Golder Associates

CORRELATION TESTING FOR
GOOD COMBUSTION PRACTICES
BOILER NO. 5
ATLANTIC SUGAR ASSOCIATION
BELLE GLADE, FLORIDA

Prepared For:

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Belle Glade, Florida

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LIST OF ACRONYMS AND ABBREVIATIONS

CO	carbon monoxide
CO_e	carbon monoxide equivalent
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
ASA	Atlantic Sugar Association

1.0 INTRODUCTION

Atlantic Sugar Association (ASA) operates a sugar mill and refinery located near Belle Glade, Palm Beach County, Florida. Bagasse, a fibrous byproduct of sugar cane processing, is burned as boiler fuel to provide heat and steam for the mill. The facility currently has five permitted bagasse/oil-fired boilers.

In June 2001, an air construction permit was issued by the Florida Department of Environmental Regulation (FDEP) to ASA for an increase in operation to accommodate a predicted increase in sugarcane availability (Permit No. 0990016-004-AC/PSD-FL-078A). A condition of the construction permit (Section III, Emissions Unit 005, Condition No. 8) 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. 5.

As a critical part of the GCPs, ASA was required to install and operate process monitors to measure the oxygen (O_2) and CO content of the Boiler No. 5 exhaust flue gases. It was also required to conduct at least twelve 1-hour test runs for CO and NO_x emissions on Boiler No. 5, using U.S. Environmental Protection Agency (EPA) Method 10 for CO and Methods 7/7E for NO_x, while also measuring other flue gas constituents. The purpose of the testing is to determine if any relationship exists between flue gas O_2 content, CO and NO_x emissions, 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 December 17 through 20, 2001.

This report summarizes the test methods and operation parameters; presents data and results; discusses the relationships between flue gas O_2, CO, and NO_x 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. Recommendations are made concerning a revised emission standard for NO_x emissions. Finally, recommendations concerning revised permit wording and revisions to Appendix GCP of the Boiler No. 5 construction permit are presented.

2.0 OPERATION PARAMETERS AND TEST METHODS

2.1 INTRODUCTION

As required by Air Construction Permit No. 0990016-004-AC, CO and NO_x correlation testing and must be performed on Boiler No. 5 for at least twelve 1-hour test runs using EPA Methods 10 and 7/7E. The CO and NO_x correlation testing for Boiler No. 5 at ASA began December 17, 2001 and was concluded on December 20, 2001.

2.2 OPERATION PARAMETERS

The maximum permitted steam capacity for Boiler No. 5 is 130,000 pounds per hour (lb/hr) and 115,000 lb/hr for a 24-hour average. The maximum 1-hour steam rate achieved by the boiler in previous compliance tests has been approximately 127,000 lb/hr.

The CO and NO_x correlation tests were conducted from December 17 through 20, 2001, and included a total of 12 test runs of approximately 1-hour duration. Boiler No. 5 was operated at a 1-hour average steam rate ranging from 107,250 and 130,875 lb/hr, or 83 to 101 percent of the maximum permitted 1-hour steam rate and 93 to 114 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).

It is noted that no adjustments to boiler operating conditions were made, beyond the normal actions taken by the operators, to reduce CO or NO_x 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, NO_x, moisture, temperature, and flow rate at the stack; and
- Oxygen and CO as indicated by the process monitors.

2.3 TEST METHODS

During the testing of Boiler No. 5, CO, O_2, NO_x, 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 3A, and stack gas moisture content was measured using EPA Method 4. NO_x emissions were measured using EPA Method 7E.

2.4 PROCESS MONITORS

ASA has installed a combination O_2 and CO process monitor on Boiler No. 5. The monitor is a Bailey Type SMA2 Smart Analyzer 90. The O_2 reading is a continuous percent by volume measurement of the net oxygen in the flue gas. The CO reading is actually carbon monoxide equivalent (CO_e), which indicates mostly CO but also responds to other combustibles in the gas stream. A more complete description of the analyzer is provided in Attachment C.

3.0 DATA AND RESULTS

3.1 TEST DATA

Results of the correlation testing performed on Boiler No. 5 are presented in Table 1. The boiler steam rate (lb/hr), process monitor CO_e [in parts per million (ppm)] and O_2 (percent), and stack exhaust CO (ppm, wet, and lb/MMBtu), O_2 (percent, dry), and NO_x (lb/MMBtu) are shown in Table 1. All stack data are obtained from the accompanying source test report by Air Consulting and Engineering, submitted previously to the Department. For convenience, the test data from Appendix E of the Air Consulting and Engineering report are presented in Attachment A.

All process monitor data are contained in Attachment B. The O_2 and CO_e process monitors are equipped with a display in the boiler control room. The display provides the instantaneous O_2 (%) and CO_e (ppm) levels, as well as the 1-hour block average. The display is programmed to reset the 1-hour block average to zero at the beginning of each hour. However, the block average can be manually reset at any time. In order to determine the average O_2 and CO_e levels from the process monitors for each test run, the following procedure was used:

1. At the beginning of the run, the block average display was reset to zero, and the start time recorded (for example 12:45 p.m.).
2. Just prior to the end of the calendar hour, the average O_2 and CO_e readings were recorded. Therefore, this represented the average O_2/CO_e from 12:45 – 1:00 p.m. The display automatically reset to zero at the end of the calendar hour (i.e., 1:00 p.m.).
3. At the end of the test run, the block average reading and time were recorded (i.e., at 1:50 p.m.). This represents the average O_2/CO_e level from 1:00 – 1:50 p.m.
4. The overall average O_2 and CO_e for the test run was determined by time-weighting the readings over the entire test run.

The data and resulting averages are shown in Attachment B.

3.2 ANALYSIS OF RESULTS

Correlation plots between the following parameters are presented in Figures 1 through 6: CO_e measured at the stack and measured by the process monitor, O_2 (at stack and process monitor), and NO_x emissions (at stack).

The relationship between process monitor CO_e (ppm) and stack CO (lb/MMBtu) is represented in Figure 1. This plot indicates an excellent linear correlation between the process monitor CO_e levels in ppm and the stack CO levels in lb/MMBtu. As process monitor CO_e (ppm) increases, stack CO (lb/MMBtu) also increases proportionately. This demonstrates that the CO_e process monitor is an adequate indicator of actual stack CO emissions. The plot also indicates that only at high levels of CO_e (i.e., greater than about 10,000 ppm as read by the process monitor) is a stack CO emission rate of 6.5 lb/MMBtu exceeded. This stack CO emission rate is the current permit limit for Boiler No. 5.

The correlation between stack O_2 levels and process monitor O_2 levels (measured in percent) is presented in Figure 2. 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.

The relationship between CO emission rate (lb/MMBtu) at the stack exhaust and O_2 (percent) as read by the process monitor is shown in Figure 3. 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 2.0 percent, stack CO levels increase beyond a stack 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).

The relationship between stack CO emission rate (lb/MMBtu) and stack NO_x emission rate (lb/MMBtu) is depicted in Figure 4. This plot indicates a good correlation between stack CO levels and stack NO_x levels. However, the data indicate at lower levels of stack CO emissions (less than about 4 lb/MMBtu), stack NO_x levels increase above 0.16 lb/MMBtu, which is the current NO_x permit limit for Boiler No. 5.

The relationship between process monitor O_2 (%) and stack NO_x emission rate (lb/MMBtu) is presented in Figure 5. This plot indicates a good correlation between process monitor O_2 and stack NO_x levels. The graph indicates that, at O_2 levels above approximately 3.0 percent, stack NO_x emissions exceed the current permit limit of 0.16 lb/MMBtu.

The correlation between process monitor CO_e (ppm) and stack NO_x (lb/MMBtu) is presented in Figure 6. This plot indicates a good correlation between process monitor CO_e levels and stack NO_x

levels. However, the data indicate at lower levels of process monitor CO_e emissions (less than about 7,000 ppm), NO_x levels increase above 0.16 lb/MMBtu, which is the current NO_x limit for Boiler No. 5.

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, NO_x emissions, and process monitor O_2 levels indicates that O_2 levels below approximately 2.0 percent, and process monitor CO_e levels above approximately 10,000 ppm, correlate with higher CO levels approaching or exceeding 6.5 lb/MMBtu. Therefore, it is recommended that a minimum process monitor O_2 level of 2.0 percent (1-hour block average) and a maximum process monitor CO_e level of 10,000 ppm (1-hour block average) be maintained to the extent practical to represent GCPs for Boiler No. 5.

Based on the test data gathered during the correlation testing, the stack CO emissions would need to be maintained above approximately 4 lb/MMBtu in order to comply with the NO_x limit of 0.16 lb/MMBtu (Figure 4). At the same time, stack CO must be kept below the CO limit of 6.5 lb/MMBtu. As a result, the process monitor levels would need to be maintained between 7,000 and 10,000 ppm CO_e, and between 2.0 and 3.0 percent O_2, to simultaneously comply with both the CO and the NO_x emission limits for Boiler No. 5. Given the variable nature of emissions from bagasse boilers, this operating regimen would be highly impractical. In addition, the current focus of GCPs is to improve combustion efficiency, which directly lowers CO, PM and VOC emissions, but increases NO_x emissions. A higher NO_x emissions rate will allow O_2 levels to be increased in the boiler, promoting better combustion. Operating the boiler to continuously meet the current NO_x emission limit of 0.16 lb/MMBtu would require ASA to operate the boiler in an inefficient manner, resulting in increased emissions of CO, VOC and PM. As a result, a higher NO_x limit is indicated for Boiler No. 5.

The current permitted NO_x emission rate for Boiler No. 5 is 0.16 lb/MMBtu. ASA requested a NO_x emission rate of 0.25 lb/MMBtu in the prevention of significant deterioration (PSD) application submitted for Boiler No. 5. All required control technology analysis, air quality impact analysis, and additional impact analysis to support the PSD application were based upon a NO_x limit of 0.25 lb/MMBtu. As a result, it is requested that the Department approve the previously requested NO_x emission limit of 0.25 lb/MMBtu.

ASA will implement GCPs on Boiler No. 5 by taking corrective action whenever the O_2 process monitor indicates an O_2 level of 2.0 percent or less (1-hour block average) or a CO_e level of 10,000 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_e 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 2.0 percent or greater or a CO_e level of less than 10,000 ppm, as appropriate, is achieved and maintained for a minimum of one hour.

The Boiler No. 5 construction permit, Condition 8 for Emissions Unit 005, states in part as follows: "Based on the available information, the Department shall determine additional GCPs including the optimum operating ranges for CO and O_2 flue gas concentrations. This specific condition and *Appendix GCP* shall be revised to reflect the final GCPs with appropriate monitoring. The Department shall make these revisions as a minor permit amendment." Suggested wording for the revised Condition 8 is presented below. The proposed revisions to Appendix GCP are presented in Attachment D.

Suggested revisions to Condition 8:

> 8. 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 equivalent carbon monoxide (CO_e) content of the exhaust flue gas in the boiler furnace. The oxygen process monitor shall include an alarm with a set point of 2.0% (minimum) flue gas oxygen content based on a 1-hour block average. It shall display both the instantaneous and the 1-hour block average of flue gas oxygen content (in percent oxygen). The CO_e process monitor shall include an alarm with a set point at 10,000 ppm (maximum) flue gas CO_e concentration based on a 1-hour block average. It shall display both the instantaneous and the 1-hour block average of the flue gas CO_e concentration (in ppm). Readouts of these process monitors shall be provided in the boiler control room. If the alarm is tripped for either process monitor (low oxygen content or high CO_e concentration), the boiler operator shall take corrective actions consistent with good combustion practices. Correction actions include, but are not limited to, adjusting the air-to-fuel ratio, adjusting the ratio of under-fire to over-fire air, and firing some fuel oil in place of bagasse. For each such incident, the operator shall summarize the corrective actions taken and the appropriate time when operation within the target parameter(s) was regained. It is noted that the monitored flue gas equivalent carbon monoxide content is for the purpose of determining efficient combustion and may not be representative of the actual CO emissions from the stack. Operation outside of the specified operating range for either monitored parameter is not a violation of this permit, in and of itself. However, continued or frequent operation outside of the specified operating range for either monitored parameter without corrective action may be considered circumvention of "good combustion practices".

Table 1. Correlation Test Results for Boiler No. 5, Atlantic Sugar Association

Run Number	Steam Rate	Boiler No. 5 Process Monitors		Boiler No. 5 Stack Gas			
		CO_e	O_2	CO		O_2	NO_x
	(lb/hr)	(ppm)	(%)	(ppm, dry)	(lb/MMBtu)	(%, dry)	(lb/MMBtu)
1	122,727	2,493	4.16	2,052	2.365	7.55	0.199
2	125,813	6,818	2.95	4,455	4.836	6.56	0.156
3	130,125	10,926	2.06	6,275	6.636	5.93	0.131
4	130,875	7,502	2.61	5,752	5.947	6.28	0.138
5	121,200	5,458	3.19	4,080	4.611	7.06	0.161
6	117,600	5,917	3.95	3,281	3.889	7.69	0.194
7	113,250	3,228	5.15	1,831	2.304	9.06	0.221
8	112,800	2,750	5.27	1,775	2.217	9.12	0.206
9	107,250	883	6.81	945	1.297	9.97	0.250
10	123,469	4,029	4.13	2,882	3.226	7.65	0.180
11	125,905	17,263	0.87	9,957	10.215	5.67	0.139
12	127,219	17,063	0.93	10,210	10.607	5.60	0.144

Figure 1. Process Monitor CO_e (ppm) vs. Stack CO (lb/MMBtu)
Boiler No. 5
12/17/01-12/19/01

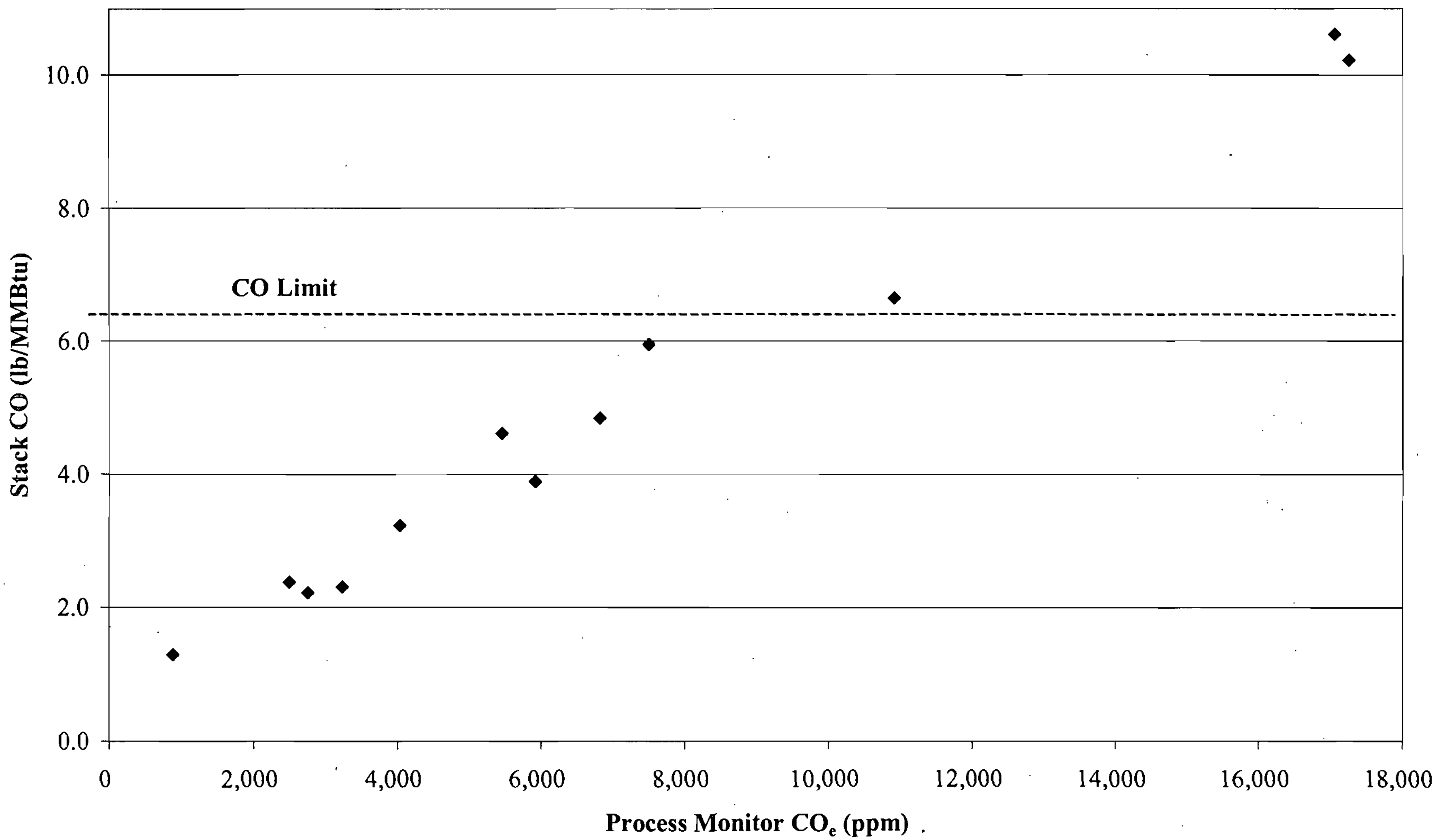


Figure 2. Process Monitor O_2 (%) vs. Stack O_2 (%, dry)
Boiler No. 5
12/17/01 - 12/20/01

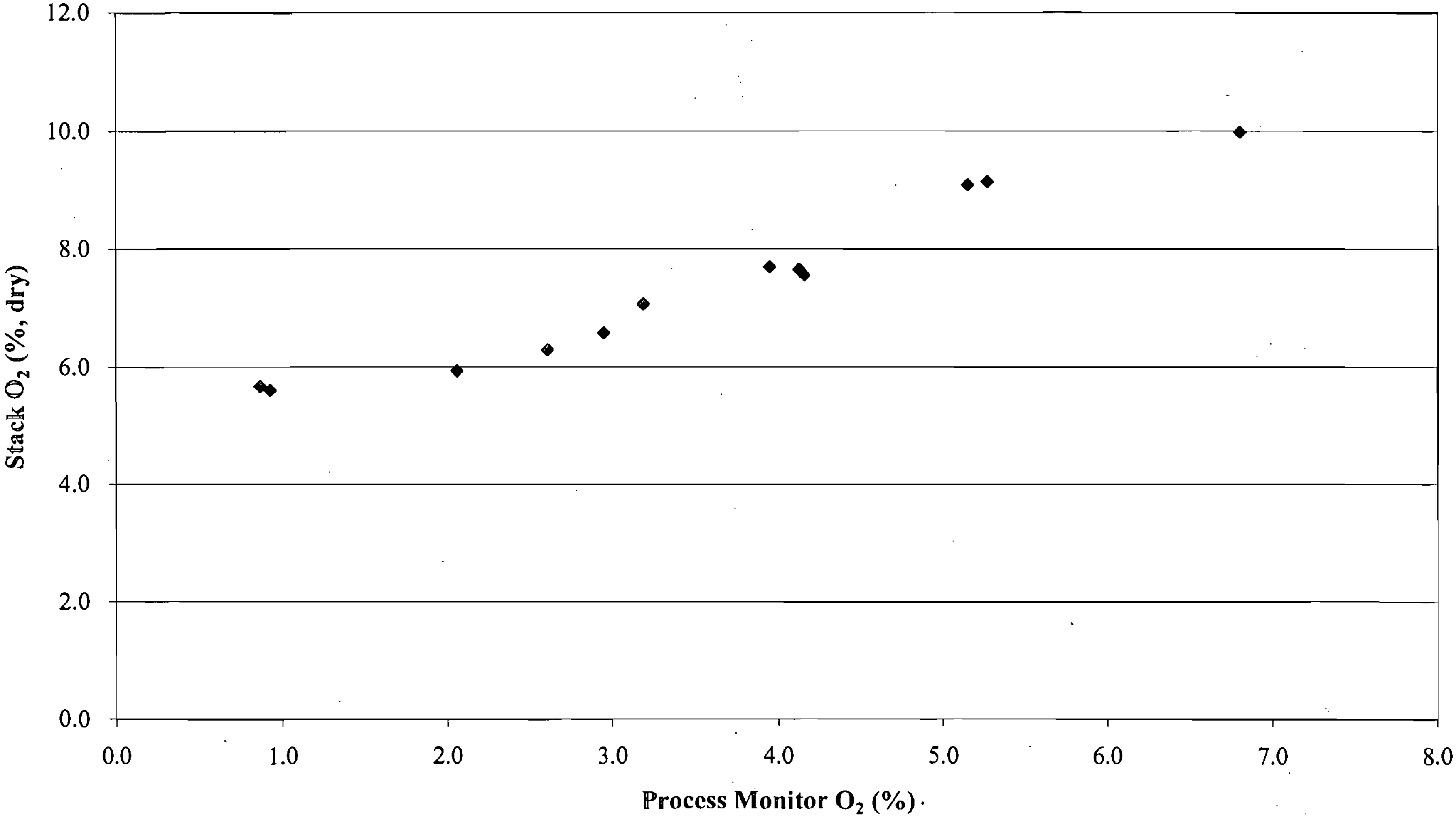


Figure 3. Process Monitor O_2 (%) vs. Stack CO (lb/MMBtu)
Boiler No. 5
12/17/01-12/20/01

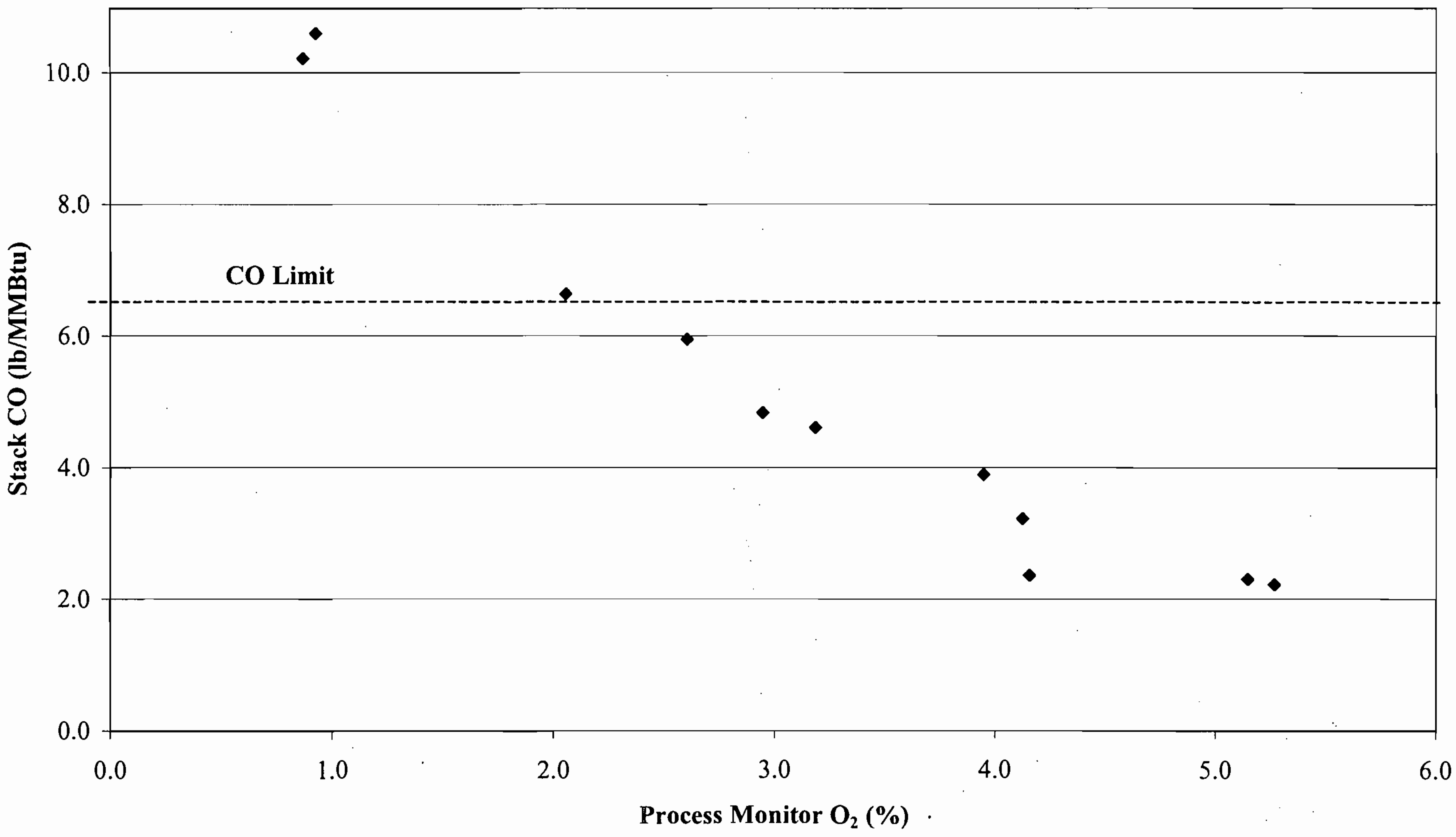
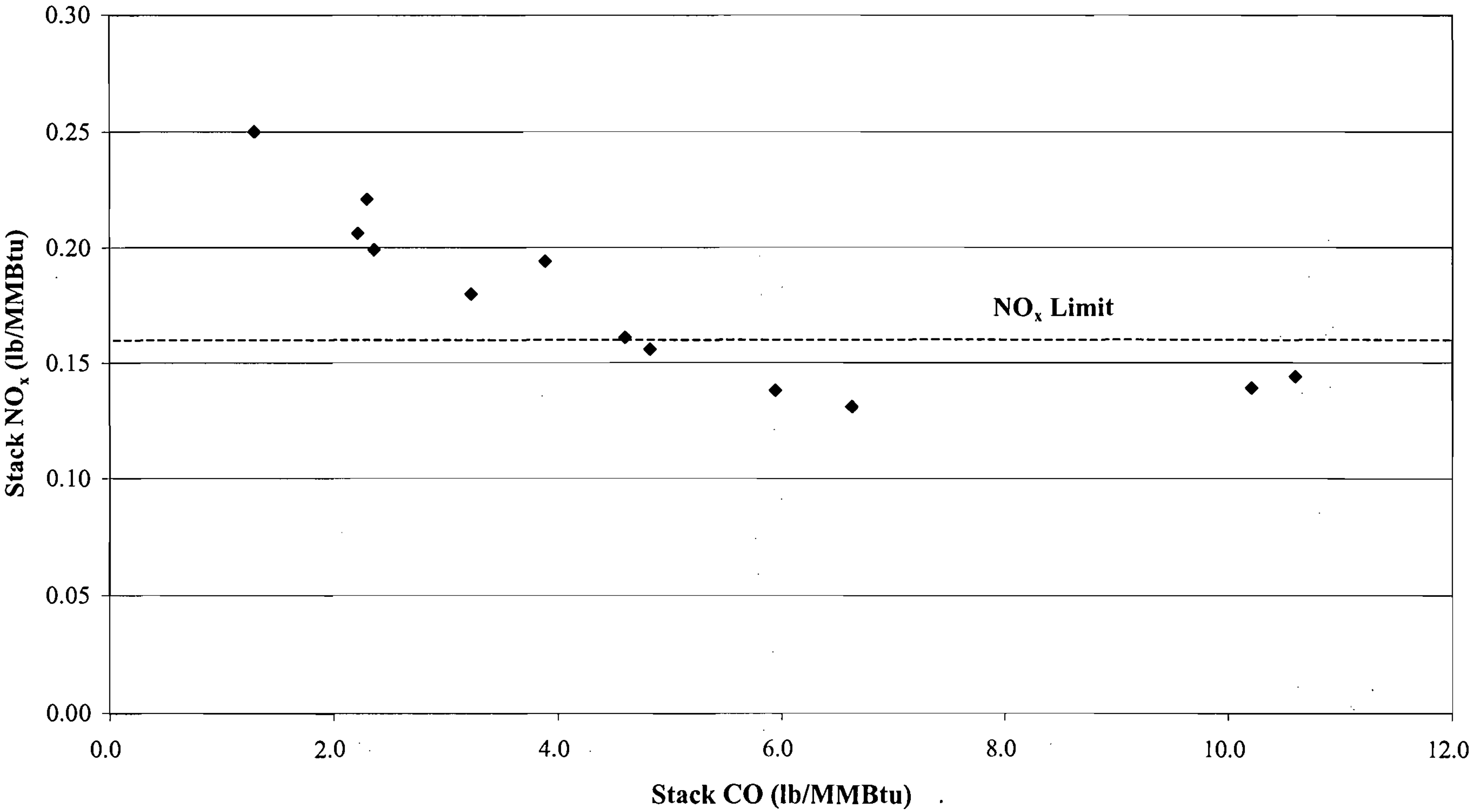


Figure 4. Stack CO (lb/MMBtu) vs. Stack NO$_x$ (lb/MMBtu)
Boiler No. 5
12/17/01 - 12/19/01



0137560/4/4.2/4.2.2/Boiler5.xls/Figure 5
2/13/02

Figure 5. Process Monitor O_2 (%) vs. Stack NO_x (lb/MMBtu)
Boiler No. 5
12/17/01 - 12/19/01

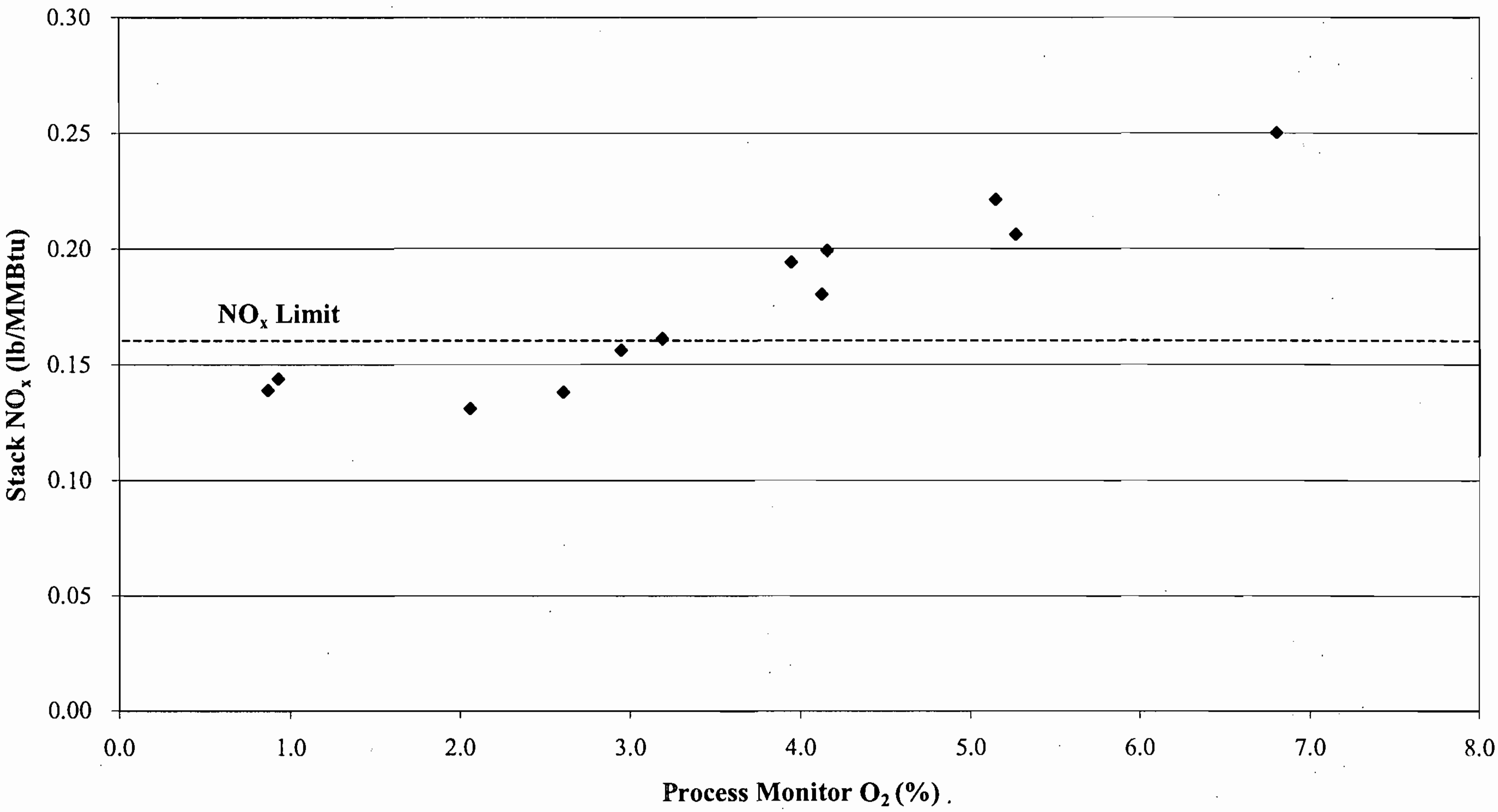
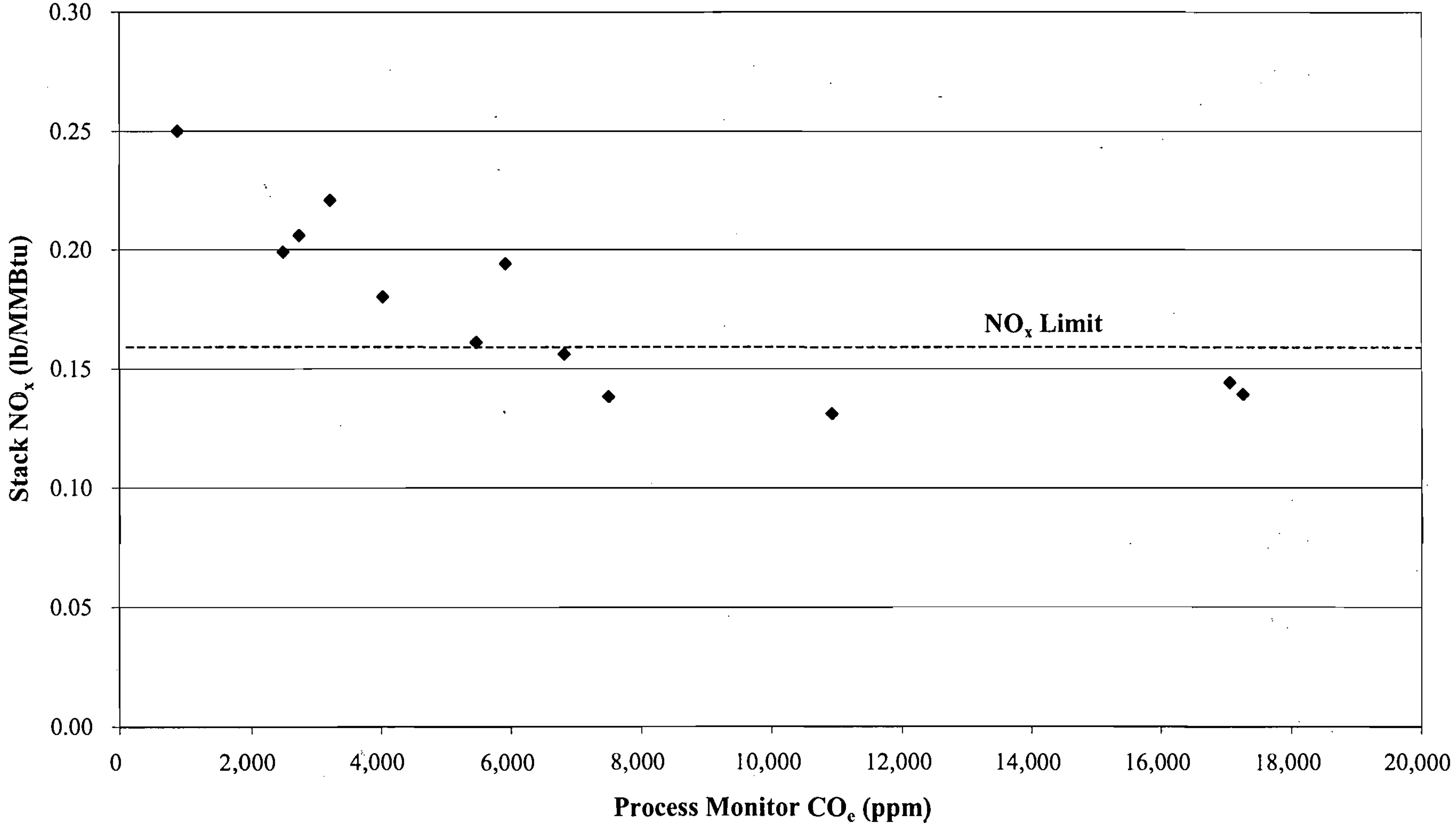


Figure 6. Process Monitor CO_e (ppm) vs. Stack NO_x (lb/MMBtu)
Boiler No. 5
12/17/01 - 12/20/01



ATTACHMENT A

BOILER NO. 5 STACK GAS
SUMMARY SHEETS
12/17/01 – 12/20/01

AIR CONSULTING and ENGINEERING, INC.

COMPLETE EMISSION DATA

ATLANTIC SUGAR ASSOCIATION
BELLE GLADE, FLORIDA
NUMBER 5 BOILER
12/17/01

RUN NUMBER:	1	2	3	4	
BEGIN TIME:	11:06 AM	12:47 PM	2:22 PM	16:02	
END TIME:	12:07 PM	1:48 PM	3:23 PM	17:03	
OXYGEN %:	7.55	6.56	5.93	6.28	
VOLUMETRIC FLOW (SCFMD):	61608	59583	60034	59026	
TOTAL HEAT INPUT (MMBTUH):	233.3	239.3	247.5	248.90	
"F" FACTOR:	NA	NA	NA	NA	
OXIDES of NITROGEN (NOx) PPM:	105	87.4	75.6	80.99	
TOTAL HYDROCARBONS PPM as PROPANE (THC):	103	364.1	585.8	475.9	
METHANE PPM (CH4):	86	320	470	380	
CARBON MONOXIDE PPM (C0):	2052	4455	6275	5752	
SULFUR DIOXIDE PPM (SO2):	NA	NA	NA	NA	
NOx:					
LB/HR:	46.34	37.31	32.51	34.25	37.60
LB/MMBTU	0.199	0.156	0.131	0.138	0.156
VOC as CARBON:					
LB/HR:	25.67	85.98	144.40	115.54	92.90
LB/MMBTU:	0.110	0.359	0.583	0.464	0.379
CO:					
LB/HR:	551.14	1157.23	1642.31	1480.15	1207.71
LB/MMBTU:	2.362	4.836	6.636	5.947	4.945
SO2:					
LB/HR:	NA	NA	NA	NA	#DIV/0!
LB/MMBTU:	NA	NA	NA	NA	#DIV/0!
PM:					
LB/HR:	25.13	23.24	24.85	23.60	24.21
LB/MMBTU:	0.108	0.097	0.100	0.095	0.100
STEAM RATE: LB/HR:	122727	125813	130125	130875	

AIR CONSULTING and ENGINEERING, INC.

COMPLETE EMISSION DATA

ATLANTIC SUGAR ASSOCIATION
BELLE GLADE, FLORIDA
NUMBER 5 BOILER
12/18/01

			12/19/01	12/19/01	12/19/01	
RUN NUMBER:		5	6	7	8	
BEGIN TIME:		8:01 AM	12:17 PM	1:48 PM	15:16	
END TIME:		9:02 AM	1:18 PM	2:49 PM	16:17	
OXYGEN %:		7.06	7.69	9.06	9.12	
VOLUMETRIC FLOW (SCFMD):		59625	60820	62175	61483	
TOTAL HEAT INPUT (MMBTUH):		230.0	223.7	215.4	214.57	
"F" FACTOR:		NA	NA	NA	NA	
OXIDES of NITROGEN (NOx) PPM:		86.6	99.6	106.8	100.5	
TOTAL HYDROCARBONS PPM as PROPANE (THC):		299.5	192.75	72.9	59.45	
METHANE PPM (CH4):		190	135	60	49	
CARBON MONOXIDE PPM (C0):		4080	3281	1831	1775	
SULFUR DIOXIDE PPM (SO2):		NA	NA	NA	NA	
NOx						
	LB/HR:	36.99	43.40	47.57	44.27	43.06
	LB/MMBTU	0.161	0.194	0.221	0.206	0.195
VOC as CARBON:						
	LB/HR:	78.93	50.37	18.44	14.86	40.65
	LB/MMBTU:	0.343	0.225	0.086	0.069	0.181
CO:						
	LB/HR:	1060.55	869.96	496.31	475.78	725.65
	LB/MMBTU:	4.611	3.889	2.304	2.217	3.255
SO2:						
	LB/HR:	NA	NA	NA	NA	NA
	LB/MMBTU:	NA	NA	NA	NA	NA
PM:						
	LB/HR:	23.64	24.79	25.46	24.42	24.58
	LB/MMBTU:	0.103	0.111	0.118	0.114	0.111
STEAM RATE:	LB/HR:	121200	117600	113250	112800	

AIR CONSULTING and ENGINEERING, INC.

COMPLETE EMISSION DATA

ATLANTIC SUGAR ASSOCIATION
BELLE GLADE, FLORIDA
NUMBER 5 BOILER
12/20/01

RUN NUMBER:	9	10	11	12	
BEGIN TIME:	8:01 AM	9:32 AM	11:01 AM	12:33	
END TIME:	9:02 AM	10:33 AM	12:02 PM	13:34	
OXYGEN %:	9.97	7.65	5.67	5.6	
VOLUMETRIC FLOW (SCFMD):	64146	60164	56354	57647	
TOTAL HEAT INPUT (MMBTUH):	203.7	234.3	239.5	241.90	
"F" FACTOR:	NA	NA	NA	NA	
OXIDES of NITROGEN (NOx) PPM:	110.8	97.95	82.52	84.44	
TOTAL HYDROCARBONS PPM as PROPANE (THC):	13.53	174.5	1156.25	1215.9	
METHANE PPM (CH4):	10	132	650	660	
CARBON MONOXIDE PPM (C0):	945	2882	9957.4	10209.5	
SULFUR DIOXIDE PPM (SO2):	NA	NA	NA	NA	
NOx					
LB/HR:	50.92	42.22	33.31	34.87	40.33
LB/MMBTU	0.250	0.180	0.139	0.144	0.178
VOC as CARBON:					
LB/HR:	3.67	44.01	296.79	321.80	166.57
LB/MMBTU:	0.018	0.188	1.239	1.330	0.694
CO:					
LB/HR:	264.27	755.92	2446.32	2565.82	1508.08
LB/MMBTU:	1.297	3.226	10.215	10.607	6.336
SO2:					
LB/HR:	NA	NA	NA	NA	NA
LB/MMBTU:	NA	NA	NA	NA	NA
PM:					
LB/HR:	20.69	22.56	27.38	28.40	24.76
LB/MMBTU:	0.102	0.096	0.114	0.117	0.107
STEAM RATE: LB/HR:	107250	123469	125905	127219	

ATTACHMENT B

BOILER NO. 5 CO AND O_2
PROCESS MONITOR DATA

12/17/01 – 12/20/01

Table B. Boiler No. 5 CO and O_2 Process Monitor Data

			Process Monitor		Average Process Monitor	
Run Number	Date	Time	CO_e (ppm)	O_2 (%)	CO_e (ppm)	O_2 (%)
1	12/17/01	11:00 - 12:00	2,610	4.10	--	--
1	12/17/01	12:00 - 12:10	1,790	4.50	--	--
1	12/17/01	--	--	--	2,493	4.16
2	12/17/01	12:45 - 1:00	2,110	4.1	--	--
2	12/17/01	1:00 - 1:50	8,230	2.6	--	--
2	12/17/01	--	--	--	6,818	2.95
3	12/17/01	2:21 - 3:00	10,880	2.1	--	--
3	12/17/01	3:00 - 3:24	11,000	2.0	--	--
3	12/17/01	--	--	--	10,926	2.06
4	12/17/01	4:00 - 5:00	7,560	2.6	--	--
4	12/17/01	5:00 - 5:05	6,800	2.7	--	--
4	12/17/01	--	--	--	7,502	2.61
5	12/18/01	8:00 - 9:00	5,540	3.2	--	--
5	12/18/01	9:00 - 9:05	4,470	3.1	--	--
5	12/18/01	--	--	--	5,458	3.19
6	12/19/01	12:15 - 1:00	7,120	3.5	--	--
6	12/19/01	1:00 - 1:21	3,340	4.9	--	--
6	12/19/01	--	--	--	5,917	3.95
7	12/19/01	1:46 - 2:00	2,400	5.7	--	--
7	12/19/01	2:00 - 2:50	3,460	5.0	--	--
7	12/19/01	--	--	--	3,228	5.15
8	12/19/01	3:14 - 4:00	2,700	5.3	--	--
8	12/19/01	4:00 - 4:19	2,870	5.2	--	--
8	12/19/01	--	--	--	2,750	5.27
9	12/20/01	8:00 - 9:00	890	6.8	--	--
9	12/20/01	9:00 - 9:04	770	6.9	--	--
9	12/20/01	--	--	--	883	6.81
10	12/20/01	9:31 - 10:00	1,880	4.9	--	--
10	12/20/01	10:00 - 10:35	5,810	3.5	--	--
10	12/20/01	--	--	--	4,029	4.13
11	12/20/01	11:00 - 12:00	17,170	0.9	--	--
11	12/20/01	12:00 - 12:03	19,120	0.3	--	--
11	12/20/01	--	--	--	17,263	0.87
12	12/20/01	12:33 - 1:00	16,440	1.1	--	--
12	12/20/01	1:00 - 1:36	17,530	0.8	--	--
12	12/20/01	--	--	--	17,063	0.93

ATTACHMENT C

BAILEY O_2/CO_e PROCESS MONITOR INFORMATION

SECTION 1 - INTRODUCTION

OVERVIEW

This instruction manual gives personnel a working knowledge of the Type SMA Smart Analyzer 90. The manual explains the analyzer operation and provides step-by-step procedures for specific tasks.

The Type SMA Smart Analyzer 90 is a combustion analyzer. It continuously samples and analyzes industrial flue gases. The Type SMA1 Analyzer 90 monitors oxygen (O_2) only. The Type SMA2 Smart Analyzer 90 monitors both O_2 and carbon monoxide equivalent (CO_e). The O_2 reading is a continuous percent by volume measurement of the net oxygen in the flue gas. The CO_e reading indicates mostly carbon monoxide (CO), but also responds to other combustibles present in the flue gas. The analyzer uses a close coupled sampling system which does not remove water vapor from the sample. The analyzer accepts thermocouple inputs for process temperature measurement and calculates combustion efficiency.

INTENDED USER

Personnel requirements for installation, start-up, operation, maintenance and repair of the Type SMA Smart Analyzer 90 are:

- An electrician and a mechanic to install the Type SMA analyzer.
- A combustion/start-up engineer familiar with the process and combustion in general to start up the Type SMA analyzer.
- A person trained in and familiar with the process to operate the Type SMA analyzer.
- An electrical or service technician to maintain and perform repair/replacement procedures.

EQUIPMENT DESCRIPTION

The Type SMA analyzer has four main assemblies: the sensor assembly, the probe with filter assembly, the electronics assembly and the cable assembly (Figure 1-1).

The Type SMA1 analyzer uses an O_2 only sensor assembly that contains the flange manifold, O_2 sensor, heaters and the termination chamber (Figure 1-2). The Type SMA2 analyzer uses a combination O_2 and CO_e sensor assembly that contains the CO_e sensor and all of the components in the O_2 only sensor assembly (Figure 1-3).

The probe with filter assembly comes in one of three types: the standard probe with filter, the standard probe with optional dual filter and the optional high temperature probe with filter (Figure 1-4).

The electronics assembly consists of the operator interface, input/output (I/O) board, microprocessor board, valve manifold and the termination unit board (Figures 1-5 and 1-6).

The cable assembly comes in a standard 15-meter (50-foot) length. Optional 30-meter (100-foot) and 46-meter (150-foot) lengths are available (Figure 1-7).

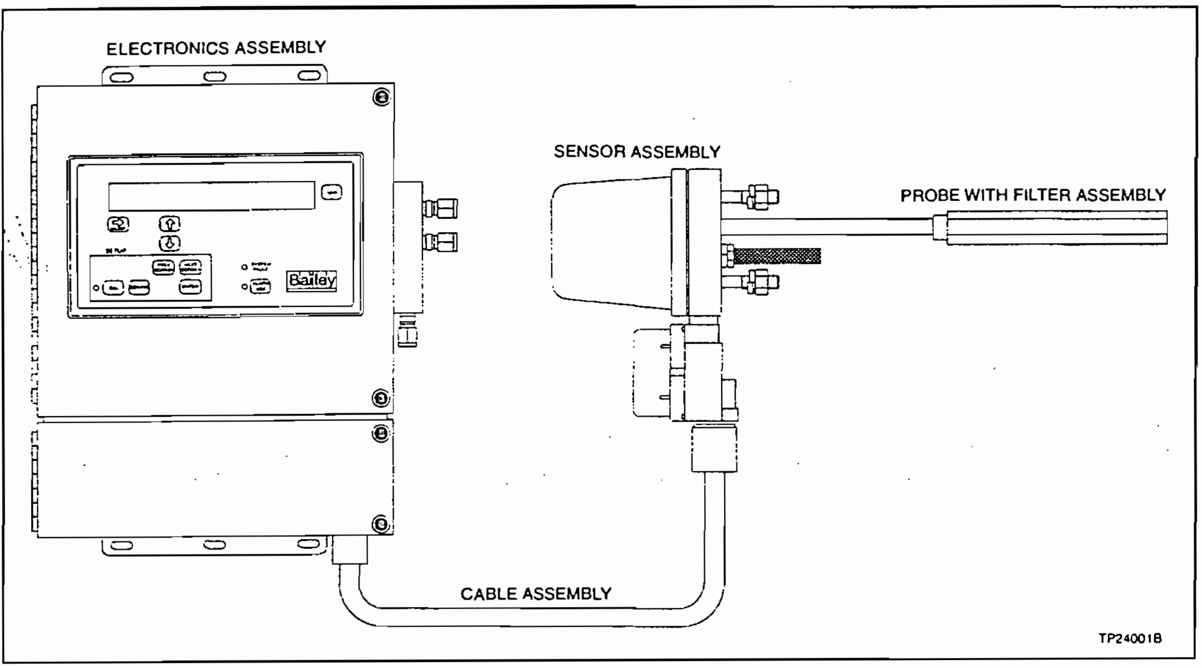


Figure 1-1. Main Assemblies

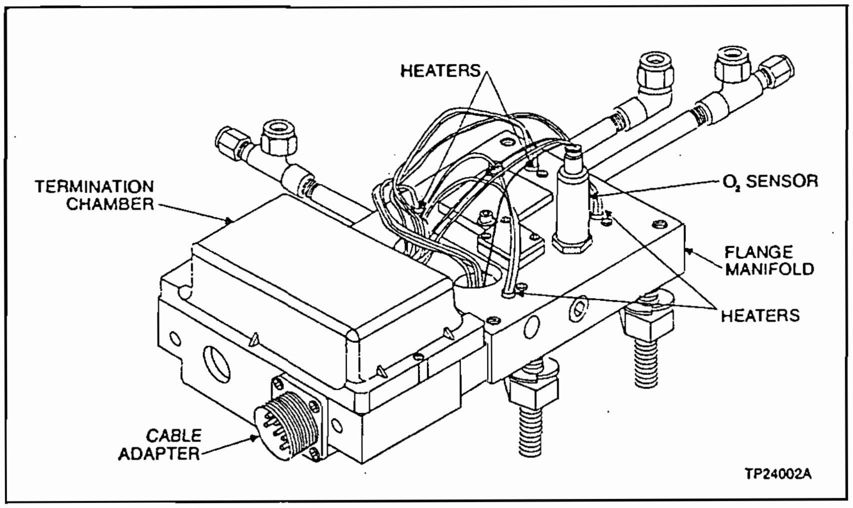


Figure 1-2. Type SMA1 Sensor Assembly

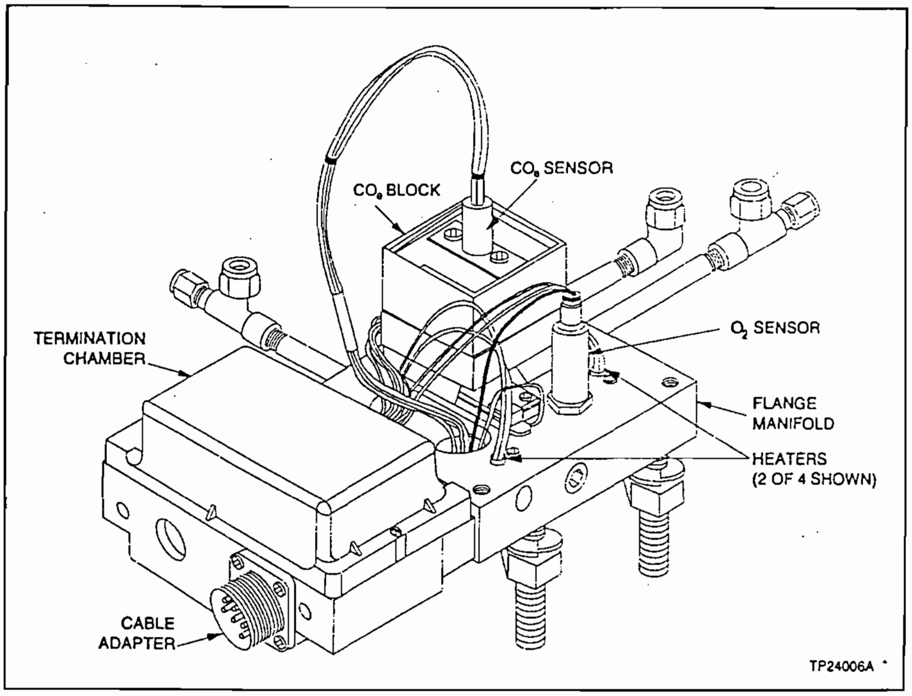


Figure 1-3. Type SMA2 Sensor Assembly

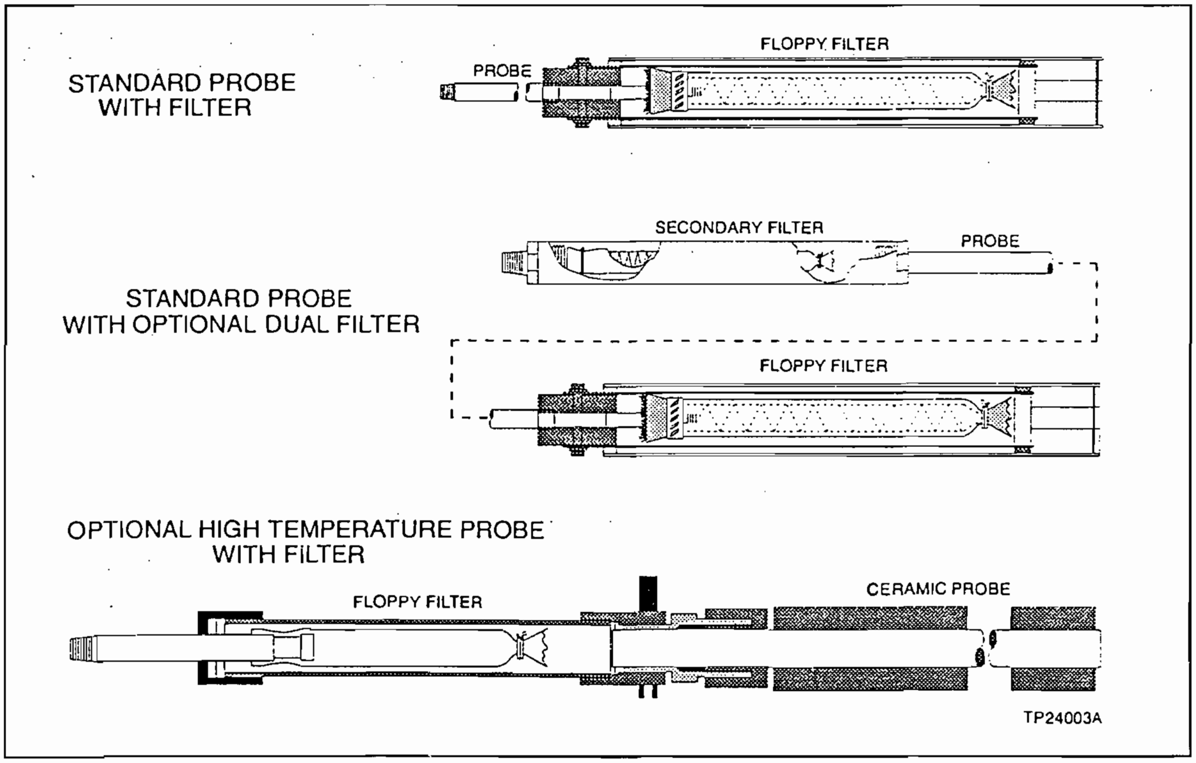


Figure 1-4. Probe with Filter Assemblies

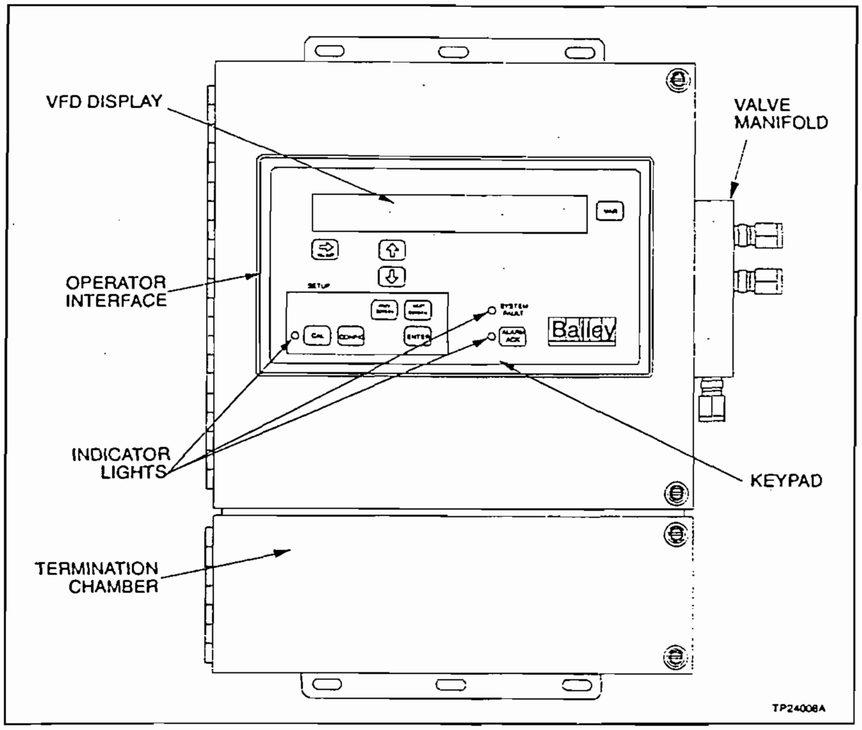


Figure 1-5. Electronics Assembly (External View)

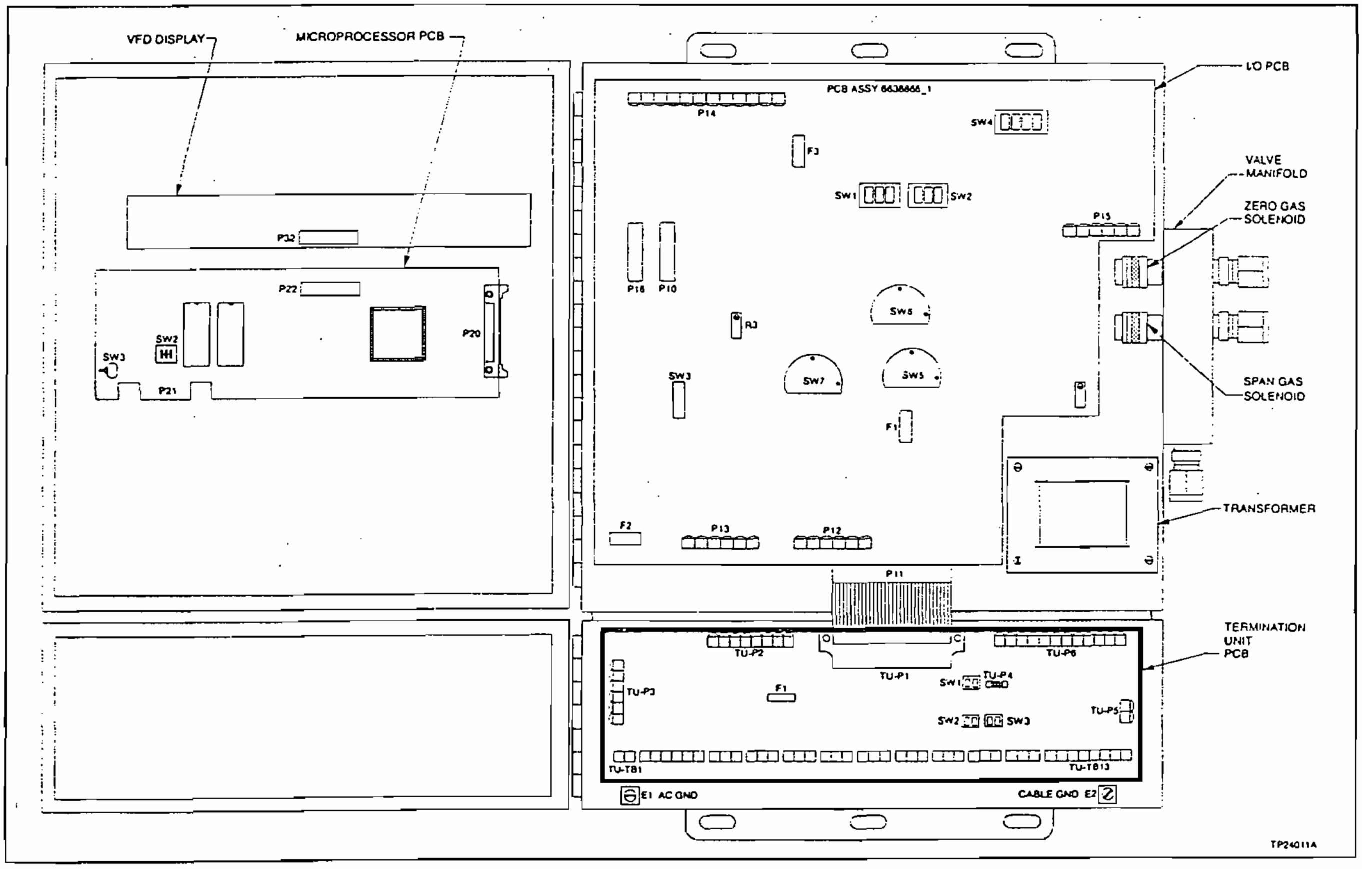


Figure 1-6. Electronics Assembly (Internal View)

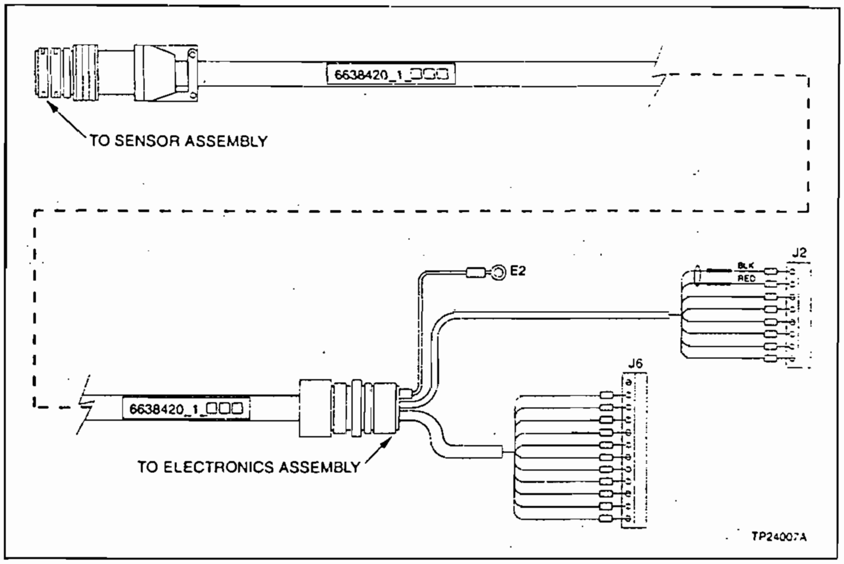


Figure 1-7. Cable Assembly

FEATURES/BENEFITS

New Rugged Industrial Design. The stainless steel heater block, extrusion honed metals and corrosion resistant plastics have hardened this rugged design. The Type SMA Smart Analyzer 90 is built to withstand demanding utility, petrochemical and other industrial applications.

Highly Accurate Sensors. The patented O_2 sensor is a reliable zirconium oxide design. It has built-in contaminant protection and an integral self-controlled heater for longer life expectancies. A catalytic type, RTD based sensor is used for the CO_e measurement. The high sensitivity of the RTD combined with the poison resistant catalyst provides improved performance. The accuracy of both O_2 and CO_e measurements is not affected by flue gas temperature, particulates or variations in either water vapor or carbon dioxide.

Self-Diagnostics and Alarming. The microprocessor based electronics continuously analyzes and monitors the operation of the sensors, analyzer and combustion process. Sensor calibration data is normalized against known test gas concentrations to warn of an impending sensor failure. Analyzer alarm messages display on the screen in English. Form C relay contacts are provided for alarms.

Patented Close Coupled Sample System. The close coupled sample system saves maintenance time and increases the life of the sensor when compared with typical measurement techniques. The floppy filter removes flue gas particulates before analysis while the patented self-cleaning action eliminates filter buildup and plugging. The industry proven hot gas sample system uses heated passages to keep the process sample at a temperature above dew point to insure trouble-free operation.

High Temperature Operating Range. The analyzer assembly with the standard stainless steel probe and floppy filter assembly handles flue gas temperatures up to 649 degrees Centigrade (1200 degrees Fahrenheit). Other optional probe with filter assemblies are available for temperatures up to 1649 degrees Centigrade (3000 degrees Fahrenheit).

Easy Installation and Start-Up. Flange mounting, plug-in cable connectors and menu-driven start-up procedures significantly reduce installation, commissioning and operator training times.

Simplified In-House Maintenance. The sensors are field replaceable without having to remove the sensor assembly. Easy access is provided to all sensor assembly components and electrical connections. Extensive self-diagnostics and optional filter blowback further reduce maintenance requirements.

Automatic Sensor Calibration (Standard). The automatic calibration permits unattended operation and eliminates labor intensive calibration checks required by other analyzers. Calibrations can be programmed to start automatically at specific intervals, manually via the operator interface or remotely by digital inputs. Contact outputs indicating calibration alarms and calibration in progress signal external control systems of the analyzer calibration status.

Low Cost Integrated Solution. No other combustion analyzer provides both O_2 and low range CO_e measurements and automatic calibration in a single, low cost package.

Remote Blowback (Optional). The analyzer may be fitted with an optional dual filter and remote blowback solenoid to offer added protection in applications with abnormally high levels of fine particulate.

Distinctive Operator Interface. A ten-key keypad and a two-line 80-character vacuum fluorescent display provide a highly visible, menu-driven operator interface. Front panel mounted LEDs readily indicate the status of the analyzer.

Process Temperature Measurement. The analyzer accepts thermocouple inputs for inlet air and outlet flue gas temperature measurements.

Combustion Efficiency Calculation (Standard). Combustion efficiency is calculated based on the inlet and outlet temperature measurements and the flue gas composition (O_2 and CO_e content). It is available for natural gas, light oil, heavy oil, anthracite, bituminous and lignite.

EQUIPMENT APPLICATION

WARNING	**Do not use the Type SMA2 analyzer to detect explosive levels (LEL) of any combustible gases. The CO_e sensor is designed to respond to CO and H_2. It may not detect other combustible gases such as methane.**
AVERTISSEMENT	**N'utilisez pas l'analyseur SMA pour détecter les niveaux explosifs (LEL) de gaz combustibles. L'analyseur SMA n'est pas destiné aux applications de sécurité. Le détecteur de CO_e est conçu en fonction de détecter les gaz CO et H_2. Il ne peut pas détecter d'autres gaz combustibles comme le méthane.**

The Type SMA analyzer samples flue gases from an industrial combustion process fueled by oil, coal or gas. Typical applications include boilers and furnaces. Analog outputs provide four to 20 milliamp or one to five VDC signals based on the measured gas samples. Thermocouple inputs at the sensor and electronics assemblies provide for inlet air and outlet flue gas temperature measurements. The type of fuel and the temperature measurements provide required data for the combustion efficiency calculation. Contact Bailey Controls Company before using the analyzer in applications such as kilns, recovery boilers (red liquor and black liquor), incinerators, high vanadium oils, waste oils or liquid wastes.

INSTRUCTION CONTENT

This instruction book covers installation, operation and maintenance of the Type SMA analyzer.

Introduction	Describes the manual and introduces the analyzer. It includes a glossary of terms and abbreviations (Table 1-1), reference documents (Table 1-2), nomenclature (Table 1-3), accessories (Table 1-4) and specifications (Table 1-5).
Description and Operation	Describes the functional operation of the probe with filter, sensor, cable and electronics assemblies.
Operator Interface	Explains the operator interface and how to use it. Topics include the display, indicator lights and keypad.
Installation	Contains information about special handling considerations, unpacking and inspection, location considerations, air quality requirements and physical installation. Includes adjustments that must be performed before placing the system into service.
Configuration	Lists step-by-step procedures and screen explanations to configure the analyzer.

Calibration	Lists step-by-step procedures and screen explanations to calibrate the analyzer. Includes an initial sensor assembly operation checkout and calibration that must be performed prior to placing the analyzer in service.
Operating Procedures	Includes procedures for normal operations and lists step-by-step procedures and screen explanations to operate the analyzer.
Troubleshooting	Shows the alarm screens and corrective action flowcharts to assist with troubleshooting the analyzer.
Maintenance	Includes a maintenance schedule and preventive maintenance procedures for the probe with filter, sensor and electronics assemblies.
Repair/Replacement Procedures	Contains step-by-step procedures for repair and replacement of the sensor, probe with filter and electronics assemblies.
Support Services	Contains the recommended spare parts list, parts kits and assembly drawings.
Appendices	Includes descriptions of the sensors and efficiency calculation.

HOW TO USE THIS MANUAL

It is important for safety and operating reasons to read and understand this manual. Do not install or attempt any task until you have thoroughly read this instruction book.

The sections of this instruction book are sequentially arranged as they relate to installation and start-up (configuration, calibration and operation). After start-up, refer to each section of this instruction book as needed.

GLOSSARY OF TERMS AND ABBREVIATIONS

Table 1-1. Glossary of Terms and Abbreviations

Term	Definition
Analog	Continuously variable as opposed to discretely variable.
Blowback	A short pulse of air applied to the probe to remove particulate buildup from the filter.
CO_e	Carbon monoxide equivalent. Combustibles measured in terms of CO concentration required to generate the equivalent sensor output.
Configuration	The act of setting up equipment to accomplish specific functions or a list of parameters associated with the setup.
Dew Point	The temperature at which a vapor begins to condense.
Digital	A discretely variable signal usually having only two states, on or off.

Table 1-1. Glossary of Terms and Abbreviations (continued)

Term	Definition
Dry Measurement	Measurement with water vapor removed from the sample.
EPROM	Electronically programmable read only memory. Contents remain when power is removed.
ESD	Electrostatic sensitive devices. Electronic components subject to damage or failure when exposed to an electrostatic charge; require special handling.
LED	Light emitting diode.
MFT	Machine fault timer. Reset by the processor during normal operation. If not reset regularly, the MFT times out and the unit stops.
Net O_2	Oxygen remaining after all combustibles have been consumed.
NVRAM	Nonvolatile random access memory. Retains stored information when power is removed.
ppm	Parts per million. A measurement unit for concentration (10,000 ppm = 1%).
RTD	Resistance temperature detector. A sensing device that changes resistance within a temperature range.
TU	Termination unit. Provides input/output connection points.
T/C	Thermocouple. A bimetallic sensor used for temperature measurements.
Wet Measurement	Measurement with water vapor not removed from the sample.
VFD	Vacuum fluorescent display. An output device that communicates information through illuminated alphanumerics.

REFERENCE DOCUMENTS

Table 1-2. Reference Documents

Document Number	Description
C-E65-76	Type SMA Smart Analyzer 90 Product Specification
ISA S7.3	Quality Standard for Instrument Air, Sections 4.1.1 (Outdoor Installations), 4.2 (Particle Size) and 4.3 (Oil Content)

NOMENCLATURE

Table 1-3. Type SMA Nomenclature

Position	4	5	6	7	8	
Type SMA	☐	☐	☐	☐	☐	**Smart Analyzer 90**
						Measurement
	1					O_2 only
	2					O_2 and CO_e
						Cable length
		1				Standard 15 m (50 ft)
		2				Optional 30 m (100 ft)
		3				Optional 46 m (150 ft)
						Probe with filter

6	Type	Temp	Length m (ft)	
			Probe	Probe with Filter[1]
1	Standard probe with filter	649°C (1200°F)	1.22 (4.00)	1.55 (5.08)
2			2.13 (7.00)	2.46 (8.08)
3	Standard probe with optional dual filter	816°C (1500°F)	1.22 (4.00)	1.75 (5.75)
4			2.13 (7.00)	2.67 (8.75)
5	Optional high temperature probe with filter	1649°C (3000°F)	1.22 (4.00)	1.57 (5.13)

7	8	
		Blowback
0		None
1		120 VAC Solenoid
2		240 VAC Solenoid
		Instrument air filters
	0	None
	1	Two Stage Filter System

NOTE:

1. Length is from end to end with the filter assembled on the probe.

ACCESSORIES

Table 1-4. Accessory Part/Kit Number and Application

Accessory	Part/Kit No.	Application
Blowback solenoid	258525_1 (110 VAC) 258525_2 (220 VAC)	Performs a preventive maintenance activity to momentarily direct high pressure aspirating air to clean the filter in the probe with filter assembly.
Panel mount kit	258524_1	Allows for the electronics assembly to be panel mounted.
Adapter flange kit	258407_1	Standard mounting uses a 2-in. flange. The kit contains an adapter piece for mounting to a 3-in. or 4-in. flange. This kit is included with the optional high temperature probe with filter assembly.

Table 1-4. Accessory Part/Kit Number and Application (continued)

Accessory	Part/Kit No.	Application
Probe flange kit	258536_1	Isolates probe with filter assembly from the sensor assembly to ease maintenance in a positive pressure application.
Maintenance kit	258432_1	Includes 3-way valve and 2 pressure gages use to measure suction and sample pressures.
Instrument air filters	258560_1	Recommended to clean instrument air before it enters the analyzer.
Test gas kit	258274_2	Portable maintenance test gas kit, good for a fe calibrations. Not meant to replace customer supplied test gas.

SPECIFICATIONS

Table 1-5. Specifications

Property	Characteristic/Value
Variable analog output ranges	
O_2 span	Minimum 0 to 5% Maximum 0 to 25%
CO_e span	Minimum 0 to 200 ppm (0.00 to 0.02%) Maximum 0 to 20000 ppm (0.00 to 2.00%)
Temperature zero	-46° to 1371°C (-50° to 2500°F)
Temperature span	Minimum 260°C (500°F) Maximum 1649°C (3000°F)
Display screen accuracy	
O_2	±2.5% of reading (0.1 to 25.0%)
CO_e	±20 ppm (from 200 to 999 ppm) ±2% of span (from 1000 to 20000 ppm)
Temperature: Thermocouple type:	
E, J, K or T	±3.3°C (6.0°F)
R or S	±11.1°C (±20°F) (from -46° to 538°C [-50° to 1000°F]) ±5.5°C (±10°F) (from 538° to 1649°C [1000° to 3000°F])
Analog output accuracy	
O_2	±2.5% of measured value; (1 to 5 VDC or 4 to 20 mA)
CO_e	$\frac{\pm 20\ ppm}{span} \times$ 100% of span (from 200 to 999 ppm) ±2% of span (from 1000 to 20000 ppm)
Temperature: Thermocouple type:	
E, J, K or T	±1.5% of span
R or S	±4.5% of span (from 260° to 538°C [500° to 1000°F]) ±1.5% of span (from 538° to 1649°C [1000° to 3000°F])

Table 1-5. Specifications (continued)

Property	Characteristic/Value
Measurement errors due to flue gas variables	
CO_2	None
Water vapor	None
Particulate	None
Sensor response time to 63% of span	
O_2	< 3.5 secs
CO_e	< 13 secs
Power supply requirements	
Supply voltage	105 to 128 VAC, 47 to 63 Hz or 211 to 257 VAC, 47 to 63 Hz
Power (during start-up)	730 W
Power (operating)	310 W
Air supply pressure	207 kPa (±3 kPa) at 0.93 m^3/hr 30.0 psig (±0.5 psig) at 0.55 scfm
Input signals	
Four digital: DI1: Remote calibration DI2: Remote blowback DI3: Remote zero gas DI4: Remote span gas	120/240 VAC, 50/60 Hz or 24 VDC
Two thermocouple: Inlet temperature Outlet temperature	Types E, J, K, T, S or R (isolated)
Output signals	
Four analog[1]: AO1: Process O_2 AO2: Process CO_e AO3: Inlet/outlet temperature AO4: Combustion efficiency	1 to 5 VDC or 4 to 20 mA (isolated[2] or nonisolated)
Six isolated digital[3]: DO1: Process O_2 alarm DO2: Process CO_e alarm DO3: Process temperature alarm DO4: Combustion efficiency alarm DO5: Analyzer fault alarm DO6: Calibration in progress	Form C relay contacts rated for 2 A at 120/240 VAC, 50/60 Hz or 24 VDC
Maximum analog output loading	
Voltage mode	250 kΩ, 600 mH
Current mode	600 Ω, 600 mH

Table 1-5. Specifications (continued)

Property	Characteristic/Value
Self-monitoring (default output)	
Digital outputs	Alarm state: NC to COM is open and NO to COM is closed
Analog outputs	Switch selectable to low or high output: Low: 0 VDC or 0 mA High: 6.2 VDC or 25 mA
Probe with filter assembly length	
Standard probe with filter	1.55 m (5.08 ft) or 2.46 m (8.08 ft)
Standard probe with optional dual filter	1.75 m (5.75 ft) or 2.67 m (8.75 ft)
Optional high temperature probe with filter	1.57 m (5.13 ft)
Cable	
Standard length	15 m (50 ft)
Optional lengths	30 m (100 ft); 46 m (150 ft)
Minimum bend radius	17.8 cm (7 in.)
Maximum diameter (outside diameter)	1.9 cm (0.75 in.)
Environmental	
Sensor assembly (pending)	NEMA 4 (indoor/outdoor)
Electronics assembly (pending)	NEMA 4 (indoor)
Maximum probe with filter assembly temperature	
Standard probe with filter	649°C (1200°F)
Standard probe with optional dual filter	816°C (1500°F)
Optional high temperature probe with filter	1649°C (3000°F)
Ambient temperature limits	
Sensor housing	-18° to 93°C (0° to 199°F)
Electronics housing	0° to 60°C (32° to 140°F)
Cable	-18° to 93°C (0° to 199°F)
Humidity	
Sensor assembly	95% relative humidity at 93°C (199°F) noncondensing
Electronics assembly	95% relative humidity at 60°C (140°F)
Weight (approximate)	
Cable assembly:	
Standard 15 m (50 ft)	8.6 kg (19 lbs)
Optional 30 m (100 ft)	16.8 kg (37 lbs)
Optional 46 m (150 ft)	24.5 kg (54 lbs)
Sensor assembly	6.4 kg (14 lbs)
Electronics assembly	12.7 kg (28 lbs)

Table 1-5. Specifications (continued)

Property	Characteristic/Value
Approvals/certifications	
Factory Mutual (pending)	Approved against flashback into duct
Factory Mutual (pending)	Approved for use in Class I, Division 2, groups B, C and D; and for use in Class II, Division 2, groups E, F and G
Canadian Standard Association (pending)	Certified for use in ordinary nonhazardous locations

NOTES:

1. AO2 (CO_e) defaults to 4 mA or 1.0 VDC when a Type SMA1 analyzer is installed. AO3 (inlet/outlet temperature) and AO4 (combustion efficiency) default to 4 mA or 1.0 VDC when these options are not selected.
2. Analog outputs can be selected for isolation in pairs. AO1 and AO2 define a pair. AO3 and AO4 define another pair.
3. DO2 (process CO_e alarm) defaults to normal state when a Type SMA1 analyzer is installed. DO3 (process temperature alarm) and DO4 (combustion efficiency alarm) default to normal state when these options are not selected.

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

SECTION 2 - DESCRIPTION AND OPERATION

INTRODUCTION

This section gives an overview of the Type SMA Smart Analyzer 90. Included are descriptions of the probe with filter assembly, sensor assembly, cable assembly and electronics assembly.

FUNCTIONAL OPERATION

The Type SMA1 Smart Analyzer 90 continuously monitors the process flue gas net oxygen (O_2) content. The Type SMA2 Smart Analyzer 90 continuously monitors the process flue gas net O_2 and carbon monoxide equivalent (CO_e) content. Two thermocouple inputs allow for inlet air and outlet flue gas temperature measurements. The process flue gas content and temperature measurements provide the data for the combustion efficiency calculation.

The sensor assembly mounts directly to the process wall. Samples of the process flue gas are filtered and drawn through the sensor assembly by an air powered aspirator. A zirconium oxide O_2 sensor provides for oxygen measurements on both types of sensor assemblies. The combination O_2 and CO_e sensor assembly uses a catalytic CO_e sensor for carbon monoxide equivalent measurements. The gas samples are maintained above dew point at all times providing a wet basis measurement.

The electronics assembly controls the temperature of the sensor assembly. It initiates and performs sensor calibrations. It also converts the sensor inputs, thermocouple inputs and efficiency calculations to four to 20 milliamp or one to five VDC analog output signals. The digital inputs remotely start the calibration, filter blowback and insertion of sensor check gases. The digital outputs indicate the process measurement alarms, analyzer fault alarms and the calibration status.

Probe with Filter Assembly

The probe with filter assembly (Figure 1-4) connects to the sensor assembly and protrudes into the flue gas stream. Samples of the flue gas are passed through the probe with filter assembly to the sensor assembly for analysis. A choice of three probe with filter assemblies allows the analyzer to work in a variety of process environments. The assemblies are the standard probe with filter, standard probe with optional dual filter and optional high temperature probe with filter. The probes are varied lengths and can be cut to any desired length.

The standard probe with filter assembly consists of a ¼-inch stainless steel probe with filter assembly. It operates in flue gas temperatures up to 649 degrees Centigrade (1200 degrees Fahrenheit). The filter assembly contains a patented floppy filter made up of a multilayer ceramic cloth that is highly resistant to particulate buildup. A filter shield protects the floppy filter from direct impact by particulate matter. The ¼-inch schedule 80, stainless steel probe is available in 1.22-meter (4.00-foot) and 2.13-meter (7.00-foot) lengths.

The standard probe with optional dual filter assembly consists of the standard probe with filter assembly and a secondary filter. Flue gases that contain fine, abrasive or high concentrations of particulate matter require this assembly. The secondary filter allows the standard probe with filter to operate in flue gas temperatures up to 816 degrees Centigrade (1500 degrees Fahrenheit). The secondary filter consists of a floppy filter inside a stainless steel tube. A ¼-inch female fitting accepts the standard probe and the ¼-inch male fitting screws into the sensor assembly.

The optional high temperature probe with filter assembly consists of a ceramic probe with a floppy filter. It operates in flue gas temperatures up to 1649 degrees Centigrade (3000 degrees Fahrenheit). It is used where the flue gas temperature exceeds the limits of the other probe with filter assemblies. The ceramic probe is 1.22 meters (4.00 feet) long. Insulating sleeves provided with the probe minimize thermal shock. The filter assembly consists of a floppy filter inside a stainless steel tube. This assembly requires a 3-inch mounting flange instead of the standard 2-inch mounting flange.

Sensor Assembly

The sensor assembly mounts to a duct or process wall so that the probe with filter assembly protrudes into the flue gas stream. An air powered aspirator continuously pulls samples of the process flue gas through the probe with filter assembly. The gas sample is drawn through a heated path inside the manifold block. The Type SMA1 analyzer splits the gas sample into two passages. One path travels to the O_2 sensor. The other path acts as a bypass to keep the Type SMA1 analyzer response equal to the Type SMA2 analyzer response. The Type SMA2 analyzer splits the gas sample into two passages. One path travels to the O_2 sensor and the other path leads to the CO_e sensor. The gas sample is diluted with air before it reaches the CO_e sensor. After the gas sample flows past the sensors, it combines with the aspirator air and returns to the duct. See Figure 2-1 for the Type SMA1 sensor assembly flow diagram. See Figure 2-2 for the Type SMA2 sensor assembly flow diagram.

The 207 kilopascals (30 pounds per square inch gage) aspirator supply air serves four purposes. First, it powers the

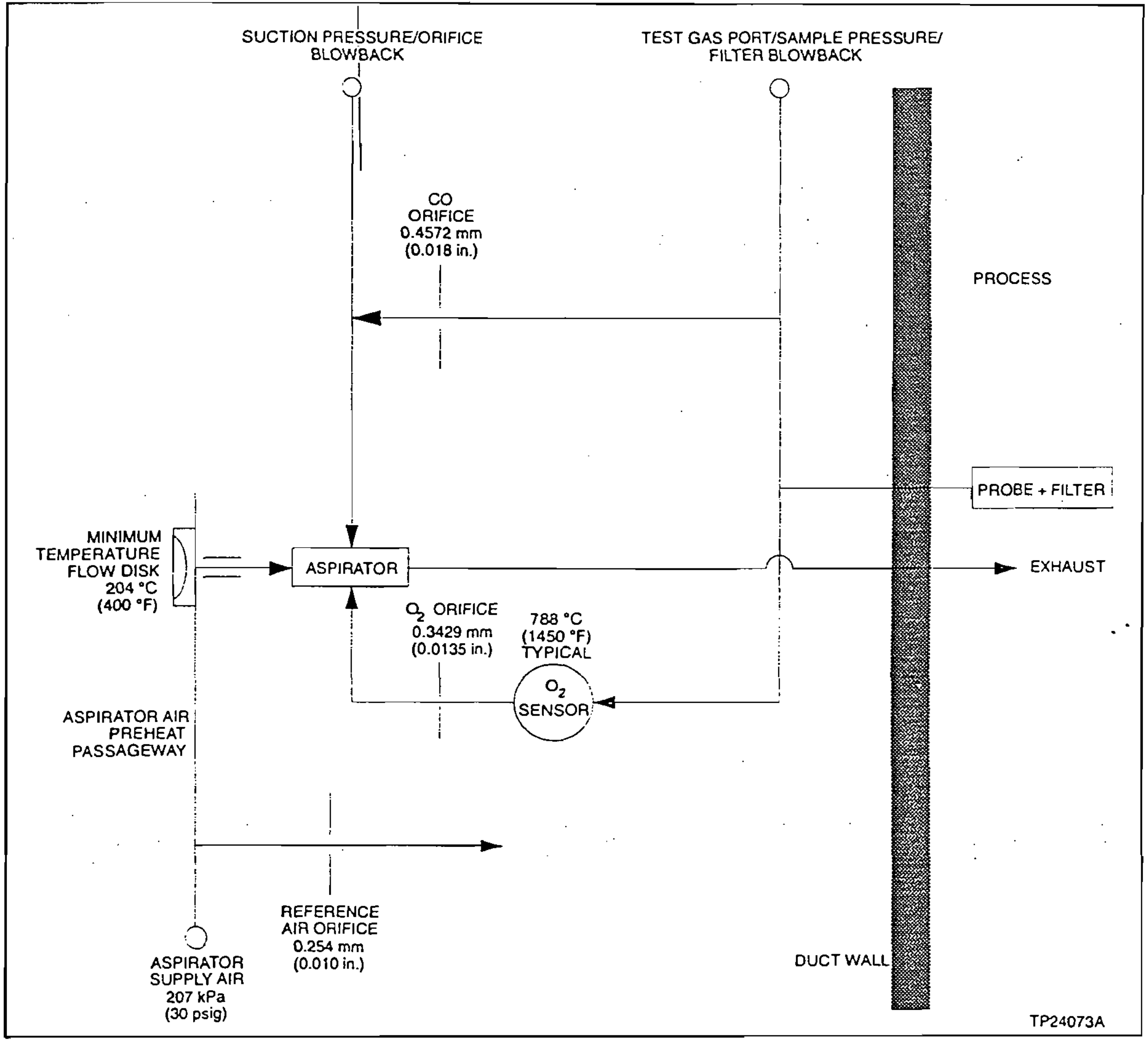


Figure 2-1. Type SMA1 Sensor Assembly Flow Diagram

aspirator creating 55.2 to 62.1 kilopascals (eight to nine pounds per square inch) suction pressure in the sensor assembly. The suction pressure draws the sample gases through the sensor assembly.

Second, it supplies the dilution air added to the sample gases prior to the CO_e sensor when the Type SMA2 analyzer is installed. Refer to Appendix B for an explanation of why dilution air is added. Third, it provides the reference air needed by the O_2 sensor. Fourth, it provides air to the optional blowback solenoid. The minimum temperature flow disk permits air flow to the aspirator only when the sensor assembly is near operating temperature. This minimizes the amount of sampled process flue gas being pulled into a cold sensor assembly causing condensation which can plug the

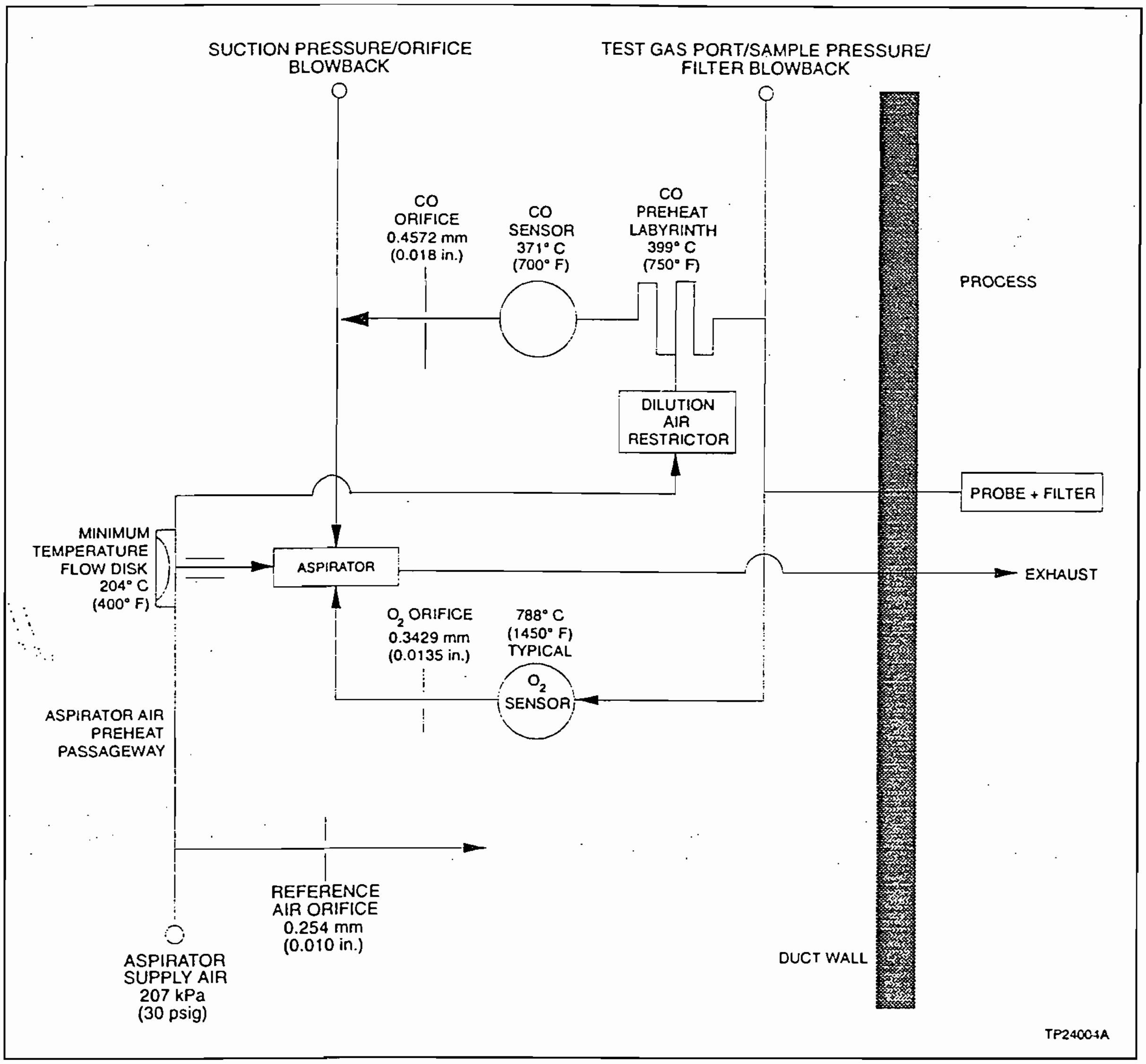


Figure 2-2. Type SMA2 Sensor Assembly Flow Diagram

orifices. Critical orifices insure a constant sample flow rate that is not affected by variations in the duct pressure or by a pressure drop across the filter. See Figure 2-3 for the actual port locations on the sensor assembly.

The main body of the sensor assembly consists of the flange manifold. The termination chamber mounts directly to the flange manifold and contains the connector for the cable assembly. The termination chamber also contains connectors for the outlet flue gas thermocouple and the optional blowback solenoid.

On both types of sensor assemblies, the O_2 sensor screws into the flange manifold. Four 100-watt heaters maintain the flange manifold at 204 degrees Centigrade (400 degrees

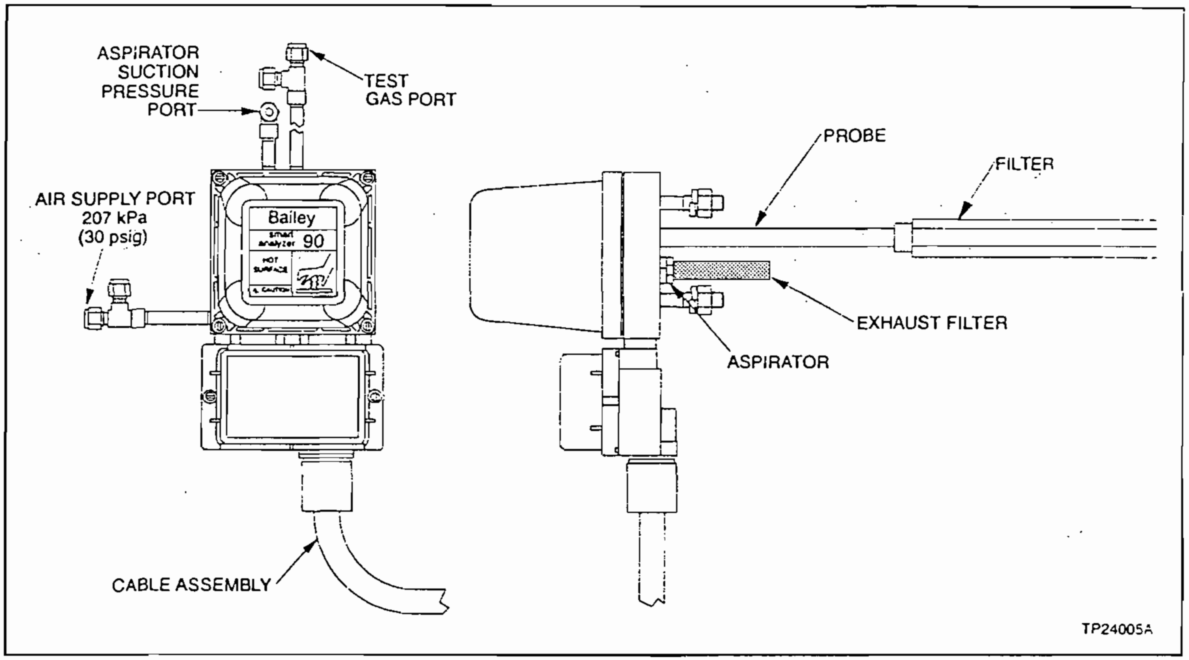


Figure 2-3. Sensor Assembly Port Locations

Fahrenheit). For the Type SMA2 analyzer the CO_e sensor mounts into the CO_e block. Two 60-watt heaters keep the CO_e preheater block at 399 degrees Centigrade (750 degrees Fahrenheit).

The O_2 sensor consists of a zirconium oxide sensor and a self-regulating heater. The O_2 sensor generates a millivolt output that is a logarithmic function of the net oxygen concentration in the sample gases. Refer to Appendix A for more information on the operation of the O_2 sensor.

The CO_e sensor consists of an inert coated reference element and a catalyst coated active element. Both elements are resistance temperature detectors (RTD). As the sample gases flow by the sensor, the combustible gases oxidize on the surface of the active element. The heat generated by the oxidation causes a temperature difference between the active and the reference elements. This temperature difference produces a resistance relationship between the two elements that is directly proportional to the concentration of combustibles in the sample gases. Refer to Appendix B for more information on the operation of the CO_e sensor.

Cable Assembly

CAUTION	**Do not modify the cable assembly in the field (i.e., shorten the cable or remove the connectors for routing through conduit). Modification of the cable voids the warranty and may damage the analyzer.**
ATTENTION	**Ne modifiez pas l'assemblage du câble en chantier (par exemple, en raccourcissant le câble ou en retirant les connecteurs à des fins d'insertion dans un conduit). Toute modification du câble annule la garantie et risque d'endommager l'analyseur.**

The cable assembly comes in a standard 15-meter (50-foot), optional 30-meter (100-foot) or optional 46-meter (150-foot) length. One end of the cable connects to the sensor assembly termination chamber. The other end connects to the electronics assembly termination chamber. Threaded and plug-in connectors ease installation and maintenance. The cable assembly carries the sensor and thermocouple signals from the sensor assembly to the electronics assembly. It also carries the heater power and blowback solenoid power from the electronics assembly to the sensor assembly.

Electronics Assembly

The main components of the electronics assembly are the operator interface, microprocessor circuit board, termination unit (TU) circuit board, input/output (I/O) circuit board and the valve manifold.

OPERATOR INTERFACE

The operator interface consists of a keypad, a two-line 80-character vacuum fluorescent display (VFD) and three indicator lights (Figure 1-5). The operator interface is used to set up and operate the analyzer through menu-driven screens.

The mode (setup or operate) and the environment (calibrate, configure or alarm) determine which set of screens are active. Both modes provide access to the analyzer alarm screens. The ***setup*** mode provides access to screens and procedures used to configure the analyzer during initial installation, and provides diagnostic screens for repair/replacement procedures. The ***operate*** mode provides access to screens used to calibrate the sensors. The operate mode is always accessible. A password must be entered to access the setup mode. The factory set password is SMA and can be changed to any combination of three letters and numbers. See Figure 2-4 for the mode and environment access flowchart.

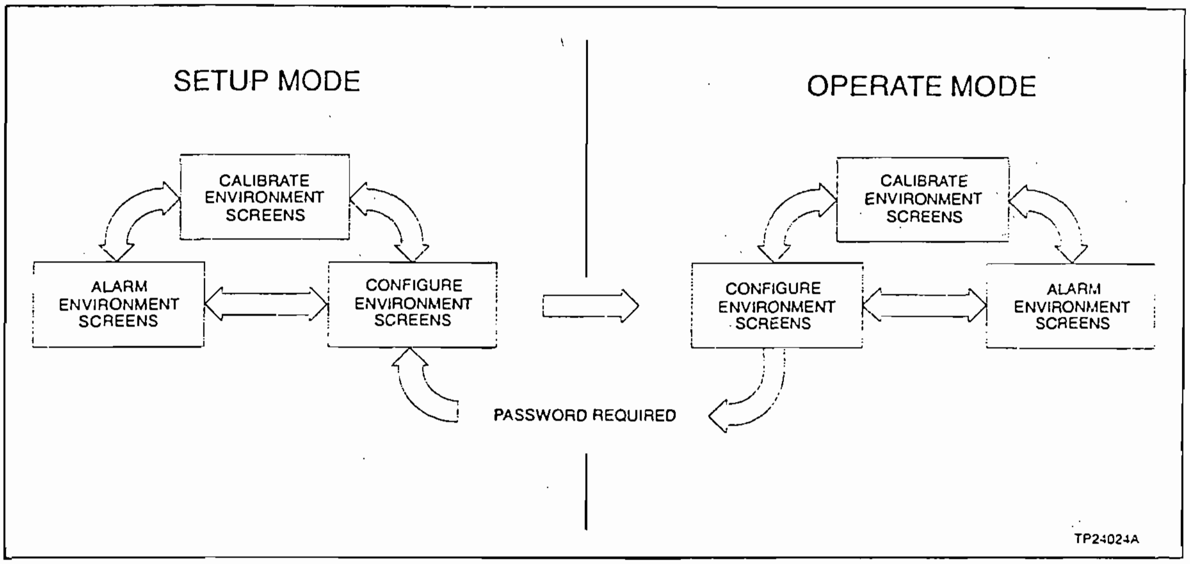


Figure 2-4. Mode and Environment Access

MICROPROCESSOR CIRCUIT BOARD

The microprocessor board controls the display, sensor assembly and the digital and analog outputs. It receives the digitized process signals from the I/O board and performs all of the computations. It scans the keypad and responds to any pressed keys. The reset button on the microprocessor circuit board resets the microprocessor and should be used only in the event of an electronic failure. The dipswitch on the microprocessor board is for factory use and initialization of NVRAM.

TERMINATION UNIT (TU) CIRCUIT BOARD

The TU board interfaces customer field wiring to the analyzer. It contains termination blocks for the digital inputs, inlet thermocouple, digital outputs, analog outputs, and power to the analyzer. The digital inputs require external power using 24 VDC or 120/240 VAC. The TU board also contains connectors for the electronics end of the cable assembly and the inlet air thermocouple.

INPUT/OUTPUT (I/O) CIRCUIT BOARD

The I/O board amplifies the thermocouple and sensor process signals, converts them to a digital format and passes them on to the microprocessor board for analysis. The I/O board supplies the power for the sensor assembly heaters, microprocessor board, VFD display and the analog and digital outputs. Switches SW1 through SW7 located on the I/O board configure the analog outputs, apply power to the sensor assembly heaters and configure the analyzer for 120 or 240 VAC power. Refer to Section 4 for information on the switch settings.

VALVE MANIFOLD

The valve manifold is located on the side of the electronics assembly. It releases zero and span test gases to the sensor assembly using solenoids. The solenoids are energized by the calibration sequence. Refer to Section 6 for information on calibration.

SECTION 3 - OPERATOR INTERFACE

INTRODUCTION

This section describes the Type SMA Smart Analyzer 90 operator interface. The operator interface is used to configure, calibrate, operate and troubleshoot the analyzer. The operator interface consists of the display, indicator lights and the keypad (Figure 1-5). The keypad conveys information to the analyzer through ten keys. The display and indicator lights convey information from the analyzer through menu-driven screens and alarm signals.

DISPLAY

The display consists of a highly visible, 80-character, two-line vacuum fluorescent display (VFD). The menu-driven screens convey information about a procedure, configuration or an alarm status. A cursor consisting of two angle brackets < > indicates which option or changeable parameter is selected in the menu-driven screen. The cursor has two states: on or blinking (Table 3-1). In the cursor example, the cursor surrounds *SETUP* indicating it is selected.

Cursor example: [OPERATE <SETUP>]

Table 3-1. Cursor Selection Memory Status

State	Description
On	The indicated option or data is stored in memory.
Blinking	The indicated option or data is not stored in memory. Pressing the **ENTER** key stores the changed selection or number into memory and the cursor stops blinking.

INDICATOR LIGHTS

There are three indicator lights located on the keypad. They show the present status of the analyzer. The yellow light next to the **CAL** key has three states: on, blinking or off (Table 3-2). The red indicator light next to the **ALARM ACK** key has three states: on, blinking or off (Table 3-3). The red indicator light labeled SYSTEM FAULT has two states: on or off (Table 3-4).

KEYPAD

The keypad consists of ten keys, each with its own unique function. Table 3-5 explains the functions assigned to each key and the text used throughout the manual to indicate each key. The keys are used to make selections on the screen, enter and retrieve data and to scroll through the screens.

Table 3-2. Zero and Span Gas Indicator Light (Yellow)

State	Description
On	Calibration or blowback in progress.
Blinking	The zero or span gas solenoid is turned on manually and must be turned off manually upon completion of the procedure. This occurs during the sample flow test and the test gas procedures in Section 6 (calibration) and Section 10 (repair/replacement).
Off	The zero and span gas solenoids are off.

Table 3-3. Alarm Indicator Light (Red)

State	Description
On	All existing alarms have been acknowledged and displayed.
Blinking	Alarms exist that have not been acknowledged and displayed.
Off	No alarms exist. Alarms that did exist have been cleared.

Table 3-4. System Fault Indicator Light (Red)

State	Description
On	The microprocessor within the analyzer is not functioning properly. There is a fault within the electronics which has caused the outputs to go to the default state. The indicator light stays on during start-up until all diagnostics are complete.
Off	The microprocessor within the analyzer is functioning properly.

Table 3-5. Keypad Operation

Key	Text Reference	Description
VAR	VAR	Displays the process variables being measured. These can include O_2, CO_e process temperature and combustion efficiency.
→ SELECT	SELECT	Moves the cursor from one selection to another.
⇧	UP ARROW	Increases the number or letter displayed within the cursor causing the cursor to start blinking. The **ENTER** key must be pressed after changing a number or letter for it to be stored into memory.
⇩	DOWN ARROW	Decreases the number or letter displayed within the cursor causing the cursor to start blinking. The **ENTER** key must be pressed after changing a number or letter for it to be stored into memory.

Table 3-5. Keypad Operation (continued)

Key	Text Reference	Description
PREV SCREEN	PREV SCREEN	Scrolls the display to the previous active screen.
NEXT SCREEN	NEXT SCREEN	Scrolls the display to the next active screen.
CAL	CAL	Accesses the calibration environment screens.
CONFIG	CONFIG	Accesses the configuration environment screens.
ENTER	ENTER	Stores changed parameter values and selected options into memory.
ALARM ACK TP24059A	ALARM ACK	Accesses the alarm environment screens. Displays and acknowledges the alarms.

APPENDIX B - CO_e SENSOR

INTRODUCTION

The Type SMA Smart Analyzer 90 CO_e sensor is a catalytic sensor consisting of two RTD elements. One RTD is the reference element coated with an inert coating (white). The other RTD element is the active element coated with a catalyst. The catalyst on the active element combines the combustibles present in the gas sample with oxygen which is also present. This oxidation produces heat and a temperature rise in the active element. This temperature rise is directly proportional to the concentration of combustibles in the gas sample.

CO_e DEFINED

The catalyst is specifically designed to detect carbon monoxide (CO), but the sensor responds to other combustible gases. The sensor is calibrated using carbon monoxide (CO); thus the output should be expressed in terms of CO. However, the output cannot be labeled as just CO since the sensor detects other combustible gases. The response of the sensor to other combustible gases gives an output that is ***equivalent*** to the sensor detecting CO. Bailey Controls Company uses the term CO_c to describe the sensor output. This term indicates that the sensor is calibrated in terms of CO, and that the sensor output is ***equivalent*** to CO but not specific to CO.

WHY MEASURE COMBUSTIBLES AS CO_e

Minimizing the losses due to excess air and unconsumed fuel (combustibles) optimizes combustion efficiency. An oxygen measurement monitors the amount of excess air and a combustibles measurement monitors the amount of unconsumed fuel. Under normal combustion conditions CO is the most and last consumed combustible in the flue gas; thus the combustible output is measured in terms of CO.

ADDITION OF DILUTION AIR TO THE SAMPLE

Some analyzers that use a catalytic sensor do not add dilution air to the sample. These analyzers depend on the oxygen in the process gases to fully oxidize any combustible gases. However, as the combustion process approaches stoichiometric conditions, combustible gases begin to appear in larger concentrations while the available oxygen concentration decreases. When there are large amounts of combustible gases there may not be enough oxygen in the sample for the sensor to function properly. Adding dilution air insures that there is adequate oxygen.

ATTACHMENT D

PROPOSED REVISIONS TO
APPENDIX GCP

GOOD COMBUSTION PRACTICES

The following procedures were based upon Appendix GCP of Atlantic Sugar's Permit No.0990016-004-AC; PSD-FL-078A.

Purpose of GCP Plan

The determination of Best Available Control Technology for carbon monoxide (CO), nitrogen oxides (NOx), and volatile organic compounds (VOC) emissions from Boiler No. 5 (EU-005) relied on "good combustion practices" (GCPs). The purpose of this document is to summarize the operational, maintenance, and monitoring procedures that will lead to the minimization of CO, VOC, and particulate matter (PM) emissions and the optimization of NOx emissions, consistent with good combustion practices.

Off Season Equipment Preparation

Prior to each harvest, the following activities shall be performed.

1. Inspect, clean, and perform routine maintenance for the boiler proper, its air ductwork, air heaters and scrubber.
2. Inspect and repair all refractory and boiler casing where needed
3. Remove loose scale removed from outside of boiler tubes and remove loose scale, sand and other debris from boiler.
4. Inspect, clean, and check the boiler grate for proper mechanical operation.
5. Inspect and repair all fans and fan drives as needed.
6. Inspect and repair all pumps and pump drives as needed.
7. Inspect and clean all oil burners, related oil piping, atomizing steam and air registers.
8. Identify and mark the skirt level of the scrubber on the outside to provide a permanent reference.
9. Inspect, repair, and calibrate all instruments for boiler operation and control, including the process oxygen and equivalent carbon monoxide monitors, as required. Information is recorded by the instrument shop in its repair log.

Training

Prior to each harvest season, an instructional program shall be developed and presented to all boiler operators and boiler room supervisors regarding the following items:

- Efficient combustion: minimizing CO, VOC, and PM emissions while optimizing NOx emissions;
- Reducing startup emissions;
- Proper wet scrubber operations;
- Record keeping required by the air permit; and
- Utilization of the process oxygen and equivalent carbon monoxide monitors to promote good combustion.

The senior most experienced boiler supervisor instructs other boiler room supervisors, boiler operators, and other appropriate personnel in proper boiler and scrubber operations. The training will impress upon supervisors and operators the importance of proper boiler operation in order to minimize emissions.

Good Combustion Practices - Operation

Emissions of CO, PM/PM10, and VOC shall be minimized by ensuring efficient combustion through the proper application of GCPs. To provide reasonable assurance that GCPs are being employed, the boiler operator shall:

1. Maintain the steam production rate at optimal rate by controlling feed of bagasse fuel into the boiler. Sufficient combustion air shall be maintained to promote good combustion.
2. Periodically view the stack plume to visually confirm that good combustion is taking place. 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. Examine the boiler grates at least twice per shift for proper fuel distribution and make appropriate adjustments. Unusual observations shall be logged.
4. Perform a walk-around inspection of the boiler once per day shift to check and repair the following: Fans, pumps, casing, ducting, scrubber, and monitoring equipment.
5. Inspect the burners once per shift and clean as necessary.

These actions may be performed by the operator or other personnel under the operator's supervision. The information collected shall be reported to the boiler operator.

6. Process monitors shall be installed to monitor the oxygen (O_2) content and the equivalent carbon monoxide (COe) 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 the instantaneous and the 1-hour block average. The boiler operators will be instructed in the use of the O_2 and COe flue gas process monitors for combustion control and to ensure sufficient excess air levels. The boiler operators shall periodically observe each process monitor and adjust the boiler operation, consistent with good combustion practices. The process O_2 monitor shall be equipped with an alarm with a set point at 2.0% (minimum) flue gas oxygen content based upon a 1-hour block average. The process COe monitor shall be equipped with an alarm with a set point at 10,000 ppm (maximum) flue gas COe concentration based on a 1-hour block average. At such time that an alarm on either monitor is tripped, the boiler operator shall take corrective action and adjust the boiler operation, consistent with good combustion practices. Corrective actions shall include, but are not limited to, adjusting the air-to-fuel ratio, adjusting the ratio of under-fire air to to over-fire air, or firing some fuel oil in place of bagasse. Corrective actions shall continue until the O_2 and/or COe flue gas levels are maintained at acceptable levels.

NOx Controls

NOx emissions are to be optimized by the proper application of GCPs. However, the application of GCP to minimize CO and VOC emissions may result in increased NOx emissions. This is because factors that 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, GCPs to optimize NOx emissions is considered to be the same practices used to minimize CO and VOC emissions, as described above.