



Project Summary

Environmental Assessment: Source Test and Evaluation Report—Exxon Miniplant Pressurized Fluidized-Bed Combustor with Sorbent Regeneration

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The report gives results of a comprehensive emission sampling and analysis program conducted at the EPA-sponsored Exxon Miniplant, a pressurized coal-fired fluidized-bed combustor and sorbent regeneration system. The sampling and analysis methods used provide screening data on organic and inorganic pollutants and indications of biological activity; however, in general, they are not designed to provide final quantitative results.

Air pollutant emissions of trace elements were measured and compared to appropriate emissions goals. Seven inorganic trace elements exceeded emissions goals in the combustor flue gas, indicating a need for further investigation.

Air pollutant emissions of total organics were less than for comparable conventional combustion systems. Limited further analyses for specific polynuclear aromatic compounds indicated that emissions of one of these compounds exceed its emissions goal.

Analysis of laboratory-generated leachates from solid waste samples revealed trace metal concentrations well below Federal hazardous waste criteria.

Positive results for mutagenicity and cytotoxicity screening tests require further investigation. Similar results have been reported for other coal-fired fluidized-bed combustors and conventional combustion systems.

This Project Summary was developed by EPA's Industrial Environmental 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

The development of fluidized-bed combustion (FBC) is being supported by the Federal government, private industry, and utility groups because of its potential advantages over conventional coal combustion methods. Reduction of SO₂ during the combustion process is the primary advantage of FBC because it eliminates the need for add-on flue gas desulfurization equipment. Other advantages include a potential reduction in capital costs (compared to a conventional coal-fired boiler) and the capability to burn a wide variety of fuels, including such low-grade fuels as anthracite culm, coal cleaning wastes, and industrial wastes. An additional

advantage of pressurized fluidized bed technology is the potential to achieve higher fuel-to-electricity efficiencies than conventional systems.

In fluidized-bed combustion, a mixture of coal and limestone is supported on a grid at the bottom of a boiler. Combustion air passes through the grid at high velocities, typically 1.2 - 2.4 m/s (4 - 8 ft/s). The upward flow of the air holds the solids in suspension, creating a quasi-fluid that possesses many of the properties of the liquid. The most important liquid-like property to the boiler designer is the fact that bed material is exceptionally well mixed and flows throughout the system without agitation. This well-mixed semiliquid state produces high heat transfer rates and permits combustion at temperatures in the 760 - 930°C (1400 - 1700°F) range.

The EPA-sponsored Exxon Miniplant was a pressurized fluidized-bed combustor (PFBC) and sorbent regeneration system with a coal-firing capacity of 1.8 MW (6.3 x 10⁶ Btu/hr). Exxon operated the Miniplant from early 1974 to the summer of 1979, when the program ended. During the several thousand operating hours, extensive investigations of sulfur capture, NO_x emissions and control, high-pressure/high-temperature particulate control, combustion efficiencies, and many other aspects of FBC were completed. Sorbent regeneration was demonstrated in 1975 and an experimental program including sorbent regeneration was conducted during the first half of 1979.

This report discusses results of comprehensive sampling and analysis conducted by GCA/Technology Division at the Exxon Miniplant in May 1979.* These efforts were based on a phased approach to environmental assessment developed by EPA's Process Measurements Branch at the Industrial Environmental Research Laboratory at Research Triangle Park, NC (IERL-RTP). The first phase, Level 1, involves a screening approach using sampling and analytical techniques that sacrifice accuracy and compound specificity in order to identify any possible problem areas in a cost-effective manner. Level 1 should yield final analytical results within a factor of ±3. These results can be used to: provide preliminary envi-

ronmental assessment data; identify problem areas; and formulate the data needed to rank energy and industrial processes, streams within a process, and components within a stream, for further consideration in the overall assessment. The second phase, Level 2, is directed by Level 1 results and is designed to provide additional, more specific, accurate, and quantitative information that will confirm and expand the data gathered in Level 1. The primary focus of the sampling and analysis discussed in this report was at Level 1. Some Level 2 analytical work was conducted.

Facilities Description and Emission Streams Sampled

Figure 1 is a simplified schematic diagram of the Exxon Miniplant as it operated during the Level 1 sampling program. As indicated, 11 streams were sampled for Level 1 analysis at the Miniplant. These samples are listed and described in Table 1. Individual components of the process are briefly described below.

Process Description

Coal and sorbent are injected pneumatically into the combustor through a single port, 28 cm (11 in.)-above the water-cooled fluidizing grid. The flow of coal is controlled to maintain constant temperature in the combustor.

The combustor is a 9.75 m (32 ft) high refractory-lined vessel with an i.d. of 33 cm (13 in.). Heat of combustion is removed by water-cooled tubes in the fluidized bed. Coal feed rates of 230 kg/hr (500 lb/hr) and expanded bed heights of 6.1 m (20 ft) are possible, but the unit usually operates at about half these values. The unit is water cooled with both the cooling water temperature and metal temperature continuously measured.

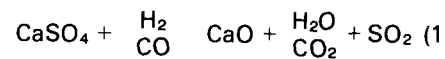
Solids are rejected from the combustor through a port above the fluidizing grid. From this port, the solids flow by gravity through a steel pipe into a pulse pot. The solids are then pneumatically transported by controlled nitrogen pulses to a pressurized lockhopper from which they are periodically dumped into metal drums. A similar system, not including a pressurized lockhopper, is used to transfer solids to the regenerator.

Combustion and fluidizing air are provided by a main air compressor (shown in Figure 1). Pressure in the combustor is controlled by maintaining a specified gas flow, across an appro-

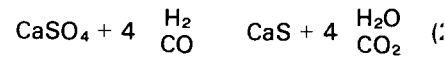
priately sized ceramic-coated orifice, by dilution of the flue gases with high pressure air as shown in the top of Figure 1.

The sorbent regenerator consists of refractory-lined vessel with an i.d. of 2.3 m (8.5 in.) and an overall height of 6.1 m (22 ft). Operating temperatures as high as 1100°C (2000°F) and pressure up to 1000 kPa (10 atm) can be achieved in the regenerator. Typical superficial velocity is 0.6 m/s (2 ft/s) with an expanded bed height of 2.3 m (7.5 ft).

The regeneration process is based on the one-step reductive decomposition of CaSO₄ by the reaction:



An undesirable competing reaction involving the formation of CaS also occurs:



Therefore, an oxidizing zone is provided in the regeneration vessel to convert CaS to CaSO₄:



At the Miniplant, natural gas is burned in the plenum below the fluidizing grid to achieve the reactor temperature. Additional fuel is injected directly into the bed, just above the fluidizing grid, to create a reducing zone in which reaction (1) occurs. Supplementary air is injected into the fluidized bed to create an oxidizing zone to convert CaS to CaSO₄ via reaction (3).

Flue Gas and Flue Gas Particulate Handling

Flue gas and entrained solids (fly ash and sorbent) exit the top of the combustor and enter a three-stage cyclone system. Solids separated by the first-stage cyclone drop through a steel dipleg and enter a pulse pot from which they are pneumatically conveyed back to the combustor (100 percent reinjected). Solids (primarily fly ash) escaping the primary cyclone enter more efficient second- and third-stage cyclones where finer sizes of solids are captured. The third-stage cyclone operates at 85 to 94 percent efficiency. The final flue gases generally contain 0.03 to 0.15 g/Nm³ of particulates with a mass median diameter of 1 to 3 μm. The collected solids from these cyclones pass through separate diplegs and enter pressurized

*GCA/Technology Division conducted the field measurement program under U.S. EPA Contract 68-02-2693, Exxon Research and Engineering operated the Miniplant and supported the field program under U.S. EPA Contract 68-02-1312.

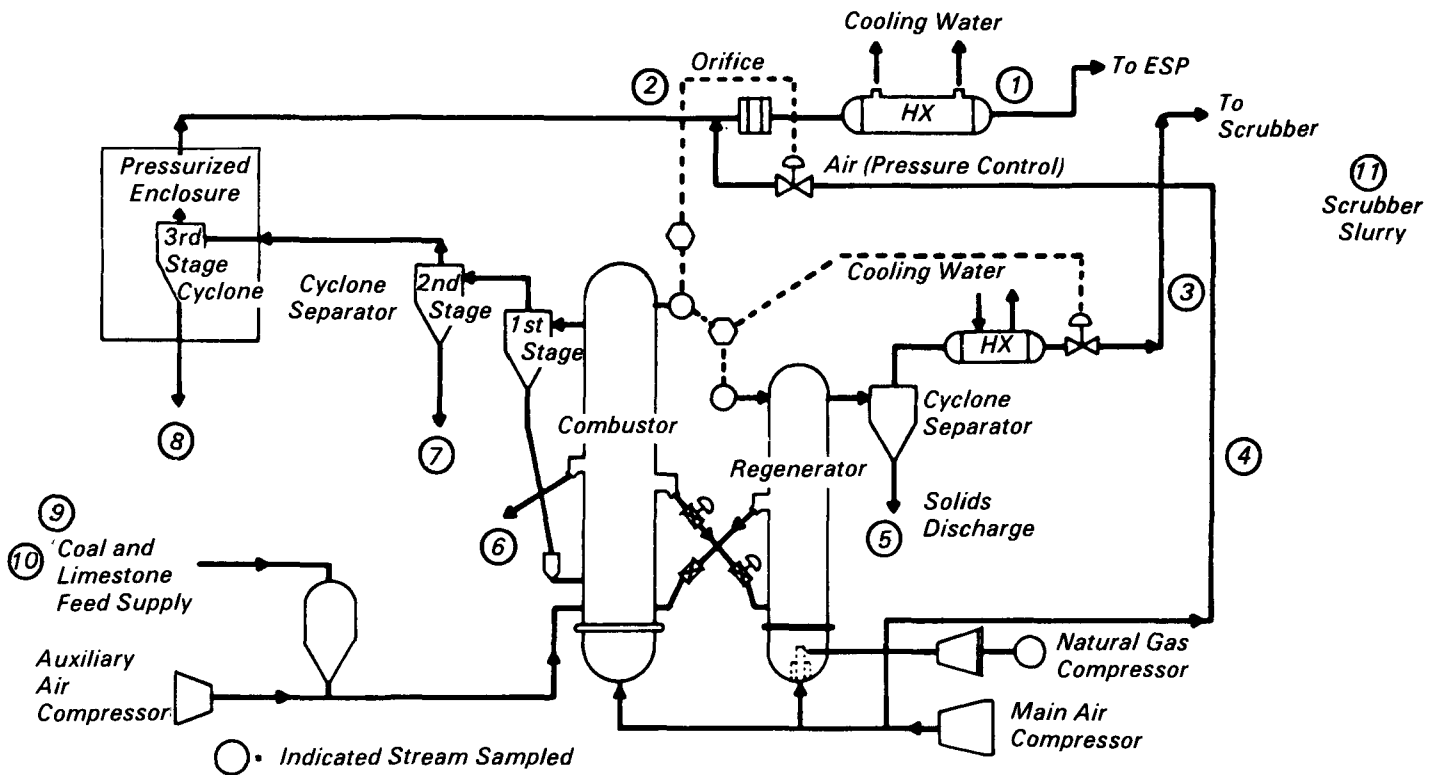


Figure 1. Schematic of the Miniplant PFBC as it operated during the Level 1 environmental assessment with Level 1 sampling points indicated.

lockhoppers from which solids are periodically dumped into metal drums.

After leaving the third-stage cyclone, the flue gas expands through a converging nozzle. A secondary source of high pressure air is metered through a ball valve with a pneumatic actuator and positioner. Superimposing this secondary flow of air on the primary flow of flue gas through the nozzle, maintains gas pressure in the combustor at the desired level, typically 950 kPa (9.5 atm).

During the Level 1 tests, the EPA mobile electrostatic precipitator was used to remove additional particulate from the cooled, depressurized flue gases. This experiment was conducted because the final particulate concentration of 0.03 to 0.15 g/Nm³ might be adequate for process performance, but emissions would need to be limited to 13 ng/J (about 0.035 g/Nm³) to meet Federal New Source Performance Standards for utility boilers.

Hot flue gases from the regenerator pass through a cyclone to remove entrained particles. Next the gases are

cooled from 930°C (1700°F) to about 200°C (390°F) in a water-cooled heat exchanger. Gases are depressurized before entering a scrubber for final cleanup before venting to the atmosphere.

Operating Conditions

Combustor and regenerator operating conditions during the EPA tests are listed in Table 2. Champion coal (with a sulfur content of 1.7 percent) and Grove limestone were used. It was necessary to feed significant quantities of fresh limestone to compensate for elutriation and to maintain the bed in the combustor. Because high sulfur coal was not available, the resultant Ca/S ratio was 1.29, much higher than desirable for commercial regenerative operation. Also, system pressure was 700 kPa (7 atm), instead of the normal 950 kPa (9.5 atm), to achieve adequate fluidizing velocities in the regenerator. Because the pressure was 30 percent lower than previous experimental runs, coal feed rate was reduced to maintain the

desired excess air at the specified fluidizing velocity.

Sampling and Analytical Methodology

Sampling Techniques

Six solid streams were sampled at the Miniplant: two feed streams and four waste streams. Samples for chemical and most biological analyses were collected every 2 hours during the flue gas sampling. All solid samples were split for organic and inorganic analysis. The individual organic and inorganic samples were each composited during the test run to provide a representative sample of each solid stream.

To provide samples of the combustor flue gas and the regenerator offgas for Level 1 Environmental Assessment analysis, the Source Assessment Sampling System (SASS) was used to collect samples of the particulate and gaseous components of each indicated gaseous stream.

The SASS train collects particles in a series of three cyclones with nominal

Table 1. Summary of Stream Sample Characteristics

Sample Point Identification No.	Stream Description	Physical State	Collected By	Important Characteristics
1	Diluted combustor flue gas (cooled) (ESP hopper catch)	Gas and solid	GCA	Fly ash entrained in combustion gases, particle concentration about 0.15 g/Nm ³ , mass median particle size below 5 μ m. Temperature 175°C (350°F), pressure 13 kPa (5 psig).
2	Undiluted combustor flue gas (hot)	Gas	GCA	Similar to (1) but temperature is 750°C (1500°F) and pressure is 700 kPa (7 atm).
3	Regenerator flue gas (cooled)	Gas	GCA	Sorbent particles entrained in off gases, low particle loading, temperature and pressure similar to (1).
4	High pressure dilution air	Gas	GCA	Compressor output containing organic residue from lubricating oil, pressure is 700 kPa (7 atm).
5	Solids from regenerator cyclone	Solid	Exxon	No special characteristics.
6	Spent combustion bed solids	Solid	Exxon	Solids stream containing spent sorbent and some bottom ash, discharge temperature approximately 900°C (1700°F).
7	Solids from second combustor cyclone	Solid	Exxon	Stream contains fly ash, particles of mass median diameter approximately 17 μ m, temperature approximately 150 to 300°C (300 to 600°F).
8	Solids from third combustor cyclone	Solid	Exxon	Stream contains fly ash, particles of mass median diameter approximately 4 μ m, temperature approximately 150 to 300°C (300 to 600°F).
9	Cool feed	Solid	Exxon	No special characteristics.
10	Sorbent feed	Solid	Exxon	No special characteristics.
11	Scrubber slurry	Liquid	Exxon	Liquid stream containing fly ash from stream 3 to condensed compounds, also ammonia, temperature 25 to 40°C (70 to 100°F).

cut points of 10 μ m, 3 μ m, and 1 μ m. A 150-mm filter collects the particles that are less than 1 μ m in diameter. The volatile organics are captured by 150 g of XAD-2 resin in a temperature-controlled trap. A series of impingers follows the resin trap to capture volatile metals. Setup and performance of the SASS train followed Level 1 specifications.

The SASS train samples of the diluted combustion flue gas (stream 1) were obtained from a temporary duct leading to the mobile ESP. Samples were collected on May 3 and 4, 1979.

Because organic contamination of the diluted combustor flue gas by the compressed air used for dilution was suspected, additional sampling was conducted before dilution (stream 2).

The SASS train cyclones, filter, and oven were not used at this sampling location because the Balston filter in the sample treatment system had already collected the particulates. The Balston filter operated at 260°C (500°F). A SASS train organic module was used to collect volatile and nonvolatile organic species. Sampling was accomplished by connecting a flexible stainless steel line to the existing metering valve.

The regenerator flue gases were also sampled with the SASS train. Sampling was conducted at approximately isokinetic conditions in the center of the 6.4 cm (2.5 in.) i.d. pipe transporting the regenerator flue gases. Sampling was conducted on May 2 and 3, 1979.

A small resin trap containing 25 g of clean XAD-2 was used to collect

organics in the dilution air. For sample collection, the resin trap was adapted to a glass EPA Method 5 sampling train. The sampling train was attached to an existing tap on the compressed air supply line. A metering valve was used to control the sample flow rate and reduce the pressure to acceptable levels. The samples were recovered by transferring the XAD-2 to an amber glass jar and then rinsing the resin trap with methylene chloride (distilled-in-glass grade).

Gaseous components of the Mini plant flue gas streams were sampled for subsequent analysis using a combination of continuous withdrawal, grab sampling, and special impinger train techniques. Analyses were conducted

Table 2. Summary of Miniplant PFBC Operating Conditions

Parameter	Combustor	Regenerator
Length of run, hr	99	81
Pressure, kPa	700	705
Average bed temperature, °C	894	1010-1031 (oxidizing-reducing)
Expanded bed height, m	3.1	1.9
Superficial velocity, m/s	1.5	0.6-0.8 (oxidizing-reducing)
Ca/S molar ratio	1.29	—
Coal feed rate, kg/hr	77	—
Coal type (percent S)	Champion (1.7)	—
Coal higher heating value, kJ/kg	31,400	—
Coal size, mesh	<16	—
Sorbent feed rate, kg/hr	5.4	—
Sorbent type	Grove limestone	Grove limestone
Sorbent size, mesh	8 x 25	—
Excess air, percent	46	—
Flue gas oxygen content, percent	4.1	0.3

for CO, CO₂, O₂, N₂, SO₂, H₂S, COS, CS₂, ammonia, and cyanide.

Grab samples of the four gaseous streams for low-boiling (< 100°C) organic analysis were obtained in evacuated 2-liter glass sampling bulbs. Inorganic fixed gas samples were obtained as integrated Tedlar bag samples.

Exxon personnel provided a single sample of scrubber slurry for Level 1 testing.

Analytical Techniques

Inorganic constituents of Miniplant effluent stream samples were quantified using a combination of instrumental and wet chemical techniques. The primary Level 1 inorganic analysis technique is spark source mass spectrometry, which provides sensitive detection limits for about 70 elements. Interferences, such as variations in the ion source discharge conditions and the photoplate interpretation techniques used in Level 1, provide only semi-quantitative data accurate to within a factor of 2 or 3.

Miniplant bulk solid streams, having the potential to be disposed of in a landfill or another area where leaching could occur, were subjected to inorganic analysis of both the solid material and laboratory-generated distilled water leachates. Atomic absorption spectrometry was used to accurately quantify selected elements in the leachates.

The Level 1 test protocol attempts to identify the major organic compound classes within each sample stream

tested. Methylene chloride extracts of the samples are analyzed. Qualitative and some quantitative data are generated, using gravimetry, gas chromatography, liquid chromatography, infrared spectroscopy, and low resolution mass spectrometry. These Level 1 techniques, in general, do not provide data on specific compounds. Level 1 methods were supplemented with high performance liquid chromatography using fluorescence detection for polynuclear aromatic compounds.

Volatile organics (boiling points below 100°C) are separated into six boiling point ranges by onsite gas chromatography. Moderately volatile organics (boiling points 100 - 300°C), in methylene chloride extracts, are analyzed in the laboratory by gas chromatography. Flame ionization detection is used in both of the above cases. Nonvolatile organics (boiling points above 300°C) are measured by gravimetric methods in methylene chloride extracts. These organic concentration data provide some qualitative indication of the types of compounds that may be present.

Level 1 liquid chromatographic (LC) separation was designed to separate samples into seven reasonably distinct classes of organic compounds and was applied to all samples that contained a minimum of 15 mg combined volatile and nonvolatile organics. A sample was placed on a silica gel liquid chromatographic column, and a series of eluants of sequentially increasing polarity were used to separate the sample into fractions for further analysis.

Infrared analysis was used to determine the functional groups in an organic sample or liquid chromatography fraction of a partitioned sample. The interpreted spectra provide information on functionality (e.g., carbonyl, aromatic hydrocarbon, alcohol, amine, aliphatic hydrocarbon, and halogenated organic).

Level 1 bioassays are a cost-effective initial screening tool that indicates potential health or ecological effects. As such, the test results should be used to point out areas requiring further investigation. Health effects tests consisted of the Ames test for mutagenicity, and mammalian cell cytotoxicity assays using rabbit alveolar macrophages (RAM) and Chinese hamster ovary (CHO) cells. Fathead minnows, daphnids, and algae were used to test for acute ecological effects.

Results

Data Handling

Criteria or standards for air, water, and solid waste pollutants are needed to properly determine the implications of test results. Federal standards exist for some pollutants, such as total particulates, NO_x, and SO₂ in boiler flue gases. Federal criteria are also available to determine if a solid waste is considered hazardous. However, emission standards do not exist for most of the pollutants measured in this and other environmental assessment programs.

IERL-RTP has developed a set of conservative Discharge Multimedia Environmental Goals (DMEGs). They are derived using models incorporating available exposure or recommendations data such as industrial Threshold Limit Values (TLV), NIOSH recommendations for worker exposure, drinking water criteria, results of toxicity experiments using animals, and EPA/NIOSH ordering numbers or animal data on carcinogenicity. These goals are emission concentrations that are used in IERL-RTP research programs to provide perspective on potential environmental hazards, to provide direction for control technology research programs, and to rank emission streams for future investigation. These conservative goals are a screening tool to provide focus for further, more detailed investigation.

The simplest model used to derive DMEG limits incorporates TLVs as air pollutant emission goals. Emission concentrations below the TLV are assumed to be safe, since dispersion usually produces ground-level concen-

trations lower than stack concentrations by a factor of 1000 or more. This dilution factor should, in general, provide adequate protection for chronic exposure of the general population. The other goals and models are based on similar but more complex (and, at times, more tenuous) extrapolations.

Measured trace element concentrations for each Miniplant effluent stream sample were compared to their individual DMEG specific for the media of interest (air, water, solid wastes). Elements in excess of their goals were "flagged," providing a mechanism to estimate potential hazards associated with emission of that stream. Such estimates may be made to reflect both human health and ecology. Elements in excess of their DMEG indicate a need for further investigation.

Summary of Test Results

Data generated from Level 1 analyses of Miniplant samples were of three general types: inorganic analysis relying on spark source mass spectroscopy (SSMS), atomic absorption spectrometry (AA), or wet chemical techniques; organic analysis using gravimetry, liquid chromatographic separation, infrared spectrophotometry, or low resolution mass spectrometry (and onsite gas chromatography for gaseous streams); and bioassay results of specific health or ecological effects testing.

Inorganic Data

Table 3 summarizes inorganic elemental data for Miniplant samples. Data are from SSMS or AA for gaseous waste stream samples, solid stream samples, and laboratory-generated distilled water leachates. Measured concentrations were compared to their respective appropriate emission goals (DMEGs).

Table 3 data show seven elements exceeding emissions goals in combustor flue gas. Flagging of these elements indicates a potential area for Level 2 investigation. However, Level 2 efforts would have to be preceded by validation of the Level 1 SSMS results. Some elemental concentrations, especially Cr, Ni, and Fe, may have been high because of contamination from the stainless steel of the sampling train. Although four elements exceed their DMEG in regenerator flue gas, further analyses of this stream are unlikely. Regenerator flue gas would be treated

Table 3. Summary of Inorganic Trace Element Data for Miniplant Samples

Stream Description	Number of Chemical Species >DMEG	Identity of Chemical Species >DMEG
<i>Gaseous waste streams^a</i>		
<i>Regenerator flue gas</i>	4	<i>V, Cr, Ni, Rh</i>
<i>Combustor flue gas^b</i>	7	<i>P, Ca, V, Cr, Fe, Ni, As</i>
<i>Solid streams^c</i>		
<i>Regenerator cyclone solids</i>	14	<i>Be, Al, P, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Cd</i>
<i>ESP hopper ash</i>	16	<i>Al, P, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Se, Cd, Ba, Pb</i>
<i>Second combustor cyclone solids</i>	14	<i>Al, P, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Cd, Pb</i>
<i>Third combustor cyclone solids</i>	15	<i>Al, P, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Se, Cd, Pb</i>
<i>Spent combustion bed material</i>	4	<i>Ca, P, Fe, Ni</i>
<i>Laboratory-generated, distilled water leachates^d</i>		
<i>Regenerator cyclone solids</i>	0	
<i>Second combustor cyclone solids</i>	0	
<i>Third combustor cyclone solids</i>	0	
<i>Spent combustion bed material</i>	0	
<i>Coal feed</i>	0	
<i>Sorbent feed</i>	0	

^aAir DMEGs used for comparison.

^bResults represent emissions for the total flue gas stream. Dilution air was not analyzed and is assumed not to contribute to the totals of inorganics analyzed.

^cLand DMEGs used for comparison.

^dWater DMEGs used for comparison.

before venting to the atmosphere and thus does not represent a true emission stream.

Bulk solid waste streams from the Miniplant PFBC were chemically evaluated in two ways. Solid samples were analyzed for trace elements by SSMS (AA for Hg and Sb) and compared to land DMEG emission goals. In addition, distilled water leachates were prepared, analyzed in a similar manner, and the results compared to water DMEGs.

As seen in Table 3, numerous, albeit similar, trace elements exceeded their respective land DMEGs in all solids collected by the various control devices used at the Miniplant. Only four elements exceeded one or both land DMEGs for Spent Combustor Bed Material. When laboratory leachates of these bulk solid materials were prepared and analyzed, however, no element in any sample exceeded any

discharge goal. In fact, most elemental concentrations in the leachates were more than two orders of magnitude below their goals. Based on these leachate data, leaching of potentially toxic species from disposed solid waste streams at the Miniplant would not appear to be a problem. Solid waste streams would, therefore, be at a lower priority for subsequent Level 2 analysis than would flue gas particles.

Organic Data

Samples from the Miniplant generally contained low levels of organic compounds compared to DMEGs and Level 1 organic analysis criteria.

The SASS train organic module (XAD-2 resin adsorbent extracted with CH₂Cl₂) from the regenerator flue gas streams and the diluted combustor flue gas stream were the only samples analyzed that contained sufficient organic mate-

Table 4. Summary of Bioassay Results of Miniplant PFBC Samples

Sample Description	Health Effects Tests			Ecological Effects Tests		
	Ames Mutagenicity ^a	RAM Cytotoxicity	CHO Cytotoxicity ^c	Fish (96-hour LC ₅₀)	Daphnids (48-hour LC ₅₀)	Algae [EC ₅₀]
Scrubber slurry	-	N ^b	-	High	High	Moderate
XAD blank	-	N	-	N	N	N
Combustor flue gas - XAD	+	N	-	N	N	N
Regenerator flue gas - XAD	+	N	High	N	N	N
Fine SASS particulate	+	N	N	N	N	N
Coarse SASS particulate	+	N	N	N	N	N
SASS filter-control	-	N	N	N	N	N
ESP hopper ash	+	Low	N	N	N	N
Regenerator cyclone	-	Low	N	High	High	High
Combustor bed material	-	Low	N	High	High	High
2nd Cyclone catch	-	Low	N	High	High	High
3rd Cyclone catch	-	Moderate	N	Low	Moderate	High

^a+/- = positive/negative mutagenic response; no detectable toxicity.

^bN = not run for indicated sample.

^c- = negative CHO cytotoxicity response

rial to require liquid chromatographic separation. Because organic concentrations were so low, the infrared spectrometry and low resolution mass spectrometry analyses provided only general results that were of limited use

Samples analyzed from the Miniplant generally contained such low levels of organic compounds that these data were interpreted as:

1. Initial Level 1 organic data were compiled, including totals for volatile species (TCO-total chromatographable organics), non-volatile species (GRAV-gravimetric), and onsite GC spectra where applicable.
2. A survey was made of all DMEG values that have been adopted for organic compounds or classes of compounds (586 to date).
3. It was assumed that the total weight of organics present in the sample analyzed was representative of one compound, as a worst case, and all species whose DMEG was lower than this total were listed. This exercise resulted (for some samples) in a list of compounds of "potential concern". In other samples, this exercise resulted in eliminating organic

compounds as an area of concern for future investigation.

4. These compounds were then reviewed based on knowledge of process chemistry, operating conditions, and the available Level 1 bioassay results. This review eliminated some species that could not possibly be present in these FBC emission streams.

5. A final list (on a stream-by-stream basis) of organic compounds of potential concern was compiled.

Organic compounds of concern in Miniplant emission streams appear to be limited to polynuclear aromatic (PNA) species that might be present in SASS train samples (particles and XAD) from combustor and regenerator flue gases.

Bioassay Data

Results of testing Miniplant samples in the Level 1 bioassay screen are summarized in Table 4. Results are listed based on qualitative Level 1 bioassay response criteria, except Ames results, which are listed as positive/negative.

Five samples were positive (mutagenic) in the Ames test. Except for the third cyclone catch, all streams exhibited low toxicity to RAM cells. Regenerator flue-gas XAD extract was the only

sample toxic to CHO cells. Regenerator cyclone catch leachate, spent combustion bed material leachate, and second cyclone catch leachate all exhibited high toxicity in all ecological effects tests. Third cyclone catch leachate was variably toxic in these tests depending on the organism exposed. The toxicity found in the ecological tests is probably attributable to high pH.

The resulting three sets of data from Level 1 analysis for each tested stream from the Miniplant PFBC were compared. Inorganic species that were flagged as exceeding one of their emission goals, organic species of potential concern possibly present in a sample (as determined above), and the response of a sample in the Level 1 battery of biological tests were all considered in making the final evaluation of which streams should receive priority for level 2 analysis.

Radioassay of Miniplant Samples

Multimedia samples collected during the May 1979 Level 1 sampling program at the Miniplant were analyzed for selected radioisotopes. Radioisotope emissions data from FBC are required

by the EPA's Office of Radiation Programs to evaluate the need, if any, for emissions limitations or other standards or criteria as instructed by the Clean Air Act Amendments. Also, these data serve as an initial effort toward incorporation of radioactivity (as an environmental pollutant) into the environmental assessment methodology developed by the EPA Office of Research and Development through IERL-RTP.

Seven solid samples were analyzed. Coal and sorbent feedstocks were analyzed for isotopic uranium (^{234}U , ^{235}U , ^{238}U) and isotopic thorium (^{228}Th , ^{230}Th). ESP hopper ash was not available in sufficient quantity to permit analysis for thorium isotopes but was analyzed for isotopic uranium, ^{226}Ra , ^{228}Ac , ^{210}Pb , and ^{210}Po . Regenerator cyclone solids, solids captured by second and third combustor cyclones, and spent bed material were assayed for all nine isotopes.

Data indicate that most of the radioisotopes leave the system as part of the second and third combustor cyclone catches. Radioisotopes escaping the plant in the Miniplant flue gases or in a commercial FBC facility would probably be 1 - 20 percent of those measured in the ESP hopper catch.

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John O. Milliken is the EPA Project Officer (see below).

The complete report, entitled "Environmental Assessment: Source Test and Evaluation Report—Exxon Miniplant Pressurized Fluidized-Bed Combustor with Sorbent Regeneration," (Order No. PB 82-196 858; Cost: \$18.00, 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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