b>Fuel Gas 2 Temperature</b>	<b>F</b>	69.2	85.8
<b>Emissions</b>			
<b>Actual O2 % (Dry)</b>		2.05	2.06
<b>NOx @ 3% O2</b>	<b>PPMV</b>	32.88	21.71
Honeywell - Confidential			

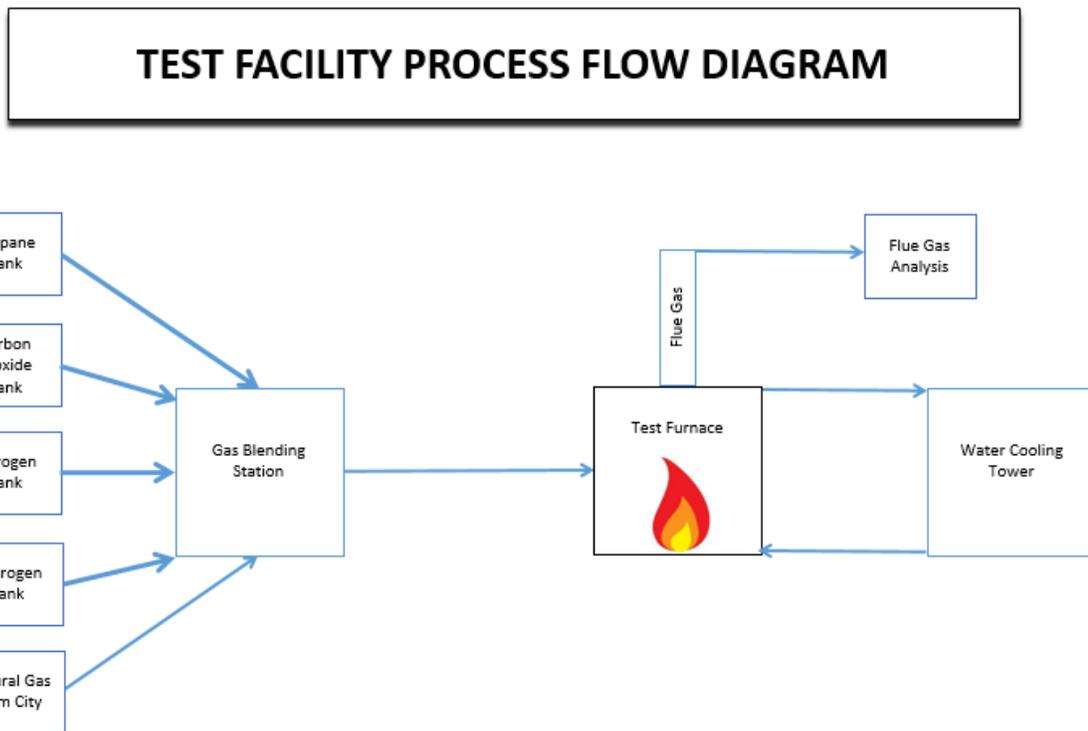
## **B. Test Equipment**

## 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, mixing in a fuel header and delivering to the test burner. Each test fuel gas is calculated to simulate as best as possible the site fuel gas using wobble 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.)



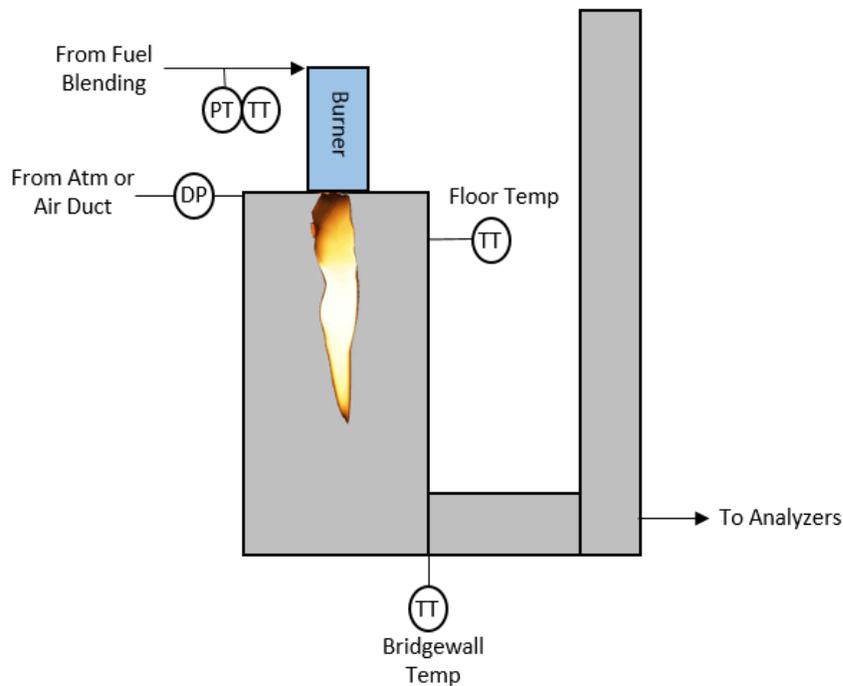
**FIGURE 1**

## 2. Test Furnace

Furnace 3: The test furnace itself is rectangular in section, measuring 6 ft. each side with an overall height of 22.5 ft. inside. Burners are mounted on the roof, firing down. The furnace is equipped with a 2' I.D. stack with an overall height of 50 ft. above the floor. Cooling tubes are located adjacent to one wall (opposite the burner) to simulate process tubes in a fired heater. Refractory covers the interior surfaces. Ceramic fiber is used on the walls and castable refractory covers the floor, roof, and stack. A draft connection is located at the roof and in the combustion air duct. A temperature connection is provided at the top of the radiant section.

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 is measured via a differential pressure. The downstream pressure tap is located at the roof 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**

# Furnace #3 DownFired



**FIGURE 2**

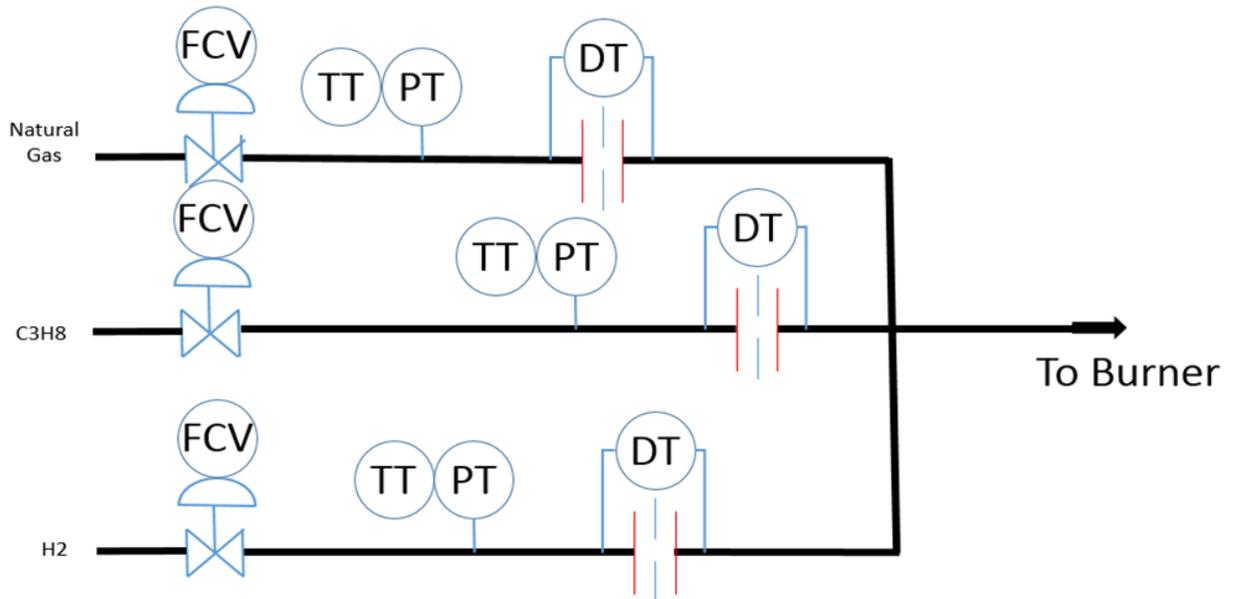
### 3. Instrumentation

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 / bridgwall 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.

### Example Blending Station

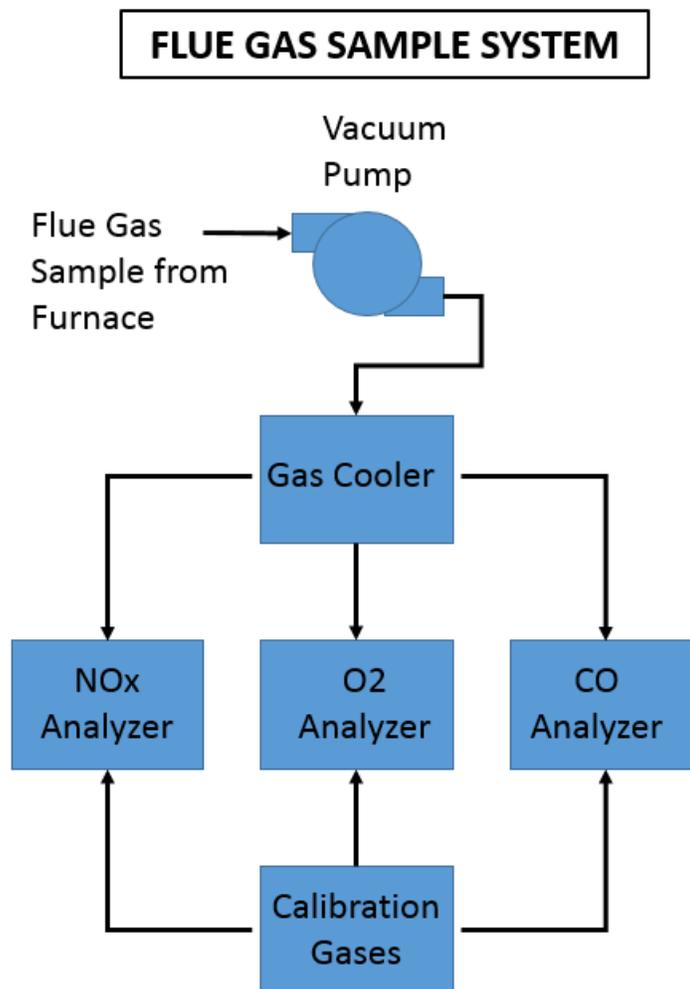


**FIGURE 3**

#### 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 CEMS, then delivered to analyzers for analysis.

NO<sub>x</sub> content is measured using Chemluminescence 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 are 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 Distributed Control System. 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<sub>x</sub> 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.