INVENO ENGINEERING LLC

BEST PRACTICE NO. 35

COMBUSTION TESTING PROCESS AND DOCUMENTATION

With today's high energy costs and the need to reduce emissions, it is necessary to obtain data from the steam boiler at different firing rates during the combustion testing process.

The combustion process in the steam boiler transfers the chemical energy to thermal energy, which in turn is absorbed by the water in the boiler. To measure combustion process and efficiency, the plant must have equipment or have an outside firm analyze the flue gases from the combustion process. Combustion refers to the rapid chemical union of oxygen with fuel.

COMBUSTION OVERVIEW

The perfect combustion of fuel would result in:

- Carbon dioxide
- Nitrogen
- Water vapor
- Sulphur dioxide

The oxygen required to burn the fuel is obtained from the air. Air is a mechanical mixture containing by weight 21% oxygen, 78% nitrogen, and 1% other gases. Only oxygen is used in combustion. Nitrogen is an inert gas that has no chemical effect upon combustion.

The chemical combination obtained during combustion results in the liberation of heat energy. Actually, what happens is a rearrangement of the atoms of the chemical elements into new combinations of molecules. In other words, when the fuel temperature (in the presence of oxygen) is increased to the ignition point, a chemical reaction occurs. The fuel begins to separate and unite with specific amounts of oxygen to form an entirely new substance. Heat energy is given off in the process.

Perfect combustion is the objective. However, this has been impossible to achieve as yet in either a boiler or the cylinders of an internal-combustion engine. Theoretically, it is simple. It consists of bringing each particle of the fuel (heated to its ignition temperature) into contact with the correct amount of oxygen.

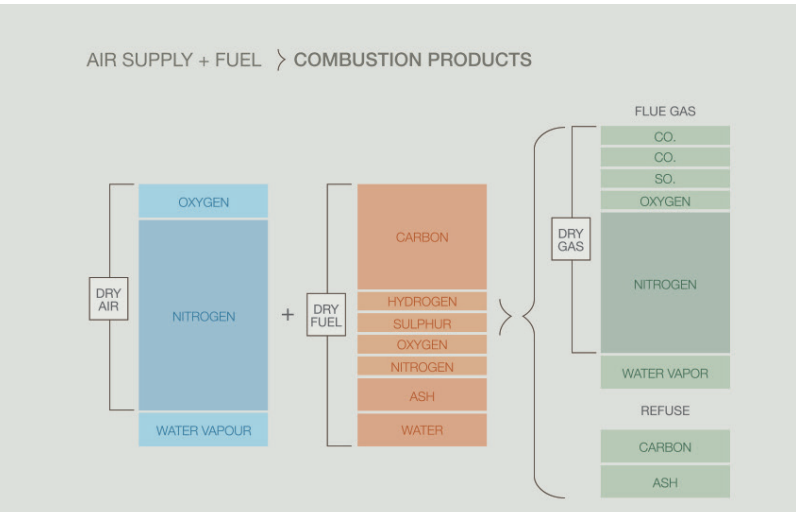

Figure 1: Combustion Process

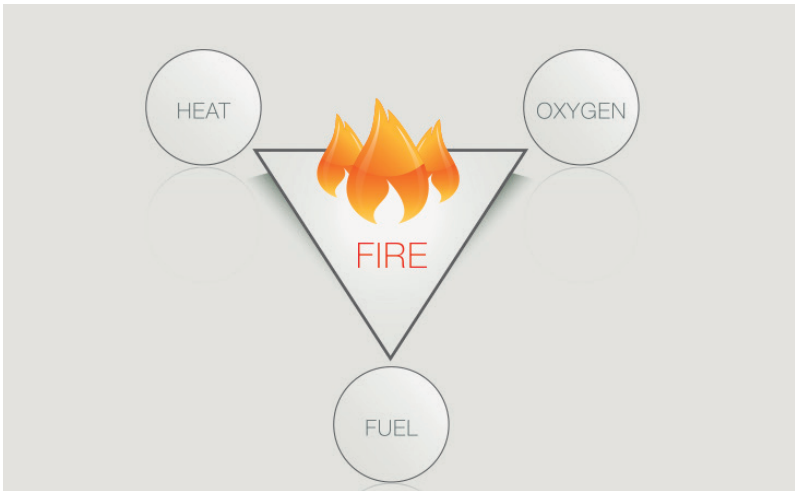

Figure 2: The Fire Triangle

The following factors are involved:

- Sufficient oxygen must be supplied.
- The oxygen and fuel particles must be thoroughly mixed.
- Temperatures must be high enough to maintain combustion.
- Enough time must be allowed to permit completion of the process.

Complete combustion can be achieved. This is accomplished by more oxygen being supplied to the process than would be required if perfect combustion were possible. The result is that some of the excess oxygen or excess air appears in the combustion gases.

OUTSIDE COMBUSTION TESTING CONTRACTOR

If an outside firm is used for the combustion testing procedure, the plant needs to ensure the company and individual are qualified to conduct the combustion test. A number of items should be provided by the outside firm:

1. Insurance documentation to meet the plant requirements.

2. Standard operating procedures (SOPs) on the combustion testing process

a. The SOP should be a step by step documented procedure. A typical SOP is five to eight pages in length

3. Validation and calibration of the combustion analyzer and any other test instruments used for the combustion testing

4. A sample of the report that will be delivered after the testing is completed

5. A sample of the combustion testing data sheet that will be used during the combustion testing procedure (see a sample combustion testing data sheet at the end of this Best Practice)

COMBUSTION TESTING DATA SHEET

It is extremely important to have all the data taken during combustion testing to establish the boiler benchmarks for comparison against the original boiler manufacturer's benchmarks. See the last page for a sample combustion testing data sheet.

Do not let the combustion testing person(s) provide the plant with only the printouts off a combustion analyzer. That is only a very small percentage of the required information to properly manage the boiler operation and energy.

CORRECT COMBUSTION TESTING DATA SHEETS

As viewed in the sample combustion testing data sheet (see next page), items such as burner ring pressure, windbox pressure, flue gas temperatures, etc. are an example of the required items. All data has to be taken on ten different percentages of the firing rate of the boiler.

TIME	12:22:09 pm		TIME	12:25:39 pm	
DATE	03/10/2011		DATE	03/10/2011	
	FUEL			FUEL	
	Natural Gas			Natural Gas	
O2	11.3	%	O2	10.1	%
CO	62	ppm	CO	68	ppm
EFF	79.2	%	EFF	80.4	%
CO2	5.4	%	CO2	6.1	%
T-STACK	350	°F	T-STACK	353	°F
T-AIR	79.4	°F (I)	T-AIR	80.5	°F (I)
EA	105	%	EA	82	%
NO	35	ppm	NO	39	ppm
NO2	0	ppm	NO2	0	ppm
NOX	35	ppm	NOX	39	ppm
CO(3)	116	ppm	CO(3)	113	ppm
NO(3)	66	ppm	NO(3)	64	ppm
NO2(3)	0	ppm	NO2(3)	0	ppm
NOX(3)	66	ppm	NOX(3)	64	ppm
COMMENTS:			COMMENTS:		

Figure 3: Unacceptable Combustion Data Reporting

You can use the data sheet template on the following page to capture this data.

INVENO ENGINEERING LLC

BOILER COMBUSTION TESTING DATA SHEET

Plant Name:					Date			Boiler No.			
Plant Location					Person Testing						
Ten Testing Points (min to max firing rate)	0	1	2	3	4	5	6	7	8	9	10
Boiler Master % or Sub Master											
Steam Pressure PSIG											
Degree of Superheat											
Steam Flow K / Lb Hr											
Windbox Pressure W.C.											
Furnace Pressure W.C.											
Over Fire Air Pressure W.C.											
Drum Level											
Feed water Valve Position											
Feedwater Flow											
Feedwater Temperature before Economizer											
Feedwater Temperature after Economizer											
Air Drive or Actuator Position %											
Air Flow lb/hr											
Ambient Temperature (Boiler Plt.)											
Air Flow Temperature Before Air Heater											
Air Flow Temperature After Air Heater											
Fuel Valve Position											
FD Motor Amps											
Fuel Flow / Volume											
Supply Nat. Gas or Fuel Oil Pressure											
Burner Gas Pressure W.C.											
Flue Gas Temperature Outlet of Boiler and Before Economizer											
Flue Gas Temperature Outlet of Economizer before Air Heater											
Flue Gas Temperature Outlet of Air Heater											
O2 %											
CO2 %											
CO PPM											
NO PPM											
NO2 PPM											
NOX PPM											
SO2											
Excess Air %											
Insitu Analyzer %O2											
Oxygen Setpoint %O2											
Deaerator Pressure											
Deaerator Temperature											
Combustion Efficiency %											
Remarks:											