Marathon Sensors Inc.

Carbon Probe
Operations Manual

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Manual Part No:
F210000

Congratulations!

You have purchased the finest oxygen sensor on the market. To realize the capabilities of this superb device, please observe the recommendations in this instruction manual.

Important

When the sensor is placed into service, please send the enclosed postage-paid warranty registration card. In the unlikely event that your sensor fails prematurely, please follow these directions in order to expedite your claim:

1. Carefully fill out the claim form, giving as much information as possible about the sensors conditions of use and failure to help accelerate your claim and help us improve our product.

2. Enclose the claim form with the sensor intact and in the original packaging and return to 3100 East Kemper Rd, Cincinnati, OH 45241.

Disclaimer

All zirconia oxygen sensors manufactured by Marathon Sensors Inc. are to be used by the industrial operator under his/her direction. Marathon Sensors Inc. is not responsible or liable for any product, process or damage or injury incurred while using on of its sensors. Marathon Sensors Inc. makes no representation or warranties with respect to the contents hereof and specifically disclaims any implied warranties of merchantability or fitness for any particular purpose.

12 Month Warranty

There are no warranties, expressed or implied, including the warranties of merchantability and fitness for use, made by the exclusive distributor or representative for zirconia carbon sensors, except the expressed warranty against defects in material and workmanship described below.

Marathon Sensors Inc. (MSI), as manufacturer, warrants above to be free from defects in material and workmanship under normal use and service. MSI's obligation under this warranty is limited to replacing or repairing, at its option, zirconia carbon sensors herein listed, should failure occur within the warranty period. If premature failure occurs, the sensor, along with warranty claim form must be returned in the original shipping container to MSI. Upon receipt at MSI an examination shall disclose to its satisfaction the sensor to have been thus defective, at which time action will be taken.

There will be no applicable warranty in the event of breakage resulting from thermal or mechanical shock. Additionally, there will be no applicable warranty to a sensor which has been subject to misuse, negligence or accident. This warranty only applies to sensors being used at temperatures below 1850°F. At temperatures above 1850°F, the warranty is prorated as shown below. Any sensor is covered by the usage warranty as indicated from the date of installation

Operating Temperature	Warranty Length
Less than 1850°F	12 months
1850-1950°F	6 months
1950-2050°F	3 months
Above 2050°F	No warranty

This warranty will not be honored unless the warranty card is filled out and returned to MSI and only if installation is accomplished according to MSI's specifications and procedures as described in operating/instruction manuals. MSI shall in no way be liable for special or consequential damages.

Unpacking Your Sensor

Your sensor contains ceramic parts which can withstand high temperatures and harsh environments. These ceramics are also very fragile and the sensor must be handled with the utmost care from the time it is unpacked. Your sensor is shipped from Marathon Sensors Inc. in a package designed specifically to ensure the sensor's safety in transit to you. **<u>This package should be retained to facilitate any potential return of the sensor to MSI.</u>** Please note that the package consists of an outer box and two foam pads which support the sensor.

Follow these steps to remove sensor:

1. Place package on flat surface.

2. Cut tape from top of outer box.

3. Remove top layer of foam.

4. Carefully remove sensor.

5. Reassemble empty pack and hold for possible reshipment.

> Remember to fill out the registration card and drop it in the mail when you install your sensor. This extends your warranty to be the time in the furnace so that "shelf time" is not included.

Contents

Each pack contains the following components:

- ☐ Statement of Carbon Sensor Accuracy
- ☐ Sensor Assembly
- ☐ Operating Manual
- ☐ Warranty Registration Card
- ☐ Additional Fittings & Parts

On your sensor's head is a label which lists the sensor type, part number and serial number. Please refer to Figures 1-3 for diagrams of our most popular sensors which also show any additional fittings or accessories and installation requirements.

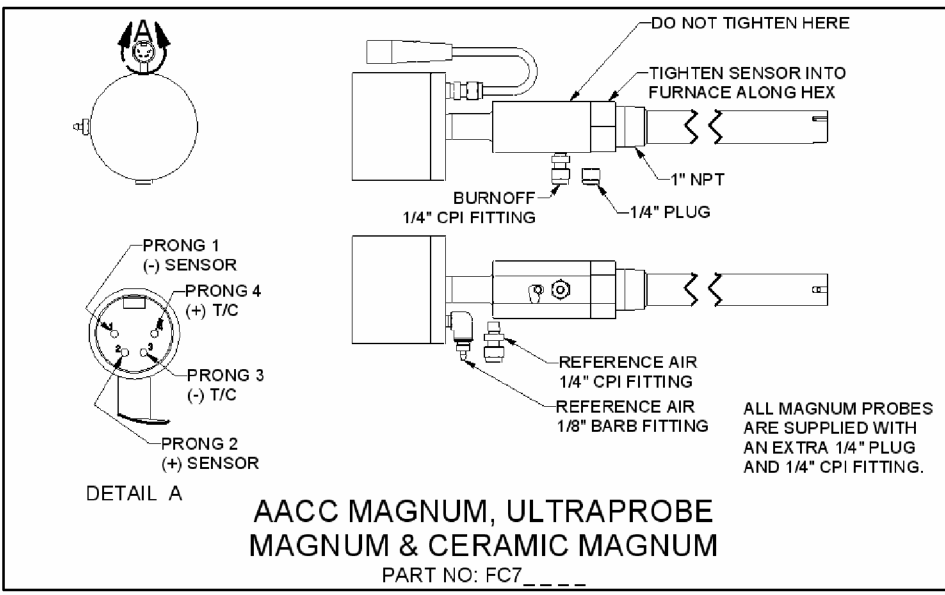


Figure 1

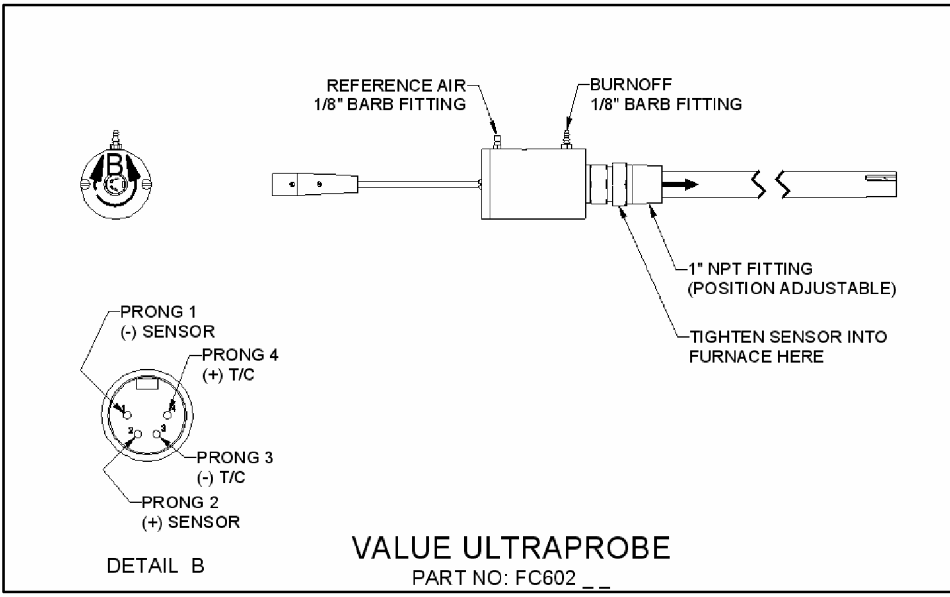


Figure 2

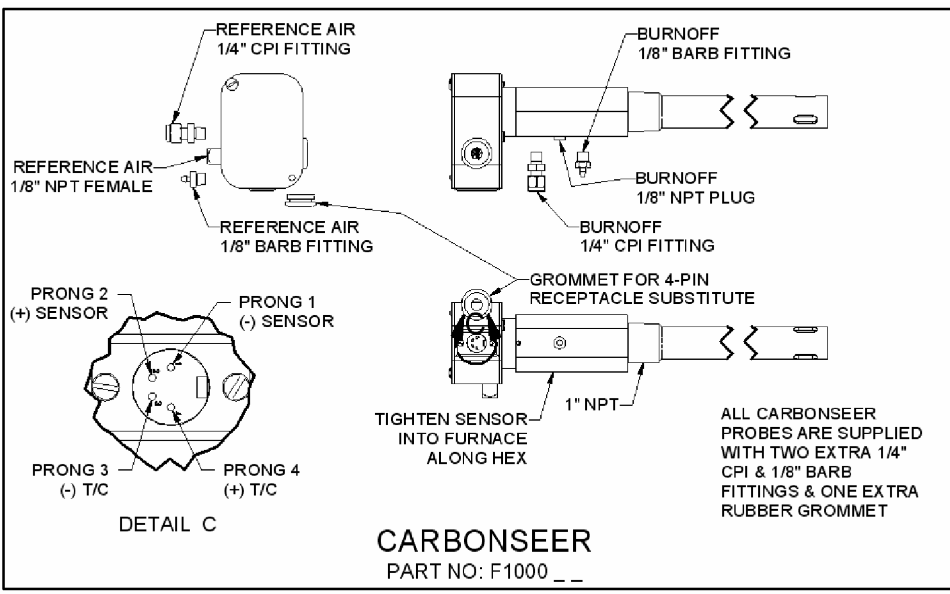


Figure 3

Installation Considerations

Remember these considerations when installing your sensor.

Location Considerations

- Locate sensor horizontally if possible.
- Locate sensor near furnace control thermocouple if possible.
- Locate sensor to avoid unnecessary close contact with heat sources (radiant tubes, heating elements) or fans.
- Locate sensor to avoid direct contact with inlet flow of carrier gas.
- When installed, the sensor should extend 2″ – 6″ (5 – 15 cm) beyond the hot face wall of the furnace.
- Locate sensor in the upper $^{1}/_{3}$ of work zone if possible.

Port/Fitting Considerations

- Some models are shipped with additional fittings as shown in Figures 1-3. Use the fittings that best suit your needs.
- Install sensor in furnace through access hole with minimum 1-$^{1}/_{2}$″ diameter minimum.
- Assure center lines of access hole and pipe coupling are concentric for correct line up.
- Assure gas-tight weld of pipe coupling to steel furnace shell.
- Assure connections on **ALL** external fittings adjacent to sensor are gas-tight.
- Teflon tape is preferred to other pipe dope compounds for sealing.

- Use the supplied Teflon-insulated, shielded signal cable for sensor signal connections. Observe correct polarity and connect the wire shield to the negative signal terminal at the sensor.

- Connect reference air tubing to reference air supply inlet fitting on sensor.

- Assure that reference air is flowing at sensor head (1 – 2 SCFH).

Insertion Requirements

- When inserting the sensor into the furnace, maximum insertion rate is $^1/_2$ inch per minute (1" per 2 minutes). Faster insertion may cause thermal shock and will void the warranty. A recommended method for achieving this rate is below.

Recommended Insertion Procedure

Mark the sheath of the sensor in 1" increments using a permanent marker. Insert the tip of sensor into furnace port to the point that the sensor will remain cantilevered in the furnace without assistance. Every two minutes, insert sensor one additional marking until fully inserted. Once inserted, thread the sensor into the fitting in the furnace wall, ensuring a gas-tight seal. Refer to Figures 1-3 for a permissible location to tighten the sensor with wrench.

Maintenance

Do not disassemble your sensor!

The carbon sensor which you have purchased requires no mechanical maintenance. Any attempt to dismantle it could cause irreparable damage and will invalidate the warranty.

Sensor Burnoff

A carbon sensor operates in a very harsh environment where carbon deposits (soot) often form on the sensor. As soot accumulates at the tip of the sensor, the sensing surface of the sensor is shielded from the furnace atmosphere. This results in false, elevated carbon readings which will cause the controller to reduce the flow of enriching gas, resulting in low carbon or decarburizing conditions.

This effect is amplified in processes using elevated carbon set points such as boost and diffuse carburizing. Additionally, the high nickel content in the protective sheath alloy, while adding resistance to high temperatures, also acts as a catalyst, accelerating the deposit of carbon on the sheath.

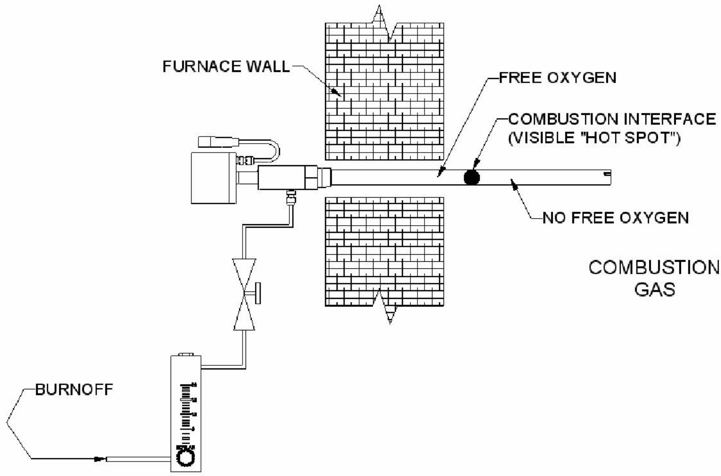
Fact: Over 80% of carbon probe electrode failures are due to excessive carbon buildup at the outer electrode.

Fortunately, removal of carbon deposits is as simple as running air through the "Burnoff" fitting supplied on all Marathon Sensors Inc. carbon probes.

Self-cleaning of carbon probes using air burnoff of accumulated carbon can be done successfully if the variables involved in the process are understood. The following items all contribute to the process, in order of importance:

- amount of air added for burnoff
- atmosphere circulation around the probe
- location and amount of carbon that has accumulated

When air is forced into the probe sheath (Figure 4) a combustion reaction between the air and the furnace atmosphere takes place. The location of this reaction will naturally settle at some equilibrium location. In some furnaces, it is possible to see exactly where this reaction is taking place by watching the probe sheath during burnoff. A "hot spot" will mark the location.



INSUFFICIENT BURNOFF
FLOW RATE

Figure 4

As the amount of air is changed, the location of the combustion interface can be changed. The higher the air flow, the further out in the probe sheath the interface will move (Figure 5). If enough air is added, the combustion reaction can actually be moved completely outside of the probe (Figure 6).

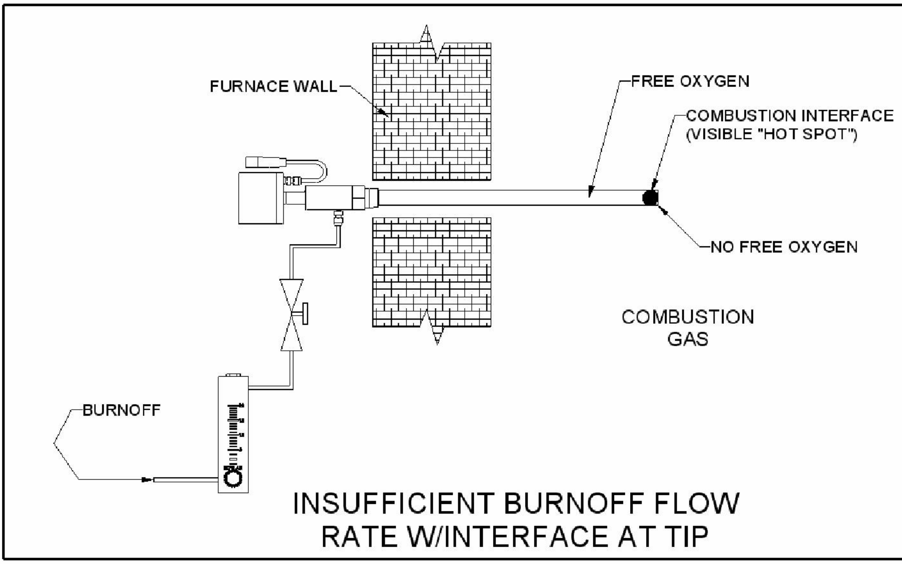


Figure 5

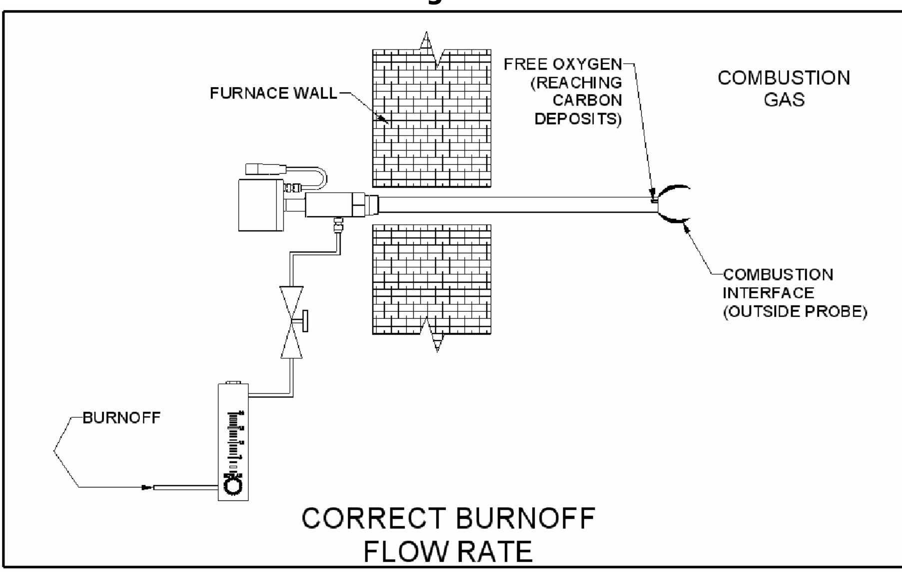


Figure 6

Note that the atmosphere in front of the interface does not contain significant amounts of free oxygen while the atmosphere behind the interface does. Removal of solid carbon is much more efficient if free oxygen is present to react with it. This means that enough air should be used to push the combustion interface at least to the probe electrode and preferably slightly beyond. To judge the free oxygen level, it is necessary to interpret the probe millivolt output. For example, at 1700°F, the following values apply:

O_2 mV	$\%O_2$
1150	9.9×10^{-19}
700	3.6×10^{-11}
100	.43

Table 1

A lower mV reading from the probe indicates how much burnoff air is reaching the tip. The mV will never reach a 0 mV level with process atmosphere present but it should drop significantly.

The amount of air required in a given installation depends heavily on the amount of circulation of furnace atmosphere around the probe. The higher the circulation velocity, the more air is required to get the interface out to the probe tip. One example noted that 20 CFH (9400 cc/min) was not enough to overcome the atmosphere circulation, yet when the furnace fan was shut off, less than 2 CFH (950 cc/min) was found to be adequate.

When the combustion reaction (burnoff) is centered at the probe tip, a rise of as much as 200°F may be observed in the probe thermocouple (T/C). Care must be taken to keep the probe tip below 1850°, or permanent damage may result. Determination of the required flow rate of burnoff air is estimated by plotting the flow rate of air versus the sensor's mV reading.

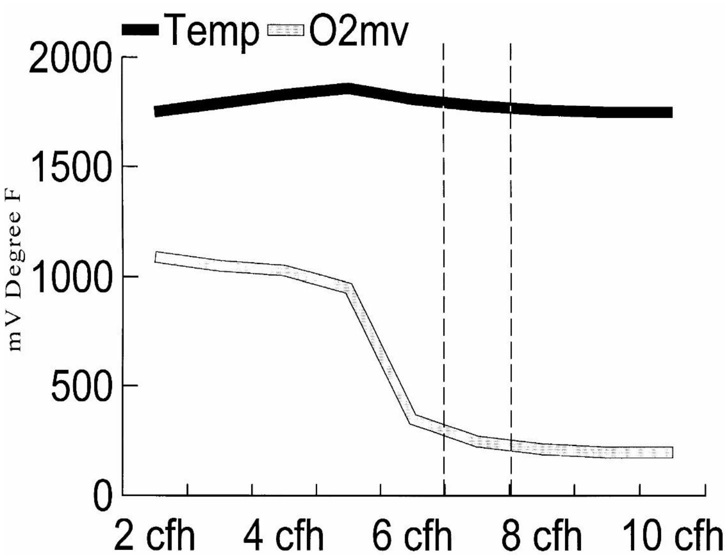


Figure 7

Figure 7 shows a typical example of data used to determine the flow rate of air required for burnoff. In this situation, a flow rate of 6-7 CFH would be selected because this provides a lower temperature as well as some free oxygen at the probe tip. If the amount of air required is found to be so high that interference with product processing is anticipated, the probe should be relocated to a spot that will offer less impingement from the atmosphere circulation system.

Probe burnoff duration is typically 3-6 minutes. The frequency of the operation depends upon the rate at which carbon is being accumulated. In continuous furnace applications, the burnoff process is run 3-6 times daily, while in batch applications, the burnoff should be done at the start of each cycle. To verify the effectiveness of the burnoff procedure, simply remove the probe after a burnoff and examine it.

Furnace Burnout

Continuous operation at high carbon levels and temperatures will cause damage to most furnace components, including your sensor. It is recommended that frequent gentle burnouts be conducted to avoid the cumulative effects of deposited carbon. “Gentle” burnouts are normally conducted at 1500-1600°F and can be monitored for completion by assuring that the carbon sensor output drops to 200 mV and increases to no more than 250 mV in the 15 minutes after burnout air is discontinued.

Electrode Impedance Test

It is important to track sensor impedance over a period of time to help determine the replacement schedule for the sensor. A high impedance (>50 kohm) indicates that the electrode contact on the sensor’s zirconia has deteriorated to a level that warrants replacement.

High sensor impedance results in a lower signal output from the sensor and an eventual failure of the electrode connection on the process side of the zirconia ceramic. This deterioration is more of a factor in highly reducing atmospheres where it may be necessary to check the impedance at least once a month. Under light reducing, annealing or brazing operations, the impedance may not have to be checked unless there is a question about the probe’s performance.

Typical impedance readings for a new probe are less than 1 kohm. As the probe starts to age, the impedance will increase. Once past 20 kohm, the sensor should be monitored more closely and above 50 kohm, the sensor should be replaced.

When it is necessary to replace a sensor with high impedance, remove it following the instructions supplied with the sensor. Do not discard the sensor as it is often possible to rebuild the sensor, provided the ceramic parts are intact. Contact MSI for information on rebuilding your sensor.

An impedance test can only be performed if the probe temperature is at or above 1100°F with stable atmosphere present. All Marathon instruments capable of performing this test will freeze all control functions and process signals during the test.

The sensor must be in a stable atmosphere condition where the mV output will not vary during the test. To test the impedance, a 10 kohm resistor is shunted across the sensor output. The sensor impedance is calculated using Formula 1.

$$R_x = \left(\frac{E_o}{E_s} - 1 \right) \cdot R_s \qquad (1)$$

R_x = sensor impedance
E_o = open circuit voltage of sensor
E_s = shunted voltage of sensor
R_s = shunt resistor's impedance (10 kohm)

Appendix A: Troubleshooting Your Probe

When there is a problem making consistent product in a carburizing furnace you must consider all the possibilities before replacing the carbon sensor. In many cases, using the sensor and the control instrument to troubleshoot the problem can lead to the actual solution without replacing working equipment, incurring extended down time, sensor damage and expense.

The following table lists typical problems encountered during the operation of a carburizing furnace when carbon levels are monitored or controlled using a carbon probe. In all cases, the last resort is to replace the probe, particularly if nothing has been done to try and troubleshoot the problem. It is necessary to consider all the components of the control system, including the control instrument, actuators and linkages, gas supply, furnace seals, burner integrity, as well as the carbon probe.

Table 2

Problem	Troubleshooting path
Carbon readings are always the same or consistently higher than typical carbon levels under normal furnace conditions.	Go to Burnoff Check.
Carbon readings are too low and/or do not change.	Go to Reference Air Check, Leak Check and Signal Check. Go to Furnace Check.
Carbon readings are erratic or carbon level keeps oscillating.	Go to Signal Level Check, Impedence Check. Go to Furnace Check.
Carbon readings drop drastically for short periods of time.	Go to Burnoff Check. Go to Furnace Check.
Carbon readings react with changes in the furnace but the load case depth is heavy or light.	Go to Process Factor Check.
There is no reference air flow.	Go to Reference Air Check.
There is no burnoff air flow.	Go to Burnoff Check.

Reference Air Check

1. Ensure that reference air source is providing clean room air that is free of airborne contaminates. Do not use compressed air unless it is free from oil and regulated to 2 PSI or less. If in doubt about the reference air source, try an alternative source.
2. If reference airflow is not 0.5-1.0 CFH (470 cc/min) on flow meter, ensure that airflow is getting to the sensor. Disconnect the reference air tube at the probe and see if tube will bubble in a cup of water and flow meter is working. If bubbles are present then reference air is definitely getting to the probe. If there is no flow when the tube is reattached to the probe, the reference air tubing in the sensor is blocked. Replace the sensor.

Leak Check

1. Put the control instrument in manual control mode and verify that the probe millivolt reading does not drop more than 5 mV. If the reading drops more than this it is probably due to a crack in the probe substrate and the probe should be replaced.
2. Stop the reference air flow to the probe and see if the mV reading from the probe drops more than 5 mV in 30 seconds. If this occurs then the probe substrate is cracked and should be replaced.

Burnoff Check

1. Perform a burnoff with the probe at 1500° minimum. The probe temperature should increase slightly (100°F) above the ambient furnace temperature and the probe millivolts should drop from pre-burnoff levels.
2. Check burnoff airflow. Verify that the burnoff event is active and that the burnoff solenoid is on. Verify that airflow is being supplied to the probe by doing the bubble test as described in "Reference Air Check." MAKE SURE THAT THE BURNOFF AIR AND REFERENCE AIR TUBES ARE CONNECTED TO THE CORRECT PORTS ON THE PROBE.
3. If all of the above is correct but the probe millivolts still do not drop, repeat the burnoff procedure at a more frequent interval.

If after a minimum of five burnoffs there is no change in the millivolt reading and proper response to carbon changes, remove the probe and inspect for heavy sooting. See Probe Replacement.

Impedance Check

1. Check the sensor's impedance with a minimum temperature of 1500°F. A good sensor's impedance should be between 0.1-50 kohm. If the impedance is above 50 kohm, the probe electrodes are failing and the probe should be replaced. If the impedance is good, check Process Factor or see Furnace Checks.
2. If the probe impedance is high during one test and low or normal during another test, check the connections between the instrument and the probe. If the impedance readings are still intermittent, see Probe Replacement.

Signal Level Check

1. If the carbon probe measurement system does, in fact, disagree with alternative measurement technique (e.g. Alnor Dewpointer, shim stock analysis), check the probe temperature and millivolt readings with the Percent Carbon chart (Table 2) and see Process Factor Check. If these values agree then go to the Furnace Checks.
2. If probe thermocouple display on instrument is not within ±25°F of furnace control thermocouple, make sure the instrument thermocouple type is set to the same thermocouple as the sensor thermocouple. If the reading is negative, check thermocouple connections. If the reading is >2300°F, check for an open or loose connection or open thermocouple.
3. Check the oxygen millivolt reading and ensure it agrees within ±6 mV of simultaneous readings from a digital voltmeter. Use a voltmeter with a 0.5% DC accuracy and 10 Mohm minimum input impedance. If the reading at the instrument is negative or zero, check for reversed, open or loose connections.
4. Connect a voltmeter directly to the probe lead wires. When the positive probe lead wire is disconnected from the probe terminal block, the reading on the voltmeter should not change more than 2 mV. If the reading does change, make sure that the signal cable shield is connected at only the instrument ground

and that the instrument has been properly grounded. Verify that the signal wire has not melted, been crushed or shorted between the leads, shield or ground. If the grounding and cable shield are good, verify that the instrument input is not loading down the probe signal. Connect the probe to another controller or change the input board on the controller. If the signal level still drops, go to the next step.

5. Short the probe millivolt terminals for 15 seconds. If the probe millivolt does not return to its original reading, ±10 mV, within 30 seconds as measured with one voltmeter, go to the Impedance Check.

Process Factor Check

1. Ensure that the process factor is set to an appropriate value. A typical process factor for a new probe in a methane based endothermic gas (20% CO) would be 150. The process factor would be 128 in a nitrogen-methanol system, but this is dependant on the ratio of methanol to nitrogen. In a pure methanol atmosphere, the theoretical process factor would be 85.
2. Increasing the process factor will lower the calculated percent carbon and cause the controller to increase the trim gas flow to the furnace. Decreasing the process factor will increase the calculated percent carbon and cause the controller to increase the trim air and/or decrease the trim gas. If the process factor has to be adjusted to very high (>800) or very low (<50) values, go to the Impedance Check.

Furnace Check

1. Try to determine if changes in the sensor carbon reading occur during other events on the furnace. For example, high carbon fluctuations may correspond to gas-fired burners coming during the early part of the heat cycle. This would indicate that there is a hole in a burner tube that is allowing raw methane into the furnace.
2. An air leak or a water leak on a water jacket may cause low carbon readings.
3. Check actuator operation or linkage if the control stays at a 0% or 100% output with no resulting change in carbon level.

4. Verify that the controller is moving the actuators properly by placing the controller in manual mode and changing the output from 0% to 100%..
5. Verify that the endo gas, trim gas and trim air lines are opened and that manually adjusted flow meters are fully open.
6. Verify that trim lines are not bypassed if this feature is available.

Probe Replacement

1. Always remove and insert a probe at $^1/_2$" per minute if furnace is hot. Even if the probe has been found at fault, always remove it at $^1/_2$" per minute. It is usually possible to rebuild a faulty probe, but if the substrate cracks as a result of thermal shock, the most expensive part of the probe must be replaced.
2. Ensure that the sensor sheath shows no significant accumulation of soot or other deposits.
3. Make sure that the main ceramic tube of the sensor is physically in tact.
4. Be sure that the sensor sheath is not is not warped.
5. Note the above conditions and the sensor's serial number. Call MSI for an RMA to test and possibly rebuild the probe.

Marathon Sensors Inc.
Percent Carbon Chart

mV	Temperature in °F								
	1500	1525	1550	1575	1600	1625	1650	1675	1700
1000	0.10	0.10	0.09	0.09	0.08	0.08	0.07	0.07	0.07
1005	0.11	0.11	0.10	0.09	0.09	0.08	0.08	0.08	0.07
1010	0.12	0.12	0.11	0.10	0.10	0.09	0.09	0.08	0.08
1015	0.14	0.13	0.12	0.12	0.11	0.10	0.10	0.09	0.09
1020	0.15	0.14	0.14	0.13	0.12	0.11	0.11	0.10	0.10
1025	0.17	0.16	0.15	0.14	0.13	0.13	0.12	0.11	0.11
1030	0.19	0.18	0.17	0.16	0.15	0.14	0.13	0.12	0.12
1035	0.21	0.19	0.18	0.17	0.16	0.15	0.14	0.14	0.13
1040	0.23	0.22	0.20	0.19	0.18	0.17	0.16	0.15	0.14
1045	0.25	0.24	0.22	0.21	0.20	0.19	0.17	0.16	0.16
1050	0.28	0.26	0.25	0.23	0.22	0.20	0.19	0.18	0.17
1055	0.31	0.29	0.27	0.26	0.24	0.22	0.21	0.20	0.19
1060	0.34	0.32	0.30	0.28	0.26	0.25	0.23	0.22	0.21
1065	0.38	0.35	0.33	0.31	0.29	0.27	0.26	0.24	0.23
1070	0.42	0.39	0.36	0.34	0.32	0.30	0.28	0.26	0.25
1075	0.46	0.43	0.40	0.37	0.35	0.33	0.31	0.29	0.27
1080	0.51	0.47	0.44	0.41	0.39	0.36	0.34	0.32	0.30
1085	0.56	0.52	0.49	0.45	0.42	0.40	0.37	0.35	0.33
1090	0.61	0.57	0.53	0.50	0.46	0.43	0.41	0.38	0.36
1095	0.67	0.63	0.58	0.54	0.51	0.48	0.44	0.42	0.39
1100	0.74	0.69	0.64	0.60	0.56	0.52	0.49	0.46	0.43
1105	0.81	0.75	0.70	0.65	0.61	0.57	0.53	0.50	0.47
1110	0.88	0.82	0.77	0.71	0.67	0.62	0.58	0.54	0.51
1115	0.97	0.90	0.84	0.78	0.73	0.68	0.63	0.59	0.55
1120	1.05	0.98	0.91	0.85	0.79	0.74	0.69	0.65	0.60
1125	1.14	1.06	0.99	0.92	0.86	0.80	0.75	0.70	0.66
1130	1.24	1.16	1.08	1.00	0.94	0.88	0.82	0.76	0.72
1135	1.34	1.25	1.17	1.09	1.02	0.95	0.89	0.83	0.78
1140	1.45	1.36	1.26	1.18	1.10	1.03	0.96	0.90	0.84
1145	1.56	1.46	1.37	1.28	1.19	1.11	1.04	0.98	0.91
1150	1.68	1.57	1.47	1.38	1.29	1.20	1.13	1.05	0.99
1155	1.81	1.69	1.58	1.48	1.39	1.30	1.22	1.14	1.07
1160	1.93	1.81	1.70	1.59	1.49	1.40	1.31	1.23	1.15
1165	2.06	1.94	1.82	1.71	1.60	1.50	1.41	1.32	1.24
1170	2.19	2.06	1.94	1.83	1.72	1.61	1.51	1.42	1.33
1175	2.33	2.20	2.07	1.95	1.83	1.72	1.62	1.52	1.43
1180	2.46	2.33	2.20	2.07	1.95	1.84	1.73	1.63	1.53
1185	2.60	2.46	2.33	2.20	2.08	1.96	1.85	1.74	1.64
1190	2.73	2.60	2.46	2.33	2.20	2.08	1.96	1.85	1.75
1195	2.87	2.73	2.59	2.46	2.33	2.21	2.08	1.97	1.86

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Percent Carbon Chart (cont)

mV	Temperature in °F								
	1500	1525	1550	1575	1600	1625	1650	1675	1700
1200	3.00	2.86	2.73	2.59	2.46	2.33	2.21	2.09	1.97
1205	3.13	2.99	2.86	2.72	2.59	2.46	2.33	2.21	2.09
1215	3.38	3.25	3.11	2.98	2.85	2.71	2.58	2.46	2.33
1220	3.50	3.37	3.24	3.11	2.97	2.84	2.71	2.58	2.46
1225	3.62	3.49	3.36	3.23	3.10	2.97	2.84	2.71	2.58
1230	3.73	3.60	3.48	3.35	3.22	3.09	2.96	2.83	2.70
1235	3.83	3.71	3.59	3.46	3.34	3.21	3.08	2.95	2.83
1240	3.93	3.82	3.70	3.58	3.45	3.33	3.20	3.07	2.95
1245	4.02	3.91	3.80	3.68	3.56	3.44	3.32	3.19	3.07
1250	4.11	4.01	3.90	3.79	3.67	3.55	3.43	3.31	3.18
1255	4.19	4.10	3.99	3.88	3.77	3.66	3.54	3.42	3.30
1260	4.27	4.18	4.08	3.98	3.87	3.76	3.65	3.53	3.41
1265	4.34	4.25	4.16	4.06	3.96	3.86	3.75	3.63	3.52
1270	4.41	4.33	4.24	4.15	4.05	3.95	3.84	3.73	3.62
1275	4.47	4.39	4.31	4.22	4.13	4.03	3.93	3.83	3.72
1280	4.53	4.45	4.38	4.30	4.21	4.12	4.02	3.92	3.81
1285	4.58	4.51	4.44	4.36	4.28	4.19	4.10	4.01	3.91
1290	4.63	4.56	4.50	4.43	4.35	4.27	4.18	4.09	3.99
1295	4.67	4.61	4.55	4.48	4.41	4.33	4.25	4.17	4.07
1300	4.71	4.66	4.60	4.54	4.47	4.40	4.32	4.24	4.15
1305	4.75	4.70	4.65	4.59	4.52	4.46	4.38	4.31	4.22
1310	4.78	4.74	4.69	4.63	4.57	4.51	4.44	4.37	4.29
1315	4.81	4.77	4.72	4.67	4.62	4.56	4.50	4.43	4.36
1320	4.84	4.80	4.76	4.71	4.66	4.61	4.55	4.48	4.41
1325	4.86	4.83	4.79	4.75	4.70	4.65	4.59	4.53	4.47
1330	4.89	4.86	4.82	4.78	4.74	4.69	4.64	4.58	4.52
1335	4.91	4.88	4.85	4.81	4.77	4.73	4.68	4.63	4.57
1340	4.93	4.90	4.87	4.84	4.80	4.76	4.72	4.67	4.61
1345	4.94	4.92	4.89	4.86	4.83	4.79	4.75	4.70	4.66
1350	4.96	4.94	4.91	4.88	4.85	4.82	4.78	4.74	4.69
1355	4.97	4.95	4.93	4.90	4.88	4.84	4.81	4.77	4.73
1360	4.99	4.97	4.95	4.92	4.90	4.87	4.84	4.80	4.76
1365	5.00	4.98	4.96	4.94	4.92	4.89	4.86	4.83	4.79
1370	5.01	4.99	4.98	4.96	4.93	4.91	4.88	4.85	4.82
1375	5.02	5.00	4.99	4.97	4.95	4.93	4.90	4.87	4.84
1380	5.03	5.01	5.00	4.98	4.96	4.94	4.92	4.89	4.86
1385	5.03	5.02	5.01	4.99	4.98	4.96	4.94	4.91	4.89
1390	5.04	5.03	5.02	5.00	4.99	4.97	4.95	4.93	4.90
1395	5.05	5.04	5.03	5.01	5.00	4.98	4.96	4.94	4.92