

Furnace Control Corp
FurnaceDoctor®



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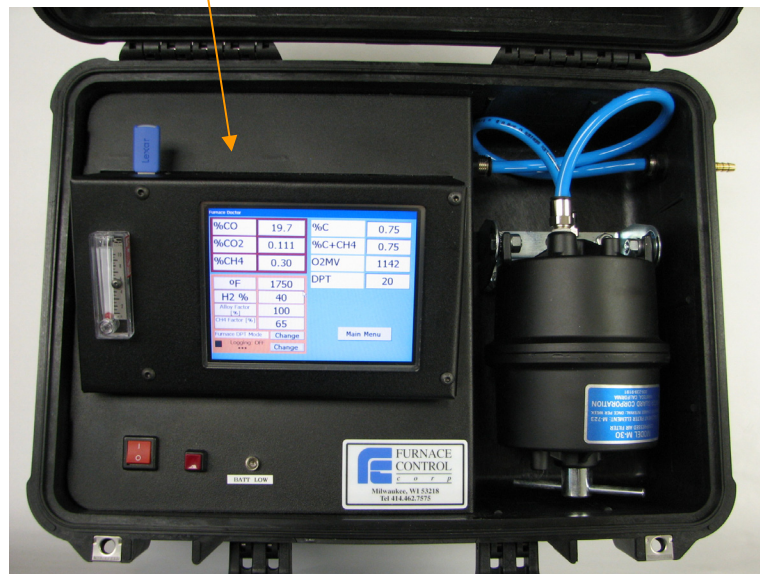
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SAFETY

Please read the instructions before operating the instrument.

This instrument complies with accepted industrial safety standards.

Do NOT operate this instrument with the internal top cover removed.



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EQUIPMENT RATINGS:

Supply Voltage	110 –240 Vac
Supply Frequency	50/60 Hz
Power Consumption	3.2/1.8 Amps

	CO₂	CO	CH₄	
Ranges:	(0–2%)	(0–30%)	0– 10% or 30%)	Other Ranges Available
Resolution:	(20ppm)	(0.02%)	(0– 02%)	
Accuracy:	2% of gas Range 1% for CO₂			

Operating Temperature	40° F - 120° F Be sure the enclosure Has adequate ventilation.
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Relative Humidity	5% to 90%, non condensing.
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Atmosphere	The instrument is not suitable for operations in explosive or corrosive atmospheres.
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Why Infrared ?

By purchasing your new Furnace Doctor, you have obviously made the decision that your current process measurement methods require some enhancement. This may be due to customer requirements for back-up process verification to your existing oxygen probe based system, or simply a matter of answering the question "is that probe really working?" You might be looking for more complete information of what is happening with respect to your furnace atmosphere.

Whatever your reasons, the use of I/R analysis, and the Furnace Doctor will satisfy these requirements.

Since most Furnace Doctor owners are either performing gas carburizing, or neutral hardening in an endothermic atmosphere, the following discussion will help to understand the meaning of the measured values:

Endothermic atmospheres in use for the these applications have this basic composition:

CO \cong 20%	(carbon monoxide)
H ₂ \cong 40%	(Hydrogen)
CO ₂ \cong Trace	(carbon dioxide)
CH ₄ \cong Trace	(methane, usually from natural gas)
O ₂ \cong Trace	(oxygen)
H ₂ O \cong Trace	(water vapor)
N ₂ .Balance	(nitrogen)

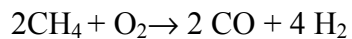
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These ratios are typical whether you are producing gas by means of an endothermic generator, or using prepared gasses such as nitrogen and methanol. Ratios are slightly different if propane is used rather than methane for the production of carrier gas.

Obviously any increase in volume in one of the gasses means a decrease in one or more of the other gasses. We often get asked the question "Why is my generator producing 20% CO, but I only measure 17% at my furnace?". "It is even lower when I add ammonia!" One part of the answer to this question is simple volumetric displacement. There is only room in the furnace for 100% of the atmosphere!

How can the Furnace Doctor help me with my generator?

The basic chemical reaction taking place in an endothermic generator is as follows:



Ignoring the nitrogen

Remember you are mixing gas and air together and heating it up to produce the above described gas composition. The reaction takes place in two stages: First some of the methane burns with air and makes heat. The by-products of this combustion are H₂O (water vapor) , and

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CO₂. In the second stage, the remaining methane reacts with the CO₂ and H₂O. It becomes obvious that we want this reaction to be as complete as possible!

This is the reason for the nickel catalyst in the generator.

Assuming that the main air gas ratio is set somewhere between 2.7 and 2.85 parts air to 1 part gas, there are two considerations:

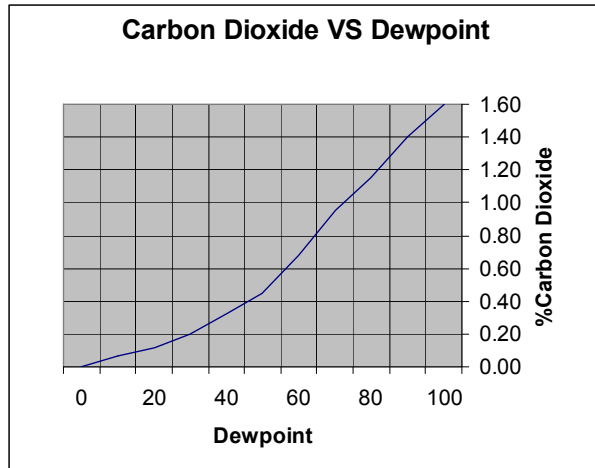
1. The catalyst must be clean, and free from soot. If soot is present, the efficiency of the above reactions goes down.
2. You must have adequate temperature to keep the rate of the reactions high enough.

So how can the Furnace Doctor help?

First by measuring the generator's methane content you can determine whether or not the catalyst is operating efficiently. .8% CH₄ is about the upper limit. Above this level it is possible that the catalyst is laden with soot, or the catalyst is simply spent. Another indication of this condition would be a high CO₂, or dew point. The Furnace Doctor provides a convenient way to obtain dew point, CO, CO₂, and CH₄.

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Check to see that the basic gas composition is as expected. CO should be around 20%. Check the CH₄ level and be sure that it is less than .8%, observe the CO₂, and the dew point readings. Note the relationship between dew point, and CO₂.

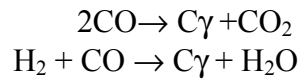


Make adjustments to either your oxygen probe control system, or the generator carburator to obtain the desired dew point.

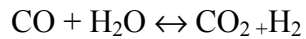
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**How will the Furnace Doctor help me
with my Furnace atmosphere?**

If you are using oxygen probes the Furnace Doctor can supply independent, traceable verification of your probes accuracy. It will also give you a much more complete picture of what is happening in your furnace atmosphere.

The primary reactions involved in carbon transfer are well understood as:



These reactions are assumed to be close to equilibrium. The theory behind this is that a reaction sometimes called the water-gas reaction, is busy keeping the H₂ and O₂ in balance:



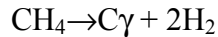
The measurement of %Carbon in your atmosphere with an oxygen probe is based on the assumption that the above is true:



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Note that it is assumed that the primary mechanism of carbon transfer is CO dependant. What is really happening is that the ratio of CO to CO₂ is much more accurate means of determining equilibrium carbon.

One problem is that we use CH₄ as enriching gas. What happens to the CH₄ once it enters the furnace? It decomposes - mostly near the hot catalytic surfaces in your furnace. It may be replenishing depleted CO, based on equilibrium "rules" it may be making soot crumbs on your hearth, or it may be reacting directly with the surface of the material:



How much of the above reaction is happening is dependant on how much methane is present in your furnace. The reaction also happens faster at higher temperatures, but is still slow compared to the equilibrium reactions.

For example at 1600 with an equilibrium carbon potential of .4%, and methane content of .5 the theoretical carbon potential is actually .44%. In reality the effect is usually about 6/10 of what the theoretical calculations deliver making the carbon potential closer to .42%. By contrast if we

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were to up the methane content to 5%, the actual carbon potential might be closer to .6%, a significant difference!

Whether the work really ends up seeing this is dependant on a number of issues - temperature – governing the rate of reaction, the surface area of the work and the level of saturation at the surface, atmosphere circulation, etc.

Using the Furnace Doctor to analyze furnace atmosphere.

Probe condition:

Carbon is computed using actual gas values, so it is more accurate than the assumptions made by the probe. Compare the %C calculated by the Furnace Doctor to %C displayed on the Carbon Control instrument.

Your carbon controller is set up with some assumptions about the content of the furnace atmosphere. Most controllers assume a CO to be 20% “out of the box” you may use the Furnace Doctor to correct this situation by adjusting this “factor” to the correct %CO.

Observe the probe millivolts as computed by the Furnace Doctor, and displayed by the carbon controller. These should be within 1-2 % of each other. If not, and you have

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entered the process temperature into the furnace doctor correctly, you probably have a problem with the probe or the controller. First check the millivolt reading at the back of the probe with a meter to eliminate any possible instrument problems.

Next be sure that the probe is free of soot by burning the probe off. If the numbers still do not agree, perform an impedance test on the probe to help determine the electrode condition. You will also want to check to see how fast the probe recovers after this test. Recovery time should be in seconds, not minutes.

Finally disconnect the probes reference air tube, and see if the millivolt reading on the controller changes, if it does you have a leak in the probe substrate.

If you change the probe, or if you are sure that the probe is ok, check to be sure you are obtaining a good sample at the Furnace Doctor. Many times sample ports are the cause of the problem. A good non-metallic sample probe helps solve this. One trick is to use the probe burnoff port to obtain a sample. This has a few problems associated with it in furnaces running high methane contents. The methane will crack near the alloy surface of the probe creating a local reaction not representative of the overall furnace atmosphere.

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Interpreting the gas value readings:

CO: For most atmospheres in use this number should be around 18-20%. If it is lower than this observe the following:

- Check generator for proper operation.
- If you are using nitrogen methanol, check the ratio of nitrogen to methanol. Also be sure that the atmosphere sparger is in good condition. If you are using nitrogen to “push” the methanol into the furnace be sure that the methanol is not getting nitrogen bubbles in it.
- If you are using ammonia, the ammonia additions will dilute the %CO in the furnace. Remember there is only room for 100% of the gas in the furnace
- Check for leaks. This can be confirmed by a high CO₂.
- If you are asking for a high carbon potential, high methane content, may also dilute atmosphere mix.
- Check for leaks. Air leaks typically cause the control system to add more natural gas to the furnace.
- High surface area loads will be able to draw more carbon out of the atmosphere. Typically the methane content will go up because of this.

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CO₂: This number can be anywhere between .05% to 1% it is depending on temperature, and gas composition. It tracks inversely to carbon potential. At 1600F a .4%C will be about .62%CO₂ (assuming 20% CO). To achieve a .4% carbon at 1750 CO₂ will be around .25

- If the carbon potential is lower than expected the CO₂ should be higher than expected.
- Check for air leaks.
- Check for burner tube leaks.
- Check for furnace fan water jacket leaks.
- Check generator or nitrogen methanol system.
- If the probe system is in agreement with the Furnace Doctor, be sure there is adequate carrier gas flow, and adequate enriching gas flow.
- Is carbon controller turning on the natural gas when it should?

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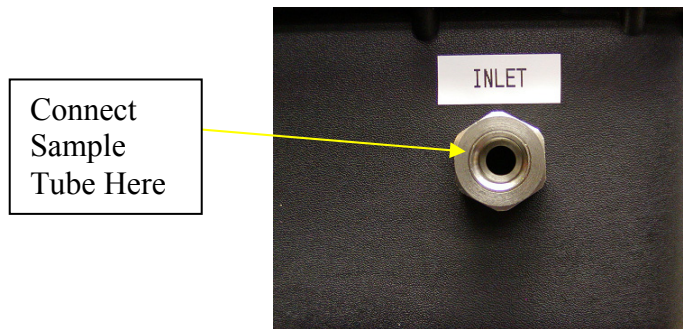
CH₄: Most batch furnaces will operate with a CH₄ content ranging from .1% to 4-5%. At the start of the cycle this number is higher than when the atmosphere, and the work approach equilibrium with each other. Continuous furnaces performing carburizing will usually operate at higher methane levels. In fact in some belt furnace applications this is necessary for the process to work!

- High free methane content is usually a product of the control system calling for too much natural gas due to an air leak, unusually high surface area in the load.
- Check for air leaks.
- Check for burner tube leaks.
- Check for furnace fan water jacket leaks.
- Check generator or nitrogen methanol system
- Be sure that the probe control system is working properly

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OPERATION:

- Connect one end of the sample tube to the inlet. Connect the other end to the furnace sample port. Do not connect to a port with a lambs wool, or angel hair filter already installed. Be sure to properly vent exhaust!
- We strongly recommend a small diameter ($\frac{1}{2}$ " id or less), non-metallic sample tube that can be inserted at least 2" past the refractory wall hot face to ensure an accurate sample.



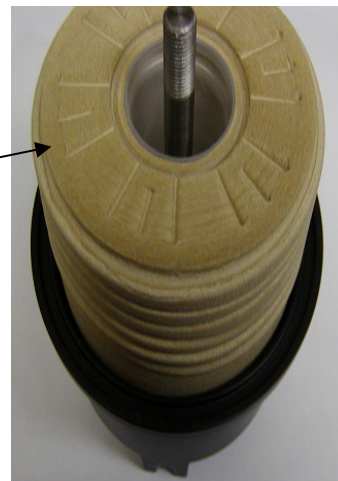
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Rotate Handel CCW and
remove cover.



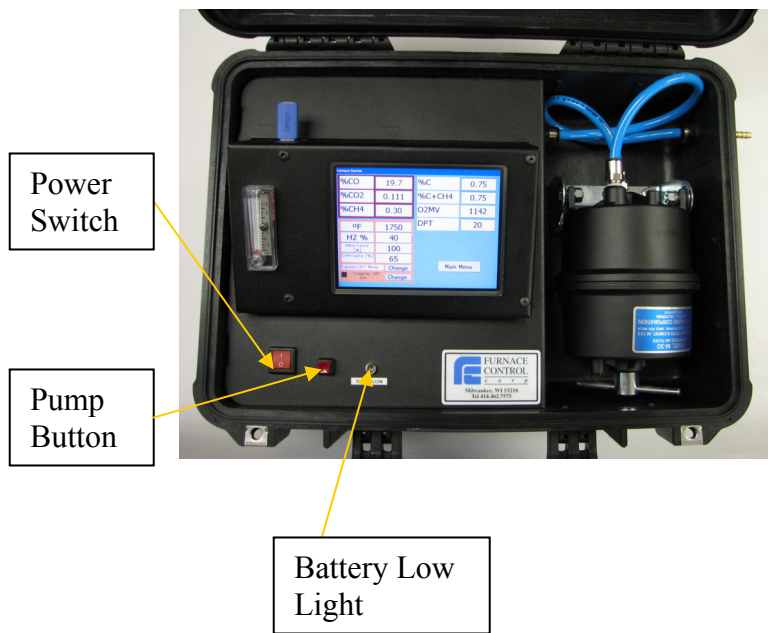
Lift Filter To upright
position

Be sure that the filter is
clean, and free from
moisture!
Soot build up or
discoloration in the
sample element requires
the element to be
replaced.



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- Turn on the power switch. Depress the Pump button to start sampling. You Furnace Doctor is equipped with a battery monitor. When a red light is present it is time to charge your Furnace Doctor.



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- The LCD display will illuminate, and the internal pump will start after pump button is depressed. Manually inputted fields are in yellow, live and calculated fields are in white. Buttons are grey.

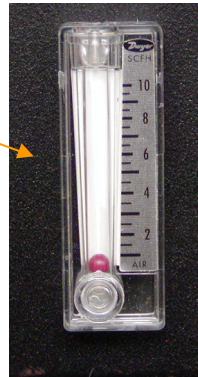
Furnace Doctor			
%CO	19.7	CP	0.82
%CO2	0.098	%C	0.82
%CH4	0.20	%C+CH4	0.82
°F	1750	O2MV	1148
H2 %	40.00	DPT	17
Alloy Factor [%]	100	<input type="button" value="Main Menu"/>	
CH4 Factor [%]	65		
Furnace DPT Mode	<input type="button" value="Change"/>		
LOGGING: OFF	<input type="button" value="Change"/>		

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After 30 seconds gas values will be measured and displayed.

Furnace Display	
%CO	19.7
%CO2	0.098
%CH4	0.20
°F	1750
H2 %	40.00
Alloy Factor [%]	100
CH4 Factor [%]	65
Furnace DPT Mode	Change
LOGGING: OFF	Change
CP	0.82
%C	0.82
%C+CH4	0.82
O2MV	1148
DPT	17
Main Menu	

- Ensure that sample flow is adequate. If you are sampling a generator with significant pressure at the sample port, 10 SCFH, it is recommended that you partially close the port valve so you do not compress the gas leading to an incorrect reading.



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A note about sample ports:

In a large percentage of heat treats we have found that the furnace sample ports are either plugged, or leaking. Even if you can look into the port, and it appears unobstructed, the port may leak somewhere behind the hot face of the refractory. This may cause the sample to be drawn from between the brick, and the furnace shell, or even out side of the furnace. It is also necessary to keep the sample velocity high in order to quickly stabilize the CO₂

For this reason we strongly recommend the use of a non-metallic sample probe that will penetrate the furnace wall at least 2" past the hot face of the refractory.

If you are unable to use a non-metallic probe and if you are getting numbers that just do not make sense, (I.E. Extremely low CO values or high CO₂) try taking a sample from the oxygen probe burn-off port (not the reference airport). ***Only use this method if no other working port is available. This method will affect the probe reading.***

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- The following display is shown on the LCD when power is applied to the unit.

Furnace Doctor			
%CO	19.7	CP	0.82
%CO ₂	0.098	%C	0.82
%CH ₄	0.20	%C+CH ₄	0.82
°F	1750	O ₂ MV	1148
H ₂ %	40.00	DPT	17
Alloy Factor [%]	100	<input type="button" value="Main Menu"/>	
CH ₄ Factor [%]	65		
Furnace DPT Mode	<input type="button" value="Change"/>		
<input checked="" type="checkbox"/> LOGGING: OFF	<input type="button" value="Change"/>		

- Measurement begins approximately 1 min after start up and is continuous after the process temperature is entered. The unit will not correctly display O₂mv, Carbon, or Dewpoint until temperature is entered. The display includes actual CO, CO₂, CH₄ as readings, calculated theoretical carbon and dewpoint and milli-volts for the computed %Carbon and manually entered temperature

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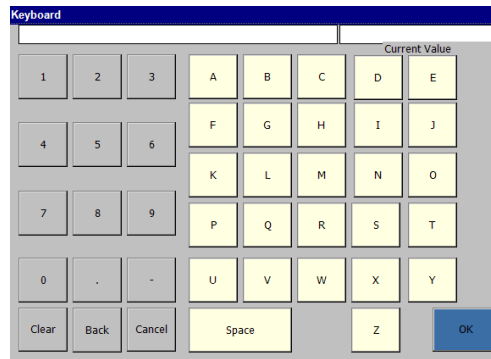
- To compute the correct %C associated with the CO, CO₂, CH₄ measured gasses you must enter the process temperature.

The screenshot displays the 'Furnace Doctor' control interface. It features a grid of data fields and control buttons. A callout box points to the '%CO', '%CO2', and '%CH4' fields, stating 'Enter Process Temperature Here'. Another callout box points to the temperature field, stating 'Touch here to change to °C and back to °F'. The interface includes a 'Main Menu' button and status indicators for 'Furnace DPT Mode' and 'LOGGING: OFF'.

Furnace Doctor			
%CO	19.7	CP	0.82
%CO2	0.098	%C	0.82
%CH4	0.20	%C+CH4	0.82
°F	1750	O2MV	1148
H2 %	40.00	DPT	17
Alloy Factor [%]	100		
CH4 Factor [%]	65		
Furnace DPT Mode	Change	Main Menu	
LOGGING: OFF	Change		

Touch the temperature field and a numeric key pad will appear. Enter the process temperature and press the OK button.

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- The instrument displays the carbon, dewpoint for the measured CO, CO₂, CH₄ gasses and entered probe temperature. Additionally, it displays calculated probe millivolts.
- The instrument will take at least 60 seconds from cold start to display any meaningful information. Ensure that sample flow is adequate! It's always a good idea to allow at least 3 minutes to obtain a meaningful reading.
- The Furnace Doctor can be switched between Deg F and Deg C by touching the °F / °C box

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Selecting the Dew point Calculation Mode:

The instrument will compute dew point using either a temperature based calculation, used when measuring furnace atmospheres where you can identify the process temperature, or a simplified table look up method based on CO₂ to be used when measuring the dew point of endothermic generators.

If you use the furnace calculation when measuring your endothermic generator, and enter a process temperature of 1900F or so, you will get meaningless values for dew point.

If you have the generator calculation selected, it is not necessary to enter a process temperature. You must select the correct carrier gas from the *Configure I/R Screen*. From this screen you can select the correct carrier gas for you process.

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Furnace Doctor			
%CO	19.7	CP	0.82
%CO2	0.098	%C	0.82
%CH4	0.20	%C+CH4	0.82
°F	1750	O2MV	1148
H2 %	40.00	DPT	17
Alloy Factor [%]	100	Main Menu	
CH4 Factor [%]	65		
Furnace DPT Mode	Change		
LOGGING: OFF	Change		

Touch here to toggle between furnace and generator dew point calculation

- Touch the *Change* button next to the *Furnace DPT mode* text and the instrument will toggle to Gen Dpt Mode.
- Touch the button again to return to the furnace dew point mode

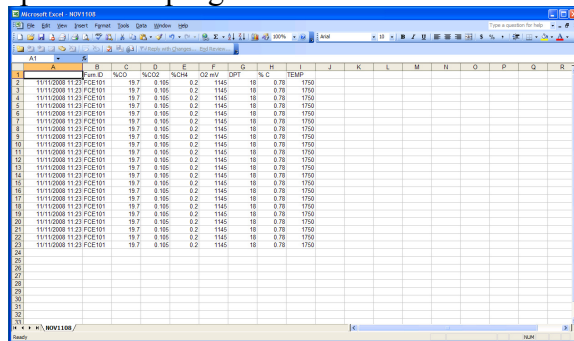
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Data Logging:

Your Furnace Doctor CE is equipped with a built in USB memory data logging system. Data on all gas values is stored on a 1-999 seconds intervals and is available for review from your PC in MS Excel

Data log data is stored on industry standard USB memory stick

File types are .txt and are easily read by any spreadsheet program



The screenshot shows a Microsoft Excel spreadsheet with the following data:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
2	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
3	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
4	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
5	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
6	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
7	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
8	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
9	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
10	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
11	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
12	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
13	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
14	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
15	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
16	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
17	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
18	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
19	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
20	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
21	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
22	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
23	10/12/2008	11:23	FCE101	19.7	0.165	0.2	1145	18	0.78	1750								
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Data saved will include time, date, Log Id, co, co₂, ch₄, and user entered temperature. Expected o₂mv, dew point, %Carbon, will be determined in the “Configure I/R Screen”. The checked items will be data logged. (See Utilities)

Starting the data logger:

The screenshot shows the 'Furnace Doctor' interface with a grid of data points and control buttons. The data points are as follows:

%CO	19.7	CP	0.82
%CO ₂	0.098	%C	0.82
%CH ₄	0.20	%C+CH ₄	0.82
°F	1750	O ₂ MV	1148
H ₂ %	40.00	DPT	17
Alloy Factor [%]	100		
CH ₄ Factor [%]	65		

At the bottom left, there are two 'Change' buttons: one for 'Furnace DPT Mode' and one for 'LOGGING: OFF'. A 'Main Menu' button is located in the bottom right. An arrow points from a text box to the 'LOGGING: OFF' button.

**Touch here to start
Data Logging**

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Touch the *Change* button and this window will pop up

The screenshot shows the 'Change Logging Settings' dialog box overlaid on a control panel. The dialog box has the following fields and options:

- Log I.D.:** FCE101
- logfile:** NOV1108
- Data Log Interval (secs):** 60
- Start Logging
- Stop Logging
- OK** button

Callouts with arrows point to these fields:

- Left callout: "Enter the Log I.D. for the data log file here" (points to Log I.D.)
- Right callout: "Enter the file name for the data log file here" (points to logfile)
- Bottom-right callout: "Enter the Data Logging Interval Here. 1-999 secs" (points to Data Log Interval)

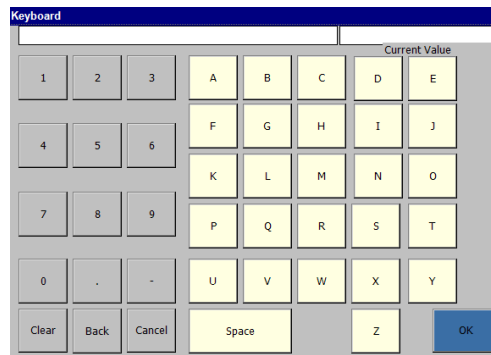
The background control panel includes a table of gas percentages and two 'Change' buttons.

%CO	.55
%CO2	.55
%CH4	.55
OF	135
H2 %	19
Alloy Factor [%]	
CH4 Factor [%]	

Buttons: Generator DPT Mode Change, LOGGING: OFF Change, Main Menu

You must first enter a *Log I.D.* name for the file that will contain the data.

To enter the *Log I.D.* simply touch the filename field and the alpha numeric keyboard will appear.



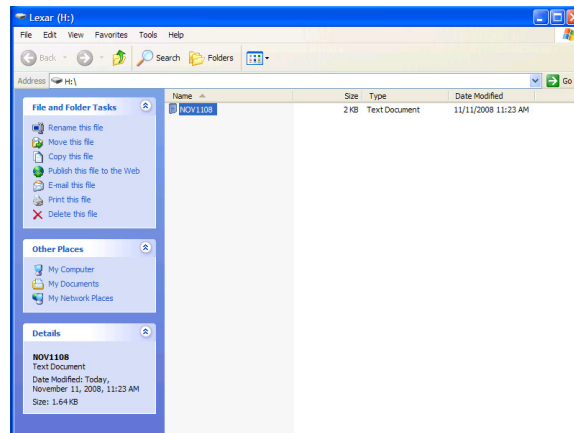
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The *Log I.D.* field allows you to enter a message that will be data logged with the I/R data.

For example you may name the log file May2105 for May 21st, 2005

Then in the *Log I.D.* field you type the furnace name. As you move from furnace to furnace you change the *Log I.D.* field. You will end up with a spread sheet for that day that contains all of the furnace readings.

The *logfile* assigns a name to the file. This is the name you will see when you insert the USB drive into your computer and open.



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Starting and Stopping Data logging:

To start data logging insert the USB flash drive in to the side of the Furnace Doctor.



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Touch the *Change* button next to the *LOGGING: OFF* text.

The screenshot shows the 'Furnace Doctor' interface with the following data and controls:

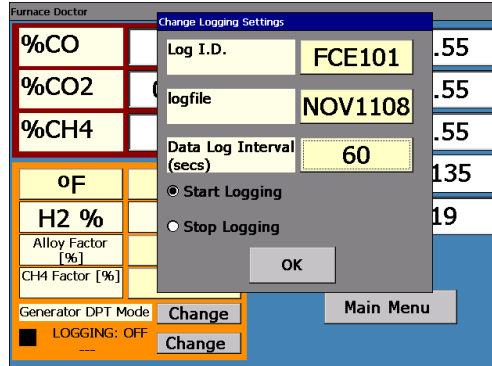
%CO	19.7	CP	0.82
%CO2	0.098	%C	0.82
%CH4	0.20	%C+CH4	0.82
°F	1750	O2MV	1148
H2 %	40.00	DPT	17
Alloy Factor [%]	100		
CH4 Factor [%]	65		
Furnace DPT Mode	Change		
LOGGING: OFF	Change		

Buttons: Main Menu

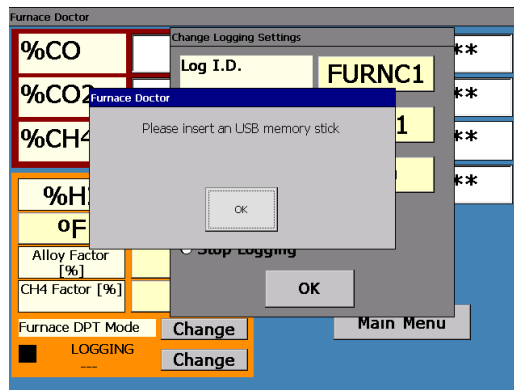
Touch here to start and stop data logging

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A window will pop up. Enter the *Log I.D.*, *logfile* name and *Data Log Interval* by touching the appropriate area. Touch the *Start Logging* button and touch *OK*.



A window will popup stating *Please insert a USB memory stick*. Insert the USB stick and touch OK to start data logging.



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After Touching OK the text next to the *Change* button will state *Logging: ON* and will display the *logfile* name in green.

The screenshot shows the 'Furnace Doctor' control interface. It features several data tables and control elements:

%CO	19.7	%C	0.54
%CO2	0.097	%C+CH4	0.54
%CH4	0.20	O2MV	1135

°F	1850	DPT	20
----	------	-----	----

H2 %	40
Alloy Factor [%]	100
CH4 Factor [%]	65

Generator DPT Mode

Logging: ON

2015-07-10 10:10:10

Logfile Name in Green

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To stop Data Logging push the *Change* button.

The screenshot shows the 'Furnace Doctor' interface with the following data:

%CO	19.7	%C	0.54
%CO2	0.097	%C+CH4	0.54
%CH4	0.20	O2MV	1135
°F	1850	DPT	20
H2 %	40		
Alloy Factor [%]	100		
CH4 Factor [%]	65		

At the bottom, there are two 'Change' buttons: one for 'Generator DPT Mode' and one for 'Logging: ON'. A yellow arrow points to the 'Logging: ON' button.

Touch the *Change* button to stop Data Logging

You will see this screen. Touch on the *Stop Logging* and then touch OK.

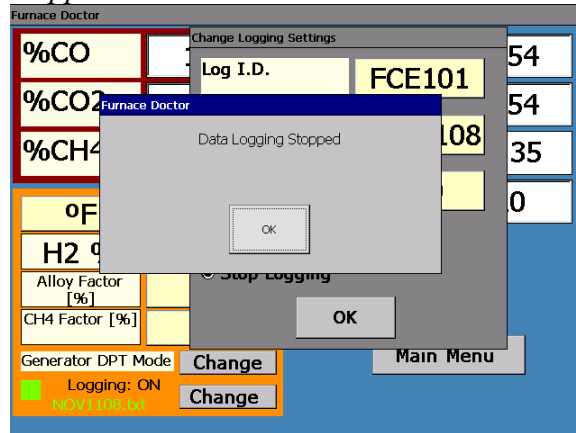
The screenshot shows the 'Furnace Doctor' interface with a 'Change Logging Settings' dialog box overlaid. The dialog box contains the following settings:

Log I.D.	FCE101
logfile	NOV1108
Data Log Interval (secs)	120
Start Logging	<input type="radio"/>
Stop Logging	<input checked="" type="radio"/>

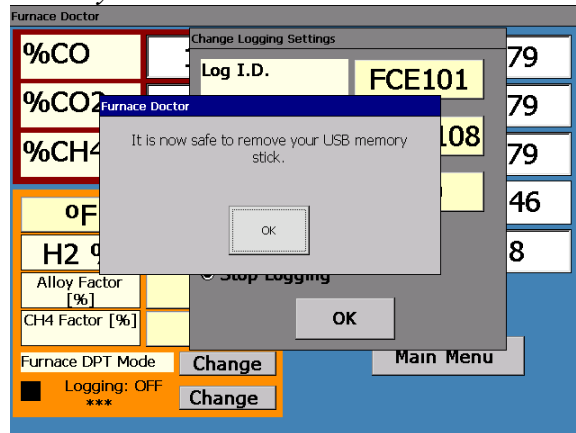
An 'OK' button is visible at the bottom of the dialog box. The background interface is partially obscured by the dialog box.

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A window will pop up stating *Data Logging Stopped*

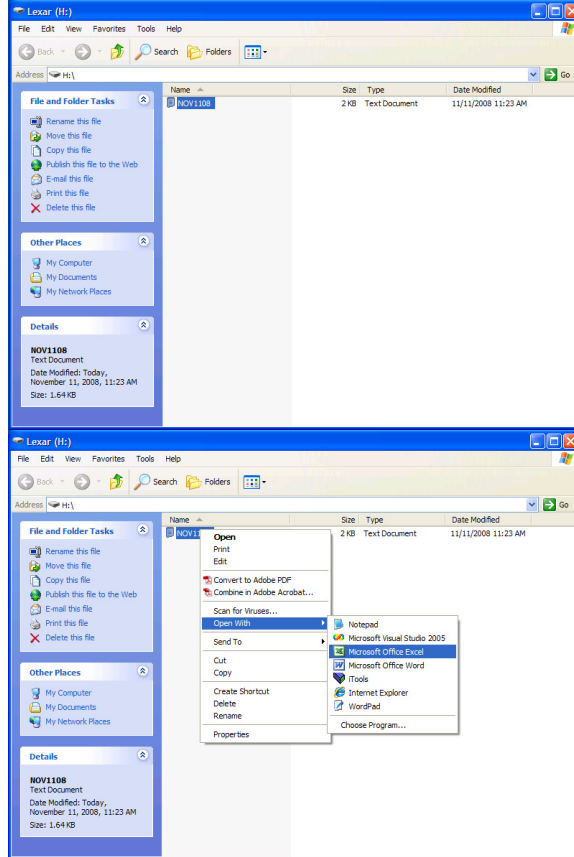


Touch OK and another window will pop up stating *It is now safe to remove your USB memory stick.*



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Press OK to acknowledge. Remove the USB drive and insert into you PC to read the data in a .txt file. Right click on the file of you want to open the file in Excel.



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The Menu System:

The screenshot shows the 'Furnace Doctor' interface with the following data:

%CO	19.7	%C	0.54
%CO2	0.097	%C+CH4	0.54
%CH4	0.20	O2MV	1135
oF	1850	DPT	20
H2 %	40		
Alloy Factor [%]	100		
CH4 Factor [%]	65		

Control elements include: Generator DPT Mode Change, Logging: ON (with a green indicator), and another Change button.

Main Menu

Main Menu Button

Touching the Main Menu button will take you to the system main menu.

The main menu features the following options:

- Calibration (with a gas analyzer icon)
- I/R Gas Values (with a graph icon)
- Proc Calc (with a calculator icon)
- Utilities (with a fire bucket icon)
- About (with the United Process Controls logo)

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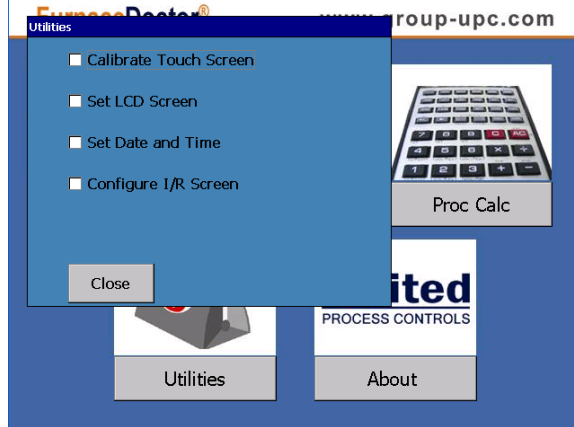
The following options are available on the main menu:

- *I/R Gas values* – This is the display that you see when the instrument is first powered up. Data includes CO, CO₂, CH₄, and user entered temperature. Expected O₂mv, dew point, %Carbon, will be determined in the “Configure I/R Screen” page 45. The checked items will be displayed and logged.
- *Utilities* - This allows you to set the LCD Screen, Calibrate the touch screen, set the date and time, and configure the *I/R Gas Values* screen.
- *Proc Calc* – Allows you to enter temperature, oxygen probe millivolts or CO, CO₂, CH₄, H₂, Alloy Factor, and CH₄ Factor to compute carbon potential and dew point. You can also enter the dew point and temperature to compute the above.
- *Calibration* – This option allows you to calibrate the instrument to certified grade gasses
- *About*—Tells about software version, customer support and the members of United Process Controls.

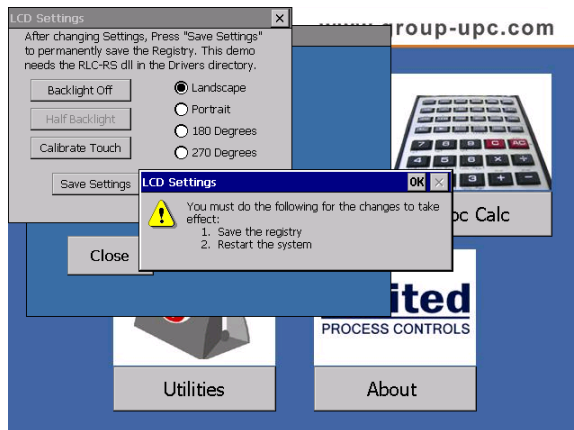
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Utilities:

Touch the desired option to select. A new window will pop up.



LCD Setup:



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- *Backlight Off*—Turns off the backlight. Touching the screen again will turn it back on.
- *Calibrate Touch* – Allows you to calibrate the touch positions on the screen by locating a target for you to touch at various positions on the screen.

Carefully press and briefly hold stylus on the center of the target.
Repeat as the target moves around the screen.
Press the Esc key to cancel.

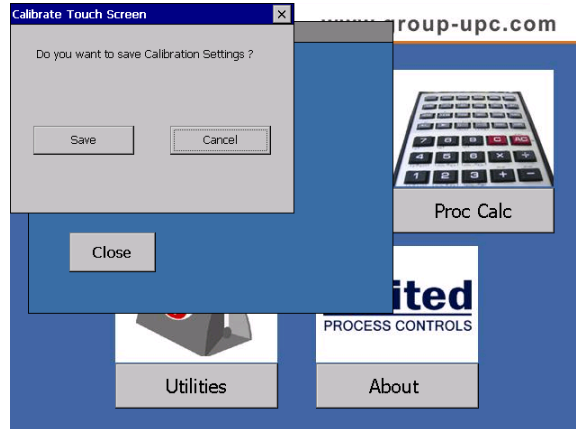


Follow the instructions to calibrate the touch screen. After completion of touch screen calibration the cross will disappear. It may take several tries. You will see this screen.

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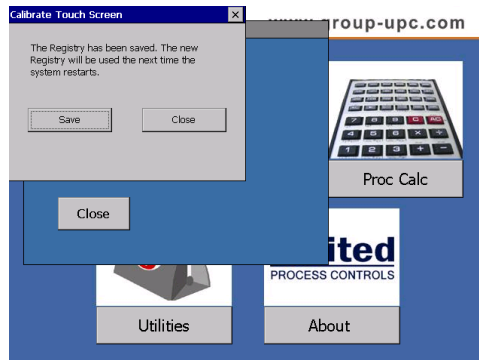
New calibration settings have been measured.
Press the Enter key to accept the new settings.
Press the Esc key to keep the old settings.

Touch anywhere on the screen to finish the touch screen calibration. You will then be prompted to save Calibration Settings.



Touch *Save*. You will then see this screen

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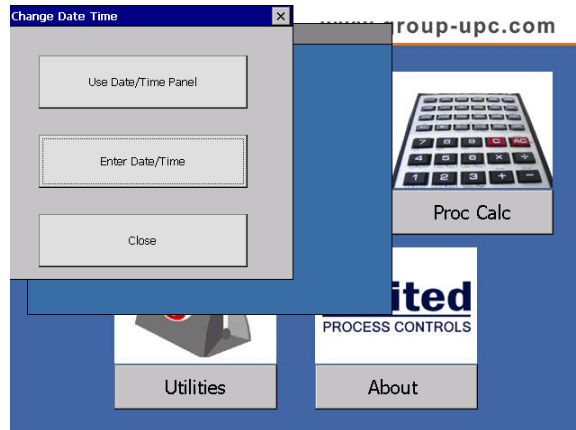


Touch *Close* and the touch screen calibration will be saved. The new setting will apply the next time the unit is turned back on.

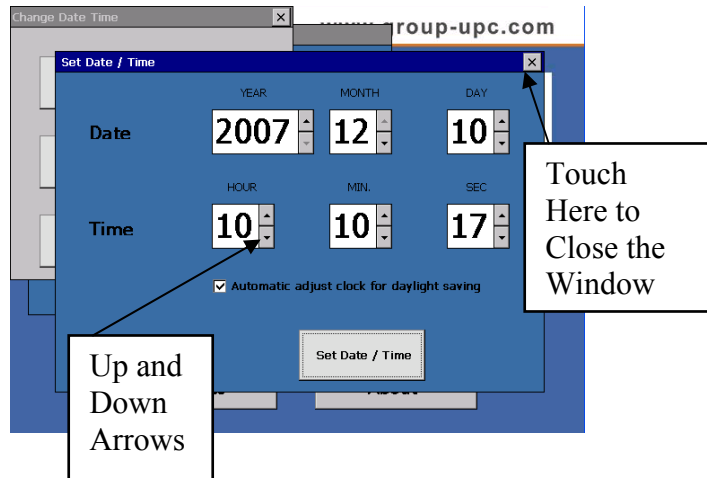
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Date and Time

Touch the *Set Date and Time* check box and the following screen will appear.



Touch on the *Enter Date/Time* button you will see this screen

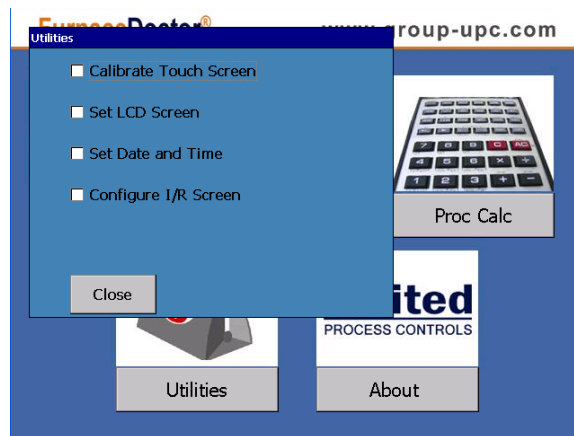


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Use the up and down arrows to change the Date and Time. After the correct date and time are entered touch the *Set Date / Time* button. The new Date and Time will then be saved. Touch the x in the upper right hand to close the window.

Configure I/R Screen:

This screen is for configuring the *I/R Gas Values* screen. Touch the *Configure I/R Screen* box.

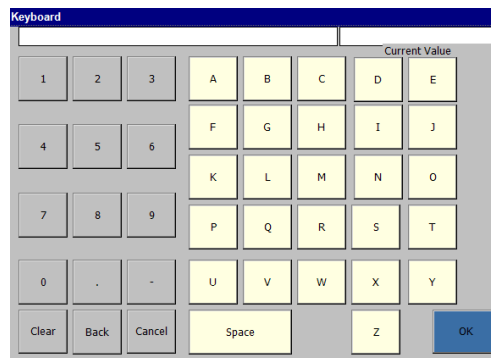


A new window will pop up you will be asked for a password. The password is 7575.

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Touch *OK* and an alpha numeric keyboard will appear.



Enter the password and click *OK*.

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Options include:

- ✓ *Show Atmosphere Carbon Potential.* This is displayed on the *I/R Gas Values screen* as *CP*. It is a carbon calculation that displays the carbon potential of the atmosphere using CO, CO₂, and manually entered process temperature.
- ✓ *Show Steel Surface Carbon.* This is displayed on the *I/R Gas Values screen* as *%C*. It is a carbon calculation that displays the carbon potential of the steel surface using CO, CO₂, and manually entered process temperature with the option of an *Alloy Factor*. The *Alloy Factor* is a process factor that can be determined by a shim stock test. The Furnace Doctor can then be adjusted to match you shim stock tests. 100 is nominal.
- ✓ *Show CH₄ Corrected Carbon Potential.* This is displayed on the *I/R Gas Values screen* as *%C + CH₄*. It is a carbon calculation that displays the carbon potential of the atmosphere using CO, CO₂, CH₄, and manually entered process temperature with the option of a *CH₄ Corrected Carbon Potential*. The *CH₄ Corrected Carbon Potential* is a process factor that corrects for the catalytic effect that is happening in

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the furnace from free CH₄. The %c + CH₄ box that will be displayed on the *I/R Gas Values* page will turn red if the furnace is not in equilibrium. 65 is the recommended default setting if you choose to use this feature.

- ✓ *Show O2 Probe Calculated Signal.* This is displayed on the *I/R Gas Values screen* as *O2MV*. It is a calculated O₂ Probe millivolt using CO, CO₂, and manually entered process temperature.
- ✓ *Show Calculated Dew Point.* This is displayed on the *I/R Gas Values screen* as *DPT*. It is a calculated Dew Point using CO, CO₂, and manually entered process temperature and H₂. There are 4 selections of carrier gasses available.
 1. *Nitrogen / Methanol* which calculates the amount of H₂ from the amount of CO that is present in the atmosphere to calculate dew point, and carbon potential.
 2. *Endo from Natural Gas* which will use a 40% H₂ to calculate dew point and carbon potential.
 3. *Endo from Propane* which will use a 31% H₂ to calculate dew point and carbon potential.

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4. *Other* – Please specify *H2 content* which will use a manually entered *H2* to calculate dew point.

The screenshot shows the 'I/R Configuration' screen with several options and input fields. Three callout boxes point to specific input fields:

- Callout 1: 'Touch Here to Enter the Alloy Factor %' points to the 'Alloy Factor [%]' field containing '100'.
- Callout 2: 'Touch Here to Enter the CH4 Factor %' points to the 'CH4 Factor [%]' field containing '65'.
- Callout 3: 'Touch Here to Enter the H2 % For Dew Point Calculation' points to the 'H2 (%)' field containing '***'.

Other visible options include 'Show Steel Surface Carbon', 'Show CH4 Corrected Carbon Potential', 'Show O2 Probe Calculated Signal', and 'Show Calculated Dew Point'. Under 'Please Select Carrier Gas', 'Endo from Natural Gas' is selected. 'OK' and 'Cancel' buttons are also visible.

To Enter the *Alloy Factor* %, *CH4 Factor* %, and the *H2* % for Dew Point and carbon potential calculations touch the corresponding box. An alpha numeric keyboard will appear to enter the value. Touch *OK* when done.

The screenshot shows the 'Keyboard' input screen. It features a grid of keys for numbers 1-9, 0, and symbols like '.', '-', and 'Space'. A separate grid contains letters A-Z. There are also 'Clear', 'Back', 'Cancel', and 'OK' buttons. A 'Current Value' field is located at the top right.

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After you have configure the *I/R Screen* touch *OK* and you will be taken to the main menu. Cancel will discard any changes you have made.

The screenshot shows the 'I/R Configuration' screen with the following settings:

- Show Atmosphere Carbon Potential
- Show Steel Surface Carbon
 - Alloy Factor [%] 100
- Show CH4 Corrected Carbon Potential
 - CH4 Factor [%] 65
- Show O2 Probe Calculated Signal
- Show Calculated Dew Point
 - Please Select Carrier Gas
 - Nitrogen / Methanol
 - Endo from Natural Gas
 - Endo from Propane
 - Other - Please specify H2 content
 - H2 (%) ***

Buttons: OK, Cancel

Callout box: Touch Here after completion of the I/R Screen configuration.

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Process Calculator:

This feature has several options for computing carbon potential, dew point, and probe millivolts. Input fields include %CO, the carbon monoxide percentage, %CO₂, the carbon dioxide percentage, %CH₄, the methane percentage, %H₂, the hydrogen percentage, and °F or °C temperature. To change from °F to °C touching the °F button will change it to °C and vice versa.

Other inputs are O₂MV, the carbon probe millivolts, DPT, the dew point, Alloy Factor [%], the Alloy Factor is a process factor that can be determined by a shim stock test. The Furnace Doctor can then be adjusted to match you shim stock tests. 100 is nominal, CH₄ Factor [%], the CH₄ Factor is a process factor that corrects for the catalytic effect that is happening in the furnace from free CH₄. 0 turns this feature off.

Once an input percentage has been changed the CALCULATE button will turn red.

Touch the CALCULATE button to calculate the changes.

To input a value touch on the appropriate input box.

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Touch Here to input appropriate values..

Input	Value	Input	Value
%CO	20	O2MV	1143
%CO2	0.2	DPT.	25
%CH4	0	CP atm	1.21
%H2	40	%C	1.21
°F	1550	%C+ch4	1.21
Alloy Factor [%]	100	Sat. %C	1
CH4 Factor [%]	65	% Oxygen	4.615E-020

Calculation Method Set to:

Use Gas Input
 Use mV Input
 Use DPT Input

Options:

- *Use Gas Input.* By entering the *CO*, *CO2*, *CH4*, *Alloy Factor [%]*, *CH4 Factor [%]* and process temperature, the *O2MV*, *DPT*, *CP atm*, *%C*, *%C+ch4*, *Sat. %C*, and *% Oxygen* will be computed. The *%CO* calculates the *%H2*. Touch the *CALCULATE* button to calculate.
- *Use mV Input.* By entering the oxygen probe millivolts, *Alloy*

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Factor [%], CH4 Factor [%] and process temperature, the DPT, CP atm, %C, %C+ch4, Sat. %C, and % Oxygen will be computed. CO2 is also calculated. Changing the % CO will calculate the %H2. This will change the calculated DPT, CP atm, %C, %C+ch4. Touch the CALCULATE button to calculate.

- *Use DPT Input. By entering the dew point (DPT), Alloy Factor [%], CH4 Factor [%] and process temperature the O2MV, CP atm, %C, %C+ch4, Sat. %C, and % Oxygen will be computed. CO2 is also calculated. Changing the %CO will calculate the %H2. This will change the calculated, O2MV, CP atm, %C, %C+ch4. Touch the CALCULATE button to calculate.*

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I/R Maintenance & Calibration:

You may calibrate your unit with certified grade span gas, and nitrogen. If you have plant nitrogen available be sure to regulate it to approximately 1 PSI. Span bottle gas must have a bottle top regulator that will be capable of regulation at 1 PSI. ***Be sure that your gas supplier provides you with a certified analysis of the gas in the bottle!*** You may purchase span gas bottles from Furnace Control Corp. Please contact your local Furnace Control Corp representative.

Values for span gas should be 20- 25.0%CO, .7-1.0%CO₂, and 8-15.0% CH₄ and 40% H₂ with the balance of nitrogen. It is recommended that you select span gas with values approximately 20% higher than typical observed process value. Span gas values may be higher, or lower, but should not exceed the ranges of the measuring cells of 30%CO, 2%CO₂, 15% CH₄.

Be sure to keep the second stage regulator pressure around 1-2 PSI. Your Furnace Doctor is equipped with good internal pressure regulation, but too much pressure may override the regulator's ability to control the pressure in the cells.

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It is important to understand the I/R cells are very pressure sensitive by nature. Realize that for a given species of gas there are more molecules of that gas present in a cell with a pressure of 1.5 PSI., than in a cell with a cell pressure of .5 PSI. this will lead to measurement error if the unit is calibrated at a high pressure, and then applied to low pressure measurements.

You may observe this phenomena by closing of the exhaust of the instrument while measuring a furnace. Note the quick rise in the CO value.

Calibration Frequency:

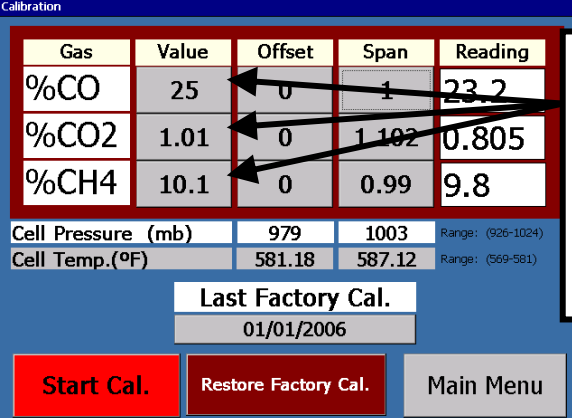
Furnace Control Corp recommends the following procedure:

- Connect the span bottle to the instrument and measure it on a weekly basis. If the instrument measures the span bottle within 2% of the analyzed values on the bottle it is not necessary to calibrate the instrument.
- If calibration is required do it in the environment that the instrument will be used in. If you calibrate the instrument in an office that is 70 degrees, and then go use the instrument in a 110 degree heat treat, you will probably experience some error in measurement.

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To begin calibration:

- The procedure for Span gas values only needs to be performed when a new span bottle is to be used.
- Touch the *Main Menu* button from the main screen then the *Calibration* button to get to the calibration page. Be sure that the span gas values on the calibration page match the certified gas values provided with the span gas bottle.



Gas	Value	Offset	Span	Reading
%CO	25	0	1	23.2
%CO2	1.01	0	1.102	0.805
%CH4	10.1	0	0.99	9.8

Cell Pressure (mb) 979 1003 Range: (926-1024)

Cell Temp.(°F) 581.18 587.12 Range: (569-581)

Last Factory Cal.
01/01/2006

Start Cal. Restore Factory Cal. Main Menu

Be sure these values match the values supplied by the certification with your gas cylinder.

If these values need to be changed touch the appropriate field and enter the new value from the cylinder certification.

The offset and span values will be computed automatically during calibration. The value fields are the actual measured values.

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Starting Calibration:

- Connect and turn on the nitrogen gas and turn on the pump. Be sure that you have adequate flow, and touch the *Start Cal.* button. The following screen will appear:

Calibration

Gas	Value	Offset	Span	Reading
%CO	25	0	1	23
%CO				0.77
%CH				9.7

Cell Pres
Cell Tem

Range: (926-1024)
Range: (569-581)

Last Factory Cal.
01/01/2006

Start Cal. **Restore Factory Cal.** **Main Menu**

Calibration count will show here.

- Touch *Yes* on the dialog box and the instrument will then start to count up to 120 or touch *CANCEL* or *NO* to cancel the calibration.

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After *YES* is pressed you will see this screen. After nitrogen has been connected and have adequate flow press *OK* to start the calibration.

Calibration

Gas	Value	Offset	Span	Reading
%CO	0.05	0	1.000	0
%CO				0.02
%CH				0

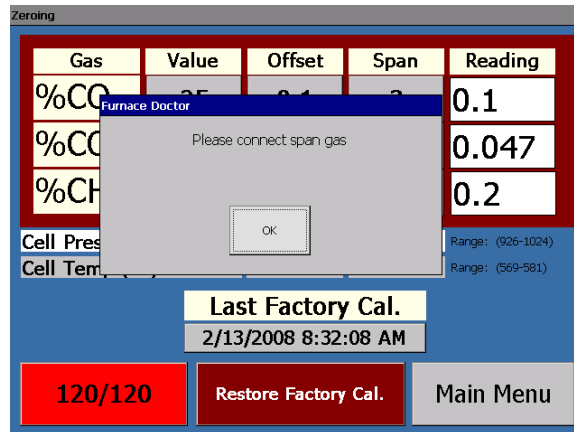
Cell Pres Range: (926-1024)
Cell Tem Range: (569-581)

Last Factory Cal.
01/01/2006

Start Cal. **Restore Factory Cal.** **Main Menu**

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The Furnace Doctor will count up to 120. When it has reached 120 this screen will appear.



Connect and turn on the span gas, be sure that you have adequate flow, and touch *OK* on the dialog box.

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Calibration				
Gas	Value	Offset	Span	Reading
%CO	25	0	1	23.2
%CO2	1.01	0	1.102	0.805
%CH4	10.1	0	0.99	9.8
Cell Pressure (mb)	979	1003	Range: (926-1024)	
Cell Temp.(°F)	581.18	587.12	Range: (569-581)	
Last Factory Cal.				
01/01/2006				
Start Cal.		Restore Factory Cal.		Main Menu

- Once the unit has counted up to 120 the calibration is complete. You can now return to the *I/R Gas Values* screen. The instrument should read the values in the bottle within 2% of the cell range. (i.e. 30% CO should be +/- .6% CO.)

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Restoring Factory Calibration:

If you wish to restore the calibration performed at the factory then touch the *Restore Factory Cal.* button.

Calibration

Gas	Value	Offset	Span	Reading
%CO	25	0	1	23.2
%CO2	1.01	0	1.102	0.805
%CH4	10.1	0	0.99	9.8

Cell Pressure (mb)	979	1003	Range: (926-1024)
Cell Temp.(°F)	581.18	587.12	Range: (569-581)

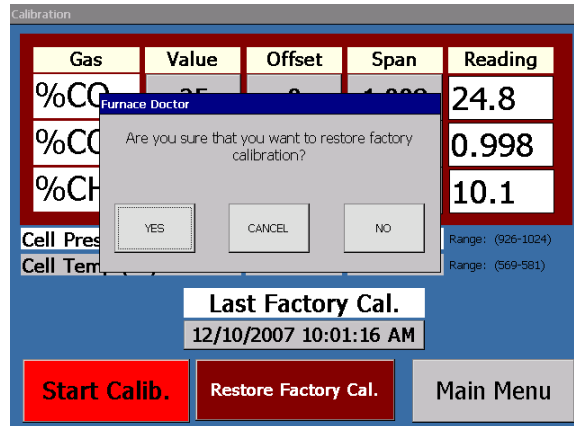
Last Factory Cal.
01/01/2006

Start Cal. Restore Factory Cal. Main Menu

Touch here
to restore
factory
calibration.

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You will be prompted with *Are You Sure you want to restore factory calibration.* Touch *OK* on the dialog box and the last factory calibration data will be restored



You will see this screen next. Touch *OK* to complete the restoration of factory calibration.

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Calibration

Gas	Value	Offset	Span	Reading
%CO	25	0	1.000	24.7
%CO ₂	1.01	0	1.102	0.987
%CH ₄	10.1	0	0.99	10.2

Cell Pressure (mb) 979 1003 Range: (926-1024)
 Cell Temp. (°F) 581.18 587.12 Range: (569-581)

Last Factory Cal.
12/10/2007 10:01:16 AM

Start Calib.
Restore Factory Cal.
Main Menu

Furnace Doctor

Factory calibration has been restored.

OK

Factory Calibration Data:

Calibration

Gas	Value	Offset	Span	Reading
%CO	25	0	1	23.2
%CO ₂	1.01	0	1.102	0.805
%CH ₄	10.1	0	0.99	9.8

Cell Pressure (mb) 979 1003 Range: (926-1024)
 Cell Temp. (°F) 581.18 587.12 Range: (569-581)

Last Factory Cal.
01/01/2006

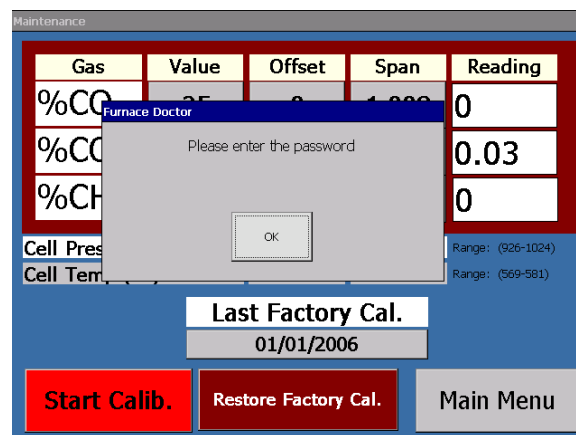
Start Cal.
Restore Factory Cal.
Main Menu

Factory
Calibration date

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When you send your analyzer into Furnace Control Corp. for calibration, the calibration data, and the factory calibration date are entered and stored in the analyzer's memory.

If you have a service other than Furnace Control perform certified calibration they will need to contact Furnace Control for a password, the calibration data may be saved along with the date of the calibration by touching the factory calibration date field. If you touch this field you will be prompted to enter a password



The Factory Calibration is only accessible by a certified Furnace Doctor technician or approved calibration facility.

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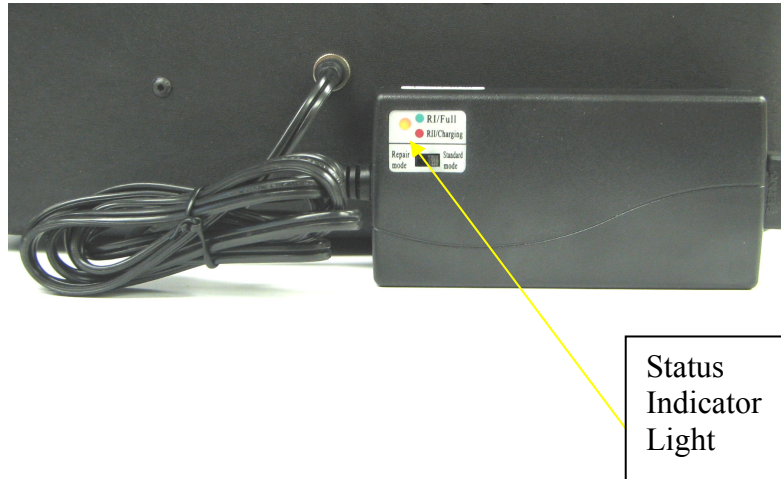
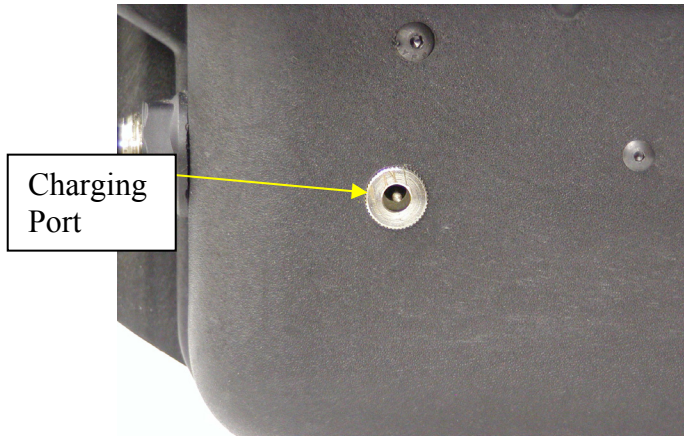
Your Furnace Doctor includes a battery charger



Charging

- Unit will operate continuously for approximately 4 hours with out recharging. A full charge will take approximately 6 hours to complete. It is not necessary to completely discharge the battery before charging.
- To charge the unit turn the Furnace Doctor power switch to the off position.
- Connect the supplied batter charger to the charging port on the side making sure the switch on the charger is in standard mode.
- Red Status Indicator Light –battery is charging
- Green Status Indicator Light- battery is charged

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Note: Unit is designed to operate with a charged battery. Using the charger as an AC adapter will not allow the battery to charge properly. Eventually the battery will not be able to sustain operation of the analyzer. Please connect the charger with the unit's power off and charge only when Batt Low light is on.

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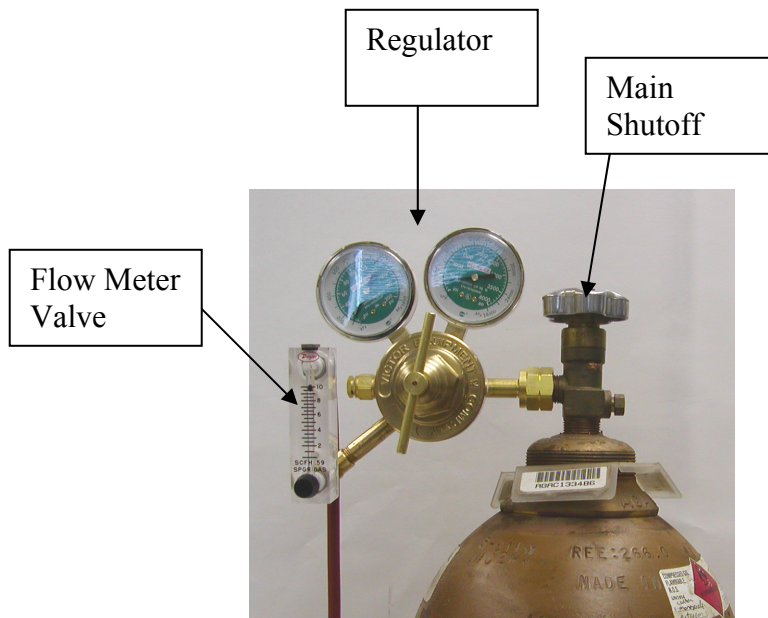
Using the Regulator

Connect the gas regulator to your bottle of gas.

Connect the Furnace Doctor hose to the barbed fitting on the flow meter.

Open the main shut off valve.

Adjust the regulator by slowly turning handle clockwise and flow meter valve until 10CFH of gas is flowing. Do not exceed 10CFH on the flow meter attached to the regulator or on the Furnace Doctor flow meter.



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