United States
Environmental Protection
Agency

Air and Energy Engineering
Research Laboratory
Research Triangle Park, NC 27711

Research and Development

EPA/600/S7-86/006 Apr. 1986

EPA

Project Summary

Environmental Assessment: Source Test and Evaluation Report— Stoic Low-Btu Gasifier

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The report gives results of a source test and evaluation of the Foster Wheeler/Stoic gasifier at the University of Minnesota-Duluth. The test, from February 23 to March 6, 1981, was designed to collect data pertinent to an environmental assessment of the Foster Wheeler/Stoic two-stage gasification process, including evaluation of the emissions from the combustion of both the product gas and the by-product electrostatic precipitator (ESP) oil.

Distribution of minor and trace elements in the product, by-product, and discharge streams was calculated from elemental mass flow rates. Elemental behavior was also evaluated by comparing the concentration of an element in a stream to the concentration of the element in the ash mineral fraction of that stream.

Extractable organic material in product gas, by-product ESP oil, and discharge streams was characterized by total organic loading and by gas chromatographic analysis. Priority pollutants were identified and quantitated for major streams. The gas clean-up devices (ESP and cyclone) were evaluated for both efficiency and effects on the gas composition.

Test results indicated that combustion of ESP oil and product gas destroyed priority organic pollutants to the extent that less than 1 percent of the original levels were detected. Also, most of the hydrocarbons (C1-C6) present in the combined product gas were destroyed by combustion.

Although federal New Source Performance Standards (NSPS) do not apply to the Foster Wheeler/Stoic gasifier boilers because of their size, if these standards were applied, SO_2 emissions would fall slightly above or slightly below NSPS levels, depending on the method of calculation. NO_x emissions would be marginally above NSPS, and emission levels of particulates would fall well below NSPS.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

From February 23 through March 6, 1981, a source test and evaluation was performed at the Foster Wheeler/Stoic two-stage gasifier at the University of Minnesota-Duluth (UMD). The UMD constructed the gasifier with funding from the Department of Energy's (DOE) "Gasifiers in Industry" Program. The purpose of the test was to gather data for the environmental assessment of commercially viable low—and medium—Btu coal gasification systems and to evaluate the emissions from the combustion of both the product gas and the by-product electrostatic precipitator (ESP) oil.

The resulting report presents the findings of a limited environmental assessment of the two-stage gasifier developed by Stoic Combustion (Pty.), Ltd., of Johannesburg, South Africa, and marketed by Foster Wheeler Energy Corporation. The test program was conducted as part of a joint field test effort between Oak Ridge National Laboratories (ORNL) and EPA.

Test Overview

The source test, designed to collect data pertinent to the environmental assessment of the Foster Wheeler/Stoic gasifier, was conducted under "steady state" operating conditions. The bituminous fuel coal used during the test program was mined from the Pinnacle Seam by Sun Coal Co., Milner, Colorado. About 280 metric tons of bituminous coal was gasified at an average rate of 270 g/s (2140 lb/hr) during the 12-day test. Major discharge and process streams of the gasification process were characterized to assess their potential impacts on the environment. Streams were selected for testing according to five program objectives:

- Performance of an environmental assessment of the Foster Wheeler/Stoic two-stage gasification process, including the gaseous discharge streams resulting from combustion of the product gas and by-product ESP oil.
- Calculation of material balance.
- Evaluation of emissions from combustion of the product gas as related to product gas composition.
- Evaluation of emissions from combustion of ESP oil as related to ESP oil composition.
- Evaluation of the efficiency of product gas clean-up systems (ESP and cyclone) and their effect on gas composition.

Samples were collected from five gaseous process streams: combined product gas, raw top product gas, treated top product gas, raw bottom product gas, and treated bottom product gas. An ESP, designed and fabricated by Radian under a previous contract with ORNL, was used to collect samples of the aerosolized oils from the process gas stream. Grab samples for quantitation of major gases, hydrocarbons, and sulfur species were collected in cleaned, silanized glass bombs. Particulate matter in the gas streams which did not contain aerosolized oils was collected on glass fiber filters.

Trace organic and trace element samples were collected from two combustion emission streams using the High Volume Source Assessment Sampling System (SASS). Sulfur oxides (SP_x) and particulate matter were quantitated in the combustion emissions using combined EPA Methods 5 and 6, and nitrogen oxides (NO_x) were quantitated in the combustion emissions using EPA Method 7.

Three solid streams were sampled during the tests: coal, gasifier ash, and cyclone dust. Coal samples were collected as the coal fell from the conveyor belt into the weigh hopper, and the ash samples were collected as the ash fell from buckets onto the conveyor belt. Dust removed from the bottom product gas by the cyclone was collected in a lockhopper.

Three liquid streams were sampled: ESP oil to storage, ESP oil to boiler No.3, and ash pan water. Samples of the ESP oil were collected through a valve in the transport line between the ESP and storage tank. Samples of the ESP oil to boiler No.3 were collected through a valve in the transfer line between the pump and boiler. Ash pan water samples were collected directly from the ash pan.

Results

Material and major component balances around the gasifier closed within 3-14 percent. Carbon and sulfur showed the greatest difference between mass in and mass out. The gasifier had a cold gas efficiency (measure of the ability of a gasifier to convert potential combustion energy in coal to potential combustion energy in dry, tar-free product gas) of 80 percent during the tests.

Material and component balances around the product gas boilers closed within 10-50 percent, while material and component balances around the boiler firing ESP oils indicated closure within 4-10 percent for all species except sulfur.

Analytical data allowed an evaluation of the elemental behavior of 65 elements. Of these, 43 had 95 percent or more of their mass discharged in the gasifier ash. Five elements (antimony, bromine, chlorine, sulfur, and tin) had more than 25 percent of their total mass in the combined product gas stream and exhibit volatile behavior.

Most extractable organic materials leaving the gasification process are found in the ESP oil and product gas streams and are combusted in the boilers. Combustion of the ESP oil and product gas destroyed priority pollutants to the extent that less than 1 percent of the fuel priority pollutants were found in the emissions from ESP oil combustion and less than 1 percent of the priority pollutants found in the product gas were detected in the combustion emissions. Also, most of the hydrocarbons (C1-C6) present in the combined product gas were destroyed by combustion.

The collection efficiency of the ESP used to remove aerosolized oils and particulate matter from the top product gas was about 98 percent for oils and 72-74 percent for particulate matter. The collection efficiency of the cyclone could not be evaluated from the data because of inconsistent gas flow at the sampling point.

The composition data for ash pan water indicated that the concentration of barium and mercury exceed the National Interim Primary Drinking Water Standards. However, this comparison is between process wastewater and drinking water standards which are intended to be non-enforceable guidelines relating to aesthetic qualities and public acceptance of drinking water. The gasifier ash and cyclone dust streams would be considered non-hazardous according to RCRA criteria.

Although federal New Source Performance Standards (NSPS) do not apply to these boilers because of their size, if they were applied, emission levels of particulates would be well below NSPS. SO_2 emissions would be slightly above or slightly below NSPS, depending on the method of calculation, and NO_x emissions would be marginally above NSPS.

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The complete report, entitled "Environmental Assessment: Source Test and Evaluation Report—Stoic Low-Btu Gasifier," (Order No. PB 86-167 012/AS; Cost: $28.95, subject to change) will be available only from:
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600/S7-86/006