Energy Systems Associates A CORPORATION

November 26, 1984
ESA 17700-144

AP42 Section 1.4
4/93
Reference 16

Mr. Florian Wisinski
Engineering Manager
Cleaver-Brooks
3707 No. Richards St
Milwaukee, WI 53212

Dear Mr. Wisinski:

SUBJECT: Results from Performance Tests
California Milk Producers Boiler No. 5
October 30-31, 1984

This letter presents the results of the emissions performance tests conducted for Cleaver-Brooks on California Milk Producers Boiler No. 5 in Artesia, California. The performance tests were conducted on October 30-31, 1984. Included in addition to the results are a brief unit and sampling site description, and a description of the test conditions, test procedures, and sampling equipment.

UNIT DESCRIPTION

California Milk Producers Boiler 5 is a Cleaver-Brooks package boiler. It has a rated full load capacity of 47,000 lb/hr steam (600 °F, 150 psi). The boiler has the capability of firing both natural gas and #2 fuel oil. It is equipped with a Cleaver-Brooks designed flue gas recirculation (FGR) system and an oxygen trim system.

The FGR system extracts a portion of the combustion products from the boiler exit duct and delivers the gas to be mixed with the combustion air at the burner. FGR recirculation rate is controlled by a butterfly valve in the duct between the FGR fan and the burner.

SAMPLING SITE DESCRIPTION

The sampling for NOx, O_2, and CO was conducted from the boiler stack upstream of a finned-tube economizer. Two sample ports were installed on the 42 in. diameter stack (90 deg apart). The sample ports were installed upstream of the economizer due to the economizer position relative to the stack exit. In addition to the gaseous sampling, flue gas velocity and temperature measurements were also taken using these sample ports.

Two sampling ports were also installed on the 12 in. diameter FGR duct eight diameters downstream and two diameters upstream of any flow disturbances. These sample ports were used to measure gas velocity and temperature in the FGR duct.

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TEST CONDITIONS

Table 1 presents the array of conditions at which the tests were performed. NOx, O_2, and CO concentrations were measured at each of the conditions shown in the table according to methodology approved by the SCAQMD. FGR and stack flow rates were measured at all except the 0% FGR conditions. The maximum percent FGR was determined by fan limitation and flame appearance.

TABLE 1.
TEXT MATRIX CONDITIONS

Fuel	Load	Test Conditions (Percent FGR)		
Natural Gas	60% 100%	0 0	10 10 (or max.)	20 (or max.)
Oil	60% 100%	0 0	10 10 (or max.)	20 (or max.)

TEST PROCEDURES

Energy Systems Associates (ESA) utilized a continuous emissions monitoring system with analyzers for NOx, O_2, and CO. The analyzers are the types (or equivalent) suggested by the California Air Resources Board. Table 2 below provides detailed information on the analyzers which were used in testing.

TABLE 2.
TEST PROGRAM ON CEM ANALYZERS

Species	Manufacturer	Measurement Principle	Accuracy
NOx	Thermo Electron	Chemiluminescent	± 1% full scale
O_2	Teledyne	Micro Fuel Cell	± 1% full scale
CO	Horiba	Nondispersive Infrared	± 1% full scale

The above analyzers, used in conjunction with sample extraction and conditioning components and the calibration gas system, make up the continuous emissions monitor package. The sample extraction and conditioning system draws a sample from the stack, dries it, removes any particulate matter, and

delivers the clean, dry sample to the analyzers. The calibration system delivers gases of known concentration to the analyzers to set the instrument's zero and span outputs. ESA uses gases which are certified accurate to ± 1%. The NOx calibration gases are NBS-traceable.

The sampling system was set up and operated as outlined by Bay Area Air Quality Management District ST9 13A and 14, for CO, NOx, and O_2. A preliminary traverse of the stack was made to determine the level of stratification in flue gas. Based on the results of this test, all subsequent gas samples were extracted from a single point. The data from the stratification test can be found in the appendix. The test duration at each condition was 20-30 minutes. This time period was chosen in consideration of boiler operating criteria, boiler stability at a condition, and conversation with cognizant SCAQMD personnel. Where appropriate, stack gas and FGR flow rates were measured using EPA method 1 procedures during the same interval as the measurement of the gaseous constituents. The relation of these flow rates yielded the percent FGR. All calculations were performed according to appropriate reference method procedures or their equivalents. These calculations are included in the appendix.

RESULTS

The results of the performance test are presented in Table 3. The continuous measurement values presented are average values for the test period. The NOx and CO concentrations have been corrected to a reference condition of 3% O_2. Copies of the field data sheets and strip charts are included in the appendix. If you have any questions, please call.

Sincerely,

ENERGY SYSTEMS ASSOCIATES

Robert A. Finken/gc

Robert A. Finken
Manager, Testing Services

RAF:rs

Attachment/Enclosures: As Noted

TABLE 3.
TEST RESULTS

Test No.	Time	Fuel	% Load	Steam Flow (Avg, lb/hr)	% FGR	O_2,%	NOx, ppm at 3% O_2	CO, ppm
4	1210-1235	Natural gas	60	29,400	0	3.62	64.4	182
6	1427-1457	Natural gas	60	29,800	9.7	3.45	29.7	47
7	1515-1545	Natural gas	60	30,250	15.98	3.05	22.0	85
3	1130-1155	Natural gas	100	49,000	0	3.54	81.7	455
5	1345-1415	Natural gas	100	48,000	9.63*	3.09	33.9	386
9	1020-1045	#2 fuel oil	60	29,500	0	3.64	136	21
14	1605-1630	#2 fuel oil	60	28,500	10.69	3.59	115	24
15	1635-1700	#2 fuel oil	60	27,300	18.45	3.53	104	24
8	0910-0938	#2 fuel oil	100	49,300	0	3.49	144	20
13	1525-1555	#2 fuel oil	100	47,250	10.47*	3.38	118	24

*Maximum operating percent FGR at this load.

A sample of the fuel oil was analyzed for sulfur and API gravity. The results are as follows:

Sulfur (% wt) = 0.06%
API Gravity = 31.9

NG $\frac{24.7}{64.4} = 54\%$ red
$\frac{22}{64} = 66\%$ red
$\frac{33.9}{81.7} = 59\%$ red

#2 oil $\frac{115}{136} = 15\%$ red
$\frac{104}{136} = 24\%$ red $\frac{118}{144} = 18\%$

[illegible]

SOURCE CATEGORY: Natural Gas

EXCLUSION CRITERIA CHECKLIST

REFERENCE [illegible]

CRITERIA	YES	NO
1. Test series averages are reported in units that can be converted to the selected reporting units?	✓	
2. Test series represent compatible test methods?	✓	
3. In tests in which emission control devices were used, the control devices are fully specified?	✓	
4. Is it clear whether or not the emissions were controlled (or not controlled)?	✓	

Form filled out by [illegible]

Date [illegible]

INDICATE WHETHER ANSWER IS YES OR NO WITH AN "X" IN APPROPRIATE BOX.

IF ALL ANSWERS ARE "YES" PROCEED TO **METHODOLOGY/DETAIL CRITERIA CHECKLIST.**

SOURCE CATEGORY Primary Zinc

METHODOLOGY/DETAIL CRITERIA CHECKLIST

REFERENCE Journal Metals Processes

CRITERIA	YES	NO	COMMENTS
1. Is the manner in which the source was operated well documented in the report?	✓		Poor info on feed rate
Was the source operating within typical parameters during the test?	✓		
2. Did sampling procedures deviate from standard methods?	✓		
If so, were the deviations well documented?			
Were the deviations appropriate?			
Comment on how any alterations in sampling procedure may have influenced the results.			
3. Were there wide variations in the results?		✓	
If yes, can the variations be adequately explained by information in the report?			NA
If the variations are not well explained, should the data be considered of poor quality?			NA
4. Do the test reports contain the raw data sheets?		✓	
Are the nomenclature and equations used equivalent to those specified by the EPA?	✓		
Comment on the consistency and completeness of the results.			Some info not given

Form filled out by [illegible]

Date [illegible]

INDICATE YES OR NO WITH AN "X" IN THE APPROPRIATE BOX. FILL IN COMMENTS.

IF, BASED ON ABOVE ANSWERS, THE SOURCE REPORT PROVIDES ADEQUATE DETAIL AND DEMONSTRATES SOUND METHODOLOGY, PROCEED TO RATING THE DATA IN THE RATING CRITERIA CHECKLIST.

SOURCE CATEGORY [illegible]

RATING CRITERIA CHECKLIST

Reference [illegible]

RATING CRITERIA	YES	NO
A Tests performed by a sound methodology and reported in enough detail for adequate validation?		
B Tests were performed by a generally sound methodology, but not enough detail for adequate validation?	[illegible] ✓	
C Were tests based on untested or new methodology that lacks significant amount of background data?		
D Were tests based on generally unacceptable methods, but may provide order-of-magnitude values for the source?		

COMMENTS
[illegible]

Form filled out by [illegible]

Date [illegible]

BASED ON ANSWERS AND COMMENTS ABOVE, ASSIGN A RANK TO THIS LITERATURE SOURCE:

B [illegible]

RANK ASSIGNED TO EMISSION SOURCE DATA

ESA/California Milk Producers

Natural gas combustion

Without flue gas recirculation

Test No.	Load, % of Max	Emissions, ppm: CO	Emissions, ppm: NOx 3% O2	Emissions, ppm: CO2	% O2	Emissions @ 0% O2: CO	Emissions @ 0% O2: NOx	Emissions @ 0% O2: CO2	CO EF, lb/MM ft3	NOx EF, lb/MM ft3	CO2 EF, lb/MM ft3	
4	60	182	64.4	-	3.62	220	75	ERR	150	84	ERR	60
3	100	455	81.7	-	3.54	548	95	ERR	374	107	ERR	100
								Averages	262.3	95.7	ERR	

With flue gas recirculation

Test No.	Load, % of Max	Emissions, ppm: CO	Emissions, ppm: NOx 3% O2	Emissions, ppm: CO2	% O2	Emissions @ 0% O2: CO	Emissions @ 0% O2: NOx	Emissions @ 0% O2: CO2	CO EF, lb/MM ft3	NOx EF, lb/MM ft3	CO2 EF, lb/MM ft3	NOx Red'n, %
6	60	47	29.7	-	3.45	56	35	ERR	38	39	ERR	53.9
7	60	85	22	-	3.05	100	26	ERR	68	29	ERR	65.8
5	100	386	33.9	-	3.09	453	40	ERR	309	44	ERR	58.5
								Averages	53.2	33.9	ERR	59.9

Note: FGR rates were 9.7, 16.0, and 9.6 % of total flue gas flow for Tests 6, 7, and 5, respectively.

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