Golder Associates

# CORRELATION TESTING FOR GOOD COMBUSTION PRACTICES BOILER NO. 4 U.S. SUGAR CORPORATION CLEWISTON, FLORIDA

Prepared For:

U.S. Sugar Corporation
111 Ponce de Leon Avenue
Clewiston, Florida 33440

Prepared By:

Golder Associates Inc.
6241 NW 23rd Street, Suite 500
Gainesville, Florida 32653-1500

January 2001
0037629B/R1

DISTRIBUTION:
2 Copies - FDEP
2 Copies - U.S. Sugar
2 Copies - Golder Associates Inc.

TABLE OF CONTENTS

TABLE OF CONTENTS

(Cont'd)

IN ORDER
FOLLOWING
PAGE 8

## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| CO | carbon monoxide |
| EPA | U.S. Environmental Protection Agency |
| FDEP | Florida Department of Environmental Protection |
| GCP | good combustion practice |
| lb/hr | pounds per hour |
| lb/MMBtu | pounds per million British thermal unit |
| $NO_x$ | nitrogen oxide |
| $O_2$ | oxygen |
| PM | particulate matter |
| $PM_{10}$ | particulate matter with particle size of 10 microns or less |
| ppm | parts per million |
| U.S. Sugar | United States Sugar Corporation |
| VOC | volatile organic compound |

# 1.0 INTRODUCTION

United States Sugar Corporation (U.S. Sugar) operates a sugar mill and refinery located in Clewiston, Hendry County, Florida. Bagasse, a fibrous byproduct of sugar cane processing, is burned as boiler fuel to provide heat and steam for the mill and refinery. The facility currently has five permitted bagasse boilers.

In November 1999, an air construction permit was issued by the Florida Department of Environmental Regulation (FDEP) to U.S. Sugar for an increase in annual steam production for Boiler No. 4 and for modifications to the sugar refinery operations (Air Construction Permit No. 0510003-009-AC; PSD Permit No. PSD-FL-272). A condition of the construction permit (Section III, Emissions Unit 009, Condition No. 9) is the use of Good Combustion Practices (GCPs) to minimize emissions of carbon monoxide (CO), particulate matter/particulate matter with a diameter of less than 10 microns ($PM/PM_{10}$), volatile organic compounds (VOCs), and nitrogen oxides ($NO_x$) emissions from Boiler No. 4.

As a critical part of the GCPs, U.S. Sugar was required to install and operate process monitors to measure the oxygen ($O_2$) and CO content of the Boiler No. 4 exhaust gases. At least twelve 1-hour test runs were required to be conducted, using U.S. Environmental Protection Agency (EPA) Method 10 for CO emissions, while also measuring other flue gas constituents. The purpose of the testing was to determine if any relationship exists between flue gas $O_2$ and CO content and combustion efficiency. The results of the correlation testing are to be used to determine a minimum flue gas $O_2$ and maximum CO content that represents adherence to GCPs. The correlation testing was conducted from November 13 through 16, 2000.

In addition to the CO correlation testing, U.S. Sugar was required to conduct VOC stack testing by FDEP Consent Order 00-0908-26-AP dated August 1, 2000. At least twelve 1-hour VOC runs were to be conducted, concurrent with the CO correlation testing. The results of the testing are to be used to further define GCPs to minimize VOC emissions.

This report summarizes the test methods and operation parameters; presents data and results; discusses the relationships between flue gas $O_2$, CO and VOC content, and combustion efficiency; and makes recommendations for an acceptable minimum flue gas $O_2$ content and maximum CO content that indicates adherence to GCPs. Finally, recommendations concerning revised permit wording and revisions to Appendix GCP of the Boiler No. 4 construction permit are presented.

# 2.0 TEST METHODS AND OPERATION PARAMETERS

## 2.1 INTRODUCTION

As required by Air Construction Permit No. 051-0003-009-AC, CO correlation testing must be performed on Boiler No. 4 for at least twelve 1-hour test runs using EPA Method 10. According to FDEP Consent Order 00-0908-26-AP, VOC testing must be performed on Boiler No. 4 for at least twelve 1-hour test runs. The CO correlation testing and VOC testing for Boiler No. 4 at the Clewiston Mill began November 13, 2000 and was concluded on November 16, 2000.

## 2.2 OPERATION PARAMETERS

The maximum permitted steam capacity for Boiler No. 4 is 300,000 pounds per hour (lb/hr) and 285,000 lb/hr for a 24-hour average. The maximum 1-hour steam rate achieved by the boiler in previous compliance tests has been approximately 292,000 lb/hr.

The CO correlation and VOC tests were conducted from November 13 through 16, 2000, included a total of 15 test runs of approximately 1-hour duration. Boiler No. 4 was operated at a 1-hour steam rate between 217,600 and 267,000 lb/hr, or 72 to 89 percent of the maximum permitted 1-hour steam rate and 76 to 94 percent of the permitted 24-hour steam rate. During testing, the boiler was operated under normal conditions (i.e., air/fuel ratio, steam, and scrubber conditions) except for two periods of time, as described below:

- During Run 10 (performed November 15) wet bagasse was piled on the grate for a portion of the run, causing higher CO levels as indicated by the process monitor.
- During Run 12, one of the two cane grinding mills was shutdown. As a result, bagasse fuel for Boiler No. 4 was being received from both the operating sugar mill and the bagasse storage pile. Normally, bagasse for Boiler No. 4 is fed directly from the two sugar cane grinding mills to the boiler.

These conditions, although occurring relatively infrequently, are part of the normal operation of a bagasse boiler located at a sugar mill.

It is noted that no adjustments to boiler operating conditions were made, beyond the normal actions taken by the operators, to reduce CO emissions during the testing period. The intent of the testing was to operate over a range of conditions to establish GCP criteria.

The following parameters were measured and recorded during each test run:

- Steam production rate;
- Steam conditions (temperature, pressure);
- Feedwater conditions (temperature, pressure);
- Heat input rate (using steam conditions and assumed boiler efficiency);
- Wet scrubber operating parameters (water flow rate, pressure drop);
- Oxygen, CO, VOC, moisture, temperature, and flow rate at the stack; and
- Oxygen and CO as indicated by the process monitors (reading taken from monitor display approximately every 2 minutes).

## 2.3 TEST METHODS

During the testing of Boiler No. 4, CO, $O_2$, total hydrocarbon (THC), methane, carbon dioxide ($CO_2$), temperature, velocity, and moisture content were measured at the stack exhaust for each test run. CO was measured using EPA Method 10, velocity and temperature were measured using EPA Methods 1 and 2, $O_2$ and $CO_2$ were measured using EPA Method 3, and stack gas moisture content was measured using EPA Method 4. THC emissions were measured by EPA Method 25A [reported as pounds per million British thermal unit (lb/MMBtu) propane]. Methane emissions were measured by using EPA Method 18 (reported as lb/MMBtu propane). Regulated VOC emissions were determined as the difference between the methane emissions and THC emissions (reported as lb/MMBtu propane).

# 3.0 DATA AND RESULTS

## 3.1 TEST DATA

Test results for the correlation testing performed on Boiler No. 4 are presented in Table 1. The boiler steam rate (lb/hr), process monitor CO [in parts per million (ppm)], stack exhaust CO (ppm, wet, and lb/MMBtu), stack $O_2$ (percent, dry), process monitor $O_2$ (percent), and VOC (lb/MMBtu) are shown in Table 1. All stack data are obtained from the accompanying source test report by Air Consulting and Engineering. All process monitor data are contained in Attachment A.

## 3.2 ANALYSIS OF RESULTS

Correlation plots between the following parameters are presented in Figures 1 through 4: CO measured at the stack and measured by the process monitor, $O_2$ (at stack and process monitor), and VOC emissions (at stack).

The relationship between process monitor CO (ppm) and stack CO (lb/MMBtu) is represented in Figure 1. This plot indicates an excellent linear correlation between the process monitor CO levels in ppm and the stack CO levels in lb/MMBtu. As process monitor CO (ppm) increases, stack CO also increases (lb/MMBtu). This demonstrates that the CO process monitor is an adequate indicator of actual stack CO emissions. The plot also indicates that only at high levels of CO (i.e., greater than about 3,700 ppm as read by the process monitor) is a CO emission rate of 6.5 lb/MMBtu approached.

Figure 2 represents the correlation between stack $O_2$ levels and process monitor $O_2$ levels (measured as percent). This plot also indicates a good linear relationship between stack $O_2$ levels and process monitor $O_2$ levels. This demonstrates that the process $O_2$ monitor can be used as an adequate indicator of actual stack $O_2$ levels.

Figure 3 depicts the relationship between stack CO emission rate (lb/MMBtu) and stack VOC emission rate (lb/MMBtu). This plot indicates a good correlation between stack CO levels (lb/MMBtu) and stack VOC levels (lb/MMBtu). Since there is also a good correlation between process monitor CO and $O_2$ levels and stack CO levels, this would indicate a good relationship between stack VOC levels and process monitor CO levels. Therefore, the process CO and $O_2$ monitors provide a good indicator of actual stack VOC emissions.

Figure 4 represents the relationship between CO emission rate (lb/MMBtu) at the stack exhaust and $O_2$ (percent) read by the process monitor. This plot indicates that as process monitor $O_2$ levels decrease, stack CO levels increase. This plot also indicates that, for process monitor $O_2$ levels below approximately 1.2 percent, stack CO levels begin to increase beyond a CO emission rate of 6.5 lb/MMBtu. These results are based on an averaging time of approximately 1 hour (approximate time of individual test runs).

## 4.0 RECOMMENDATIONS AND CONCLUSIONS

A discussion of the data obtained from the GCPs testing program was presented in Section 3.0. The relationship between CO emissions, VOC emissions, and process monitor $O_2$ levels indicates that $O_2$ levels below approximately 1.2 percent, and process monitor CO levels above approximately 3,700 ppm, correlate with higher CO and VOC levels, approaching 6.5 and 0.5 lb/MMBtu, respectively. Therefore, it is recommended that a minimum process monitor $O_2$ level of 1.2 percent (1-hour block average) and a maximum process monitor CO level of 3,700 ppm (1-hour block average) be maintained to the extent practical to represent GCPs for Boiler No. 4.

U.S. Sugar will implement GCPs on Boiler No. 4 by taking corrective action whenever the $O_2$ process monitors indicate an $O_2$ level of 1.2 percent or less (1-hour block average) or a CO level of 3,700 ppm or greater (1-hour block average). The process monitors will be equipped with an alarm, which will trip anytime the $O_2$ or CO levels fall outside the threshold level based on a 1-hour block average. The corrective actions can include, but may not be limited to, adjusting air/fuel ratio, adjusting ratio of underfire to overfire air, and firing of fuel oil. Adjustments will be made as expeditiously as practical until a process monitor $O_2$ level of 1.2 percent or greater or a CO level of less than 3,700 ppm, as appropriate, is achieved and maintained for a minimum of 1 hour.

The Boiler No. 4 construction permit, Condition 9 for Emissions Unit 009, states as follows: "Based on the test results and recommendation, the Department shall revise this condition and Appendix GCP to reflect additional good combustion practices and appropriate monitoring." Suggested wording for the revised Condition 9 is presented below. The proposed revisions to Appendix GCP are attached.

Suggested revisions to Condition 9:

> 9. Good Combustion Practices: The permittee shall use the Good Combustion Practices (GCPs) defined in Appendix GCP to minimize emissions of CO, $NO_x$, $PM/PM_{10}$ and VOC from this boiler. As a critical part of the GCPs, the permittee shall install, calibrate, operate, and maintain process monitors to indicate the oxygen and carbon monoxide content of the exhaust flue gas in the boiler furnace. The monitors shall be equipped with alarms to indicate to the boiler

operators when corrective action is needed, according to Appendix GCP. Readouts of these process monitors shall be provided in the boiler control room.

The permittee shall maintain a record of periods when the minimum flue gas oxygen content falls below the GCP set point and periods when the maximum flue gas carbon monoxide content falls above the GCP set point (refer to Appendix GCP for set points). Any specific problems observed with the boiler operation, and any corrective actions taken, shall also be recorded. Operation below the specified set point for oxygen content or above the specified set point for carbon monoxide content is not a violation of this permit, in and of itself. However, continued operation below or above these set points, as appropriate, without attempting corrective action may be considered circumvention of air pollution control equipment.

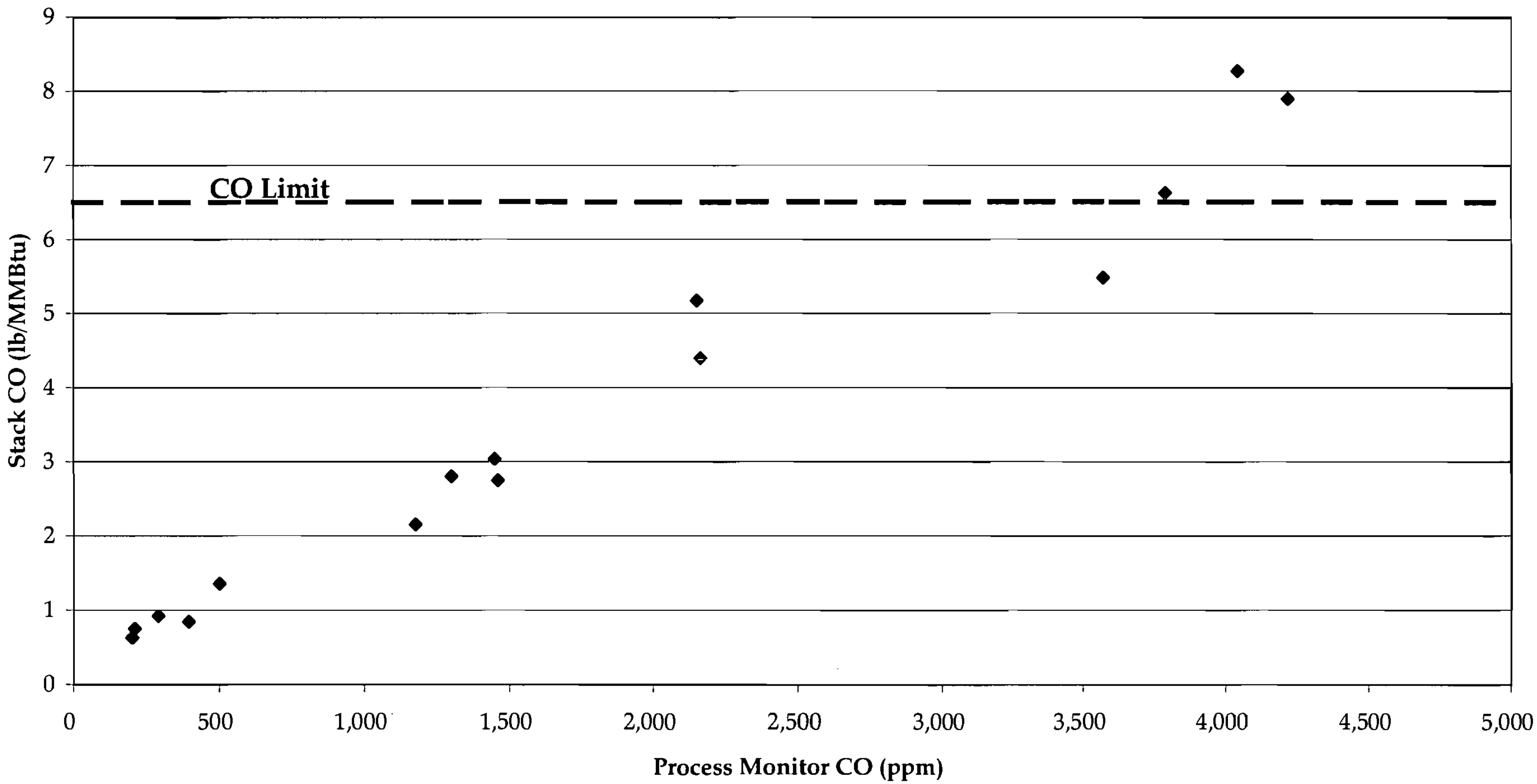
It is noted that the monitored flue gas carbon monoxide content is for the purpose of determining efficient combustion and may not be representative of the actual CO or VOC emissions from the stack, and as such the monitor is not for compliance purposes.

[Applicant Request; Rule 62-4.070(3); Rule 62-212.400 (BACT), F.A.C.]

Table 1. Correlation Test Results-Boiler No.4

| Run Number | Steam Rate | Boiler No. 4 Process Monitor | | Boiler No. 4 Stack | | | |
|---|---|---|---|---|---|---|---|
| | | CO | $O_2$ | CO | | $O_2$ | VOC |
| | (lb/hr) | (ppm) | (%) | (ppm, wet) | (lb/MMBtu) | (%, dry) | (lb/MMBtu) |
| 1 | 219,474 | 290 | 3.0 | 494 | 0.92 | 10.8 | 0.025 |
| 2 | 217,600 | 200 | 3.7 | 331 | 0.63 | 11.0 | 0.012 |
| 3 | 221,167 | 209 | 3.5 | 401 | 0.75 | 10.9 | 0.029 |
| 4 | 249,730 | 1,447 | 0.9 | 1,874 | 3.03 | 9.4 | 0.161 |
| 5 | 238,356 | 500 | 2.4 | 798 | 1.36 | 10.3 | 0.062 |
| 6 | 235,068 | 1,300 | 2.1 | 1,605 | 2.80 | 10.1 | 0.151 |
| 7 | 230,833 | 394 | 2.9 | 475 | 0.84 | 10.6 | 0.043 |
| 8 | 249,041 | 1,178 | 2.0 | 1,295 | 2.15 | 10.0 | 0.095 |
| 9 | 263,200 | 2,164 | 1.3 | 2,816 | 4.40 | 9.4 | 0.330 |
| 10 | 241,622 | 4,043 | 1.2 | 4,800 | 8.27 | 9.1 | 0.823 |
| 11 | 261,370 | 2,151 | 1.0 | 3,219 | 5.17 | 9.2 | 0.323 |
| 12 | 267,042 | 3,569 | 0.9 | 3,476 | 5.48 | 9.2 | 0.470 |
| 13 | 250,685 | 4,219 | 0.9 | 4,693 | 7.89 | 9.3 | 0.614 |
| 14 | 260,548 | 3,790 | 1.1 | 4,107 | 6.62 | 9.4 | 0.517 |
| 15 | 252,500 | 1,458 | 2.1 | 1,631 | 2.74 | 10.1 | 0.229 |

**Figure 1. Process Monitor CO (ppm) vs. Stack CO (lb/MMBtu)**
**Boiler No. 4**
**11/13/00-11/16/00**



## Figure 2. Stack $O_2$ vs. Process Monitor $O_2$
## Boiler No. 4
## 11/13/00-11/16/00

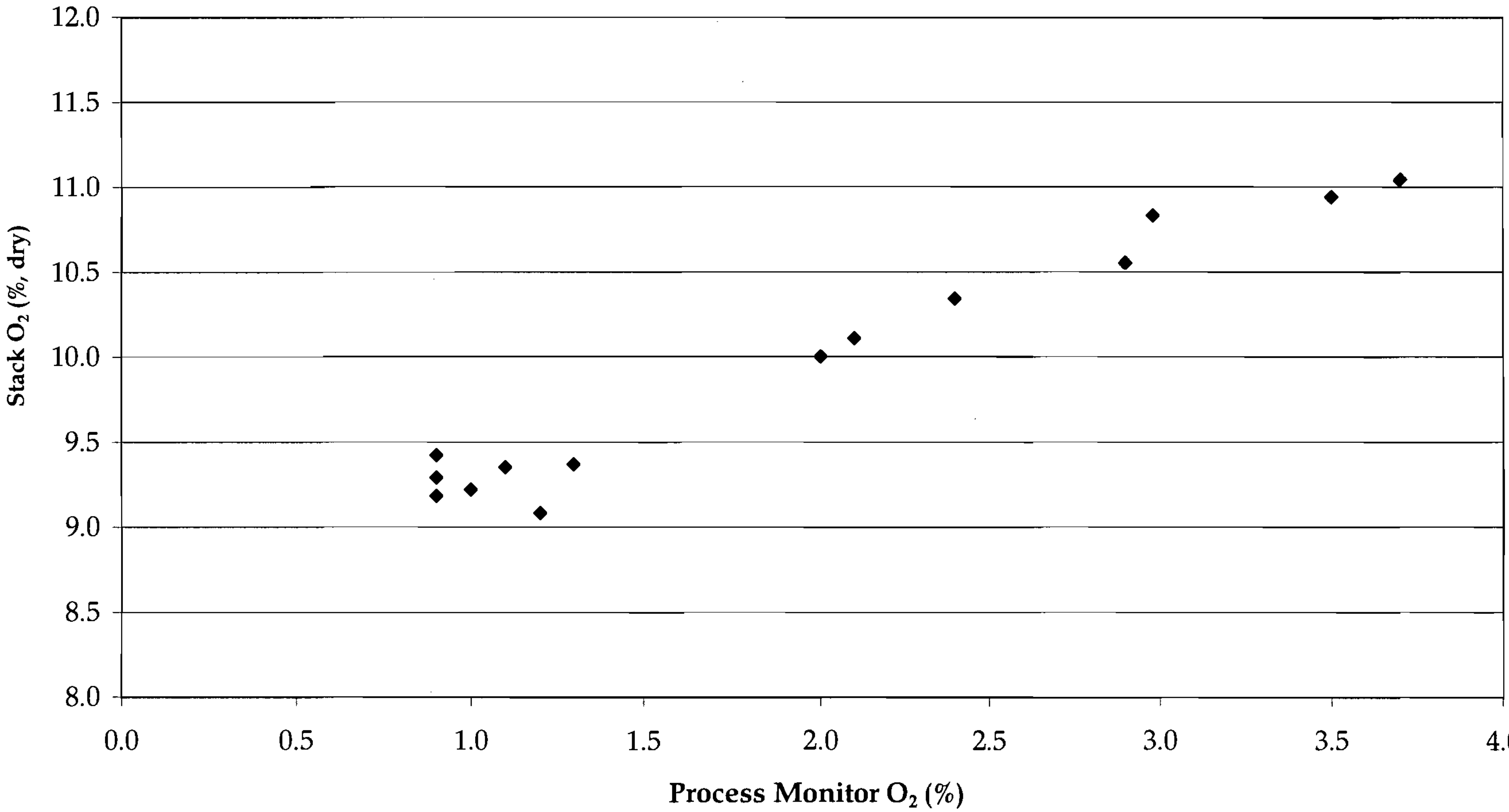


**Figure 3. Stack CO (lb/MMBtu) vs. Stack VOC (lb/MMBtu)**
**Boiler No. 4**
**11/13/00-11/16/00**

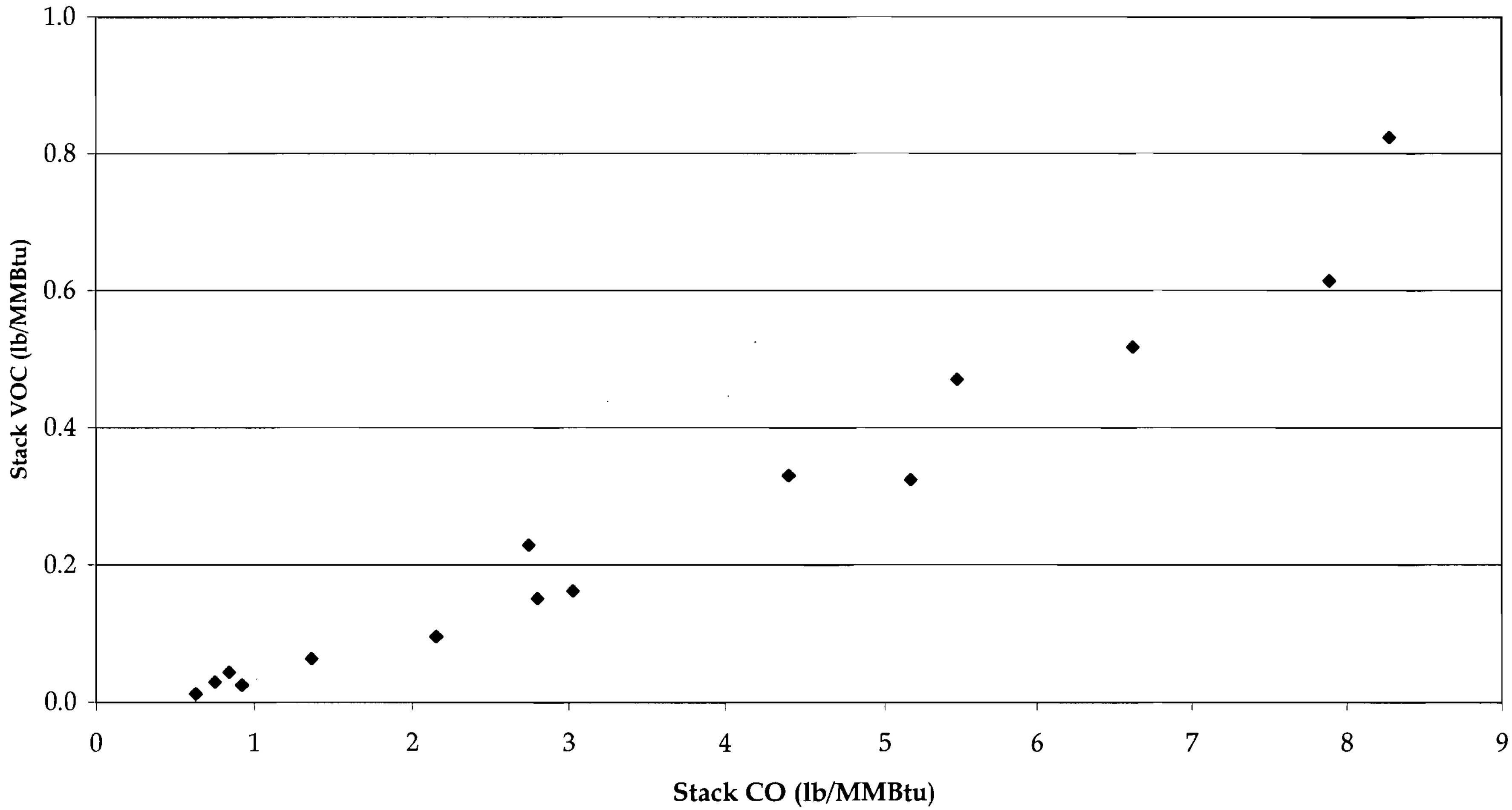
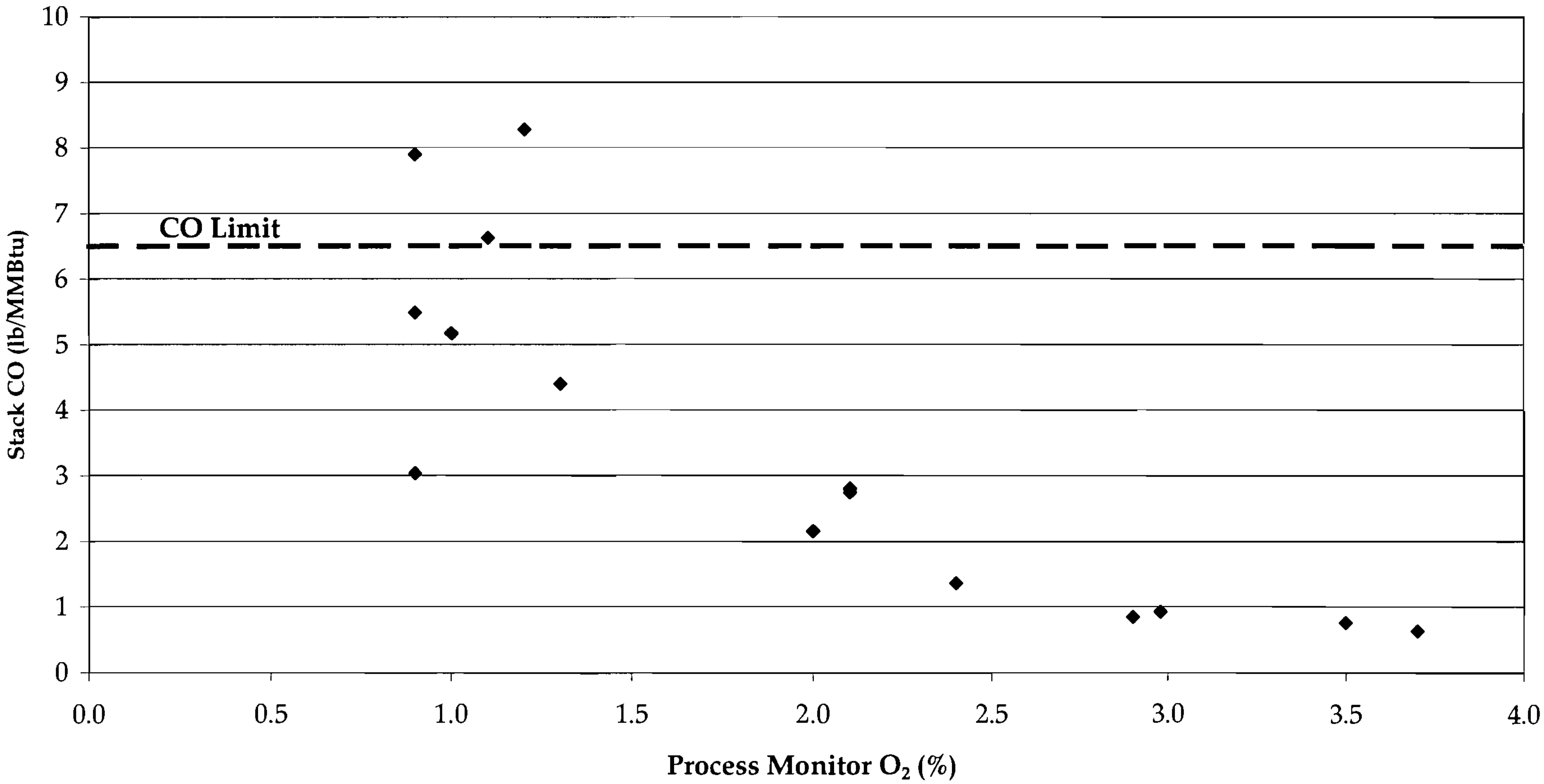


**Figure 4. Process Monitor $O_2$ (%) vs. Stack CO (lb/MMBtu)**
**Boiler No.4**
**11/13/00-11/16/00**



ATTACHMENT A

BOILER NO. 4 CO AND $O_2$

PROCESS MONITOR DATA

11/13/00-11/16/00

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/13/00 | | | |
| Run 1 | | | |
| | 11:30 | 3.8 | 200 |
| | 11:33 | 4.3 | 200 |
| | 11:34 | 4.4 | 200 |
| | 11:36 | 3.9 | 200 |
| | 11:38 | 3.9 | 200 |
| | 11:40 | 3.1 | 200 |
| | 11:42 | 3.2 | 200 |
| | 11:45 | 4.1 | 100 |
| | 11:47 | 4.0 | 100 |
| | 11:51 | 3.6 | 100 |
| | 11:53 | 3.5 | 200 |
| | 11:56 | 2.5 | 200 |
| | 11:58 | 2.4 | 600 |
| | 12:00 | 2.1 | 500 |
| | 12:02 | 2.3 | 300 |
| | 12:04 | 2.6 | 300 |
| | 12:06 | 3.7 | 200 |
| | 12:08 | 1.7 | 300 |
| | 12:10 | 1.9 | 500 |
| | 12:12 | 1.7 | 600 |
| | 12:14 | 2.4 | 300 |
| | 12:16 | 2.3 | 400 |
| | 12:18 | 2.0 | 300 |
| | 12:20 | 2.3 | 500 |
| | 12:22 | 3.2 | 300 |
| | 12:24 | 2.7 | 300 |
| | 12:26 | 2.3 | 300 |
| | 12:39 | 3.2 | 300 |
| | 12:40 | 3.2 | 300 |
| | 12:44 | 3.2 | 300 |
| Average | | 3.0 | 290 |

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/13/00 | | | |
| Run 2 | | | |
| | 1:43 | 2.7 | 100 |
| | 1:45 | 2.1 | 100 |
| | 1:47 | 2.9 | 200 |
| | 1:49 | 2.7 | 200 |
| | 1:51 | 3.2 | 200 |
| | 1:53 | 3.4 | 200 |
| | 1:55 | 3.1 | 200 |
| | 1:57 | 3.8 | 200 |
| | 1:59 | 3.9 | 200 |
| | 2:01 | 3.8 | 200 |
| | 2:03 | 3.4 | 300 |
| | 2:07 | 4.0 | 100 |
| | 2:09 | 4.1 | 200 |
| | 2:11 | 3.3 | 200 |
| | 2:13 | 2.9 | 400 |
| | 2:15 | 3.3 | 200 |
| | 2:17 | 3.3 | 200 |
| | 2:19 | 3.5 | 300 |
| | 2:21 | 4.0 | 200 |
| | 2:23 | 3.6 | 200 |
| | 2:25 | 5.6 | 200 |
| | 2:27 | 5.3 | 100 |
| | 2:29 | 4.0 | 200 |
| | 2:31 | 4.1 | 300 |
| | 2:33 | 3.7 | 200 |
| | 2:35 | 3.9 | 200 |
| | 2:37 | 3.5 | 200 |
| | 2:39 | 3.9 | 200 |
| | 2:41 | 3.4 | 200 |
| | 2:43 | 3.4 | 200 |
| | 2:45 | 3.1 | 300 |
| | 2:47 | 4.1 | 200 |
| | 2:49 | 4.2 | 100 |
| | 2:51 | 3.7 | 200 |
| | 2:53 | 5.2 | 100 |
| | 2:55 | 3.7 | 200 |
| Average | | 3.7 | 200 |

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/13/00 | | | |
| Run 3 | | | |
| | 3:46 | 3.7 | 300 |
| | 3:48 | 3.4 | 200 |
| | 3:56 | 3.9 | 200 |
| | 3:58 | 3.7 | 200 |
| | 4:00 | 4.0 | 100 |
| | 4:04 | 3.1 | 200 |
| | 4:08 | 4.1 | 200 |
| | 4:12 | 2.9 | 200 |
| | 4:15 | 3.1 | 300 |
| | 4:19 | 3.1 | 200 |
| | 4:21 | 3.0 | 200 |
| | 4:23 | 5.0 | 100 |
| | 4:25 | 3.4 | 200 |
| | 4:27 | 3.5 | 200 |
| | 4:29 | 2.5 | 300 |
| | 4:31 | 2.8 | 200 |
| | 4:33 | 2.9 | 300 |
| | 4:35 | 2.8 | 200 |
| | 4:37 | 3.8 | 200 |
| | 4:39 | 3.9 | 200 |
| | 4:41 | 3.6 | 200 |
| | 4:43 | 3.8 | 200 |
| Average | | 3.5 | 209 |

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/14/00 | | | |
| Run 4 | | | |
| | 8:40 | 1.7 | 800 |
| | 8:42 | 0.8 | 1000 |
| | 8:44 | 1.2 | 1700 |
| | 8:46 | 1.1 | 1400 |
| | 8:48 | 1.3 | 1000 |
| | 8:50 | 1.5 | 400 |
| | 8:52 | 0.7 | 1200 |
| | 8:56 | 0.7 | 700 |
| | 8:58 | 1.0 | 900 |
| | 9:00 | 1.4 | 600 |
| | 9:02 | 1.0 | 400 |
| | 9:04 | 1.0 | 500 |
| | 9:06 | 1.3 | 700 |
| | 9:08 | 1.0 | 300 |
| | 9:10 | 1.0 | 700 |
| | 9:12 | 0.4 | 1800 |
| | 9:14 | 0.6 | 1700 |
| | 9:16 | 0.8 | 900 |
| | 9:18 | 0.4 | 2500 |
| | 9:20 | 0.8 | 1100 |
| | 9:22 | 0.7 | 1400 |
| | 9:24 | 1.2 | 1400 |
| | 9:26 | 0.1 | 2100 |
| | 9:28 | 0.8 | 1300 |
| | 9:30 | 0.5 | 3300 |
| | 9:32 | 0.7 | 2800 |
| | 9:34 | 1.4 | 1600 |
| | 9:36 | 1.0 | 1400 |
| | 9:38 | 1.3 | 1600 |
| | 9:40 | 0.6 | 1000 |
| | 9:42 | 0.4 | 3000 |
| | 9:44 | 0.3 | 4100 |
| | 9:46 | 0.8 | 2000 |
| | 9:48 | 0.7 | 1900 |
| Average | | 0.9 | 1447 |

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/14/00 | | | |
| Run 5 | | | |
| | 10:25 | 2.8 | 300 |
| | 10:26 | 2.7 | 400 |
| | 10:30 | 3.0 | 200 |
| | 10:32 | 2.6 | 300 |
| | 10:34 | 2.9 | 300 |
| | 10:36 | 3.8 | 200 |
| | 10:38 | 3.3 | 200 |
| | 10:40 | 3.1 | 200 |
| | 10:42 | 2.8 | 400 |
| | 10:44 | 2.7 | 300 |
| | 10:46 | 2.8 | 400 |
| | 10:48 | 2.6 | 700 |
| | 10:50 | 2.6 | 400 |
| | 10:52 | 2.5 | 800 |
| | 10:54 | 2.1 | 500 |
| | 10:56 | 2.6 | 300 |
| | 10:58 | 2.6 | 500 |
| | 11:00 | 2.6 | 300 |
| | 11:02 | 2.1 | 500 |
| | 11:04 | 2.1 | 600 |
| | 11:06 | 2.7 | 500 |
| | 11:08 | 3.4 | 400 |
| | 11:10 | 3.2 | 200 |
| | 11:12 | 2.2 | 600 |
| | 11:14 | 1.5 | 600 |
| | 11:16 | 1.6 | 600 |
| | 11:18 | 1.5 | 800 |
| | 11:20 | 1.7 | 800 |
| | 11:22 | 1.3 | 1000 |
| | 11:24 | 1.5 | 1000 |
| | 11:26 | 2.0 | 600 |
| | 11:28 | 1.6 | 500 |
| | 11:30 | 2.0 | 600 |
| | 11:32 | 1.6 | 900 |
| | 11:34 | 1.8 | 700 |
| | 11:36 | 2.8 | 400 |
| Average | | 2.4 | 500 |

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/14/00 | | | |
| Run 6 | | | |
| | 2:14 | 2.6 | 400 |
| | 2:16 | 2.0 | 300 |
| | 2:18 | 2.2 | 700 |
| | 2:20 | 2.4 | 400 |
| | 2:22 | 2.4 | 300 |
| | 2:24 | 6.8 | 200 |
| | 2:26 | 6.7 | 100 |
| | 2:28 | 5.7 | 100 |
| | 2:30 | 6.2 | 100 |
| | 2:32 | 2.8 | 300 |
| | 2:34 | 2.9 | 400 |
| | 2:36 | 2.7 | 400 |
| | 2:38 | 2.9 | 600 |
| | 2:40 | 2.6 | 600 |
| | 2:42 | 2.6 | 700 |
| | 2:44 | 2.8 | 500 |
| | 2:46 | 1.9 | 600 |
| | 2:48 | 1.3 | 1100 |
| | 2:50 | 0.2 | 3900 |
| | 2:52 | 1.0 | 2300 |
| | 2:54 | 0.6 | 2700 |
| | 2:56 | 0.6 | 2900 |
| | 2:58 | 1.1 | 1400 |
| | 3:00 | 0.8 | 1800 |
| | 3:02 | 0.7 | 1900 |
| | 3:04 | 0.8 | 1400 |
| | 3:06 | 0.7 | 2000 |
| | 3:08 | 0.4 | 2000 |
| | 3:10 | 0.4 | 2800 |
| | 3:12 | 0.3 | 2000 |
| | 3:14 | 0.2 | 4000 |
| | 3:16 | 0.4 | 2000 |
| | 3:18 | 0.6 | 2000 |
| Average | | 2.1 | 1300 |

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/15/00 | | | |
| Run 7 | | | |
| | 8:50 | 3.1 | 400 |
| | 8:52 | 3.6 | 300 |
| | 8:54 | 3.6 | 300 |
| | 8:56 | 4.7 | 300 |
| | 8:58 | 3.4 | 300 |
| | 9:00 | 3.7 | 300 |
| | 9:02 | 2.6 | 600 |
| | 9:04 | 2.3 | 300 |
| | 9:06 | 3.3 | 200 |
| | 9:08 | 2.8 | 300 |
| | 9:10 | 2.6 | 300 |
| | 9:12 | 3.2 | 300 |
| | 9:14 | 3.8 | 200 |
| | 9:16 | 4.0 | 300 |
| | 9:18 | 3.0 | 300 |
| | 9:20 | 2.8 | 200 |
| | 9:22 | 2.7 | 400 |
| | 9:24 | 2.6 | 300 |
| | 9:26 | 2.5 | 400 |
| | 9:28 | 2.5 | 400 |
| | 9:30 | 2.0 | 600 |
| | 9:32 | 2.9 | 600 |
| | 9:34 | 2.1 | 500 |
| | 9:36 | 2.9 | 500 |
| | 9:38 | 3.1 | 400 |
| | 9:40 | 2.7 | 400 |
| | 9:42 | 2.9 | 400 |
| | 9:44 | 2.0 | 500 |
| | 9:46 | 2.9 | 300 |
| | 9:48 | 2.5 | 500 |
| | 9:50 | 2.0 | 600 |
| | 9:52 | 2.6 | 900 |
| | 9:54 | 2.4 | 500 |
| | 9:56 | 2.6 | 300 |
| Average | | 2.9 | 394 |

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/15/00 | | | |
| Run 8 | | | |
| | 10:36 | 2.5 | 800 |
| | 10:38 | 2.8 | 500 |
| | 10:40 | 1.7 | 900 |
| | 10:42 | 2.6 | 600 |
| | 10:44 | 2.3 | 600 |
| | 10:46 | 2.1 | 700 |
| | 10:48 | 2.5 | 700 |
| | 10:50 | 2.0 | 500 |
| | 10:52 | 3.0 | 600 |
| | 10:54 | 2.8 | 700 |
| | 10:56 | 2.5 | 400 |
| | 10:58 | 2.1 | 900 |
| | 11:00 | 2.7 | 500 |
| | 11:02 | 2.3 | 1100 |
| | 11:04 | 2.3 | 700 |
| | 11:06 | 2.4 | 600 |
| | 11:08 | 3.1 | 600 |
| | 11:10 | 1.7 | 1100 |
| | 11:12 | 1.9 | 1500 |
| | 11:14 | 1.4 | 1500 |
| | 11:16 | 1.4 | 1300 |
| | 11:18 | 1.1 | 1900 |
| | 11:20 | 1.2 | 2100 |
| | 11:22 | 1.4 | 1600 |
| | 11:24 | 0.9 | 2800 |
| | 11:26 | 1.9 | 1600 |
| | 11:28 | 1.5 | 1100 |
| | 11:30 | 2.1 | 1200 |
| | 11:32 | 1.7 | 900 |
| | 11:34 | 1.5 | 1900 |
| | 11:36 | 1.7 | 1900 |
| | 11:38 | 1.6 | 1400 |
| | 11:40 | 1.7 | 1200 |
| | 11:42 | 1.1 | 1700 |
| | 11:44 | 1.4 | 2500 |
| | 11:46 | 1.4 | 1800 |
| Average | | 2.0 | 1178 |

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/15/00 | | | |
| Run 9 | | | |
| | 1:06 | 1.6 | 1200 |
| | 1:08 | 2.2 | 1100 |
| | 1:14 | 2.0 | 1000 |
| | 1:16 | 1.7 | 800 |
| | 1:18 | 1.6 | 1100 |
| | 1:20 | 1.0 | 1900 |
| | 1:22 | 1.2 | 1500 |
| | 1:24 | 1.4 | 1900 |
| | 1:26 | 1.6 | 1600 |
| | 1:28 | 1.5 | 1200 |
| | 1:30 | 1.2 | 2300 |
| | 1:32 | 1.0 | 2700 |
| | 1:34 | 0.9 | 2400 |
| | 1:36 | 0.7 | 2500 |
| | 1:38 | 1.1 | 3200 |
| | 1:42 | 0.7 | 4500 |
| | 1:44 | 1.1 | 2700 |
| | 1:46 | 0.8 | 3400 |
| | 1:48 | 1.1 | 3400 |
| | 1:52 | 1.3 | 2000 |
| | 1:54 | 1.3 | 2000 |
| | 1:56 | 1.3 | 2000 |
| | 1:58 | 1.3 | 1500 |
| | 2:00 | 1.3 | 1400 |
| | 2:02 | 1.6 | 2600 |
| | 2:04 | 0.5 | 1800 |
| | 2:06 | 0.9 | 3500 |
| | 2:08 | 1.7 | 2300 |
| | 2:10 | 1.4 | 2400 |
| | 2:12 | 1.6 | 3100 |
| | 2:14 | 1.8 | 1700 |
| | 2:16 | 1.1 | 2200 |
| | 2:18 | 0.9 | 2500 |
| Average | | 1.3 | 2164 |

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/15/00 | | | |
| Run 10: Note: wet bagasse piled up on grate during Run 10, causing high CO. | | | |
| | 2:50 | 0.8 | 3700 |
| | 2:52 | 1.7 | 2000 |
| | 2:54 | 2.8 | 400 |
| | 2:56 | 0.2 | 4600 |
| | 2:58 | 0.4 | 4200 |
| | 3:00 | 0.1 | 4600 |
| | 3:02 | 0.0 | 7300 |
| | 3:04 | 0.0 | 5800 |
| | 3:06 | 0.0 | 7500 |
| | 3:08 | 0.0 | 7400 |
| | 3:10 | 0.0 | 5400 |
| | 3:12 | 0.0 | 5700 |
| | 3:14 | 0.0 | 5900 |
| | 3:16 | 0.4 | 4500 |
| | 3:18 | 0.0 | 5400 |
| | 3:20 | 0.0 | 7600 |
| | 3:22 | 0.0 | 10300 |
| | 3:24 | 0.0 | 6200 |
| | 3:26 | 0.0 | 4600 |
| | 3:28 | 0.0 | 5300 |
| | 3:30 | 0.0 | 6700 |
| | 3:32 | 0.0 | 2100 |
| | 3:24 | 0.0 | 12100 |
| | 3:36 | 0.0 | 5500 |
| | 3:38 | 0.0 | 2900 |
| | 3:40 | 2.9 | 1000 |
| | 3:42 | 4.2 | 600 |
| | 3:44 | 4.3 | 300 |
| | 3:46 | 4.8 | 200 |
| | 3:48 | 3.3 | 300 |
| | 3:50 | 3.3 | 300 |
| | 3:52 | 3.2 | 200 |
| | 3:54 | 2.9 | 300 |
| | 3:56 | 2.7 | 300 |
| | 3:58 | 3.3 | 300 |
| Average | | 1.2 | 4043 |

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/15/00 | | | |
| Run 11 | | | |
| | 4:36 | 1.4 | 900 |
| | 4:38 | 1.2 | 2100 |
| | 4:40 | 0.9 | 2000 |
| | 4:42 | 0.5 | 2200 |
| | 4:44 | 1.1 | 2200 |
| | 4:46 | 0.6 | 3000 |
| | 4:48 | 1.5 | 1800 |
| | 4:50 | 1.4 | 1200 |
| | 4:52 | 2.1 | 600 |
| | 4:54 | 1.6 | 900 |
| | 4:56 | 2.1 | 1000 |
| | 4:58 | 2.2 | 1400 |
| | 5:00 | 1.9 | 800 |
| | 5:02 | 1.2 | 1500 |
| | 5:04 | 0.9 | 2500 |
| | 5:06 | 1.0 | 2100 |
| | 5:08 | 0.5 | 3600 |
| | 5:10 | 0.9 | 2200 |
| | 5:12 | 0.7 | 3200 |
| | 5:14 | 0.9 | 1800 |
| | 5:16 | 0.5 | 3000 |
| | 5:18 | 0.7 | 2900 |
| | 5:20 | 1.0 | 1900 |
| | 5:22 | 0.6 | 2000 |
| | 5:24 | 0.7 | 2800 |
| | 5:26 | 0.5 | 2200 |
| | 5:28 | 0.7 | 2600 |
| | 5:30 | 0.4 | 3200 |
| | 5:32 | 0.0 | 3200 |
| | 5:34 | 1.0 | 2300 |
| | 5:36 | 1.4 | 1200 |
| | 5:38 | 1.2 | 1300 |
| | 5:40 | 0.2 | 2800 |
| | 5:42 | 0.1 | 4300 |
| | 5:44 | 0.5 | 2600 |
| Average | | 1.0 | 2151 |

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/16/00 | | | |
| Run 12: One mill down; bagasse coming from operating mill plus backfeed from bagasse storagepile. | | | |
| | 8:34 | 1.6 | 2600 |
| | 8:36 | 1.3 | 1900 |
| | 8:38 | 1.1 | 2900 |
| | 8:40 | 1.1 | 2900 |
| | 8:42 | 1.1 | 2600 |
| | 8:48 | 0.6 | 4200 |
| | 8:50 | 0.6 | 4100 |
| | 8:52 | 0.5 | 4500 |
| | 8:56 | 0.6 | 4400 |
| | 8:58 | 1.0 | 4500 |
| | 9:00 | 1.2 | 3500 |
| | 9:04 | 0.7 | 3800 |
| | 9:06 | 0.6 | 4800 |
| | 9:08 | 1.0 | 3500 |
| | 9:10 | 0.7 | 3900 |
| | 9:12 | 0.8 | 3100 |
| | 9:14 | 1.1 | 2500 |
| | 9:16 | 1.0 | 3100 |
| | 9:18 | 0.9 | 2500 |
| | 9:20 | 1.0 | 3200 |
| | 9:22 | 0.7 | 3400 |
| | 9:24 | 1.0 | 3700 |
| | 9:26 | 1.0 | 4000 |
| | 9:28 | 0.2 | 5100 |
| | 9:30 | 0.9 | 4800 |
| | 9:34 | 1.0 | 4400 |
| | 9:36 | 1.3 | 3400 |
| | 9:38 | 1.0 | 2900 |
| | 9:42 | 1.3 | 3300 |
| Average | | 0.9 | 3569 |

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/16/00 | | | |
| Run 13 | | | |
| | 10:34 | 0.4 | 5200 |
| | 10:36 | 1.5 | 4800 |
| | 10:38 | 0.7 | 4300 |
| | 10:42 | 0.8 | 3900 |
| | 10:46 | 0.0 | 8100 |
| | 10:48 | 3.4 | 2200 |
| | 10:50 | 3.8 | 400 |
| | 10:52 | 0.8 | 3800 |
| | 10:58 | 0.5 | 5000 |
| | 11:00 | 0.8 | 4500 |
| | 11:02 | 0.2 | 5600 |
| | 11:04 | 0.7 | 6700 |
| | 11:06 | 0.7 | 3600 |
| | 11:08 | 0.6 | 4500 |
| | 11:10 | 0.1 | 6700 |
| | 11:12 | 0.3 | 4000 |
| | 11:14 | 0.1 | 7400 |
| | 11:16 | 1.3 | 1300 |
| | 11:18 | 0.9 | 3900 |
| | 11:20 | 1.0 | 2500 |
| | 11:22 | 0.8 | 4300 |
| | 11:24 | 0.2 | 7100 |
| | 11:26 | 0.7 | 4700 |
| | 11:28 | 1.5 | 2100 |
| | 11:30 | 1.0 | 2300 |
| | 11:32 | 0.9 | 3500 |
| | 11:34 | 0.8 | 3300 |
| | 11:36 | 0.6 | 3700 |
| | 11:38 | 0.7 | 4000 |
| | 11:40 | 0.9 | 3700 |
| | 11:42 | 1.2 | 4900 |
| | 11:44 | 1.0 | 3000 |
| Average | | 0.9 | 4219 |

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/16/00 | | | |
| Run 14 | | | |
| | 12:15 | 1.4 | 3300 |
| | 12:17 | 1.0 | 4000 |
| | 12:19 | 2.1 | 2000 |
| | 12:21 | 1.6 | 1800 |
| | 12:23 | 1.6 | 2200 |
| | 12:25 | 1.4 | 2300 |
| | 12:27 | 1.8 | 2600 |
| | 12:29 | 1.3 | 1400 |
| | 12:31 | 0.3 | 6600 |
| | 12:33 | 1.2 | 4900 |
| | 12:35 | 0.4 | 7700 |
| | 12:37 | 0.9 | 4100 |
| | 12:39 | 1.3 | 4200 |
| | 12:41 | 0.9 | 4100 |
| | 12:43 | 0.3 | 5400 |
| | 12:45 | 1.2 | 4200 |
| | 12:47 | 1.6 | 4300 |
| | 12:49 | 1.2 | 3300 |
| | 12:51 | 0.5 | 6300 |
| | 12:53 | 0.3 | 3900 |
| | 12:55 | 0.4 | 6100 |
| | 12:57 | 1.7 | 3900 |
| | 12:59 | 1.7 | 2200 |
| | 13:01 | 1.3 | 2600 |
| | 13:03 | 1.0 | 4700 |
| | 13:05 | 1.4 | 3300 |
| | 13:07 | 1.1 | 3300 |
| | 13:09 | 1.3 | 2600 |
| | 13:11 | 1.0 | 3900 |
| | 13:13 | 0.7 | 3800 |
| | 13:15 | 1.4 | 2500 |
| Average | | 1.1 | 3790 |

Boiler No. 4 CO and $O_2$ Process Monitor Data

| | Time | Oxygen (%) | CO (ppm) |
|---|---|---|---|
| 11/16/00 | | | |
| Run 15 | | | |
| | 14:00 | 1.3 | 3000 |
| | 14:02 | 1.6 | 1700 |
| | 14:04 | 1.9 | 1500 |
| | 14:06 | 2.2 | 1600 |
| | 14:08 | 2.1 | 1100 |
| | 14:10 | 3.5 | 600 |
| | 14:12 | 2.5 | 900 |
| | 14:14 | 2.9 | 800 |
| | 14:16 | 3.1 | 600 |
| | 14:18 | 2.3 | 1100 |
| | 14:20 | 1.7 | 1100 |
| | 14:22 | 2.4 | 1500 |
| | 14:24 | 2.6 | 700 |
| | 14:26 | 2.7 | 1100 |
| | 14:28 | 2.5 | 1300 |
| | 14:30 | 2.5 | 1000 |
| | 14:32 | 2.6 | 1000 |
| | 14:34 | 2.3 | 1100 |
| | 14:36 | 2.3 | 900 |
| | 14:38 | 2.5 | 1000 |
| | 14:40 | 1.6 | 1500 |
| | 14:42 | 2.6 | 800 |
| | 14:44 | 2.3 | 900 |
| | 14:46 | 1.7 | 1300 |
| | 14:48 | 2.0 | 1800 |
| | 14:50 | 2.0 | 1900 |
| | 14:52 | 1.9 | 1700 |
| | 14:54 | 0.9 | 2900 |
| | 14:56 | 0.9 | 3300 |
| | 14:58 | 1.0 | 3500 |
| | 15:00 | 1.9 | 2000 |
| Average | | 2.1 | 1458 |

APPENDIX GCP

## Good Combustion Practices

*The following procedures were based upon the most recent update from Golder Associates of the Operation and Maintenance Plan for the Clewiston Boiler No. 4 dated January ~~9, 1997~~ 17, 2001 and received by the Department January ~~13, 1997~~ ??, 2001. A part of this plan is the attached Startup and Shutdown Procedures.*

Purpose of GCP Plan

The determination of Best Available Control Technology for CO, NOx, and VOC emissions from Boiler No. 4 (EU-009) relied on "good combustion practices". The purpose of this document is to summarize the operational, maintenance, and monitoring procedures that will lead to the minimization of CO and VOC emissions and the optimization of NOx emissions, consistent with good combustion practices.

Preparation for Operations

1. Prior to each harvest season, the boiler proper, its air duct work, air heaters and scrubber are properly cleaned, inspected and repaired.
2. All refractory and boiler casing will be inspected and repaired where needed.
3. Outside of boiler tubes will have loose scale removed and boiler will be cleaned of loose scale, sand and other debris.
4. Boiler grates will be inspected and cleaned as well as being checked for mechanical operation.
5. All fans and fan drives will be inspected and repaired as needed.
6. All pumps and pump drives will be inspected and repaired as needed.
7. All oil burners will be cleaned and inspected as well as related oil piping, atomizing steam and air registers.
8. Prior to each harvest season, the skirt level of the scrubber is identified and marked on the outside so that a permanent reference is available.
9. Prior to each harvest season, all instruments for boiler operation and control, including the process oxygen and carbon monoxide monitors, are inspected, repaired and calibrated as required. This is recorded by the instrument shop in its repair log.

Boiler Operation and Controls

The senior most experienced boiler supervisor instructs other boiler room supervisors, boiler operators, and other appropriate personnel in proper boiler and scrubber operations so as to minimize stack emissions of CO and VOC, and so as to optimize stack emissions of NOx. Instruction will also be provided for utilization of the process oxygen and carbon monoxide monitors to promote good combustion. This instructional program is presented prior to each harvest season and is included in the orientation and training provided to new boiler room employees. The training will impress upon supervisors and operators the importance of proper boiler operation in order to minimize emissions.

CO and VOC Controls

CO emissions are to be minimized by the proper application of Good Combustion Practices (GCP). To provide reasonable assurance that GCP are being employed:

1. The boiler operator will maintain steam rate at optimal or desired rate by controlling feed of bagasse fuel into the boiler. Combustion air to the boiler will be maintained at the highest possible level (resulting in sufficient excess air whenever feasible) in order to promote good combustion.
2. The boiler operator will periodically (at least once per hour) view the stack video monitor to visually confirm that good combustion is taking place. (Individual stack plumes are monitored continuously through a closed circuit television system.) If an abnormal plume is observed, the operator will immediately take

corrective action. The boiler operator will log the occurrence and duration of all such events in the boiler operation log, along with the corrective action taken. These records will be kept for a period of at least two years.

3. Process monitors shall be installed to monitor the oxygen ($O_2$) content and the carbon monoxide (CO) content of the boiler flue gas. The instrument readouts will be located in the boiler control room to provide real time data to the boiler operator, and will each display a block 1-hour average. The boiler operators will be instructed in the use of the $O_2$ and CO flue gas process monitors for combustion control and to ensure sufficient excess air levels. The process O2 monitor shall be equipped with an alarm with a set point at 1.2%. The process CO monitor shall be equipped with an alarm with a set point at 3,700 ppm. At such time that an alarm on either monitor is tripped, Tthe boiler operators shall ~~periodically observe each process monitor and~~ take corrective action and adjust the boiler operation, consistent with good combustion practices. Corrective actions shall continue until the O2 and/or CO flue gas levels are maintained at acceptable levels. ~~The specific conditions of this permit require additional CO testing after installation of the process monitors. This portion of the GCPs will be revised based on the test results.~~

NOx Controls

NOx emissions are to be optimized by the proper application of Good Combustion Practices (GCP). However, the application of GCP to minimize CO and VOC emissions may result in increased NOx emissions. This is because factors which promote good combustion and result in lower CO and VOC emissions, such as higher excess air and higher combustion temperatures, result in higher NOx emissions. This is the nature of the combustion process. Therefore, GCP to optimize NOx emissions is considered to be the same practices used to minimize CO and VOC emissions, as described above.

Miscellaneous

1. Several times per shift, the boiler grates and feeders are examined for proper distribution and any necessary operational changes are made. Any unusual observations are logged once per shift.
2. Once per day, on the day shift, the boiler will be given a walk-around inspection with the following items being checked and repaired as needed and in coordination with the production schedule: Fans, pumps, casing, ducting, and scrubber.
3. On every shift burners are inspected and cleaned if dirty.
4. On every shift, precautions will be taken as necessary to control visible emissions of fugitive matter (dust and bagasse, etc.)

### STARTUP AND SHUTDOWN PROCEDURE

*The following procedure was submitted by U.S. Sugar as a supplement to the PSD application received on June 25, 1999.*

During startup and shutdown of the boilers, excess CO, PM, NOx, and VOC emissions for more than 2 hours in a 24-hour period are possible. Pursuant to Rule 62-210.700(1), F.A.C., the following procedures and precautions shall be taken to minimize the magnitude and duration of excess emissions during startup and shutdown of Boiler No. 4. The boiler room foreman and operating personnel shall receive proper training on emissions control procedures at least once per year.

Cold Startup (approximately 4 to 5 hours)

1. Feed solid fuel into boiler construction chamber.
2. Start fire in combustion chamber using a propane torch designed for that purpose.
3. As boiler heats up and starts to make steam, continuously observe the boiler and scrubber water levels, and stack plume.

4. Light a burner at the lowest rate, continue to observe the stck plume and adjust if necessary, by adjusting fuel, atomizing steam, and air to obtain proper combustion.
5. Feed carbonaceous fuel from the mill to the boiler slowly at first; as the furnace gets hotter and the carbonaceous fuel is burning better, decrease fuel oil flow until burners can be turned off.
6. Continue to observe the stack plume, the scrubber water level, and the carbonaceous fuel level, making adjustments to drafts, fuel, and scrubber to maintain the optimum operating conditions.

Hot Startup (approximately 1 hour)

1. This type of startup is applicable when the boiler has been shutdown for a short period of time and is still hot.
2. Check the boiler and scrubber water levels, circulating pump and spray nozzles, and make sure they are functioning properly.
3. Light a burner, continue to observe the stack plume, water levels, and burners.
4. As the carbonaceous fuel fire gets hot enough to meet demand, reduce the burner fuel until it can be turned off. Adjust the dampers to get optimum carbonaceous fuel firing.
5. Continue to observe the stack plume, scrubber water level, and carbonaceous fuel level, making adjustments to drafts, fuel, and scrubber to maintain the optimum operating conditions.

Shutdown

1. Stop fuel flow to the boiler, reduce the forced draft, distributor air, overfire air, and induced forced draft.
2. Continue to observe the stack plume and water levels and make adjustments to maintain safe and optimum operating conditions.