Combustion studies of natural gas with special reference to the Bozeman supply
by Albert D Ford

A THESIS Submitted to the Graduate Committee in partial fulfillment of the requirements for the Degree of Master of Science in Mechanical Engineering at Montana State College
Montana State University

Abstract:
This thesis discusses tests of combustion products from natural gas, burned in warm air furnaces and steam boiler furnaces.

Charts are included and explained which may be constructed and used to check the completeness of combustion of any gas from the Orsat analysis even though the analysis of the fuel gas is not known. These charts were checked by other methods which showed that when CO was indicated H2 was found in the flue gas. Other combustibles were also found when an excess of O2 was indicated by the Orsnt analysis even though CO was not present.

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Charts are included and explained which may be constructed and used to check the completeness of combustion of any gas from the Orsat analysis even though the analysis of the fuel gas is not known. These charts were checked by other methods which showed that when CO was indicated H_2 was found in the flue gas. Other combustibles were also found when an excess of O_2 was indicated by the Orsat analysis even though CO was not present.

INTRODUCTION

It has been known for several years that when natural gas, such as the Bozeman supply, is burned, the calculations of weights of materials leaving the furnace, based upon the Orsat analyses of the products of combustion do not agree with the calculated values of materials entering the furnace as closely as they do when other types of fuel, such as coal and oil, are burned. As long as the CO_2 content of the flue gas is below certain limits the agreement is fairly close but as the air supply is decreased toward the theoretical air requirements, a discrepancy is noted, and this discrepancy increases as the air supply is decreased.

The percentage of CO_2 which it is possible to obtain seems to vary considerably, due to difference in installations burning natural gas even from the same supply mains.

It has also long been known by chemists that intermediate products are formed which may be carried over with the products of complete combustion.

Professor W. A. Bone (4, 5) and his associates conducted many experiments on the combustion of hydrocarbons but they worked with the pure gases, mostly methane, but also hydrogen, the latter produced in the laboratory, by the electrolysis of water.

They found that even under carefully controlled conditions

the $CH_4 + CO_2$ did not always burn to $CO_2 + 2H_2O$ and if insufficient O_2 was present formaldehyde was formed to some extent. They found that the higher hydrocarbons formed other products by adding oxygen rather than by breaking up to form the simple products of CO_2 and H_2O.

This work of Professor Bone's suggested to the writer that these laboratory experiments might offer the explanation for the failure of Orsat measurements when used with natural gas combustion products; and also gave him a clue as to what products might be present in the flue gases not indicated by the Orsat analysis.

PURPOSE OF INVESTIGATION

The purpose of this investigation is to find out why the Orsat analysis does not balance out when natural gas is burned in domestic hot air furnaces or industrial steam boilers with very nearly the theoretical requirements of air.

More specifically stated, the purpose is to study the combustion of natural gas in commercial furnaces to determine why the weights of materials entering the furnace as calculated from a slow combustion analysis of the fuel gas, do not check with the weights of materials leaving the furnace as calculated from the Orsat analysis of the combustion gases.

The occasion for the study was the failure of purely mechanical measurements of fuel gas and air supply entering the furnace to check with the weights of chimney gases as made by a previous investigator. (6)