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Project Summary

Addendum to "Environmental Assessment: Source Test and Evaluation Report—Chapman Low-BTU Gasification"

D. Scott Lewis and G. C. Page

This report is as an addendum to "Source Test and Evaluation Report—Chapman Low-Btu Gasification" published by the Environmental Protection Agency in 1978 (NTIS No. PB289 940). It contains detailed organic analysis data on six streams, trace element and organic data on the solid waste leachates, and trace element data on the feed coal. These data were not included in the original report.

A total of six samples were analyzed by gas chromatography/mass spectrometry to provide a detailed organic characterization of waste streams and potential fugitive emissions from an operating Chapman low-Btu gasification facility using Virginia bituminous coal. The streams analyzed were: coal feeder vent discharge, separator vent discharge, separator liquor, separator tar, gasifier ash, and cyclone dust. The extractable organics in four of the six samples were fractionated using an acid-base-neutral fractionation scheme prior to analysis, to simplify compound identification.

All streams analyzed except the ash and dust contained concentrations of organic compounds at levels of concern to health when evaluated by Source Assessment Model/IA (SAM/IA) methodology. Phenols in the separator vent discharge, and liquor along with fused polycyclics in the coal feeder vent discharge and the separator tar were identified as the compounds of greatest concern. When compared to screening data, potential effects are lower, but relative ranking of streams is essentially unchanged.

Trace element analysis was performed on the feed coal. In addition, trace element and organic loading analyses were performed on Resource Conservation and Recovery Act (RCRA) and deionized water leachates of the gasifier ash and cyclone dust. The SAM/IA results indicated the ash and dust had a low potential for health and ecological effects. The concentrations of all elements with RCRA specified limits were significantly below those limits.

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

Introduction

Radian Corporation of Austin, Texas, is performing a comprehensive environmental assessment of low- and medium-Btu gasification technology under a contract with the Environmental

Protection Agency (EPA). A major portion of this assessment involves Source Test and Evaluation (STE) programs at operating low-Btu gasification facilities.

In 1978, Radian Corporation, in conjunction with EPA, conducted an STE program at a commercial Chapman low-Btu gasification facility. The objectives of this program were, in part, to perform chemical and bioassay screening tests on the gasifier waste streams and potential fugitive emissions (process streams). These data were reported in the Source Test and Evaluation Report (STER) resulting from the Chapman STE program (1).

The STE program did not include detailed organic characterization of any process or waste streams. It also did not include trace element analysis of the feed coal or trace element and organic loading analyses of the solid waste leachates. These analyses have now been performed on samples taken during the STE sampling campaign.

The purpose of this addedum to the Chapman STER is:

- To report the results of the detailed organic analysis of the gasifier waste streams and potential fugitive emissions (process streams),
- to report the results of additional testing of the feed coal and the leachates from the solid waste streams, and
- to provide conclusions and recommendations based on these additional data.

Results and Conclusions

This section summarizes the results of the detailed organic analysis of the waste streams and potential fugitive emissions (process streams) from the Chapman facility and compares the detailed organic data to the Source Assessment Model/IA (SAM/IA) analysis (2) of the chemical screening data. Summaries of the trace element analysis of the feed coal and the trace element and organic loading analyses of the solid waste leachates are presented.

Summary of the Results of the Detailed Organic Analyses and Their Comparison to the SAM/IA Analysis of the Chemical Screening Data

The SAM/IA is used to identify and prioritize waste streams and potential fugitive emissions (process streams) that have potential for health and/or ecological effects. Specific compounds are assigned discharge multimedia environmental goal (DMEG) values (3-5). A DMEG value is a concentration of a substance in a discharge stream estimated not to cause adverse health or ecological effects. Discharge severities (DS) for individual compounds are calcuated by dividing the discharge concentration by the DMEG. The total of the individual DS values for the stream is expressed as the total discharge severity (TDS). When the discharge rate of the stream is multiplied by the DS value for a component, the result is expressed as the Weighted Discharge Severity (WDS). The sum of the WDS values for a stream is expressed as the total weighted discharge severity (TWDS). The TDS values and TWDS values are used to rank streams in terms of potential effect and indicate the relative need for detailed analysis. In the original Chapman STER (1), potential degree of hazard (PDOH) and potential toxic unit discharge rate (PTUDR) were used in place of and are synonymous with DS and WDS, respectively.

The waste streams and potential fugitive emissions subjected to detailed organic analysis and their total discharge severities (TDS) and total weighted discharge severities (TWDS) for extractable organics are given in Table 1. All streams analyzed, except the gasifier ash and cyclone dust, contain concentrations of organic compounds yielding TDS health values greater than 1. In addition, the total weighted discharge severity for the ash indicates potential ecological effects. However, it should be noted that these potential ecological effects are due primarily to phthalates. Phthalates are common artifacts in trace level organic analysis. The TWDS ecology value for the ash is reduced to 0.2 g/sec from 7 g/sec if the concentrations of the phthalates are excluded from the calculations. The cyclone dust has TWDS values for organic compounds of less that 1 g/sec for both health and ecology.

Of the potential fugitive emissions, the extractable organics in the separator tar have the highest potential for health effects based on DMEG values for a liquid. Although the tar contains at least 15 compounds with a discharge severity (DS) >1, the primary compound contributing to the TDS is benzo(a)pyrene [B(a)P]. The analytical technique employed did not distinguish B(a)P from a group of up to six isomers of the same molecular weight (252). However, if it is

Table 1. *Detailed Organic Analysis: Results of the SAM/IA Analysis for All Organic Compounds with Assigned DMEG Values Detected by GC/MS*

	TDS (Organics)		TWDS (Organics)		
	Health	Ecology	Health	Ecology	Principal Compounds
Gaseous Waste Streams					
Coal Feeder Vent Discharge	4E4[1]	—	2E3 (m^3/sec)	—	Benzo(a)pyrene
Separator Vent Discharge	2E2	—	1E2 (m^3/sec)	—	Phenols
Solid Waste Streams					
Cyclone Dust	6E-6	1E-1	1E-5 (g/sec)	2E-1 (g/sec)	Phthalates
Gasifier Ash	2E-4	4E0	4E-3 (g/sec)	7E1 (g/sec)	Phthalates
Potential Fugitive Emissions					
Separator Liquor	1E2	1E3	—	—	Phenols
Separator Tar	3E6	—	—	—	Benzo(a)pyrene, Phenols

[1] $aEb = a \times 10^b$

TDS: Total Discharge Severity

TWDS: Total Weighted Discharge Severity

assumed that only 15% of the mass attributed to B(a)P is actually contributed by B(a)P, the TDS for the stream still remains over 5E5 (5×10^5).

The extractable organics in the separator liquor have potential effects for both health and ecology, with organic TDS values of 4E5 and 4E3, respectively. For both health and ecology, phenols comprise the major group of compounds of concern with phthalates making a minor contribution to the potential ecological effects.

Recently, a change in the DMEG values for phenol in water published in "Multimedia Environmental Goals for Environmental Assessment: Volume IV," (5) from 5.0 to 1.7E4 μg/L for health and from 5.0E2 to 3.0E3 μg/L for ecology has been suggested by Research Triangle Institute, based on 1979 proposed water quality criteria for phenols. The proposed values for phenol are applied to all phenolic compounds which had previously been assigned DMEG health and ecology values of 5.0 μg/L and 5.0E2 μg/L, respectively.

The extractable organics from the XAD-2 resin, organic module rinses, probe rinse and condensate from both the gaseous waste streams, the coal feeder vent, and the separator vent discharge streams have organic TDS health values of 4E4 and 2E2 and TWDS health values of 2E3 and 1E2 m^3/sec, respectively. The major compounds of concern are B(a)P for the coal feeder vent discharge and phenols for the separator vent discharge.

A comparison of the TDS and TWDS values (organics and inorganics) from the chemical screening data and the detailed analytical data for all the streams sampled is given in Figures 1 through 3. The values for the chemical screening data are calculated from data given in the Chapman STER (1). Detailed analytical data values are based on inorganic data from the STER and detailed organic data from gas chromatography-mass spectrometry (GC-MS) analysis.

Figure 1 compares the TDS health values for the detailed organic analytical data and the chemical screening data for the waste streams and potential fugitive emissions from the Chapman facility. In general, values derived from the detailed organic and inorganic analytical data are from 2 to 4.5 orders of magnitude lower than values derived from the chemical screening data. However, the relative ranking of severity

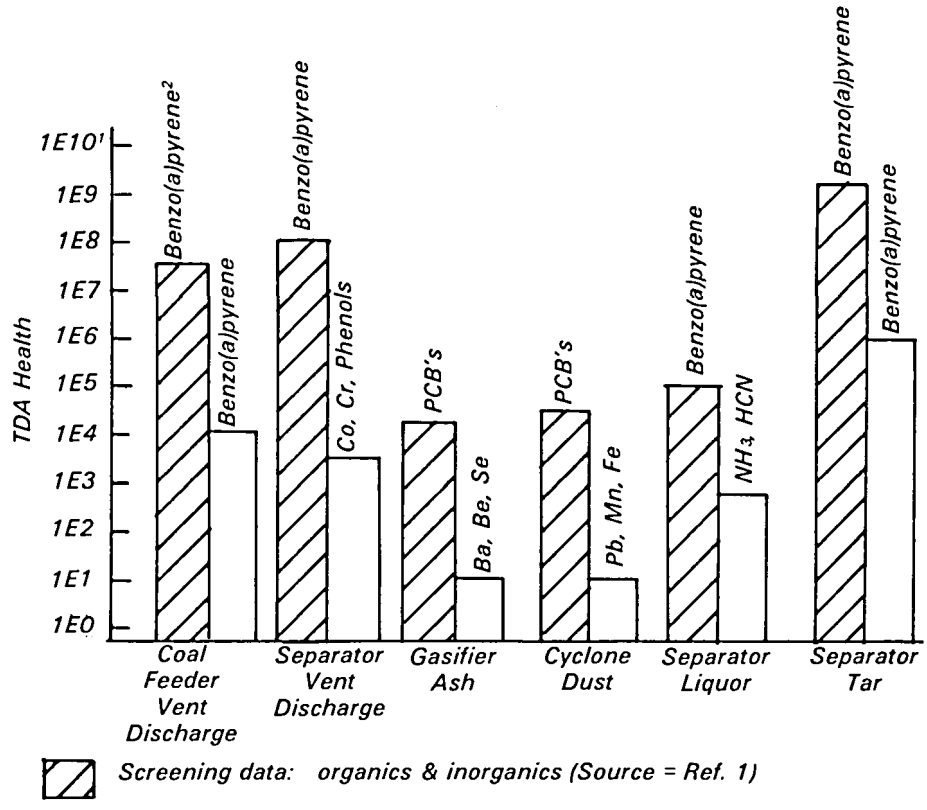
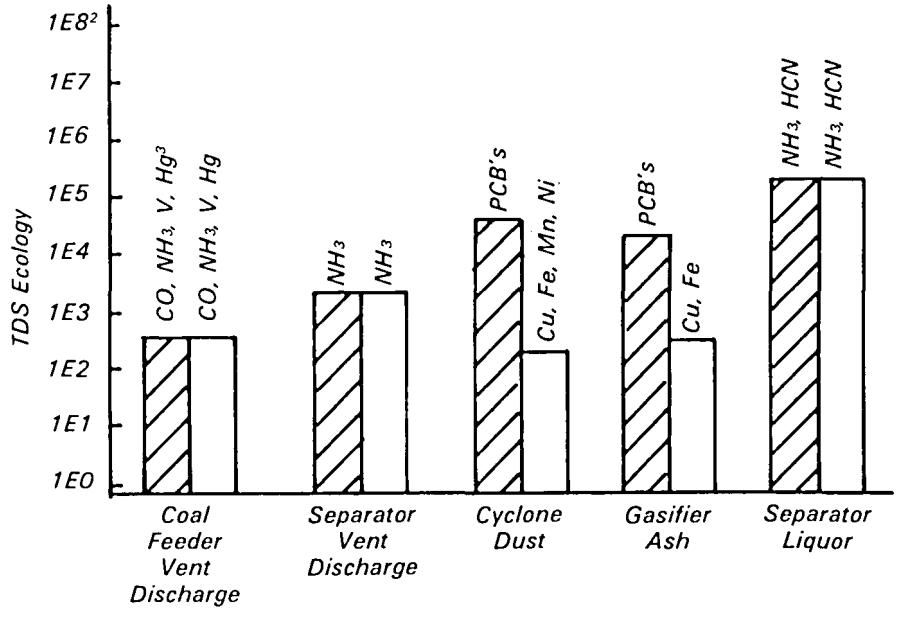


Figure 1. A comparision of total discharge severity health values and principal contributing compounds from the chemical screening data and the detailed organic analytical data.

is similar in both cases with the exception of minor changes in the relative positions of the coal feeder vent discharge and the separator vent discharge. This indicates that TDS values for chemical screening data are valuable in ranking streams for health effects. Qualitatively, the principal contributing compound, benzo(a)pyrene, is the same in both cases for the coal feeder vent discharge and the separator tar. However, for the other streams, much of the discharge severity from organics in the screening analysis is eliminated by the detailed organic analysis, resulting in an increase in the relative contribution of inorganic compounds.

Figure 2 compares the TDS ecology values for the screening data and the detailed organic analytical data for the emissions and potential fugitive emissions. Because of the relatively large contributions of inorganics to the ecology values, little change is seen as a result of the detailed organic analysis. The only streams impacted are the cyclone dust and gasifier ash. The TDS ecology values for these two streams are lowered by approximately one-half an order of magnitude. The relative ranking of the stream is not changed by the detailed analysis.

Figure 3 compares the TWDS health and ecology values for the chemical screening data (organics and inorganics) and the detailed organic analytical data and inorganics. The same trends are seen in the TWDS values that occurred in the TDS values. Health values are significantly lower with no change in



[1]Ecology values were not calculated for the separator tar
[2]aEb = a x 10[b]
[3]Major constituents contributing to TDS

Figure 2. A comparison of the total discharge severity ecology values and principal contributing compounds from the chemical screening data and the detailed organic analytical data.[1]

stream ranking while ecology values are little changed.

Summary of the Results of the Gasifier Ash and Cyclone Dust Leachate Analysis

Both the gasifier ash and the cyclone dust were leached using the Resource Conservation and Recovery Act procedure (6) and using the RCRA procedure without the addition of a pH buffer. All leachates analyzed have relatively low potentials for health and ecological effects. Organic loading analyses indicate an absence of organics in the leachates and therefore no contribution by organics to the resulting TDS values. The spark source mass spectrometry (SSMS) results from the RCRA and unbuffered leachates indicate differences in trace element concentrations. The TDS values from the SAM/IA analysis of the results along with the principal contributing elements are illustrated comparatively in Figure 4.

In general, the recovery of trace elements in the leachates from the solids is very low. Only arsenic in the cyclone dust and arsenic, fluorine and sulfur in the gasifier ash have recoveries greater than 10%.

When the leachates are compared to RCRA specified extract limits, all trace elements present with RCRA limits are significantly below those limits. Limits and leachate concentrations for specific elements are given in Table 2.

Relatively low DS values, an absence of organic loading and low concentrations of trace elements all indicate that both the ash and dust should be given low priority as potentially harmful wastes.

Summary of the Results of the Feed Coal Analysis

The feed coal was analyzed for trace elements by SSMS. A total of 54 trace elements were detected in the coal. Of these, Al, Ca, Fe, Mg, P, K, Se, Sr, S and Ti have mass flows in excess of 100 g/hr. The input rate for the feed coal was 1094 kg/hr.

In general, the bulk of the trace element mass exiting the gasifier in the solid waste streams is found in the gasifier ash with relatively low concentrations in the cyclone dust. Fifteen elements were preferentially concentrated in the ash. These elements are Al, Ba, Be, B, Ca, Co, Cu, Cd, Pb, Mg, Ni, Ru, Sc, Sn and Ti.

Recommendations

Specific recommendations for consideration in future Chapman gasifier STE programs fall into two categories:

- additional data needs, and
- methodology recommendations

Data Needs

In general, the short term data needs for an initial assessment have been met for the waste streams and potential fugitive emissions from the Chapman facility using Virginia bituminous feed coal. The organic and trace element characterization of the streams presented in this report, along with the data already available in the Chapman STER (1) should be sufficient to provide preliminary guidance in the selection of a control scheme to treat process and waste streams with potential health and ecological effects. Long-term (30-day) monitoring to establish process variability and data for additional coal types is required to provide support for the development of regulations. The compounds and elements listed as "principal" contributors to the TDS values for the streams, and any other compounds which exceed regulatory standards should be subjected to long-term monitoring in the input and output streams of any control employed.

Additional data which are needed to

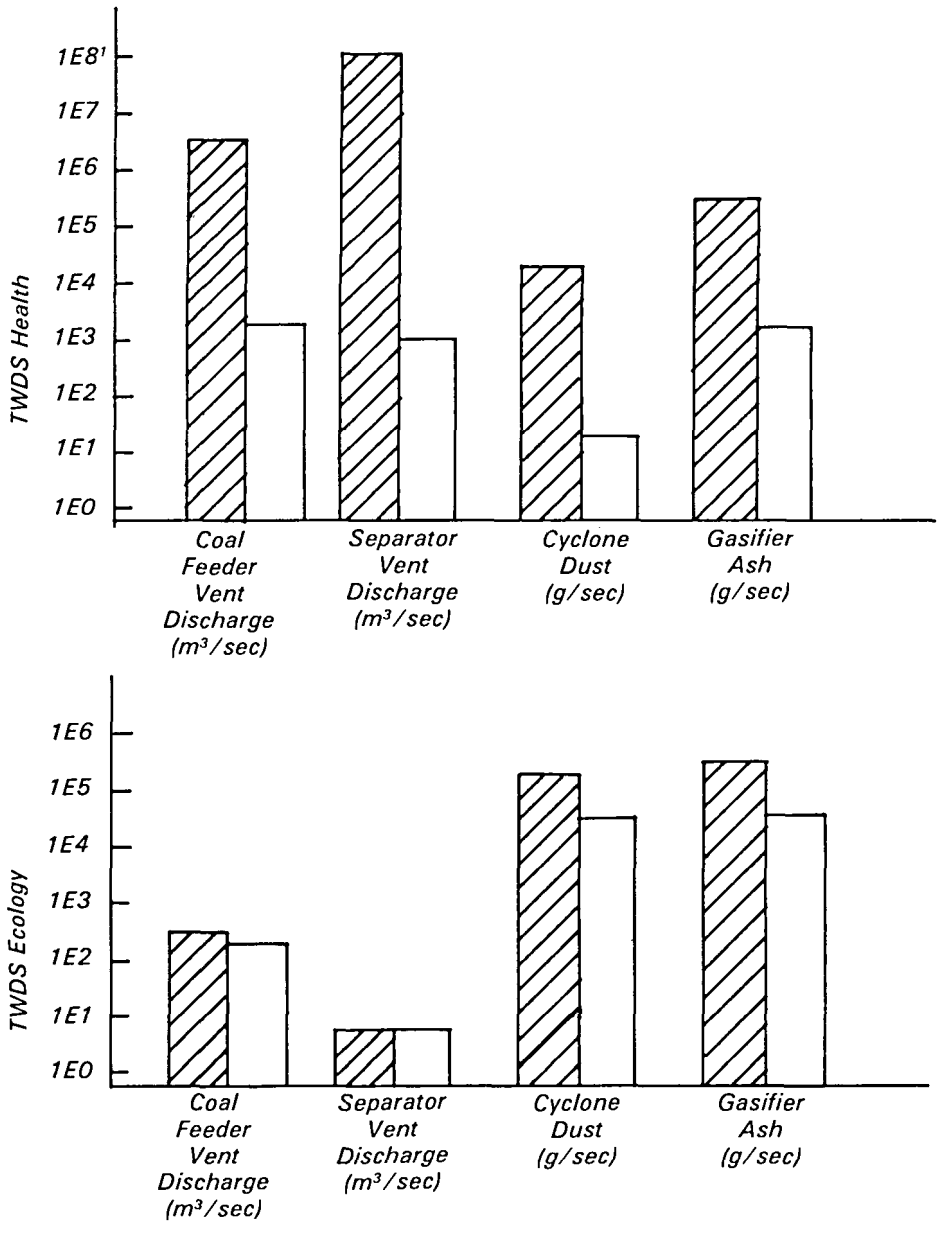


Figure 3. *A comparison of the total weighted discharge severity values from the chemical screening data and the detailed analytical data.*

assess the potential health ecological effects are:

- a characterization of the combustion products of the product gas, in order to assess the possible effects of burning the product gas,
- a characterization of the gaseous discharge from the quench liquor forced evaporator,
- a characterization of phthalates in the gasifier ash to determine if detected phthalates are artifactual, and
- a detailed characterization of the polycyclic hydrocarbons, including specifically, the speciation of the 252 molecular weight isomeric group containing B(a)P for those streams in which B(a)P contributes the bulk of the potential health effects.

Methodology Recommendations

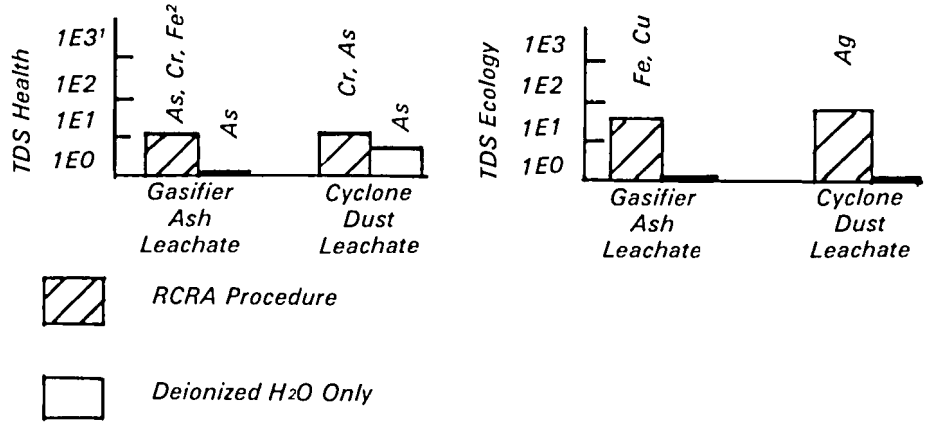
The analytical methodologies employed for the detailed analyses were satisfactory except in the resolution of polycyclic hydrocarbons. It is recommended that samples high in polycyclics should be analyzed by a technique such as gas chromatography/mass spectrometry, using a liquid crystal column to provide detailed data on specific environmentally significant polycyclic hydrocarbons such as B(a)P.

The comparison of RCRA and unbuffered (deionized water) leaching procedures indicates that differences in trace element concentrations occur in the leachates derived from the two procedures. It is recommended that solid wastes should be leached using both procedures to provide a better characterization of possible leachates entering the environment.

References

1. Page, G. C. Environmental Assessment: Source Test and Evaluation Report—Chapman Low-Btu Gasification. NTIS Report PB-289 940, EPA-600/7-78-202. Radian Corp., Austin, Texas, October 1978.
2. Schalit, L. M., and K. J. Wolfe. SAM/IA: A Rapid Screening Method for Environmental Assessment of Fossil Energy Process Effluents. NTIS Report PB-277 088, EPA-600/7-78-015. Acurex Corporation/Aerotherm Division, Mountain View, California, February 1978.
3. Cleland, J. G., and G. L. Kingsbury. Multimedia Environmental Goals for Environmental Assessment: Volume I and Volume II. MEG Charts and Background Information. NTIS Reports PB-276 919, PB-276 920, EPA-600/7-77-136a,b. Research Triangle Institute, Research Triangle Park, NC, November 1977.
4. Kingsbury, G. L., R. C. Sims, and J. B. White. Multimedia Environmental Goals for Environmental Assess-

ment: Volume III. MEG Charts and Background Information Summaries (Categories 1-12). NTIS Report PB 80-115 108, EPA-600/7-79-176a. Research Triangle Institute, Research Triangle Park, NC, August 1979.
5. Kingsbury, G. L., R. C. Sims, and J. B. White. Multimedia Environmental Goals for Environmental Assessment: Volume IV. MEG Charts and Background Information Summaries (Categories 13-26). NTIS Report PB 80-115 116, EPA-600/7-79-176b. Research Triangle Institute, Research Triangle Park, NC, August 1979.
6. Environmental Protection Agency. Hazardous Waste Management System, Identification and Listing of Hazardous Waste. Federal Register, 45(98):33084-33133, 1980.



[1]$aEb = a \times 10^{b}$
[2]*Major constituents contributing to TDS.*

Figure 4. *TDS values and principal contributing elements for the gasifier ash cyclone dust leachates.*

Table 2. *Comparison Of Solid Waste Leachates And RCRA Extract Limits*

	RCRA Limits	Gasifier Ash Leachate		Cyclone Dust Leachate	
Element	(5/18/80) (mg/L)	RCRA (mg/L)	DI H_2O	RCRA (mg/L)	DI H_2O
As	5.0	0.01	0.003	0.02	0.02
Ba	100	2.0	≤BC[1]	<0.3	<0.002
Cd	1.0	<0.002	<0.002	<0.002	<0.002
Cr	5.0	≤0.003	<0.002	<0.008	≤BC
Pb	5.0	0.010	≤BC	≤BC	≤BC
Se	1.0	0.002	≤BC	<0.002	<0.002
Ag	5.0	<0.002	<0.002	≤0.002	<0.002

[1] ≤BC = *less than or equal to the blank concentration.*

D. Scott Lewis and G. C. Page are with Radian Corporation, Austin, TX 78766
J. D. Kilgroe *is the EPA Project Officer (see below).*
The complete report, entitled "Addendum to 'Environmental Assessment: Source Test and Evaluation Report—Chapman Low-BTU Gasification'," (Order No. PB 81-113 003; Cost: $9.50, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
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Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
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U.S. Environmental Protection Agency
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