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Project Summary

Pollution Control Considerations for Low- and Medium-Btu Coal Gasification Processes

William E. Corbett, Lynn M. Erickson, and Nancy P. Meserole

This report contains a summary and an analysis of data collected by the U.S. EPA from 1977 to 1981, which relate to the characteristics of controlled and uncontrolled waste streams from low- and medium-Btu gasification processes. This analysis focuses on the key waste streams which are likely to require control in a commercial coal gasification facility and identifies the pollutants which will have the greatest impacts on pollution control process selection, design, and/or performance. Key data gaps and areas of process/performance uncertainty which should be considered by permit writers and reviewers of proposed environmental monitoring plans are indicated.

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

In the past decade, the EPA has conducted numerous environmental data acquisition studies at coal gasification facilities both in the U.S. and abroad. Facilities employing moving-bed, fluid-bed, and entrained-bed coal gasifiers have been examined, and data on the characteristics of key process and waste streams have been obtained from these sampling programs. These data can be used to define the general characteristics of the waste streams produced in commercial coal gasification facilities and to evaluate potentially applicable control technologies.

The EPA is called upon periodically to provide assistance to state and local regulatory authorities who must issue new facility construction and operating permits. These authorities may require support in assessing the adequacy and appropriateness of proposed control strategies and discharge limits. The EPA's environmental assessment data base provides information to aid these groups in:

- Identifing environmental and health issues requiring further definition through data acquisition;
- Recognizing process- or facility-specific waste stream characteristics which should be considered in control process selection design; and
- Identifying areas of control process performance uncertainty.

In order to support this effort, five documents have been prepared which address specific categories of environ-

mental pollutant discharges. These categories are: sulfur and nitrogen species, organics, trace elements, wastewater, and solid wastes. Each document summarizes the environmental data gathered at a series of facilities employing moving-bed, fluid-bed, and entrained-bed gasification processes. These data have been evaluated to identify trends and/or develop correlations that can be used to assess the characteristics of discharge streams associated with different gasification processes.

This report summarizes the findings of the five reports from the standpoints of: relative waste stream characteristics; relative potential control options; and data gaps which, if filled, might resolve some indicated areas of uncertainty.

This presentation is organized according to the general class of the waste stream (gaseous, aqueous, or solid) being addressed.

Note that many of the facilities where EPA-sponsored tests were conducted were either: (1) developmental units which were not equipped with fully integrated pollution control systems, or (2) commercial facilities which are not designed to meet current U.S. environmental standards. Thus, much of the data which were acquired should be viewed as being more representative of control process input streams than discharges from a modern, well controlled facility.

Objectives

The overall objective of this report is to present a concise summary of publicly available information related to the characteristics of controlled and uncontrolled waste streams from commercial scale coal gasification processes. The data available from environmental assessment efforts, supplemented by literature data, are compiled, summarized, and evaluated to:

- Identify trends in pollutant behavior across processes;
- Identify unique or specific waste stream characteristics of individual gasification processes;
- Compare control process selection, design, and performannce issues, revealing those common to all processes and those unique to individual processes; and
- Recommend ways to monitor future commercial scale systems to further define unresolved issues or to confirm trends in pollutant behavior.

This document provides those involved in assessing pollution controls for new gasification facilities, both facility designers and regulatory agencies, with a consolidated source of information on available performance data and current commercial practices.

Results and Conclusions

Comments on the characteristics of key gasification process discharge streams, potential control options for the pollutants which may be present in those streams, and additional data requirements are summarized in Tables 1, 2, and 3. These comments were derived from an analysis of the data gathered in the EPA-sponsored source test and evaluation programs which are the subject of this report.

In the design of most new coal gasification facilities, the high volume waste streams listed in Tables 1 through 3 generally receive the most attention from the standpoint of control strategy development and detailed design review. The comments offered in the tables related to the availability of data are consistent with this level of interest. Most of the high volume discharge streams listed have been studied extensively, and representative characterization data are available for a wide range of gasifier types and operating modes. Most of the low volume discharge streams, however, have not received as much attention in past test programs. Generally, control processes for these streams are not as well defined or demonstrated as those which apply to the high volume streams. As noted, characterization of some of the low volume discharge streams and evaluations of control processes which may be applicable to them should be a primary goal of future data acquisition programs.

Of the gaseous discharge streams listed in Table 1, combustion flue gases and acid gases/tail gases from acid gas removal/sulfur recovery systems are the two highest volume waste streams. Because these streams are common to many existing and most proposed commercial-scale coal gasification facilities, applicable control techniques for these streams are well established, and several types are commercially available. Many of the remaining gaseous discharge streams listed are the result of venting losses. Coal feeder vent gases, flash gases, by-product storage tank vent gases, and fugitive losses all contain varying amounts of the pollutant species found in raw product gas. Because of this characteristic, these streams are usually either recycled or incinerated. Other vent gases and offgases have highly varying flow rates and compositions, and controls for those streams must take into account their unique sources and characteristics.

The two aqueous discharge streams which result directly from the quenching and cleaning of the raw product gas are raw gas liquor/process condensate and acid gas removal (AGR) condensate. These streams generally have similar compositions and may be blended together for treatment. Another high volume discharge stream is cooling tower blowdown. Although generated in large quantities, this stream is usually of little concern because it should not contain materials unique to coal gasification facilities unless treated process wastewater is used as cooling tower makeup. The other aqueous discharge streams will have varying types and amounts of contaminants depending on their source. Environmentally acceptable and cost effective treatment and disposal techniques for these streams will likewise be unique to each application.

Many of the solid discharges generated in the quenching and cleaning of the gasification process still retain good fuel qualities and can be recycled or used as fuel in boilers or incinerators. Coal fines char/ash fines in product gas, and by product tars and oils generally do not pose a waste disposal problem because they are among the by-products/wastes that can be used as fuel. Available data on ashes from combustion processes particularly gasifiers and steam/power boilers, suggest that these residues can be disposed of as non-hazardous wastes. Testing of specific ashes/residues is needed to confirm this characteristic however.

By-product sulfur is usually assumed to be of saleable quality. Disposal options for contaminated or off-spec sulfur have not been addressed publicly. Likewise very limited data are available which describe the characteristics, treatment methods, or disposal options for most of the low volume solid discharges from coal gasification facilities. Generally these streams are specific to the downstream treatment processes chosen

Although these streams are of low volume, they may contain pollutants at high enough levels to require special treatment or disposal.

Table 1. *Gaseous Discharge Streams: Characteristics, Control Options, and Data Base Status*

Waste Stream	*Characteristics and Determining Factors*	*Typical and/or Possible Control Options*	*Status of Data*
High Volume Wastes			
Raw or Quenched Gasifier Product Gas[a]	*Low-Btu (air blown) gasifiers produce a high N_2, low CO_2 product gas. Oxygen-blown gasifiers produce a low-N_2, high CO_2 product gas. A diverse array of reduced sulfur- and nitrogen-containing species are also normally found in this stream with the distribution determined by the coal type and gasifier operating characteristics.*	*Particulate removal followed by processes to remove reduced sulfur/nitrogen species and possibly CO_2 and hydrocarbons depending on product gas end use specifications*	*The raw or quenched product gas stream was sampled and analyzed at all of the facilities tested This stream is well characterized*
Combustion Flue Gas	*Characteristics depend on combustor feed stream properties and combustor design/operating characteristics. Generally, NO_x, SO_x, and particulates are the main flue gas contaminants present. Trace elements and toxic organics may be present at low but still environmentally significant levels.*	*A combination of NO_x, SO_x, particulate, and/or toxic substances controls. Monitoring and control of combustion process variables can be used to achieve acceptable combustion efficiencies while minimizing NO_x formation. Add-on controls generally used to achieve acceptable particulate and/or SO_2 emissions control.*	*Considerable data on emissions from boilers and incinerators exist. However, very little of this data base deals with coal gasification product and/or waste stream combustion.*
Acid Gases	*All acid gas removal systems produce H_2S-rich streams; some also produce CO_2-rich streams if the AGR system is operated in a selective mode. Hydrocarbons, reduced nitrogen species, and non-H_2S reduced sulfur species may also be present at significant levels.*	*All AGR systems remove H_2S. A wide range of sulfur recovery systems are available to process the H_2S-rich gas stream. Process selection decisions are usually dictated by waste stream properties (minor and trace species are important) and also control requirements/emission limits.*	*Some of these streams were not available for sampling in the EPA Source Test Program Also, limited data have been collected on specific components within these streams such as hydrocarbons and non-H_2S reduced sulfur species which may impact control system selection, design, and performance*
Low Volume Wastes			
Coal Feeder Vent Gases	*Composition similar to raw product gas unless inert pressurants or seal fluids employed. Amount produced depends on gasifier operating pressure and feeder system design features.*	*Some streams may require reduced sulfur in addition to hydrocarbon/particulate emission controls; this stream would normally be recycled or incinerated after scrubbing for particulate removal.*	*Few facilities have measured these emissions. Although some product gas species are usually present, extensive data on emission rates for different types of feeders in both pressurized and atmospheric systems are scarce*
Flash Gases from Liquid Product/Waste Stream Depressurization	*Composed of volatile and semi-volatile components of raw product gas with specific composition determined by source.*	*Depending on source, these streams may require reduced sulfur/nitrogen or VOC controls; these streams would normally be collected and recycled or incinerated.*	*Only limited opportunities to characterize these streams were available in the EPA Source Test Program.*
Vent Gases from By-Product Storage Tanks	*Composed of VOCs and reduced sulfur/nitrogen species present in by-products*	*Depending on source, these streams may require reduced sulfur/nitrogen or VOC controls, these streams would normally be collected and recycled or incinerated.*	*While limited characterization data on these streams are available, needs and options for control of streams are relatively well established.*

Table 1. Continued

Waste Stream	Characteristics and Determining Factors	Typical and/or Possible Control Options	Status of Data
Fugitive Losses	Composed of any of the species found in the process.	Depending on source, these streams are normally controlled through a periodic inspection (source screening)/follow-up maintenance program.	Fugitive emission rates were determined in only one of the facilities tested in the EPA Source Test Program. Needs and options for control of these streams are relatively well established.
Vent Gases from Coal, Ash, and Other Solids Handling Operations	Amounts and characteristics of these emissions are highly process- and equipment-dependent. Particulates are always the major concern with these streams unless other fugitive gases (e.g., raw product gas) are present.	Some streams may require VOC or reduced sulfur controls in addition to those for particulates, this stream would normally be vented to the atmosphere after the removal of particulates or incinerated if residual pollutant levels high.	Limited data on the characteristics of these streams were gathered in the EPA Source Test Program. This is not considered to be an area of great deficiency.
Vent Gases from Pollution Control Equipment and Processes	Highly variable depending on characteristics of inlet waste streams and control process design and operating features.	Highly variable depending on stream characteristics.	Limited opportunities to gather data on the characteristics of these streams were available in the EPA Source Test Program because most of the facilities tested were essentially "uncontrolled."
Catalyst Regeneration Offgases	Similar to combustion flue gas characteristics with higher probability of VOC and trace metal contamination.	Some streams may require VOC, sulfur, or particulate control.	No opportunities to characterize these streams were available in the EPA Source Test Program.

[a]Although product gas is not a waste stream itself, an evaluation of its composition provides insight into the components which may be present in discharges from downstream processing operations.

Table 2. *Aqueous Discharge Streams: Characteristics, Control Options, and Data Base Status*

Waste Stream	Characteristics and Determining Factors	Typical and/or Possible Control Options	Status of Data
High Volume Wastes			
Raw Gas Liquor/Process Condensate	*Tar-producing gasifiers generate condensate streams with high organic loadings. Entrained and fluidized-bed gasifiers produce condensate streams with low organic loadings. In all systems, these streams will contain dissolved inorganics (incl. trace metals) and dissolved gas species (e.g., CO_2, H_2S, HCN, NH_3, HCL).*	*Gravity separation and/or filtration to remove suspended tars, oils, and solids, solvent extraction, biological oxidation, and/or carbon adsorption to recover organics; and steam stripping to remove volatile gases are examples of controls which are typically proposed for use with these streams.*	*These streams were sampled and analyzed in all of the facilities in which they were generated during the EPA Source Test Program Extensive characterization data from other related studies are also available*
Acid Gas Removal System Condensates and Blowdown Solvents	*These streams are highly variable in flow and composition depending on process-specific factors.*	*Blended and treated with process condensate (if these streams have compatible treatment needs) or separately (if not).*	*Only two facilities (both of which employed the Rectisol process) were available for sampling in the EPA Source Test Program*
Cooling Tower Blowdown	*High volume but usually contaminated mainly with inorganic species from makeup water and treatment chemical residuals in concentrated form.*	*Minimal treatment is usually necessary; discharge standards for conventional systems are based on tight control of treatment chemical use; if contaminated water source is used as makeup, extensive treatment may be required*	*"Conventional" waste streams of this type were not studied in the EPA Source Test Program. Extensive data on the characteristics of these types of streams are available from other sources*
Low Volume Wastes			
Ash/Slag Quench/Sluice Water	*Contains mainly suspended and dissolved inorganics derived from contact with the ash as well as makeup water species in concentrated form.*	*Either co-disposed with ash or discharged after suspended solids removed (and pH adjustment if necessary).*	*Only limited data on the characteristics of these streams were obtained in the EPA Source Test Program.*
Discharges from Auxiliary Facilities and Air Pollution Control Equipment	*Highly variable depending on source.*	*Each of these wastes must be evaluated individually; blending with higher volume streams having compatible treatment requirements is attractive in many situations; highly contaminated streams may require unique treatment approaches.*	*No characterization data on these streams were obtained in the EPA Source Test Program.*
Storm and Area Runoff	*Highly variable and intermittent; likely to contain oily wastes and other contaminants resulting from process spills.*	*Discharged directly or to holding pond; generally treated in combination with other similar streams if highly contaminated.*	*No characterization data needed for these streams; good engineering practice in facility design and proper operating guidelines needed to manage these wastes.*

Table 3. Solid Waste: Characteristics, Control Options, and Data Base Status

Waste Stream	Characteristics and Determining Factors	Typical and/or Possible Control Options	Status of Data
High Volume Wastes			
Coal Fines	*Fines can represent up to 30% (wt) of the raw coal feed.*	*Used as gasifier or boiler fuel.*	*Extensive data on coal properties are available.*
Gasifier Ash/Slag	*This stream can represent up to 30% (wt) of the dried coal fed to the gasifier. It consists mainly of unreactive mineral matter in coal.*	*Usually land-disposed as a non-hazardous waste*	*A substantial data base on the characteristics of these wastes exists. All samples tested to date have been non-hazardous according to RCRA leach test criteria.*
Char/Ash Fines in Product Gas	*Unreacted coal fines, usually collected in cyclone or other particulate control device.*	*Recycled to gasifier; fuel for boiler or incinerator; or land disposal if neither of the above is an attractive option.*	*Similar to partially reacted, devolatilized coal fines.*
Boiler/Incinerator Ash	*Depends mainly on feed stream properties.*	*Co-disposal with gasifier ash/slag or other sludges, unless shown to be hazardous.*	*Coal fired boiler ashes are well characterized. Incinerator ashes are less well characterized; thus data are lacking.*
By-Product Tars and Oils	*Usually generated only in systems employing fixed-bed gasifiers. Characteristics and yields determined mainly by coal feed properties and gasifier design/ operation (e.g., temperature).*	*Sold as fuel, used as supplementary fuel on-site (in boilers), or recycled to extinction in gasifier.*	*Available data indicate that these materials are reasonably high quality fuels, relative to the parent coal.*
By-Product Sulfur	*Ideally, this stream consists of relatively pure, elemental sulfur. It may be contaminated with trace metals or organics, depending on feed stream properties and sulfur recovery process used.*	*Sold as by-product or disposed of as hazardous/non-hazardous waste if not marketable.*	*No opportunities to characterize this stream were available in the EPA Source Test Program.*
Low Volume Wastes			
Spent Catalysts, Sorbents, and Filter Media	*Could contain tarry residues, organics, heavy metals, and/or sulfur species depending on service history.*	*Catalysts may be recycled. Non-recycled catalysts and wastes not usable as fuels may be incinerated and/or disposed of as hazardous/non-hazardous waste depending on characteristics.*	*No opportunities were available t characterize these wastes in the EPA Source Test Program. Future data acquisition programs should address these streams.*
Sludges and Brines from Pollution Control and Raw Water Treatment Processes	*These are facility-specific wastes. May contain pollutant species originally present in feed stream in concentrated form.*	*Co-disposed of with gasifier ash/ slag, recycled to gasifier, incinerated, or disposed of as hazardous/non-hazardous waste.*	*No opportunities were available t characterize these wastes in the EPA Source Test Program Data for these streams are lacking.*

W. E. Corbett, L. M. Erickson, and N. P. Meserole are with Radian Corporation, Austin, TX 78766.
***William J. Rhodes** is the EPA Project Officer (see below).*
The complete report, entitled "Pollution Control Considerations for Low- and Medium-Btu Coal Gasification Processes," (Order No. PB 88-131 305/AS; Cost: $19.95) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
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U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

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