CARBON SENSOR TROUBLESHOOTING

by Stephen Thompson

Technical Data

There are several key components in all atmosphere control systems. When a difficulty arises, it is important to identify the cause with a minimum of effort and expended time. The procedure that follows is designed to aid in that process.

INTRODUCTION

The starting point for any troubleshooting procedure is to properly identify the symptom that necessitates it. The cause of the symptom can often be elicited by answering some preliminary questions.

Is this a startup problem, or has the system been operating under control? If this is a startup problem, it is necessary to establish that all system components have been properly connected and configured for the application.

If the system has been operating properly and there has been either a gradual or sudden change in the control performance, it may conceivably be a problem with the probe. In order to establish the correct performance of a carbon sensor, **resist the temptation to remove the probe from the furnace.** All of the tests outlined here must be done while the sensor is located in the furnace, at temperature, and exposed to a reducing atmosphere. This procedure can be performed on the SSi Gold Probe and on most other manufacturer's sensors. We strongly recommend that you call us at 800-666-4330 before you remove the probe.

NOTE: IF YOU HAVE ALREADY REPLACED THE PROBE AND THE PROBLEM PERSISTS.....THE PROBE MAY NOT BE THE PROBLEM!

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PROCEDURE

Does a shim stock analysis, a 3-gas analysis (SSi PGA300 / PGA3500) or a dew point analysis (SSi DP2000) verify the indicated % Carbon value (based on the probe O2 millivolts and probe temperature) from the probe? If the % Carbon values are close to the same, the problem is not likely the Gold Probe. If the temperature or % Carbon values are not similar, continue with the following steps:

1. Verify that both probe cable (mV) and the T/C extension wire between the sensor and the controller are clean and connected firmly to the Gold Probe and AC20 (or atmosphere) controller terminals. Verify polarity.

2. Verify that the reference air supply is connected to the reference air fitting. This will be the fitting closest to you when you face the probe. It has been found that on occasion the reference air has been connected in error to the burnoff fitting, causing low readings. Burnout fitting should be "CAPPED" if you are NOT burning out probe.

3. Check that the reference air is flowing. Disconnect the air supply at the probe and submerge it in a cup of water. Bubbles verify the flow.

4. Verify that no air is flowing into the burnoff fitting by submerging the burnoff tubing in a cup of water. (Flow can occur if the burnoff air pump is subject to external vibration.)

5. **<u>Leak test-</u> This test should be done when the probe millivolts are steady state (toward the end of a soak cycle).** The test can detect a cracked or broken substrate in your Gold Probe. Verify that reference air is flowing at 0.5 to 2.0 cfh. **WRITE DOWN** the millivolts observed either on the atmosphere controller or the volt meter. Disconnect or turn off the reference air for 1 ½ - 2 minutes and **WRITE DOWN** the Gold Probe millivolts once again. If the difference is greater than 20 mV's the probe substrate is leaking. Turn the reference air back on.

6. Is the atmosphere controller **COF** set to the proper value? This factor is referred to by other descriptions such as Process Factor, Furnace Factor, CO Factor, Circulation Factor, Gas Factor, or Calibration Factor. The factor may require adjustment to eliminate any offset or discrepancy between the indicated carbon potential and the actual achieved result in the work pieces or shim stock

7. Do the probe temperature and mV output (after disconnecting one of the probe leads and one of the T/C leads) when measured by an independent digital voltmeter agree with the indicated probe mV's and temperature mV's on the controller. If not, there is most likely a controller calibration problem or a cable problem. (Disconnecting the leads eliminates the possibility of a "loading" effect on the voltmeter.

8. Short the + / - probe terminals for 5 seconds. Does the Gold Probe mV signal return to within 10mV of it's original value in 1 minute as measured by a digital voltmeter? If it does not, go to step 10.

9. <u>Probe impedance (resistance) test-</u> this is one of several electrical tests that determine the electrical integrity and reliability of the Gold Probe. Some contemporary controllers can perform it. If yours does not, conduct this simple test: at process temperature, disconnect the controller cable at the Gold Probe mV output and measure the mV value with a VOM. Then shunt the signal with a 100 kilohm resistor. After 10 seconds, read the new mV value, divide the original value by the new value, subtract 1 from the result and multiply by the value of the shunt resistor (=100). The calculated value is the sensor resistance in kilohms, which should be less than 25 kilohms…. See chart below

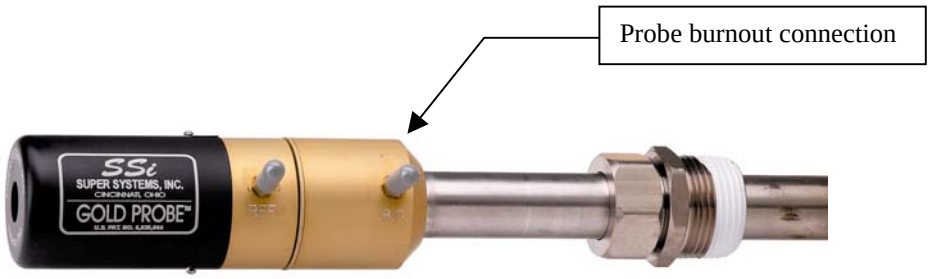
Temperature	K-Ohms
1500 F.	Less than 25 K Ohms
1700 F.	Less than 10 K Ohms

10. Guidelines for SSi Gold Probe Burnout

A. Duration of the burnout should NOT EXCEED 90 seconds to avoid excessive heating of the probe and process upsets.
B. Frequency of burnout (these are guidelines)
    a. Neutral hardening furnaces (0.10 – 0.50 % C) – Once every 24 hours for 60 to 90 seconds
    b. Typical carburizing as shown on the chart (on the next page) for non saturation – NO more than twice a day
    c. Saturation carburizing (the "gray" area of the chart on the next page) – call SSi (513-772-0060)
C. Furnace types (continuous versus batch)
    a. I/Q batch furnaces – inner door limit switch burnout activation – if more frequent than the recommendation above – shorten the burnout time to 45 – 60 seconds
    b. Continuous furnaces – Once per day recommended. Do not exceed every 12 hours.
D. Probe burnout air flow
    a. There should be enough airflow to move the "flame" outside the probe. Typically 10 to 20 SCFH
    b. There should be enough airflow to reduce the probe millivolts below 200 mV's
    c. This may require the furnace fan to be turned "OFF" for the duration of the burnout, remember NO MORE than 90 seconds
    d. The probe burnout airflow might cause the temperature of the probe to rise – this should not exceed 50 – 100 degrees F. greater than the current furnace temperature. The less the rise in temperature, the better.

When troubleshooting a probe, repetitive burnouts are OK but should only be done with an empty furnace. To maximize the burnout result, turn off the furnace fan for 60 seconds during these burnouts.

See chart on next page for saturation information



Chart

Carbon	1400	1425	1450	1475	1500	1525	1550	1575	1600	1625	1650	1675	1700	1725	1750
0.05	957	959	961	963	965	967	968	970	972	974	976	978	979	981	983
0.10	989	991	993	996	998	1000	1002	1005	1007	1009	1011	1014	1016	1018	1020
0.15	1007	1010	1012	1015	1018	1020	1023	1025	1028	1030	1033	1035	1038	1040	1043
0.20	1021	1024	1026	1029	1032	1034	1037	1040	1042	1045	1048	1050	1053	1056	1059
0.25	1031	1034	1037	1040	1043	1046	1048	1051	1054	1057	1060	1063	1065	1068	1071
0.30	1040	1043	1046	1049	1052	1055	1058	1061	1064	1067	1070	1073	1076	1078	1081
0.35	1048	1051	1054	1057	1060	1063	1066	1069	1072	1075	1078	1081	1084	1087	1090
0.40	1054	1057	1061	1064	1067	1070	1073	1076	1079	1082	1086	1089	1092	1095	1098
0.45	1060	1063	1067	1070	1073	1076	1079	1083	1086	1089	1092	1096	1099	1102	1105
0.50	1065	1069	1072	1075	1079	1082	1085	1089	1092	1095	1098	1102	1105	1108	1112
0.55	1070	1074	1077	1080	1084	1087	1091	1094	1097	1101	1104	1107	1111	1114	1117
0.60	1075	1078	1082	1085	1089	1092	1095	1099	1102	1106	1109	1113	1116	1119	1123
0.65	1079	1083	1086	1090	1093	1097	1100	1104	1107	1110	1114	1117	1121	1124	1128
0.70	1083	1087	1090	1094	1097	1101	1104	1108	1111	1115	1119	1122	1126	1129	1133
0.75	1087	1091	1094	1098	1101	1105	1108	1112	1116	1119	1123	1126	1130	1134	1137
0.80	1091	1094	1098	1102	1105	1109	1112	1116	1120	1123	1127	1131	1134	1138	1141
0.85	1094	1098	1101	1105	1109	1112	1116	1120	1123	1127	1131	1134	1138	1142	1146
0.90	1097	1101	1105	1109	1112	1116	1120	1123	1127	1131	1135	1138	1142	1146	1149
0.95	1101	1104	1108	1112	1116	1119	1123	1127	1131	1134	1138	1142	1146	1149	1153
1.00	1104	1107	1111	1115	1119	1123	1126	1130	1134	1138	1142	1145	1149	1153	1157
1.05	1107	1110	1114	1118	1122	1126	1130	1133	1137	1141	1145	1149	1153	1157	1160
1.10	1109	1113	1117	1121	1125	1129	1133	1137	1141	1144	1148	1152	1156	1160	1164
1.15	1112	1116	1120	1124	1128	1132	1136	1140	1144	1148	1151	1155	1159	1163	1167
1.20	1115	1119	1123	1127	1131	1135	1139	1143	1147	1151	1155	1159	1162	1166	1170
1.25	1118	1122	1126	1130	1134	1138	1142	1146	1150	1154	1158	1162	1166	1170	1174
1.30	1120	1124	1128	1132	1136	1140	1144	1149	1153	1157	1161	1165	1169	1173	1177
1.35	1123	1127	1131	1135	1139	1143	1147	1151	1155	1159	1164	1168	1172	1176	1180

Darker area is “theoretical” carbon saturation

11. If the problem is not corrected by probe and/or furnace burnout as described in the Gold Probe Manual and your system manual, and the problem is a faulty probe, contact SSi at (800) 666-4330 and describe your problem to our technician. You may then request a Returned Material Authorization for repair or replacement of your Gold Probe.
12. **WARNING-** even though you suspect a faulty sensor, **do not** remove your Gold Probe from a hot furnace at a rate faster than 2 inches per minute. Cool the sensor on an insulating medium to avoid thermal shock. This will prevent damage that is expensive to repair.

Our technical support staff is available Monday – Friday, 7:00 a.m.to 6:00 p.m. EST to assist you and answer your atmosphere control problems.

Revision	Description	Date
A	Original Issue	
B	Revised – Added Saturation Chart	January 26, 2007

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Notes:

SSi SUPER SYSTEMS INC.
7205 Edington Drive ● CINCINNATI, OH 45249
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