CARBON PROBE
Troubleshooting A

MANUAL #: 509

Revision #	Revision Date	Revision Description

THIS MANUAL IS SUPPLIED ELECTRONICALLY.

TECHNICAL ASSISTANCE

For all questions or concerns regarding the operation of the **Carbon Probe**, please consult the last page of this manual for contact information.

Table of Contents

1 INTRODUCTION

When there is a problem making consistent product in a carburizing furnace you must consider all the possibilities before replacing the oxygen 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. The system includes the control instrument, actuators and linkages, gas supply, furnace seals, burner integrity, as well as the carbon probe.

NOTE

All of the following tests assume that the oxygen sensor is operating above 1100°F and the process that is being read is stable.

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

2 REFERENCE AIR CHECK

Reference air consists of clean room air, free of airborne contaminants. Do not use compressed air. Try using an alternate source of reference air if in doubt.

Reference airflow is .5 to 1.0 CFH on flow meter, if not do next step.

Disconnected at 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 air is reattached to the probe, the reference air tubing in the probe is blocked. Replace the probe.

3 LEAK CHECK

Put the control instrument in manual control mode and verify that the probe millivolt reading is stable. Shut off the reference air for 30 seconds. 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.

4 BURN OFF CHECK

Do a probe burnoff check with probe at 1500°F minimum. The probe temperature should increase slightly (100°F) above ambient furnace temperature and the probe millivolts should drop from pre-burnoff levels. If these responses do not occur, check the burnoff air flow. Verify that the burnoff event is active and that the burnoff solenoid is on. Verify that air flow is being supplied to the probe (See Reference Air Check). **MAKE SURE THAT THE BURNOFF AIR AND REFERENCE AIR TUBES ARE CONNECTED TO THE CORRECT PORTS ON THE PROBE**.

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.

5 IMPEDANCE CHECK

Do a probe impedance check with probe at 1500°F minimum. A good probe impedance should be between 0.1 Kohm to 20 Kohm. If the impedance is above 20 Kohm, the probe electrodes are failing, and the probe should be replaced. If the impedance is good check Process Factor or see Furnace Checks.

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. Replace the probe if the impedance readings are still intermittent. See Probe Replacement.

6 SIGNAL LEVEL CHECK

Oxygen 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 below and see Process Factor Check. If these values agree then go to the Furnace checks.

Probe thermocouple display on instrument is within ±25°F of furnace control thermocouple. If not, make sure the instrument thermocouple type is set to the same thermocouple as the probe thermocouple. If reading is negative, check thermocouple connections. If reading is > 2300°F check for an open or loose connections or open thermocouple.

O_2 mV reading on instrument agrees within ±6 mV of simultaneous readings from a digital voltmeter. Use a voltmeter with a 0.5% DC accuracy and a 10 Mohm minimum input impedance. If the reading at the instrument is negative or zero, check for reversed, open or loose connections.

Connect a voltmeter directly to the probe lead wires. When the positive probe lead wire is disconnected from probe terminal block the reading on voltmeter should not change more than 2 mV. If the reading does change, make sure the signal cable shield is connected at only the instrument ground and that the instrument is properly grounded. Verify that the signal wire has not melted, been crushed, or is shorted between the leads, the shield, or ground. If the grounding and cable shielding is 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.

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

7 PROCESS FACTOR CHECK

Process factor is set to 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.

Increasing the process factor will lower the calculated % carbon and cause the controller to increase the trim gas flow to the furnace. Decreasing the process factor will increase the calculated % 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 (>500) or very low (<50) values, go to the Impedance Check.

8 FURNACE CHECK

Try to determine if changes in the probe 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.

An air leak or a water leak on a water jacket may cause low carbon readings.

Check actuator operation or linkage if the control stays at a 0% or 100% output with no resulting change in carbon level.

Verify that the controller is moving the actuators properly by placing the controller in manual mode and changing the output from 0% to 100%.

Verify that the endo gas, trim gas, and trim air lines are opened and that manually adjusted flow meters are fully open.

Verify that trim lines are not by-passed if the feature is available.

9 PROBE REPLACEMENT

Always remove and insert a probe at ½" inch per minute if furnace is hot. Even if the probe has been found at fault always remove it at the ½" inch per minute rate. 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.

Probe/Sheath combination shows no significant accumulation of soot or other deposits.

Probe main ceramic tube is physically intact.

Integral protection sheath is not warped.

Note the above conditions and the probe serial number. Call UPC-Marathon. for an RMA to test and possibly rebuild the probe.

9.1 MV

Percent Carbon Chart									
Temperature in F									
MV	**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

Percent Carbon Chart									
Temperature in F									
MV	**1500**	**1525**	**1550**	**1575**	**1600**	**1625**	**1650**	**1675**	**1700**
1195	2.87	2.73	2.59	2.46	2.33	2.21	2.08	1.97	1.86
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

9.2 MV

Percent Carbon Chart									
Temperature in F									
MV	**1500**	**1525**	**1550**	**1575**	**1600**	**1625**	**1650**	**1675**	**1700**
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

Percent Carbon Chart									
Temperature in F									
MV	**1500**	**1525**	**1550**	**1575**	**1600**	**1625**	**1650**	**1675**	**1700**
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

Note: Chart assumes a PF of 150 and 20% CO in a methane based endothermic atmosphere.

10 CUSTOMER SUPPORT

Americas	Asia	Europe
support.na@upc-marathon.com **USA**: +1 414 462 8200 **Canada**: +1 514 335-7191	service@mmichina.cn **Shanghai:** +86 21 3463 0376 **Beijing:** +86 10 8217 6427	support.eu@upc-marathon.com **France**: +33 3 81 48 37 37 **Germany**: +49 7161 94888-0 **Poland**: +48 32 296 66 00

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