BOILER COMBUSTION ANALYSIS

INTRODUCTION:

For any given fuel, the theoretical maximum percent CO_2 (Ultimate CO_2) would be produced when exactly enough air (but no excess air whatsoever) is supplied to burn all of the fuel. As increasing amounts of excess air are supplied, the percentage of CO_2 naturally decreases from theoretical Ultimate CO_2 due to the diluting effect of excess air.

Thus measuring percent CO_2 is also a method of indicating excess air to ensure that enough is supplied to permit clean combustion without adding so much that combustion efficiency is unnecessarily decreased.

TOO MUCH EXCESS AIR:

Excess combustion air is heated and carries some of this heat to the flue where it is wasted. Calculation of combustion efficiency is possible (assuming complete combustion) if the percentage of CO_2 and the net temperature of the combustion products are known.

PROPER CO_2 VALUE:

Proper CO_2 is that which will ensure complete, clean combustion with some safety margin for variations in fuel, draft, atmospheric conditions, and mechanical wear. Consult the manufacturer of the heating equipment for specific recommendations. Generally accepted values for good combustion practice in residential furnaces and boilers when firing the following fuels are:

Natural Gas……...…8 to 9.5% CO_2
No. 2 Oil……..…….10 to 12.5% CO_2

However these are only guidelines and in all cases recommendations of the equipment or fuel supplier would also include recommendations for allowable smoke (oil firing) or combustibles (gas firing) which are undesirable combustion by-products.

COMBUSTION EFFICIENCY:

Measure percent CO_2 in the flue gases. Then measure the flue gas temperature with a suitable thermometer at the same sampling point. Deduct the temperature of the basement or combustion air supplied from the measured flue gas temperature to obtain the net flue gas temperature. Use the attached table to calculate combustion efficiency.

EXCESS AIR CALCULATION:

All fuels require some excess air (in addition to air theoretically required to burn the fuel) to ensure clean, complete combustion. As the amount of this excess air increases, the percentage of O_2 in the combustion products increases. Since excess combustion air wastes heat by carrying away heat to the flue, it is desired to adjust the excess air to a minimum which will permit clean efficient combustion.

PROPER O_2 VALUE:

Proper O_2 content for any fuel fired is the lowest O_2 value which will ensure complete clean combustion with an adequate safety margin for variations in fuel, draft, atmospheric conditions, and mechanical wear. Consult the heating equipment manufacturer for specific recommendations.

For guidance, it should be added that modern boilers are capable of 80% or greater combustion efficiency. Rough guidelines for setting conventional power burners are 10-15% excess air for natural gas and 15-20% excess air for oil, with little or no smoke and carbon monoxide formation.

MEASURING BOTH O_2 AND CO_2:

It is good practice to measure oxygen, in addition to carbon dioxide when firing gaseous fuels since the same carbon dioxide reading can be obtained on both sides of the stoichiometric (or perfect) mixture. On the fuel rich side of the stoichiometric (or perfect) mixture, a low carbon dioxide reading can be obtained due to in complete combustion; while on the excess air side of the stoichiometric (or perfect) mixture, the same carbon dioxide reading can be obtained by the dilution of the carbon dioxide with excess air. Carbon dioxide alone cannot be used to define the proper excess air operation for gaseous fuels.

Thus a check must be made for the presence of oxygen which confirms operation with excess air (rather than the fuel rich, incomplete combustion). Gaseous fuels should also be checked for the presence of carbon monoxide (CO) in the flue gases and adjusted for either "no CO" or to conform to applicable safety regulations.

WHERE TO MEASURE:

For residential and most commercial and industrial units, percent CO_2 or O_2 is measured by analyzing the gas sample obtained through a ¼ inch diameter hole located between the flue outlet (breaching) and any mechanical opening in the flue such as the barometric draft regulator or draft diverter. The best practice is to locate the sampling hole at least six inches upstream from such flue openings.

For larger installations consult the combustion equipment manufacturer for special instructions regarding a sampling point, any special sampling tube requirements, or advice on average readings.

Information extracted from a United Technologies Bacharach Instruction Manual for the Operation and Maintenance of a Bacharach Fyrite Gas Analyzer For Measuring Carbon Dioxide (CO_2) or Oxygen (O_2).