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Report of Visit to CO_2 Acceptor Pilot Plant
Rapid City, South Dakota
Rockville, MD, Enviro Control, Inc.
Oct 26-27, 1976
(Submitted to NIOSH under Contract No. 210-76-0171)

Mr. Cohen and I visited the CO_2 Acceptor Pilot Plant on October 26 and 27, 1976 in the company of Dr. E. Lee Husting of Greenfield, Attaway and Tyler, Inc. Dr. Husting was visiting the CO_2 Acceptor Pilot Plant at this time at the request of Mr. John Abrahams with regard to a contract which GAT has with ERDA. Said contract is in our files.

We met with Mr. Duane McCoy, Manager, at the pilot plant for Conoco Coal Development Corporation; with Marian Vaderman, Manager, at the CO_2 Acceptor Pilot Plant for the operators Stearns-Roger; Kenneth Martin, Safety Engineer, for Stearns-Roger; Larry Pierce, Assistant to Mr. Martin; and with Tom Holen, Project Engineer.

The CO_2 Acceptor Pilot Plant is unique among the high-Btu gasification processes in several senses. It is truly a second generation process in that it uses an advanced technique for supplying heat to the gasifier, and in that it is a low temperature process, it produces virtually no tars or light oils above the molecular weight of ethane. This fact has been verified by Conoco, Michael J. Massey, and in initial efforts by Radian Corporation.

The heart of any gasification process is described by the normal endothermic steam-carbon-hydrogen reactions in coal devolatilization:

$$C + H_2O \longrightarrow CO + H_2$$

A second formula:

$$2C + H2O + H2 \longrightarrow CH4 + CO$$

These common reactions are accompanied by the reactions between the dolomite in the system (or limestone) and carbon dioxide and are described as follows:

$$CaO + CO_2 \longrightarrow CaCO_3$$
$$CO + H_2O \longrightarrow CO_2 + H_2$$

Heat released by these latter two reactions is used in furthering the gasification process.

In practice, the plant gasifier and the generator system operate as follows: calcined domomite or limestone sized to 6 by 8 mesh flows into the gasifier in a controlled quantity about 10 foot above the fluid bed. It showers down through the gasifier bed

reacting with the carbon dioxide and with the sulfur and in turn supplying heat to the gasifier bed by the exothermic chemical reaction keeping the gasifier bed at approximately 1520°F. The dolomite collects at the bottom of the gasifier and is removed from the bed through a withdrawal line where it goes to a hold pot. At the hold pot, acceptor makeup is added to the system and the used acceptor and new acceptor are lifted pneumatically to the regenerator. In the regenerator, air is added to the bed and the new material heated to 1850°F where the calcium carbonate gives up CO_2 and H_2S. Fine attrited calcium oxide and all ash leave the regenerator with the flue gas. The solids are removed from the flue gas stream via a cyclone. Lignite is added to the bottom of the gasifier bed at a temperature of 500°F. Here it reacts with steam which is used to fluidize the gasifier. A portion of the char is withdrawn from the bed and it is pneumatically transferred to the regenerator where its reaction with air supplies the heat to calcine the dolomite or limestone in the regenerator bed. Product gas from the gasifier has the following composition:

carbon monoxide - 15.5 mole percent
CO_2 - 9.1 mole percent
hydrogen - 58.8 mole percent
methane - 13.7 mole percent
$H_2S + CO_S$ - 0.0 mole percent
nitrogen + argon (which come from a variety of purges) - 2.9 mole percent
heat value, Btu per standard cubic foot, dry - 380

Coal is brought into the plant via truck and dumped into an underground bin. From the bin the coal is taken to a 300 ton tank. From the tank, it is carried to a hammer mill and then to a pressurized Williams mill where it is ground to 100% - 8 mesh and then dried at 350°F in a recycled gas containing no more than 3 to 5% oxygen. The coal is disengaged from the recycle drying gas in a cyclone where it is dropped into the lignite preheater, a fluid-bed unit which also acts as a surge bin. In the preheater, the coal is further heated to 500°F and then sent to one of two lockhopper bins. The lockhopper bins operate as already described for the Synthane plant except that coal is fed from the lockhopper bins via a carefully calibrated star feeder. Further, these lockhoppers are connected directly to the reactor.

While the coal is being ground, the dolomite is also ground to 6 by 8 mesh. The oversized material is fed back into the system and the undersized material is taken from the plant to the town dump. Dolomite is fed into the regenerator at a rate of 600 pounds per hour while coal is fed to the gasifier at a rate of 2730 pounds per hour.

Gas from the regenerator is treated by first going through one hot cyclone and then a second hot cyclone Solids are dropped into several lockhoppers then slurried and sent to a water pond. The hot flue gas is then scrubbed with a water venturi and subsequently the SO_2 scrubbed from it in a Benfield unit. This flue gas is then recompressed and used for the carrier gas in the pneumatic regenerator feed lines or is fed to the thermal oxidizer.

The product gas from the gasifier goes through an internal cyclone to return most of the solids back into the bed. Then it goes through an external cyclone and solids are collected for removal to the waste water pond. From the second cyclone, water goes to a venturi where it is thoroughly scrubbed then to a zinc oxide guard pot to remove vestigial traces of H_2S. From the guard pot, the product gas goes to a packed bed methanator where the carbon monoxide, carbon dioxide and hydrogen react to form a gas having an as is Btu value of approximately 900 Btu per standard cubic foot.

There are several problem areas in the plant including dolomite crushing system and the coal crushing system. In both of these systems, there can be considerable dust and especially if or when the bins or the equipment are cleaned out. Under these circumstances, operators wear respirators. When the plant is operating, the limestone crushing and coal crushing areas are washed down approximately every 30 hours to remove all traces of extraneous dust in the surrounding areas. A second problem area includes the valves on both sides of the lockhopper. These valves wear very rapidly and plant personnel are in the habit of changing them every several days when the plant is operating. All gas systems within the plant must be very carefully monitored to make certain that they contain correct amounts of CO_2 and/or oxygen. Excessive quantities of either of these compounds in the wrong system could cause considerable damage to the unit.

The plant is monitored with 38 carbon monoxide sensors scattered throughout the plant as well as to a number of combustible gas meters. Each system is attached to an alarm system to indicate the presence of these gases in unacceptable quantities. Prior to each run, the unit is leak tested and then all flanges and valves are monitored by the safety personnel for possibility of leaks. If a leak is discovered, it is reported to the maintenance department and they are repaired immediately.

There are no precautions taken for aromatic liquids. Personnel have stated, categorically, that they have never seen any liquids or tars under any condition whatsoever during plant operations start-up or shut-down. Mr. Cohen and I investigated the dump pond twice during the day of the 27th while the plant was in operation and came to the conclusion that no tars or liquids had been dumped in the pond during the preceding three to four days. There was a smell of H_2S from the quench gas venturi scrub water during our first visit early in the morning but there was no noticeable quantity of gas present during our second visit to the pond site.

The plant has a very extensive safety program which includes labelling of noise areas, danger areas, sensitive paint on vessels and lines where excessive temperatures may be likely to occur, etc.

Mr. Martin has conducted a very serious effort in fire prevention. His equipment includes a number of MSA airpacks located on every floor of the pilot plant, four work masks with fresh air, a hot vessel entry suit good for a possible 140°F which includes a vortex unit, one fire entry suit good for 2000°F radiates heat, and one fire approach suit. All of these apparatus are easily accessible to the plant personnel.

The plant does not require a pre-employment physical exam nor are physical examinations given at any time during the operator's or maintenance people's employment. There are no nurses at the plant nor are there any doctors. However, there is a very good clinic and hospital within a mile and a half from the plant. In addition, Mr. Martin is an EMD, two of the employees are paramedics, 29 employees have advanced AIME certificates and first aid, and there are 69 first aid certificates among the employees from the Red Cross. Medical equipment also includes a training manikin.

While showers are available to the plant personnel, showers and other personal hygiene measures are not required. The plant does supply clothing including pants, shirt, windbreakers, rubber boots and PVC clothing for use around the dowtherm system. No shoes are supplied. Employees are required to wear heavy boots but not safety shoes. Hard hats and safety glasses are required throughout the plant and there are posted areas where respirators and/or hearing protection are required. Barrier creams are available for all the workers, especially in the limestone and coal grinding areas. It is found that these barrier creams have been readily accepted by the operators as they make cleaning after work extremely easy.

The control room and the main stairs are designated fresh air retreats for the plant operators. Some high-vol monitoring of the plant and personnel monitoring has been done. However, the records were not available to us at the plant. If we should require them, they would probably be made available upon request by John Abrahams to Dr. John Sudbury at Consol.

It was noted that C.F. Braun has conducted a hazard analysis of the CO_2 Acceptor Pilot Plant and a copy of Mr. McCoy's paper which was given at the recent Pipeline Gas Symposium in Chicago.

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15. Supplementary Notes

16. Abstract (Limit: 200 words) A visit was made to a carbon-dioxide acceptor facility to meet with facility personnel. The facility was unique among the high BTU gasification using an advanced technique for supplying heat to the gasifier and that it is a low temperature process and therefore produced virtually no tars or light oils above the molecular weight of ethane. Several problems were noted at the site including both the dolomite and the coal crushing systems. There could be considerable dust generated, particularly when the bins or the equipment were cleaned. Operators wore respirators under these circumstances. A second problem noted concerned the valves on both sides of the lockhopper. The facility was monitored with 38 carbon-monoxide (630080) sensors as well as with a number of combustible gas meters. No precautions were taken for aromatic liquids. The facility had a very extensive safety program which included labeling of noise areas and danger areas, sensitive paint on vessels and lines where excessive temperatures may be likely to occur, and a good effort in fire prevention. No preemployment physical was required of the workers nor were physical examinations given at any time during employment.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms NIOSH-Publication, NIOSH-Contract, Contract-210-76-0171, Coal-workers, Coal-gasification, Coal-products, Dust-inhalation, Airborne-dusts, Coal-dust, Industrial-hygiene

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