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Thirty-day Field Tests of Industrial Boilers: Site 3 — Pulverized-coal-fired Boiler

Interagency Energy/Environment R&D Program Report

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Thirty-day Field Tests of Industrial Boilers: Site 3 — Pulverized-coal-fired Boiler

by

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ABSTRACT

This is a final report on a test program to evaluate the long-term effectiveness of combustion modifications for lowering emissions from industrial boilers. During previous programs short-term tests have been performed on industrial boilers to determine the effect of combustion modifications on air pollutant emissions such as NO_x, SO_x, CO, HC, and particulate. The objective of this program was to determine whether the combustion modification techniques which were effective for short-duration tests are feasible for a longer period. This report presents the results of a 30-day field test of a 76.2 MW (260,000 lb steam/hr) output, pulverized-coal-fired water tube boiler. The NO_x control technology employed on this unit was staged combustion air and low excess air. The results indicate that staged combustion air and low excess air can be effective techniques for NO_x control. However, additional operational problems such as flame stability can be encountered. The baseline NO measurement was 498 ng/J (815 ppm @ 3% O_2, dry) with the unit operating at approximately 70% of capacity. At approximately the same load, low NO_x operation yielded an NO emission level of 422 ng/J (691 ppm @ 3% O_2 dry) for a reduction of approximately 15%. The average NO emission level for 30 days, firing with staged combustion air and low excess air at loads varying from 15 MW to 63 MW, was 340 ng/J (557 ppm @ 3% O_2, dry). Boiler efficiency showed an increase of approximately 1% under low NO_x firing condition.

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SECTION 1.0

SUMMARY

1.1 OBJECTIVE AND SCOPE

The objective of this field test was to determine whether combustion modification techniques which brought about reduction of air pollutant emissions during short-term tests are feasible for longer periods. In addition, boiler performance and reliability were monitored. The combustion modifications have previously been shown to be effective on industrial boilers (Refs. 1, 2, 3).

The program scope provides for 30-day field tests of a total of seven industrial boilers with design capacities ranging from 14.65 to 73.25 MW thermal output (50,000 to 250,000 lb steam/hr). Fuels to be burned include natural gas, light oil, residual oil, and coal. This final report is for a 76.2 MW thermal output (260,000 lb steam/hr) pulverized-coal-fired boiler using staged combustion air (SCA) and low excess air (LEA) as the emission control technology.

During the test period, continuous monitor certification tests were performed concurrently with low NOx testing. Emissions measured were particulate, NO, CO_2, CO, and O_2. Boiler efficiency was calculated several times during the program to determine the effect of combustion modification on boiler efficiency.

This is a final report on the 30-day test, documenting test equipment, summarizing the test data, and discussing the data in relation to the control technology employed for this type of boiler.

1.2 RESULTS

A pulverized-coal-fired boiler using SCA and LEA as the NOx control technology was selected for this field test. A survey was made of previous tests conducted on pulverized-coal-fired boilers with SCA as the NOx control technology. It was desirable to select a boiler which had been tested previously in order to know its capability for low NOx operation and to minimize setup time.

The boiler tested at Site 3 was selected on the basis that previous testing had been performed by KVB and the unit had shown a capability of operation under low NOx conditions. Selection of a unit in this category was limited because the desired capacity is the lower and of the range for pulverized-coal-fired boilers.

A survey and analysis of the population of industrial boilers is presented in Reference 4. This study showed that pulverized-coal-fired boilers account nationally for only 12% of the total of coal-fired industrial boilers.

After permission to test was obtained, the continuous monitor was shipped to the site and installed. The next task was to perform the certification tasks outlined in Performance Specifications 2 and 3, 40 CFR60, Appendix B. (See Appendix D, this report.)

Following the monitor certification, the 30-day field test was conducted. The test was set up according to "Plan for Performing Source Evaluation Tests in Support of NSPS for Industrial Boilers." Emissions of NO, CO, CO_2, and O_2 were measured continuously. Particulate measurements were made in triplicate at the start and conclusion of the test period. In addition, triplicate particulate measurements were made with the boiler in the as-found (unmodified) condition. Measurements of polycyclic organic matter were made in both the low NOx and unmodified condition.

Results of the 30-day test are discussed in detail in Section 3.0. Table 1-1 presents a summary of the 24-hour averages of the stack emissions. The result of the statistical analysis of the data is illustrated in Figure 1-1 where the 24-hour averages for all boiler load conditions are plotted on log-probability paper. These data indicate that the NO data are log-normally distributed and the mean value is 340 ng/J with a geometric dispersion of 1.13.

TABLE 1-1. SUMMARY OF 24-HOUR AVERAGES OF STACK EMISSIONS FROM A PULVERIZED-COAL-FIRED BOILER

24 HOUR DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/ 1/79		55.4	6.6	11.3	28.	529.	35.	662.	12.	389.
6/ 2/79		19.8	8.3	11.0	21.	455.	30.	644.	11.	378.
6/ 3/79		14.4	9.0	.0	16.	392.	24.	588.	9.	345.
6/ 4/79		34.7	8.5	.0	18.	389.	26.	559.	9.	328.
6/ 5/79		19.7	9.5	10.3	20.	369.	32.	485.	11.	285.
6/ 6/79		22.6	8.1	10.4	21.	366.	30.	514.	11.	302.
6/ 7/79		29.4	8.3	10.8	31.	383.	44.	544.	16.	320.
6/ 8/79		30.3	8.1	10.5	28.	410.	40.	572.	14.	336.
6/ 9/79		19.9	8.4	10.1	27.	406.	38.	581.	14.	341.
6/10/79		16.4	8.6	10.0	33.	396.	48.	576.	17.	338.
6/11/79		18.6	8.5	10.3	38.	388.	55.	561.	20.	329.
6/12/79		30.5	8.8	10.4	0.	408.	0.	602.	0.	353.
6/13/79		23.3	9.0	10.6	0.	397.	0.	599.	0.	352.
6/14/79		38.6	8.5	10.5	49.	444.	71.	641.	25.	376.
6/15/79		18.3	9.2	10.2	86.	324.	131.	495.	47.	291.
6/16/79		21.8	9.1	10.2	0.	364.	0.	551.	0.	323.
6/17/79		19.4	8.8	10.3	0.	356.	0.	526.	0.	309.
6/18/79		21.7	8.8	10.3	0.	357.	0.	530.	0.	311.
19/79		20.7	8.9	10.0	35.	358.	52.	532.	19.	312.
20/79		18.9	9.0	10.0	33.	361.	50.	544.	18.	319.
6/21/79		31.7	8.8	10.7	21.	431.	31.	637.	11.	374.
6/22/79		18.8	8.6	10.5	35.	450.	51.	656.	18.	385.
6/23/79		22.6	8.4	10.6	36.	449.	52.	641.	18.	377.
6/24/79		20.3	8.6	10.2	34.	395.	50.	577.	16.	339.
6/25/79		23.1	9.0	10.2	36.	410.	54.	616.	19.	361.
6/26/79		18.8	8.9	10.3	37.	427.	55.	639.	20.	375.
6/27/79		20.2	8.6	10.3	15.	426.	22.	620.	8.	364.
6/28/79		21.0	8.6	10.5	25.	473.	37.	686.	13.	403.
6/29/79		19.8	8.5	10.4	34.	504.	48.	728.	17.	427.
6/30/79		19.2	8.8	10.2	30.	438.	44.	647.	16.	380.
7/ 1/79		17.6	8.8	9.9	33.	455.	48.	673.	17.	395.
7/ 2/79		18.9	8.5	10.3	33.	436.	47.	629.	17.	369.
7/ 3/79		37.2	8.3	10.6	19.	487.	28.	694.	10.	407.
7/ 4/79		19.8	8.6	10.3	35.	424.	51.	618.	18.	363.
7/ 5/79		20.7	8.5	10.3	15.	416.	21.	599.	7.	352.
7/ 6/79		22.3	8.4	10.3	21.	385.	30.	550.	11.	323.
7/ 7/79		19.1	8.5	10.2	35.	384.	50.	556.	18.	326.
7/ 8/79		17.7	8.7	9.9	47.	351.	69.	514.	25.	302.
7/ 9/79		18.4	8.4	10.3	80.	366.	115.	526.	41.	309.
7/10/79		37.6	9.0	9.9	92.	453.	139.	681.	50.	400.
7/11/79		45.6	7.8	11.2	75.	519.	102.	708.	37.	416.
7/12/79		33.0	8.0	10.6	84.	407.	117.	566.	42.	332.

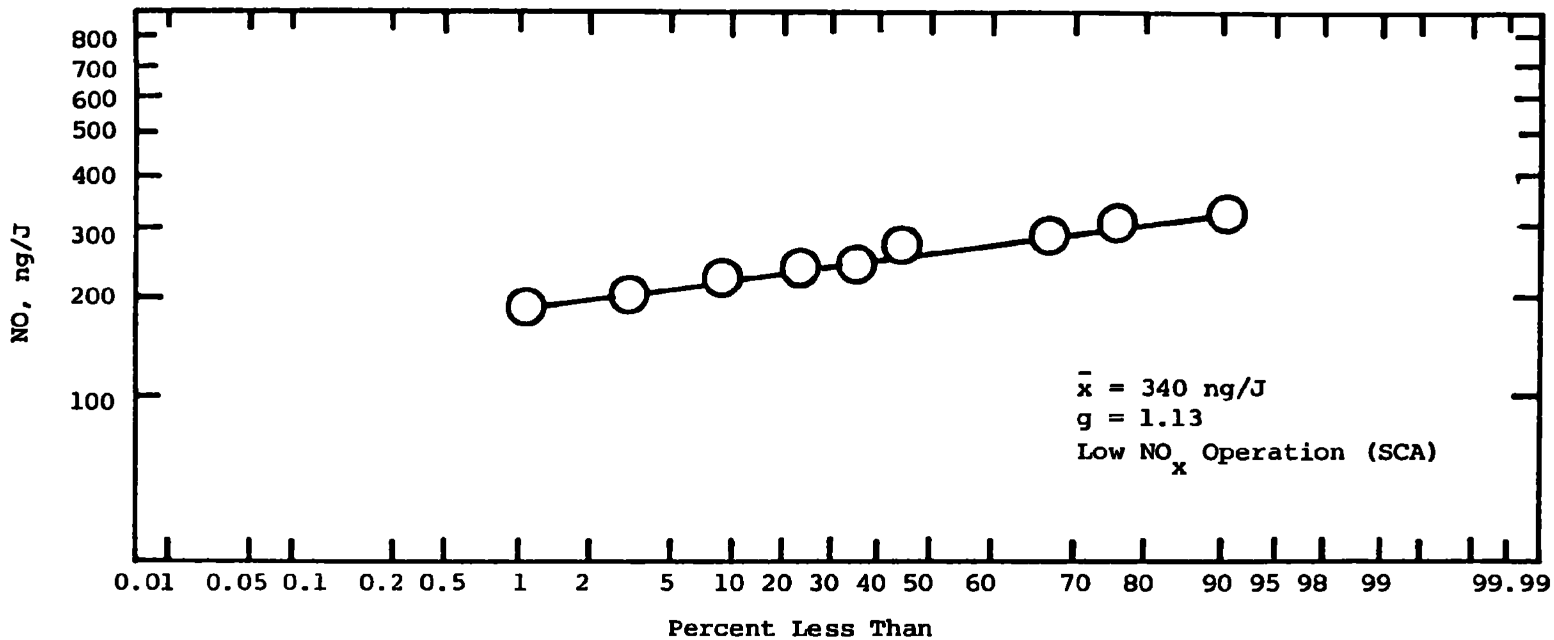


Figure 1-1. NO Emissions from Site 3 - Pulverized Coal-Fired Boiler

1.3 CONCLUSIONS

Based on the results of this 30-day field test, the following conclusions are presented.

1. Staged combustion air is an effective NO_x control technology for certain pulverized-coal-fired boilers. The low NO_x mode (SCA) was maintained for 42 days with an average NO emission rate of 340 ng/J. Boiler load varied from 14.4 to 63.0 MW thermal input.

2. Boiler operation in the low NOx mode (SCA) required special attention to the burners. With the upper two burners biased for operating air rich, a problem with flame stability can be encountered.

3. The continuous monitor system utilizing an extractive sampling system provided accurate, reliable data for the 30-day test period. Daily calibration of instruments is necessary as is preventive maintenance on the sample system.

4. Operation of industrial boilers ususally is characterized by large swings in load. Any effective control technology must be capable of operation over large load changes. Staged combustion air by biasing the mills is effective at the upper load range but presents operational problems at low load.

SECTION 2.0

INSTRUMENTATION AND PROCEDURES

This section presents a description of the instrumentation used to measure the gaseous and particulate emissions, the test procedures, and techniques for certifying the continuous monitor and a description of the boiler tested.

2.1 EMISSIONS MEASUREMENT INSTRUMENTATION

The emissions measurements were made using a continuous monitor fabricated by KVB for this program. The analytical instrumentation and sample handling equipment are contained in a cabinet 1.2 m wide x 0.76 m deep x 183 m high (48"W x 30"D x 72"H). A photograph of the continuous monitor is shown in Figure 2-1. Gaseous emission measurements were made with the analytical instruments listed in Table 2-1.

Total particulate measurements were made using an EPA Method 5 sampling train manufactured by Western Precipitation Division of Joy Manufacturing Company. Samples for measurement of polycyclic organic matter (POM) were obtained using an XAD-2 module supplied by Battelle Columbus Laboratories. These modules were returned to Battelle for analysis following the test.

2.1.1 Gaseous Emissions

The continuous monitor is equipped with analytical instruments to measure concentrations of NO, CO, CO_2, and O_2. The sample gas is delivered to the analyzers at the proper condition and flow rate through the sampling

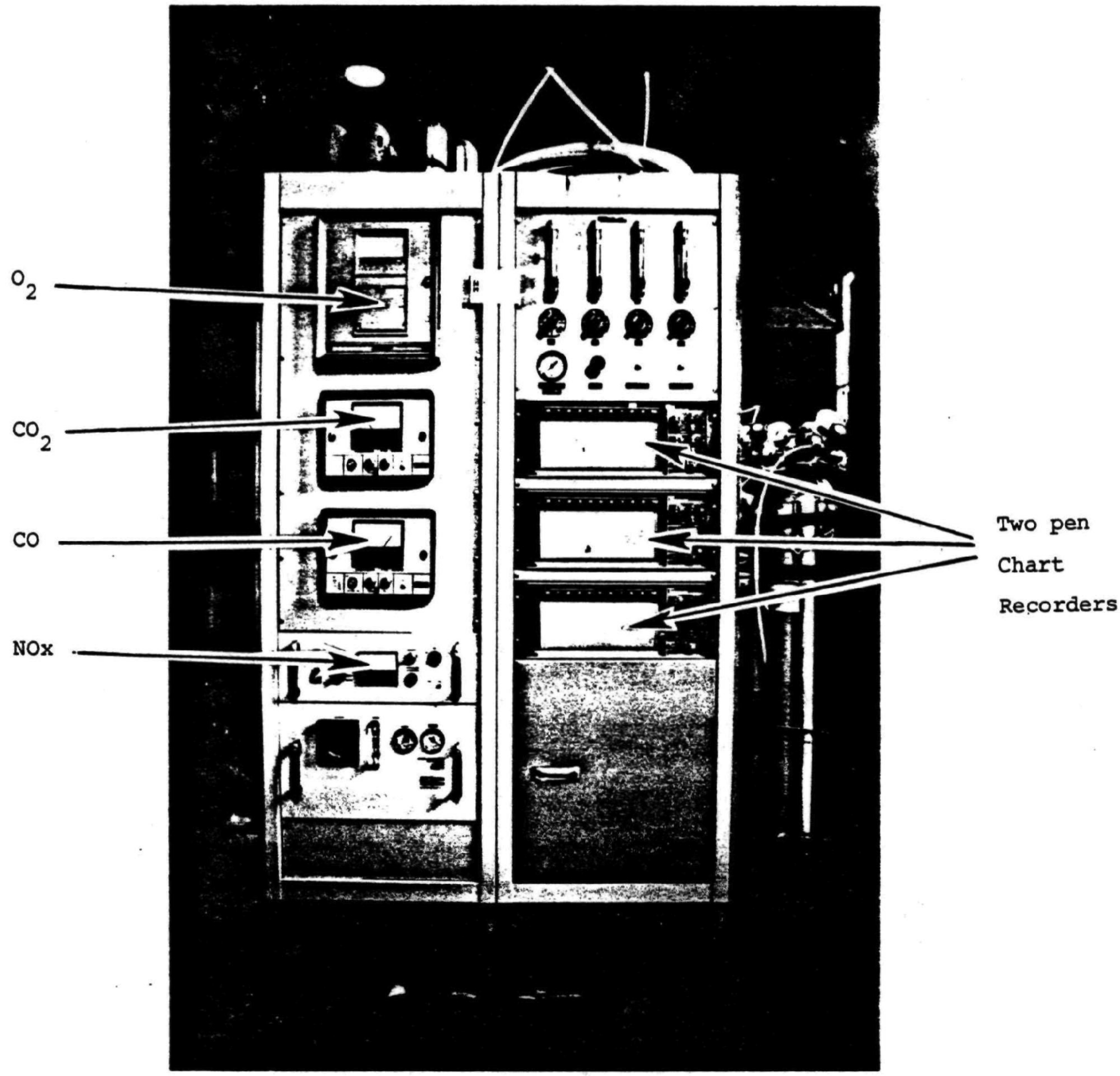


Figure 2-1. Photograph of KVB Continuous Monitor for measuring gaseous emissions.

TABLE 2-1. ANALYTICAL INSTRUMENTATION

Emission Species	Manufacturer	Measurement Method	Model No.
Nitrogen Oxides	Thermo Electron	Chemiluminescent	10A
Oxygen	Beckman Instrument	Polarographic	742
Carbon Dioxide	Horiba Instrument	NDIR	PIR-2000
Carbon Monoxide	Horiba Instrument	NDIR	PIR-2000
Opacity	Dynatron	Transmissometer	1100

and conditioning system shown schematically in Figure 2-2. A probe with a 0.7-micrometer sintered stainless steel filter was installed in the stack to sample the flue gas. The following paragraphs describe the analytical instrumentation.

A. Nitrogen Oxides--

The oxides of nitrogen monitoring instrument used was a Thermo Electron chemiluminescent nitric oxide analyzer. The operational basis of the instrument is the chemiluminescent reaction of NO and O_3 to form NO_2 in an excited state. Light emission results when excited NO_2 molecules revert to their ground state. The resulting chemiluminescence is monitored through an optical filter by a high sensitivity photomultiplier tube, the output of which is electronically processed so it is linearly proportional to the NO concentration.

Air for the ozonator is drawn from ambient through an air dryer and a 10-micrometer filter element. Flow control for the instrument is accomplished by means of a small bellows pump mounted on the vent of the instrument downstream of a separator which insures that no water collects in the pump.

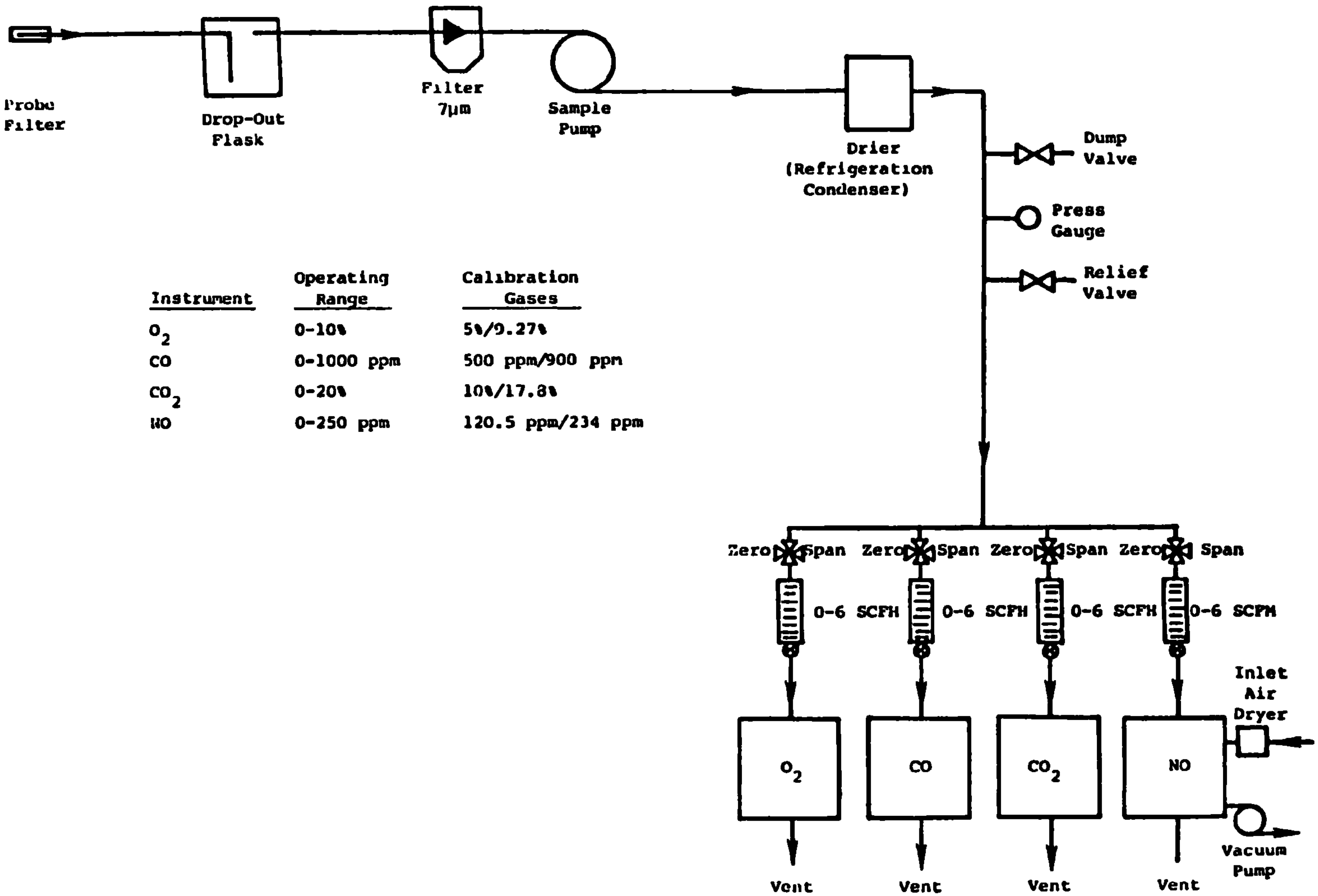
The basic analyzer is sensitive only to NO molecules. To measure NOx (i.e., NO + NO_2), the NO_2 is first converted to NO. This is accomplished by a converter which is included with the analyzer. The conversion occurs as the gas passes through a thermally insulated, resistance heated, stainless steel coil. With the application of heat, NO_2 molecules in the sample gas are reduced to NO molecules, and the analyzer then reads NOx. NO_2 is obtained by the difference in readings obtained with and without the converter in operation.

Specifications

Accuracy: 1% of full scale

Span drift: $\pm$ 1% of full scale in 24 hours

Zero drift: $\pm$ 1 ppm in 24 hours



Instrument	Operating Range	Calibration Gases
O_2	0-10%	5%/9.27%
CO	0-1000 ppm	500 ppm/900 ppm
CO_2	0-20%	10%/17.8%
NO	0-250 ppm	120.5 ppm/234 ppm

Figure 2-2. Schematic of continuous monitor sampling and conditioning system.

Power requirements: 115 ± 10V, 60 Hz, 1000 watts

Response: 90% of F.S. in 1 sec (NO_x mode); 0.7 sec (NO mode)

Output: 4-20 ma

Sensitivity: 0.5 ppm

Linearity: ± 1% of full scale

Vacuum detector operation

Range: 2.5, 10 25, 100, 250, 1000, 2500, 10,000 ppm F.S.

Only the NO concentration was measured during this program. Because of the added complexity of heated sample lines and controllers necessary for measuring NO_2 and the small percentage of NO_2 in the flue gas, based on previous tests (References 1, 2, and 3) EPA decided that only NO measurement was necessary. Therefore, an unheated sample line was installed, and the moisture was removed from the sample gas by a dropout flask and a refrigerated condenser.

B. Carbon Monoxide and Carbon Dioxide--

Carbon monoxide (CO) and carbon dioxide (CO_2) concentrations were measured by Horiba Instruments PIR-2000 short-path-length nondispersive infrared analyzers. These instruments measure the differential in infrared energy absorbed from energy beams passed through a reference cell (containing a gas selected to have minimal absorption of infrared energy in the wave length absorbed by the gas component of interest) and a sample cell through which the sample gas flows continuously. The differential absorption appears as a reading on a scale of zero to 100% and is then related to the concentration of the species of interest by calibration curves supplied with theinstrument. A linearizer was supplied with the CO analyzer to provide a linear output over the range of interest. The operating ranges for the CO analyzer are zero to 500, zero to 1000, and zero to 2000 ppm, and the ranges for the CO_2 analyzer are zero to 5, zero to 10, and zero to 20%.

Specifications

Accuracy: 1% of full scale

Repeatability: ± 0.5% of full scale

Zero drift: $\pm$ 1% of full scale in 24 hours

Span drift: $\pm$ 1% of full scale in 24 hours

Response time: selectable - 90% of full scale in 0.5, 1.2, 3, or 5 seconds

Power requirements: 115 VAC $\pm$ 10%, 60 Hz

Warm up time: 30 minutes

Output: 0-10 MV

C. Oxygen--

A Beckman Model 742 oxygen analyzer was used to continuously determine the oxygen content of the flue gas sample. The oxygen measuring element contains a silver anode and gold cathode that are protected from the sample by a thin membrane of Teflon. An aqueous KCL solution, retained in the sensor by the membrane, serves as an electrolytic agent. As Teflon is permeable to gases, oxygen will diffuse from the sample to the cathode in the following oxidation-reduction reaction:

Cathode reaction: $O_2 + 2H_2O + 4e \rightarrow 4OH$

Anode reaction: $4Ag + 4Cl \rightarrow 4AgCl + 4e$

With an applied potential between the cathode and anode, oxygen will be reduced at the cathode causing a current to flow. The magnitude of this current is proportional to the partial pressure of oxygen present in the sample. The instrument has operating ranges of zero to 1%, zero to 10%, and zero to 25% oxygen.

Specifications

Accuracy: $\pm$ 1% of full scale or $\pm$ 0.05% O_2 which ever is greater

Sensor stability: $\pm$ 1% of full scale per 24 hours

Response time: 90% in 20 seconds

Output: 0-10 MV

Power requirement: 120 $\pm$ 10 VAC, 60 Hz

2.1.2 Particulate Emissions

Particulate samples were taken from two ports on the side of the duct located 90° from the gaseous emission sample port. The samples were taken using a Joy Manufacturing Company portable effluent sampler. This system, which meets the EPA design specifications for Test Method 5 (Determination of Particulate Emissions from Stationary Sources, Federal Register, Volume 42, No. 160, page 41754, August 18, 1977) is used to perform both the initial velocity traverse and the particulate sample collection. Dry particulates are collected in a heated case that contains, first, a cyclone to separate particles larger than 5 micrometers and, second, a 100-mm glass-fiber filter for retention of particles down to 0.3 micrometers. Condensible particulates are collected in a train of four Greenburg-Smith impingers in a chilled water bath.

2.1.3 Polycyclic Organic Matter (POM) Emissions

Particulate and gaseous samples for analysis of polycyclic organic matter were taken at the sample port used for Method 5 particulate tests. The sampling system is a modified Method 5 sampling train developed by Battelle Columbus Laboratories. A combination of conventional filtration with collection of organic vapors by means of a high surface area polymeric adsorbent (XAD-2) proved highly efficient for collection of all but the more volatile organic species. The modified sampling system consists of the standard EPA train with the adsorbent sampler (Figure 2-3) located between the filter and the impingers. With this system filterable particulate can be determined from the filter catch and the probe wash according to Method 5, whereas the organic materials present can be determined from the analysis of the filterable particulate and the adsorbent sampler catch. The impingers are only used to cool the stream and protect the dry-gas meter, and their contents are discarded.

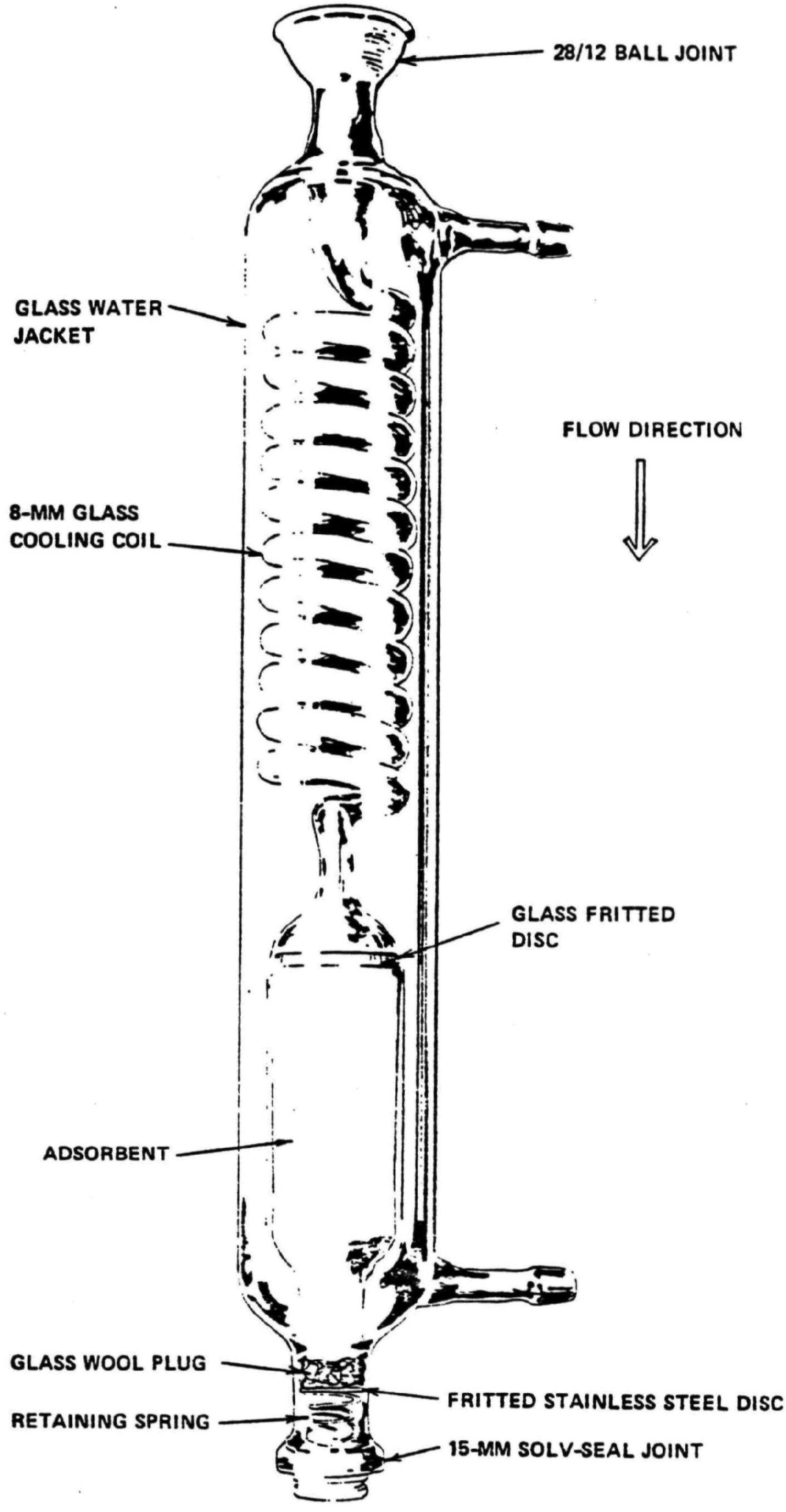


Figure 2-3. Mark III adsorbent sampling system.

2.1.4 Opacity Measurement

Stack opacity was measured continuously in the stack with a transmissometer permanently installed by the plant. In addition to the transmissometer reading, a visual determination of opacity was made. The visual determination of opacity was made by a qualified observer provided by EPA. The procedure, Method 9-CFR60, Appendix A, was followed for all tests where particulate were measured. Opacity measurements for each particulate test are tabulated in Table 3-4.

2.1.5 Data Recording

The millivolt output from the gaseous analyzers was recorded on two dual-channel strip chart recorders and a 20-channel digital data logger. The following paragraphs describe the recorders.

A. Strip Chart Recorder--

The strip chart recorders were Linear Instruments Corp. Model 432 two-channel crossover recorders. The recorder specifications are as follows:

Input span: 1 mV to 100 VDC
Accuracy: ± 0.5% span
Temperature stability: 1μV/°C
Response: 0.5 sec. over full 250 mm span
Zero: Right hand zero in standard. 100% zero suppression is standard
Power requirements: 115 VAC, 60 Hz, <20 watts
Weight: 11.4 kg (25 lb)

B. Digital Data Logger--

The data logger used for recording analyzer output was a Monitor Labs Model 9300 microprocessor-based data logger. The data logger has capability for input of 20 channels of analog voltage, current, and temperature. The data logger specifications are as follows:

Ranges: ± 30,000 mW, ± 300.00 mW, ± 3.0000 V, ± 12.000 V

Resolution: 1µV on 30.000 mV range (1 part in 30,000 except on 12V range; then 1 part in 12,000)

Accuracy: ± 0.02% reading ± 0.01%; Range ± 1 digit

Input impedance: 100 megohms

Temperature range: Operating, 0° to 50°C (32° to 122°F)
Storage, -20° to 65°C (-4° to 149°F)

Relative humidity: 0 - 95%, non-condensing

Main frame power: 115/230 V ± 10%, 60 Hz, less than 125 watts

Main frame dimensions: 18cm x 48.3cm x 56 cm (7" x 19" x 22")

Main frame weight: 18.2 kg (40 lb)

2.2 BOILER DESCRIPTION AND CHARACTERISTICS

The boiler tested at Site 3 was manufactured by Erie City Company in 1963 and is installed in a small midwestern power station. It is a 76.2 MW (260,000 lb/hr steam) pulverized-coal-burning unit of the two-drum Stirling type as shown in Figure 2-4. The unit is face-fired with four CE burners arranged in two rows of two. Pulverized coal is supplied to the burners by two CE Raymond Bowl mills.

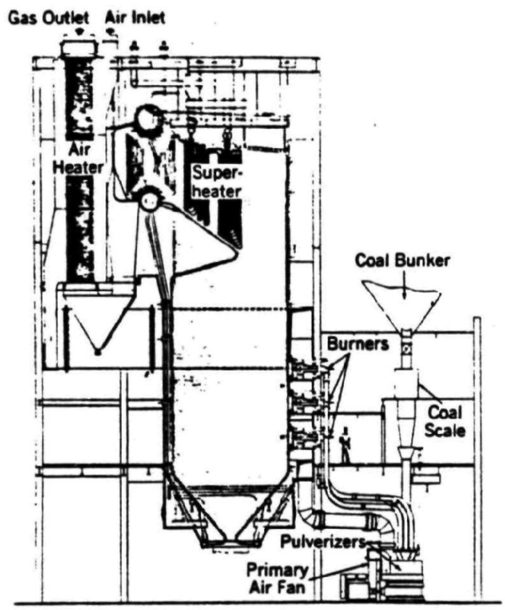


Figure 2-4. Two-drum Stirling boiler for pulverized coal (Typ.).

The unit also has the capability to fire natural gas. The boiler utilizes either propane or natural gas for startup.

Incoming combustion air is preheated by a two-pass tubular-type air heater. The flue gases pass through a pendant-type superheater before beginning the final boiler pass. Superheated steam temperature is controlled at 910°F by a coil-type attemperator. Fly ash is removed by a ten-compartment structural baghouse similar to the type shown in Figure 2-5. Material collected in the baghouse hoppers is periodically discharged at the bottom through a pneumatic conveying system. Bottom ash from the boiler is mixed with water and piped to a settling pond and eventually used for landfill.

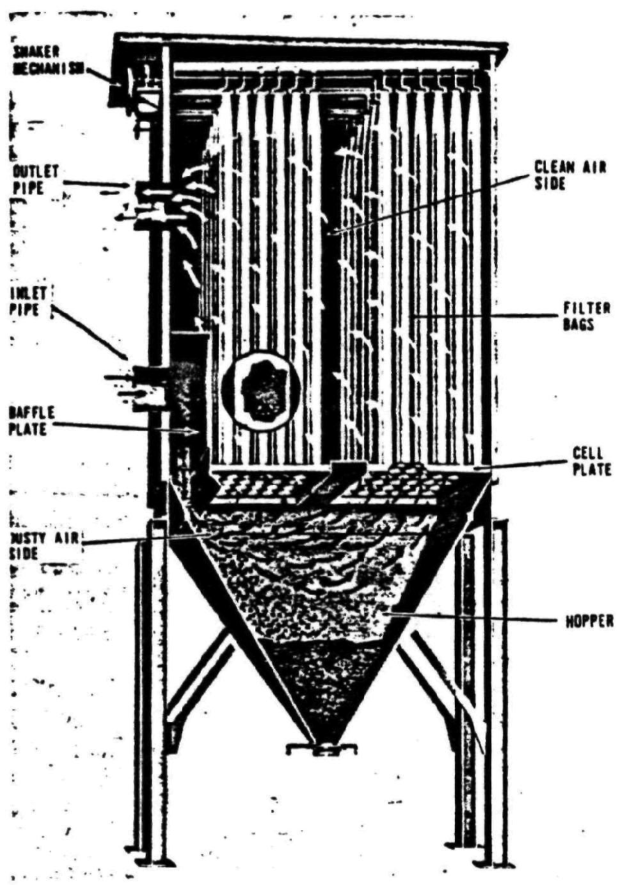


Figure 2-5. Typical simple baghouse with mechanical shaking (Wheelabrator Corporation, Mishawaka, Indiana).

The unit is a balanced draft type with both induced draft and forced draft fans.

The following design data apply to Test Site 3:

Boiler rating:	76.2 MW (260,000 lb/hr) steam flow
Design pressure:	6.3 MPa (900 psig)
Design temperature:	761K (910°F)
Year built:	1963
Furnace volume:	552 m^3 (19500 ft^3)
Furnace heating surface:	460 m^2 (4950 ft^2)

SECTION 3.0

TEST RESULTS

This section summarizes the emission and efficiency data collected on the pulverized-coal-fired boiler. This field test took place over a period of 44 days. The tests were conducted with a low-sulfur western coal as the fuel. The results presented herein summarize the gaseous and particulate emissions data, efficiency, and conclusions for the boiler operating on the low-NOx condition for extended duration.

3.1 CONTINUOUS MONITOR CERTIFICATION TEST 5

The continuous monitor described in the previous section was used to measure boiler gaseous emissions. Following shipment to the test site, the monitoring system was installed and certification tests performed in accordance with Performance Specifications 2 (PS2) and 3 (PS3), 40 CFR 60 Specifications. Appendix B (see Appendix D of this document) establishes minimum performance specifications that the NO monitoring system must meet in terms of eight parameters: accuracy, calibration error, two- and 24-hour zero drifts, two- and 24-hour calibration drifts, response time, and operational period.

The continuous monitor system was installed, and the analyzers were initially calibrated on May 30, 1979. A daily event schedule for the certification tests is presented in Table 3-1.

The performance of the continuous monitor is summarized in Table 3-2 where the measured values are compared with the specification values. Included in this table is the performance of the CO analyzer, which is not covered by the performance specification. The CO analyzer is used to monitor the combustion conditions in the boiler since it is a very sensitive indicator of combustion performance. Tables C-1 through C-18, Appendix C, show the performance of each of the analyzers for the certification tests.

TABLE 3-1. SCHEDULE OF CERTIFICATION TEST EVENTS

Date	Time	Event
6-4-79	1000	Calibration error determination
6-5-79	0850	Initial 24-hour zero and span reading. Initial 2-hour zero and span reading.
6-5-79	0850	1st 2-hour zero and span drift point
6-5-79	1050	2nd 2-hour zero and span drift point
6-5-79	1250	3rd 2-hour zero and span drift point
6-5-79	1450	4th 2-hour zero and span drift point
6-5-79	1650	5th 2-hour zero and span drift point
6-5-79	1850	6th 2-hour zero and span drift point
6-6-79	0850	7th 2-hour zero and span drift point
6-6-79	0850	1st 24-hour zero and calibration drift point. Initial 2-hour zero and calibration reading.
6-6-79	1050	8th 2-hour zero and span drift point
6-6-79	1250	9th 2-hour zero and span drift point
6-6-79	1450	10th 2-hour zero and span drift point
6-6-79	1650	11th 2-hour zero and span drift point
6-6-79	1850	12th 2-hour zero and span drift point
6-7-79	0850	2nd 24-hour zero and calibration drift point, initial 2-hour zero and calibration reading.
6-7-79	1050	13th 2-hour zero and span drift point
6-7-79	1250	14th 2-hour zero and span drift point
6-7-79	1450	15th 2-hour zero and span drift point
6-7-79	1650	16th 2-hour zero and span drift point
6-7-79	1850	17th 2-hour zero and span drift point
6-7-79	1000	Instrument response time tests
6-8-79	0850	3rd 24-hour zero and calibration drift
6-8-79	0930	1st set of relative accuracy samples taken
6-8-79	1030	2nd set of relative accuracy samples taken
6-8-79	1130	3rd set of relative accuracy samples taken
6-8-79	1230	4th set of relative accuracy samples taken
6-8-79	1330	5th set of relative accuracy samples taken
6-8-79	1430	6th set of relative accuracy samples taken
6-8-79	1530	7th set of relative accuracy samples taken
6-8-79	1630	8th set of relative accuracy samples taken
6-8-79	1730	9th set of relative accuracy samples taken
6-9-79	0850	4th 24-hour zero and calibration drift point
6-10-79	0850	5th 24-hour zero and calibration drift point
6-11-79	0850	6th 24-hour zero and calibration drift point
6-12-79	0850	7th and final 24-hour zero and calibration drift point
7-10-79	0830	1st set of relative accuracy samples taken
7-10-79	0930	2nd set of relative accuracy samples taken
7-10-79	1030	3rd set of relative accuracy samples taken
7-10-79	1130	4th set of relative accuracy samples taken
7-10-79	1230	5th set of relative accuracy samples taken
7-10-79	1330	6th set of relative accuracy samples taken
7-10-79	1430	7th set of relative accuracy samples taken
7-10-79	1530	8th set of relative accuracy samples taken
7-10-79	1630	9th set of relative accuracy samples taken

TABLE 3-2. INSTRUMENT SPECIFICATIONS AND PERFORMANCE

Parameter		Specifications	Performance
A. Thermo Electron Series 10 NOx Analyzer			
1. Accuracy		≤ 20% of mean ref. value	17.70%
2. Calibration error	mid	≤ 5% cal gas value	1.05%
	high	≤ 5% of cal gas value	0%
3. Zero drift (2 hour)		2% of span	1.99%
4. Zero drift (24 hour)		2% of span	1.79%
5. Calibration drift (2 hour)		2% of span	1.40%
6. Calibration drift (24 hour)		2.5% of span	0%
7. Response time		15 minute maximum	83 sec
8. Operational period		168 hour minimum	720 hr
B. Horiba Instruments PIR 2000 CO_2 Analyzer			
1. Zero drift (2 hour)		≤ 0.4 pct CO_2	0%
2. Zero drift (24 hour)		≤ 0.5 pct CO_2	0%
3. Calibration drift (2 hour)		≤ 0.4 pct CO_2	0.05%
4. Calibration drift (24 hour)		≤ 0.5 pct CO_2	0%
5. Response time		10 minutes	77 sec
6. Operational period		168 hour minimum	720 hr
C. Beckman Instruments Model 742 O_2 Analyzer			
1. Zero drift (2 hour)		≤ 0.4 pct O_2	DNA*
2. Zero drift (24 hour)		≤ 0.5 pct O_2	DNA*
3. Calibration drift (2 hour)		≤ 0.4 pct O_2	0.07%
4. Calibration drift (24 hour)		≤ 0.5 pct O_2	0.16%
5. Response time		10 minutes	89 sec
6. Operational period		168 hour minimum	720 hr
D. Horiba Instruments PIR 2000 CO Analyzer			
1. Calibration error	mid	≤ 5% of cal gas value	CO instrument was out for service
	high	≤ 5% of cal gas value	
2. Zero drift (2 hour)		2% of span	
3. Zero drift (24 hour)		2% of span	
4. Calibration drift (2 hour)		2% of span	
5. Calibration drift (24 hour)		2.5% of span	
6. Response time		15 minute maximum	
7. Operational period		168 hour minimum	

* Instrument has no zero adjustment.

Certified calibration gases were obtained from Scott Environmental Technology, Inc. The calibration gases included 50% and 90% span gases for the NO, CO_2, CO, and O_2 analyzers and a zero gas (N_2). In addition to the certified analysis supplied by the vendor, sample flasks were taken for each calibration gas and sent to an independent laboratory for analysis.

Relative accuracy tests for the NO analyzer were performed as outlined in PS2 using EPA Reference Method 7 (phenoldisulfonic acid [PDS] colorimetric) as the standard. Nine sets of three PDS flasks were collected at one-hour intervals at the beginning and end of the 30-day test period. At the fifteenth day, an abbreviated series of six flasks were taken. All sample flasks were returned to an independent laboratory for analysis. The results of the relative accuracy determination are shown in Tables C-17 and C-18 for the beginning and end of the 30-day test period. Both tests show that the NO instrument was well within the accuracy requirements of PS2. The relative accuracy of the Thermo Electron NO analyzer was % based on the first PDS test series and % based on the final test series. The relative accuracy requirement set forth in PS2 is $\leq$ 20% of mean reference value.

3.2 PULVERIZED COAL-FIRED BOILER TESTS

The continuous monitor was installed by KVB personnel on May 30, 1979, outside the control room at Site 3, a pulverized-coal-fired boiler. A single unheated 9.5 mm (3/8") nylon sample line was strung from the duct downstream of the baghouse to the continuous monitor. A single stainless steel probe with a sintered stainless steel filter was installed in the sampling port. Particulate samples were collected from two ports in the stack located 90 deg apart.

The boiler was initially tested in the as-found condition on June 6, 1979. The boiler load for these tests was 49.2 MW thermal output (168,000 lb steam/hr).

Boiler operation was then modified to incorporate staged combustion as the control technology. Staged combustion was achieved by biasing the coal pulverizing mills which feed the burners. The boiler has two rows of two burners on the front face and two pulverizing mills. Each mill feeds one row of burners. In order to effect staged combustion, the power to the mills was biased so that the lower burners were fed more coal than the upper burners. The total air flow was held constant, which produced a fuel-rich condition in the lower zone with an air-rich zone above. With two burners biased to give staged combustion, the maximum steam flow was approximately 200,000 lb/hr.

3.2.1 Gaseous Emissions

A summary of the daily observations of gaseous emissions and comments on boiler operating conditions is presented in Table 3-3. These data were recorded hourly by a technician. Also included in Table 3-3 are the particulate and efficiency measurements for the boiler. These data are used to verify measurements recorded on the strip charts and the automatic data logger.

3.2.2 Particulate Emissions

The results of the particulate tests are presented in Table 3-4 for low-NOx tests and baseline tests. Two of the tests (Nos. 3-3 and 3-4) were also used for collecting samples for analysis of polycyclic organic matter (POM) by modifying the Method 5 sampling train as described in paragraph 2.1.3. The average particulate loading for the unmodified operation (Tests 3, 4, 5, and 6) was 6.2 ng/J (0.0143 lb/10^6 Btu), while the average particulate loading in the modified or low-NOx mode was 6.3 ng/J (0.0147 lb/10^6 Btu). These data show that there is no significant difference in particulate emission between operation in the modified condition and operation in the normal mode.

The boilers at this facility had recently been outfitted with baghouse-type particulate collection equipment, and the stack effluent was extremely clear of any particulate matter. No visible emission was detected at any time during the test period.

3.2.3 POM Emissions

Samples were collected for analysis of polycyclic organic matter using a Method 5 sampling train with XAD-2, a POM absorber, inserted. Sample time was extended to two hours to provide a large enough sample for Battelle to analyze. Following the sampling period, the organic resin module was sealed and returned to Battelle Columbus Laboratories for analysis. The sampling probe and glassware were washed with a 50-50 mixture of methylene chloride and methanol per Battelle instructions. The filter and wash were also sent to Battelle following weighing.

TABLE 3-3. SUMMARY OF GASEOUS AND PARTICULATE EMISSIONS AT SITE 3 PULVERIZED COAL FIRED BOILER

Date 1979	Load Condition	Time		Gener.	Nominal Steam Load				NO*		CO*		Particulate		Stack Temp.			Comments
		Start	Finish	MW	K lb/hr	MWTH	% O_2	% CO_2	ng/J	ppm	ng/J	ppm	ng/J	lb/MMB	°K	°F	Eff.%	
6/1	High	2100	2200	22	198	58.0	6.4	11.3	379	646	12	34						As Found
	Low	2000	2100	19	172	50.4	6.4	11.2	355	605	13	37						
	7 Hr. Average	1700	2400	21	187	55.4	6.6	11.3	389	662	12	35						
6/2	High	2000	2100	24	208	55.1	6.1	0	424	722	12	35						SCA
	Low	1300	1900	5	48	14.2	7.6	13.3	339	577	12	32						
	24 Hr. Average	0000	2400	8	69	19.8	8.3	11.0	378	644	11	30						
6/3	High	1100	1200	7	64	18.8	9.1	0	351	597	7	19						SCA
	Low	1200	2400	5	48	14.1	7.9	0	310	527	11	31						
	24 Hr. Average	0000	2400	5	49	14.4	9.0	0	345	588	9	24						
6/4	High	1000	1500	24	208	60.0	8.5	0	411	701	8	22						SCA + LEA
	Low	0000	0700	5	48	14.1	10.1	0	297	506	6	18						
	Average	0900	1700	22	191	55.4	8.3	0	390	663	8	22						
	24 Hr. Average	0000	2400	14	120	34.7	8.5	0	328	559	9	26						
6/5	High	1600	1700	11	100	28.7	8.7	10.4	338	581	11	32						SCA
	Low	0000	0200	6	50	14.5	9.2	0	233	397	9	26						
	Average	0900	1700	9	76	22.0	8.9	10.3	293	498	15	41						
	24 Hr. Average	0000	2400	8	68	19.7	9.5	10.3	285	485	11	32						
6/6	High	1600	1900	18	162	47.4	7.2	10.8	266	453	2	6						SCA + LEA
	Low	0000	1300	6	56	16.2	8.2	10.4	305	519	11	30						
	Average	0900	1700	9	83	23.9	8.1	10.3	304	518	16	44						
	24 Hr. Average	0000	2400	9	78	22.6	8.1	10.4	302	514	11	30						

(continued)

* Corrected to 3% O_2.

**SCA = Staged Combustion Air
LEA = Low Excess Air

TABLE 3-3. (continued)

Date 1979	Load Condition	Time Start	Time Finish	Gener. MW	Nominal Steam Load K lb/hr	Nominal Steam Load MWTH	% O_2	% CO_2	NO* ng/J	NO* ppm	CO* ng/J	CO* ppm	Particulate ng/J	Particulate lb/MMB	Stack Temp. °K	Stack Temp. °F	Eff.%	Comments
6/7	High	1500	1900	19.0	168	49.2	7.4	11.6	285	466	16	42			449	349		SCA + LEA
	Low	1100	--	6.6	60	17.6	9.1	10.3	335	549	14	37			430	315		
	Average	0900	1700	11.6	100	29.3	8.4	10.8	316	518	15	40			439	330		
	Partic. Test 3-1	1500	1900	19.0	168	49.2	7.4	11.6	305	499	16	42	12.77	.0297	449	349	85.70	Low NO_x condition, Meth. 5 Test
	24 Hr. Average	0000	2400	11.6	100	29.3	8.4	10.7	337	551	16	44						
6/8	High	0900	1100	19.5	168	49.2	7.7	11.5	397	650	15	40			445	342		SCA + LEA
	Low	1300	1400	19.0	164	48.1	7.8	11.3	342	559	20	53			447	345		
	Average	0900	1700	19.2	166	48.6	7.7	11.3	369	604	19	50			446	344		
	Partic. Test 3-2	1300	1700	19.0	166	48.6	7.8	11.1	348	569	22	60	8.43	.0196	447	345	84.67	Low NO_x condition, Meth. 5 Test
	24 Hr. Average	0000	2400	11.9	103	30.2	8.3	10.8	345	564	22	58						
6/9	High	1100	1300	10.5	85	24.9	8.6	10.1	367	600	14	38			415	288		SCA + LEA
	Low	0900	--	7.5	64	18.8	8.0	10.9	328	537	19	50			423	302		
	Average	0800	1500	9.3	78	22.9	8.5	10.2	359	587	15	41			417	292		
	24 Hr. Average	0000	2400	7.9	68	19.9	8.6	10.2	346	566	17	46						
6/10	High	1200	--	7.5	64	18.8	7.4	10.1	351	574	17	45			415	288		SCA + LEA
	Low	1500	--	7 1	60	17.6	8.6	10.0	360	590	22	58			416	290		
	Average	0800	1500	7.3	62	18.2	8.7	10.0	360	590	21	56			415	287		
	24 Hr. Average	0000	2400	7.3	63	18.5	8.8	10.1	352	576	17	47						
6/11	High	0800	1100	8.4	69	20.2	8.5	10.6	336	550	17	46			422	300		CO instrument disconnected for service
	Low	1500	--	7.6	56	16.4	8.5	10.3	350	573	--	--			422	300		
	Average	0800	1500	8.1	67	19.6	8 5	10.5	343	562	--	--			422	300		SCA + LEA
	24 Hr. Average	0000	2400	7.3	63	18.5	8.6	10.4	343	562	--	--						
6/12	High	1500	--	19 0	164	48.1	7.7	11.2	396	648	--	--			449	349		SCA + LEA
	Low	0800	--	8.7	74	21.7	8.9	10.3	367	600	--	--			422	300		
	Average	0800	1500	12.0	102	29.9	8.2	10.7	371	608	--	--			431	317		
	Part. Test 3-3	1500	1800	19.0	164	48.1	7.4	11.3	361	591	--	--	7.75	.0180	446	344	85.06	Low NO_x condition, Meth. 5 Test, POM
	24 Hr. Average	0000	2400	12.1	104	30.5	8.6	10.3	373	610	--	--						

* Corrected to 3% O_2.

(continued)

TABLE 3-3. (continued)

Date 1979	Load Condition	Time Start	Time Finish	Gener. MW	Nominal Steam Load K lb/hr	Nominal Steam Load MWTH	% O_2	% CO_2	NO* ng/J	NO* ppm	CO* ng/J	CO* ppm	Particulate ng/J	Particulate lb/MMB	Stack Temp. °K	Stack Temp. °F	Eff.%	Comments
6/13	High	0800	1400	11.5	94	27.5	8.7	10.8	395	646	--	--			426	308		SCA + LEA
	Low	1500	--	9.0	76	22.3	8.6	10.9	381	624	--	--			427	310		
	Average	0800	1500	11.2	92	27.0	8.7	10.8	393	643	--	--			426	308		
	24 Hr. Average	0000	2400	9.3	80	23.4	9.0	10.6	371	607	--	--						
6/14	High	1300	1600	24.0	215	63.0	8.5	10.8	495	810	--	--			461	371		
	Low	1100	1200	7.0	58	17.0	8.6	10.4	284	464	--	--			425	305		
	Average	0800	1600	15.6	158	46.3	8.4	10.7	393	644	--	--			441	334		
	Partic. Test 3-4	1300	1600	24.0	215	63.0	8.2	10.8	495	810	--	--	7.82	.0180	461	371	83.85	Baseline, Meth. 5 Test, POM
	24 Hr. Average	0000	2400	15.3	132	38.7	8.4	10.7	393	643	--	--						
6/15	High	1100	1300	7.8	66	19.3	9.1	10.5	310	507	--	--			436	326		Baseline
	Low	0800	--	7.0	60	17.6	9.2	10.0	266	436	--	--			432	318		
	Average	0800	1500	7.6	65	19.0	9.1	10.3	302	495	--	--			435	324		
	24 Hr. Average	0000	2400	7.2	62	18.2	9.2	10.2	304	497	--	--						
6/16	Spot Reading	1200	--	7.2	60	17.6	9.4	9.9	330	540	--	--			436	325		SCA
	24 Hr. Average	0000	2400	8.6	74	21.7	9.0	10.3	334	546	--	--						
6/17	Spot Reading	1200	--	7.8	68	19.9	8.9	10.1	337	551	--	--			433	320		SCA
	24 Hr. Average	0000	2400	7.7	66	19.3	8.8	10.3	321	526	--	--						
6/18	High	1000	--	11.2	100	29.3	9.1	10.2	357	584	--	--			433	320		SCA + LEA
	Low	1200	1500	7.0	60	17.6	9.1	10.1	331	542	--	--			433	320		
	Average	0800	1500	8.8	77	22.6	8.9	10.2	338	554	--	--			433	320		
	24 Hr. Average	0000	2400	8.6	74	21.7	8.8	10.3	322	527								
6/19	High	0900	--	11.5	100	29.3	8.9	10.1	350	573	--	--			427	310		SCA + LEA
	Low	1100	1300	7.0	60	17.6	9.0	9.9	332	543	--	--			433	320		
	Average	0800	1500	8.8	77	22.6	9.2	9.7	329	539	--	--			432	318		
	24 Hr. Average	0000	2400	8.2	71	20.8	9.0	9.9	343	561								
6/20	High	0900	--	10.0	79	23.1	8.6	10.0	335	549	24	65			430	315		CO instrument back in service
	Low	1000	1500	7.5	65	19.0	8.8	10.1	337	551	18	48			420	322		SCA + LEA
	Average	0800	1500	7.9	68	19.9	8.8	10.1	336	550	20	53			434	321		
	24 Hr. Average	0000	2400	7.5	65	19.0	9.0	10.1	328	538	9	2						

* Corrected to 3% O_2.

(continued)

TABLE 3-3. (continued)

Date 1979	Load Condition	Time Start	Time Finish	Gener. MW	Nominal Steam Load K lb/hr	Nominal Steam Load MWTH	% O_2	% CO_2	NO* ng/J	NO* ppm	CO* ng/J	CO* ppm	Particulate ng/J	Particulate lb/MMB	Stack Temp. °K	Stack Temp. °F	Eff.%	Comments
6/21	High	1400	1500	17.0	149	43.7	7.8	11.4	459	751	<1	<1			455	360		SCA + LEA
	Low	1200	--	8.0	70	20.5	8.4	10.7	295	483	5	13			436	325		
	Average	0800	1500	12.2	102	29.9	8.6	10.7	368	602	3	9			424	330		
	24 Hr. Average	0000	2400	12.5	108	31.6	8.8	10.7	389	637	12	31						
6/22	Steady Load	0800	1500	7.5	65	19.0	8.7	10.5	400	655	14	37			420	297		LEA
	24 Hr. Average	0000	2400	7.4	64	18.8	8.6	10.5	399	653	16	44						
6/23	Spot Reading	1300	--	11.7	100	29.3	8.2	10.6	406	665	23	63			427	310		SCA + LEA
	24 Hr. Average	0000	2400	8.9	77	22.6	8.4	10.7	390	638	17	46						
6/24	Spot Reading	1300	--	8.0	70	20.5	8.5	10.7	340	557	7	20			436	325		SCA + LEA
	24 Hr. Average	0000	2400	8.0	69	20.2	8.7	10.7	349	571	16	43						
6/25	High	1500	1700	11.3	94	27.5	8.9	10.5	340	557	6	15			425	305		SCA + LEA
	Low	0800	--	8.5	70	20.5	9.1	10.2	341	558	33	88			427	310		
	Average	0800	1700	10.5	88	25.8	9.0	10.6	317	519	13	36			426	307		
	24 Hr. Average	0000	2400	9.2	79	23.1	8.9	10.4	346	566	19	50						
6/26	High	1000	1100	9.9	83	24.3	9.0	10.5	396	648	48	129			426	308		SCA + LEA
	Low	1200	1600	7.0	60	17.6	8.4	10.7	370	606	16	44			427	307		
	Average	0800	1600	8.2	70	20.5	8.7	10.6	382	625	27	72			425	305		
	24 Hr. Average	0000	2400	7.4	64	18.8	8.8	10.4	385	631	19	50						
6/27	High	1200	1300	10.2	87	25.5	8.6	12.4	394	645	16	43			426	307		Data logger out 1200-1400 SCA+LEA
	Low	1500	1600	8.1	68	19.9	8.5	14.2	395	647	14	37			430	315		
	Average	0800	1600	9.3	77	22.6	8.6	12.1	392	642	16	42			427	309		
	24 Hr. Average	0000	2400	8.0	69	20.2	8.6	12.7	374	613	15	39						
6/28	High	1000	--	10.8	90	26.4	8.2	10.9	404	661	13	34			426	307		SCA + LEA
	Low	1500	--	7.8	70	20.5	8.2	10.8	380	622	15	40			432	319		
	Average	0800	1600	9.2	77	22.6	8.3	10.7	373	611	15	40			429	312		
	24 Hr. Average	0000	2400	8.4	72	21.1	8.6	10.5	419	686	14	37						
6/29	High	1300	--	13.2	114	33.4	8.1	11.0	458	749	4	10			446	344		SCA + LEA
	Low	0700	--	6.6	54	15.8	8.7	10.3	521	853	34	92			430	314		
	Average	0700	1500	9.9	84	24.6	8.5	10.6	444	726	12	33			435	324		
	24 Hr. Average	0000	2400	7.9	68	19.9	8.5	10.4	446	730	18	48						

* Corrected to 3% O_2.

(continued)

TABLE 3-3. (continued)

Date 1979	Load Condition	Time Start	Time Finish	Gener. MW	Nominal Steam Load K lb/hr	Nominal Steam Load MWTH	% O_2	% CO_2	NO* ng/J	NO* ppm	CO* ng/J	CO* ppm	Particulate ng/J	Particulate lb/MMB	Stack Temp. °K	Stack Temp. °F	Eff.%	Comments
6/30	Spot Reading	1000	--	7.8	66	19.3	8.7	10.6	417	682	7	19			425	305		SCA + LEA
	24 Hr. Average	0000	2400	7.7	66	19.3	8.8	10.1	395	646	16	44						
7/1	Spot Reading	0800	--	6.2	50	14.7	9.2	9.8	398	651	8	22			425	305		SCA + LEA
	24 Hr. Average	0000	0800	7.0	60	17.6	9.2	9.6	397	649	19	52						Data logger out 0900-2400 No data taken
7/2	High	0900	1000	8.3	70	20.5	8.5	10.5	391	640	2	6			422	301		Data logger out 0000-1300 SCA + LEA No data taken
	Low	1600	--	7.8	66	19.3	8.3	10.7	364	595	8	22			421	298		
	Average	0800	1600	8.1	68	19.9	8.4	10.5	375	613	6	17			422	300		
	24 Hr. Average	1300	2400	7.5	65	19.0	8.4	10.6	365	598	11	29						
7/3	High	1500	--	24.9	223	65.3	8.0	11.0	521	853	4	10			461	370		SCA + LEA
	Low	1100	--	8.2	69	20.2	8.4	10.6	381	623	3	8			425	305		
	Average	0800	1500	15.1	136	39.8	8.4	10.7	421	689	6	16			440	333		
	24 Hr. Average	0000	2400	14.7	127	37.2	8.3	10.6	421	690	10	27						
7/4	Spot Reading	1100	--	8.6	73	21.4	8.5	10.5	375	613	5	13			418	293		SCA + LEA
	24 Hr. Average	0000	1800	7.9	68	19.9	8.6	10.2	373	611	18	48						Data logger out 1900-2400 No data taken
7/5	High	1100	--	11.8	101	29.6	9.1	9.8	469	768	3	9			445	341		SCA + LEA
	Low	1200	--	8.7	76	22.3	8.7	10.2	359	588	8	21			429	312		Data logger out 0000-0800
	Average	0900	1600	9.8	86	25.2	8.3	10.5	370	605	7	18			430	314		
	24 Hr. Average	0900	2400	8.2	71	20.8	8.3	10.4	346	566	7	19						
7/6	High	1200	--	12.3	100	29.3	8.3	10.6	332	544	7	19			427	310		SCA + LEA
	Low	0800	--	7.7	67	19.6	8.8	10.7	318	521	7	18			422	301		
	Average	0800	1500	10.2	88	25.8	8.5	10.5	328	537	197	23			425	305		
	24 Hr. Average	0000	2400	8.8	76	22.3	8.4	10.4	335	549	11	29						
7/7	Spot Reading	1100	--	8.3	74	21.7	8.5	10.3	352	576	17	47			422	301		SCA + LEA
	24 Hr. Average	0000	2400	7.5	65	19.0	8.5	10.2	337	552	19	50						
7/8	Spot Reading	1300	--	6.2	50	14.7	9.0	9.6	337	552	27	72			421	299		SCA +LEA
	24 Hr. Average	0000	1700	7.0	60	17.6	8.9	10.0	345	565	32	87						Data logger out 1700-2400

* Corrected to 3% O_2.

(continued)

TABLE 3-3. (continued)

Date 1979	Load Condition	Time Start	Time Finish	Gener. MW	Nominal Steam Load K lb/hr	Nominal Steam Load MWTH	% O_2	% CO_2	NO* ng/J	NO* ppm	CO* ng/J	CO* ppm	Particulate ng/J	Particulate lb/MMB	Stack Temp. °K	Stack Temp. °F	Eff.%	Comments
7/9	High	0900	--	9.8	73	21.4	8.3	10.7	340	557	33	89			429	312		SCA + LEA
	Low	1300	1600	7.1	59	17.3	8.5	10.5	315	516	41	111			425	306		Data logger out 0000-0700
	Average	0900	1600	7.6	62	18.2	8.5	10.5	327	536	36	96			426	308		
	24 Hr. Average	0800	2400	7.3	63	18.5	8.5	10.5	317	519	59	135						
7/10	High	1600	1900	21.3	189	55.4	8.3	10.7	504	825	38	101			464	375		
	Low	0800	--	7.7	67	19.6	8.6	10.5	360	589	35	93			426	308		Baseline
	Average	0800	1900	18.3	163	47.8	8.4	10.7	472	773	39	106			454	358		Unit #7 down 2100-2400
	Partic. Test 3-5	1100	1400	19.6	173	50.7	8.2	10.8	494	809	33	90	6.41	.0149	457	363	84.88	
	Partic. Test 3-6	1600	1900	21.3	189	55.4	8.3	10.7	504	825	38	101	4.27	.0099	464	375	84.47	Baseline, Meth. 5 Test
	24 Hr. Average	0000	2100	14.8	128	37.5	9.0	9.9	415	679	52	139						Baseline, Meth. 5 Test
7/11	High	1600	--	21.1	186	54.5	7.7	11.2	475	777	38	103			459	367		
	Low	1300	--	19.0	166	48.6	7.8	11.5	380	622	36	97			454	358		SCA + LEA
	Average	0900	1800	20.0	176	51.6	7.7	11.4	414	677	36	96			455	360		Unit #7 down 0000-0800
	Partic. Test 3-7	1000	1300	19.1	167	48.9	7.8	11.6	385	630	36	97	2.53	.0059	454	357	85.65	
	Partic. Test 3-8	1500	1800	20.8	185	54.2	7.8	11.2	458	749	36	97	3.20	.0074	459	366	85.14	Low NO_x condition, Meth. 5 Test
	24 Hr. Average	0800	2400	18.1	156	45.7	7.8	11.2	428	701	39	104						Low NO_x condition, Meth. 5 Test
7/12	High	0800	--	19.4	164	48.1	7.2	11.6	330	540	34	91			443	338		SCA + LEA
	Low	1200	--	19.0	168	49.2	7.7	11.3	375	614	36	96			454	358		
	Average	0800	1300	19.2	168	49.2	7.6	11.3	365	598	35	94			452	354		
	Partic. Test 3-9	1000	1300	19.1	170	49.8	7.7	11.2	370	606	35	95	3.24	.0075	454	358	85.34	
	24 Hr. Average	0000	1300	13.1	113	33.1	8.0	10.7	348	569	43	116						Low NO_x condition, Meth. 5 Test

* Corrected to 3% O_2.

TABLE 3-4. PARTICULATE DATA SUMMARY - SITE 3, PULVERIZED COAL FIRED BOILER

Test No.	Date 1979	Load MW	Load 10^3 lb/hr	O_2 %	Particulate ng/J	Particulate lb/10^6Btu	Opacity %	Test Description
3-1	6/7	49.2	168	7.4	12.77	0.0297	0	Low NOx
3-2	6/8	48.6	166	7.8	8.43	0.0196	0	Low NOx
3-3	6/12	48.0	164	7.4	7.75	0.0180	0	Low NOx-POM sample
3-4	6/14	63.0	215	8.2	7.82	0.0180	0	Baseline-POM sample
3-5	7/10	50.7	173	8.2	6.41	0.0149	0	Baseline
3-6	7/10	55.4	189	8.3	4.27	0.0099	0	Baseline
3-7	7/11	48.9	167	7.8	2.53	0.0059	0	Low NOx
3-8	7/11	54.2	185	7.8	3.20	0.0074	0	Low NOx
3-9	7/12	49.8	170	7.7	3.24	0.0075	0	Low NOx

These samples were analyzed by capillary-EI GC-MS utilizing a 30M SE-52 column with hydrogen as a carrier gas. All data were collected by single ion monitoring (SIM) to improve selectivity and sensitivity.

The results of the analyses are presented in µg per total sample. The quantitative detection limit was 0.5 µg; thus samples with POM's present at levels lower than this are reported as < 0.5 µg (the standard deviation at lower levels was prohibitively high for accurate quantitation). Samples reporting POM values of ND (none detected) are at a level of less than 0.1 µg (the approximate qualitative detection limit). The standard deviation on points around 0.5 µg averaged around ± 20%; at levels around 5 µg it averaged around ± 15%; and at levels above 12 µg the standard deviation averaged around ± 10%.

The results of the Battelle analyses are presented in Table 3-5 for the low-NOx and baseline operating conditions. The POM analyses for the low-NOx condition are presented in the first six columns for the XAD-2 module, the filter and probe wash, and total. The corresponding data for the unmodified condition are shown in the last six columns.

The total POM showed only a very small difference (about 3.5%) between the two conditions. The low-NOx condition resulted in a 40% lower phenanthrene measurement but showed a corresponding increase in benzofluoranthenes and perylene.

3.2.4 Boiler Efficiency

Boiler efficiency calculations were made for as-found and low-NOx operating conditions. The ASME Abbreviated Efficiency Test Method was used to determine the boiler efficiency. This test method is described in Appendix A.

Coal, fly ash, and bottom ash samples were collected during the test series. The coal and ash samples were submitted to an independent laboratory for ultimate and heating value analyses. Fly ash and bottom ash samples were analyzed for carbon content and heating value. The fly ash with the highest carbon content did not ignite in the colorimeter; therefore, the determination

TABLE 3-5. SUMMARY OF POM ANALYSES FOR SITE 3, PULVERIZED COAL FIRED BOILER

	LOW NO_x TEST						BASE LINE TEST					
	XAD-2 Module		Filter & Probe Wash		Total		XAD-2 Module		Filter & Probe Wash		Total	
PAH	µg	µg/m³	µg	µg/m³	µg	µg/m³	µg	µg/m³	µg	µg/m³	µg	µg/m³
Phenanthrene	39.0	25.81	1.1	0.73	40.1	26.54	87.4	42.84	2.9	1.42	90.3	44.26
Anthracene	3.0	1.98	ND	-	3.0	1.98	1.0	0.49	<0.5	<0.24	1.0<1.5	0.49<0.74
Methyl Anthracenes/Phenanthrenes	25.2	16.68	1.7	1.12	26.9	17.80	27.9	13.68	3.8	1.86	31.7	15.54
Fluoranthene	2.5	1.65	<0.5	<0.33	2.5<3.0	1.65<1.98	2.8	1.37	<0.5	<0.24	2.8<3.3	1.37<1.62
Pyrene	4.8	3.18	0.6	0.40	5.4	3.57	5.4	2.65	0.7	0.34	6.1	2.99
Methyl Pyrene/Fluoranthene	1.4	0.93	<0.5	<0.33	1.4<1.9	.93<1.26	1.4	0.69	<0.5	<0.24	1.4<1.9	0.69<0.93
Benzo(c)phenanthrene	ND	-	ND	-	ND	-	ND	-	ND	-	ND	-
Benz(a)anthracene	ND	-	ND	-	ND	-	ND	-	<0.5	<0.24	<0.5	<0.24
Chrysene	ND	-	<0.5	<0.33	<0.5	<0.33	<0.5	<0.24	<0.5	<0.24	<1.0	<0.49
Methyl Chrysenes	ND	-	<0.5	<0.33	<0.5	<0.33	ND	-	<0.5	<0.24	<0.5	<0.24
Dimethylbenzanthracenes	<0.5	<0.33	ND	-	<0.5	<0.33	ND	-	ND	-	ND	-
Benzofluoranthenes	10.9	7.21	<0.5	<0.33	10.9<11.4	7.21<7.54	1.2	0.59	<0.5	<0.24	1.2<1.7	0.59<0.83
Benz(e)pyrene	1.5	0.99	<0.5	<0.33	1.5<2.0	0.99<1.32	0.9	0.44	<0.5	<0.24	0.9<1.4	0.44<0.69
Benz(a)pyrene	<0.5	<0.33	ND	-	<0.5	<0.33	1.0	0.49	ND	-	1.0	0.49
Perylene	5.9	3.90	<0.5	<0.33	5.9<6.4	3.90<4.24	<0.5	<0.24	<0.5	<0.24	<1.0	<0.49
Indeno-pyrene	ND	-	ND	-	ND	-	<0.5	<0.24	<0.5	<0.24	<1.0	<0.49
Benzo(ghi)perylene	ND	-	<0.5	<0.33	<0.5	<0.33	<0.5	<0.24	<0.5	<0.24	<1.0	<0.49
3-Methylcholanthrene	ND	-	ND	-	ND	-	ND	-	ND	-	ND	-
Dibenzanthracenes	ND	-	ND	-	ND	-	ND	-	ND	-	ND	-
Dibenzpyrenes	ND	-	ND	-	ND	-	ND	-	ND	-	ND	-
Coronene	ND	-	<0.5	<0.33	<0.5	<0.33	ND	-	<0.5	<0.24	<0.5	<0.24
TOTAL (µg/m³)		62.3<62.9		2.3<4.9		64.6<67.8		63.2<64.2		3.6<6.5		66.8<70.7
Sample Volume (m³)				1.511						2.040		

of the heat of combustion was not attempted on the remaining fly ash sample with the lower carbon content. The results of the coal, fly ash, and bottom ash analyses are tabulated in Table 3-6. Tabulated chronologically, the data indicate that the ash content of the coal changed from 14.95% to 7.36% during the test series.

Table 3-7 lists a summary of the boiler efficiencies. The data in this table show that during low-NOx operation with low excess air, an efficiency increase of about 1% was achieved, with the primary contribution due to dry gas losses.

Figure 3-1 shows unit efficiency as a function of excess oxygen for the boiler. This figure clearly illustrates the effect of low-NOx operation on boiler efficiency.

3.2.5 Data Reduction

The gaseous emissions data measured by the analyzers were recorded on both strip chart recorders and an automatic data logger. A log of all appropriate control room data was also kept. Daily steam flow charts were also collected from the operators.

A tabulation of hourly averages was compiled for the entire test period. Each hourly average consists of approximately 900 measurements from each analyzer. After the data were compiled, they were spot checked and edited to detect obvious errors and anomalies. The data were then keypunched on cards for input to the computer. Table 3-8 is an example of the listing of hourly averages. The entire listing of hourly averages is presented in Appendix E.

After data editing was completed, 24-hour averages were calculated. For an average to be valid, at least 75 percent of the hourly points in that interval had to be valid. Table 3-9 shows a summary of the 24-hour averages for the 30-day test at Site 3.

A statistical summary was prepared to determine the following parameters for the 24-hour averages: mean, standard deviation, maximum, minimum, range, and average deviation. These parameters were calculated assuming the data were normally distributed. When the data were plotted on normal probability paper it was apparent that the data were not normally distributed.

TABLE 3-6. SUMMARY OF COAL AND ASH ANALYSIS FROM SITE 3

Coal	Test 3-1 3-2 3-3 3-4	Test 3-5 3-6 3-7 3-8 3-9
Ultimate Analysis:		
Moisture, percent	5.6	10.67
Carbon, percent	57.40	59.55
Hydrogen, percent	4.31	4.15
Nitrogen, percent	1.25	1.03
Sulfur, percent	0.73	0.30
Ash, percent	14.95	7.36
Oxygen, percent (by difference)	15.76	16.94
Heat of Combustion:		
Gross Btu/lb	10,160	10,910
Net Btu/lb	9,760	10,520
Ash		
Fly Ash:		
Carbon, percent	1.76	1.72
Bottom Ash:		
Carbon, percent	11.72	11.72
Gross Btu/lb	1,800	1,800
Net Btu/lb	1,750	1,750

TABLE 3-7. SUMMARY OF BOILER EFFICIENCY CALCULATIONS FOR SITE 3
PULVERIZED COAL FIRED BOILER

Test Number Date	3-1 6-7-79	3-2 6-8-79	3-3 6-12-79	3-4 6-14-79	3-5 7-10-79	3-6 7-10-79	3-7 7-11-79	3-8 7-11-79	3-9 7-12-79
Test Load									
10^3 lb/hr	168	166	164	215	173	189	167	185	170
Generator MW	19.0	19.0	19.0	24.0	19.6	21.3	19.1	20.8	19.1
Percent of Capacity	65	64	63	83	67	73	64	71	65
Stack O_2, percent	7.4	7.8	7.4	8.2	8.2	8.3	7.8	7.8	7.7
Stack CO, ppm	42	60	--	--	90	101	97	97	95
Stack Temperature (°K/°F)	449/349	447/345	446/344	461/371	457/363	464/375	454/357	459/366	454/358
Ambient Temperature (°K/°F)	294/70	294/70	294/70	294/70	294/70	294/70	294/70	294/70	294/70
Boiler Heat Losses									
Dry Gas	7.57	8.57	8.18	9.39	8.85	9.30	8.11	8.64	8.41
Moisture in Fuel	0.65	0.65	0.65	0.67	1.16	1.17	1.16	1.16	1.16
Moisture from H_2	4.47	4.50	4.50	4.63	4.06	4.08	4.05	4.07	4.05
Combustibles	1.06	1.06	1.06	1.06	0.49	0.49	0.49	0.49	0.49
Radiation	0.55	0.55	0.55	0.40	0.55	0.50	0.55	0.50	0.55
Total Losses	14.30	15.33	14.94	16.15	15.12	15.53	14.35	14.86	14.66
Boiler Efficiency, percent	85.70	84.67	85.06	83.85	84.88	84.47	85.65	85.14	85.34

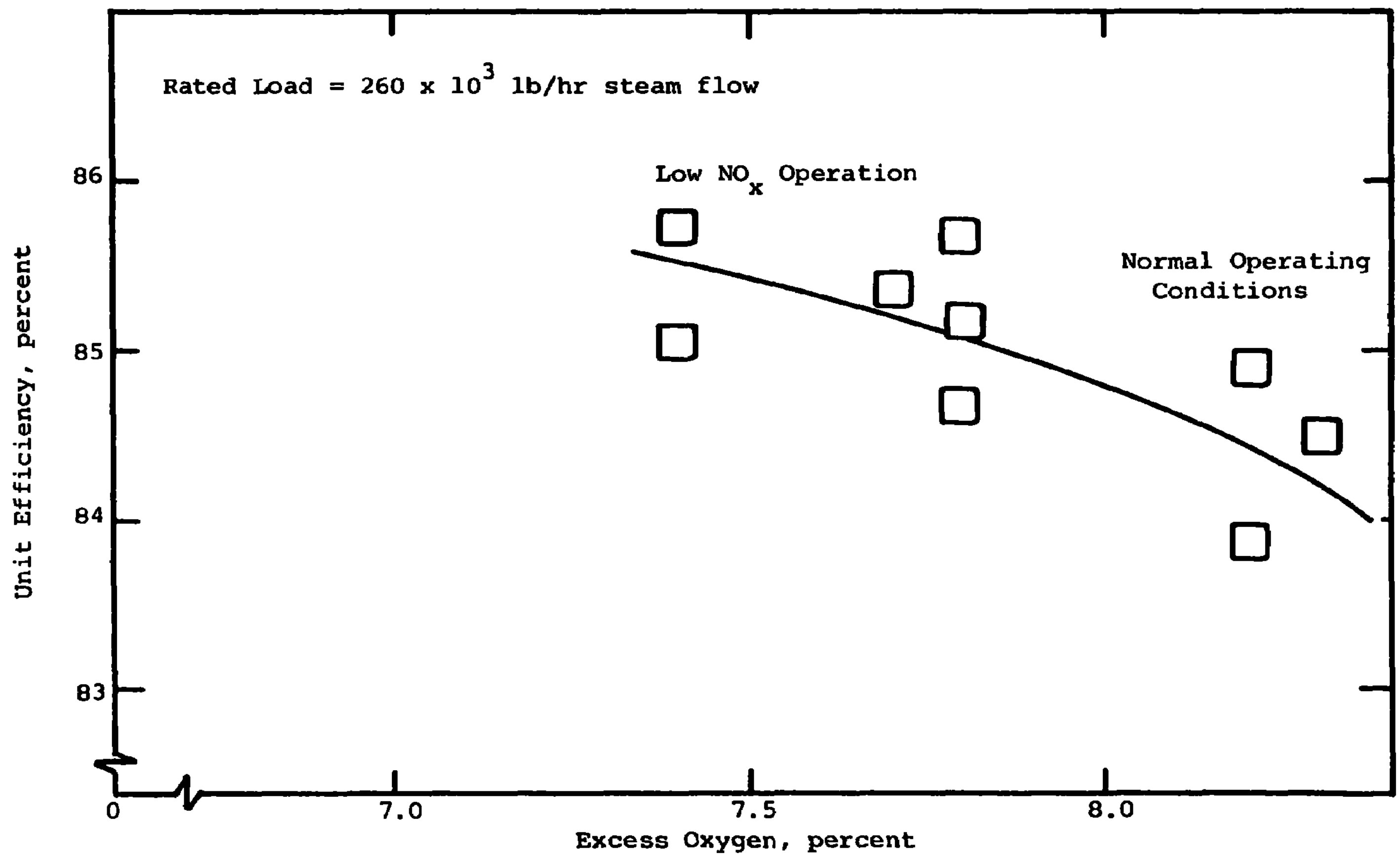


Figure 3-1. Boiler Efficiency vs Excess O_2. Pulverized Coal Fired Boiler, Site 3.

TABLE 3-8. FORMAT OF HOURLY EMISSIONS DATA FOR SITE 3, PULVERIZED COAL FIRED BOILER

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CH PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/ 2/79	100	39.8	7.4	11.0	19.	501.	25.	665.	9.	390.
6/ 2/79	200	17.6	8.5	9.9	18.	428.	27.	618.	9.	363.
6/ 2/79	300	15.2	9.4	9.9	17.	417.	26.	650.	9.	381.
6/ 2/79	400	15.2	9.5	.0	15.	418.	23.	656.	8.	385.
6/ 2/79	500	15.8	9.6	.0	15.	414.	24.	655.	8.	385.
6/ 2/79	600	15.8	9.6	.0	13.	415.	21.	658.	8.	386.
6/ 2/79	700	15.8	9.2	.0	13.	416.	19.	636.	7.	373.
6/ 2/79	800	16.4	8.9	.0	12.	413.	18.	616.	7.	361.
6/ 2/79	900	16.4	9.1	.0	13.	430.	20.	652.	7.	383.
6/ 2/79	1000	15.8	9.2	.0	16.	443.	24.	678.	9.	398.
6/ 2/79	1100	15.8	9.4	.0	15.	454.	24.	707.	8.	415.
6/ 2/79	1200	20.2	9.5	.0	22.	445.	35.	699.	13.	411.
6/ 2/79	1300	15.2	9.1	.0	23.	455.	35.	690.	12.	405.
6/ 2/79	1400	14.4	8.2	.0	24.	461.	35.	649.	12.	381.
6/ 2/79	1500	14.1	.0	13.3	19.	465.	16.	398.	6.	234.
6/ 2/79	1600	14.6	8.1	.0	25.	446.	34.	624.	12.	366.
6/ 2/79	1700	14.1	7.4	.0	27.	453.	36.	600.	13.	352.
6/ 2/79	1800	14.1	7.4	.0	27.	455.	36.	603.	13.	354.
6/ 2/79	1900	14.1	7.0	.0	28.	458.	36.	590.	13.	346.
6/ 2/79	2000	36.9	6.4	.0	28.	510.	35.	630.	13.	370.
6/ 2/79	2100	55.1	6.1	.0	29.	597.	35.	722.	12.	424.
6/ 2/79	2200	35.2	6.5	.0	28.	534.	35.	664.	13.	390.
6/ 2/79	2300	14.1	7.2	.0	29.	453.	38.	592.	14.	347.
6/ 2/79	2400	14.1	7.4	.0	25.	437.	33.	579.	12.	340.

TABLE 3-9. SUMMARY OF 24-HOUR AVERAGES OF STACK EMISSIONS FROM A PULVERIZED-COAL-FIRED BOILER (SITE 3)

24 HOUR DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/ 1/79		55.4	6.6	11.3	28.	529.	35.	662.	12.	389.
6/ 2/79		19.8	8.3	11.0	21.	455.	30.	644.	11.	378.
6/ 3/79		14.4	9.0	.0	16.	392.	24.	588.	9.	345.
6/ 4/79		34.7	8.5	.0	18.	389.	26.	559.	9.	328.
6/ 5/79		19.7	9.5	10.3	20.	309.	32.	485.	11.	285.
6/ 6/79		22.6	8.1	10.4	21.	366.	30.	514.	11.	302.
6/ 7/79		29.4	8.3	10.8	31.	383.	44.	544.	16.	320.
6/ 8/79		30.3	8.1	10.5	28.	410.	40.	572.	14.	336.
6/ 9/79		19.9	8.4	10.1	27.	406.	38.	581.	14.	341.
6/10/79		16.4	8.6	10.0	33.	396.	48.	576.	17.	338.
6/11/79		18.6	8.5	10.3	38.	388.	55.	561.	20.	329.
6/12/79		30.5	8.8	10.4	0.	408.	0.	602.	0.	353.
6/13/79		23.3	9.0	10.6	0.	397.	0.	599.	0.	352.
6/14/79		38.6	8.5	10.5	49.	444.	71.	641.	25.	376.
6/15/79		18.3	9.2	10.2	86.	324.	131.	495.	47.	291.
6/16/79		21.8	9.1	10.2	0.	364.	0.	551.	0.	323.
6/17/79		19.4	8.8	10.3	0.	356.	0.	526.	0.	309.
6/18/79		21.7	8.8	10.3	0.	357.	0.	530.	0.	311.
6/19/79		20.7	8.9	10.0	35.	358.	52.	532.	19.	312.
6/20/79		18.9	9.0	10.0	33.	361.	50.	544.	18.	319.
6/21/79		31.7	8.8	10.7	21.	431.	31.	637.	11.	374.
6/22/79		18.8	8.6	10.5	35.	450.	51.	656.	18.	385.
6/23/79		22.6	8.4	10.6	36.	449.	52.	641.	18.	377.
6/24/79		20.3	8.6	10.2	34.	395.	50.	577.	16.	339.
6/25/79		23.1	9.0	10.2	36.	410.	54.	616.	19.	361.
6/26/79		18.8	8.9	10.3	37.	427.	55.	639.	20.	375.
6/27/79		20.2	8.6	10.3	15.	426.	22.	620.	8.	364.
6/28/79		21.0	8.6	10.5	25.	473.	37.	686.	13.	403.
6/29/79		19.8	8.5	10.4	34.	504.	48.	728.	17.	427.
6/30/79		19.2	8.8	10.2	30.	438.	44.	647.	16.	380.
7/ 1/79		17.6	8.8	9.9	33.	455.	48.	673.	17.	395.
7/ 2/79		18.9	8.5	10.3	33.	436.	47.	629.	17.	369.
7/ 3/79		37.2	8.3	10.6	19.	487.	28.	694.	10.	407.
7/ 4/79		19.8	8.6	10.3	35.	424.	51.	618.	18.	363.
7/ 5/79		20.7	8.5	10.3	15.	416.	21.	599.	7.	352.
7/ 6/79		22.3	8.4	10.3	21.	385.	30.	550.	11.	323.
7/ 7/79		19.1	8.5	10.2	35.	384.	50.	556.	18.	326.
7/ 8/79		17.7	8.7	9.9	47.	351.	69.	514.	25.	302.
7/ 9/79		18.4	8.4	10.3	80.	366.	115.	526.	41.	309.
7/10/79		37.6	9.0	9.9	92.	453.	139.	681.	50.	400.
7/11/79		45.6	7.8	11.2	75.	519.	102.	708.	37.	416.
7/12/79		33.0	8.0	10.6	84.	407.	117.	566.	42.	332.

Further analysis indicated that the data were log-normally distributed. The graph shown in Figure 3-2 illustrates the performance of the pulverized-coal-fired boiler based on the 24-hour averages for all data. The mean NO emission rate is 340 ng/J with a geometric dispersion of 1.13. The data presented in this figure represent 42 24-hour averages. A frequency chart of the hourly averages is presented as Table 3-10. These data were then used to prepare the graph shown as Figure 3-2. The data were subsequently divided into two load ranges to determine the effect boiler load has on the distribution. Table 3-11 presents a frequency distribution of NO_x emissions for boiler load less than 20 MW thermal output and for greater than 20 MW. The data for less than 20 MW are plotted in Figure 3-3. This curve shows the mean value is 340 ng/J with a dispersion of 1.13. The data for greater than 20 MW are presented in Figure 3-4 where the mean value is 350 ng/J with a dispersion of 1.10. These data show that 99% of the data are less than 430 ng/J for boiler loads greater than 20 MW and 460 ng/J for loads less than 20 MW.

The 24-hour average NO_x emissions data were plotted as a function of time from the start of testing. These data are presented in Figure 3-5. Solid symbols indicate steam loads greater than 20 MW thermal output and open symbols indicate steam loads less than 20 MW. This figure illustrates the variation in NO_x emissions measurements for this unit. Figure 3-6 shows the daily average excess O_2 as a function of time from the start of testing. As this illustrates the excess O_2 did not vary greatly over the test period. These measurements were made in the stack downstream of the baghouse. A measurement of stack gas O_2 was made at the boiler outlet for comparison purposes. The excess O_2 measured at the boiler outlet was 4.2% compared with 8.5% O_2 after the baghouse.

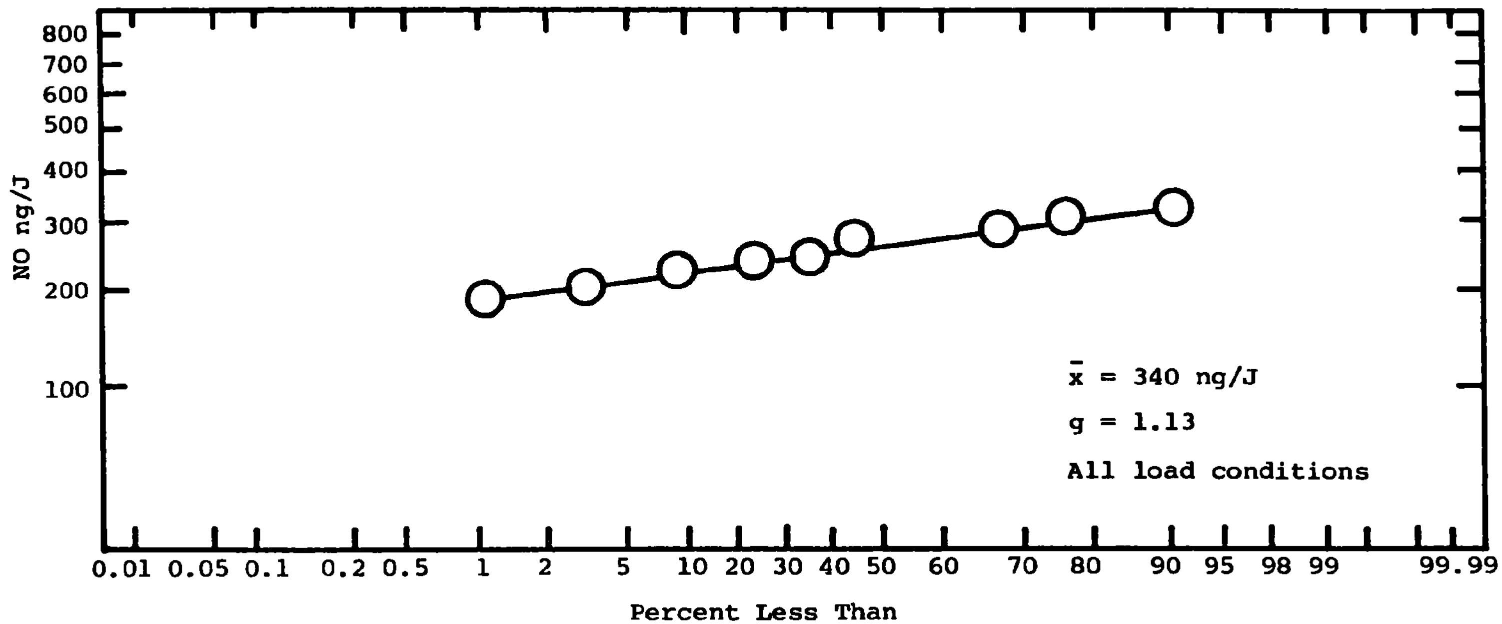


Figure 3-2. NO Emissions from Site 3 - Pulverized Coal-Fired Boiler

TABLE 3-10. NO EMISSION - FREQUENCY DATA
SITE 3 - PULVERIZED COAL-FIRED BOILER

Call	Frequency	Cum. Frequency	Plot Percent
280-295	2	2	5
296-310	4	6	14
311-325	6	12	28
326-340	7	19	44
341-355	5	24	56
356-370	4	28	65
371-385	7	35	81
386-400	3	38	88
401-415	2	40	93
416-430	2	42	98

$\bar{x}$ = 340 ng/J

g.d = 1.13

TABLE 3-11. NO EMISSION-FREQUENCY DATA FOR
SITE 3 - PULVERIZED-COAL-FIRED BOILER

Load <20 MW			
Cell	Frequency	Cum. Frequency	Percent Plot
285-294	2	2	10
295-304	1	3	15
305-314	2	5	25
315-324	1	6	30
325-334	2	8	40
335-344	2	10	50
345-354	1	11	55
355-364	1	12	60
365-374	1	13	65
375-384	3	16	80
385-394	1	17	85
395-404	1	18	90
405-414	0	-	-
415-424	0	-	-
425-434	1	19	95

Load ≥20 MW			
Cell	Frequency	Cum. Frequency	Percent Plot
301-310	1	1	4
311-320	3	4	17
321-330	3	7	29
331-340	3	10	42
341-350	0	10	42
351-360	3	13	54
361-370	2	15	62
371-380	3	18	75
381-390	1	19	79
391-400	1	20	83
401-410	2	22	92
411-420	1	23	96

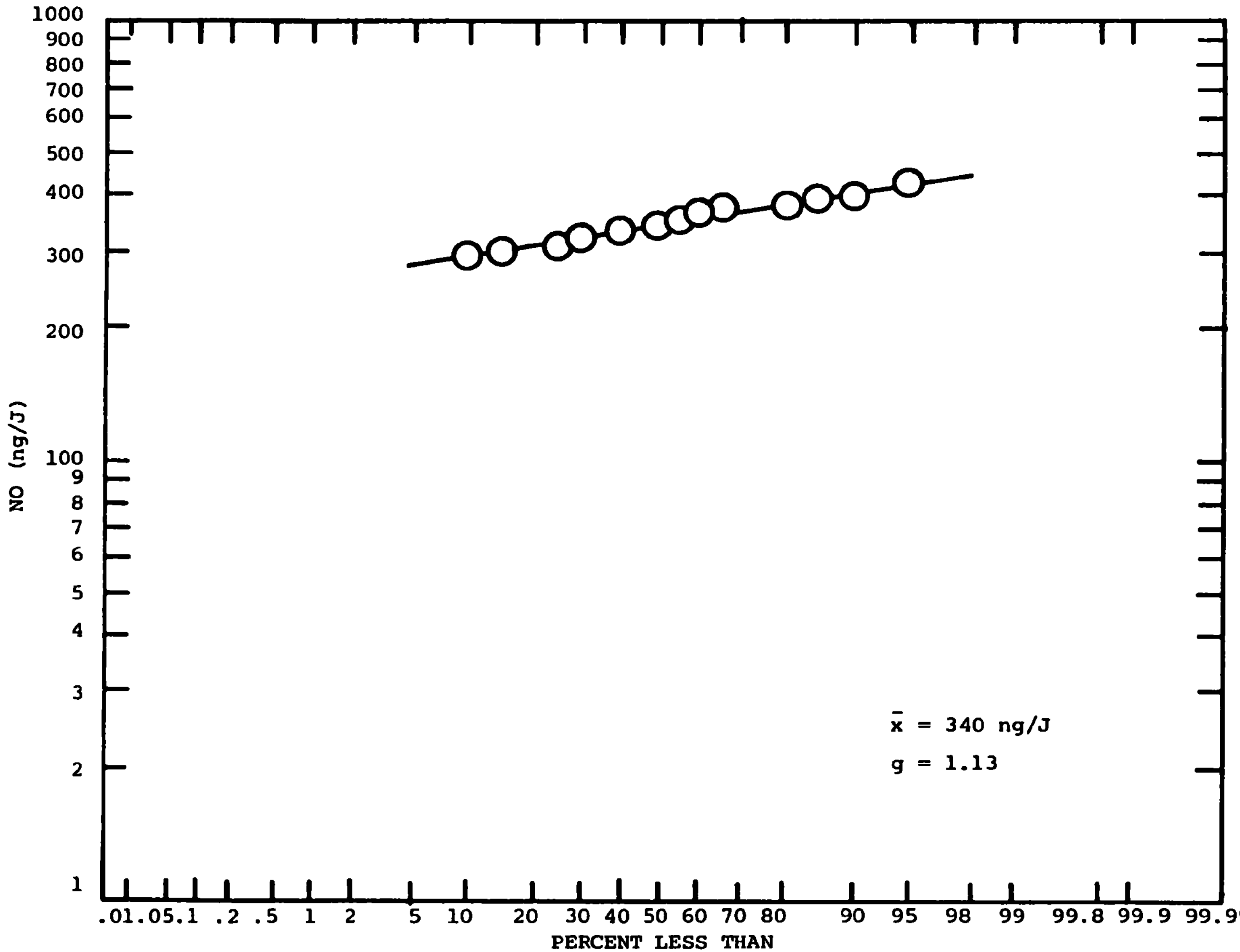


Figure 3-3. NO Emissions from Site 3, a Pulverized Coal Fired Boiler
Boiler Load <20 MW

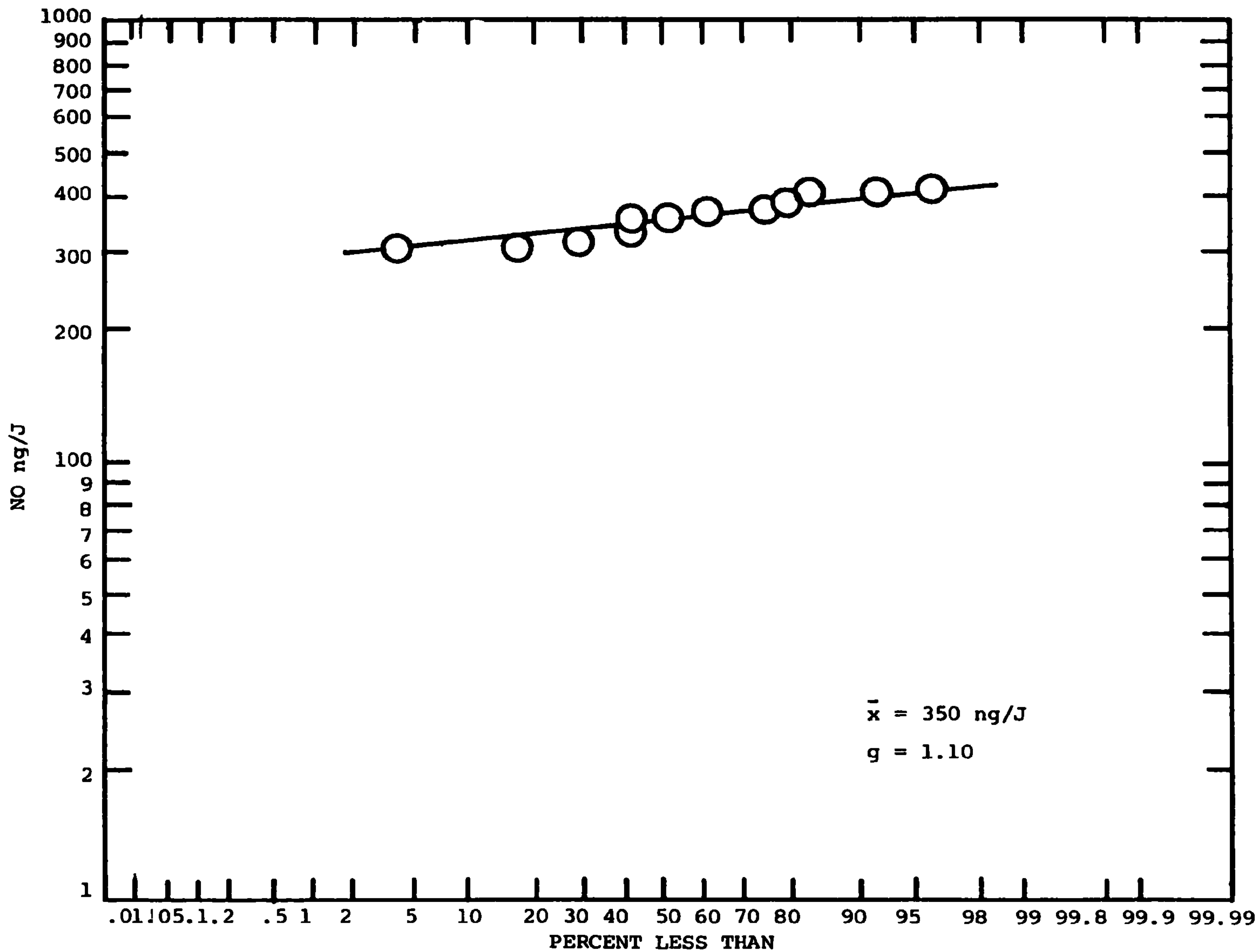


Figure 3-4. NO Emissions from Site 3, a Pulverized Coal Fired Boiler
Boiler Load ≥20 MW

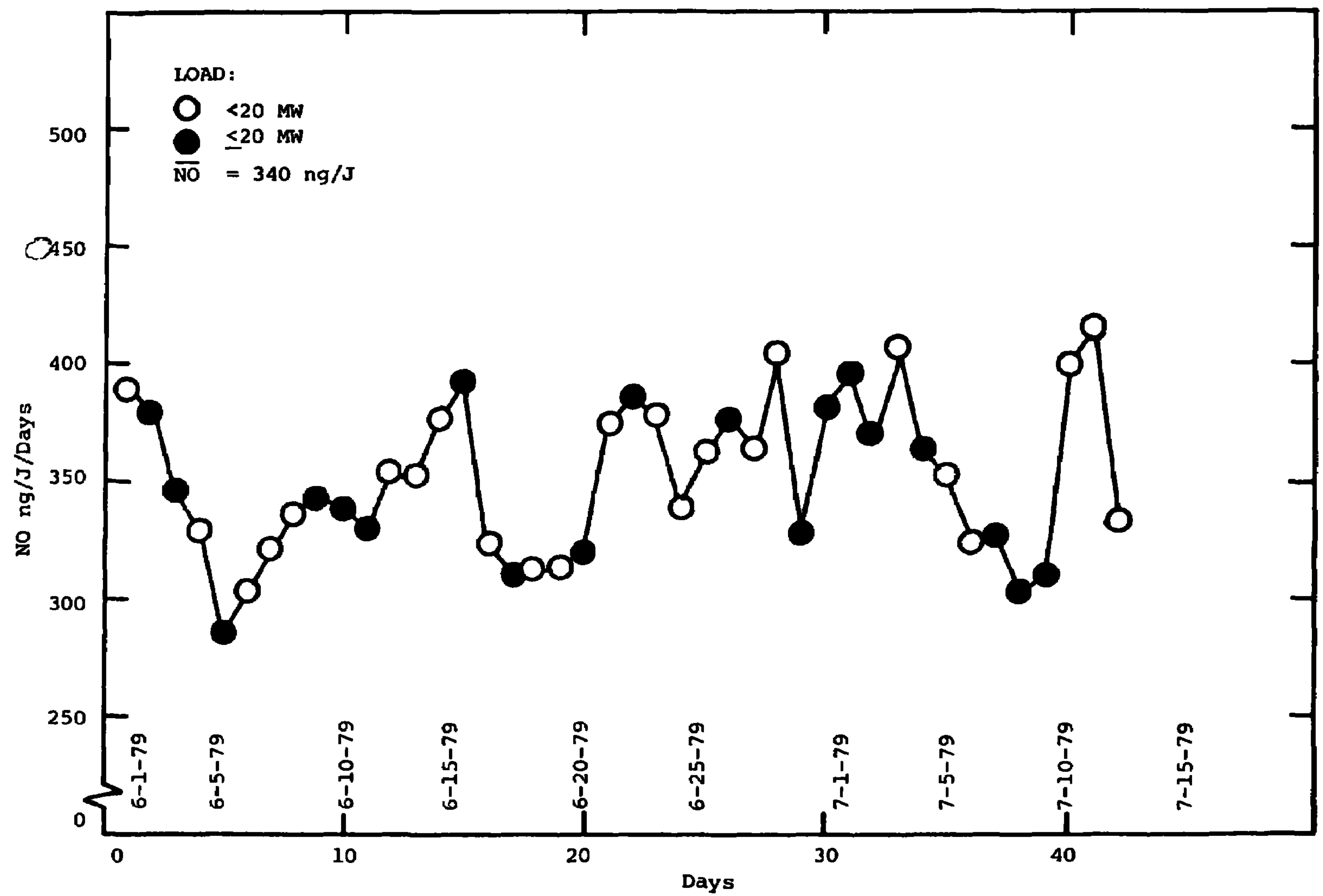


Figure 3-5. Daily average NO_x emissions for Site 3 - Pulverized coal fired boiler

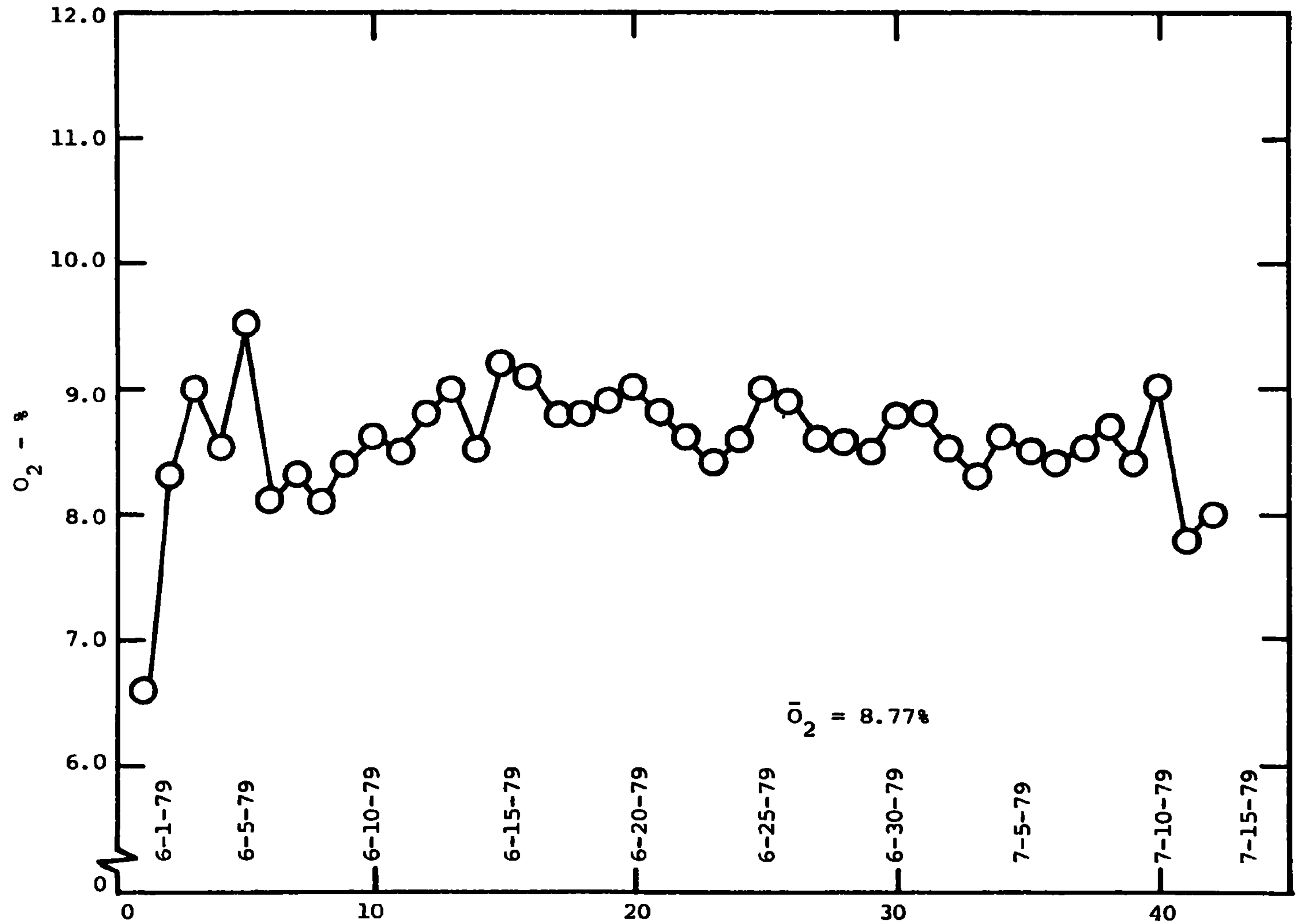


Figure 3-6. Daily average O_2 measurements for Site 3. Pulverized coal fired boiler.

Emission factors for the pulverized-coal-fired boiler were calculated using the procedure set forth in 40 CFR 60, Subpart D. The NO emission factor (dry basis) was calculated using the following equation:

$$E = C_d F_d \frac{20.9}{20.9 - \% O_{2_d}}$$

where

E = pollutant emission rate, ng/J (lb/million Btu)

C_d = NO concentration, ng/scm (lb/scf)

F_d = stoichiometric conversion factor, 2.63×10^{-7} dscm/J (9,780 dscf/million Btu), for bituminous coal

O_{2_d} = oxygen concentration, percent by volume, dry

The conversion of measured No values (ppmV) to ng/scm is made by multiplying by 1.912×10^{6}. To convert from ppm to lb/scf, multiply by 1.19×10^{-7}.

NO_x emissions are measured as NO and the NO_x emission rates reported herein are calculated based on the molecular weight of NO_2.

SECTION 4.0

REFERENCES

1. Maloney, K. L. et al., "Systems Evaluation of the Use of Low-Sulfur Western Coal in Existing Small and Intermediate-Sized Boilers," EPA Contract No. 68-02-1863, EPA 600/7-78-153a.

2. Cato, G. A. et al., "Field Testing: Application of Combustion Modifications to Control Pollutant Emissions from Industrial Boilers - Phase I," EPA 650/2-74-078a, NTIS No. PB 238 920, June 1975.

3. Cato, G. A. et al., "Field Testing: Application of Combustion Modifications to Control Pollutant Emissions from Industrial Boilers - Phase II, "EPA 600-2-76-086a, NTIS No. PB 253 500, April 1976.

4. Devitt, T. et al., "Population and Characterization of Industrial/ Commercial Boilers in the U.S.," EPA-600/7-79-178a, August 1979.

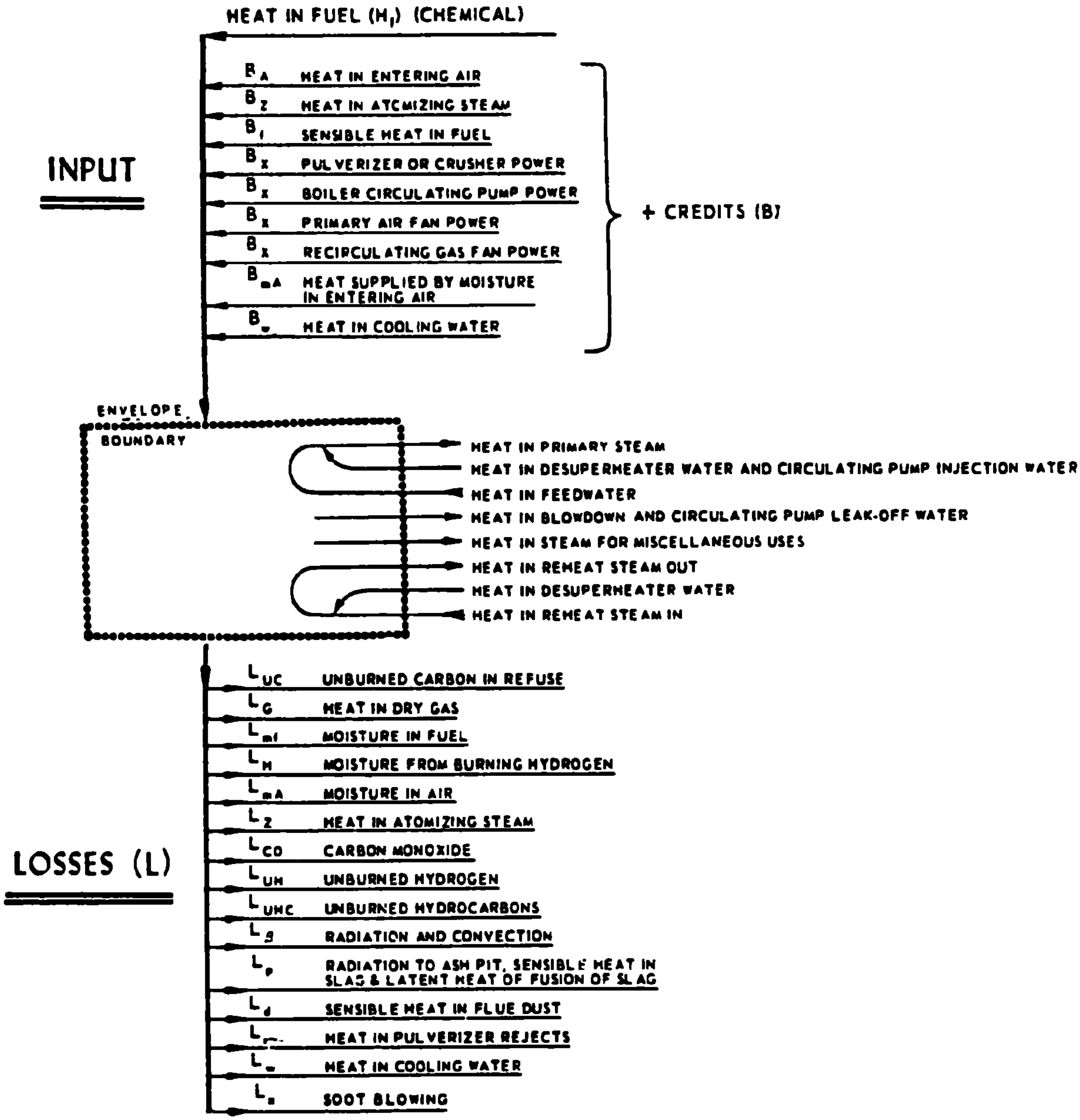
APPENDIX A

EFFICIENCY MEASUREMENTS

EFFICIENCY

Unit efficiencies for boilers are calculated and reported according to the ASME Power Test Codes for Steam Generation Units, PTC 4.1-1965. These codes present instructions for two acceptable methods of determining thermal efficiency. One method is the direct measurement of input and output and requires the accurate measurement of the quantity and high-heating value of the fuel, heat credits, and the heat absorbed by the working fluids. The second method involves the direct measurements of heat losses and is referred to as the heat loss method. This method requires the determination of losses, heat credits, and ultimate analysis and high-heat value of the fuel. Some of the major heat losses include losses due to heat in dry flue gas, losses due to fuel moisture content, losses due to combustible material in refuse and flue gas, and radiation losses. Heat credits are defined as those amounts added to the process in forms other than the chemical heat in the fuel "as fired." These include quantities such as sensible heat in the fuel, heat in the combustion air, and heat from power conversion in a pulverizer or fan. The relationships between input, output, credits, and losses for a steam generator are illustrated in Figure A-1.

KVB's experience has shown the heat-loss efficiency determination method to be the most reliable when working with industrial boilers. Accurate fuel input measurements are rarely possible on industrial boilers due to the lack of adequate instrumentation, thus making the input-output method undesirable. The accuracy of the efficiency based on the heat loss method is determined primarily by the accuracy of the flue gas temperature measurement immediately following the last heat removal station, the stack gas excess O_2 level, the fuel analysis, the ambient temperature, and proper identification of the combustion device external surfaces (for radiation losses). Determination of the radiation and other associated losses may appear to be a rather imposing calculation, but in practice it can be accomplished by utilizing standard efficiency calculation procedures. Inaccuracies in determining efficiency occasionally occur even with the heat



OUTPUT = INPUT − LOSSES

DEFINITION: EFFICIENCY (PERCENT) $= \eta_g (\%) = \frac{\text{OUTPUT}}{\text{INPUT}} \times 100 = \frac{\text{INPUT} - L}{H_f + B} \times 100$

HEAT BALANCE: $H_f + B = \text{OUTPUT} + L$ OR $\eta_g (\%) = \left[1 - \frac{L}{H_f + B}\right] \times 100$

Figure A-1. Heat balance of steam generator.

loss method primarily because of out-of-calibration unit instrumentation such as the stack gas exit temperature. However, this problem has been resolved by KVB test engineers through the use of portable instrumentation and separate temperature readings.

The abbreviated efficiency test procedure which considers only the major losses and the chemical heat in the fuel as input will be followed. Tables A-1 and A-2 are the ASME Test Forms for Abbreviated Efficiency Tests on steam generators which exemplify the type of forms to be used for recording the necessary data and performing the required calculations.

KVB has developed a program for the HP-67 calculator which will provide the heat loss efficiency from the stack data. Figure A-2 shows the HP-67 keyed calculation sheet for calculating efficiency by the ASME Heat Loss Method.

TABLE A-1

ASME TEST FORM
FOR ABBREVIATED EFFICIENCY TEST

SUMMARY SHEET — PTC 4.1-a (1964)

TEST NO.	BOILER NO	DATE
OWNER OF PLANT	LOCATION	
TEST CONDUCTED BY	OBJECTIVE OF TEST	DURATION
BOILER MAKE & TYPE	RATED CAPACITY	
STOKER TYPE & SIZE		
PULVERIZER, TYPE & SIZE	BURNER, TYPE & SIZE	
FUEL USED	MINE	COUNTY
STATE	SIZE AS FIRED	

PRESSURES & TEMPERATURES

1	STEAM PRESSURE IN BOILER DRUM	psia	
2	STEAM PRESSURE AT S. H. OUTLET	psia	
3	STEAM PRESSURE AT R. H. INLET	psia	
4	STEAM PRESSURE AT R. H. OUTLET	psia	
5	STEAM TEMPERATURE AT S. H. OUTLET	F	
6	STEAM TEMPERATURE AT R. H. INLET	F	
7	STEAM TEMPERATURE AT R. H. OUTLET	F	
8	WATER TEMP. ENTERING (ECON.)(BOILER)	F	
9	STEAM QUALITY % MOISTURE OR P.P.M.		
10	AIR TEMP. AROUND BOILER (AMBIENT)	F	
11	TEMP AIR FOR COMBUSTION (This is Reference Temperature) †	F	
12	TEMPERATURE OF FUEL	F	
13	GAS TEMP. LEAVING (Boiler) (Econ.) (Air Htr.)	F	
14	GAS TEMP. ENTERING AH (If conditions to be corrected to guarantee)	F	

UNIT QUANTITIES

15	ENTHALPY OF SAT. LIQUID (TOTAL HEAT)	Btu/lb	
16	ENTHALPY OF (SATURATED)(SUPERHEATED) STM	Btu/lb	
17	ENTHALPY OF SAT. FEED TO (BOILER) (ECON.)	Btu/lb	
18	ENTHALPY OF REHEATED STEAM R.H. INLET	Btu/lb	
19	ENTHALPY OF REHEATED STEAM R. H. OUTLET	Btu/lb	
20	HEAT ABS/LB OF STEAM (ITEM 16 – ITEM 17)	Btu/lb	
21	HEAT ABS/LB R.H. STEAM (ITEM 19 – ITEM 18)	Btu/lb	
22	DRY REFUSE (ASH PIT + FLY ASH) PER LB AS FIRED FUEL	lb/lb	
23	Btu PER LB IN REFUSE (WEIGHTED AVERAGE)	Btu/lb	
24	CARBON BURNED PER LB AS FIRED FUEL	lb/lb	
25	DRY GAS PER LB AS FIRED FUEL BURNED	lb/lb	

HOURLY QUANTITIES

26	ACTUAL WATER EVAPORATED	lb/hr	
27	REHEAT STEAM FLOW	lb/hr	
28	RATE OF FUEL FIRING (AS FIRED wt)	lb/hr	
29	TOTAL HEAT INPUT $\frac{\text{Item 28} \times \text{Item 41}}{1000}$	kB/hr	
30	HEAT OUTPUT IN BLOW-DOWN WATER	kB/hr	
31	TOTAL HEAT OUTPUT $\frac{(\text{Item 26} \times \text{Item 20}) + (\text{Item 27} \times \text{Item 21}) + \text{Item 30}}{1000}$	kB/hr	

FLUE GAS ANAL. (BOILER)(ECON)(AIR HTR) OUTLET

32	CO_2	% VOL	
33	O_2	% VOL	
34	CO	% VOL	
35	N_2 (BY DIFFERENCE)	% VOL	
36	EXCESS AIR	%	

FUEL DATA

	COAL AS FIRED PROX. ANALYSIS	% wt
37	MOISTURE	
38	VOL MATTER	
39	FIXED CARBON	
40	ASH	
	TOTAL	
41	Btu per lb AS FIRED	
42	ASH SOFT TEMP.* ASTM METHOD	

	COAL OR OIL AS FIRED ULTIMATE ANALYSIS	
43	CARBON	
44	HYDROGEN	
45	OXYGEN	
46	NITROGEN	
47	SULPHUR	
40	ASH	
37	MOISTURE	
	TOTAL	

	COAL PULVERIZATION	
48	GRINDABILITY INDEX*	
49	FINENESS % THRU 50 M*	
50	FINENESS % THRU 200 M*	

	OIL	
51	FLASH POINT F*	
52	Sp. Gravity Deg. API*	
53	VISCOSITY AT SSU* BURNER SSF	
44	TOTAL HYDROGEN % wt	
41	Btu per lb	

	GAS	% VOL
54	CO	
55	CH_4 METHANE	
56	C_2H_2 ACETYLENE	
57	C_2H_4 ETHYLENE	
58	C_2H_6 ETHANE	
59	H_2S	
60	CO_2	
61	H_2 HYDROGEN	
	TOTAL	
	TOTAL HYDROGEN % wt	
62	DENSITY 68 F ATM PRESS.	
63	Btu PER CU FT	
41	Btu PER LB	

64	INPUT-OUTPUT EFFICIENCY OF UNIT %	$\frac{\text{ITEM 31} \times 100}{\text{ITEM 29}}$

	HEAT LOSS EFFICIENCY	Btu/lb A. F. FUEL	% of A. F. FUEL
65	HEAT LOSS DUE TO DRY GAS		
66	HEAT LOSS DUE TO MOISTURE IN FUEL		
67	HEAT LOSS DUE TO H_2O FROM COMB. OF H_2		
68	HEAT LOSS DUE TO COMBUST. IN REFUSE		
69	HEAT LOSS DUE TO RADIATION		
70	UNMEASURED LOSSES		
71	TOTAL		
72	EFFICIENCY = (100 – Item 71)		

* Not Required for Efficiency Testing

† For Point of Measurement See Par. 7.2.8.1-PTC 4.1-1964

ASME TEST FORM FOR ABBREVIATED EFFICIENCY TEST

CALCULATION SHEET *Revised September, 1965*

OWNER OF PLANT ...... TEST NO. ...... BOILER NO. ...... DATE ......

30 HEAT OUTPUT IN BOILER BLOW-DOWN WATER = LB OF WATER BLOW-DOWN PER HR × $\left[\frac{\text{ITEM 15} - \text{ITEM 17}}{1000}\right]$ = ... kB/hr

24 *If impractical to weigh refuse, this item can be estimated as follows*

DRY REFUSE PER LB OF AS FIRED FUEL = $\frac{\text{\% ASH IN AS FIRED COAL}}{100 - \text{\% COMB. IN REFUSE SAMPLE}}$

CARBON BURNED PER LB AS FIRED FUEL = $\frac{\text{ITEM 43}}{100} - \left[\frac{\text{ITEM 22} \times \text{ITEM 23}}{14{,}500}\right]$ = ...

NOTE: IF FLUE DUST & ASH PIT REFUSE DIFFER MATERIALLY IN COMBUSTIBLE CONTENT, THEY SHOULD BE ESTIMATED SEPARATELY. SEE SECTION 7, COMPUTATIONS.

25 DRY GAS PER LB AS FIRED FUEL BURNED = $\frac{11CO_2 + 8O_2 + 7(N_2 + CO)}{3(CO_2 + CO)}$ × (LB CARBON BURNED PER LB AS FIRED FUEL + $\frac{3}{8}$ S)

$$= \frac{11 \times \text{ITEM 32} + 8 \times \text{ITEM 33} + 7\left(\text{ITEM 35} + \text{ITEM 34}\right)}{3 \times \left(\text{ITEM 32} + \text{ITEM 34}\right)} \times \left[\text{ITEM 24} + \frac{\text{ITEM 47}}{267}\right] = \ldots\ldots$$

36 EXCESS AIR † $= 100 \times \dfrac{O_2 - \frac{CO}{2}}{.2682N_2 - (O_2 - \frac{CO}{2})} = 100 \times \dfrac{\text{ITEM 33} - \frac{\text{ITEM 34}}{2}}{.2682\ (\text{ITEM 35}) - (\text{ITEM 33} - \frac{\text{ITEM 34}}{2})}$ = ...

	HEAT LOSS EFFICIENCY	Btu/lb AS FIRED FUEL	$\frac{\text{LOSS}}{\text{HHV}} \times 100$ =	LOSS %
65	HEAT LOSS DUE TO DRY GAS = LB DRY GAS PER LB AS FIRED FUEL × C_p × ($t_{lvg} - t_{air}$) = ITEM 25 × 0.24 ((ITEM 13) − (ITEM 11)) = ...	......	$\frac{65}{41}$ × 100 =	......
66	HEAT LOSS DUE TO MOISTURE IN FUEL = LB H_2O PER LB AS FIRED FUEL × [(ENTHALPY OF VAPOR AT 1 PSIA & T GAS LVG) − (ENTHALPY OF LIQUID AT T AIR)] = $\frac{\text{ITEM 37}}{100}$ × [(ENTHALPY OF VAPOR AT 1 PSIA & T ITEM 13) − (ENTHALPY OF LIQUID AT T ITEM 11)] = ...	......	$\frac{66}{41}$ × 100 =	......
67	HEAT LOSS DUE TO H_2O FROM COMB. OF H_2 = $9H_2$ × [(ENTHALPY OF VAPOR AT 1 PSIA & T GAS LVG) − (ENTHALPY OF LIQUID AT T AIR)] = 9 × $\frac{\text{ITEM 44}}{100}$ × [(ENTHALPY OF VAPOR AT 1 PSIA & T ITEM 13) − (ENTHALPY OF LIQUID AT T ITEM 11)] = ...	......	$\frac{67}{41}$ × 100 =	......
68	HEAT LOSS DUE TO COMBUSTIBLE IN REFUSE = ITEM 22 × ITEM 23 = ...	......	$\frac{68}{41}$ × 100 =	......
69	HEAT LOSS DUE TO RADIATION* = $\frac{\text{TOTAL BTU RADIATION LOSS PER HR}}{\text{LB AS FIRED FUEL} - \text{ITEM 28}}$	......	$\frac{69}{41}$ × 100 =	......
70	UNMEASURED LOSSES **	......	$\frac{70}{41}$ × 100 =	......
71	TOTAL	......	......	......
72	EFFICIENCY = (100 − ITEM 71)	......	......	......

† For rigorous determination of excess air see Appendix 9.2 – PTC 4.1-1964

* If losses are not measured, use ABMA Standard Radiation Loss Chart, Fig. 8, PTC 4.1-1964

** Unmeasured losses listed in PTC 4.1 but not tabulated above may by provided for by assigning a mutually agreed upon value for item 70.

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FIGURE A-2

HP-67 KEYED CALCULATION SHEET

ASME ABBREVIATED EFFICIENCY CALCULATION - HEAT LOSS METHOD

Test No.________ Date________ Location____________ Unit No.________ Fuel________

(Turn Calculator Off and Then On. Load Program Card.)

A. FROM FUEL ANALYSIS:

Wt. % in as-fired fuel: C ________ % (A1: (STO 0)), Moisture ________ % (A2: (STO 1)), H ________ % (A3: (STO 2)), S ________ % (A4: (STO 3))

High heating value of fuel as-fired ________ Btu/lb (A5: (STO 4))

B. FROM FLUE GAS ANALYSIS:

Volume % in flue gas of: O_2 ________ % (B1: (STO 5)), CO_2 ________ % (B2: (STO 6)), CO ________ % (B3: (STO 7))

C. FROM REFUSE (FLY ASH AND ASH PIT) ANALYSIS:

C1. Fraction of dry refuse in fuel ________ (STO 8) lbs dry refuse/lb as-fired fuel

C2. Heating value of dry refuse (weighted average) ________ (STO 9) Btu/lb dry refuse

C3. Wt. % of combustibles in refuse ________ % (f P ≷ S) (STO 4) (f P ≷ S)

D. MEASURED TEMPERATURES

D1. Gas temp. leaving boiler, econ. or air heater ________ (STO A) °F

D2. Comb. air temp. ________ (STO B) °F

E. FROM STEAM TABLES:

E1. Enthalpy: $H_2O(g)$ at temp. D1 & 1 psia ________ (STO C) Btu/lb

E2. Enthalpy: $H_2O(l)$ at comb. air temp. ________ (STO D) Btu/lb

F. FROM ABMA STANDARD RADIATION LOSS CHART (UNLESS MEASURED):

F1. Heat loss due to radiation ________ (STO E) % of gross heat input

G. FROM UNIT SPECIFICATIONS (if available, otherwise enter 0):

G1. Unmeasured losses ________ % of gross heat input (f P ≷ S) (STO 0) (f P ≷ S)

1. Excess Air $\approx \dfrac{100\,(2B1 - B3)}{0.5364\,(100 - B1 - B2) - (2B1 - B3)}$ (A)________ %

2. (Optional) Pounds dry gas per pound of fuel =

$$\frac{B1 + 4B2 + 700}{3(B2 + B3)} \times \left[\frac{A1}{100} - \frac{C1 \times C2}{14500\left(1 - \frac{C3}{100}\right)} + \frac{3A4}{800}\right]$$

(R/S)________ lbs dry gas/lb as-fired fuel

Heat Losses	% of Gross Heat Input	(Optional) Btu/lb as-fired fuel*
3. Due to dry gas = $\dfrac{24 \times EQ.2 \times (D1 - D2)}{A5}$	(B)________	(R/S)________
4. Due to moisture in fuel = $\dfrac{A2 \times (E1 - E2)}{A5}$	(C)________	(R/S)________
5. Due to H_2O from combustion of H_2 = $\dfrac{9 \times A3(E1 - E2)}{A5}$	(D)________	(R/S)________
6. Due to combustibles in refuse = $\dfrac{100 \times C1 \times C2}{A5}$	(E)________	(R/S)________
7. Total Losses = Sum of calculated losses + F1 + G1	(f a)________	(R/S)________
8. Efficiency = 100 - Total Losses	(f b)________	

*Calculated as percent of gross heat input x A5 ÷ 100

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APPENDIX B

DATA RECORDING FORMATS

DOCUMENTATION OF RESULTS

Field Measurements

During testing, two sets of measurements are recorded: 1) control room data which indicate the operating condition of the device and 2) emissions data that are the readouts of the individual analyzers.

The concentration of nitric oxide (NO), carbon dioxide (CO_2), carbon monoxide (CO), and oxygen (O_2) are measured and recorded. The concentration of these species are measured and displayed continuously by analyzers and strip chart recorders mounted in a console. The strip chart recordings are retained for future reference. Opacity, particulate loading, and POM concentration are measured at the sampling port and the measurements recorded on data sheets.

A number of data sheets have been developed for use in field measurements. These data sheets are listed below together with their purpose. An example of each sheet follows.

Figure No.	Title	Purpose
B-1	Thirty-Day Field Test Data Sheets	Record control room data
B-2	Gaseous Emissions Data	Record Gaseous Emissions Analyzer data
B-3	Nozzle Size, Q_m and ΔH Calculations	Calculate nozzle size, flow rate, and ΔH for Method 5 Test
B-4	Response Time for Continuous Instruments	Continuous monitor certification
B-5	Zero and Calibration Drift (24 hr)	Continuous monitor certification
B-6	Zero and Calibration Drift (2 hr)	Continuous monitor certification
B-7	Accuracy Determination (NOx)	Continuous monitor certification
B-8	Calibration Error Determination	Continuous monitor certification

Figure No.	Title	Purpose
B-9	Analysis of Calibration Gas Mixture	Continuous monitor certification
B-10	Particulate Calculation Sheet	Calculate weight of solid particulate catch
B-11	Stack Data	Record volumes, temperatures, pressures of Method 5 control unit.
B-12	Particulate Emission Caculations	Calculate particulate emmision factors
B-13	Velocity Traverse	Record temperature and velocity profile of stack
B-14	Liquid or Solid Fuel Calculation	Calculate stoichiometric properties of fuel

Figure B-1.

KVB, Inc.

THIRTY DAY FIELD TEST DATA SHEET

Site ______________________ Fuel ______________________

Test No.			
Date			
Time			
Load			
Test Description			
Windbox, in. H_2O			
Furnace, in. H_2O			
Overfire air, in. H_2O			
Boiler exit, in. H_2O			
Economizer exit, in. H_2O			
ID fan inlet, in. H_2O			
Steam flow, kpph			
Integrated steam flow Time/k lbs			
Air flow indic.			
Superheater outlet temp. °F			
Flue gas temp, economizer inlet, °F			
Flue gas temp, economizer outlet, °F			
Temp F.W. economizer outlet, °F			
Feed Water Control, %			
Temp F.W. heater, °F			
F.W. economizer inlet, °F			
Steam pressure, psig			
Fuel feed			
Overfire air damper			
F.D. fan			
F.D. fan damper			
I.D. fan			
I.D. fan damper			

(continued)

Data Sheet 6017-26
12/12/78
KVB11-6015-1224

Figure B-1. (Continued)

THIRTY DAY FIELD TEST DATA SHEET

Page 2

Test No.			
Smoke Indicator Chart			
Rotary speed			
Spill plate setting			
Grate speed			
Overfire air damper, % open			
Fuel flow, Time/lbs			
Flame observations			
Bed thickness			
General furnace appearance			
Clinkers			
Ambient air temp, °F & F.D. fan inlet temp.			

Comments:

Data Sheet 6017-26
12/12/78

Figure B-2.

KVB, INC.

GASEOUS EMISSIONS DATA

Date ________________

Engr. ________________

Low NO_x Control Method ________________________________

Unit No. ____________________ Location ________________

Fuel ____________________ Capacity ________________

Unit Type ____________________ Burner Type ________________

1. Test No.					
2. Time					
3. Load					
4. Process Rate					
5. Flue Diam. or Size, ft					
6. Probe Position					
7. Oxygen (%)					
8. NO_x (hot) read/3% O_2 (ppm)					
9. NO (hot) read/3% O_2 (ppm)					
10. NO_2 (hot) read/3% O_2 (ppm)					
11. Carbon Dioxide (%)					
12. Carbon Monoxide (ppm) uncor/cor					
13. Opacity					
14. Atmos. Temp. (°F/°C)					
15. Dew Point Temp. (°F/°C)					
16. Atmos. Pressure (in. Hg)					
17. Relative Humidity (%)					

Data Sheet
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Figure B-3.

HP-67 Keyed Calculation Sheet

NOZZLE SIZE, Q_m and ΔH CALCULATIONS

Test No.__________ Date__________ Location__________

Unit No.__________ Fuel__________ Sampling Method__________

Crew: Engr.__________ Techs.__________

DATA

Constants		Key	Actual Conditions		Key
Pitot Factor, F_s	____	(STO 1)	Meter Temperature, T_m(°F)	____	(STO 5)
Orifice Factor, J	____	(STO 2)	Barom. Press., P_{Bar} (in. Hg)	____	(STO 6)
Orifice Diam., D_o (in.)	____	(STO 3)	Static Press. Diff., ΔP_s (iwg)	____	(STO 7)
Ideal Meter Flow, Q_n (ACFM)	____	(STO 4)	Nozzle Temp., T_n (°F)	____	(STO 8)
			Stack Vel. Press., Δp (iwg)	____	(STO 9)

NOTE: TO RECALCULATE IDEAL NOZZLE SIZE, RESTORE DATA IN REGISTERS 4 THRU 8, CLEAR STACK AND RE-ENTER % H_2O, % O_2, and % CO_2

Gaseous Stack Composition

% H_2O	(%)	____	ENTER
% O_2 dry	(%)	____	ENTER
% CO_2 dry	(%)	____	

IDEAL NOZZLE CALCULATION

(A) Ideal Nozzle Size, $D_{n(Ideal)}$ ________ inches

METER FLOW RATE AND ORIFICE PRESS. DIFF. CALCULATIONS

Actual Nozzle Size, $D_{n(Actual)}$ ________ inches

(C) Actual Meter Flow Rate, $Q_{m(Actual)}$ ________ ACFM (on meter)

(RCL 7) Orifice Press. Diff., ΔH to obtain $Q_{m(Actual)}$ ________ iwg

NOTE: To Determine Q_m and ΔH for Other Actual Nozzle Size, Key in $D_{n(Actual)}$, Press C for Q_m, then RCL 7 for ΔH.

For one $D_{n(Actual)}$ with Changing Stack Velocity Pressure (Δp) and Nozzle Temperature (T_n)
(It is not necessary to restore data in registers 4-8 for these calculations)

Δp (ENTER) (iwg)	T_n (°F)	(E) Q_n (ACFM)	(R/S) $\Delta H'$ (iwg)

EQUATIONS

(1) $M_d = 1/25\,(4\ \%\ CO_2 + \%\ O_2) + 28$ (lb/lb mole)

(2) $M_s = M_d\left(\frac{\%\ H_2O - 100}{-100}\right) + \frac{18}{100}(\%\ H_2O)$ (lb/lb mole)

(3) $P_s = 13.6\ P_{Bar} + \Delta P_s$ (in. of water)

(4) $V_n = 18892\ F_s\sqrt{[\Delta p\ (T_n + 460)]/P_s\ M_s}$ (ft/min)

(5) $$Q_n = \frac{Q_{m(Ideal)}\ (T_n + 460)\ 13.6\ P_{Bar}\ [828475\ \pi^2 J^2 D_o^{\ 4}\ (T_m + 460)]}{[1 - (\%\ H_2O/100)](T_m + 460)\ P_s[828475\ \pi^2 J^2 D_o^{\ 4}\ (T_m + 460) - 768\ M_d\ Q^2_{m(Ideal)}]}$$ (ACFM)

(6) $D_{n(Ideal)} = \sqrt{183.35\ (Q_n/V_n)}$ (in.)

(7) $Q_{n(Actual)} = [V_n\ D^2_{n(Actual)}]/183.35$ (ACFM)

(8) $$Q_{m_i} = \frac{Q_{n(Actual)}\ (T_m + 460)(1 - \%\ H_2O/100)(13.6\ P_{Bar} + \Delta P_s)}{(T_n + 460)(13.6\ P_{Bar} + \Delta H_{i-1})}$$ assume $\Delta H_o = \Delta P_s$ (ACFM)

$i = 1,n$ where n = number of iterations to obtain ΔH_i s.t. $\frac{(\Delta H_{i-1} - \Delta H_i)}{\Delta H_{i-1}} \leq 0.001$

(9) $$\Delta H_i = \frac{760\ Q_{m_i}^{\ 2}\ M_d\ 13.6\ P_{Bar}}{828475\ \pi^2 J^2 D_o^{\ 4}\ (T_m + 460) - 760\ Q_{m_i}^{\ 2}\ M_d}$$ (in. of water)

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Figure B-4.

KVB

Engineer ____________

MONITOR PERFORMANCE TEST DATA SHEET

RESPONSE TIME FOR CONTINUOUS INSTRUMENTS

Date of Test ____________

Span Gas Concentration __________ ppm

Analyzer Span Setting __________ ppm

	1	________ seconds
Upscale	2	________ seconds
	3	________ seconds

Average upscale response ________ seconds

	1	________ seconds
Downscale	2	________ seconds
	3	________ seconds

Average downscale response ________ seconds.

System average response time (slower time) = __________ seconds.

% deviation from slower system average response = $\left[\frac{\text{average upscale minus average downscale}}{\text{slower time}}\right] \times 100\% =$ ____.

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Figure B-5.

KVB

Engineer____________

MONITOR PERFORMANCE TEST DATA SHEET

ZERO AND CALIBRATION DRIFT (24-HOUR)

Date and Time	Zero Reading	Zero Drift (ΔZero)	Span Reading (After Zero Adjustment)	Calibration Drift (ΔSpan)

Zero Drift = [Mean Zero Drift* ________ + C.I. (Zero) ________]

÷ [Instrument Span] x 100 = ________.

Calibration Drift = [Mean Span Drift* ________ + C.I. (Span) ________]

÷ [Instrument Span] x 100 = ________.

*Absolute Value

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MONITOR PERFORMANCE TEST DATA SHEET

Engineer________________

ZERO AND CALIBRATION DRIFT (2 HOUR)

Figure B-6.

Data Set No.	Time Begin	Time End	Date	Zero Reading	Zero Drift (ΔZero)	Span Reading	Span Drift (ΔSpan)	Calibration Drift (Span-Zero)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Zero Drift = [Mean Zero Drift* ________ + CI (Zero) ________] ÷ [Span] x 100 = ________.

Calibration Drift = [Mean Span Drift* ________ + CI (Span) ________] ÷ [Span] x 100 = ________.

*Absolute Value.

KVB

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Figure B-7.

MONITOR PERFORMANCE TEST DATA SHEET

ACCURACY DETERMINATION (NO_x)

Engineer ______________

Test No.	Date and Time	Reference Method Samples: NO_x Sample 1 (ppm)	NO_x Sample 2 (ppm)	NO_x Sample 3 (ppm)	NO_x Sample Average (ppm)	Analyzer 1-Hour Average (ppm)* NO_x		Difference (ppm) NO_x	
1									
2									
3									
4									
5									
6									
7									
8									
9									

Mean reference method test value (NO_x) ______________

Mean of the differences ______________

95% Confidence intervals = ± __________ ppm (NO_x)

Accuracies = $\frac{\text{Mean of the differences + 95\% confidence interval}}{\text{Mean reference method value}}$ x 100 = __________% (NO_x)

* Explain and report method used to determine integrated averages

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KVB

Figure B-8.

KVB

Engineer ______________

MONITOR PERFORMANCE TEST DATA SHEET

CALIBRATION ERROR DETERMINATION

Calibration Gas Mixture Data

Mid (50%) ______ppm High (90%) ______ppm

Run #	Calibration Gas Concentration, ppm	Measurement System Reading, ppm	Differences,[1] ppm
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

	Mid	High
Mean difference	______	______
Confidence interval	+ ______	+ ______
Calibration error = $\frac{\text{Mean Difference}^2 + \text{C.I.}}{\text{Average Calibration Gas Concentration}} \times 100$	______%	______%

[1]Calibration gas concentration - measurement system reading

[2]Absolute value

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Figure B-9.

KVB

Engineer ______________

MONITOR PERFORMANCE TEST DATA SHEET

ANALYSIS OF CALIBRATION GAS MIXTURES

Date: ________________________ Reference Method Used: ________

Mid-Range Calibration Gas Mixture

Sample 1 ____________________ ppm

Sample 2 ____________________ ppm

Sample 3 ____________________ ppm

Average ____________________ ppm

High-Range (span) Calibration Gas Mixture

Sample 1 ____________________ ppm

Sample 2 ____________________ ppm

Sample 3 ____________________ ppm

Average ____________________ ppm

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Figure B-10. **PARTICULATE CALCULATION SHEET**

Test Crew________________

Test No.____________ Date____________ Location________________________

Box No.____________ Sample Probe Position________________________

Test Description

Dry Gas Meter Vol. (ft^3)

Final ________

Initial ________

Total ________

Impinger Water Vol (ml)

	1	2	3	S. Gel	Total
Final					
Initial					
Δ Vol					

Beaker No.					Filter No.	Blank No.
Date Weighed						
Tare Wt. 1						
2						
3						
4						
5						
6						
Avg						
Bottle No.						
Content	Impinger (Water)	Probe (Acetone)	Probe (Water)	Cyclone (Acetone)	Flask (Dry)	
Rinse (ml)						
Date Weighed or 250 Bake						
Final Wt. 250 1						
2						
3						
4						
5						
6						
Avg						
Residue wt Final 250-Tare						
Date Weighed or 650 Bake						
Final Wt. 650 1						
2						
3						
4						
5						
6						
Avg						
Residue Wt Final 650-Tare						

Comments:

Data Sheet 6002-3

Figure B-11.

K V B, INC.

STACK DATA

Test No._____
Engr._______

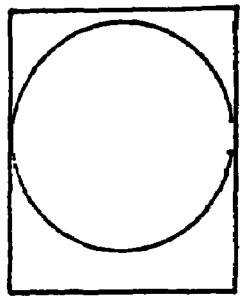
Date__________ Location__________ Unit No.__________ Fuel____________

Load___________ K#/hr or MBtu/hr Filter No._________

Sample Box No.______ Meter Box No.______Probe No._____Probe Length_____

Filter Heater Setting _____
Probe Heater Setting _____
Stack Moisture _____ %
Ambient Temperature _____ °F
Nozzle Diameter _____ in.
Atmospheric Pressure _____ in.Hg
Weather _______________
Stack Gas Pressure, Ps _____iwg
Abs. Stack Press., AP=P_s+407=____iwga
Stack Gas Sp. Gravity, Gs_____n.d.
Stack Area, As ________ft^2

diam.



Remarks

Final Meter: ________________

Initial Meter: ________________

Time	Vm Meter Volume Reading (CF)	Vacuum Gage Reading (iwg)	ΔP Pitot Tube Pressure (iwg)	H Orfice Pressure Diff (°F)	Stack Temp. (°F)	Impinger Temperature Out (°F)	Impinger Temperature In (°F)	Filter Box Temp. (°F)	Meter Temp. (°F)
Total					°F				
Avg.					°F + 460				

Ts= _______ °R

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HP-67 KEYED CALCULATION SHEET*

Figure B-12. **PARTICULATE EMISSION CALCULATIONS**

Test No.__________ Date__________ Location____________________ Engr.__________

nit No.__________ Fuel__________ Sampling Train and Method ____________________

Pitot Factor, Fs .83__________ Barometric Pressure, P_{bar} __________ (STO 0) in. Hg

Tot. Liquid Collected, V_{1c} __________ (STO 1) ml Total Particulate, M_n __________ (STO 2) m gm

Velocity Head, ΔP __________ (STO 3) iwg Stack Temp., Ts __________ (STO 4) °F Stack Area, As __________ (STO 5) ft^2

Sample Volume, Vm __________ (STO 6) ft^3 Stack Press., Psg __________ (STO 7) iwg Excess O_2, XO_2% __________ (STO 8) %

Orifice Press. Diff., H __________ (STO 9) iwg, (Flue Gas Density/Air Density) @ T_s, Gs __________ (STO A) n.d.

Sample Time, θ __________ (STO B) min Nozzle Dia., Dn __________ (STO C) in. Meter Temp., T_m __________ (STO D) °F

Select Fe	Oil (A)	Gas (B)	Coal (C)	Other:
SC Feet/10^4 Btu	92.2	87.4	98.2	(D)

Press (E) if meter is <u>not</u> temperature compensated.

1. Sample Gas Volume		$Vm_{std} = 0.0334\ Vm(P_{bar} + H/13.6)$	__________	SCF
2. Water Vapor		$Vw_{std} = 0.0474\ V_{1c}$	__________	SCF
3. Moisture Content		Bwo = Eq. 2/(Eq. 1 + Eq. 2)	__________	N.D.
4. Concentration	a.	$C = 0.0154\ Mn/Vm_{std}$	__________	grains/DSCF
	b.	$C = 2.205 \times 10^{-6}\ Mn/Vm_{std}$	__________	lb/DSCF
	c.	$C = \text{Eq. 4b} \times 16.018 \times 10^3$	__________	grams/DSCM
5. Abs. Stack Press.		$Ps = P_{bar} \times 13.6 + Psg$	__________	in. w abs.
6. Stack Gas Speed		$Vs = 174\ Fs\ \sqrt{\Delta P Ts}\ \sqrt{\frac{407}{Ps} \times \frac{1.00}{Gs}}$	__________	ft/min
7. Stack Gas Flow Rate @ 70°F	a.	$Qsw = \text{Eq. 6} \times As \times \frac{530}{Ts} \times \frac{Ps}{407}$	__________	WSCF/min
	b.	Qsd = Eq. 7a x (1. - Eq. 3)	__________	DSCF/min
8. Material Flow		Ms = Eq. 7b x Eq. 4b x 60	__________	lb/hr
9. XO_2 factor		$XO_2f = 2090/(20.9 - XO_2\%)$	__________	N.D.
10. Emission	a.	E = Eq. 4b x Fe x Eq. 9	__________	lb/MMBtu
	b.	E = Eq. 4c x Fm x Eq. 9 x 1000	__________	ng/joule
11. % Isokinetic		$I = \frac{14077 \times Ts(Vm_{std} + Vw_{std})}{\theta \times Vs \times Ps \times Dn^2}$	__________	%

*If calculating by hand:
1) Convert T_s and T_m to °R
2) Multiply EQ 1 by $530/T_m$(°R) if meter not temperature compensated.
3) $F_m = 2.684 \times 10^{-5} \times Fe$

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Figure B-13.

KVB, Inc.

VELOCITY TRAVERSE

Project: ____________________ Test Description: ____

Date: ____________________ ____________________

Location: ____________________ ____________________

Unit: ____________________ ____________________

Test: ____________________ Personnel: ____________

Fuel: ____________________ ____________________

Barometric Press. (in. Hg): ____________________

Absolute Static Press. in Stack (in. Hg): ____________ (P_s)

Pitot Tube Coefficient: ____________________ (C_p)

$$V_s = 85.48\, C_p \left[\frac{T_s \Delta P}{P_s M_s}\right]^{1/2}$$

Stack Cross Section

Time	Traverse Point Port	Traverse Point Depth	Velocity Head (in. H_2O)	Gas Temp. (°F)	Gas Temp. (°R)	Molecular Wt.	Velocity (ft/sec)	O_2 Conc. (% Dry)
			ΔP		T_s	M_s	V_s	

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Figure B-14.

KVB

Test No.__________ Date__________ Location__________ Unit No.__________

Fuel__________ Fuel Sample No.__________ Fuel Sample Point__________

LIQUID OR SOLID FUEL CALCULATIONS

(f)(CL REG), (f) (P⇄S), (f)(CL REG), Load data card, then PGRM card (both sides)

*Input HHV (Btu/lb) __________, (A)
*Input wt % C __________, (R/S)
*Input wt % H __________, (R/S)
*Input wt % S __________, (R/S)
*Input wt % O __________, (R/S)
*Input wt % N __________, (R/S) - decimal point blinks after pressing: item #1 displayed

1. Dry stoichiometric moles flue gas/lb fuel = __________.
(One may proceed to items 9, 17, or 18 by pressing (f)(A), (E), or entering MW and pressing (B), respectively.)

- -

*Input wt % H_2O in fuel (0 if none) __________

(C)	2.	Moles H_2O in flue gas/lb fuel	__________
(R/S)	3.	Total moles of flue gas (stoichiometric)/lb fuel	__________
(R/S)	4.	Dry volume/wet volume	__________
(R/S)	5.	Volume % H_2O in flue gas	__________
(R/S)	6.	Volume % CO_2, dry in flue gas	__________
(R/S)	7.	SO_2 (ppm by vol.), dry at stoichiometric	__________
(R/S)	8.	NO (ppm by vol.), dry at stoichiometric	__________

- -

(f)(A) 9. Stoichiometric air/fuel ratio (lb air/lb fuel) __________

- -

(Before items 10-16 may be determined, items 1-9 must be completed.)

(D) - 20.95 displayed

*Input measured vol. % O_2 for O_2 correction ______ ______ ______ ______

(R/S)	10.	$\frac{\text{Gas moles at \% } O_2}{\text{Gas moles, stoic.}} = \frac{20.95}{20.95 - \% O_2} =$	______	______	______	______
(R/S)	11.	Dry moles flue gas/lb fuel at % O_2	______	______	______	______
(R/S)	12.	Vol. % CO_2, dry at % O_2	______	______	______	______
(R/S)	13.	SO_2 (ppm by vol.) dry at % O_2	______	______	______	______
(R/S)	14.	NO (ppm by vol.) dry at % O_2	______	______	______	______
(R/S)	15.	Vol. % H_2O at % O_2	______	______	______	______
(R/S) (decimal pt. blinks)	16.	Percent Excess Air	______	______	______	______

- -

(RCL)(2)(E) 17. Converts item 1 to SCF dry flue gas at stoich/10^6 Btu = __________

- -

Item 18.

a. *Input MW, (B), program calculates K (lb/10^6 Btu = ppm/K)
(MW = 46 for NOx, CO = 28, HC = 16, SOx = 64)
1. *Input measured ppm at 3% O_2, dry, (R/S), program calculates lb/10^6 Btu.
2. (Optional) No input, (R/S), program converts lb/10^6 Btu → ng/J
3. Repeat steps (1) and (2) as necessary.

b. *Enter next value of MW, complete step (a) followed by steps (1), (2), and (3). Repeat for all species desired.

	MW	K for lb/10^6 Btu
NOx	46	__________
CO	28	__________
HC	16	__________
SOx	64	__________

*Indicates input is required

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APPENDIX C

CONTINUOUS MONITOR CERTIFICATION DATA SHEETS

MONITOR PERFORMANCE TEST DATA SHEET

ACCURACY DETERMINATION (NO_x)

Engineer ____________

Test No.	Date and Time	NO_x Sample 1 (ppm)	NO_x Sample 2 (ppm)	NO_x Sample 3 (ppm)	NO_x Sample Average (ppm)	Analyzer 1-Hour Average (ppm)* NO_x	Difference (ppm) NO_x
		Reference Method Samples					
1	7-10-79 830	747	743	740	743	597	-146
2	930	1002	1010	969	994	767	-227
3	1030	929	921	1071	974	793	-181
4	1130	1078	933	804	938	851	-87
5	1230	916	917	932	922	839	-83
6	1330	968	949	933	950	857	-93
7	1430	973	934	1026	978	820	-158
8	1530	1072	920	1103	1032	881	-151
9	1630	949	937	952	946	857	-89

Mean reference method test value (NO_x) 942

Mean of the differences -135

95% Confidence intervals = ± 47.19 ppm (NO_x)

$$\text{Accuracies} = \frac{\text{Mean of the differences + 95\% confidence interval}}{\text{Mean reference method value}} \times 100 = 19.34\ \%\ (NO_x)$$

* Explain and report method used to determine integrated averages

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MONITOR PERFORMANCE TEST DATA SHEET

ACCURACY DETERMINATION (NO_x)

Engineer ____________

Test No.	Date and Time	NO_x Sample 1 (ppm)	NO_x Sample 2 (ppm)	NO_x Sample 3 (ppm)	NO_x Sample Average (ppm)	Analyzer 1-Hour Average (ppm)* NO_x	Difference (ppm) NO_x
		Reference Method Samples					
1	6-8-79 9:30	749	772	752	758	681	-77
2	10:30	706	714	721	714	672	-42
3	11:30	NOT TAKEN	543	583	563	540	-23
4	12:30	555	552	538	548	488	-60
5	13:30	556	560	557	558	513	-45
6	14:30	626	619	615	620	557	-63
7	15:30	690	700	686	692	583	-109
8	16:30	694	689	700	694	594	-100
9	17:30	854	831	805	830	694	-136

Mean reference method test value (NO_x) 664

Mean of the differences -72.7

95% Confidence intervals = ± 33.91 ppm (NO_x)

Accuracies = $\frac{\text{Mean of the differences + 95\% confidence interval}}{\text{Mean reference method value}}$ x 100 = 16.05 % (NO_x)

* Explain and report method used to determine integrated averages

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MONITOR PERFORMANCE TEST DATA SHEET

RESPONSE TIME

O_2

Date of Test 6-7-79

Span Gas Concentration 9.27% ppm

Analyzer Span Setting 92.7 ppm

Upscale	1	92.0 seconds
	2	89.5 seconds
	3	85.0 seconds
	Average upscale response	88.8 seconds
Downscale	1	91.0 seconds
	2	91.2 seconds
	3	90.2 seconds
	Average downscale response	90.8 seconds.

System average response time (slower time) = 88.8 seconds.

% deviation from slower system average response = [average upscale minus average downscale / slower time] x 100% = -.02.

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MONITOR PERFORMANCE TEST DATA SHEET

RESPONSE TIME

CO_2

Date of Test 6-7-79

Span Gas Concentration 17.8% ppm

Analyzer Span Setting 95.0 ppm

Upscale

1 77 seconds

2 77 seconds

3 76.5 seconds

Average upscale response 76.8 seconds

Downscale

1 79.4 seconds

2 73.0 seconds

3 76.0 seconds

Average downscale response 76.1 seconds.

System average response time (slower time) = 76.8 seconds.

$$\text{\% deviation from slower system average response} = \left[\frac{\text{average upscale minus average downscale}}{\text{slower time}}\right] \times 100\% = .91\%.$$

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MONITOR PERFORMANCE TEST DATA SHEET

RESPONSE TIME

- NO

Date of Test 6-7-79

Span Gas Concentration 234 ppm

Analyzer Span Setting 94.0 ppm.

	1	80.4 seconds
Upscale	2	78.6 seconds
	3	86.4 seconds

Average upscale response 81.8 seconds

	1	85.0 seconds
Downscale	2	80.0 seconds
	3	83.0 seconds

Average downscale response 82.7 seconds.

System average response time (slower time) = 82.7 seconds.

% deviation from slower system average response = $\left[\frac{\text{average upscale minus average downscale}}{\text{slower time}}\right]$ x 100% = -.01.

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MONITOR PERFORMANCE TEST DATA SHEET

RESPONSE TIME

CO

Date of Test 6-7-79

Span Gas Concentration 900 ppm

Analyzer Span Setting 90.0 ppm

Upscale

1 80.5 seconds

2 81.6 seconds

3 81.0 seconds

Average upscale response 81.0 seconds

Downscale

1 87.7 seconds

2 87.0 seconds

3 84.0 seconds

Average downscale response 86.2 seconds.

System average response time (slower time) = 81.0 seconds.

% deviation from slower system average response = $\left[\frac{\text{average upscale minus average downscale}}{\text{slower time}}\right]$ x 100% = .06.

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Engineer ____________

MONITOR PERFORMANCE TEST DATA SHEET

ZERO AND CALIBRATION DRIFT (24-HOUR)

O_2

Date and Time	Zero Reading	Zero Drift (ΔZero)	Span Reading (After Zero Adjustment)	Calibration Drift (ΔSpan)
6-5-79 8:50	DNA	DNA	9.27%	—
6-6-79 8:50			9.20%	-.07
6-7-79 8:50			9.19%	-.01
6-8-79 8:50			9.27%	+.08
6-9-79 8:50			9.17%	-.1
6-10-79 8:50			9.27%	0
6-11-79 8:50			9.27%	0
6-12-79 8:50			9.27%	0

Zero Drift = [Mean Zero Drift* 0 + C.I. (Zero) DNA]
÷ [Instrument Span] x 100 = DNA .

Calibration Drift = [Mean Span Drift* .0371 + C.I. (Span) .1261]
÷ [Instrument Span] x 100 = 1.63 .

*Absolute Value

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MONITOR PERFORMANCE TEST DATA SHEET

ZERO AND CALIBRATION DRIFT (24-HOUR)

CO_2

Date and Time	Zero Reading	Zero Drift (ΔZero)	Span Reading (After Zero Adjustment)	Calibration Drift (ΔSpan)
6-5-79 8:50	0	–	17.8%	–
6-6-79 8:50	0	–	17.8%	–
6-7-79 8:50	0	–	17.8%	–
6-8-79 8:50	0	–	17.8%	–
6-9-79 8:50	0	–	17.8%	–
6-10-79 8:50	0	–	17.8%	–
6-11-79 8:50	0	–	17.8%	–
6-12-79 8:50	0	–	17.8%	–

Zero Drift = [Mean Zero Drift* 0 + C.I. (Zero) 0]
÷ [Instrument Span] x 100 = 0 .

Calibration Drift = [Mean Span Drift* 0 + C.I. (Span) 0]
÷ [Instrument Span] x 100 = 0 .

*Absolute Value

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Engineer ____________

MONITOR PERFORMANCE TEST DATA SHEET

ZERO AND CALIBRATION DRIFT (24-HOUR)

NO

Date and Time	Zero Reading	Zero Drift (ΔZero)	Span Reading (After Zero Adjustment)	Calibration Drift (ΔSpan)
6-5-79 8:50	0.0	—	234 PPM	0
6-6-79 8:50	-6 PPM	-6	234 PPM	0
6-7-79 8:50	+4 PPM	+4	234 PPM	0
6-8-79 8:50	-3 PPM	-3	234 PPM	0
6-9-79 8:50	0.0	0	234 PPM	0
6-10-79 8:50	0.0	0	234 PPM	0
6-11-79 8:50	+1 PPM	+1	234 PPM	0
6-12-79 8:50	0	0	234 PPM	0

Zero Drift = [Mean Zero Drift* 2 + C.I. (Zero) 2.20]
÷ [Instrument Span] x 100 = 1.79.

Calibration Drift = [Mean Span Drift* 0 + C.I. (Span) 0]
÷ [Instrument Span] x 100 = 0.

*Absolute Value

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Engineer ____________

MONITOR PERFORMANCE TEST DATA SHEET

ZERO AND CALIBRATION DRIFT (24-HOUR)

CO

Date and Time	Zero Reading	Zero Drift (ΔZero)	Span Reading (After Zero Adjustment)	Calibration Drift (ΔSpan)
6-5-79 8:50	0.0		900 PPM	
6-6-79 8:50	0.0		900 PPM	
6-7-79 8:50	5.0 PPM		900 PPM	
6-8-79 8:50	5.0 PPM		930 PPM	
6-9-79 8:50	8.0 PPM		900 PPM	
6-10-79 8:50	0.0		900 PPM	

Zero Drift = [Mean Zero Drift* ________ + C.I. (Zero) ________]

÷ [Instrument Span] x 100 = ________.

Calibration Drift = [Mean Span Drift* ________ + C.I. (Span) ________]

÷ [Instrument Span] x 100 = ________.

*Absolute Value

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MONITOR PERFORMANCE TEST DATA SHEET
ZERO AND CALIBRATION DRIFT (2 HOUR)

O2,

Data Set No.	Time Begin	Time End	Date	Zero Reading	Zero Drift (ΔZero)	Span Reading	Span Drift (ΔSpan)	Calibration Drift (Span-Zero)
1 START	8:50		6-5-79	NO ZERO ADJUST	D.N.A.	9.27%	—	—
2	10:50		6-5-79			9.27%	0	0
3	12:50		6-5-79			9.26%	-.01	.01
4	14:50		6-5-79			9.29%	+.03	.03
5	16:50		6-5-79			9.4%	+.11	.11
6	18:50		6-5-79			9.4%	0	0
7 START	8:50		6-6-79			9.27%	—	—
8	10:50		6-6-79			9.25%	-.02	.02
9	12:50		6-6-79			9.25%	0	0
10	14:50		6-6-79			9.25%	0	0
11	16:50		6-6-79			9.27%	+.02	.02
12	18:50		6-6-79			9.27%	0	0
13 START	8:50		6-7-79			9.27%	—	—
14	10:50		6-7-79			9.29%	+.02	.02
15	12:50		6-7-79			9.29%	0	0
16	14:50		6-7-79			9.29%	0	0
17	16:50		6-7-79			9.5%	+.21	.21
18	18:50		6-7-79			9.6%	+.1	.1
19 START	8:50		6-8-79			9.27%	—	—
20								

Zero Drift = [Mean Zero Drift* DNA + CI (Zero) DNA] ÷ [Span] x 100 = DNA.

Calibration Drift = [Mean Span Drift* .03 + CI (Span) .03] ÷ [Span] x 100 = .65%.

*Absolute Value.

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MONITOR PERFORMANCE TEST DATA SHEET
ZERO AND CALIBRATION DRIFT (2 HOUR)

CO

Data Set No.	Time Begin	Time End	Date	Zero Reading	Zero Drift (ΔZero)	Span Reading	Span Drift (ΔSpan)	Calibration Drift (Span-Zero)
1	8:50		6-5-79	0.0	0	900	0	—
2	10:50		6-5-79	5 PPM	5	900	0	-5
3	12:50		6-5-79	6 PPM	1	898	-2	-3
4	14:50		6-5-79	10 PPM	4	880	-18	-22
5	16:50		6-5-79	6 PPM	-4	870	-10	-6
6	18:50		6-5-79	0.0	-6	870	0	0
7	8:50		6-6-79	0.0	0	900	—	—
8	10:50		6-6-79	10 PPM	10	900	0	-10
9	12:50		6-6-79	10 PPM	0	900	0	0
10	14:50		6-6-79	10 PPM	0	900	0	0
11	16:50		6-6-79	15 PPM	5	900	0	-5
12	18:50		6-6-79	0.0	-15	900	0	+15
13	8:50		6-7-79	0.0	0	900	0	0
14	10:50		6-7-79	0.0	0	900	0	0
15	12:50		6-7-79	4 PPM	4	900	0	-4
16	14:50		6-7-79	0.0	0	900	0	0
17	16:50		6-7-79	0.0	0	900	0	0
18	18:50		6-7-79	0.0	0	910	10	10
19	8:50		6-8-79	0.0	—	900	—	—
20								

Zero Drift = [Mean Zero Drift* 3.37 + CI (Zero) 2.292] ÷ [Span] x 100 = .56%.

Calibration Drift = [Mean Span Drift* 5.33 + CI (Span) 3.6] ÷ [Span] x 100 = .89%.

*Absolute Value.

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MONITOR PERFORMANCE TEST DATA SHEET
ZERO AND CALIBRATION DRIFT (2 HOUR)

Data Set No.	Time Begin	Time End	Date	Zero Reading	Zero Drift (ΔZero)	Span Reading	Span Drift (ΔSpan)	Calibration Drift (Span-Zero)
1	8:50		6-5-79	0.0	—	94.0 (234)	—	
2	10:50		6-5-79	5 PPM	+5	100 (240)	+6	+1
3	12:50		6-5-79	1	-4	94.0 (234)	-6	-2
4	14:50		6-5-79	5	+4	98.0 (245)	+11	+7
5	16:50		6-5-79	11	+6	100.0 (250)	+5	-1
6	18:50		6-5-79	10	-1	99.0 (248)	-2	-1
7 START	8:50		6-6-79	0	—	94.0 (234)	—	—
8	10:50		6-6-79	8	+8	97.0 (243)	+9	+1
9	12:50		6-6-79	15	+7	99.0 (248)	+5	-2
10	14:50		6-6-79	20	+5	99.0 (248)	0	-5
11	16:50		6-6-79	17	-3	100.0 (250)	+2	+5
12	18:50		6-6-79	12	-5	97.0 (243)	-7	-2
13	8:50		6-7-79	0	—	94.0 (234)	—	—
14	10:50		6-7-79	2.5	2.5	94.0 (234)	0	-2.5
15	12:50		6-7-79	2.5	0	97.0 (243)	+8	8
16	14:50		6-7-79	12	9.5	99.0 (248)	+5	-4.5
17	16:50		6-7-79	10	-2	98.0 (245)	-3	-1
18	18:50		6-7-79	10	0	98.0 (245)	0	0
19 START	8:50		6-8-79	0	—	94.0 (234)	—	—
20	10:50		6-8-79	2	+2	94.0 (234)	0	-2

Zero Drift = [Mean Zero Drift* 3.55 + CI (Zero) 1.438] ÷ [Span] x 100 = 1.99 %.

Calibration Drift = [Mean Span Drift* 2.50 + CI (Span) 1.19] ÷ [Span] x 100 = 1.4 %.

*Absolute Value.

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MONITOR PERFORMANCE TEST DATA SHEET
ZERO AND CALIBRATION DRIFT (2 HOUR)

NO.

Data Set No.	Time Begin	Time End	Date	Zero Reading	Zero Drift (ΔZero)	Span Reading	Span Drift (ΔSpan)	Calibration Drift (Span-Zero)
21	12:50		6-8-79	2 PPM	0	94.0 (234)	0	0
22	14:50		6-8-79	2	0	94.0 (234)	0	0
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

Zero Drift = [Mean Zero Drift* ________ + CI (Zero) ________] ÷ [Span] x 100 = ________.

Calibration Drift = [Mean Span Drift* ________ + CI (Span) ________] ÷ [Span] x 100 = ________.

*Absolute Value.

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MONITOR PERFORMANCE TEST DATA SHEET
ZERO AND CALIBRATION DRIFT (2 HOUR)

CO_2

Data Set No.	Time Begin	Time End	Date	Zero Reading	Zero Drift (ΔZero)	Span Reading	Span Drift (ΔSpan)	Calibration Drift (Span-Zero)
1 START	8:50		6-5-79	0	–	17.8%	–	–
2	10:50		6-5-79	0	–	17.8%	0	0
3	12:50		6-5-79	0	–	17.8%	0	0
4	14:50		6-5-79	0	–	17.6%	-.2	.2
5	16:50		6-5-79	0	–	17.6%	0	0
6	18:50		6-5-79	0	–	17.8%	+.2	.2
7 START	8:50		6-6-79	0	–	17.8%	0	0
8	10:50		6-6-79	0	–	17.8%	0	0
9	12:50		6-6-79	0	–	17.8%	0	0
10	14:50		6-6-79	0	–	17.8%	0	0
11	16:50		6-6-79	0	–	17.8%	0	0
12	18:50		6-6-79	0	–	17.8%	0	0
13 START	8:50		6-7-79	0	–	17.8%	–	–
14	10:50		6-7-79	0	–	17.8%	0	0
15	12:50		6-7-79	0	–	17.8%	0	0
16	14:50		6-7-79	0	–	17.8%	0	0
17	16:50		6-7-79	0	–	17.8%	0	0
18	18:50		6-7-79	0	–	18.2%	+.4	.4
19 START	8:50		6-8-79	0	–	17.8%	–	–
20								

Zero Drift = [Mean Zero Drift* 0 + CI (Zero) 0] ÷ [Span] x 100 = 0 .

Calibration Drift = [Mean Span Drift* .05 + CI (Span) .14] ÷ [Span] x 100 = 0.9% .

*Absolute Value.

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MONITOR PERFORMANCE TEST DATA SHEET

CALIBRATION ERROR DETERMINATION

O_2

Calibration Gas Mixture Data

Mid (50%) 5.0% ppm High (90%) 9.27% ppm

Run #	Calibration Gas Concentration, ppm	Measurement System Reading, ppm	Differences[1], ppm
1	0	0	0
2	5.0 %	5.1 %	.1
3	0	0	0
4	9.27%	9.21%	.06
5	5.0%	5.18 %	.18
6	9.27%	9.21%	.06
7	5.0%	5.18 %	.18
8	0	0	0
9	9.27%	9.21%	.06
10	0	0	0
11	5.0 %	5.1 %	.1
12	9.27%	9.21%	.06
13	0	0	0
14	9.27%	9.21 %	.06
15	5.0 %	5.18 %	.18

	Mid	High
Mean difference	.15	.06
Confidence interval	± .05	± 0
Calibration error = $\frac{\text{Mean Difference}^2 + \text{C.I.}}{\text{Average Calibration Gas Concentration}} \times 100$	4.09 %	0.65 %

[1]Calibration gas concentration - measurement system reading

[2]Absolute value

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MONITOR PERFORMANCE TEST DATA SHEET

CALIBRATION ERROR DETERMINATION

CO_2

Calibration Gas Mixture Data

Mid (50%) 10% ppm   High (90%) 17.8% ppm

Run #	Calibration Gas Concentration, ppm	Measurement System Reading, ppm	Differences,[1] ppm
1	0	0	0
2	10%	9.8%	.2
3	0	0	0
4	17.8%	17.8%	0
5	10%	9.9%	.1
6	17.8%	17.8%	0
7	10.0	9.8%	.2
8	0	0	0
9	17.8%	17.8%	0
10	0	0	0
11	10.0%	9.8%	.2
12	17.8%	17.8%	0
13	0	0	0
14	17.8%	17.8%	0
15	10.0%	9.9%	.1

	Mid	High
Mean difference	.16	0
Confidence interval	± .07	± 0
Calibration error = $\frac{\text{Mean Difference}^2 + \text{C.I.}}{\text{Average Calibration Gas Concentration}} \times 100$	2.3 %	0 %

[1] Calibration gas concentration - measurement system reading

[2] Absolute value

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MONITOR PERFORMANCE TEST DATA SHEET

CALIBRATION ERROR DETERMINATION

NO

Calibration Gas Mixture Data

Mid (50%) 120 ppm   High (90%) 234 ppm

Run #	Calibration Gas Concentration, ppm	Measurement System Reading, ppm	Differences[1], ppm
1	0	0	0
2	120	120	0
3	0	0	0
4	234	234	0
5	120	119.5	.5
6	234	234	0
7	120	118.5	1.5
8	0	0	0
9	234	234	0
10	0	0	-
11	120	119.5	.5
12	234	234	0
13	0	0	0
14	234	234	0
15	120	120	0

	Mid	High
Mean difference	0.50	0
Confidence interval	±0.76	± 0
Calibration error = $\frac{\text{Mean Difference}^2 + \text{C.I.}}{\text{Average Calibration Gas Concentration}} \times 100$	1.05 %	0 %

[1] Calibration gas concentration - measurement system reading

[2] Absolute value

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APPENDIX D

CONTINUOUS MONITOR PERFORMANCE SPECIFICATIONS

PERFORMANCE SPECIFICATION 2—PERFORMANCE SPECIFICATIONS AND SPECIFICATION TEST PROCEDURES FOR MONITORS OF SO_2 AND NO_x FROM STATIONARY SOURCES

1. Principle and Applicability.

1.1 Principle. The concentration of sulfur dioxide or oxides of nitrogen pollutants in stack emissions is measured by a continuously operating emission measurement system. Concurrent with operation of the continuous monitoring system, the pollutant concentrations are also measured with reference methods (Appendix A). An average of the continuous monitoring system data is computed for each reference method testing period and compared to determine the relative accuracy of the continuous monitoring system. Other tests of the continuous monitoring system are also performed to determine calibration error, drift, and response characteristics of the system.

1.2 Applicability. This performance specification is applicable to evaluation of continuous monitoring systems for measurement of nitrogen oxides or sulfur dioxide pollutants. These specifications contain test procedures, installation requirements, and data computation procedures for evaluating the acceptability of the continuous monitoring systems.

2. Apparatus.

2.1 Calibration Gas Mixtures. Mixtures of known concentrations of pollutant gas in a diluent gas shall be prepared. The pollutant gas shall be sulfur dioxide or the appropriate oxide(s) of nitrogen specified by paragraph 6 and within subparts. For sulfur dioxide gas mixtures, the diluent gas may be air or nitrogen. For nitric oxide (NO) gas mixtures, the diluent gas shall be oxygen-free (<10 ppm) nitrogen, and for nitrogen dioxide (NO_2) gas mixtures the diluent gas shall be air. Concentrations of approximately 50 percent and 90 percent of span are required. The 90 percent gas mixture is used to set and to check the span and is referred to as the span gas.

2.2 Zero Gas. A gas certified by the manufacturer to contain less than 1 ppm of the pollutant gas or ambient air may be used.

2.3 Equipment for measurement of the pollutant gas concentration using the reference method specified in the applicable standard.

2.4 Data Recorder. Analog chart recorder or other suitable device with input voltage range compatible with analyzer system output. The resolution of the recorder's data output shall be sufficient to allow completion of the test procedures within this specification.

2.5 Continuous monitoring system for SO_2 or NO_x pollutants as applicable.

3. Definitions.

3.1 Continuous Monitoring System. The total equipment required for the determination of a pollutant gas concentration in a source effluent. Continuous monitoring systems consist of major subsystems as follows:

3.1.1 Sampling Interface. That portion of an extractive continuous monitoring system that performs one or more of the following operations: Acquisition, transportation, and conditioning of a sample of the source effluent or that portion of an in-situ continuous monitoring system that protects the analyzer from the effluent.

3.1.2 Analyzer. That portion of the continuous monitoring system which senses the pollutant gas and generates a signal output that is a function of the pollutant concentration.

3.1.3 Data Recorder. That portion of the continuous monitoring system that provides a permanent record of the output signal in terms of concentration units.

3.2 Span. The value of pollutant concentration at which the continuous monitoring system is set to produce the maximum data display output. The span shall be set at the concentration specified in each applicable subpart.

3.3 Accuracy (Relative). The degree of correctness with which the continuous monitoring system yields the value of gas concentration of a sample relative to the value given by a defined reference method. This accuracy is expressed in terms of error, which is the difference between the paired concentration measurements expressed as a percentage of the mean reference value.

3.4 Calibration Error. The difference between the pollutant concentration indicated by the continuous monitoring system and the known concentration of the test gas mixture.

3.5 Zero Drift. The change in the continuous monitoring system output over a stated period of time of normal continuous operation when the pollutant concentration at the time for the measurements is zero.

3.6 Calibration Drift. The change in the continuous monitoring system output over a stated time period of normal continuous operations when the pollutant concentration at the time of the measurements is the same known upscale value.

3.7 Response Time. The time interval from a step change in pollutant concentration at the input to the continuous monitoring system to the time at which 95 percent of the corresponding final value is reached as displayed on the continuous monitoring system data recorder.

3.8 Operational Period. A minimum period of time over which a measurement system is expected to operate within certain performance specifications without unscheduled maintenance, repair, or adjustment.

3.9 Stratification. A condition identified by a difference in excess of 10 percent between the average concentration in the duct or stack and the concentration at any point more than 1.0 meter from the duct or stack wall.

4. Installation Specifications. Pollutant continuous monitoring systems (SO_2 and NO_x) shall be installed at a sampling location where measurements can be made which are directly representative (4.1), or which can be corrected so as to be representative (4.2) of the total emissions from the affected

facility. Conformance with this requirement shall be accomplished as follows:

4.1 Effluent gases may be assumed to be nonstratified if a sampling location eight or more stack diameters (equivalent diameters) downstream of any air in-leakage is selected. This assumption and data correction procedures under paragraph 4.2.1 may not be applied to sampling locations upstream of an air preheater in a steam generating facility under Subpart D of this part. For sampling locations where effluent gases are either demonstrated (4.3) or may be assumed to be nonstratified (eight diameters), a point (extractive systems) or path (in-situ systems) of average concentration may be monitored.

4.2 For sampling locations where effluent gases cannot be assumed to be nonstratified (less than eight diameters) or have been shown under paragraph 4.3 to be stratified, results obtained must be consistently representative (e.g. a point of average concentration may shift with load changes) or the data generated by sampling at a point (extractive systems) or across a path (in-situ systems) must be corrected (4.2.1 and 4.2.2) so as to be representative of the total emissions from the affected facility. Conformance with this requirement may be accomplished in either of the following ways:

4.2.1 Installation of a diluent continuous monitoring system (O_2 or CO_2 as applicable) in accordance with the procedures under paragraph 4.2 of Performance Specification 3 of this appendix. If the pollutant and diluent monitoring systems are not of the same type (both extractive or both in-situ), the extractive system must use a multipoint probe.

4.2.2 Installation of extractive pollutant monitoring systems using multipoint sampling probes or in-situ pollutant monitoring systems that sample or view emissions which are consistently representative of the total emissions for the entire cross section. The Administrator may require data to be submitted to demonstrate that the emissions sampled or viewed are consistently representative for several typical facility process operating conditions.

4.3 The owner or operator may perform a traverse to characterize any stratification of effluent gases that might exist in a stack or duct. If no stratification is present, sampling procedures under paragraph 4.1 may be applied even though the eight diameter criteria is not met.

4.4 When single point sampling probes for extractive systems are installed within the stack or duct under paragraphs 4.1 and 4.2.1, the sample may not be extracted at any point less than 1.0 meter from the stack or duct wall. Multipoint sampling probes installed under paragraph 4.2.2 may be located at any points necessary to obtain consistently representative samples.

5. Continuous Monitoring System Performance Specifications

The continuous monitoring system shall meet the performance specifications in Table 2-1 to be considered acceptable under this method.

TABLE 2-1.—*Performance specifications*

Parameter	*Specification*
1. Accuracy [1]	≤20 pct of the mean value of the reference method test data.
2. Calibration error [1]	≤5 pct of each (50 pct, 90 pct) calibration gas mixture value.
3. Zero drift (2 h) [1]	2 pct of span
4. Zero drift (24 h) [1]	Do.
5. Calibration drift (2 h) [1]	Do.
6. Calibration drift (24 h) [1]	2.5 pct. of span
7. Response time	15 min maximum.
8. Operational period	168 h minimum.

[1] Expressed as sum of absolute mean value plus 95 pct confidence interval of a series of tests.

6. Performance Specification Test Procedures. The following test procedures shall be used to determine conformance with the requirements of paragraph 5. For NO_x analyzers that oxidize nitric oxide (NO) to nitrogen dioxide (NO_2), the response time test under paragraph 6.3 of this method shall be performed using nitric oxide (NO) span gas. Other tests for NO_x continuous monitoring systems under paragraphs 6.1 and 6.2 and all tests for sulfur dioxide systems shall be performed using the pollutant span gas specified by each subpart.

6.1 Calibration Error Test Procedure. Set up and calibrate the complete continuous monitoring system according to the manufacturer's written instructions. This may be accomplished either in the laboratory or in the field.

6.1.1 Calibration Gas Analyses. Triplicate analyses of the gas mixtures shall be performed within two weeks prior to use using Reference Methods 6 for SO_2 and 7 for NO_x. Analyze each calibration gas mixture (50%, 90%) and record the results on the example sheet shown in Figure 2-1. Each sample test result must be within 20 percent of the averaged result or the tests shall be repeated. This step may be omitted for non-extractive monitors where dynamic calibration gas mixtures are not used (6.1.2).

6.1.2 Calibration Error Test Procedure. Make a total of 15 nonconsecutive measurements by alternately using zero gas and each calibration gas mixture concentration (e.g., 0%, 50%, 0%, 90%, 50%, 90%, 50%, 0%, etc.). ~~For nonextractive continuous monitoring systems, this test procedure may be performed by using two or more calibration gas~~

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cells whose concentrations are certified by the manufacturer to be functionally equivalent to these gas concentrations Convert the continuous monitoring system output readings to ppm and record the results on the example sheet shown in Figure 2-2.

6.2 Field Test for Accuracy (Relative), Zero Drift, and Calibration Drift. Install and operate the continuous monitoring system in accordance with the manufacturer's written instructions and drawings as follows:

6.2.1 Conditioning Period. Offset the zero setting at least 10 percent of the span so that negative zero drift can be quantified. Operate the system for an initial 168-hour conditioning period in normal operating manner.

6.2.2 Operational Test Period Operate the continuous monitoring system for an additional 168-hour period retaining the zero offset. The system shall monitor the source effluent at all times except when being zeroed, calibrated, or backpurged.

6.2.2.1 Field Test for Accuracy (Relative). For continuous monitoring systems employing extractive sampling, the probe tip for the continuous monitoring system and the probe tip for the Reference Method sampling train should be placed at adjacent locations in the duct. For NO_x continuous monitoring systems, make 27 NO_x concentration measurements, divided into nine sets, using the applicable reference method. No more than one set of tests, consisting of three individual measurements, shall be performed in any one hour. All individual measurements of each set shall be performed concurrently, or within a three-minute interval and the results averaged. For SO_2 continuous monitoring systems, make nine SO_2 concentration measurements using the applicable reference method. No more than one measurement shall be performed in any one hour. Record the reference method test data and the continuous monitoring system concentrations on the example data sheet shown in Figure 2-3.

6.2.2.2 Field Test for Zero Drift and Calibration Drift. For extractive systems, determine the values given by zero and span gas pollutant concentrations at two-hour intervals until 15 sets of data are obtained. For nonextractive measurement systems, the zero value may be determined by mechanically producing a zero condition that provides a system check of the analyzer internal mirrors and all electronic circuitry including the radiation source and detector assembly or by inserting three or more calibration gas cells and computing the zero point from the upscale measurements. If this latter technique is used, a graph(s) must be retained by the owner or operator for each measurement system that shows the relationship between the upscale measurements and the zero point. The span of the system shall be checked by using a calibration gas cell certified by the manufacturer to be functionally equivalent to 50 percent of span concentration. Record the zero and span measurements (or the computed zero drift) on the example data sheet shown in Figure 2-4. The two-hour periods over which measurements are conducted need not be consecutive but may not overlap. All measurements required under this paragraph may be conducted concurrent with tests under paragraph 6.2.2.1.

6.2.2.3 Adjustments. Zero and calibration corrections and adjustments are allowed only at 24-hour intervals or at such shorter intervals as the manufacturer's written instructions specify. Automatic corrections made by the measurement system without operator intervention or initiation are allowable at any time During the entire 168-hour operational test period, record on the example sheet shown in Figure 2-5 the values given by zero and span gas pollutant concentrations before and after adjustment at 24-hour intervals.

6.3 Field Test for Response Time.

6.3.1 Scope of Test. Use the entire continuous monitoring system as installed, including sample transport lines if used. Flow rates, line diameters, pumping rates, pressures (do not allow the pressurized calibration gas to change the normal operating pressure in the sample line), etc., shall be at the nominal values for normal operation as specified in the manufacturer's written instructions. If the analyzer is used to sample more than one pollutant source (stack), repeat this test for each sampling point.

6.3.2 Response Time Test Procedure. Introduce zero gas into the continuous monitoring system sampling interface or as close to the sampling interface as possible. When the system output reading has stabilized, switch quickly to a known concentration of pollutant gas. Record the time from concentration switching to 95 percent of final stable response. For non-extractive monitors, the highest available calibration gas concentration shall be switched into and out of the sample path and response times recorded Perform this test sequence three (3) times. Record the results of each test on the example sheet shown in Figure 2-6.

7. Calculations, Data Analysis and Reporting

7.1 Procedure for determination of mean values and confidence intervals.

7.1.1 The mean value of a data set is calculated according to equation 2-1.

$$\bar{x}=\frac{1}{n}\sum_{i=1}^{n} x_i \qquad \text{Equation 2-1}$$

where:

x_i=absolute value of the measurements,

Σ=sum of the individual values,

$\bar{x}$=mean value, and

n=number of data points.

7.1.2 The 95 percent confidence interval (two-sided) is calculated according to equation 2-2:

$$C.I._{95}=\frac{t_{.975}}{n\sqrt{n-1}}\sqrt{n(\Sigma x_i^2)-(\Sigma x_i)^2}$$

Equation 2-2

where:

$\sum x_i$ = sum of all data points,

$t_{.975} = t_1 - \alpha/2$, and

$C.I._{95}$ = 95 percent confidence interval estimate of the average mean value.

Values for $t_{.975}$

n	$t_{.975}$
2	12.706
3	4.303
4	3.182
5	2.776
6	2.571
7	2.447
8	2.365
9	2.306
10	2.262
11	2.228
12	2.201
13	2.179
14	2.160
15	2.145
16	2.131

The values in this table are already corrected for n-1 degrees of freedom. Use n equal to the number of samples as data points.

7.2 Data Analysis and Reporting.

7.2.1 Accuracy (Relative). For each of the nine reference method test points, determine the average pollutant concentration reported by the continuous monitoring system. These average concentrations shall be determined from the continuous monitoring system data recorded under 7.2.2 by integrating or averaging the pollutant concentrations over each of the time intervals concurrent with each reference method testing period. Before proceeding to the next step, determine the basis (wet or dry) of the continuous monitoring system data and reference method test data concentrations. If the bases are not consistent, apply a moisture correction to either reference method concentrations or the continuous monitoring system concentrations as appropriate. Determine the correction factor by moisture tests concurrent with the reference method testing periods. Report the moisture test method and the correction procedure employed. For each of the nine test runs determine the difference for each test run by subtracting the respective reference method test concentrations (use average of each set of three measurements for NO_x) from the continuous monitoring system integrated or averaged concentrations. Using these data, compute the mean difference and the 95 percent confidence interval of the differences (equations 2-1 and 2-2). Accuracy is reported as the sum of the absolute value of the mean difference and the 95 percent confidence interval of the differences expressed as a percentage of the mean reference method value. Use the example sheet shown in Figure 2-3.

7.2.2 Calibration Error. Using the data from paragraph 6.1, subtract the measured pollutant concentration determined under paragraph 6.1.1 (Figure 2-1) from the value shown by the continuous monitoring system for each of the five readings at each concentration measured under 6.1.2 (Figure 2-2). Calculate the mean of these difference values and the 95 percent confidence intervals according to equations 2-1 and 2-2. Report the calibration error (the sum of the absolute value of the mean difference and the 95 percent confidence interval) as a percentage of each respective calibration gas concentration. Use example sheet shown in Figure 2-2.

7.2.3 Zero Drift (2-hour). Using the zero concentration values measured each two hours during the field test, calculate the differences between consecutive two-hour readings expressed in ppm. Calculate the mean difference and the confidence interval using equations 2-1 and 2-2. Report the zero drift as the sum of the absolute mean value and the confidence interval as a percentage of span. Use example sheet shown in Figure 2-4.

7.2.4 Zero Drift (24-hour). Using the zero concentration values measured every 24 hours during the field test, calculate the differences between the zero point after zero adjustment and the zero value 24 hours later just prior to zero adjustment. Calculate the mean value of these points and the confidence interval using equations 2-1 and 2-2. Report the zero drift (the sum of the absolute mean and confidence interval) as a percentage of span. Use example sheet shown in Figure 2-5.

7.2.5 Calibration Drift (2-hour). Using the calibration values obtained at two-hour intervals during the field test, calculate the differences between consecutive two-hour readings expressed as ppm. These values should be corrected for the corresponding zero drift during that two-hour period. Calculate the mean and confidence interval of these corrected difference values using equations 2-1 and 2-2. Do not use the differences between non-consecutive readings. Report the calibration drift as the sum of the absolute mean and confidence interval as a percentage of span. Use example sheet shown in Figure 2-4.

7.2.6 Calibration Drift (24-hour). Using the calibration values measured every 24 hours during the field test, calculate the differences between the calibration concentration reading after zero and calibration adjustment, and the calibration concentration reading 24 hours later after zero adjustment but before calibration adjustment. Calculate the mean value of these differences and the confidence interval using equations 2-1 and 2-2. Report the calibration drift (the sum of the absolute mean and confidence interval) as a percentage of span. Use the example sheet shown in Figure 2-5.

7.2.7 Response Time. Using the charts from paragraph 6.3, calculate the time interval from concentration switching to 95 percent to the final stable value for all upscale and downscale tests. Report the mean of the three upscale test times and the mean of the three downscale test times. The two average times should not differ by more than 15 percent of the slower time. Report the slower time as the system response time. Use the example sheet shown in Figure 2-6.

7.2.8 Operational Test Period. During the 168-hour performance and operational test period, the continuous monitoring system shall not require any corrective maintenance, repair, replacement, or adjustment other than that clearly specified as required in the operation and maintenance manuals as routine and expected during a one-week period. If the continuous monitoring system operates within the specified performance parameters and does not require corrective maintenance, repair, replacement or adjustment other than as specified above during the 168-hour test period, the operational period will be successfully concluded. Failure of the continuous monitoring system to meet this requirement shall call for a repetition of the 168-hour test period. Portions of the test which were satisfactorily completed need not be repeated. Failure to meet any performance specifications shall call for a repetition of the one-week performance test period and that portion of the testing which is related to the failed specification. All maintenance and adjustments required shall be recorded. Output readings shall be recorded *before* and *after* all adjustments.

8. References.

8.1 "Monitoring Instrumentation for the Measurement of Sulfur Dioxide in Stationary Source Emissions," Environmental Protection Agency, Research Triangle Park, N.C., February 1973.

8.2 "Instrumentation for the Determination of Nitrogen Oxides Content of Stationary Source Emissions," Environmental Protection Agency, Research Triangle Park, N.C., Volume 1, APTD-0847, October 1971; Volume 2, APTD-0942, January 1972.

8.3 "Experimental Statistics," Department of Commerce, Handbook 91, 1963, pp 3-31, paragraphs 3-3.1.4.

8.4 "Performance Specifications for Stationary-Source Monitoring Systems for Gases and Visible Emissions," Environmental Protection Agency, Research Triangle Park, N.C., EPA-650/2-74-013, January 1974.

Date ________ Reference Method Used ____

Mid-Range Calibration Gas Mixture

Sample 1 ________ ppm

Sample 2 ________ ppm

Sample 3 ________ ppm

Average ________ ppm

High-Range (span) Calibration Gas Mixture

Sample 1 ________ ppm

Sample 2 ________ ppm

Sample 3 ________ ppm

Average ________ ppm

Figure 2-1. Analysis of Calibration Gas Mixtures

Calibration Gas Mixture Data (From Figure 2-1)

Mid (50%) _____ ppm High (90%) _____ ppm

Run #	Calibration Gas Concentration, ppm	Measurement System Reading, ppm	Differences,[1] ppm
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

	Mid	High
Mean difference	_____	_____
Confidence interval	± _____	± _____
Calibration error = $\frac{\text{Mean Difference}^2 + \text{C.I.}}{\text{Average Calibration Gas Concentration}} \times 100$	_____ %	_____ %

[1]Calibration gas concentration - measurement system reading

[2]Absolute value

Figure 2-2. Calibration Error Determination

Test No.	Date and Time	Reference Method Samples					Analyzer 1-Hour Average (ppm)*		Difference (ppm)	
		SO_2 Sample 1 (ppm)	NO Sample 1 (ppm)	NO Sample 2 (ppm)	NO Sample 3 (ppm)	NO Sample Average (ppm)	SO_2	NO_x	SO_2	NO_x
1										
2										
3										
4										
5										
6										
7										
8										
9										

Mean reference method test value (SO_2) ______ Mean reference method test value (NO_x) ______ Mean of the differences ______

95% Confidence Intervals = ± ______ ppm (SO_2) = ± ______ ppm (NO_x)

Accuracies = $\frac{\text{Mean of the differences} + \text{95\% confidence interval}}{\text{Mean reference method value}}$ x 100 = ____% (SO_2) = ____% (NO_x)

* Explain and report method used to determine integrated averages

Figure 2-3. Accuracy Determination (SO_2 and NO_x)

Data Set No.	Time Begin	Time End	Date	Zero Reading	Zero Drift (ΔZero)	Span Reading	Span Drift (ΔSpan)	Calibration Drift (Span- Zero)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Zero Drift = [Mean Zero Drift* ______ + CI (Zero) ______] ÷ [Span] x 100 = ______.
Calibration Drift = [Mean Span Drift* ______ + CI (Span) ______] ÷ [Span] x 100 = ______.
*Absolute Value.

Figure 2-4. Zero and Calibration Drift (2 Hour)

Date and Time	Zero Reading	Zero Drift (ΔZero)	Span Reading (After zero adjustment)	Calibration Drift (ΔSpan)

Zero Drift = [Mean Zero Drift* ______ + C.I. (Zero) ______]

÷ [Instrument Span] x 100 = ______.

Calibration Drift = [Mean Span Drift* ______ + C.I. (Span) ______]

÷ [Instrument Span] x 100 = ______.

* Absolute value

Figure 2-5. Zero and Calibration Drift (24-hour)

Date of Test ____________

Span Gas Concentration ________ppm

Analyzer Span Setting ________ppm

Upscale	1 ________seconds	
	2 ________seconds	
	3 ________seconds	
	Average upscale response ________seconds	
Downscale	1 ________seconds	
	2 ________seconds	
	3 ________seconds	
	Average downscale response ______seconds	

System average response time (slower time) = _______seconds.

$$\text{\%deviation from slower system average response} = \left[\frac{\text{average upscale minus average downscale}}{\text{slower time}}\right] \times 100\% = \_\_\_\_.$$

CO2 & O2

Figure 2-6. Response Time

Performance Specification 3—Performance specifications and specification test procedures for monitors of CO_2 and O_2 from stationary sources.

1. Principle and Applicability.

1.1 *Principle.* Effluent gases are continuously sampled and are analyzed for carbon dioxide or oxygen by a continuous monitoring system. Tests of the system are performed during a minimum operating period to determine zero drift, calibration drift, and response time characteristics.

1.2 *Applicability.* This performance specification is applicable to evaluation of continuous monitoring systems for measurement of carbon dioxide or oxygen. These specifications contain test procedures, installation requirements, and data computation procedures for evaluating the acceptability of the continuous monitoring systems subject to approval by the Administrator. Sampling may include either extractive or non-extractive (in-situ) procedures.

2. Apparatus.

2.1 Continuous Monitoring System for Carbon Dioxide or Oxygen.

2.2 *Calibration Gas Mixtures.* Mixture of known concentrations of carbon dioxide or oxygen in nitrogen or air. Midrange and 90 percent of span carbon dioxide or oxygen concentrations are required. The 90 percent of span gas mixture is to be used to set and check the analyzer span and is referred to as span gas. For oxygen analyzers, if the span is higher than 21 percent O_2, ambient air may be used in place of the 90 percent of span calibration gas mixture. Triplicate analyses of the gas mixture (except ambient air) shall be performed within two weeks prior to use using Reference Method 3 of this part.

2.3 *Zero Gas.* A gas containing less than 100 ppm of carbon dioxide or oxygen.

2.4 *Data Recorder.* Analog chart recorder or other suitable device with input voltage range compatible with analyzer system output. The resolution of the recorder's data output shall be sufficient to allow completion of the test procedures within this specification.

3. Definitions.

3.1 *Continuous Monitoring System.* The total equipment required for the determination of carbon dioxide or oxygen in a given source effluent. The system consists of three major subsystems:

3.1.1 *Sampling Interface.* That portion of the continuous monitoring system that performs one or more of the following operations: Delineation, acquisition, transportation, and conditioning of a sample of the source effluent or protection of the analyzer from the hostile aspects of the sample or source environment.

3.1.2 Analyzer. That portion of the continuous monitoring system which senses the pollutant gas and generates a signal output that is a function of the pollutant concentration.

3.1.3 Data Recorder. That portion of the continuous monitoring system that provides a permanent record of the output signal in terms of concentration units.

3.2 Span. The value of oxygen or carbon dioxide concentration at which the continuous monitoring system is set that produces the maximum data display output. For the purposes of this method, the span shall be set no less than 1.5 to 2.5 times the normal carbon dioxide or normal oxygen concentration in the stack gas of the affected facility.

3.3 Midrange. The value of oxygen or carbon dioxide concentration that is representative of the normal conditions in the stack gas of the affected facility at typical operating rates.

3.4 Zero Drift. The change in the continuous monitoring system output over a stated period of time of normal continuous operation when the carbon dioxide or oxygen concentration at the time for the measurements is zero.

3.5 Calibration Drift. The change in the continuous monitoring system output over a stated time period of normal continuous operation when the carbon dioxide or oxygen continuous monitoring system is measuring the concentration of span gas.

3.6 Operational Test Period. A minimum period of time over which the continuous monitoring system is expected to operate within certain performance specifications without unscheduled maintenance, repair, or adjustment.

3.7 Response time. The time interval from a step change in concentration at the input to the continuous monitoring system to the time at which 95 percent of the corresponding final value is displayed on the continuous monitoring system data recorder.

4. Installation Specification.

Oxygen or carbon dioxide continuous monitoring systems shall be installed at a location where measurements are directly representative of the total effluent from the affected facility or representative of the same effluent sampled by a SO_2 or NO_x continuous monitoring system. This requirement shall be complied with by use of applicable requirements in Performance Specification 2 of this appendix as follows:

4.1 Installation of Oxygen or Carbon Dioxide Continuous Monitoring Systems Not Used to Convert Pollutant Data. A sampling location shall be selected in accordance with the procedures under paragraphs 4.2.1 or 4.2.2, or Performance Specification 2 of this appendix.

4.2 Installation of Oxygen or Carbon Dioxide Continuous Monitoring Systems Used to Convert Pollutant Continuous Monitoring System Data to Units of Applicable Standards. The diluent continuous monitoring system (oxygen or carbon dioxide) shall be installed at a sampling location where measurements that can be made are representative of the effluent gases sampled by the pollutant continuous monitoring system(s). Conformance with this requirement may be accomplished in any of the following ways:

4.2.1 The sampling location for the diluent system shall be near the sampling location for the pollutant continuous monitoring system such that the same approximate point(s) (extractive systems) or path (in-situ systems) in the cross section is sampled or viewed.

4.2.2 The diluent and pollutant continuous monitoring systems may be installed at different locations if the effluent gases at both sampling locations are nonstratified as determined under paragraphs 4.1 or 4.3, Performance Specification 2 of this appendix and there is no in-leakage occurring between the two sampling locations. If the effluent gases are stratified at either location, the procedures under paragraph 4.2.2, Performance Specification 2 of this appendix shall be used for installing continuous monitoring systems at that location.

5. Continuous Monitoring System Performance Specifications.

The continuous monitoring system shall meet the performance specifications in Table 3-1 to be considered acceptable under this method.

6. Performance Specification Test Procedures.

The following test procedures shall be used to determine conformance with the requirements of paragraph 4. Due to the wide variation existing in analyzer designs and principles of operation, these procedures are not applicable to all analyzers. Where this occurs, alternative procedures, subject to the approval of the Administrator, may be employed. Any such alternative procedures must fulfill the same purposes (verify response, drift, and accuracy) as the following procedures, and must clearly demonstrate conformance with specifications in Table 3-1.

6.1 Calibration Check. Establish a calibration curve for the continuous monitoring system using zero, midrange, and span concentration gas mixtures. Verify that the resultant curve of analyzer reading compared with the calibration gas value is consistent with the expected response curve as described by the analyzer manufacturer. If the expected response curve is not produced, additional calibration gas measurements shall be made, or additional steps undertaken to verify the accuracy of the response curve of the analyzer.

6.2 Field Test for Zero Drift and Calibration Drift. Install and operate the continuous monitoring system in accordance with the manufacturer's written instructions and drawings as follows:

TABLE 3-1.—*Performance specifications*

Parameter	*Specification*
1. Zero drift (2 h) [1]	≤0.4 pct O_2 or CO_2
2. Zero drift (24 h) [1]	≤0.5 pct O_2 or CO_2
3. Calibration drift (2 h) [1]	≤0.4 pct O_2 or CO_2
4. Calibration drift (24 h) [1]	≤0.5 pct O_2 or CO_2
5. Operational period	168 h minimum
6. Response time	10 min.

[1] Expressed as sum of absolute mean value plus 95 pct confidence interval of a series of tests.

6.2.1 Conditioning Period. Offset the zero setting at least 10 percent of span so that negative zero drift may be quantified. Operate the continuous monitoring system for an initial 168-hour conditioning period in a normal operational manner.

6.2.2. Operational Test Period. Operate the continuous monitoring system for an additional 168-hour period maintaining the zero offset. The system shall monitor the source effluent at all times except when being zeroed, calibrated, or backpurged.

6.2.3 Field Test for Zero Drift and Calibration Drift. Determine the values given by zero and midrange gas concentrations at two-hour intervals until 15 sets of data are obtained. For non-extractive continuous monitoring systems, determine the zero value given by a mechanically produced zero condition or by computing the zero value from upscale measurements using calibrated gas cells certified by the manufacturer. The midrange checks shall be performed by using certified calibration gas cells functionally equivalent to less than 50 percent of span. Record these readings on the example sheet shown in Figure 3-1. These two-hour periods need not be consecutive but may not overlap. In-situ CO_2 or O_2 analyzers which cannot be fitted with a calibration gas cell may be calibrated by alternative procedures acceptable to the Administrator. Zero and calibration corrections and adjustments are allowed only at 24-hour intervals or at such shorter intervals as the manufacturer's written instructions specify. Automatic corrections made by the continuous monitoring system without operator intervention or initiation are allowable at any time. During the entire 168-hour test period, record the values given by zero and span gas concentrations before and after adjustment at 24-hour intervals in the example sheet shown in Figure 3-2.

6.3 Field Test for Response Time.

6.3.1 Scope of Test.

This test shall be accomplished using the continuous monitoring system as installed, including sample transport lines if used. Flow rates, line diameters, pumping rates, pressures (do not allow the pressurized calibration gas to change the normal operating pressure in the sample line), etc., shall be at the nominal values for normal operation as specified in the manufacturer's written instructions. If the analyzer is used to sample more than one source (stack), this test shall be repeated for each sampling point.

6.3.2 Response Time Test Procedure.

Introduce zero gas into the continuous monitoring system sampling interface or as close to the sampling interface as possible. When the system output reading has stabilized, switch quickly to a known concentration of gas at 90 percent of span. Record the time from concentration switching to 95 percent of final stable response. After the system response has stabilized at the upper level, switch quickly to a zero gas. Record the time from concentration switching to 95 percent of final stable response. Alternatively, for nonextractive continuous monitoring systems, the highest available calibration gas concentration shall be switched into and out of the sample path and response times recorded. Perform this test sequence three (3) times. For each test, record the results on the data sheet shown in Figure 3-3.

7. Calculations, Data Analysis, and Reporting.

7.1 Procedure for determination of mean values and confidence intervals.

7.1.1 The mean value of a data set is calculated according to equation 3-1.

$$\bar{x}=\frac{1}{n}\sum_{i=1}^{n}x_i \qquad \text{Equation 3-1}$$

where:

x_i = absolute value of the measurements,
Σ = sum of the individual values,
$\bar{x}$ = mean value, and
n = number of data points

7.2.1 The 95 percent confidence interval (two-sided) is calculated according to equation 3-2:

$$C.I._{95}=\frac{t_{.975}}{n\sqrt{n-1}}\sqrt{n(\Sigma x_i^2)-(\Sigma x_i)^2} \qquad \text{Equation 3-2}$$

where:

ΣX = sum of all data points,
$t_{.975}=t_1-\alpha/2$, and
$C.I._{95}$ = 95 percent confidence interval estimates of the average mean value.

Values for $t_{.975}$

n	$t_{.975}$
2	12.706
3	4.303
4	3.182
5	2.776
6	2.571
7	2.447
8	2.365
9	2.306
10	2.262
11	2.228
12	2.201
13	2.179
14	2.160
15	2.145
16	2.131

The values in this table are already corrected for n-1 degrees of freedom. Use n equal to the number of samples as data points.

7.2 Data Analysis and Reporting.

7.2.1 Zero Drift (2-hour). Using the zero concentration values measured each two hours during the field test, calculate the differences between the consecutive two-hour readings expressed in ppm. Calculate the mean difference and the confidence interval using equations 3-1 and 3-2. Record the sum of the absolute mean value and the confidence interval on the data sheet shown in Figure 3-1.

7.2.2 Zero Drift (24-hour). Using the zero concentration values measured every 24 hours during the field test, calculate the differences between the zero point after zero adjustment and the zero value 24 hours later just prior to zero adjustment. Calculate the mean value of these points and the confidence interval using equations 3-1 and 3-2. Record the zero drift (the sum of the absolute mean and confidence interval) on the data sheet shown in Figure 3-2.

7.2.3 Calibration Drift (2-hour). Using the calibration values obtained at two-hour intervals during the field test, calculate the differences between consecutive two-hour readings expressed as ppm. These values should be corrected for the corresponding zero drift during that two-hour period. Calculate the mean and confidence interval of these corrected difference values using equations 3-1 and 3-2. Do not use the differences between non-consecutive readings. Record the sum of the absolute mean and confidence interval upon the data sheet shown in Figure 3-1.

7.2.4 Calibration Drift (24-hour). Using the calibration values measured every 24 hours during the field test, calculate the differences between the calibration concentration reading after zero and calibration adjustment and the calibration concentration reading 24 hours later after zero adjustment but before calibration adjustment. Calculate the mean value of these differences and the confidence interval using equations 3-1 and 3-2. Record the sum of the absolute mean and confidence interval on the data sheet shown in Figure 3-2.

7.2.5 Operational Test Period. During the 168-hour performance and operational test period, the continuous monitoring system shall not receive any corrective maintenance, repair, replacement, or adjustment other than that clearly specified as required in the manufacturer's written operation and maintenance manuals as routine and expected during a one-week period. If the continuous monitoring system operates within the specified performance parameters and does not require corrective maintenance, repair, replacement or adjustment other than as specified above during the 168-hour test period, the operational period will be successfully concluded. Failure of the continuous monitoring system to meet this requirement shall call for a repetition of the 168 hour test period. Portions of the test which were satisfactorily completed need not be repeated. Failure to meet any performance specifications shall call for a repetition of the one-week performance test period and that portion of the testing which is related to the failed specification. All maintenance and adjustments required shall be recorded. Output readings shall be recorded before and after all adjustments.

7.2.6 Response Time. Using the data developed under paragraph 6.3, calculate the time interval from concentration switching to 95 percent to the final stable value for all upscale and downscale tests. Report the mean of the three upscale test times and the mean of the three downscale test times. The two average times should not differ by more than 15 percent of the slower time. Report the slower time as the system response time. Record the results on Figure 3-3.

8. References.

8.1 "Performance Specifications for Stationary Source Monitoring Systems for Gases and Visible Emissions," Environmental Protection Agency, Research Triangle Park, N.C., EPA-650/2-74-013, January 1974.

8.2 "Experimental Statistics," Department of Commerce, National Bureau of Standards Handbook 91, 1963, pp. 3-31, paragraphs 3-3.1.4.

Data Set No.	Time Begin	Time End	Date	Zero Reading	Zero Drift (ΔZero)	Span Reading	Span Drift (ΔSpan)	Calibration Drift (ΔSpan-ΔZero)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								

Zero Drift = [Mean Zero Drift* ________ + CI (Zero) ________] = ________.
Calibration Drift = [Mean Span Drift* ________ + CI (Span ________] = ________.
*Absolute Value.

Figure 3-1. Zero and Calibration Drift (2 Hour).

Date and Time	Zero Reading	Zero Drift (ΔZero)	Span Reading (After zero adjustment)	Calibration Drift (ΔSpan)

Zero Drift = [Mean Zero Drift* ______ + C.I. (Zero) ______]

= ______.

Calibration Drift = [Mean Span Drift* ______ + C.I. (Span) ______]

= ______.

* Absolute value

Figure 3-2. Zero and Calibration Drift (24-hour)

Date of Test ____________

Span Gas Concentration ________ ppm

Analyzer Span Setting ________ ppm

Upscale
1. ________ seconds
2. ________ seconds
3. ________ seconds

Average upscale response ________ seconds

Downscale
1. ________ seconds
2. ________ seconds
3. ________ seconds

Average downscale response ________ seconds

System average response time (slower time) = ________ seconds

% deviation from slower system average response = $\frac{\text{average upscale minus average downscale}}{\text{slower time}}$ x 100%

= ________.

Figure 3-3. Response

[40 FR 46259, Oct. 6, 1975, 40 FR 59204, 59205, Dec. 22, 1975, as amended at 42 FR 5937, Jan. 31, 1977]

APPENDIX C—DETERMINATION OF EMISSION RATE CHANGE

1. *Introduction.*

1.1 The following method shall be used to determine whether a physical or operational change to an existing facility resulted in an increase in the emission rate to the atmosphere. The method used is the Student's *t* test, commonly used to make inferences from small samples.

2. *Data.*

2.1 Each emission test shall consist of *n* runs (usually three) which produce *n* emission rates. Thus two sets of emission rates are generated, one before and one after the change, the two sets being of equal size.

2.2 When using manual emission tests, except as provided in § 60.8(b) of this part, the reference methods of Appendix A to this part shall be used in accordance with the procedures specified in the applicable subpart both before and after the change to obtain the data.

2.3 When using continuous monitors, the facility shall be operated as if a manual emission test were being performed. Valid data using the averaging time which would be required if a manual emission test were being conducted shall be used.

3. *Procedure.*

3.1 Subscripts a and b denote prechange and postchange respectively.

3.2 Calculate the arithmetic mean emission rate, $\bar{E}$, for each set of data using Equation 1.

$$\bar{E}=\frac{\sum_{i=1}^{n} E_i}{n}=\frac{E_1+E_2 \ldots +E_n}{n} \quad (1)$$

where:

E_i=Emission rate for the *i* th run.
n=number of runs

3.3 Calculate the sample variance, S^2, for each set of data using Equation 2.

$$S^2=\frac{\sum_{i=1}^{n}(E_i-\bar{E})^2}{n-1}=\frac{\sum_{i=1}^{n}E_i^2-\left(\sum_{i=1}^{n}E_i\right)^2/n}{n-1} \quad (2)$$

3.4 Calculate the pooled estimate, S_p, using Equation 3.

$$S_p=\left[\frac{(n_a-1)\,S_a^2+(n_b-1)\,S_b^2}{n_a+n_b-2}\right]^{1/2} \quad (3)$$

3.5 Calculate the test statistic, *t*, using Equation 4.

APPENDIX E

TABULATION OF HOURLY EMISSIONS DATA

24 HOUR DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/ 1/79		55.4	6.6	11.3	28.	529.	35.	662.	12.	389.
6/ 2/79		19.8	8.3	11.0	21.	455.	30.	644.	11.	378.
6/ 3/79		14.4	9.0	.0	16.	392.	24.	588.	9.	345.
6/ 4/79		34.7	8.5	.0	18.	389.	26.	559.	9.	328.
6/ 5/79		19.7	9.5	10.3	20.	309.	32.	485.	11.	285.
6/ 6/79		22.6	8.1	10.4	21.	366.	30.	514.	11.	302.
6/ 7/79		29.4	8.3	10.8	31.	383.	44.	544.	16.	320.
6/ 8/79		30.3	8.1	10.5	28.	410.	40.	572.	14.	336.
6/ 9/79		19.9	8.4	10.1	27.	406.	38.	581.	14.	341.
6/10/79		18.4	8.6	10.0	33.	396.	48.	576.	17.	338.
6/11/79		18.6	8.5	10.3	38.	388.	55.	561.	20.	329.
6/12/79		30.5	8.8	10.4	0.	408.	0.	602.	0.	353.
6/13/79		23.3	9.0	10.6	0.	397.	0.	599.	0.	352.
6/14/79		38.6	8.5	10.5	49.	444.	71.	641.	25.	376.
6/15/79		18.3	9.2	10.2	86.	324.	131.	495.	47.	291.
6/16/79		21.8	9.1	10.2	0.	364.	0.	551.	0.	323.
6/17/79		19.4	8.8	10.3	0.	356.	0.	526.	0.	309.
6/18/79		21.7	8.8	10.3	0.	357.	0.	530.	0.	311.
6/19/79		20.7	8.9	10.0	35.	358.	52.	532.	19.	312.
6/20/79		18.9	9.0	10.0	33.	361.	50.	544.	18.	319.
6/21/79		31.7	8.8	10.7	21.	431.	31.	637.	11.	374.
6/22/79		18.8	8.6	10.5	35.	450.	51.	656.	18.	385.
6/23/79		22.6	8.4	10.6	36.	449.	52.	641.	18.	377.
6/24/79		20.3	8.6	10.2	34.	395.	50.	577.	18.	339.
6/25/79		23.1	9.0	10.2	36.	410.	54.	616.	19.	361.
6/26/79		18.8	8.9	10.3	37.	427.	55.	639.	20.	375.
6/27/79		20.2	8.6	10.3	15.	426.	22.	620.	8.	364.
6/28/79		21.0	8.6	10.5	25.	473.	37.	686.	13.	403.
6/29/79		19.8	8.5	10.4	34.	504.	48.	728.	17.	427.
6/30/79		19.2	8.8	10.2	30.	438.	44.	647.	16.	380.
7/ 1/79		17.6	8.8	9.9	33.	455.	48.	673.	17.	395.
7/ 2/79		18.9	8.5	10.3	33.	436.	47.	629.	17.	369.
7/ 3/79		37.2	8.3	10.6	19.	487.	28.	694.	10.	407.
7/ 4/79		19.8	8.6	10.3	35.	424.	51.	618.	18.	363.
7/ 5/79		20.7	8.5	10.3	15.	416.	21.	599.	7.	352.
7/ 6/79		22.3	8.4	10.3	21.	385.	30.	550.	11.	323.
7/ 7/79		19.1	8.5	10.2	35.	384.	50.	556.	18.	326.
7/ 8/79		17.7	8.7	9.9	47.	351.	69.	514.	25.	302.
7/ 9/79		18.4	8.4	10.3	80.	366.	115.	526.	41.	309.
7/10/79		37.6	9.0	9.9	92.	453.	139.	681.	50.	400.
7/11/79		45.6	7.8	11.2	75.	519.	102.	708.	37.	416.
7/12/79		33.0	8.0	10.6	84.	407.	117.	566.	42.	332.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
6/ 1/79	1600	59.2	7.5	11.1	28.	578.	37.	772.	13.	453.
6/ 1/79	1700	56.3	6.7	11.3	31.	565.	39.	712.	14.	418.
6/ 1/79	1800	55.1	6.3	11.3	29.	531.	36.	651.	13.	382.
6/ 1/79	1900	55.1	6.3	11.3	30.	518.	36.	636.	13.	373.
6/ 1/79	2000	52.7	6.3	11.2	30.	514.	37.	630.	13.	370.
6/ 1/79	2100	50.4	6.4	11.2	30.	490.	37.	605.	13.	355.
6/ 1/79	2200	58.0	6.4	11.3	27.	523.	34.	646.	12.	379.
6/ 1/79	2300	56.3	6.6	11.3	24.	523.	30.	655.	11.	384.
6/ 1/79	2400	55.7	6.9	11.3	22.	516.	28.	660.	10.	387.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CH PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/ 2/79	100	39.8	7.4	11.0	19.	501.	25.	665.	9.	390.
6/ 2/79	200	17.6	8.5	9.9	18.	428.	27.	618.	9.	363.
6/ 2/79	300	15.2	9.4	9.9	17.	417.	26.	650.	9.	381.
6/ 2/79	400	15.2	9.5	.0	15.	418.	23.	656.	8.	385.
6/ 2/79	500	15.8	9.6	.0	15.	414.	24.	655.	8.	385.
6/ 2/79	600	15.8	9.6	.0	13.	415.	21.	658.	8.	386.
6/ 2/79	700	15.8	9.2	.0	13.	416.	19.	636.	7.	373.
6/ 2/79	800	16.4	8.9	.0	12.	413.	18.	616.	7.	361.
6/ 2/79	900	16.4	9.1	.0	13.	430.	20.	652.	7.	383.
6/ 2/79	1000	15.8	9.2	.0	16.	443.	24.	678.	9.	398.
6/ 2/79	1100	15.8	9.4	.0	15.	454.	24.	707.	8.	415.
6/ 2/79	1200	20.2	9.5	.0	22.	445.	35.	699.	13.	411.
6/ 2/79	1300	15.2	9.1	.0	23.	455.	35.	690.	12.	405.
6/ 2/79	1400	14.4	8.2	.0	24.	461.	35.	649.	12.	381.
6/ 2/79	1500	14.1	.0	13.3	19.	465.	16.	398.	6.	234.
6/ 2/79	1600	14.6	8.1	.0	25.	446.	34.	624.	12.	366.
6/ 2/79	1700	14.1	7.4	.0	27.	453.	36.	600.	13.	352.
6/ 2/79	1800	14.1	7.4	.0	27.	455.	36.	603.	13.	354.
6/ 2/79	1900	14.1	7.0	.0	28.	458.	36.	590.	13.	346.
6/ 2/79	2000	36.9	6.4	.0	28.	510.	35.	630.	13.	370.
6/ 2/79	2100	55.1	6.1	.0	29.	597.	35.	722.	12.	424.
6/ 2/79	2200	35.2	6.5	.0	28.	534.	35.	664.	13.	390.
6/ 2/79	2300	14.1	7.2	.0	29.	453.	38.	592.	14.	347.
6/ 2/79	2400	14.1	7.4	.0	25.	437.	33.	579.	12.	340.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/ 3/79	100	14.1	8.1	.0	19.	417.	26.	584.	9.	343.
6/ 3/79	200	14.1	8.6	.0	14.	413.	20.	601.	7.	353.
6/ 3/79	300	14.1	9.3	.0	12.	405.	18.	624.	7.	367.
6/ 3/79	400	14.1	10.3	.0	10.	404.	17.	682.	6.	401.
6/ 3/79	500	14.1	10.6	.0	10.	399.	17.	693.	6.	407.
6/ 3/79	600	14.1	10.6	.0	8.	395.	14.	686.	5.	403.
6/ 3/79	700	14.1	10.5	.0	6.	396.	10.	681.	4.	400.
6/ 3/79	800	14.1	10.5	.0	7.	393.	12.	676.	4.	397.
6/ 3/79	900	14.1	10.7	.0	6.	391.	11.	686.	4.	403.
6/ 3/79	1000	14.4	10.7	.0	7.	395.	12.	694.	4.	407.
6/ 3/79	1100	16.7	9.9	.0	13.	412.	21.	670.	7.	393.
6/ 3/79	1200	18.8	9.1	.0	13.	394.	19.	597.	7.	351.
6/ 3/79	1300	14.1	8.8	.0	16.	403.	24.	596.	9.	350.
6/ 3/79	1400	14.1	8.1	.0	19.	400.	26.	560.	9.	329.
6/ 3/79	1500	14.1	7.7	.0	22.	406.	30.	550.	11.	323.
6/ 3/79	1600	14.1	7.3	.0	24.	415.	32.	546.	12.	321.
6/ 3/79	1700	14.1	7.1	.0	26.	428.	33.	555.	12.	326.
6/ 3/79	1800	14.1	.0	.0	0.	0.	0.	0.	0.	0.
6/ 3/79	1900	14.1	7.8	.0	26.	379.	35.	518.	13.	304.
6/ 3/79	2000	14.1	7.7	.0	25.	378.	34.	513.	12.	301.
6/ 3/79	2100	14.1	7.7	.0	25.	366.	34.	496.	12.	291.
6/ 3/79	2200	14.1	8.0	.0	24.	354.	33.	492.	12.	289.
6/ 3/79	2300	14.1	8.3	.0	22.	341.	31.	485.	11.	285.
6/ 3/79	2400	14.1	8.7	.0	21.	334.	30.	491.	11.	288.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/ 4/79	100	14.1	8.8	.0	16.	323.	24.	478.	9.	281.
6/ 4/79	200	14.1	9.2	.0	13.	298.	21.	455.	7.	267.
6/ 4/79	300	14.1	9.5	.0	0.	315.	0.	495.	0.	291.
6/ 4/79	400	14.1	9.9	.0	10.	304.	16.	494.	6.	290.
6/ 4/79	500	14.1	10.5	.0	9.	298.	16.	513.	6.	301.
6/ 4/79	600	14.1	11.1	.0	7.	295.	13.	539.	5.	316.
6/ 4/79	700	14.1	11.7	.0	8.	293.	15.	570.	5.	335.
6/ 4/79	800	23.4	11.5	.0	8.	276.	15.	526.	5.	309.
6/ 4/79	900	43.4	10.7	.0	6.	375.	11.	658.	4.	386.
6/ 4/79	1000	54.5	10.6	.0	8.	411.	15.	714.	5.	419.
6/ 4/79	1100	60.9	10.8	.0	9.	455.	16.	807.	6.	474.
6/ 4/79	1200	60.4	10.5	.0	13.	462.	22.	795.	8.	467.
6/ 4/79	1300	60.4	8.9	.0	16.	475.	24.	708.	9.	416.
6/ 4/79	1400	60.4	6.4	.0	18.	484.	22.	598.	8.	351.
6/ 4/79	1500	57.7	5.9	.0	21.	498.	25.	595.	9.	349.
6/ 4/79	1600	51.9	5.4	.0	26.	476.	30.	549.	11.	323.
6/ 4/79	1700	48.6	5.1	.0	27.	483.	31.	547.	11.	321.
6/ 4/79	1800	43.4	4.8	.0	28.	492.	31.	547.	11.	321.
6/ 4/79	1900	38.7	6.8	.0	29.	436.	36.	554.	13.	325.
6/ 4/79	2000	35.7	6.5	.0	27.	449.	34.	558.	12.	328.
6/ 4/79	2100	31.4	6.4	.0	30.	432.	38.	533.	13.	313.
6/ 4/79	2200	28.4	6.6	.0	30.	407.	38.	509.	14.	299.
6/ 4/79	2300	19.0	7.2	.0	27.	303.	35.	396.	13.	233.
6/ 4/79	2400	15.2	8.2	.0	22.	285.	31.	402.	11.	236.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CU PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/ 5/79	100	14.4	8.8	.0	19.	266.	28.	394.	10.	231.
6/ 5/79	200	14.6	9.6	.0	15.	253.	24.	400.	8.	235.
6/ 5/79	300	15.8	10.5	.0	11.	246.	19.	423.	7.	248.
6/ 5/79	400	15.2	11.2	.0	9.	241.	18.	445.	6.	261.
6/ 5/79	500	14.6	11.7	.0	9.	239.	17.	464.	6.	273.
6/ 5/79	600	14.9	12.2	.0	8.	232.	17.	477.	6.	280.
6/ 5/79	700	16.4	12.1	.0	8.	230.	17.	468.	6.	275.
6/ 5/79	800	16.4	11.9	.0	7.	225.	14.	447.	5.	262.
6/ 5/79	900	16.4	10.8	.0	48.	114.	85.	202.	30.	119.
6/ 5/79	1000	16.4	8.9	10.1	25.	355.	38.	529.	14.	311.
6/ 5/79	1100	19.3	8.9	9.9	0.	377.	1.	562.	0.	330.
6/ 5/79	1200	22.6	8.6	10.5	27.	356.	39.	517.	14.	304.
6/ 5/79	1300	23.4	8.5	10.4	28.	352.	41.	508.	15.	298.
6/ 5/79	1400	20.8	8.2	10.5	31.	348.	44.	491.	16.	288.
6/ 5/79	1500	22.3	8.5	10.2	32.	365.	47.	527.	17.	309.
6/ 5/79	1600	28.1	8.6	10.4	27.	389.	40.	567.	14.	333.
6/ 5/79	1700	28.7	8.7	10.4	22.	396.	32.	581.	11.	341.
6/ 5/79	1800	28.4	8.8	10.2	20.	389.	30.	576.	11.	338.
6/ 5/79	1900	28.1	8.8	10.1	19.	507.	29.	750.	10.	440.
6/ 5/79	2000	24.6	9.0	9.9	22.	0.	34.	0.	12.	0.
6/ 5/79	2100	20.5	8.4	10.4	23.	0.	33.	0.	12.	0.
6/ 5/79	2200	19.0	8.1	10.7	24.	0.	34.	0.	12.	0.
6/ 5/79	2300	15.8	8.6	10.1	23.	0.	33.	0.	12.	0.
6/ 5/79	2400	15.5	8.3	10.4	25.	0.	36.	0.	13.	0.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/ 6/79	100	15.8	8.1	10.6	25.	0.	36.	0.	13.	0.
6/ 6/79	200	15.8	8.2	10.5	22.	0.	31.	0.	11.	0.
6/ 6/79	300	15.8	8.2	10.5	15.	0.	21.	0.	8.	0.
6/ 6/79	400	16.4	8.2	10.5	16.	0.	22.	0.	8.	0.
6/ 6/79	500	16.1	8.3	10.3	4.	0.	6.	0.	2.	0.
6/ 6/79	600	16.1	8.3	10.3	0.	0.	0.	0.	0.	0.
6/ 6/79	700	16.4	8.2	10.5	3.	0.	4.	0.	1.	0.
6/ 6/79	800	16.7	8.0	10.6	6.	0.	9.	0.	3.	0.
6/ 6/79	900	16.7	7.5	10.1	0.	370.	0.	494.	0.	290.
6/ 6/79	1000	16.4	8.1	10.6	33.	348.	47.	486.	17.	285.
6/ 6/79	1100	16.1	8.5	10.2	33.	370.	47.	535.	17.	314.
6/ 6/79	1200	16.1	8.5	10.2	35.	376.	51.	543.	18.	319.
6/ 6/79	1300	16.4	8.4	10.3	37.	374.	53.	536.	19.	315.
6/ 6/79	1400	19.9	8.4	10.4	37.	365.	53.	523.	19.	307.
6/ 6/79	1500	26.4	8.6	10.2	36.	380.	52.	553.	19.	325.
6/ 6/79	1600	39.6	.0	.0	0.	0.	0.	0.	0.	0.
6/ 6/79	1700	47.5	6.7	10.7	3.	378.	4.	476.	2.	280.
6/ 6/79	1800	47.5	7.4	10.7	8.	285.	11.	378.	4.	222.
6/ 6/79	1900	47.2	7.5	11.0	2.	378.	3.	505.	1.	297.
6/ 6/79	2000	36.9	7.8	11.2	29.	415.	39.	568.	14.	333.
6/ 6/79	2100	20.5	8.5	10.3	29.	374.	42.	540.	15.	317.
6/ 6/79	2200	15.5	8.6	10.2	30.	365.	44.	531.	16.	312.
6/ 6/79	2300	15.2	8.7	10.1	29.	358.	43.	525.	15.	308.
6/ 6/79	2400	15.2	8.7	10.2	29.	352.	43.	517.	15.	303.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/ 7/79	100	18.2	8.7	10.1	28.	349.	41.	513.	15.	301.
6/ 7/79	200	15.2	8.5	10.3	28.	341.	41.	492.	15.	289.
6/ 7/79	300	15.2	8.6	10.2	29.	340.	43.	495.	15.	290.
6/ 7/79	400	15.5	8.4	10.4	28.	342.	41.	490.	15.	288.
6/ 7/79	500	15.2	8.5	10.3	28.	347.	40.	501.	14.	294.
6/ 7/79	600	15.2	8.5	10.4	29.	342.	42.	493.	15.	290.
6/ 7/79	700	15.5	8.4	10.4	31.	337.	45.	483.	16.	284.
6/ 7/79	800	16.1	8.6	10.3	28.	348.	41.	506.	15.	297.
6/ 7/79	900	15.8	8.7	10.2	28.	349.	41.	512.	15.	301.
6/ 7/79	1000	.0	.0	.0	0.	0.	0.	0.	0.	0.
6/ 7/79	1100	.0	.0	.0	0.	0.	0.	0.	0.	0.
6/ 7/79	1200	.0	.0	.0	0.	0.	0.	0.	0.	0.
6/ 7/79	1300	17.9	8.8	10.5	29.	369.	43.	546.	15.	321.
6/ 7/79	1400	20.8	8.5	10.6	34.	361.	50.	522.	18.	306.
6/ 7/79	1500	39.6	7.6	11.3	28.	404.	38.	544.	14.	319.
6/ 7/79	1600	49.2	7.4	11.7	32.	354.	42.	469.	15.	276.
6/ 7/79	1700	49.2	7.8	11.5	31.	371.	43.	507.	15.	298.
6/ 7/79	1800	49.2	7.8	11.5	32.	390.	44.	533.	16.	313.
6/ 7/79	1900	49.2	7.7	11.6	33.	409.	45.	555.	16.	326.
6/ 7/79	2000	48.6	.0	.0	0.	0.	0.	0.	0.	0.
6/ 7/79	2100	48.3	8.0	11.3	35.	514.	48.	713.	17.	419.
6/ 7/79	2200	48.3	8.2	11.2	34.	509.	48.	718.	17.	421.
6/ 7/79	2300	36.9	8.8	10.6	34.	466.	50.	689.	18.	405.
6/ 7/79	2400	17.9	8.7	10.7	38.	413.	56.	606.	20.	356.

KVB11-6015-1224

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/ 8/79	100	17.9	8.6	10.7	38.	413.	55.	601.	20.	353.
6/ 8/79	200	17.9	8.7	10.7	38.	411.	55.	604.	20.	354.
6/ 8/79	300	17.9	8.6	10.7	39.	409.	56.	596.	20.	350.
6/ 8/79	400	18.2	8.6	10.7	40.	410.	59.	597.	21.	350.
6/ 8/79	500	17.6	8.6	10.6	41.	413.	60.	601.	22.	353.
6/ 8/79	600	17.9	8.7	10.6	42.	411.	61.	603.	22.	354.
6/ 8/79	700	19.6	8.4	10.8	43.	412.	61.	590.	22.	347.
6/ 8/79	800	29.9	8.9	10.5	40.	412.	60.	615.	21.	361.
6/ 8/79	900	45.4	.0	.0	0.	0.	0.	0.	0.	0.
6/ 8/79	1000	49.2	.0	10.2	3.	498.	3.	427.	1.	250.
6/ 8/79	1100	49.2	7.0	10.3	3.	504.	5.	649.	2.	381.
6/ 8/79	1200	49.2	7.0	10.4	3.	412.	4.	531.	2.	312.
6/ 8/79	1300	48.6	7.0	10.4	4.	373.	5.	480.	2.	282.
6/ 8/79	1400	48.3	6.6	10.5	4.	385.	5.	482.	2.	283.
6/ 8/79	1500	48.3	6.7	10.4	4.	412.	5.	519.	2.	305.
6/ 8/79	1600	48.3	6.8	10.4	4.	431.	5.	547.	2.	321.
6/ 8/79	1700	48.3	7.1	10.3	5.	442.	6.	573.	2.	337.
6/ 8/79	1800	29.3	8.6	10.4	44.	223.	64.	325.	23.	191.
6/ 8/79	1900	16.1	8.9	9.9	44.	401.	66.	598.	24.	351.
6/ 8/79	2000	17.6	8.4	10.6	44.	404.	63.	578.	23.	339.
6/ 8/79	2100	18.5	8.7	10.3	42.	423.	62.	621.	22.	365.
6/ 8/79	2200	18.5	8.4	10.5	43.	413.	61.	592.	22.	347.
6/ 8/79	2300	18.5	8.6	10.3	42.	411.	61.	599.	22.	352.
6/ 8/79	2400	18.2	8.6	10.3	43.	410.	62.	596.	22.	350.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/ 9/79	100	18.5	8.5	10.4	42.	412.	61.	595.	22.	349.
6/ 9/79	200	18.5	8.4	10.5	41.	402.	59.	576.	21.	338.
6/ 9/79	300	18.5	8.7	10.2	41.	408.	61.	598.	22.	351.
6/ 9/79	400	18.5	8.7	10.2	42.	401.	62.	589.	22.	346.
6/ 9/79	500	18.5	8.6	10.3	41.	398.	60.	579.	22.	340.
6/ 9/79	600	18.5	8.5	10.3	41.	402.	60.	580.	21.	341.
6/ 9/79	700	18.8	8.4	10.4	42.	394.	60.	565.	21.	332.
6/ 9/79	800	18.8	8.4	10.5	42.	397.	60.	568.	21.	333.
6/ 9/79	900	18.8	8.3	10.4	7.	0.	10.	0.	3.	0.
6/ 9/79	1000	21.4	7.4	10.2	4.	412.	5.	546.	2.	321.
6/ 9/79	1100	25.8	7.8	9.8	3.	443.	4.	605.	1.	355.
6/ 9/79	1200	25.8	7.6	9.8	3.	438.	4.	589.	1.	346.
6/ 9/79	1300	24.6	7.5	9.8	3.	439.	4.	586.	2.	344.
6/ 9/79	1400	22.6	7.7	9.8	3.	419.	4.	568.	2.	334.
6/ 9/79	1500	20.2	9.0	9.7	27.	400.	40.	602.	14.	354.
6/ 9/79	1600	19.6	8.5	10.2	30.	397.	43.	573.	15.	337.
6/ 9/79	1700	19.6	8.6	10.0	29.	406.	42.	591.	15.	347.
6/ 9/79	1800	19.9	8.6	10.1	27.	411.	40.	598.	14.	351.
6/ 9/79	1900	20.5	8.5	10.2	27.	409.	39.	591.	14.	347.
6/ 9/79	2000	19.6	8.9	9.8	30.	389.	45.	580.	16.	341.
6/ 9/79	2100	17.3	8.9	9.7	28.	394.	43.	587.	15.	345.
6/ 9/79	2200	17.0	9.1	9.5	28.	380.	42.	576.	15.	338.
6/ 9/79	2300	17.9	8.7	10.0	27.	384.	39.	563.	14.	331.
6/ 9/79	2400	18.2	.0	11.5	0.	395.	0.	338.	0.	199.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/10/79	100	18.2	8.7	10.2	26.	392.	39.	575.	14.	337.
6/10/79	200	18.2	8.7	10.2	23.	389.	34.	571.	12.	335.
6/10/79	300	17.9	8.7	10.2	24.	386.	35.	566.	13.	333.
6/10/79	400	17.9	8.6	10.3	24.	385.	35.	560.	13.	329.
6/10/79	500	18.2	8.9	10.0	22.	379.	32.	566.	12.	332.
6/10/79	600	18.8	8.6	10.3	24.	376.	35.	548.	12.	322.
6/10/79	700	19.0	8.5	10.5	25.	388.	37.	560.	13.	329.
6/10/79	800	19.0	8.7	10.3	25.	393.	36.	576.	13.	338.
6/10/79	900	19.0	7.9	10.1	30.	403.	41.	555.	15.	326.
6/10/79	1000	19.0	8.0	9.8	28.	404.	39.	561.	14.	329.
6/10/79	1100	18.8	8.7	10.1	30.	395.	43.	580.	16.	340.
6/10/79	1200	18.5	8.7	10.1	32.	397.	47.	582.	17.	342.
6/10/79	1300	18.2	7.9	9.8	28.	408.	39.	562.	14.	330.
6/10/79	1400	18.2	7.8	9.8	0.	415.	0.	567.	0.	333.
6/10/79	1500	18.2	8.7	10.0	19.	401.	28.	588.	10.	346.
6/10/79	1600	18.8	8.7	10.1	41.	407.	60.	597.	21.	351.
6/10/79	1700	18.5	8.7	10.1	42.	408.	61.	598.	22.	351.
6/10/79	1800	18.5	8.8	9.9	42.	410.	62.	606.	22.	356.
6/10/79	1900	20.2	9.0	9.7	45.	387.	68.	582.	24.	342.
6/10/79	2000	17.9	8.8	9.9	44.	405.	65.	599.	23.	352.
6/10/79	2100	18.2	8.7	10.1	44.	402.	65.	590.	23.	346.
6/10/79	2200	17.6	8.8	10.0	44.	396.	65.	586.	23.	344.
6/10/79	2300	17.6	9.0	9.9	43.	392.	65.	590.	23.	346.
6/10/79	2400	17.9	9.0	9.8	46.	381.	69.	573.	25.	337.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/11/79	100	17.0	8.5	10.4	50.	377.	72.	545.	26.	320.
6/11/79	200	17.0	8.7	10.3	50.	384.	73.	563.	26.	330.
6/11/79	300	17.6	8.8	10.1	47.	385.	70.	570.	25.	335.
6/11/79	400	17.6	8.6	10.3	50.	386.	72.	562.	26.	330.
6/11/79	500	17.9	8.5	10.4	50.	389.	72.	562.	26.	330.
6/11/79	600	20.2	8.7	10.2	48.	390.	70.	572.	25.	336.
6/11/79	700	20.8	8.7	10.4	48.	389.	70.	571.	25.	335.
6/11/79	800	20.5	8.7	10.3	49.	385.	72.	565.	26.	332.
6/11/79	900	20.8	8.3	10.5	14.	0.	20.	0.	7.	0.
6/11/79	1000	20.8	8.5	10.6	11.	388.	16.	560.	6.	329.
6/11/79	1100	20.8	8.5	10.6	25.	384.	36.	555.	13.	326.
6/11/79	1200	20.8	7.8	9.9	17.	396.	23.	541.	8.	318.
6/11/79	1300	20.5	8.2	10.7	0.	389.	0.	548.	0.	322.
6/11/79	1400	20.2	8.3	10.6	0.	403.	0.	573.	0.	337.
6/11/79	1500	16.4	8.7	10.2	0.	402.	0.	590.	0.	347.
6/11/79	1600	16.4	8.4	10.4	0.	392.	0.	561.	0.	330.
6/11/79	1700	16.4	8.5	10.3	0.	398.	0.	575.	0.	338.
6/11/79	1800	18.8	8.6	10.1	0.	387.	0.	563.	0.	331.
6/11/79	1900	17.6	8.6	10.2	0.	391.	0.	569.	0.	334.
6/11/79	2000	17.6	8.6	10.3	0.	391.	0.	568.	0.	334.
6/11/79	2100	17.6	8.5	10.5	0.	381.	0.	550.	0.	323.
6/11/79	2200	17.6	8.6	10.4	0.	379.	0.	552.	0.	324.
6/11/79	2300	17.6	8.7	10.4	0.	375.	0.	550.	0.	323.
6/11/79	2400	17.3	8.6	10.3	0.	379.	0.	552.	0.	324.

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HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/12/79	100	22.3	9.0	10.0	0.	384.	0.	577.	0.	339.
6/12/79	200	22.3	8.9	10.1	0.	382.	0.	570.	0.	335.
6/12/79	300	34.0	8.9	10.1	0.	381.	0.	568.	0.	333.
6/12/79	400	47.5	9.0	10.1	0.	378.	0.	569.	0.	334.
6/12/79	500	48.3	9.0	10.1	0.	377.	0.	567.	0.	333.
6/12/79	600	48.1	9.0	10.2	0.	370.	0.	557.	0.	327.
6/12/79	700	47.8	9.0	10.2	0.	380.	0.	572.	0.	336.
6/12/79	800	47.8	9.0	10.2	0.	382.	0.	575.	0.	338.
6/12/79	900	47.8	8.9	10.2	0.	0.	0.	0.	0.	0.
6/12/79	1000	48.1	8.8	10.2	0.	406.	0.	601.	0.	353.
6/12/79	1100	47.8	8.8	10.4	0.	402.	0.	595.	0.	350.
6/12/79	1200	31.6	8.7	10.4	0.	431.	0.	632.	0.	371.
6/12/79	1300	20.2	7.9	9.9	0.	447.	0.	615.	0.	361.
6/12/79	1400	18.2	8.7	7.1	0.	258.	0.	378.	0.	222.
6/12/79	1500	18.5	.0	10.5	0.	0.	0.	0.	0.	0.
6/12/79	1600	18.5	.0	11.1	0.	0.	0.	0.	0.	0.
6/12/79	1700	18.5	.0	11.8	0.	0.	0.	0.	0.	0.
6/12/79	1800	18.5	.0	11.3	0.	0.	0.	0.	0.	0.
6/12/79	1900	18.5	.0	11.2	0.	0.	0.	0.	0.	0.
6/12/79	2000	20.2	7.8	11.1	0.	511.	0.	698.	0.	410.
6/12/79	2100	21.4	7.8	11.2	0.	507.	0.	693.	0.	407.
6/12/79	2200	21.4	8.2	11.2	0.	490.	0.	691.	0.	406.
6/12/79	2300	22.3	8.9	11.0	0.	453.	0.	675.	0.	396.
6/12/79	2400	22.3	10.0	10.4	0.	412.	0.	676.	0.	397.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/13/79	100	19.9	9.8	10.4	0.	401.	0.	647.	0.	380.
6/13/79	200	20.5	9.7	10.4	0.	397.	0.	634.	0.	372.
6/13/79	300	21.1	9.7	10.4	0.	388.	0.	619.	0.	364.
6/13/79	400	21.1	9.7	10.4	0.	389.	0.	622.	0.	365.
6/13/79	500	21.1	9.7	10.4	0.	385.	0.	615.	0.	361.
6/13/79	600	23.4	9.8	10.3	0.	354.	0.	571.	0.	335.
6/13/79	700	27.5	9.8	10.5	0.	374.	0.	603.	0.	354.
6/13/79	800	27.5	9.6	10.6	0.	373.	0.	591.	0.	347.
6/13/79	900	27.5	8.6	10.3	0.	364.	0.	530.	0.	311.
6/13/79	1000	27.5	8.9	10.0	0.	0.	0.	0.	0.	0.
6/13/79	1100	27.5	8.7	10.3	0.	394.	0.	578.	0.	339.
6/13/79	1200	27.5	8.4	11.0	0.	442.	0.	633.	0.	371.
6/13/79	1300	27.5	8.5	11.0	0.	436.	0.	629.	0.	369.
6/13/79	1400	24.6	8.5	10.7	0.	440.	0.	635.	0.	373.
6/13/79	1500	22.0	8.6	10.8	0.	421.	0.	613.	0.	360.
6/13/79	1600	22.0	8.6	10.9	0.	429.	0.	624.	0.	366.
6/13/79	1700	21.7	8.6	10.9	0.	430.	0.	625.	0.	367.
6/13/79	1800	21.7	8.6	10.8	0.	406.	0.	591.	0.	347.
6/13/79	1900	21.4	8.9	10.4	0.	305.	0.	455.	0.	267.
6/13/79	2000	21.4	8.8	10.7	0.	415.	0.	615.	0.	361.
6/13/79	2100	21.4	8.9	10.6	0.	403.	0.	601.	0.	353.
6/13/79	2200	21.4	8.9	10.6	0.	399.	0.	596.	0.	350.
6/13/79	2300	21.1	8.9	10.6	0.	393.	0.	587.	0.	345.
6/13/79	2400	20.2	8.9	10.5	0.	392.	0.	584.	0.	343.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/14/79	100	19.9	8.9	10.5	0.	387.	0.	577.	0.	339.
6/14/79	200	19.9	9.0	10.4	0.	389.	0.	585.	0.	343.
6/14/79	300	19.9	8.9	10.4	0.	386.	0.	576.	0.	338.
6/14/79	400	19.9	8.9	10.4	0.	384.	0.	574.	0.	337.
6/14/79	500	20.2	8.9	10.4	0.	385.	0.	574.	0.	337.
6/14/79	600	23.1	8.9	10.4	0.	389.	0.	581.	0.	341.
6/14/79	700	25.8	8.9	10.5	0.	392.	0.	585.	0.	344.
6/14/79	800	27.0	8.8	10.5	0.	405.	0.	600.	0.	352.
6/14/79	900	27.0	8.6	9.6	0.	420.	0.	611.	0.	359.
6/14/79	1000	24.6	8.8	10.0	0.	340.	0.	503.	0.	295.
6/14/79	1100	17.0	8.8	9.8	0.	290.	0.	429.	0.	252.
6/14/79	1200	19.9	8.9	9.8	0.	325.	0.	485.	0.	285.
6/14/79	1300	47.8	7.8	11.3	3.	506.	4.	691.	1.	406.
6/14/79	1400	63.0	.0	.0	0.	0.	0.	0.	0.	0.
6/14/79	1500	62.7	8.5	10.3	0.	575.	0.	830.	0.	487.
6/14/79	1600	62.7	8.6	10.2	0.	590.	0.	859.	0.	504.
6/14/79	1700	62.4	8.3	10.4	0.	560.	0.	796.	0.	467.
6/14/79	1800	62.7	7.5	10.7	46.	582.	62.	777.	22.	456.
6/14/79	1900	62.4	7.1	11.1	43.	574.	56.	745.	20.	437.
6/14/79	2000	62.4	7.3	11.2	44.	549.	58.	723.	21.	425.
6/14/79	2100	61.2	7.9	11.2	53.	527.	73.	726.	26.	426.
6/14/79	2200	51.6	8.6	11.3	62.	480.	91.	698.	32.	410.
6/14/79	2300	40.4	8.6	11.3	69.	444.	100.	647.	36.	380.
6/14/79	2400	21.7	9.4	10.1	73.	321.	113.	500.	40.	293.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/15/79	100	18.8	9.4	9.9	75.	277.	117.	431.	42.	253.
6/15/79	200	15.8	9.2	10.1	77.	271.	118.	414.	42.	243.
6/15/79	300	15.8	9.5	9.8	83.	286.	130.	448.	46.	263.
6/15/79	400	15.8	9.5	9.7	87.	289.	136.	454.	49.	267.
6/15/79	500	15.8	9.4	9.8	87.	292.	135.	455.	48.	267.
6/15/79	600	15.8	9.5	9.7	89.	295.	139.	463.	50.	272.
6/15/79	700	16.4	9.3	9.9	90.	288.	139.	445.	50.	261.
6/15/79	800	17.3	9.3	9.9	91.	291.	141.	449.	50.	264.
6/15/79	900	18.8	9.2	10.1	92.	289.	141.	442.	50.	259.
6/15/79	1000	19.0	9.0	9.9	0.	290.	0.	436.	0.	256.
6/15/79	1100	19.3	9.2	10.2	0.	337.	0.	515.	0.	303.
6/15/79	1200	19.0	9.1	10.4	0.	334.	0.	507.	0.	298.
6/15/79	1300	19.0	8.9	10.6	0.	338.	0.	504.	0.	296.
6/15/79	1400	19.3	9.0	10.5	0.	345.	0.	520.	0.	305.
6/15/79	1500	19.3	9.1	10.3	0.	350.	0.	531.	0.	312.
6/15/79	1600	19.0	9.2	10.4	0.	356.	0.	545.	0.	320.
6/15/79	1700	18.8	9.2	10.4	0.	358.	0.	548.	0.	321.
6/15/79	1800	18.8	9.2	10.3	0.	361.	0.	552.	0.	324.
6/15/79	1900	21.4	9.0	10.5	0.	365.	0.	549.	0.	323.
6/15/79	2000	20.5	9.1	10.5	0.	360.	0.	546.	0.	321.
6/15/79	2100	18.8	9.1	10.4	0.	353.	0.	536.	0.	315.
6/15/79	2200	18.8	9.2	10.5	0.	352.	0.	539.	0.	316.
6/15/79	2300	18.8	9.2	10.5	0.	352.	0.	538.	0.	316.
6/15/79	2400	18.5	9.1	10.4	0.	339.	0.	514.	0.	302.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/16/79	100	18.8	9.3	10.3	0.	336.	0.	519.	0.	305.
6/16/79	200	18.8	9.3	10.3	0.	341.	0.	526.	0.	309.
6/16/79	300	18.8	9.3	10.2	0.	339.	0.	524.	0.	308.
6/16/79	400	18.8	9.3	10.1	0.	340.	0.	525.	0.	308.
6/16/79	500	18.8	9.3	10.1	0.	334.	0.	515.	0.	302.
6/16/79	600	18.8	9.2	10.1	0.	326.	0.	499.	0.	293.
6/16/79	700	19.6	9.2	10.1	0.	346.	0.	529.	0.	310.
6/16/79	800	22.6	9.2	10.2	0.	374.	0.	572.	0.	336.
6/16/79	900	23.4	9.1	10.2	0.	376.	0.	570.	0.	335.
6/16/79	1000	23.4	9.1	10.2	0.	379.	0.	574.	0.	337.
6/16/79	1100	20.5	9.2	10.2	0.	371.	0.	567.	0.	333.
6/16/79	1200	17.6	9.4	10.0	0.	340.	0.	529.	0.	311.
6/16/79	1300	17.6	9.3	10.2	0.	345.	0.	532.	0.	313.
6/16/79	1400	17.6	9.3	10.1	0.	337.	0.	521.	0.	306.
6/16/79	1500	21.1	8.8	10.2	0.	350.	0.	518.	0.	304.
6/16/79	1600	29.3	8.8	10.4	0.	404.	0.	598.	0.	351.
6/16/79	1700	29.3	8.8	10.4	0.	403.	0.	597.	0.	350.
6/16/79	1800	29.3	8.9	10.3	0.	397.	0.	593.	0.	348.
6/16/79	1900	26.1	8.9	10.3	0.	392.	0.	585.	0.	344.
6/16/79	2000	23.4	8.9	10.3	0.	402.	0.	600.	0.	352.
6/16/79	2100	23.4	8.6	10.5	0.	374.	0.	544.	0.	320.
6/16/79	2200	23.4	8.7	10.5	0.	392.	0.	575.	0.	338.
6/16/79	2300	23.4	8.8	10.4	0.	385.	0.	570.	0.	334.
6/16/79	2400	19.3	8.8	10.3	0.	358.	0.	530.	0.	311.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/17/79	100	18.8	8.9	10.3	0.	346.	0.	516.	0.	303.
6/17/79	200	18.8	8.9	10.3	0.	334.	0.	498.	0.	293.
6/17/79	300	18.8	8.9	10.2	0.	330.	0.	492.	0.	289.
6/17/79	400	18.8	8.9	10.2	0.	335.	0.	500.	0.	294.
6/17/79	500	18.8	8.9	10.2	0.	336.	0.	501.	0.	294.
6/17/79	600	18.8	8.9	10.2	0.	335.	0.	500.	0.	294.
6/17/79	700	18.8	8.9	10.2	0.	338.	0.	504.	0.	296.
6/17/79	800	19.6	8.9	10.2	0.	346.	0.	516.	0.	303.
6/17/79	900	19.9	9.0	10.1	0.	366.	0.	551.	0.	323.
6/17/79	1000	19.9	8.9	10.2	0.	362.	0.	540.	0.	317.
6/17/79	1100	19.9	8.9	10.2	0.	358.	0.	534.	0.	314.
6/17/79	1200	19.9	8.9	10.2	0.	364.	0.	543.	0.	319.
6/17/79	1300	19.9	8.9	10.0	0.	380.	0.	567.	0.	333.
6/17/79	1400	19.9	8.6	10.3	0.	400.	0.	583.	0.	342.
6/17/79	1500	19.9	8.6	10.4	0.	381.	0.	554.	0.	325.
6/17/79	1600	19.9	8.6	10.4	0.	387.	0.	563.	0.	330.
6/17/79	1700	19.9	8.7	10.4	0.	382.	0.	561.	0.	329.
6/17/79	1800	22.6	8.5	10.5	0.	361.	0.	521.	0.	306.
6/17/79	1900	18.8	8.7	10.4	0.	361.	0.	530.	0.	311.
6/17/79	2000	18.8	8.6	10.4	0.	351.	0.	511.	0.	300.
6/17/79	2100	18.8	8.6	10.4	0.	351.	0.	511.	0.	300.
6/17/79	2200	18.8	8.6	10.4	0.	351.	0.	511.	0.	300.
6/17/79	2300	19.0	8.7	10.4	0.	347.	0.	510.	0.	299.
6/17/79	2400	19.0	8.7	10.4	0.	348.	0.	511.	0.	300.

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HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/18/79	100	18.8	8.7	10.4	0.	348.	0.	511.	0.	300.
6/18/79	200	18.8	8.7	10.4	0.	341.	0.	500.	0.	293.
6/18/79	300	18.8	8.7	10.4	0.	348.	0.	510.	0.	299.
6/18/79	400	18.8	8.7	10.4	0.	352.	0.	516.	0.	303.
6/18/79	500	18.8	8.7	10.4	0.	358.	0.	525.	0.	308.
6/18/79	600	18.8	8.7	10.4	0.	353.	0.	518.	0.	304.
6/18/79	700	18.8	8.7	10.4	0.	355.	0.	521.	0.	306.
6/18/79	800	23.4	8.7	10.5	0.	385.	0.	566.	0.	332.
6/18/79	900	25.2	8.7	10.6	0.	399.	0.	585.	0.	344.
6/18/79	1000	26.4	8.7	10.5	0.	394.	0.	577.	0.	339.
6/18/79	1100	29.3	8.9	10.4	0.	382.	0.	569.	0.	334.
6/18/79	1200	23.4	9.0	10.2	0.	372.	0.	560.	0.	329.
6/18/79	1300	18.2	9.0	10.2	0.	348.	0.	523.	0.	307.
6/18/79	1400	18.2	9.1	10.0	0.	360.	0.	545.	0.	320.
6/18/79	1500	17.6	9.2	9.9	0.	354.	0.	542.	0.	318.
6/18/79	1600	17.6	9.0	10.1	0.	354.	0.	532.	0.	313.
6/18/79	1700	21.1	9.0	10.2	0.	328.	0.	494.	0.	290.
6/18/79	1800	26.4	9.0	10.2	0.	333.	0.	501.	0.	294.
6/18/79	1900	26.4	8.9	10.4	0.	339.	0.	505.	0.	297.
6/18/79	2000	23.7	8.9	10.4	0.	347.	0.	517.	0.	304.
6/18/79	2100	23.4	8.8	10.4	0.	351.	0.	520.	0.	305.
6/18/79	2200	23.4	8.8	10.4	0.	352.	0.	520.	0.	305.
6/18/79	2300	22.9	8.8	10.4	0.	358.	0.	530.	0.	311.
6/18/79	2400	22.9	8.7	10.5	0.	366.	0.	536.	0.	315.

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HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/19/79	100	21.1	8.8	10.4	0.	359.	0.	531.	0.	312.
6/19/79	200	18.8	8.9	10.2	0.	350.	0.	521.	0.	306.
6/19/79	300	18.8	8.9	10.2	0.	342.	0.	510.	0.	299.
6/19/79	400	18.8	8.9	10.2	0.	343.	0.	512.	0.	301.
6/19/79	500	18.5	8.9	10.1	0.	350.	0.	522.	0.	306.
6/19/79	600	17.9	8.9	10.1	0.	344.	0.	514.	0.	302.
6/19/79	700	19.9	8.9	10.2	0.	347.	0.	518.	0.	304.
6/19/79	800	24.6	8.8	10.2	0.	382.	0.	566.	0.	332.
6/19/79	900	27.8	8.9	10.2	0.	379.	0.	565.	0.	332.
6/19/79	1000	28.7	8.9	10.1	0.	377.	0.	562.	0.	330.
6/19/79	1100	20.8	9.0	9.9	0.	364.	0.	548.	0.	321.
6/19/79	1200	17.6	9.0	9.9	0.	359.	0.	539.	0.	317.
6/19/79	1300	17.9	9.0	9.9	0.	365.	0.	549.	0.	322.
6/19/79	1400	19.9	8.7	9.9	0.	346.	0.	507.	0.	298.
6/19/79	1500	24.0	.0	.0	0.	0.	0.	0.	0.	0.
6/19/79	1600	18.5	.0	.0	0.	0.	0.	0.	0.	0.
6/19/79	1700	16.7	9.0	9.7	26.	0.	39.	0.	14.	0.
6/19/79	1800	15.8	9.0	9.7	30.	0.	46.	0.	16.	0.
6/19/79	1900	17.6	8.9	9.9	33.	0.	49.	0.	17.	0.
6/19/79	2000	19.6	8.9	9.8	35.	0.	52.	0.	18.	0.
6/19/79	2100	24.3	8.7	10.1	38.	0.	55.	0.	20.	0.
6/19/79	2200	24.6	8.7	10.2	36.	0.	54.	0.	19.	0.
6/19/79	2300	23.4	8.7	10.1	39.	0.	57.	0.	21.	0.
6/19/79	2400	21.7	8.8	10.0	42.	0.	62.	0.	22.	0.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/20/79	100	18.8	8.8	10.0	45.	0.	67.	0.	24.	0.
6/20/79	200	18.8	8.8	10.0	46.	0.	68.	0.	24.	0.
6/20/79	300	18.8	8.8	9.9	46.	0.	68.	0.	24.	0.
6/20/79	400	17.6	9.0	9.7	47.	0.	71.	0.	25.	0.
6/20/79	500	14.4	9.4	9.2	50.	0.	78.	0.	28.	0.
6/20/79	600	17.6	9.1	9.6	49.	0.	75.	0.	27.	0.
6/20/79	700	19.9	8.8	10.0	48.	0.	71.	0.	25.	0.
6/20/79	800	20.8	8.8	10.1	48.	0.	71.	0.	25.	0.
6/20/79	900	25.5	8.7	10.2	46.	0.	67.	0.	24.	0.
6/20/79	1000	20.2	8.7	10.1	45.	0.	67.	0.	24.	0.
6/20/79	1100	19.0	8.8	10.1	45.	0.	66.	0.	24.	0.
6/20/79	1200	18.8	8.8	10.1	44.	0.	65.	0.	23.	0.
6/20/79	1300	18.8	8.8	9.8	25.	378.	37.	559.	13.	328.
6/20/79	1400	18.8	8.8	9.9	16.	386.	24.	571.	8.	335.
6/20/79	1500	18.8	8.9	10.3	11.	374.	16.	559.	6.	328.
6/20/79	1600	18.8	8.9	10.4	13.	367.	19.	547.	7.	321.
6/20/79	1700	18.2	9.2	10.3	0.	367.	0.	561.	0.	329.
6/20/79	1800	17.6	9.0	10.4	7.	350.	11.	526.	4.	309.
6/20/79	1900	17.6	8.8	10.6	21.	336.	32.	498.	11.	292.
6/20/79	2000	17.6	9.4	10.1	23.	358.	36.	557.	13.	327.
6/20/79	2100	17.6	9.5	9.9	27.	357.	42.	561.	15.	329.
6/20/79	2200	20.5	9.7	9.8	31.	364.	49.	582.	17.	341.
6/20/79	2300	21.1	9.7	9.9	30.	371.	48.	593.	17.	348.
6/20/79	2400	17.9	9.3	10.3	33.	325.	51.	501.	18.	294.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/21/79	100	17.9	9.4	10.2	32.	332.	49.	517.	18.	304.
6/21/79	200	18.8	9.4	10.4	30.	329.	47.	513.	17.	301.
6/21/79	300	18.8	9.4	10.3	27.	328.	43.	510.	15.	299.
6/21/79	400	18.8	9.5	10.0	25.	333.	40.	524.	14.	307.
6/21/79	500	19.0	9.6	10.1	24.	338.	38.	536.	14.	314.
6/21/79	600	18.8	9.7	9.9	22.	336.	35.	537.	13.	315.
6/21/79	700	18.8	9.6	10.0	22.	332.	35.	525.	12.	309.
6/21/79	800	21.1	9.4	10.3	21.	355.	33.	553.	12.	325.
6/21/79	900	24.6	9.7	10.0	1.	371.	2.	593.	1.	348.
6/21/79	1000	24.9	9.2	10.5	7.	378.	11.	579.	4.	340.
6/21/79	1100	24.3	9.0	10.5	4.	385.	6.	580.	2.	340.
6/21/79	1200	22.6	8.5	10.6	8.	357.	11.	515.	4.	302.
6/21/79	1300	25.5	8.4	10.6	9.	350.	13.	501.	5.	294.
6/21/79	1400	38.1	7.9	11.2	8.	511.	11.	704.	4.	413.
6/21/79	1500	45.7	7.8	11.4	1.	552.	1.	754.	0.	443.
6/21/79	1600	50.1	7.9	11.3	6.	559.	8.	770.	3.	452.
6/21/79	1700	50.1	8.1	11.3	24.	554.	34.	775.	12.	455.
6/21/79	1800	48.9	8.1	11.3	35.	550.	49.	769.	18.	451.
6/21/79	1900	48.1	8.1	11.3	34.	555.	48.	776.	17.	456.
6/21/79	2000	48.1	8.2	11.2	31.	530.	44.	747.	16.	438.
6/21/79	2100	48.1	8.2	11.4	32.	531.	45.	748.	16.	439.
6/21/79	2200	45.1	8.2	11.3	33.	519.	47.	732.	17.	430.
6/21/79	2300	36.9	8.3	11.2	33.	499.	47.	709.	17.	417.
6/21/79	2400	27.0	9.0	10.3	33.	470.	50.	706.	18.	415.

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HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/22/79	100	18.8	8.8	10.7	38.	466.	57.	689.	20.	404.
6/22/79	200	17.9	8.6	10.7	40.	437.	59.	636.	21.	374.
6/22/79	300	17.9	8.6	10.6	41.	440.	59.	641.	21.	376.
6/22/79	400	17.9	8.7	10.5	41.	439.	60.	645.	21.	379.
6/22/79	500	18.2	8.8	10.4	41.	441.	60.	652.	21.	3M3.
6/22/79	600	17.6	8.8	10.3	41.	442.	60.	654.	21.	384.
6/22/79	700	18.2	8.8	10.4	40.	447.	60.	661.	21.	388.
6/22/79	800	17.9	8.8	10.4	40.	439.	60.	649.	21.	381.
6/22/79	900	18.8	8.8	10.4	38.	443.	57.	655.	20.	385.
6/22/79	1000	18.8	8.8	10.4	38.	438.	56.	648.	20.	380.
6/22/79	1100	18.8	8.8	10.4	37.	436.	55.	645.	20.	379.
6/22/79	1200	18.8	8.8	10.4	36.	434.	53.	642.	19.	377.
6/22/79	1300	18.8	8.5	10.6	0.	453.	0.	655.	0.	384.
6/22/79	1400	18.2	8.6	10.5	0.	459.	0.	668.	0.	392.
6/22/79	1500	18.2	8.6	10.5	0.	468.	0.	681.	0.	400.
6/22/79	1600	18.5	8.6	10.5	11.	465.	16.	677.	6.	397.
6/22/79	1700	18.2	8.5	10.4	26.	473.	37.	683.	13.	401.
6/22/79	1800	17.9	8.5	10.5	6.	480.	9.	694.	3.	407.
6/22/79	1900	17.6	8.5	10.5	30.	477.	43.	689.	15.	404.
6/22/79	2000	20.8	8.5	10.4	26.	439.	38.	633.	14.	372.
6/22/79	2100	22.9	8.5	10.4	34.	435.	50.	628.	18.	369.
6/22/79	2200	22.3	8.2	10.7	38.	440.	53.	620.	19.	364.
6/22/79	2300	19.9	8.4	10.5	39.	445.	56.	638.	20.	374.
6/22/79	2400	19.0	8.5	10.4	48.	453.	70.	655.	25.	384.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/23/79	100	19.0	8.4	10.5	42.	457.	61.	655.	22.	385.
6/23/79	200	19.9	8.2	10.7	45.	466.	63.	657.	23.	386.
6/23/79	300	19.9	8.1	10.7	45.	465.	64.	650.	23.	382.
6/23/79	400	19.9	8.2	10.7	47.	466.	66.	657.	24.	386.
6/23/79	500	19.3	8.1	10.7	47.	473.	66.	662.	24.	389.
6/23/79	600	19.3	8.1	10.7	57.	478.	80.	668.	29.	392.
6/23/79	700	19.9	8.2	10.7	48.	472.	68.	665.	24.	391.
6/23/79	800	20.5	8.2	10.7	48.	462.	68.	651.	24.	382.
6/23/79	900	20.5	8.3	10.6	48.	451.	68.	640.	24.	376.
6/23/79	1000	21.4	8.2	10.7	47.	454.	67.	639.	24.	375.
6/23/79	1100	25.5	8.2	10.7	47.	458.	66.	645.	24.	379.
6/23/79	1200	27.8	8.2	10.6	46.	474.	64.	668.	23.	392.
6/23/79	1300	27.8	8.2	10.7	46.	473.	65.	667.	23.	392.
6/23/79	1400	27.8	8.4	10.7	0.	477.	0.	682.	0.	401.
6/23/79	1500	25.5	8.4	10.5	15.	463.	21.	663.	8.	389.
6/23/79	1600	23.4	8.4	10.5	15.	443.	21.	634.	8.	372.
6/23/79	1700	23.4	8.4	10.5	15.	440.	21.	630.	8.	370.
6/23/79	1800	23.4	8.6	10.5	15.	428.	22.	623.	8.	366.
6/23/79	1900	24.3	8.8	10.5	18.	395.	27.	584.	10.	343.
6/23/79	2000	24.0	8.6	10.3	20.	415.	29.	604.	10.	355.
6/23/79	2100	23.7	8.6	10.3	25.	418.	36.	608.	13.	357.
6/23/79	2200	23.4	8.6	10.4	30.	418.	44.	608.	16.	357.
6/23/79	2300	23.1	8.6	10.5	30.	417.	44.	607.	16.	356.
6/23/79	2400	19.9	8.6	10.4	35.	421.	51.	613.	18.	360.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/24/79	100	20.2	8.6	10.3	30.	425.	44.	618.	16.	363.
6/24/79	200	20.2	8.6	10.3	40.	425.	58.	618.	21.	363.
6/24/79	300	20.5	8.7	10.3	40.	423.	59.	621.	21.	364.
6/24/79	400	20.8	8.7	10.3	50.	422.	73.	619.	26.	364.
6/24/79	500	20.8	8.7	10.3	50.	420.	73.	616.	26.	362.
6/24/79	600	21.1	8.7	10.3	51.	418.	75.	613.	27.	360.
6/24/79	700	20.2	8.7	10.3	55.	418.	81.	613.	29.	360.
6/24/79	800	20.2	8.7	10.3	56.	409.	82.	600.	29.	352.
6/24/79	900	21.1	8.6	10.3	60.	406.	87.	591.	31.	347.
6/24/79	1000	21.1	8.6	10.3	60.	402.	87.	585.	31.	343.
6/24/79	1100	20.8	8.6	10.3	60.	400.	87.	582.	31.	342.
6/24/79	1200	20.5	8.6	10.3	60.	400.	87.	582.	31.	342.
6/24/79	1300	20.2	8.6	10.3	55.	395.	80.	575.	29.	338.
6/24/79	1400	20.2	8.5	10.3	10.	380.	14.	549.	5.	322.
6/24/79	1500	19.9	8.5	10.3	10.	380.	14.	549.	5.	322.
6/24/79	1600	20.2	8.5	10.3	10.	377.	14.	544.	5.	320.
6/24/79	1700	19.9	8.5	10.3	10.	378.	14.	546.	5.	320.
6/24/79	1800	19.9	8.5	10.3	10.	381.	14.	550.	5.	323.
6/24/79	1900	19.9	8.5	10.3	10.	380.	14.	549.	5.	322.
6/24/79	2000	21.7	8.5	10.2	10.	350.	14.	505.	5.	297.
6/24/79	2100	20.5	8.8	10.0	20.	375.	30.	555.	11.	326.
6/24/79	2200	19.3	8.8	10.0	20.	372.	30.	550.	11.	323.
6/24/79	2300	19.0	8.9	10.0	20.	380.	30.	567.	11.	333.
6/24/79	2400	19.3	8.9	10.0	20.	374.	30.	558.	11.	328.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/25/79	100	19.9	8.9	9.9	30.	375.	45.	559.	16.	328.
6/25/79	200	20.2	8.9	9.9	35.	375.	52.	559.	19.	328.
6/25/79	300	20.2	8.9	9.9	38.	378.	57.	564.	20.	331.
6/25/79	400	19.9	8.9	9.9	42.	377.	63.	562.	22.	330.
6/25/79	500	19.9	9.0	9.9	48.	377.	72.	567.	26.	333.
6/25/79	600	19.9	9.0	9.9	50.	377.	75.	567.	27.	333.
6/25/79	700	20.2	9.0	10.0	55.	376.	83.	566.	30.	332.
6/25/79	800	20.8	9.0	10.0	60.	374.	90.	563.	32.	330.
6/25/79	900	20.8	9.0	10.0	60.	374.	90.	563.	32.	330.
6/25/79	1000	22.0	.0	10.1	60.	378.	51.	324.	18.	190.
6/25/79	1100	25.5	.0	10.1	60.	378.	51.	324.	18.	190.
6/25/79	1200	26.7	.0	10.2	30.	420.	26.	360.	9.	211.
6/25/79	1300	27.5	9.0	10.1	10.	455.	15.	684.	5.	402.
6/25/79	1400	27.8	9.7	10.7	5.	456.	8.	729.	3.	428.
6/25/79	1500	27.8	9.1	10.8	6.	450.	9.	682.	3.	401.
6/25/79	1600	27.8	9.0	10.0	10.	428.	15.	643.	5.	378.
6/25/79	1700	27.8	8.6	10.7	13.	441.	20.	641.	7.	377.
6/25/79	1800	25.8	8.7	10.6	20.	447.	30.	656.	11.	385.
6/25/79	1900	24.6	8.9	10.5	29.	443.	44.	660.	16.	388.
6/25/79	2000	24.6	9.1	10.3	38.	414.	57.	628.	21.	369.
6/25/79	2100	23.4	8.9	10.5	38.	435.	56.	649.	20.	381.
6/25/79	2200	23.4	8.9	10.6	40.	432.	60.	645.	21.	379.
6/25/79	2300	19.9	9.0	10.5	42.	431.	63.	649.	23.	381.
6/25/79	2400	18.8	9.2	10.3	41.	445.	63.	681.	22.	400.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/27/79	100	16.1	8.8	10.2	8.	418.	12.	618.	4.	363.
6/27/79	200	16.1	8.7	10.2	10.	413.	14.	606.	5.	356.
6/27/79	300	16.1	8.6	10.3	10.	415.	15.	604.	5.	355.
6/27/79	400	16.4	8.5	10.3	10.	418.	15.	604.	5.	355.
6/27/79	500	16.7	8.5	10.2	11.	422.	16.	609.	6.	358.
6/27/79	600	16.4	8.6	10.2	11.	422.	16.	614.	6.	360.
6/27/79	700	17.0	8.6	10.2	11.	414.	16.	603.	6.	354.
6/27/79	800	20.5	8.7	10.1	11.	417.	16.	612.	6.	359.
6/27/79	900	19.3	.0	10.0	20.	410.	17.	351.	6.	206.
6/27/79	1000	24.6	8.7	10.4	29.	441.	43.	646.	15.	380.
6/27/79	1100	24.9	8.6	10.5	30.	445.	44.	648.	16.	380.
6/27/79	1200	25.2	8.5	10.5	30.	448.	43.	647.	15.	380.
6/27/79	1300	25.2	8.5	10.5	30.	455.	43.	657.	15.	386.
6/27/79	1400	23.7	8.5	10.5	15.	460.	22.	664.	8.	390.
6/27/79	1500	19.6	8.5	10.5	22.	453.	32.	654.	11.	384.
6/27/79	1600	19.6	8.6	10.4	23.	455.	34.	662.	12.	388.
6/27/79	1700	23.7	8.6	10.3	11.	450.	17.	655.	6.	384.
6/27/79	1800	25.2	8.6	10.4	19.	448.	28.	652.	10.	383.
6/27/79	1900	25.2	8.6	10.4	18.	439.	26.	639.	9.	375.
6/27/79	2000	23.4	8.6	10.4	18.	421.	26.	612.	9.	359.
6/27/79	2100	19.9	8.7	10.3	8.	390.	11.	572.	4.	336.
6/27/79	2200	17.0	8.6	10.4	0.	396.	1.	576.	0.	338.
6/27/79	2300	16.7	8.7	10.4	1.	390.	1.	572.	0.	336.
6/27/79	2400	16.4	8.8	10.2	0.	379.	0.	561.	0.	329.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/28/79	100	17.6	8.8	10.2	9.	370.	13.	548.	5.	322.
6/28/79	200	17.9	8.7	10.2	0.	367.	0.	539.	0.	316.
6/28/79	300	18.2	8.7	10.2	3.	352.	5.	516.	2.	303.
6/28/79	400	18.2	8.8	10.2	21.	342.	31.	505.	11.	297.
6/28/79	500	18.2	8.8	10.1	19.	336.	28.	498.	10.	292.
6/28/79	600	18.2	8.8	10.1	24.	329.	36.	487.	13.	286.
6/28/79	700	18.5	8.8	10.1	8.	329.	12.	487.	4.	286.
6/28/79	800	19.9	8.8	10.1	25.	320.	38.	473.	13.	278.
6/28/79	900	23.4	8.4	10.7	25.	431.	36.	617.	13.	362.
6/28/79	1000	24.9	8.3	10.8	27.	461.	38.	655.	14.	385.
6/28/79	1100	26.7	8.4	10.7	27.	460.	38.	659.	14.	387.
6/28/79	1200	20.5	8.3	10.8	30.	422.	43.	600.	15.	352.
6/28/79	1300	19.9	8.2	10.9	29.	427.	40.	603.	14.	354.
6/28/79	1400	19.9	8.3	10.8	29.	441.	42.	627.	15.	368.
6/28/79	1500	19.6	8.2	10.7	33.	444.	47.	626.	17.	367.
6/28/79	1600	20.5	8.3	10.8	24.	468.	35.	665.	12.	390.
6/28/79	1700	27.2	8.3	10.8	18.	613.	26.	871.	9.	512.
6/28/79	1800	29.0	8.4	10.8	21.	664.	31.	951.	11.	559.
6/28/79	1900	28.7	8.4	10.8	26.	672.	37.	962.	13.	565.
6/28/79	2000	28.1	8.4	10.8	31.	675.	45.	967.	16.	568.
6/28/79	2100	20.2	8.5	10.7	39.	612.	57.	884.	20.	519.
6/28/79	2200	17.6	8.8	10.3	45.	588.	67.	870.	24.	511.
6/28/79	2300	15.8	9.1	10.0	45.	611.	69.	927.	25.	544.
6/28/79	2400	15.2	9.1	9.9	49.	606.	75.	920.	27.	540.

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HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/29/79	100	15.2	9.0	10.1	52.	600.	78.	903.	28.	530.
6/29/79	200	15.2	9.0	10.0	54.	596.	81.	897.	29.	527.
6/29/79	300	15.2	9.0	9.9	56.	590.	84.	887.	30.	521.
6/29/79	400	15.2	9.0	9.8	58.	586.	87.	882.	31.	518.
6/29/79	500	15.2	8.9	10.0	60.	592.	89.	883.	32.	518.
6/29/79	600	15.2	9.0	9.9	61.	587.	92.	883.	33.	519.
6/29/79	700	15.5	8.7	10.2	61.	579.	90.	849.	32.	499.
6/29/79	800	17.6	8.5	10.5	62.	588.	90.	849.	32.	498.
6/29/79	900	19.3	8.4	10.8	0.	447.	0.	640.	0.	376.
6/29/79	1000	22.3	8.3	10.8	16.	450.	22.	640.	8.	376.
6/29/79	1100	24.6	8.3	10.8	14.	462.	19.	656.	7.	385.
6/29/79	1200	26.7	9.0	10.0	11.	460.	17.	692.	6.	406.
6/29/79	1300	28.1	8.2	10.8	10.	531.	14.	749.	5.	440.
6/29/79	1400	32.5	8.0	11.1	11.	540.	16.	749.	6.	440.
6/29/79	1500	25.8	5.7	10.0	12.	480.	14.	565.	5.	332.
6/29/79	1600	22.3	8.0	10.7	16.	452.	22.	627.	8.	368.
6/29/79	1700	21.4	8.3	10.9	19.	454.	28.	645.	10.	379.
6/29/79	1800	21.4	8.3	10.8	24.	454.	34.	646.	12.	379.
6/29/79	1900	21.4	8.3	10.8	29.	454.	41.	646.	15.	379.
6/29/79	2000	19.9	8.4	10.8	34.	463.	49.	663.	18.	389.
6/29/79	2100	19.6	8.4	10.7	11.	426.	16.	609.	6.	358.
6/29/79	2200	15.8	8.8	10.3	44.	446.	65.	660.	23.	388.
6/29/79	2300	14.1	9.4	9.7	46.	429.	72.	668.	26.	392.
6/29/79	2400	14.6	9.1	9.8	10.	430.	15.	653.	5.	383.

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HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
6/30/79	100	14.1	9.3	9.4	53.	421.	81.	650.	29.	382.
6/30/79	200	14.1	9.3	9.6	55.	414.	85.	639.	31.	375.
6/30/79	300	14.1	9.3	9.5	58.	412.	89.	636.	32.	373.
6/30/79	400	14.1	9.3	9.5	59.	409.	91.	631.	32.	371.
6/30/79	500	14.1	9.3	9.5	61.	408.	94.	630.	34.	370.
6/30/79	600	14.1	9.3	9.5	63.	410.	97.	633.	35.	372.
6/30/79	700	14.1	9.3	9.5	65.	409.	100.	631.	36.	370.
6/30/79	800	14.1	9.2	9.6	66.	411.	102.	628.	36.	369.
6/30/79	900	17.6	8.6	10.3	70.	438.	102.	638.	36.	375.
6/30/79	1000	19.0	8.5	10.4	68.	454.	98.	655.	35.	385.
6/30/79	1100	19.9	8.4	10.7	10.	458.	15.	656.	5.	385.
6/30/79	1200	22.3	8.3	10.8	6.	459.	8.	653.	3.	383.
6/30/79	1300	23.4	8.3	10.8	3.	455.	4.	647.	2.	380.
6/30/79	1400	23.4	8.4	10.7	2.	454.	2.	650.	1.	382.
6/30/79	1500	23.7	8.4	10.7	3.	455.	4.	651.	1.	382.
6/30/79	1600	22.9	8.4	10.7	2.	454.	3.	650.	1.	382.
6/30/79	1700	22.6	8.5	10.7	3.	455.	5.	657.	2.	386.
6/30/79	1800	25.8	8.5	10.6	3.	469.	5.	677.	2.	397.
6/30/79	1900	25.8	8.5	10.6	5.	466.	7.	673.	3.	395.
6/30/79	2000	25.8	8.5	10.6	8.	463.	11.	669.	4.	393.
6/30/79	2100	24.6	8.5	10.6	10.	458.	15.	661.	5.	388.
6/30/79	2200	19.9	8.6	10.5	19.	421.	28.	613.	10.	360.
6/30/79	2300	16.7	8.8	10.1	14.	432.	21.	639.	8.	375.
6/30/79	2400	15.2	9.1	9.8	10.	430.	15.	653.	5.	383.

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HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
7/ 1/79	100	14.6	9.2	9.6	22.	426.	34.	651.	12.	382.
7/ 1/79	200	14.6	9.2	9.6	26.	428.	40.	655.	14.	385.
7/ 1/79	300	14.6	9.2	9.6	31.	429.	47.	657.	17.	386.
7/ 1/79	400	14.6	9.2	9.6	35.	424.	53.	649.	19.	381.
7/ 1/79	500	14.6	9.1	9.6	39.	423.	59.	642.	21.	377.
7/ 1/79	600	14.6	9.1	9.6	42.	423.	64.	642.	23.	377.
7/ 1/79	700	14.6	9.1	9.6	45.	425.	68.	645.	24.	379.
7/ 1/79	800	14.6	9.2	9.7	34.	426.	52.	651.	19.	382.
7/ 1/79	900	15.2	8.8	10.0	25.	448.	37.	663.	13.	389.
7/ 1/79	1000	18.2	8.8	10.0	25.	470.	37.	695.	13.	408.
7/ 1/79	1100	18.8	8.7	10.1	25.	472.	37.	693.	13.	407.
7/ 1/79	1200	19.3	8.5	10.1	25.	475.	36.	686.	13.	403.
7/ 1/79	1300	18.8	8.5	10.1	25.	475.	36.	686.	13.	403.
7/ 1/79	1400	18.8	8.5	10.1	25.	481.	36.	694.	13.	408.
7/ 1/79	1500	18.8	8.6	10.1	25.	483.	36.	703.	13.	413.
7/ 1/79	1600	19.0	8.6	10.1	26.	482.	38.	701.	14.	412.
7/ 1/79	1700	18.8	8.6	10.1	28.	487.	41.	709.	15.	416.
7/ 1/79	1800	19.9	8.6	10.1	30.	478.	44.	696.	16.	408.
7/ 1/79	1900	20.2	8.6	10.0	32.	471.	47.	685.	17.	402.
7/ 1/79	2000	20.5	8.6	10.0	36.	472.	52.	687.	19.	403.
7/ 1/79	2100	20.5	8.6	10.0	40.	463.	58.	674.	21.	396.
7/ 1/79	2200	20.8	8.7	10.0	45.	440.	66.	646.	24.	379.
7/ 1/79	2300	19.3	8.6	10.0	48.	461.	70.	671.	25.	394.
7/ 1/79	2400	17.6	8.7	10.0	50.	457.	73.	671.	26.	394.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
7/ 2/79	100	16.7	8.8	10.0	55.	448.	81.	663.	29.	389.
7/ 2/79	200	16.7	8.6	10.0	60.	448.	87.	652.	31.	383.
7/ 2/79	300	17.0	8.7	10.0	65.	455.	95.	668.	34.	392.
7/ 2/79	400	17.0	8.7	10.0	65.	457.	95.	671.	34.	394.
7/ 2/79	500	17.0	8.6	10.0	66.	453.	96.	659.	34.	387.
7/ 2/79	600	17.0	8.7	10.0	67.	448.	98.	657.	35.	386.
7/ 2/79	700	17.0	8.6	10.0	70.	452.	102.	658.	36.	386.
7/ 2/79	800	18.8	8.6	10.0	23.	454.	33.	661.	12.	388.
7/ 2/79	900	20.5	8.4	10.3	20.	452.	29.	647.	10.	380.
7/ 2/79	1000	20.5	8.4	10.2	18.	458.	26.	656.	9.	385.
7/ 2/79	1100	20.5	8.3	10.2	17.	462.	24.	656.	9.	385.
7/ 2/79	1200	20.2	8.3	10.2	20.	450.	28.	639.	10.	375.
7/ 2/79	1300	19.9	8.4	10.2	20.	425.	29.	609.	10.	357.
7/ 2/79	1400	19.9	8.4	10.6	23.	417.	33.	597.	12.	351.
7/ 2/79	1500	19.9	8.4	10.4	23.	410.	33.	587.	12.	344.
7/ 2/79	1600	19.9	8.4	10.7	18.	418.	26.	598.	9.	351.
7/ 2/79	1700	19.9	8.4	10.7	17.	423.	24.	606.	8.	356.
7/ 2/79	1800	19.9	8.4	10.7	18.	426.	25.	610.	9.	358.
7/ 2/79	1900	19.3	8.4	10.6	19.	423.	27.	606.	10.	356.
7/ 2/79	2000	19.0	8.4	10.7	20.	439.	29.	628.	10.	369.
7/ 2/79	2100	19.3	8.4	10.7	3.	434.	5.	622.	2.	365.
7/ 2/79	2200	19.3	8.5	10.5	30.	386.	44.	557.	16.	327.
7/ 2/79	2300	18.8	8.5	10.4	24.	412.	35.	595.	12.	349.
7/ 2/79	2400	18.8	8.5	10.5	25.	408.	36.	589.	13.	346.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
7/ 3/79	100	18.8	8.5	10.5	26.	424.	37.	612.	13.	359.
7/ 3/79	200	18.8	8.5	10.5	27.	422.	39.	609.	14.	357.
7/ 3/79	300	18.8	8.5	10.5	29.	398.	41.	574.	15.	337.
7/ 3/79	400	19.0	8.5	10.4	31.	390.	45.	563.	16.	330.
7/ 3/79	500	19.0	8.5	10.4	36.	400.	51.	577.	18.	339.
7/ 3/79	600	19.0	8.5	10.4	40.	391.	58.	564.	21.	331.
7/ 3/79	700	19.0	8.5	10.4	46.	390.	66.	564.	24.	331.
7/ 3/79	800	19.6	8.5	10.2	49.	391.	71.	564.	25.	331.
7/ 3/79	900	19.9	8.5	10.6	11.	357.	15.	515.	5.	302.
7/ 3/79	1000	20.5	8.5	10.6	7.	422.	10.	609.	4.	357.
7/ 3/79	1100	20.5	8.4	10.6	6.	427.	9.	611.	3.	359.
7/ 3/79	1200	24.3	8.6	10.4	5.	452.	8.	659.	3.	387.
7/ 3/79	1300	49.2	7.9	11.1	4.	573.	6.	788.	2.	463.
7/ 3/79	1400	61.5	8.3	10.8	5.	610.	7.	867.	2.	509.
7/ 3/79	1500	63.9	8.2	10.8	7.	620.	10.	874.	4.	513.
7/ 3/79	1600	65.6	8.1	10.9	12.	610.	16.	853.	6.	501.
7/ 3/79	1700	65.6	8.1	10.9	12.	606.	16.	847.	6.	497.
7/ 3/79	1800	65.6	8.1	11.0	13.	614.	18.	859.	6.	504.
7/ 3/79	1900	65.6	8.1	10.9	14.	603.	19.	843.	7.	495.
7/ 3/79	2000	65.3	8.1	10.9	15.	604.	21.	845.	8.	496.
7/ 3/79	2100	65.3	8.1	10.8	16.	606.	23.	847.	8.	497.
7/ 3/79	2200	43.9	8.2	10.7	7.	532.	9.	749.	3.	440.
7/ 3/79	2300	23.4	8.7	10.3	22.	424.	32.	622.	11.	365.
7/ 3/79	2400	19.6	8.4	10.6	27.	415.	38.	594.	14.	349.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
7/ 4/79	100	17.6	8.6	10.2	30.	405.	44.	589.	16.	346.
7/ 4/79	200	16.4	8.6	10.2	34.	415.	49.	603.	18.	354.
7/ 4/79	300	16.7	8.6	10.2	39.	418.	57.	608.	20.	357.
7/ 4/79	400	16.7	8.7	10.2	47.	420.	69.	616.	25.	362.
7/ 4/79	500	17.0	8.7	10.1	55.	422.	81.	620.	29.	364.
7/ 4/79	600	17.0	8.8	10.1	62.	422.	91.	624.	33.	366.
7/ 4/79	700	17.3	8.8	10.1	64.	423.	95.	626.	34.	367.
7/ 4/79	800	17.3	8.8	10.1	67.	419.	100.	621.	36.	364.
7/ 4/79	900	17.6	8.8	10.1	67.	418.	100.	619.	36.	363.
7/ 4/79	1000	17.9	8.8	10.1	68.	416.	101.	615.	36.	361.
7/ 4/79	1100	18.8	8.7	10.1	49.	422.	72.	619.	26.	363.
7/ 4/79	1200	21.1	8.6	10.3	6.	427.	8.	621.	3.	365.
7/ 4/79	1300	23.4	8.6	10.4	0.	437.	0.	636.	0.	373.
7/ 4/79	1400	26.4	8.6	10.4	0.	444.	0.	646.	0.	379.
7/ 4/79	1500	24.9	8.6	10.3	0.	424.	0.	617.	0.	362.
7/ 4/79	1600	23.4	8.6	10.4	0.	419.	0.	610.	0.	358.
7/ 4/79	1700	23.4	8.4	10.6	0.	415.	0.	595.	0.	349.
7/ 4/79	1800	23.4	8.4	10.6	12.	414.	17.	592.	6.	348.
7/ 4/79	1900	23.4	8.4	10.5	10.	426.	14.	610.	5.	358.
7/ 4/79	2000	19.6	8.4	10.5	11.	400.	15.	573.	5.	336.
7/ 4/79	2100	17.6	8.6	10.3	10.	448.	15.	652.	5.	383.
7/ 4/79	2200	19.9	8.6	10.3	10.	436.	15.	635.	5.	373.
7/ 4/79	2300	20.5	8.5	10.3	11.	440.	16.	635.	6.	373.
7/ 4/79	2400	17.6	8.7	10.2	11.	438.	16.	643.	6.	377.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
7/ 4/79	100	17.6	8.6	10.2	30.	405.	44.	589.	16.	346.
7/ 4/79	200	16.4	8.6	10.2	34.	415.	49.	603.	18.	354.
7/ 4/79	300	16.7	8.6	10.2	39.	418.	57.	608.	20.	357.
7/ 4/79	400	16.7	8.7	10.2	47.	420.	69.	616.	25.	362.
7/ 4/79	500	17.0	8.7	10.1	55.	422.	81.	620.	29.	364.
7/ 4/79	600	17.0	8.8	10.1	62.	422.	91.	624.	33.	366.
7/ 4/79	700	17.3	8.8	10.1	64.	423.	95.	626.	34.	367.
7/ 4/79	800	17.3	8.8	10.1	67.	419.	100.	621.	36.	364.
7/ 4/79	900	17.6	8.8	10.1	67.	418.	100.	619.	36.	363.
7/ 4/79	1000	17.9	8.8	10.1	68.	416.	101.	615.	36.	361.
7/ 4/79	1100	18.8	8.7	10.1	49.	422.	72.	619.	26.	363.
7/ 4/79	1200	21.1	8.6	10.3	6.	427.	8.	621.	3.	365.
7/ 4/79	1300	23.4	8.6	10.4	0.	437.	0.	636.	0.	373.
7/ 4/79	1400	26.4	8.6	10.4	0.	444.	0.	646.	0.	379.
7/ 4/79	1500	24.9	8.6	10.3	0.	424.	0.	617.	0.	362.
7/ 4/79	1600	23.4	8.6	10.4	0.	419.	0.	610.	0.	358.
7/ 4/79	1700	23.4	8.4	10.6	0.	415.	0.	595.	0.	349.
7/ 4/79	1800	23.4	8.4	10.6	12.	414.	17.	592.	6.	348.
7/ 4/79	1900	23.4	8.4	10.5	10.	426.	14.	610.	5.	358.
7/ 4/79	2000	19.6	8.4	10.5	11.	400.	15.	573.	5.	336.
7/ 4/79	2100	17.6	8.6	10.3	10.	448.	15.	652.	5.	383.
7/ 4/79	2200	19.9	8.6	10.3	10.	436.	15.	635.	5.	373.
7/ 4/79	2300	20.5	8.5	10.3	11.	440.	16.	635.	6.	373.
7/ 4/79	2400	17.6	8.7	10.2	11.	438.	16.	643.	6.	377.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
7/ 5/79	100	17.6	8.7	10.2	12.	447.	18.	656.	6.	385.
7/ 5/79	200	17.6	8.7	10.2	12.	447.	18.	656.	6.	385.
7/ 5/79	300	17.6	8.7	10.2	13.	448.	19.	657.	7.	386.
7/ 5/79	400	17.6	8.7	10.2	13.	448.	19.	657.	7.	386.
7/ 5/79	500	17.6	8.8	10.2	13.	442.	19.	654.	7.	384.
7/ 5/79	600	16.7	8.8	10.2	18.	443.	27.	655.	10.	385.
7/ 5/79	700	16.7	8.7	10.2	20.	454.	29.	666.	10.	391.
7/ 5/79	800	16.7	8.8	10.2	21.	460.	31.	680.	11.	400.
7/ 5/79	900	20.2	8.5	10.0	22.	430.	32.	621.	11.	364.
7/ 5/79	1000	26.4	8.3	10.6	13.	518.	18.	735.	6.	432.
7/ 5/79	1100	26.4	8.1	10.8	12.	529.	16.	740.	6.	435.
7/ 5/79	1200	23.4	8.7	10.1	14.	412.	21.	604.	8.	355.
7/ 5/79	1300	23.4	8.5	10.4	14.	392.	20.	566.	7.	332.
7/ 5/79	1400	23.4	8.3	10.6	13.	388.	19.	551.	7.	324.
7/ 5/79	1500	23.4	8.2	10.6	13.	378.	18.	532.	6.	312.
7/ 5/79	1600	23.4	8.2	10.5	11.	381.	16.	536.	6.	315.
7/ 5/79	1700	23.4	8.2	10.5	10.	377.	14.	532.	5.	312.
7/ 5/79	1800	23.4	8.2	10.5	9.	372.	13.	525.	5.	308.
7/ 5/79	1900	23.4	8.2	10.5	11.	381.	15.	538.	5.	316.
7/ 5/79	2000	20.5	8.3	10.4	16.	356.	23.	506.	8.	297.
7/ 5/79	2100	19.6	8.3	10.4	15.	376.	22.	535.	8.	314.
7/ 5/79	2200	19.0	8.2	10.4	17.	367.	24.	518.	9.	304.
7/ 5/79	2300	19.3	8.4	10.2	17.	371.	25.	531.	9.	312.
7/ 5/79	2400	19.0	8.4	10.1	19.	376.	27.	538.	10.	316.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
7/ 6/79	100	19.0	8.4	10.2	19.	375.	28.	538.	10.	316.
7/ 6/79	200	19.0	8.5	10.0	20.	384.	30.	555.	11.	326.
7/ 6/79	300	19.3	8.4	10.1	23.	380.	33.	544.	12.	319.
7/ 6/79	400	19.6	8.5	10.0	24.	383.	35.	552.	12.	324.
7/ 6/79	500	19.0	8.4	10.1	26.	375.	37.	538.	13.	316.
7/ 6/79	600	19.0	8.5	10.0	28.	375.	40.	541.	14.	318.
7/ 6/79	700	19.3	8.4	10.2	31.	368.	45.	527.	16.	309.
7/ 6/79	800	19.3	8.3	10.1	40.	360.	57.	511.	20.	300.
7/ 6/79	900	21.1	8.4	10.3	31.	362.	45.	519.	16.	305.
7/ 6/79	1000	24.9	8.5	10.5	13.	374.	19.	541.	7.	317.
7/ 6/79	1100	25.8	8.4	10.5	11.	372.	16.	532.	6.	313.
7/ 6/79	1200	29.3	8.4	10.6	12.	379.	18.	543.	6.	319.
7/ 6/79	1300	27.5	8.4	10.5	13.	378.	19.	542.	7.	318.
7/ 6/79	1400	27.8	8.4	10.5	14.	381.	20.	546.	7.	320.
7/ 6/79	1500	27.0	8.5	10.5	19.	382.	27.	552.	10.	324.
7/ 6/79	1600	25.5	8.5	10.4	19.	400.	28.	578.	10.	339.
7/ 6/79	1700	23.7	8.2	10.6	19.	409.	26.	577.	9.	339.
7/ 6/79	1800	22.3	8.3	10.5	20.	411.	28.	584.	10.	343.
7/ 6/79	1900	22.3	8.3	10.5	21.	412.	29.	585.	10.	343.
7/ 6/79	2000	22.3	8.3	10.5	26.	380.	36.	540.	13.	317.
7/ 6/79	2100	22.6	8.2	10.5	22.	405.	31.	571.	11.	335.
7/ 6/79	2200	21.1	8.2	10.5	23.	406.	32.	572.	12.	336.
7/ 6/79	2300	19.3	8.5	10.2	5.	390.	7.	563.	3.	331.
7/ 6/79	2400	18.8	8.5	10.2	29.	384.	42.	554.	15.	326.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
7/ 7/79	100	18.2	8.6	10.2	32.	381.	47.	554.	17.	325.
7/ 7/79	200	18.8	8.6	10.1	35.	383.	51.	558.	18.	328.
7/ 7/79	300	18.5	8.6	10.1	39.	380.	56.	553.	20.	325.
7/ 7/79	400	18.5	8.6	10.1	42.	377.	61.	549.	22.	322.
7/ 7/79	500	18.2	8.6	10.1	45.	386.	66.	561.	24.	330.
7/ 7/79	600	18.2	8.6	10.1	49.	386.	72.	561.	26.	330.
7/ 7/79	700	18.8	8.6	10.1	52.	395.	76.	575.	27.	338.
7/ 7/79	800	18.8	8.5	10.1	56.	389.	81.	561.	29.	330.
7/ 7/79	900	18.2	8.5	10.1	58.	383.	84.	554.	30.	325.
7/ 7/79	1000	17.6	8.5	10.1	62.	378.	90.	546.	32.	321.
7/ 7/79	1100	21.1	8.5	10.2	56.	400.	81.	578.	29.	339.
7/ 7/79	1200	21.1	8.5	10.3	28.	404.	40.	584.	14.	343.
7/ 7/79	1300	21.1	8.5	10.3	23.	406.	33.	586.	12.	344.
7/ 7/79	1400	21.1	8.6	10.3	21.	408.	30.	594.	11.	349.
7/ 7/79	1500	21.1	8.5	10.3	21.	373.	30.	539.	11.	316.
7/ 7/79	1600	19.0	8.6	10.3	21.	393.	30.	572.	11.	336.
7/ 7/79	1700	18.8	8.6	10.3	20.	383.	29.	558.	10.	328.
7/ 7/79	1800	18.5	8.6	10.2	19.	373.	28.	543.	10.	319.
7/ 7/79	1900	19.3	8.6	10.2	19.	370.	27.	538.	10.	316.
7/ 7/79	2000	19.3	8.4	10.4	25.	357.	37.	512.	13.	300.
7/ 7/79	2100	18.8	8.5	10.3	23.	371.	34.	536.	12.	315.
7/ 7/79	2200	18.5	8.5	10.3	25.	371.	36.	535.	13.	314.
7/ 7/79	2300	18.2	8.5	10.3	27.	373.	39.	538.	14.	316.
7/ 7/79	2400	18.2	8.6	10.2	30.	382.	44.	556.	16.	326.

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HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
7/ 8/79	100	19.3	8.8	10.0	32.	390.	47.	578.	17.	339.
7/ 8/79	200	18.8	8.8	10.1	38.	387.	55.	573.	20.	336.
7/ 8/79	300	18.2	8.8	10.1	44.	389.	65.	575.	23.	338.
7/ 8/79	400	18.2	8.8	10.0	51.	384.	76.	569.	27.	334.
7/ 8/79	500	18.2	8.8	10.0	59.	384.	88.	568.	31.	333.
7/ 8/79	600	18.2	8.8	10.0	67.	382.	99.	565.	35.	331.
7/ 8/79	700	18.2	8.8	10.0	71.	385.	106.	570.	38.	334.
7/ 8/79	800	18.5	8.8	10.0	74.	386.	110.	570.	39.	335.
7/ 8/79	900	15.2	9.1	9.7	78.	376.	118.	571.	42.	335.
7/ 8/79	1000	15.2	9.2	9.6	84.	369.	129.	565.	46.	331.
7/ 8/79	1100	15.2	9.2	9.5	90.	373.	137.	571.	49.	336.
7/ 8/79	1200	15.2	.0	.0	0.	0.	0.	0.	0.	0.
7/ 8/79	1300	14.6	9.1	9.7	77.	371.	117.	563.	42.	331.
7/ 8/79	1400	14.6	.0	9.5	30.	9.	26.	8.	9.	4.
7/ 8/79	1500	14.6	8.8	9.6	39.	380.	58.	562.	21.	330.
7/ 8/79	1600	17.6	8.4	10.1	38.	376.	54.	538.	19.	316.
7/ 8/79	1700	19.6	8.3	10.0	29.	375.	41.	533.	15.	313.
7/ 8/79	1800	20.2	8.2	10.0	25.	380.	35.	536.	13.	314.
7/ 8/79	1900	19.3	8.3	10.0	22.	380.	31.	540.	11.	317.
7/ 8/79	2000	19.0	8.3	10.0	22.	380.	31.	540.	11.	317.
7/ 8/79	2100	19.0	8.3	10.0	24.	382.	34.	543.	12.	319.
7/ 8/79	2200	19.0	8.4	10.0	28.	279.	40.	400.	14.	235.
7/ 8/79	2300	18.8	8.3	10.0	29.	278.	41.	395.	15.	232.
7/ 8/79	2400	18.8	8.3	10.0	30.	281.	43.	399.	15.	234.

HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
7/ 9/79	100	18.8	8.5	9.8	30.	387.	43.	559.	15.	328.
7/ 9/79	200	18.8	8.5	9.8	35.	392.	51.	566.	18.	332.
7/ 9/79	300	18.8	8.4	9.8	37.	388.	53.	556.	19.	326.
7/ 9/79	400	18.2	8.4	9.8	45.	387.	64.	554.	23.	325.
7/ 9/79	500	17.9	8.4	9.8	52.	387.	74.	554.	27.	325.
7/ 9/79	600	17.6	8.5	9.8	56.	387.	81.	559.	29.	328.
7/ 9/79	700	18.2	8.4	9.8	65.	390.	93.	558.	33.	328.
7/ 9/79	800	20.2	8.2	10.0	70.	397.	99.	560.	35.	329.
7/ 9/79	900	23.4	7.9	10.4	0.	322.	0.	444.	0.	260.
7/ 9/79	1000	18.8	8.6	10.3	59.	388.	87.	565.	31.	331.
7/ 9/79	1100	18.2	8.4	10.5	56.	382.	80.	547.	29.	321.
7/ 9/79	1200	18.8	8.4	10.6	52.	381.	75.	546.	27.	320.
7/ 9/79	1300	17.9	8.5	10.5	72.	362.	104.	523.	37.	307.
7/ 9/79	1400	17.6	8.5	10.5	77.	357.	111.	516.	40.	303.
7/ 9/79	1500	17.6	8.5	10.5	77.	359.	112.	518.	40.	304.
7/ 9/79	1600	17.6	8.5	10.5	82.	354.	118.	512.	42.	300.
7/ 9/79	1700	17.9	8.4	10.6	97.	352.	140.	505.	50.	296.
7/ 9/79	1800	17.9	8.5	10.5	110.	353.	159.	510.	57.	300.
7/ 9/79	1900	17.6	8.5	10.5	122.	358.	176.	517.	63.	304.
7/ 9/79	2000	17.6	8.5	10.5	127.	348.	184.	502.	66.	295.
7/ 9/79	2100	18.2	8.5	10.5	128.	336.	185.	485.	66.	285.
7/ 9/79	2200	18.8	8.5	10.5	129.	341.	187.	492.	67.	289.
7/ 9/79	2300	18.2	8.6	10.4	129.	333.	188.	485.	67.	285.
7/ 9/79	2400	18.8	8.6	10.4	129.	331.	187.	482.	67.	283.

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HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
7/10/79	100	18.5	8.7	10.3	129.	327.	190.	480.	68.	282.
7/10/79	200	18.5	8.8	10.2	129.	328.	192.	485.	68.	285.
7/10/79	300	18.8	8.8	10.1	130.	328.	193.	485.	69.	285.
7/10/79	400	18.8	8.8	10.1	132.	328.	195.	485.	70.	285.
7/10/79	500	18.8	8.8	10.1	133.	339.	196.	502.	70.	295.
7/10/79	600	19.6	8.8	10.0	136.	371.	201.	549.	72.	322.
7/10/79	700	19.6	8.8	10.0	140.	383.	207.	567.	74.	333.
7/10/79	800	23.4	8.7	10.1	129.	390.	189.	572.	67.	336.
7/10/79	900	23.4	8.8	10.2	66.	407.	98.	603.	35.	354.
7/10/79	1000	36.9	8.1	10.9	84.	487.	118.	680.	42.	400.
7/10/79	1100	50.4	8.2	10.9	81.	560.	114.	789.	41.	464.
7/10/79	1200	50.4	8.3	10.8	53.	577.	76.	820.	27.	481.
7/10/79	1300	50.4	8.3	10.7	54.	583.	76.	829.	27.	486.
7/10/79	1400	50.4	8.3	10.7	67.	580.	95.	825.	34.	484.
7/10/79	1500	50.4	8.3	10.7	65.	580.	93.	824.	33.	484.
7/10/79	1600	52.7	8.2	10.8	67.	581.	95.	818.	34.	480.
7/10/79	1700	55.1	8.1	11.0	72.	590.	100.	825.	36.	484.
7/10/79	1800	55.1	8.4	10.7	72.	587.	103.	840.	37.	493.
7/10/79	1900	55.1	8.8	10.3	72.	571.	107.	845.	38.	496.
7/10/79	2000	55.7	12.4	5.7	66.	357.	138.	752.	49.	441.
7/10/79	2100	55.1	14.5	3.0	63.	253.	177.	707.	63.	415.
7/10/79	2200	29.3	.0	.0	0.	0.	0.	0.	0.	0.
7/10/79	2300	.0	.0	.0	0.	0.	0.	0.	0.	0.
7/10/79	2400	.0	.0	.0	0.	0.	0.	0.	0.	0.

HOURLY DATA

DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
7/11/79	100	.0	.0	.0	0.	0.	0.	0.	0.	0.
7/11/79	200	.0	.0	.0	0.	0.	0.	0.	0.	0.
7/11/79	300	.0	.0	.0	0.	0.	0.	0.	0.	0.
7/11/79	400	.0	.0	.0	0.	0.	0.	0.	0.	0.
7/11/79	500	.0	.0	.0	0.	0.	0.	0.	0.	0.
7/11/79	600	.0	.0	.0	0.	0.	0.	0.	0.	0.
7/11/79	700	.0	.0	.0	0.	0.	0.	0.	0.	0.
7/11/79	800	.0	.0	.0	0.	0.	0.	0.	0.	0.
7/11/79	900	.0	.0	.0	0.	0.	0.	0.	0.	0.
7/11/79	1000	48.6	7.9	11.5	71.	458.	97.	630.	35.	370.
7/11/79	1100	48.6	7.9	11.6	71.	460.	97.	633.	35.	372.
7/11/79	1200	48.6	7.8	11.6	70.	473.	96.	646.	34.	379.
7/11/79	1300	48.6	7.7	11.6	72.	459.	98.	623.	35.	366.
7/11/79	1400	49.8	7.6	11.5	68.	461.	91.	620.	33.	364.
7/11/79	1500	49.8	7.7	11.3	68.	520.	92.	706.	33.	414.
7/11/79	1600	49.8	7.8	11.2	69.	557.	94.	762.	34.	447.
7/11/79	1700	49.8	7.7	11.1	70.	577.	95.	782.	34.	459.
7/11/79	1800	49.8	7.8	11.1	76.	552.	104.	754.	37.	443.
7/11/79	1900	50.4	7.7	11.1	79.	556.	108.	753.	38.	442.
7/11/79	2000	50.4	7.8	11.0	81.	580.	111.	792.	40.	465.
7/11/79	2100	49.8	8.1	10.7	84.	575.	118.	804.	42.	472.
7/11/79	2200	40.4	8.0	10.8	86.	552.	119.	765.	43.	449.
7/11/79	2300	29.3	7.6	11.1	88.	536.	118.	721.	42.	423.
7/11/79	2400	20.5	7.7	11.3	69.	463.	94.	628.	34.	369.

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HOURLY DATA
DRY STACK GAS CONCENTRATION

DATE	TIME	LOAD MWTH	O2 VOL% MEAS	CO2 VOL% MEAS	CO PPMV MEAS	NO PPMV MEAS	CO PPMV 3%O2	NO PPMV 3%O2	CO NG/J	NO NG/J
7/12/79	100	17.9	8.5	10.0	89.	394.	129.	568.	46.	334.
7/12/79	200	17.9	8.2	10.3	90.	389.	127.	548.	46.	322.
7/12/79	300	19.3	8.2	10.3	91.	397.	128.	559.	46.	328.
7/12/79	400	19.6	8.0	10.5	92.	401.	128.	556.	46.	326.
7/12/79	500	19.6	8.0	10.5	94.	399.	130.	554.	47.	325.
7/12/79	600	19.9	7.9	10.5	95.	394.	131.	543.	47.	319.
7/12/79	700	21.1	7.7	10.7	97.	392.	132.	532.	47.	312.
7/12/79	800	49.2	9.1	9.7	86.	320.	131.	485.	47.	285.
7/12/79	900	49.8	7.7	11.3	69.	463.	94.	628.	34.	369.
7/12/79	1000	49.8	7.7	11.2	68.	434.	93.	589.	33.	346.
7/12/79	1100	49.5	7.7	11.1	70.	452.	95.	613.	34.	360.
7/12/79	1200	49.2	.0	.0	0.	0.	0.	0.	0.	0.
7/12/79	1300	45.7	7.6	11.3	71.	451.	96.	606.	34.	356.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.
0/ 0/79	0	.0	.0	.0	0.	0.	0.	0.	0.	0.

*FIN

APPENDIX F

SUMMARY OF PREVIOUS TEST DATA

The results of gaseous emissions tests conducted under a previous EPA program are presented in Table F-1. These tests were conducted under Contract No. 68-02-1074 and the results are reported in EPA-600/2-76-086a. The data presented herein were used to establish the baseline emissions for the boiler at Site 3.

At a load of 14.7 MW (130,000 lb/hr steam flow) the average NO emissions were 456 ng/J (777 ppm, 3% O_2 dry).

Table F-2 presents a summary of the coal fuel analyses from the previous tests.

TABLE F-1. SUMMARY OF GASEOUS EMISSIONS AT SITE 3
PULVERIZED COAL FIRED BOILER

(Data was taken during EPA Contract No. 68-02-1074.)

Date 1974	Nominal Steam Load MW	Nominal Steam Load K lb/Hr.	O_2 Percent	CO_2 Percent	NO* ng/J	NO* ppm	CO* ng/J	CO* ppm
12-5	14.9	132	7.3	12.7	474	775	0	0
12-5	7.5	66	7.2	11.9	495	809	0	0
12-5	14.7	130	7.7	11.5	480	785	0	0
12-9	14.7	130	7.4	11.9	468	765	0	0
12-9	14.7	130	7.4	11.8	478	782	0	0

*Corrected to 3% O_2 Dry

TABLE F-2. SUMMARY OF COAL AND ASH ANALYSIS FROM SITE 3

(Samples were taken during EPA Contract No. 68-02-1074.)

ULTIMATE ANALYSIS

		Percent by Weight, As Received					
Stream	Run	Carbon	Hydrogen	Nitrogen	Sulfur	Ash	Oxygen[a/]
Coal	169-3	62.95	5.16	0.85	1.28	10.78	18.98

a/ By difference.

PROXIMATE ANALYSIS

		Percent by Weight, As Received					
Stream	Run	Moisture	Ash	Volatile Matter	Fixed Carbon	Sulfur	Heat of Combustion (Btu/lb)
Coal	169-3	6.85	10.78	38.26	44.11	1.28	11,136
Bottom Ash	169-3	1.42	92.44	6.11	0.03	0.56	a/
Fly Ash	169-3	0.06	99.14	2.03	a/	0.22	82

a/ Ash gained weight due to high iron content.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

Field	Entry
1. REPORT NO.	EPA-600/7-80-085c
2.	
3. RECIPIENT'S ACCESSION NO.	
4. TITLE AND SUBTITLE	Thirty-day Field Tests of Industrial Boilers: Site 3-- Pulverized-coal-fired Boiler
5. REPORT DATE	April 1980
6. PERFORMING ORGANIZATION CODE	
7. AUTHOR(S)	W.A. Carter and H.J. Buening
8. PERFORMING ORGANIZATION REPORT NO.	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	KVB, Inc. P.O. Box 19518 Irvine, California 92714
10. PROGRAM ELEMENT NO.	EHE624
11. CONTRACT/GRANT NO.	68-02-2645, Task 4
12. SPONSORING AGENCY NAME AND ADDRESS	EPA, Office of Research and Development Industrial Environmental Research Laboratory Research Triangle Park, NC 27711
13. TYPE OF REPORT AND PERIOD COVERED	Task Final; 3/79-3/80
14. SPONSORING AGENCY CODE	EPA/600/13

15. SUPPLEMENTARY NOTES IERL-RTP project officer is Robert E. Hall, Mail Drop 65, 919/ 541-2477.

16. ABSTRACT This is a final report for a test program to evaluate the long-term effectiveness of combustion modifications for lowering emissions from industrial boilers. Previous short-term tests had been performed on industrial boilers to determine the effect of combustion modifications on such air pollutant emissions as NOx, SOx, CO, HC, and particulate. The objective of this program was to determine if the combustion modification techniques which were effective for the short-term tests are feasible for longer periods. The report gives results of a 30-day field test of a pulverized-coal-fired, water-tube boiler rated at 76.2 MW (260,000 lb steam/ hr) output. Staged combustion air and low excess air were used to effectively control NOx emissions. However, such additional operational problems as flame instability can be encountered. The baseline NO measurement was 498 ng/J (815 ppm at 3% O2, dry) with the unit operating at about 70% of capacity. At the same load, low NOx operations yielded NO at an emission level of 422 ng/J (691 ppm at 3% O2, dry) for a 15% NO reduction. During 30 days of firing under low NOx operation with loads of 15 to 63 MW, the average NO emission level was 340 ng/J (557 ppm at 3% O2, dry). Boiler efficiency increased about 1% under low NOx firing conditions.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Nitrogen Oxides	Pollution Control	13B	
Boilers	Carbon Monoxide	Stationary Sources	13A	
Pulverized Fuels	Hydrocarbons	Industrial Boilers	21D	07C
Coal	Dust	Combustion Modification		11G
Combustion		Staged Combustion	21B	
Field Tests		Low Excess Air	14B	
Sulfur Oxides		Particulate	07B	

Field	Entry
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