Model 6203 Series
CA-CALC™
Combustion Analyzers

Operation and Service Manual

P/N 1980472 Revision –
October 2002

TSI®

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CA-CALC™
Combustion Analyzers

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LIMITATION OF WARRANTY AND LIABILITY (effective July 2000)

Seller warrants the goods sold hereunder, under normal use and service as described in the operator's manual, shall be free from defects in workmanship and material for twenty-four (24) months, or the length of time specified in the operator's manual, from the date of shipment to the customer. This warranty period is inclusive of any statutory warranty. This limited warranty is subject to the following exclusions:

a. Batteries are warranted for 90 days from the date of shipment to the customer. Electrochemical gas sensors are warranted for a period of twelve (12) months from the date of shipment to the customer.

b. Parts repaired or replaced as a result of repair services are warranted to be free from defects in workmanship and material, under normal use, for 90 days from the date of shipment.

c. Seller does not provide any warranty on finished goods manufactured by others or on any fuses, batteries or other consumable materials. Only the original manufacturer's warranty applies.

d. Unless specifically authorized in a separate writing by Seller, Seller makes no warranty with respect to, and shall have no liability in connection with, goods which are incorporated into other products or equipment, or which are modified by any person other than Seller.

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Buyer and all users are deemed to have accepted this LIMITATION OF WARRANTY AND LIABILITY, which contains the complete and exclusive limited warranty of Seller. This LIMITATION OF WARRANTY AND LIABILITY may not be amended, modified or its terms waived, except by writing signed by an Officer of Seller.

Service Policy

Knowing that inoperative or defective instruments are as detrimental to TSI as they are to our customers, our service policy is designed to give prompt attention to any problems. If any malfunction is discovered, please contact your nearest sales office or representative, or call TSI's Customer Service department at (800) 874-2811.

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Chapters

Appendixes

Introduction

Manual Purpose

This manual describes the operation and maintenance of TSI CA-CALC™ CA-6203 portable combustion analyzer.

Using This Manual

Before using your CA-CALC combustion analyzer, review this manual in its entirety.

Warnings and Cautions

The manual assumes that you have a basic understanding of combustion safety and are thoroughly familiar with the fuel burning equipment being tested. If you are using measurements as the basis for equipment adjustments, rely on your good judgment and experience together with the measured data. This is especially important for safety. Remember when adjusting equipment always follow the manufacturer's recommendations.

W A R N I N G
High temperatures and toxic gases are produced when fossil fuels are burned. Only qualified individuals, thoroughly familiar with operating and adjusting fuel-burning equipment, should use gas measurements for the purpose of making equipment adjustments.

N o t e
The CA-CALC is **not** intended for use as a continuous monitor.

Notes: *Best results are obtained if the CA-CALC combustion analyzer is allowed to stabilize at the temperature of the test environment before using.*

To reduce sensor exposure to gas and to reduce build up of water vapor in the sampling lines and water trap, turn the pump off when not making measurements.

Chapter 1

Instrument Description

The CA-CALC™ combustion analyzer, Model CA-6203 is used to evaluate the performance of burners in boilers, furnaces, and hot water tanks. The Model CA-6203 has sensors for the direct measurement of combustion gases; O_2, CO, NO; combustion gas temperatures and draft pressure. The CA-6203 performs a complete list of combustion and emission parameters for a variety of system performance evaluations. Different units and different fuel types are readily selectable.

CA-CALC™ 6203 Measurements and Calculations

Measurement	**Sensor**
Oxygen concentration	O_2, electrochemical
Carbon monoxide	CO, electrochemical
Nitric oxide	NO, electrochemical
Flue temperature	Thermocouple
Supply air temperature	On-board sensor or Thermocouple probe
Draft pressure	Pressure transducer, internal solid state
Calculations	
CO_2, Carbon Dioxide	
Excess air / λ	
Stack/Flue loss / qA	
Combustion efficiency	
Differential temperature	
NO_x	
CO undiluted	
NO undiluted	
CO_r index	
NO_x undiluted	
Emission Rates CO, NO	

The CA-CALC 6203 is supplied with a sampling probe having an in-line water trap and particulate filter.

The CA-CALC 6203 operates using either an AC power supply or C-size batteries.

The CA-CALC 6203 stores individual data samples (up to 100), and prints the data to a portable printer or computer. Stored data can be saved over a user-defined interval and averaged.

The CA-CALC 6203 has a variety of standard fuels, and enables you to modify the fuel parameters, or install your own *user*-defined fuel.

Loss and efficiency are calculated from standard ASME heat-loss calculations or using the Siegert formula (refer to Appendix B).

Chapter 2

Unpacking

Carefully unpack your CA-CALC™ combustion analyzer and accessories from the carrying case. Check the individual parts against the list of components in the table below. If items are missing or damaged, notify TSI immediately.

List of Standard Components

Qty.	Item Component	Part/ Model
1	Series CA-6203 CA-CALC combustion analyzer	802301
1	Sample probe with water trap, draft line and temperature	801989
1	Power supply 7.2V 120V *or* 230V European, *or* 230V Great Britain, *or* 240V Australian	 2613033 2613078 800169 2613106
4	C cell alkaline batteries	
1	Operation and Service manual	1980472

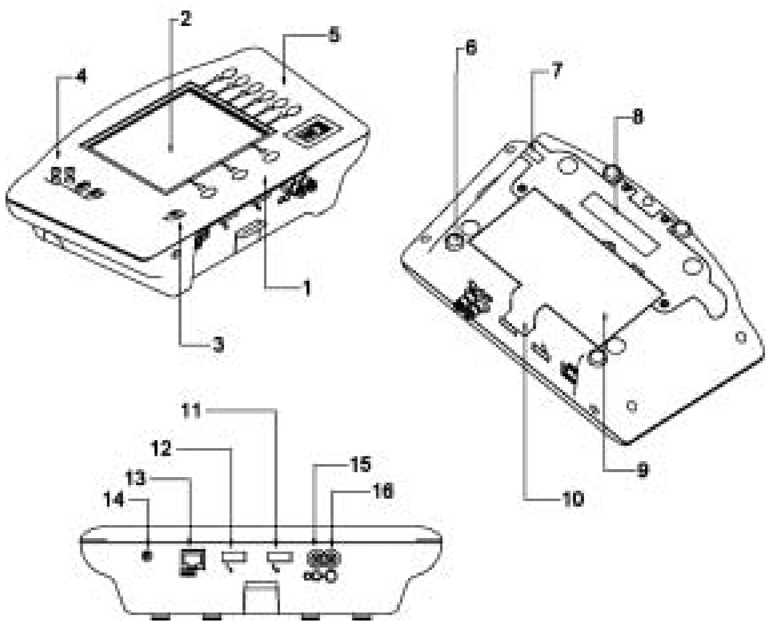
Accessories and Replacement Parts

	Item	Part/Model
	Combustion Supply Air thermocouple	3013003
	Portable printer kit	801994
	Computer cable	8940
	Hard side Carrying case	1319284
	CO replacement sensor	802014
	O_2 replacement sensor	802012
	NO replacement sensor	802007
	Water trap filters	801947
	Calibration Kit O_2 (N_2 gas) and CO	802003
	Calibration Kit CO	801999
	Calibration Kit NO	801937
	Replacement bottled gas, CO (requires Cal. Kit)	801941
	Replacement bottled gas, NO (requires Cal. Kit)	801930
	Replacement bottled gas, N_2 (requires Cal. Kit)	801980
	Bottled gas, CO with H_2 (requires Cal. Kit)	801942

Chapter 3

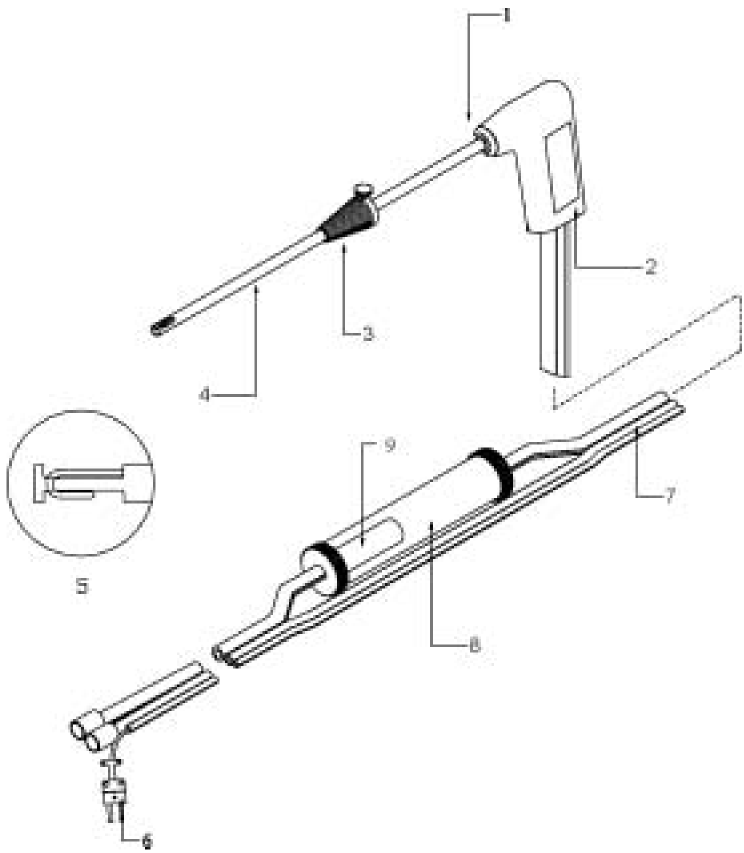
Component Identification

Key components of the CA-CALC™ combustion analyzer and sampling probe are identified in Figures 1 and 2, and under section headings in the text that follows.



1. Bottom buttons	9. Battery cover
2. LCD display	10. Battery cover tab
3. On-Off button	11. Port for *flue gas* thermocouple
4. Control buttons	12. Port for *supply air* thermocouple
5. Icon buttons	13. RS232 serial port
6. Magnets	14. Power connection
7. Vent	15. Draft sample port
8. Sensor cover	16. Gas sample port

Figure 1: CA-CALC CA- 6203



1. Tube retaining fitting	6. Thermocouple connector
2. Probe handle	7. Flexible sample line
3. Position collar	8. Water Trap
4. Sample tube	9. Water trap filter
5. Probe tip with thermocouple	

Figure 2: CA-CALC Sampling Probe Components

The Gas Sensors

The CA-CALC CA-6203 uses three gas sensors for measuring oxygen (O_2), carbon monoxide (CO) and nitric oxide (NO). CO and NO sensors are capable of operating from two to three years. The O_2 sensor typically lasts one year. Best accuracy is obtained by routine user calibration (automatic for the O_2 sensor). Calibrated replacement CO and NO sensors are also available from the factory.

The Sampling Probe

Your combustion analyzer comes equipped with a sampling probe, depicted in Figure 2. A thermocouple extends to the end of the sampling tube for making flue temperature measurements. Two flexible sampling lines are used for gas sampling and draft measurement. The sampling tube is removable for cleaning.

Flue Probe Thermocouple

The flue temperature (TS) is measured using a Type K probe, which extends through the sampling tube to the probe tip. The thermocouple probe measures temperatures up to 1000 degrees C (1800 degrees F).

On-Board Temperature Measurement

Your CA-CALC analyzer uses an on-board temperature detector to provide the *Combustion Supply Air* (TA) temperature when no supply-air accessory probe is present.

Diaphragm Pump

The CA-CALC analyzer samples exhaust gases from the flue and delivers them to the electrochemical sensors using a diaphragm sampling pump. Typical pump life is 5000 hours.

Draft Sensor

A differential pressure transducer in the CA-CALC analyzer is used to measure draft pressure.

Water Trap

The water trap, shown in Figure 2, is used to remove moisture that collects in the sample tubing when combustion gases are sampled. The water trap has a two-chamber design with a particulate filter.

Optional Combustion Supply Air Thermocouple Probe

A measurement of the *Combustion Supply Air* (TA) temperature at the source can be made using an optional thermocouple accessory probe (TSI PN 3013003). This probe is connected to the supply air temperature port shown in Figure 1.

When a Supply Air temperature probe is not used, the supply air temperature is determined from the on-board temperature sensor.

Schematic Representation of CA-CALC

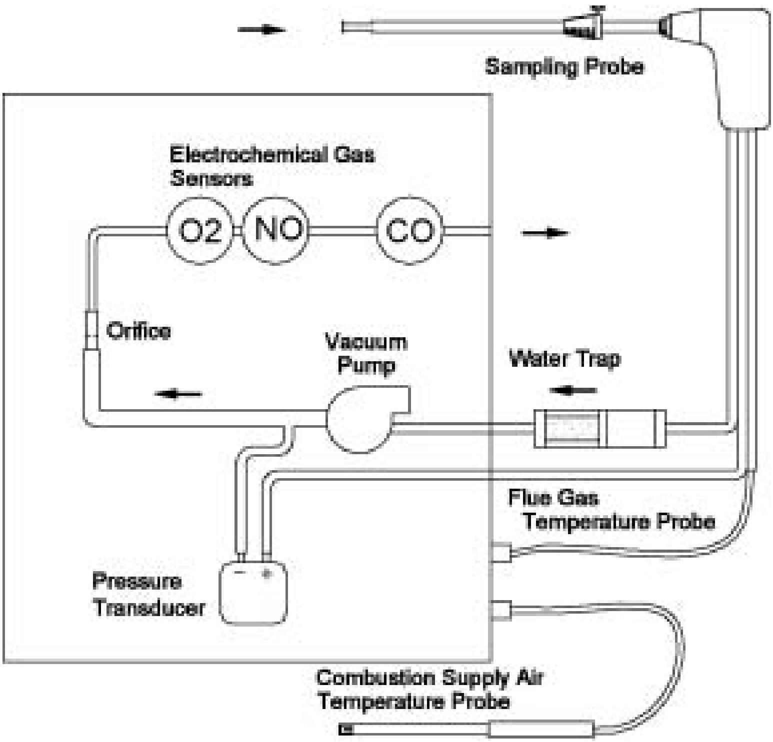


Figure 3. Schematic Representation of CA-CALC

Chapter 4

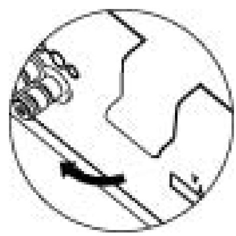
Getting Started

Supplying Power

The CA-CALC™ portable combustion analyzer operates using 4 C batteries or an AC adapter. Quality alkaline batteries enable the instrument to operate for at least 24 hours. Use of the plug-in AC adapter conserves battery life, and can be substituted for batteries.

Installing Batteries

Turn the combustion analyzer over and remove the battery cover by lifting up and out on the battery cover tab shown below. Remove the old batteries.



Note: It is not necessary to remove the battery holder when removing or installing batteries. Best results are obtained if the batteries opposite the contact springs are removed first.

Install four new C-cell batteries, noting the battery orientation depicted on the base of the battery holder. Install spring-side batteries first.

Connecting the Sampling Probe

The sampling probe depicted in Figure 2, is connected to the instrument by pushing the *brass* sample and *silver* draft connectors over the ports on the instrument. Refer to the figures below showing the proper connection of the probe tubes to the instrument sample ports. Note that the thermocouple connector can be inserted only one way. The thermocouple connector is oriented with the large spade to the right. ***Do not force the connector.***

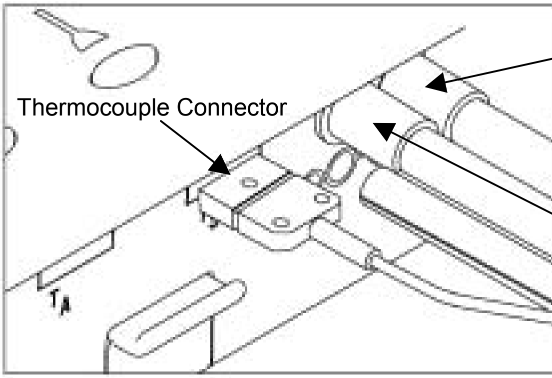


Figure 4: Sampling Probe Connections

Connecting the Optional Combustion Supply Air Temperature Probe

A type K thermocouple probe may be used to measure the temperature of the air supplied to the burner. Connect the optional supply air thermocouple (see “Accessories and Replacement Parts”) to the supply air thermocouple port depicted in Figure 1. The thermocouple connector can be inserted only one way—large spade to the right. ***Do not force the connector.***

When the optional Supply Air Temperature Probe is not used, supplied combustion air temperature is determined from the instrument temperature using an on-board sensor.

Connecting the Optional Portable Printer

Find the printer interface cable included with the optional portable printer. For the serial printer, connect the large 9-pin connector on the cable to mating connector on the printer. Connect the opposite end to the instrument’s RS232 communications and printer port. See Figure 1 for port location.

The printer and CA-CALC combustion analyzer have both been factory set for a baud rate of 1200. If baud rates are not matched, the printer will print random characters, question marks or asterisks. Printer settings are described in the printer manual, along with illustrations identifying the correct DIP-switch configuration. To set the CA-CALC baud rate and device settings, refer to Chapter 6, “MENU Options.”

Connecting to a Computer

Use the *optional* computer interface cable, Model 8940, to transfer (download) data serially from the CA-CALC analyzer to a computer. Your printer cable will not work for downloading to the computer. Connect the large 9-pin connector on the computer interface cable to the 9-pin serial connector on your computer. Connect the opposite end to the instrument's RS232 communications and printer port. See Figure 1 for port location. Set the baud rate of the CA-CALC to that of your computer, as described in Chapter 6, "MENU Options." The factory preset baud rate is 1200. Set the COMM option to COMP so serial data is formatted for output to the computer. The alternative is PRNTR, indicating output formatted for printer output. Press the PRINT button to send data to the computer.

Default Instrument Settings

The CA-CALC combustion analyzer uses a number of settings for presenting the data, performing calculations, and controlling instrument operation. These include the units displayed, the fuel used, the baud rate and so on. When shipped, these have factory preset *Default* settings. The default settings are listed below. Default settings can be changed as described in Chapter 6, "MENU Options."

Factory Default Settings (U.S.)

O_2	%
CO, CO_u	PPM (parts per million)
NO, NO_u	PPM (parts per million)
Draft units	Inches H_2O
Temp units	Degrees Fahrenheit
Excess Air	%EA
Effc./Loss basis	ASME
Effic./loss units	% (net)
Fuel parameters	C, H, H_2O, HHV, CO_2 max
Fuel list	U.S.
Fuel	Natural Gas
Baud Rate	1200
Sampling interval	1 second
Communications	Printer format

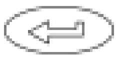
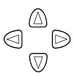
Factory Defaults (Non-U.S.)

Instruments sold outside the U.S. are often set up with *default* units and settings different than those identified in the table above. The defaults installed depend upon the letter designation present in the instrument's Model number. For example the " –D" in Model number CA-6203–D indicates that Germany is the destination country, and the instrument has appropriate units and settings installed. Refer to Appendix D for a table showing the *defaults* relating to the instrument designations. It is always possible to change the settings.

Chapter 5

Basic Operation

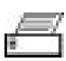
Buttons and Button Operations

	**ON-OFF** Control Button Turns the instrument **on** and **off**.
	The **ENTER** Control Button Press the **ENTER** button to execute a command, such as selecting a menu item.
	The **ESC** Control Button Used to return to the previous screen or cancel a process.
	**ARROW** Control Buttons Use the Left and Right arrow buttons to step between options. Use the Up and Down arrow buttons to change number values.

Button Indicators


Back Light ON/OFF


Pump ON/OFF

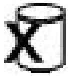

Print


Make draft measurement


Zero draft transducer


Select fuel

Bottom Buttons



Clear stored data

Review stored data

Save data

Startup

Remove the sampling probe from the flue or disconnect the sample tubing from the sampling port. Press the ON-OFF button. Refer to Figure 5 showing screens displayed during the *start up* sequence. If no errors are detected, the Main Data Display screen appears when the sequence is complete. Error codes are presented in Appendix A. ESC will bypass the error messages.

While the WARM screen is displayed, the O_2 sensor is automatically calibrated using ambient air, and the CO and NO sensors are zeroed. At the end of the WARM sequence (45 seconds), the pump stops and the draft sensor is zeroed.

The WARM sequence can be bypassed by pressing the ESC button. Do this if a new O_2 calibration and new zeros are not desired.

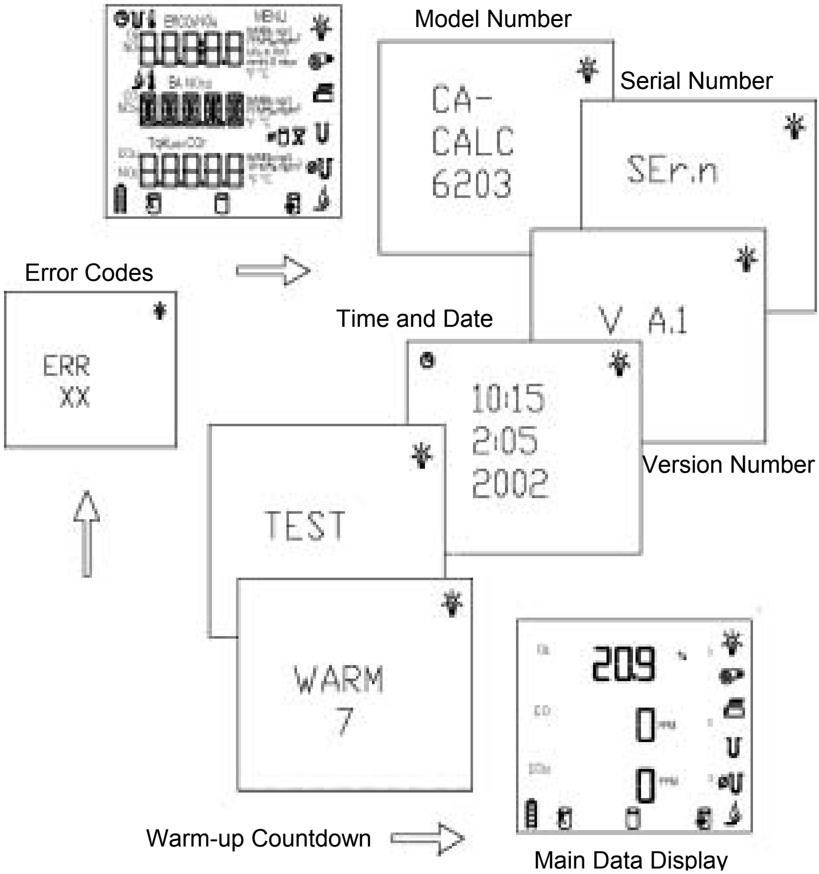


Figure 5. Startup Sequence

Characters and Display Icons

Refer to Figures 6 and 7 that follow. These identify the icons and characters found on the Model 6203 display. The display icons indicate measurements made, units, or functions performed. Some icons are not used with the Model CA-6203.

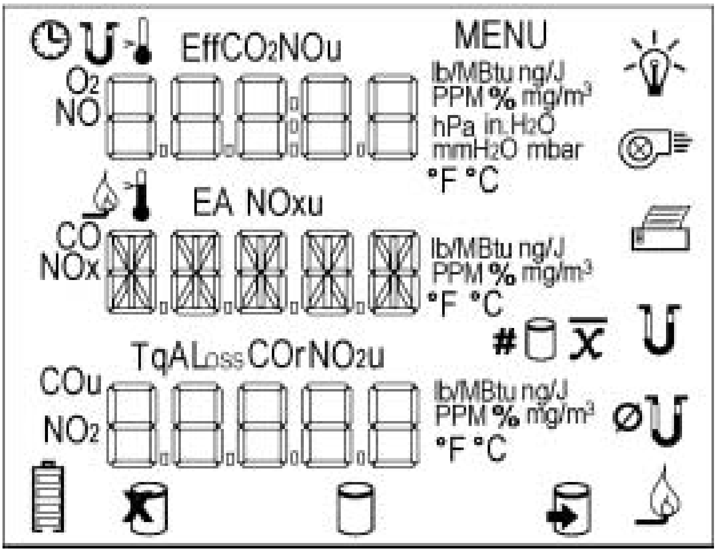


Figure 6. LCD Display Showing Icons

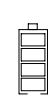
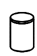
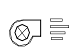
O_2	Oxygen	$\bar{x}$	Average of samples
CO	Carbon monoxide	#	Sample number
NO	Nitric oxide	NOu	NO undiluted
	Draft	COu	CO undiluted
	Supply air temperature	lb/MBtu	Pounds / million Btu
η	Efficiency (Siegert)	ng/J	Nano grams / Joule
Eff	Efficiency (ASME)	PPM	Parts per million
CO_2	Carbon Dioxide	mg/m_3	Milligrams / M^3
MENU	Menu	hPa	Hecto Pascals
	Fuel	$in.H_2O$	Inches of water
	Flue Temperature	%	Percent
λ	Lambda (excess air)	mmH_2o	Millimeters of water
EA	Excess air %	mbar	Millibars
°F	Degrees F.		Battery life
°C	Degrees C.		Clear data
NOx	NO_X		Review data
ΔT	Differential temp.		Save data
qA	Loss (Siegert)		Light on/off
Loss	Loss (ASME)		Pump on/off
COr	CO ratio		Printer
NOxu	NO_X undiluted		Zero draft sensor

Figure 7. LCD Display and Description of Icons

Measurements and Calculations

Oxygen Measurement

An O_2 electrochemical sensor measures oxygen concentration in the range of 0 to 25%. The O_2 measurement is also used to calculate the concentration of carbon dioxide (CO_2) in the exhaust, and is used in calculations of combustion efficiency and undiluted CO and NO concentrations.

Carbon Monoxide Measurement

Carbon monoxide is measured in the range of 0 to 5000 PPM.

CO_2 Measurement

%CO_2 calculated from the O_2 concentration in the flue. Refer to Appendix B for a description of the calculation.

NO Measurement

Nitric Oxide is measured in the range of 0 to 4000 PPM.

Flue/stack Temperature, TS

Flue temperature is measured with sampling probe.

Combustion Air Temperature, TA

Measurement of combustion air temperature is determined using the temperature probe accessory, TSI PN 3013003. In the absence of this probe, the combustion air temperature is assumed to be the instrument temperature, and determined from a temperature sensor in the instrument case.

ΔT, Temperature Difference

The flue/stack temperature minus the combustion air temperature.

Excess Air or Lambda (λ)

Calculations of these values are found in Appendix B.

Loss

ASME based heat loss from the hot gases exiting the flue/stack. Includes latent heat loss from the formation of water vapor. See Appendix B.

qA

Heat loss using the Siegert formula. See Appendix B.

Efficiency

Combustion efficiency, expressed as a percent. Calculated as 100 percent minus ASME heat loss (Loss) described earlier. Also see Appendix B.

ŋ Siegert Efficiency

Combustion efficiency, expressed as a percentage. Calculated as 100 percent minus qA. Also refer to Appendix B.

CO_u, Undiluted Carbon Monoxide Concentration

Calculation of the CO concentration, undiluted by excess air. This calculation uses a measurement of the O_2 concentration together with the CO measurement. Refer to Appendix B.

CO_r, CO Ratio

Ratio of CO to CO_2. See Appendix B.

NO_u, Undiluted Nitric Oxide Concentration

Calculation of the NO concentration, undiluted by excess air. This calculation requires a measurement of the O_2 concentration together with the NO measurement. Refer to Appendix B.

NO_x Concentration

NO_x is an expression of the total oxides of nitrogen in the flue gas stream. NO_x combines NO and the theoretical NO_2 concentration estimated at 5% of the NO concentration. NO_2 is not measured.

NO_{xu}, Undiluted Nitric Oxide concentration

Calculation of the NO_x concentration, undiluted by excess air. This calculation requires a measurement of the O_2 concentration and the measurement of the NO concentration. Refer to Appendix B.

Draft

Draft pressure is measured with the sampling probe inserted in the flue. The draft measurement is referenced to room pressure.

Data Display, Viewing Measurements and Calculations

Measurements and calculations are presented in the Data Display screens. The Data Displays appear once the Startup sequence is complete (illustrated earlier in Figure 5).

Data appears on three lines, with an icon indicating the measurement or calculation presented above or to the left of the data. Units are presented on the right side.

Data are viewed using the ARROW buttons, in groups of two or three. The table below shows the order of the data displayed together in vertical columns. Use the right ARROW button to scroll through the data as shown below.

Order of displayed measurements and calculations.

ARROW button →

O2	Draft	Combustion Air Temperature	Efficiency	CO_2	NO	NO_u
CO	Fuel Type	Flue Temperature	Excess Air	CO	NO_x	NO_{xu}
CO_u		Differential Temperature	Loss	CO_r		

Error Indications

A series of ERR (error) codes indicate a problem with instrument operation. Often the problem has a simple remedy. If the ERR code persists, contact the factory. Press ESC to bypass the error message.

Error codes are described in Appendix A.

Using the Sampling Probe

Gas and Temperature Measurements

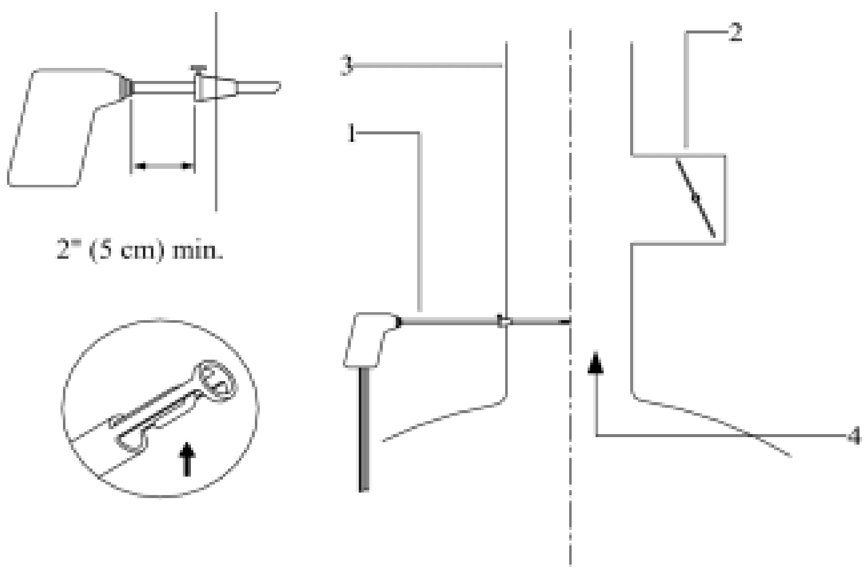
Connect the sampling probe to the CA-CALC as described in Chapter 4.

Place the Sampling probe through a hole in the exhaust flue, following recommendations presented below. Placement of the probe is important and certain considerations must be given when choosing a sampling location.

To ensure that the gas measurements are not diluted or cooled by outside air, place the probe before any draft damper or regulator as illustrated in Figure 8. Tilt the probe tip up slightly so vapor condensing in the sampling tube does not run back to the probe tip and cool the thermocouple tip.

The sampling probe tip should be placed at the point of highest exhaust gas temperature. This means at the base of the flue, before heat is lost to the flue sidewalls, and towards the center, especially for small ducts. If the flue/stack gas temperature is underestimated, the operating efficiency will be overstated. When an economizer or air heater is used, the flue/stack temperature is measured after these devices

Important: Orient the sampling tube to ensure that the thermocouple tip is exposed directly to exhaust flow (see Figure 8 below).



1. Sampling probe
2. Draft regulator
3. Exhaust flue
4. Hot exhaust gases

Figure 8: Sampling Probe Location

!	Cautions
	Hot probe! When removed, the sampling probe will be extremely hot. Avoid touching the probe tip, and avoid placing the probe on or near plastic materials such as the instrument case. These will melt. Maintain a minimum 2" (5 cm) clearance between the probe handle and position collar when the probe is mounted in flue. **Empty Water Trap!** Watch the water trap and empty it frequently to prevent the possibility of flooding the instrument. See Chapter 8 for instructions.

Making a Draft Measurement

Use the DRAFT button to the right of the DRAFT button indicator to make draft measurements. When the DRAFT button is pressed, the sampling pump turns off and the draft measurement is displayed and updated each second.

Zeroing the Draft Sensor

For the most accurate draft reading, the draft sensor must be zeroed prior to the draft measurement. To zero the draft sensor, remove the sampling probe from the flue, or separate the sampling tube from the draft port. Press the ZERO draft button. When ZERO is displayed, the draft sensor is zeroed.

Saving Draft

Whenever a sample is saved using the SAVE DATA button, a draft reading is taken. For this to occur, the pump is automatically turned off and a few seconds are allowed for the draft reading to stabilize. Draft is recorded at the end of the data-sampling interval.

Printing to the Portable Printer and to a Computer

Printing to the Portable Printer

Instrument data can be output to the optional portable printer through the RS232 serial port. Refer to "Connecting the Optional Portable Printer" in Chapter 4.

To print the information on the Data Display, press the PRINT button, to the right of the print button icon. The printer responds immediately, producing a printout of the current data. An example of this printout is shown in Figure 9.

Saved data can be printed too. Hold the Print button down until a countdown from three (3) begins. Release the button at zero (0), and **all** saved data is printed.

Printing individual saved data samples is described in the next section, "Data Saving Functions."

Printing to a Computer

Use the PRINT button to output data to a computer as well as to the portable printer. Refer to "Connecting to a Computer" in Chapter 4.

Data transferred to a computer is the same as that output to a printer (see Figure 9); however, it is formatted differently and uses the Windows® character set rather than DOS characters. You will need to set appropriate COMM MENU option before sending data to the computer. Refer to the Chapter 6, "MENU Options."

Data can be downloaded to a terminal emulator program such as the **HyperTerminal**, which accompanies the Windows® operating system program. Look for **HyperTerminal** in the **Accessories** folder. In **HyperTerminal**, use the **Capture Text** option from the **Transfer** menu for recording instrument data.

Your instrument comes configured with the following communications protocol.

Communications Protocol

Baud rate	1200 (default)
Data bits	8
Parity	None
Stop bit	1
Flow	None

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```
---------------------------------
MODEL: 6203
SERIAL:
-----------------------------------
Current Data
----------------------------------
DATE: 01/01/99
TIME: 15:00:18
Fuel: Nat Gas

Fuel Parameters:
C: 75
H: 25
CO2MX: 11.8
KBTU: 23.8
H2O: 0
O2          6.0
CO          5 PPM
NO:         0 PPM
COu         7 PPM
COr         NA
NO          40 PPM
NOu         56 PPM
NOx         42 PPM
TA          70 °F
TS          300 °F
Draft       0.01 inH2O
CO2         8.4 %
Lambda      OVER
Effc        84%
LOSS        16%
```

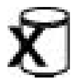
Figure 9: Example Printout

Handling Data

Saving Data 

Up to one hundred (100) separate measurements can be made and saved to the instrument memory as data *Samples*. Press the SAVE DATA button located below the SAVE DATA icon at the bottom of the display. When SAVE DATA is pressed, measurements are sampled and averaged over the interval set in the INT.SA MENU option described in Chapter 6. As data is sampled, the sample number is displayed, and the save data icon blinks.

Note: *The pump turns off while the draft is measured and saved.*

CLEAR Data 

While in the Data Display screen, press and hold the CLEAR DATA button for three (3) seconds to erase all saved data from the instrument memory. The button must be released when zero is displayed. If the button is held longer than three (3) seconds, nothing is cleared.

To clear the last Sample only, release the CLEAR data button before the end of the countdown, during 3, 2, or 1.

REVIEW Data Samples 

Press the REVIEW DATA button briefly to recall saved Samples. The number of the last Sample appears. Select the specific data Sample you wish to view using the ARROW buttons and press ENTER. When the Sample number (#) is displayed, use the ARROW buttons to review the different measurements.

Printing

To print individual saved Samples, press the PRINT button while the saved Sample is shown. To print **all** saved Samples, hold the PRINT button down until a countdown from three (3) begins. Release the button at zero, (0) and all saved Samples are printed.

Averaging Saved Samples 

To average the last three (3) saved Samples, press and ***hold*** the REVIEW DATA for a couple of seconds. The screen blanks during this interval. When averaged, the X-bar icon appears indicating that the data presented is an average of the Samples. Data averaging works only from the main Data Display screen.

MENU Options

The Series 6203 CA-CALC instrument has a variety of user selectable parameters, available as MENU options. The user-selectable MENU options are shown in the schematic below. Press ENTER to access the MENU options from the Main Data Display screen. View the MENU options by using the ARROW buttons. Once the screen of interest is displayed, press the ENTER button again to choose the MENU option. Refer to Figure 14, which shows the MENU options.

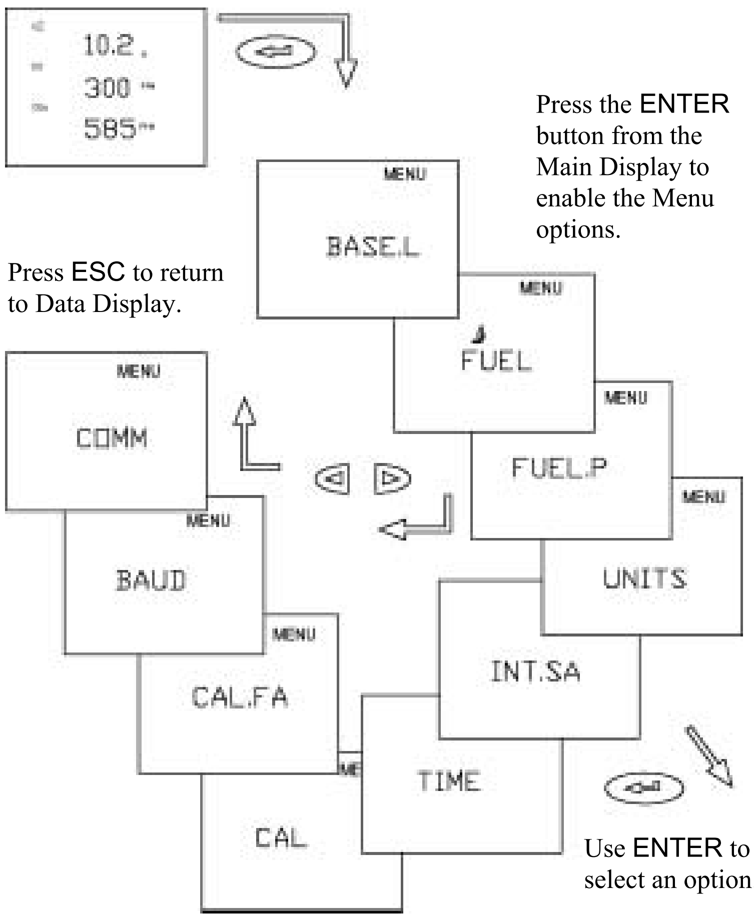


Figure 10. Menu Option

BASE.L MENU—Option Update Sensor Baselines

Use the BASE.L MENU option to update the zero concentration baselines for your electrochemical sensors. Make sure the sampling probe is removed from the flue or disconnected from the instrument during zeroing. If ESC is pressed before zeroing is complete, previous baseline values are restored.

FUEL MENU Option—Select Fuel

Use the FUEL option to select from seven preset U.S. fuels or six Siegert fuels, or select the USER fuel. The fuels parameter list presented (U.S. or Siegert), is determined by the selection, LOSS or qA, respectively, made from the UNITS MENU option

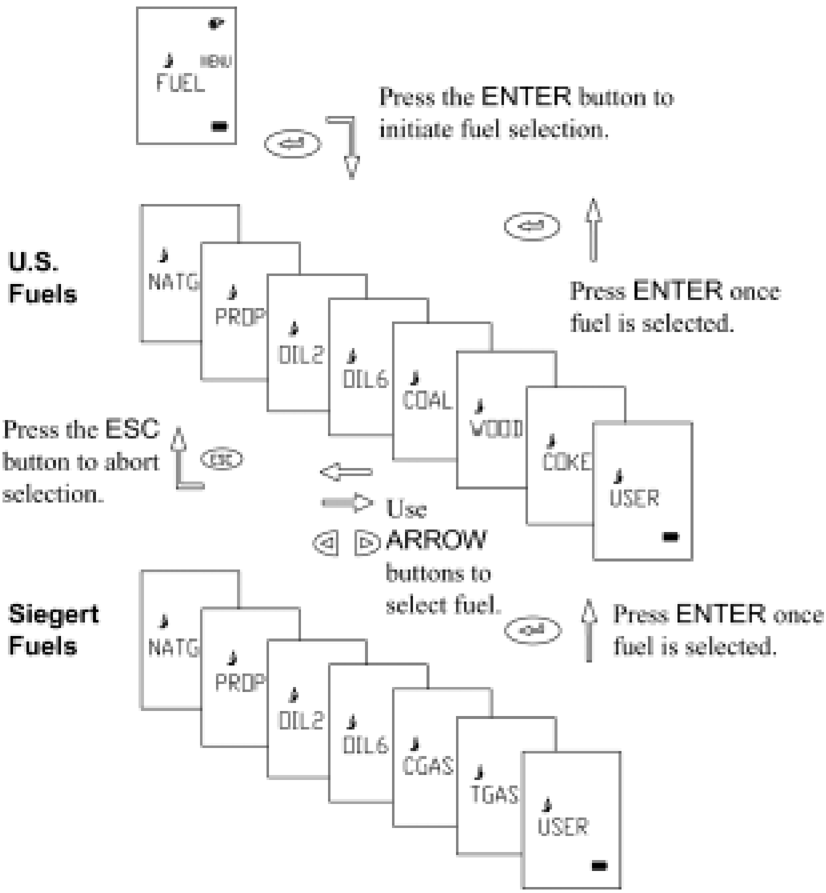


Figure 11. FUEL Options

FP MENU Option—Fuel Parameters

See later.

UNITS MENU Option (changing units)

It is possible to display data in different measurement units as indicated in the table below.

Optional Units

Measurement	UNIT Options
TEMP (temperature)	Degrees F, Degrees C
GAS (for CO, NO, NO_x concentrations)	PPM, mg/m^3, lb/Mbtu, ng/J
PRESS (draft)	In.H_2O, mbar, hPa, mmH_2O
LOSS (flue gas heat loss)	Loss (ASME), qA (Siegert)
Excess Air	% (EA), λ (Lambda)
DECIMI	Periods or commas for printing
DATE	Date format, MM/DD or DD/MM for printing

To change units, press the ENTER key from the Data Display screen.

Using the ARROW buttons, find UNITS from the MENU options and press ENTER. Continue using the ARROW buttons to find the measurement for which units are to be changed. Use the up and down ARROW buttons to select the desired unit and press ENTER.

Use ESC when complete to return to the Data Display screen.

INT.SA MENU Option—Sampling Interval for Saving Data

This option enables you to change the sampling interval over which data is averaged and saved. Select this option using the ENTER button. Use the up and down ARROW buttons to choose the sampling interval from the following: 1, 5, 10, 15, 20, 25, and 30 seconds. Press ENTER to select the interval.

Use the SAVE DATA button to save data over the sampling interval.

TIME MENU Option—Set Time and Date for Printout

Press the ENTER button when the TIME MENU item is displayed. Use the ARROW buttons to select the field to be changed. The field will blink as it is changed with the right and left ARROW button. To change the value, use the up and down ARROW buttons. Press ENTER to install the new value. Press ESC to abort and return to the previous screen. Use the DATE option in UNITS to change the month/day presentation.

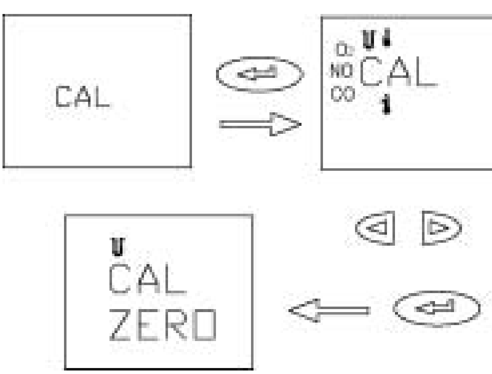
Time and Date fields	HR:MN MM.DD 2 0 Y Y	*or*	HR:MN DD.MM 2 0 Y Y

CALIB MENU Option (select sensor for calibration)

The CALIB MENU option is used for performing calibrations of the on-board sensors. When this option is chosen using the ENTER key, characters and icons associated with the installed sensor will be displayed, one at a time. Press an ARROW button and scroll through the options until the desired sensor for calibration appears. Press ENTER to begin the calibration process.

Example, Draft calibration initiated.

Icons below appear one at a time. See Chapter 5 for a description of icons.



Use ARROW buttons to choose sensor for calibration. Press ENTER to initiate the calibration.

O_2 Gas Sensor Calibration

The Oxygen (O_2) sensor is *SPAN* calibrated in room air whenever the instrument is turned on and allowed to complete the Startup sequence. Using the BASE.L MENU option also spans the O_2 sensor. Additional calibration is generally not required.

Calibrating the O_2 sensor is done to determine a new *zero* value (no O_2 present) for the sensor. This is done if a drift in the sensor zero value is suspected.

Select CALIB from the MENU options using the ENTER button. Select the O_2 icon from the icons displayed using an ARROW button, and press ENTER. Attach the zero gas (nitrogen, N_2) to the sampling probe as described in Chapter 7, "Setup for Gas Calibration." When ready, press ENTER to begin the zero calibration. Once complete, the SPAN calibration screen appears. The O_2 concentration can be adjusted using the ARROW buttons. If room air is used as the calibration gas, use the value displayed initially, 20.9%. Press the ENTER button to begin the SPAN calibration. Once complete, use the ESC button to return to the Data Display screen.

Calibration of the CO (hydrogen compensated) Sensor

The presence of hydrogen gas (H_2) produces a false signal on electrochemical CO sensors. The CO sensor in your CA-CALC has a second internal sensor that detects the H_2 concentration and enables the instrument software to subtract the error caused by the presence of hydrogen gas.

You can elect to calibrate using both the CO and H_2, or calibrate with CO only. In the second case the sensor retains the previous correction for H_2.

Calibration Steps

From the MENU screen select the CALIB option. Press ENTER. Use the ARROW buttons to select the CO icon and press ENTER. Sampling from the room air, press ENTER to perform the ZERO calibration. When complete, connect your CO calibration gas as depicted in Chapter 7, "Setup for Gas Calibration." Use the ARROW buttons and adjust the CO gas calibration number to match the concentration of your gas bottle. Press ENTER to initiate the CO calibration. Once complete, connect your calibration gas bottle containing both carbon monoxide and hydrogen (see note below). Use the ARROW buttons to adjust to the CO bottle concentration under the SPAN.CO heading, then press ENTER. Under the SPAN.H_2 heading adjust the number using the ARROW buttons to match the hydrogen concentration. Press ENTER to start the calibration.

Note: It is possible to do only the CO part of the calibration. To bypass the calibration using the combined CO and H_2 bottle, press the ESC key after the CO portion of the calibration is complete.

!	CAUTION
	Toxic Gases! Familiarize yourself with the toxic properties of the calibration gases by reading the supplied Material Safety Data Sheets (MSDS) accompanying the gas cylinders. Do **not** perform calibrations in a confined space. Make sure calibrations are performed in an area with proper ventilation, or under an exhaust hood.

Draft Calibration

Span calibration of the draft sensor is normally not required. The draft sensor should be routinely zeroed, however, using the DRAFT ZERO button. This is especially important prior to making measurements at low draft pressures. When zeroing, make sure the sample probe is disconnected or that the probe is not in the flue.

Calibration Procedure

Required: An apparatus to provide stable calibration pressures of between *plus* 10–30 inches of water (25–75 hPa), and stable calibration pressures of between *minus* 10–30 inches of water (minus 25–75 hPa).

From the Main Data Display screen, press the Enter key. Select CALIB from the MENU options presented using the ENTER button. Select the draft icon from the icons displayed using an ARROW button and press ENTER. Begin the calibration by pressing the ENTER button to perform a ZERO calibration. When the zero is complete, use the arrow buttons to adjust your positive supply reference pressure. Connect your positive pressure to the draft port and press ENTER. Once the positive calibration is complete, connect your negative pressure reference to the draft port. Adjust the negative calibration pressure value using the ARROW buttons and press ENTER. Once the calibration is complete, use the ESC button to return to the main Data Display screen.

Temperature Calibration

Calibration of the flue and ambient thermocouple sensors is not recommended. Thermocouples are very repeatable, and even if replacement of a sampling probe is required, or a combustion air temperature probe is purchased as an accessory, it is unnecessary to calibrate it.

Thermocouple accuracy can be improved for a specific temperature range if a calibration is preformed in that range. You will need to provide an accurate temperature reference. Refer to the steps below if calibration of a thermocouple is desired.

Calibration Procedure

Select the CALIB MENU option. Select the appropriate thermometer icon in the CALIB screen using the ARROW buttons. Install your sampling probe thermocouple or accessory thermocouple at the appropriate TS or TA connector. Press ENTER and set the calibration temperature to that of your supplied standard. Bring your thermocouple to the entered temperature and initiate the calibration by pressing ENTER.

CAL.FA MENU Option—Setting the Calibration Factor for a Replacement Gas Sensor

Install your new sensor as described in Chapter 8, "Maintenance and Troubleshooting."

CO Sensor

Find the *Calibration Factor* sheet. Use the MENU option CAL.FA and press ENTER. Change the AVAL, BVAL, CVAL and DVAL to values on the calibration sheet using the up and down ARROW buttons. Follow each change by pressing the ENTER button. Figure 12 shows the steps. Pressing ESC takes you out of the entry sequence but keeps values which were saved with the ENTER button.

Once complete, review entered values by stepping through the calibration factor screens using ENTER.

Use the ARROW buttons to find the CAL.FA MENU option.
Press the ENTER button.

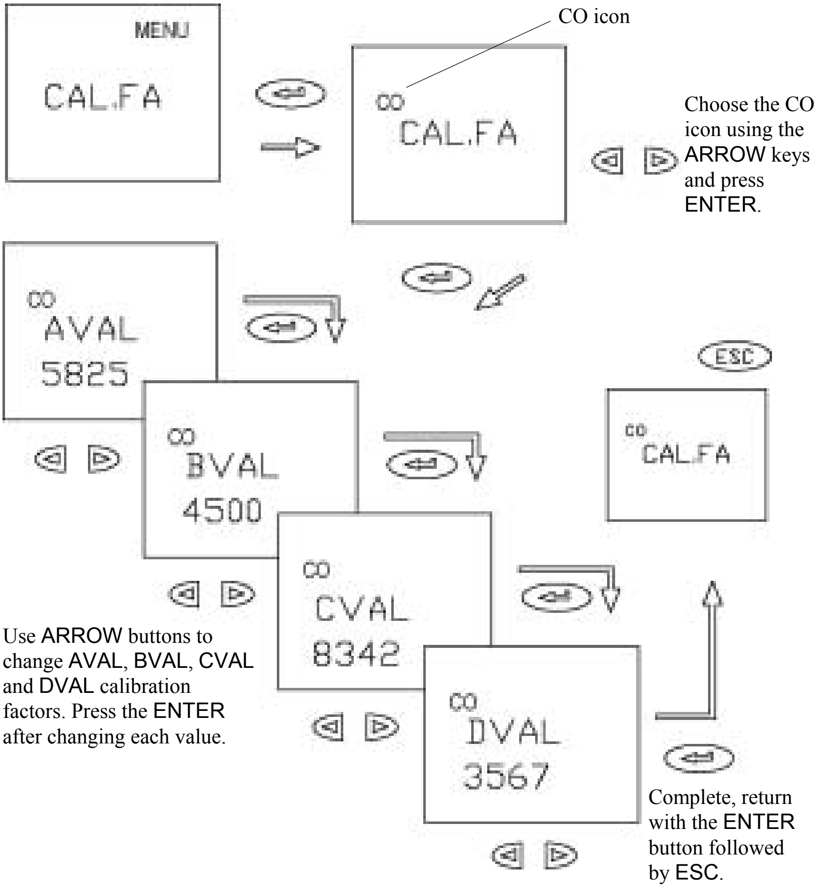


Figure 12. Setting the Calibration Factor

NO Sensor

After installing your new sensor, as described in Chapter 8, "Maintenance and Troubleshooting," find the NO calibration factor sheet. Use the ARROW buttons in the MENU option and find CAL.FA. Press ENTER. Use the ARROW buttons and select the NO sensor icon, press ENTER. Adjust the number displayed to match the value on the calibration sheet. Press ENTER to finish. Press the ESC button to return to the Data Display.

BAUD Rate MENU Option

Baud rate can be set to match your computer or portable printer. Your instrument is delivered with a default baud rate of 1200 to match the printer.

Baud rate values are displayed in the BAUD rate MENU option divided by 1000. The following baud rates can be set. 1.2 (1200), 2.4 (2400), 4.8 (4800), 9.6 (9600), 19.2 (19200).

To set the baud rate, select BAUD from the MENU option using the ENTER button. Step through the BAUD rates using the ARROW buttons and choose the desired value with the ENTER button. Use the ESC button to return.

COMM MENU Option—Set the Output Communications Device

Your CA-CALC transfers current or saved data to a serial printer or computer. The COMM MENU option is used to select the device that you want to communicate with. Failure to select the correct device may cause incorrect characters to appear on your printout or computer file.

COMM options are COMP and PRNTR, for computer and printer, respectively. Set the device COMM from the MENU options using the ENTER button. Use the ARROW buttons and choose the desired option followed by pressing the ENTER button. Use the ESC button to return.

FP MENU Option—Fuel Parameters

U.S. Fuel Parameters

Note: For U.S. fuels and fuel parameters to be displayed, the fuel heat LOSS selection must be set to Loss, not qA. Refer to the section “Changing Units” in this chapter.

For calculations of flue losses, maximum %CO_2, fuel composition and fuel heat content are used. These are the Fuel Parameters. In your CA-CALC, U.S. fuel parameters are the carbon and hydrogen content, moisture content, sulfur content, and maximum %CO_2, CO2MX.

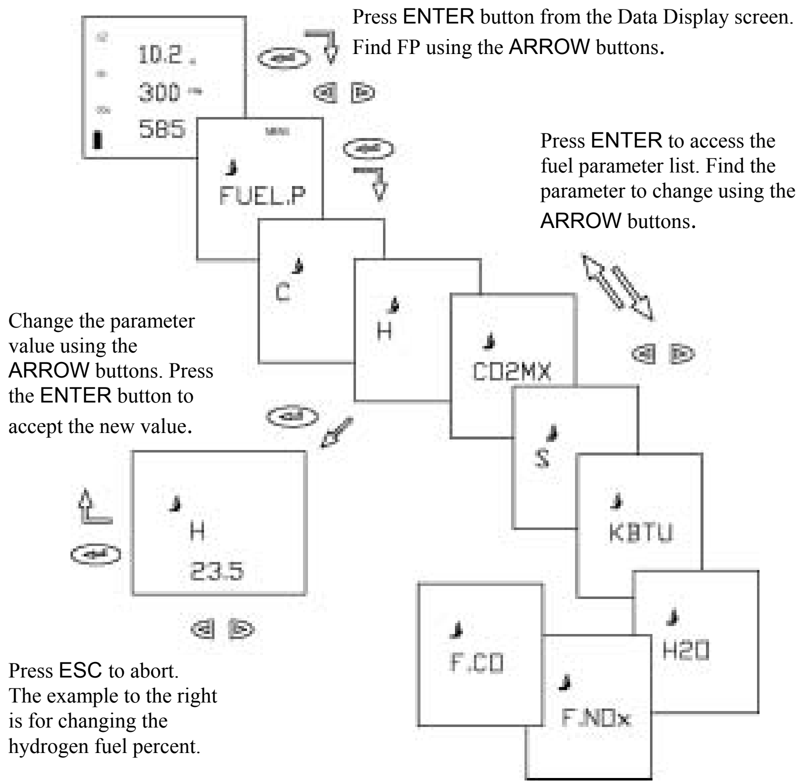


Figure 13. Fuel Parameters for U.S. Fuels.

Refer to the diagrams below (Figures 24 and 25), for information on viewing and changing fuel parameters.

Your CA-CALC has parameters for seven common U.S. fuels in instrument memory. Fuel parameters for these fuels can be changed, if you know, for example, that your fuel has a different composition than that stored. The instrument fuel parameters values are presented in Appendix B, with additional technical information.

Fuel Parameter	**Description**
C	% carbon by weight
H	% hydrogen by weight
H_2O	% moisture content by weight
S	% sulfur by weight
CO2MX	CO_2 maximum %
KBTU	Heating value in kiloBTUs, (BTU/1000)
F.CO F.NOx	Emission Factors

FP Fuel Parameters for Siegert Calculation—Siegert Fuel Parameters

Note: For Siegert fuels and fuel parameters to be displayed, the fuel heat LOSS selection must be set to qA not LOSS. Refer to the section “Changing Units” in Chapter 6.

The Siegert value for flue loss, given the designation qA, is used widely in Europe. Two coefficients are used in the Siegert formula for flue loss, derived from typical fuel compositions. These are given the designations, A2 and B.

Fuel Parameter	**Description**
A2	Siegert factor, fuel specific
B	Siegert factor, fuel specific
CO2MX	CO_2 maximum %
F.CO F.NOx	Emission Factors

The default Siegert coefficient values in your CA-CALC, are those used in Germany. Siegert coefficients used in other countries may be different, reflecting differences in local fuel compositions.

Figure 25 diagrams the steps in changing the Siegert fuel parameters.

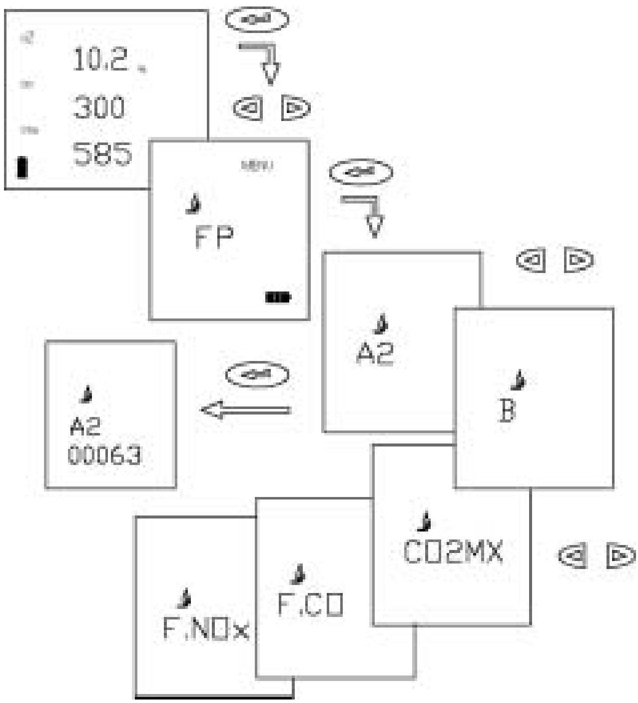


Figure 14. Changing Fuel Parameters for Siegert Fuels

Chapter 7

Setup for Gas Calibration

The Calibration Setups

Note: To perform your gas sensor calibration, you will also need to refer back to Chapter 6, and the section "CALIB MENU Option."

CO, NO and O_2 gas sensors can be calibrated periodically to maintain the best accuracy. Gas sensors do drift over time, depending upon the operating environment and gas exposure history. CO and NO gas sensors can lose sensitivity by as much as by 10% per year. Since O_2 sensors are calibrated in room air, loss in sensitivity poses no real problem. However, a drift in the *zero* (no O_2 present) can occur, impacting the accuracy when measuring low O_2 concentrations.

With the proper equipment, such as that shown in the figures below, it is easy to calibrate your CA-CALC™ analyzer gas sensors. However, if you wish, you may also return your instrument to TSI for a new *factory* calibration.

The equipment needed to calibrate individual gas sensors can be purchased from TSI as calibration kits. Model numbers for these kits are found in Chapter 2, "Unpacking." You may also elect to put together your own calibration system. Two calibration setups are presented in Figures 26 and 27. A brief discussion of these calibration setups is presented in the following section.

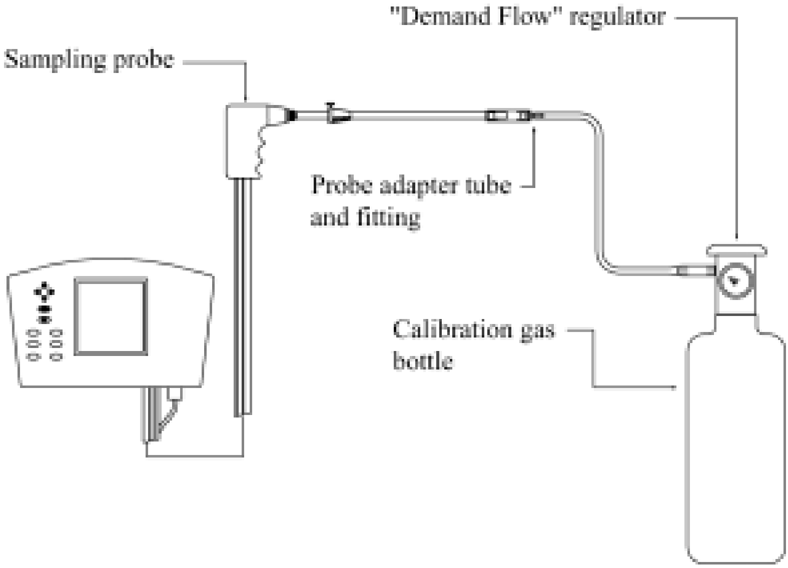


Figure 15. Calibration with TSI Calibration Kit

A TSI supplied calibration kit (Figure 15) uses a *demand flow* regulator to supply gas to the CA-CALC analyzer in response to the draw of the instrument sampling the pump. If a conventional regulator and valve are used (Figure 16), the setup requires a tee to a bleed-off extra gas. This prevents a forced flow at the instrument inlet. The bead-type flow meter depicted in the figure is used to verify there is extra flow (.5 to 2 LPM recommended). Extra flow is required to prevent room air from being drawn in, diluting the sample.

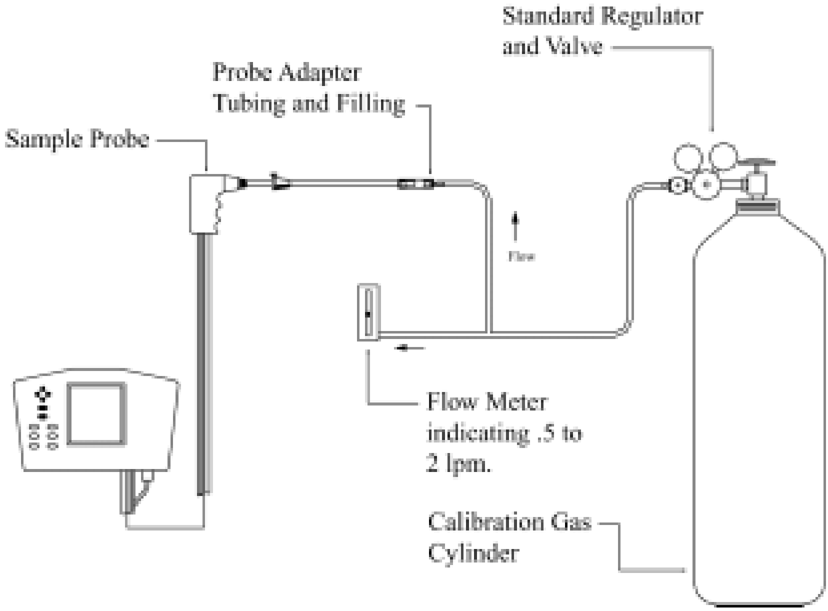


Figure 16. Alternative Calibration Setup

Chapter 8

Maintenance and Troubleshooting

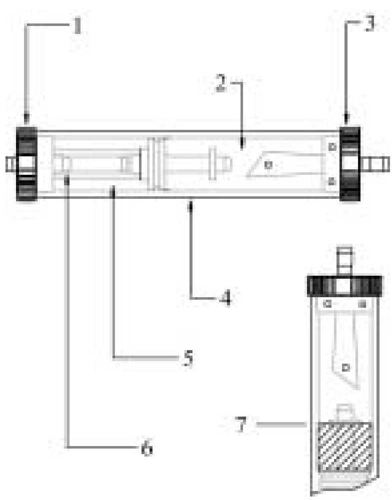
Emptying Water Trap

Refer back to Figure 2 showing the water trap in the sample line and to Figure 17 below. Liquid water forms in the first chamber of the water trap as gases are sampled from the flue. The water trap is designed so even when shaken, or when its orientation is changed, water does not pass to the second chamber. The water level must remain below the level depicted in the figure, however.

To empty the water trap:

1. First separate it from the sampling tube by pulling the tube ends off the barbs on the end caps.
2. Remove the probe side end cap by pulling outward with a twisting motion.
3. Pour out the water and replace the end cap. Re-install the trap.

Important: Make sure the water trap is oriented so that end-cap 1 below is toward the instrument.



1. Instrument side end-cap
2. First chamber
3. Probe side end-cap
4. Polycarbonate trap body
5. Second chamber
6. Plastic filter
7. Maximum water level

Figure 17: In-line Water Trap

Changing the Water Trap Filter

Identify the water trap filter (refer to Figure 17). This filter is designed to remove soot particles before they contaminate the instrument. The filter can be removed for cleaning or replacement by following these steps:

1. Remove the instrument side end cap by pulling it out with a twisting motion.
2. Grasp the filter using a needle-nose pliers and pull it out.
3. To clean the filter, remove the bulk of the soot by tapping the filter. The soot may be removed by rinsing with water or isopropyl alcohol. The effectiveness of the rinse depends on the soot composition—is it dry or oily. Avoid rubbing, which may drive contaminates into the filter causing permanent plugging.
4. Whether cleaned or replaced, install the filter by pushing it over the stub in the filter body, then replace the end cap.

Cleaning the Sample Probe

Cleaning may be necessary in high-soot environments. Soot accumulates in the steel sampling tube and sampling line and over time may contribute to a blocked flow path.

1. Remove the water trap by separating the sample tube from the tube stub on each end of the trap.
2. Rinse the tubing, allowing the water to drain from the probe end. When the water is clear, discontinue the rinse. Orient the probe and tubing so excess water drains from the sample lines.
3. Allow adequate time for the interior of the probe to dry. Replace the water trap making sure the water trap is oriented properly. The filter must be toward the instrument.

Lithium Battery Replacement

The lithium battery supports measurement data saved in memory. Typical battery life is three years. An ERR code 63 indicates a low lithium battery. To replace the battery open the battery compartment and remove the C-cell battery holder. Find the ½ AA lithium battery after removing the white foam battery retainer. Replace the battery in the correct plus/minus orientation. Replace the white foam retainer, C-cell holder and battery cover.

Replacing a Gas Sensor

Remove the sensor cover identified in Figure 1 (8). From the left side, pry back the black rubber sensor cups to expose the gas sensors. Do **not** separate any fittings connected to the rubber cups. To remove a senor, grasp the sensor and lift straight up. When installing a sensor, note the orientation of the sensor pins at the bottom of the sensor and the orientation of the receptacles in the instrument. Tilt the sensor, aligning the base pin with the base receptacle and the right pin with the right receptacle. Once aligned, stand the sensor up and push in. When installed properly, the sensor will not twist.

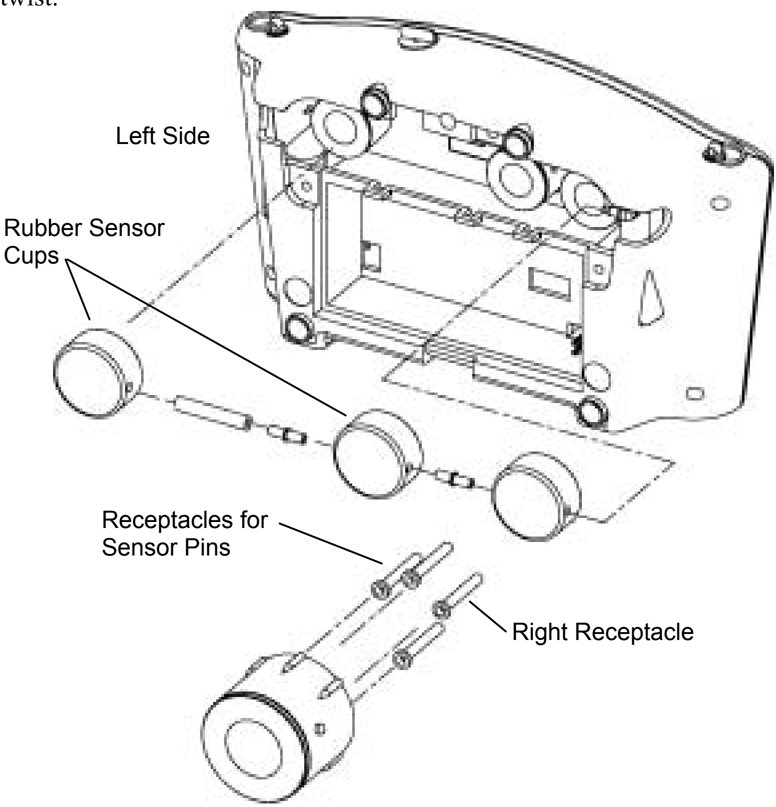


Figure 18. Sensor and Sensor Cup Assembly

Appendix A

Error Codes

7) Error in logged data.
9) Can't save data to EEPROM.
10) Fuel type changed to Natural Gas (fuel and LOSS type mismatch)
11) An invalid fuel parameter was corrected.
12) Model number checksum error.
13) TA thermocouple checksum error.
14) TS thermocouple checksum error.
15) Draft sensor checksum error.
16) A/D calibration checksum error.
17) CO sensor checksum error.
18) O2 sensor checksum error.
19) NO sensor checksum error.
50) O2 zero voltage out of range.
51) CO zero voltage out of range.
52) COAUX zero voltage out of range.
53) NO zero voltage out of range.
54) TA sensor zero voltage out of range.
55) TS sensor zero voltage out of range.
56) Instrument temperature out of range.
57) Draft zero voltage out of range.
58) Draft gain calibration out of range.
59) O2 span (baseline) voltage out of range.
60) Error in CO sensor-present test.
61) Error in COAUX sensor-present test.
62) Error in NO sensor-present test.
63) Lithium battery voltage is low.
64) TA sensor gain factor out of range.
65) TS sensor gain factor out of range.
66) NO sensor gain factor out of range.
67) CO sensor A_VALUE out of range.
68) CO sensor B_VALUE out of range.
69) CO sensor C_VALUE out of range.
70) CO sensor D_VALUE out of range.
71) Instrument temperature sensor offset factor out of range.
72) AtoD converter gain factor out of range.
73) Pump vacuum out of range.
74) or higher: Internal program error-contact TSI.

Appendix B

Calculations

Undiluted Gas Concentration Calculation (CO_u, NO_u, NO_{xu})

$$GASundiluted = GASmeasured\ (PPM) x \frac{20.9}{20.9 - 0_2\ measured}$$

Excess Air Calculation

$$\%\ Excess\ Air\ = \frac{\%O_2 - \%CO/2}{20.9 - (\%O_2 - \%CO/2)} \times 100$$

Another expression of excess is λ (Greek letter Lambda) also used. The relationship between % EA and Lambda is shown below:

$$\lambda = \frac{\%EA}{100} + 1$$

Calculating Combustion Efficiency for U.S. Fuels

Net Combustion Efficiency (Effic Net)

$$\%\ Combustion\ Efficiency = 100 - \frac{fuel\ heat\ losses}{fuel\ heating\ value} \times 100$$

flue heat losses = heat loss from dry gas
+ heat loss due to moisture from burning hydrogen
+ heat loss due to moisture in fuel
+ heat loss from the formation of CO

Heat losses are per unit weight of fuel
Fuel heating value: HHV or LHV (high heating and low heating, respectively).

This basic method is described in the ASME (American Society of Mechanical Engineers) Power Test Code 4.1. Note, however, the calculation of *Combustion Efficiency* considers only flue losses. In ASME PTC 4.1 losses from other sources (e.g., radiation, convection) are also considered.

Fuel Parameters for U.S. Fuels

Fuel Parameters	NATG, Methane	PROP, Propane	OIL2, Oil #2	OIL6, Oil #6	COAL	WOOD	COKE
%C (carbon)	75	81.8	85.84	87.49	94.5	51.8	98.2
%H (hydrogen)	25	18.18	12.46	9.92	5.2	6.3	1.5
KBTU/lb HHV	23800	21600	19500	18300	13400	9100	16.5
CO_2 max	11.8	13.8	15.6	16.5	17	19.1	20.1
%S (sulfur)	0	0	1.6	1.40	0.034	0	0
$\%H_2O$ (moisture)	0	0	0	0	0.12	0	.5

Siegert Formula

This formula is widely used in Europe to determine flue gas losses (qA) and efficiency.

$$qA = (Ts - Ta)\ x \left(\frac{A2}{(21 - O_2)} + B \right)$$

Efficiency = 100 – qA

where:

qA = dry gas losses
Ts = flue temperature
Ta = supply air temperature
O_2 = measured volumetric oxygen concentration expressed as a percent
$A2$, B = fuel dependent constants

The constants *A2* and *B* are based on the composition of combustibles in the fuels. In Germany, the following prescribed values are provided for common fuels.

Fuel Parameters for Siegert Fuels

Fuel Type	A2	B
NATG, Natural gas	.66	.009
OIL2, light fuel oil	.68	.007
OIL6, heavy oil	.68	.007
TGAS, Town gas	.63	.011
CGAS, Coking oven gas	.60	.011
PROP, propane	.63	.008

Determining CO_2 Using the O_2 Concentration

$$\%CO_2 \text{ (by volume)} = CO_2 \text{ max} \times \frac{(20.9 - \%O_2 \text{ measured})}{20.9}$$

CO_2max is the theoretical maximum concentration produced for the fuel used.

Emission Rate Calculations Using Emission Factors

Emission rate expresses the CO and NO_x concentrations in units of mass of effluent per amount of energy (fuel) consumed (lb./Mbtu or ng/J). Since fuel energy differs from fuel to fuel, emissions, expressed in PPM for example, must be converted using a fuel specific parameters. This is where the *Emission Factors* F.CO and F.NO_x are used.

The emission rate calculation presented below is described in EPA Method 19. This uses the dry gas factor Fd. Dry factors are incorporated into the values found in the Table I, below. The table values (Ft), convert the measured concentrations of emission gases, CO, NO_X, and SO_2 from PPM to pounds per million Btu of fuel. Note: The bracketed quantity converts the emission rate to the *undiluted* value.

$$E = \text{Cg Ft} \times \left(\frac{20.9}{20.9 - \text{O}_2 \text{ measured}} \right)$$

where:

E	= Emission Rate (pounds/MBtu of fuel, ng/J)
Cg	= Gas Concentration (PPM)
Ft	= factor from Table I (below)
O_2 *measured*	= Oxygen concentration from flue measurement (%)

Emission Rate Factors

Factor (Ft)	Nat. Gas	Propane	Oil #2	Oil #6	Coal	Wood (dry)	Bagasse	Coke
F.NOx	.00104	.00104	.00110	.00110	.00118	.00110	0.001	0.00118
F.CO	.00063	.00063	.00067	.00067	.00072	.00067	0.00067	0.00072

Ft units: lb./MBtu PPM

For those familiar with Method 19, *Ft* is related to *Fd* in the following way:

Ft, in units lbs/(MBtu ppm)

Fd, in units scf/MBtu

Ft = *Fd* x lb/(scf ppm)

Important Note
The Emission Rate factors shown in the table above are always expressed in units of lb./MBtu PPM regardless of whether the instrument is configured to display lb./MBtu or ng/J. This is important to recognize if entering your own factors.

A General Equation for the Combustion of a Simple Hydrocarbon in Air

$$C_xH_y + \left(\frac{4x+y}{4}\right)O_2 \Rightarrow CO_2 + \frac{y}{2}H_2O$$

x and y are the number of atoms of carbon and hydrogen in the fuel.

Calculating CO_2 Max From the Carbon Content

$$\%CO_2\ max = \frac{moles\ CO_2}{(moles\ CO_2 + moles\ N2)} \times 100$$

$$moles\ CO_2 = x\ moles$$

$$moles\ N2 = \frac{(4x+y) \times 3.76}{4}$$

Calculation of Combustion Air Requirement

Pounds Air / Pound Fuel = 11.5C + 34.3(H_2 - O_2/8) + 4.3S

C, H_2, O_2 and S are the fractions, by weight, of each chemical constituent of the fuel.

Appendix C

Series CA-6203 CA-CALC™ Combustion Analyzer Specifications*

Oxygen (O_2)

Sensor Type	Electrochemical
Range:	0–25%
Accuracy:	±0.3% O_2
Resolution:	0.1% O_2
Response Time:	<30 seconds to 90% of step change

Carbon Monoxide (CO)

Sensor Type	Electrochemical
Range:	0–5000 ppm
Accuracy:	0–100 ppm ±5 ppm or 10% of reading 100–5000: ±10 ppm or 5%
Resolution:	1 ppm
Response Time:	<30 seconds to 90% of step change

Sampling Probe

Hose length	7.5’ std (2.4 m)
Probe diameter:	5/16” (0.8 cm)

Nitric Oxide(NO)

Sensor Type	Electrochemical
Range:	0–4000 ppm
Accuracy:	0–100 ppm ±5 ppm or 10% of reading 100–4000: ±10 ppm or 5%
Resolution:	1 ppm
Response Time:	<30 seconds to 90% of step change

Sampling Probe

Hose length	7.5’ std (2.4 m)
Probe diameter:	5/16” (0.8 cm)

Flue/stack Temperature

Range	0–1000°C.
Resolution	1°C
Accuracy	±2°C, or .5% of reading

Supply Air Temperature Probe

Range	0–150°C.
Resolution	1°C
Accuracy	±1°C or 1%

*Specifications are subject to change without notice. Specification giving lowest accuracy is applied.

Draft

Range ....± 30"H_2O (±80mbar)
Resolution ....±.0.01"H_2O
Accuracy ....±1%rdg or .01"H_2O (zeroed)

External Dimensions: *............ 6" x 10" x 2.5"*

Communication Interface:

Type: ....Serial
Baud rate:.................................1200–19200 selectable

Power Requirements:

Batteries:..............................4 C cell alkaline batteries
Battery life: ....>24 hours (pump on)
AC Adapter: ....Use only TSI-supplied adapter
Backup battery: ....Lithium
Backup battery life:..............3 yrs

***Note**: These specifications assume the instrument is allowed to stabilize at the operating temperature before being turned on.*

Appendix D

Default Settings For Different Model Letter Designations

Defaults Models with Country Codes	O_2	CO	Draft Units	Temp Units	Excess Air	Effic/Loss Basis
CA- 6203	%	PPM	“H_20	°F	%EA	ASME/heat loss
CA- 6203-**D**	%	PPM	hPa	°C	Lambda	Siegert
CA- 6203-**EU**	%	PPM	mbar	°C	Lambda	Siegert
CA-6203-**M**	%	PPM	mbar	°C	%EA	ASME/heat loss
CA-6203-**UK**	%	PPM	mbar	°C	%EA	ASME/heat loss
CA-6203-**AU**	%	PPM	mbar	°C	%EA	ASME/heat loss

Defaults Models with Country Codes	Efficiency and Loss	Fuel Parameters	Fuel List	Fuel	Baud	COM
CA-6203	Eff/Net effic	C,H,H_2O,S, HV,CO2MX F.CO, F.NO_x	U.S.	Nat gas	1200	PRN
CA-6203-**D**	η / qA	A,B,CO2MX F.CO, F.NO_x	German	Nat gas	1200	PRN
CA-6203-**EU**	η / qA	A,B,CO2MX F.CO, F.NO_x	German	Nat gas	1200	PRN
CA-6203-**M**	Eff / Net effic	C,H,H_2O,S, HV, CO2MX F.CO, F.NO_x	U.S.	Nat gas	1200	PRN
CA-6203-**UK**	Eff / Net effic	C,H,H_2O,S, HV, CO2MX F.CO, F.NO_x	U.S.	Nat gas	1200	PRN
CA-6203-**AU**	Eff/ Net effic	C,H,H_2O,S, HV, CO2MX F.CO, F.NO_x	U.S.	Nat gas	1200	PRN

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