Introducing: Heat of Combustion (HOC) Testing

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The heat of combustion for a chemical is defined as the heat released when that chemical undergoes complete combustion with oxygen at standard conditions, typically 1 atmosphere of pressure and 20 °C. The heat of combustion can be measured experimentally through a few different laboratory equipment arrangements. One such setup is an Oxygen Bomb Calorimeter, shown in Figure 1, which can be used to determine the Higher Heating Value (HHV) heat of combustion for any solid or liquid sample.

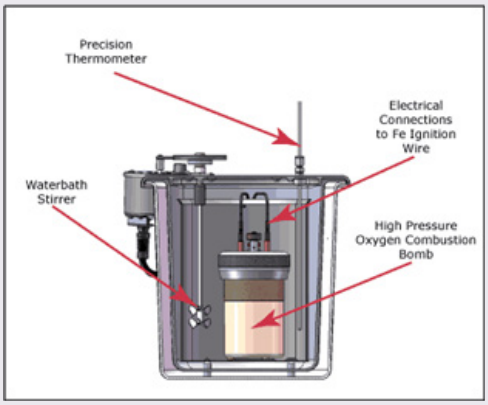

Figure 1: Oxygen Bomb Calorimeter Schematic

The HHV is determined by cooling the reaction products down to the starting temperature, typically around 20 °C. Heat of combustion is an important test for anyone concerned with the energy content of a solid or liquid, including fuels (particularly for use in weight-limiting craft such as aircraft and hydrofoils), combustible wastes, food items and feeds. The heat of combustion value is also important for determining the thermal efficiency of equipment for producing power or heat. The theoretical heat released is compared with the delivered power or heat, giving the user the efficiency of their equipment.

An Oxygen Bomb Calorimeter has recently been acquired by Fauske & Associates in order to diversify our testing capabilities. With a few small modifications, the test method is performed to comply with ASTM International Standard D240, "*Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimetry*." This standard is the basis for the allowed precision and bias of our testing. Another potential HOC standard is ASTM International Standard D4809, "*Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)*," which calls for more precise mass and temperature measurements and reagent quality water.

For both methods, the heat capacity for the system is determined using a standard reference material for which the heat of combustion is known and has been previously verified. Benzoic acid is the industrial standard typically used for oxygen bomb calorimetry and was used for FAI's standardization procedures. Table 1 shows the heat capacity of the oxygen bomb system and repeatability of the heat capacity after 10 standardization test runs.

Table 1: System Heat Capacity and Accuracy

Heat Capacity (cal/°C)	Standard Deviation (cal/°C)	Relative St. Dev. (%)
2429.2	9.25	0.38

The procedures for both ASTM D240 and D4809 are very similar. The chemical is weighed and placed inside the bomb reactor, which is submerged into a pre-measured quantity of water. A high degree of repeatability in the quantity of water used between experiments is very important in order to maintain a high degree of precision and low bias. The bomb reactor is charged with oxygen and then ignition is initiated via a fuse wire.

The measured temperature rise of the water from the oxidation reaction can be used in combination with the heat capacity of the system to determine the heat of combustion for the chemical of interest. The accuracy of the experimental test method and the values it generates has also been validated against other chemicals with known heats of combustion. Methanol, ethanol and tert-butanol were chosen as the three chemicals to be tested for validation of the apparatus and test methodology. Each test was performed in triplicate to provide a baseline statistical error and standard deviation measurement. Table 2 compares the experimental and literature values for the heat of combustion of these three chemicals.

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