CARBON SENSOR
Zirconia Tip

Operations Manual

Carbonseer-M™

QuickSilver™

Version# 14

Manual #: 027

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Toll-Free North America +1-800-547-1055

upc.support@group-upc.com

www.group-upc.com

Contents

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. Call UPC for an RMA number - Tel: 513 772 1000

3. Enclose the claim form with the sensor intact and in the original packaging and return to:

   United Process Controls
   8904 Beckett Road
   West Chester, OH 45069

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.

United Process Controls Inc. (UPC), as manufacturer, warrants above to be free from defects in material and workmanship under normal use and service. UPC'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 UPC. Upon receipt at UPC 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 UPC and only if installation is accomplished according to UPC's specifications and procedures as described in operating/instruction manuals. UPC 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 United Process Controls Inc. in a package designed specifically to ensure the sensor's safety in transit to you. **This package should be retained to facilitate any potential return of the sensor to UPC.** 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.*
- *If your sensor is not operating properly, please contact your Local UPC representative before removing the sensor. There may be trouble shooting technique only accomplished while the sensor is still installed to alleviate the problem.*


Each pack contains the following:
☐ Statement of Carbon Sensor Accuracy
☐ Sensor Assembly
☐ Operating Manual
☐ Warranty Registration Card
☐ Additional Fittings & Parts

On your sensor's head is the sensor type, part number, and serial number. Please refer to the Sensor Drawing which will show additional fittings and accessories.

SPECIFICATION

Carbon Potential Range	0.10% to 1.4%
Output in normal heat treating	1000 to 1200 mV DC
Normal operating temp	1400°F to 1850°F *SEE WARRANTY CARD*
MIN operating temp	1150 °F
Sensor cover temp limit	200 °F max.
Sensitivity	0.02 mV or .0025% C
Accuracy	±0.03% C
Stability	±1 mV over sensor life
Response time	Less than 1 second
Impedance	Less than 6 K ohm
Sensor construction	Stabilized zirconia solid electrolyte; patented alloy electrode
Sensor thermal shock	Caution is advised, outer alloy sheath protects ceramic zircon tube.
Sensor Life	About 2 years with normal use
Warranty	1 year usage, non-prorated
Serviceability	No field service required, rebuildable at factory with substanti savings
Reference air requirement	0.2 to 0.5 MAX SCFH filtered air *SEE REFERENCE AIR INSTALLATION*

SENSOR DRAWING – CARBONSEER-M
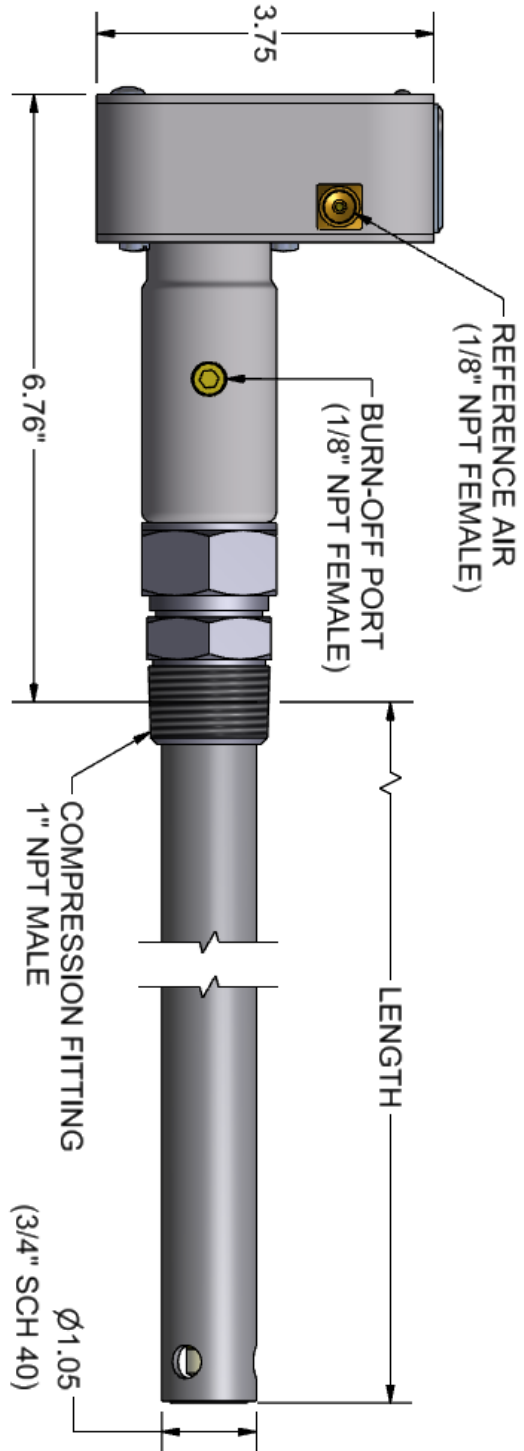
ALL CARBONSEER PROBES
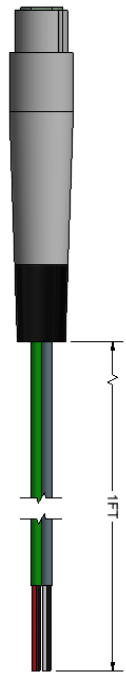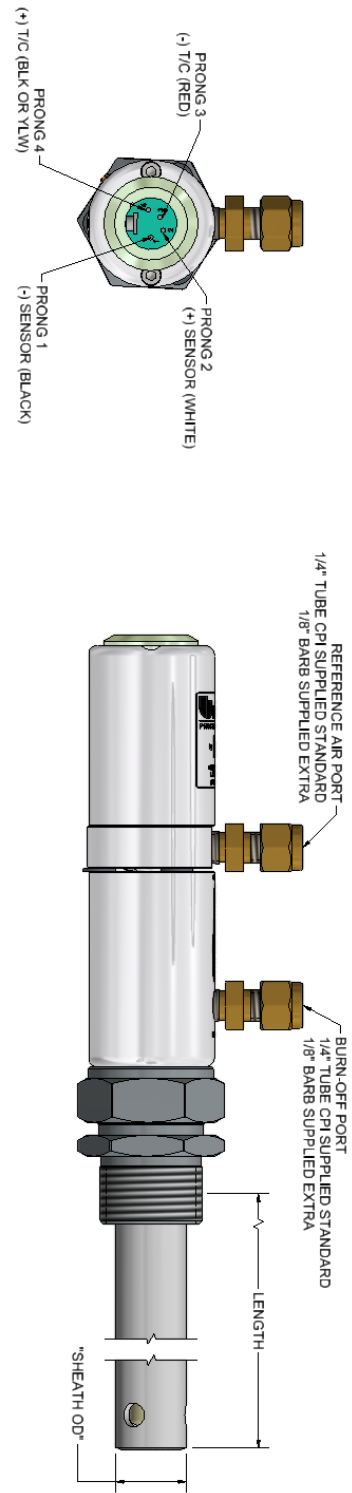ARE SUPPLIED WITH:
(2) 1/4" CPI FITTINGS
(2) 1/8" BARB FITTINGS
(1) RUBBER GROMMET

3.75

6.76"

REFERENCE AIR
(1/8" NPT FEMALE)

BURN-OFF PORT
(1/8" NPT FEMALE)

COMPRESSION FITTING
1" NPT MALE

LENGTH

Ø1.05
(3/4" SCH 40)

PRONG 1
(-) SENSOR (BLACK)

PRONG 2
(+) SENSOR (WHITE)

PRONG 3
(-) T/C (RED)

PRONG 4
(+) T/C (BLACK)
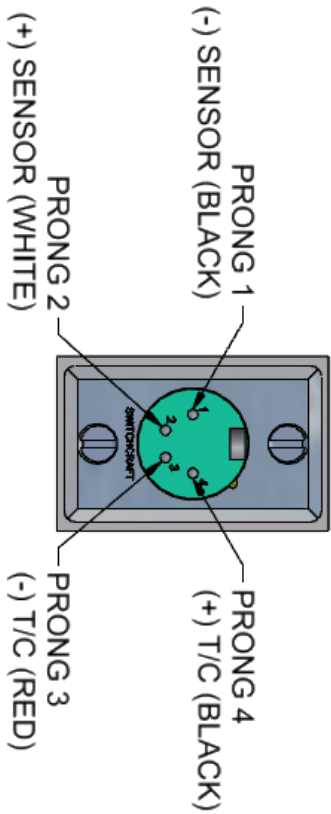
SENSOR DRAWING – QUICKSILVER FAMILY

PRONG 3
(-) T/C (RED)

PRONG 4
(+) T/C (BLK OR YLW)

PRONG 1
(-) SENSOR (BLACK)

PRONG 2
(+) SENSOR (WHITE)

CA1 CABLE 1FT ASSEMBLY
SUPPLIED STANDARD
SENSOR (GREY), T/C (GREEN 'R' & 'S', YELLOW 'K')
EXTENDED LENGTH ASSEMBLES AVAILABLE (10FT INCREMENTS)
REFERENCE AIR TUBING OPTIONAL

1FT

PART	MODEL	Part Table	SHEATH OD
FC5	QUICKSILVER-XT		1.05" OD PIPE 3/4" SCH40
FC6	QUICKSILVER		0.84" OD PIPE 1/2" SCH40

.13 NPTM RELIEF VALVE
Opening Pressure .09-.20 PSI

1-11.5 NPT
3/4" NPT OPTIONAL
WITH 0.84" OD 1/2" PIPE
FC6 & FC8 PROBES ONLY

COMPRESSION FITTING
FOR DEPTH ADJUSTMENTS

REFERENCE AIR PORT
1/4" TUBE CPI SUPPLIED STANDARD
1/8" BARB SUPPLIED EXTRA

BURN-OFF PORT
1/4" TUBE CPI SUPPLIED STANDARD
1/8" BARB SUPPLIED EXTRA

LENGTH

"SHEATH OD"
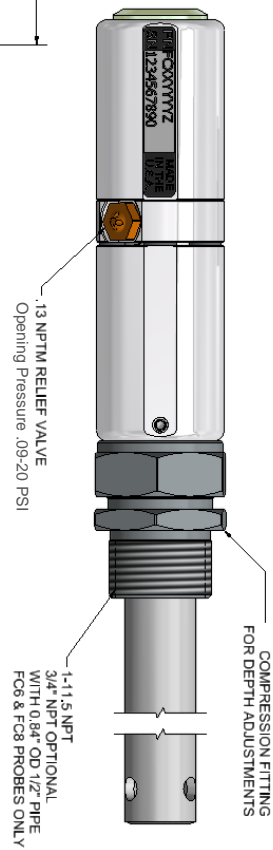
CONNECTION CABLE ASSEMBLIES

All new installations will require the purchase of an installation cable. Connection cables can be orders in preassembled, 10ft increments (10ft, 20ft... 100ft), for the EMF and Thermocouple sensor outputs. Using the table below, pick your sensor type, desired length (in Feet), and sensor thermocouple type.

CA1 = Carbonseer-M & Quicksilver Sensors (FC2, FC3, FC5, FC6, FC7, FC8)
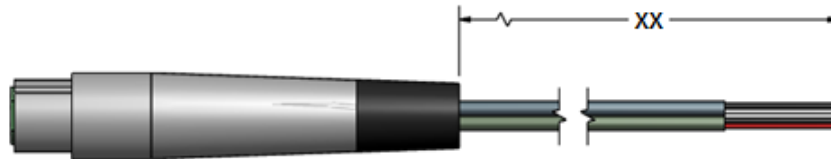
CA1 CABLE ASSEMBLY

Cable Part # CAX-XX-Y-Z	CAX	-XX	-Y	-Z
Sensor Cable Type				
Carbonseer & QuickSilver	CA1			
Cable Length				
FT M				
10 3.0		10		
20 6.1		20		
30 9.1		30		
40 12.2		40		
50 15.2		50		
TC Type				
NO Thermocouple			-X	
Thermocouple Type B			-B	
Thermocouple Type K			-K	
Thermocouple Types R & S			-RS	
Modification				
(BLANK FOR STANDARD BUILD)				

*Longer lengths are available
*Example: FC60600S QuickSilver, Type S thermocouple, 80ft cable is required: CA1-80-RS

INSTALLATION CONSIDERATIONS

Remember these considerations when installing your sensor.

LOCATION CONSIDERATIONS

- ➢ Locate sensor near parts/work zone to get a meaningful reading.
- ➢ 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.
- ➢ Installation depth, the sensor should extend 2" – 6" (5 – 15 cm) beyond the hot face wall of the furnace.
  - ▪ Installations that exceed the 6" (15 cm) depth beyond the hot furnace wall will have an increase in sag (creep). Over time this will cause the sensor to fail prematurely.
- ➢ Locate sensor in the upper 1/3 of work zone if possible.
- ➢ If installing the sensor in areas which vibration may occur (e.g. in furnace covers or fan assemblies), the sensor must be inserted into a protection tube with mineral fiber packing around the sheath as a damper.

PORT FITTING CONSIDERATIONS
- ➢ Models are shipped with additional fittings as shown in the Sensor Drawings. Use the fittings that best suit your needs.
- ➢ Install sensor in furnace through an access hole with minimum of 1½" diameter.
- ➢ 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.

REFERENCE AIR INSTALLATION

In order for your sensor to function properly, reference air (20.9% O_2) must be supplied to the inner zirconia electrolyte tip. A .13 NPTM relief valve(opening pressure .09-20 psi) has been added to the head of the sensor to protect from over pressurizing the sensor and also allows accurate flow to the tip of sensor. The flow and quality of the ref air is critical for very important reasons:

1. Carbon potential (C_p) and O_2 calculations

2. O_2 leaks into the process, lowering the Sensor mV signal and artificially lowering C_p levels

3. The reference air flow must be between 0.2 – 0.5 SCFH with a reference air pressure (P_R) of 1.0 – 3.0 inH_2O and equal to or less than the process pressure (P_P).

4. Reference air must be filtered free of contaminants and water in order to eliminate contaminants from reaching the inner electrode, impeding the sensor output.
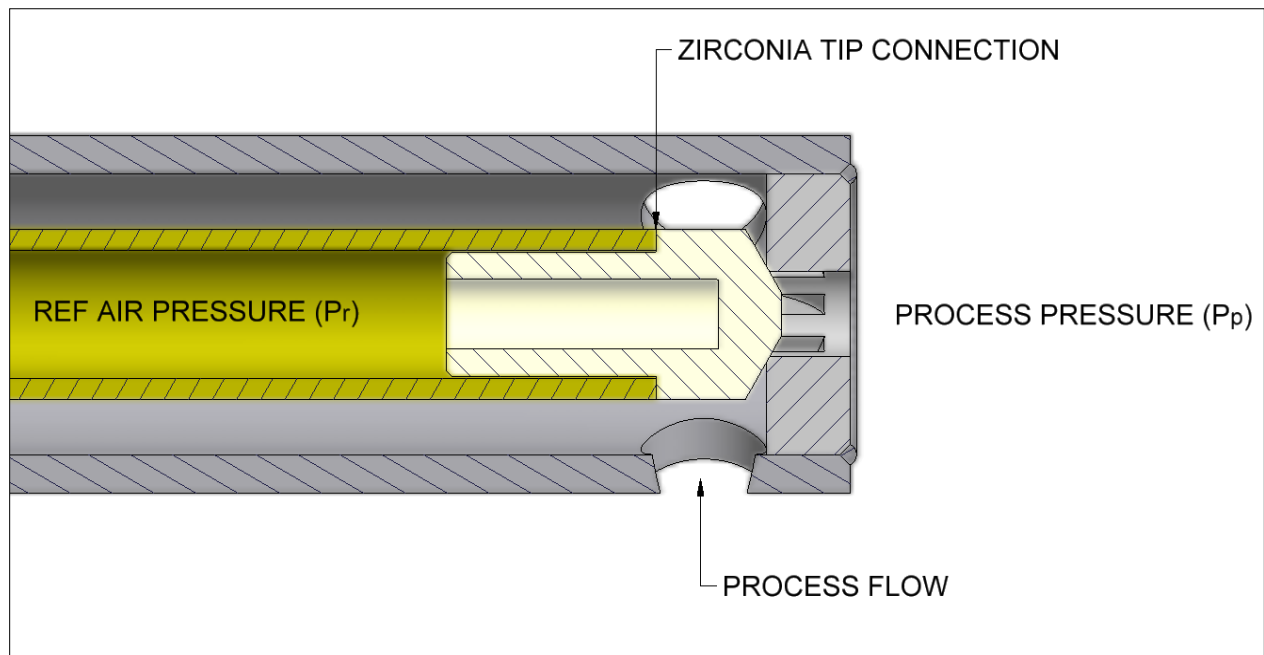
The process pressure (P_p) must match the ref air pressure (P_r) or be slightly greater in order to prevent false High levels of O_2 in the process. High levels of O_2 will correlate to low C_p levels and high Dew Point temperatures.

RECOMMENDED INSERTION/REMOVAL PROCEDURE

- Mark the sheath of the sensor in 1" increments using a permanent marker.
- Insert the (Teflon tape) coated NPT body of the compression fitting into the furnace port and tighten accordingly ensuring a gas-tight seal.
- Place the CPI fitting and ferrule over the body of the sensor.
- Insert the tip of sensor into furnace port 6" deep initially to fully support the sensor. Allow the tip to heat up for 5 minutes.
- Insert carefully and slowly in one motion at 1/2" per second MAX. Use the 1" markings as a visual aid while inserting the sensor. If you are inserting at the correct rate, the 1" markings will insert every 2 seconds.
- Once the sensor is inserted to the desired depth, tighten the compression fitting accordingly ensuring a gas tight seal.
- Remove in the same manner. Place the sensor in an insulated blanket, once completely removed, and allow the sensor to cool to room temperature.

MAINTENANCE

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 sensor 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 United Process Controls Inc. carbon sensors.

Self-cleaning of carbon sensors 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 sensor

- location and amount of carbon that has accumulated

When air is forced into the sensor burnoff system, a combustion reaction between the air and the furnace atmosphere takes place. When air is added, the combustion reaction moves completely outside of the sensor (Figure 1). This process ensures sensor duration and accuracy by removing carbon buildup on the conducting cell.
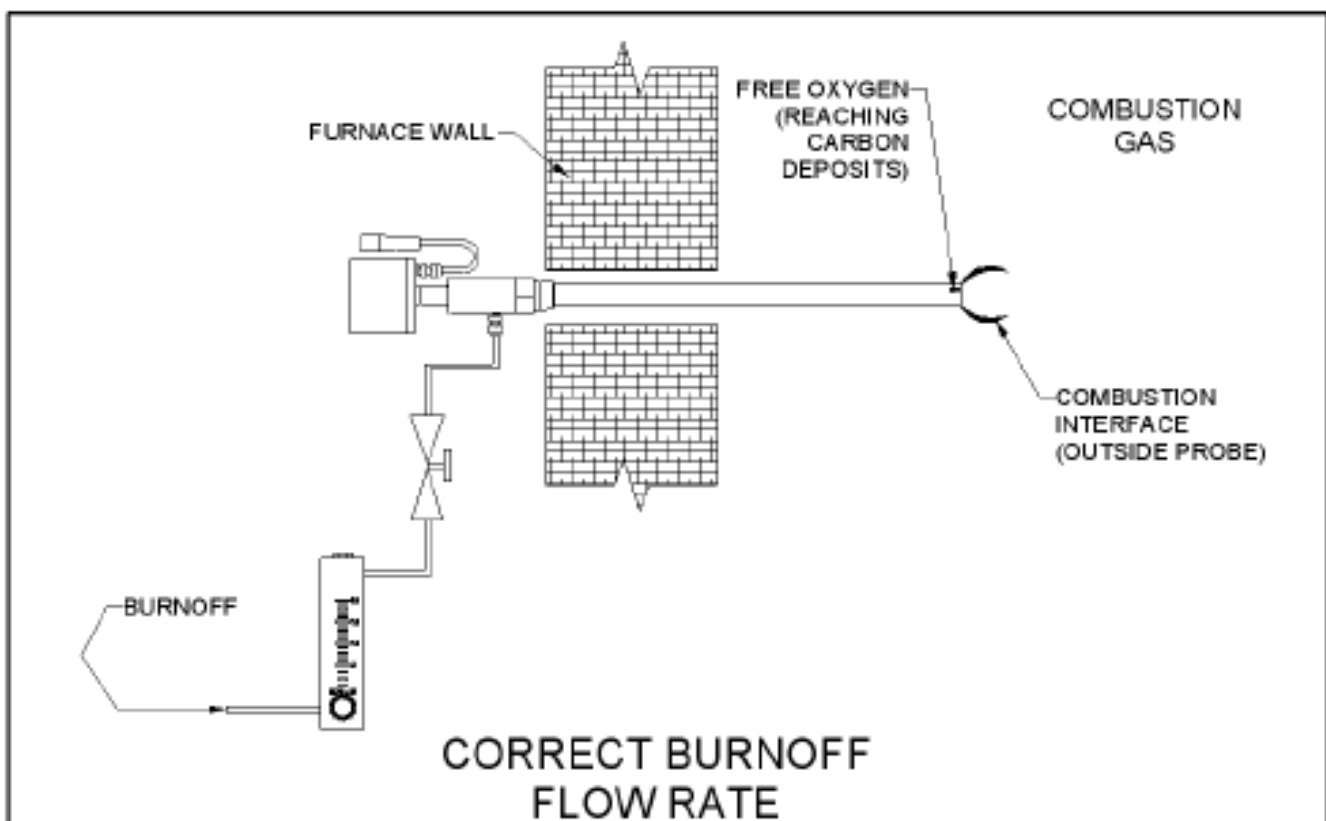

Figure 1

Removal of solid carbon is much more efficient if free oxygen is present to react with it. To judge the free oxygen level, it is necessary to interpret the sensor mV 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	0.43

Table 1

A lower mV reading from the sensor 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 sensor. The higher the circulation velocity, the more air is required. One example noted that 20 SCFH (9400 cc/min) was not enough to overcome the atmosphere circulation, yet when the furnace fan was shut off, less than 2 SCFH (950 cc/min) was found to be adequate.

When the combustion reaction (burnoff) is centered at the sensor tip, a MAX rise of 100°F may be observed in the sensor thermocouple (T/C). Do not exceed a delta change in temperature of 100°F. Care must be taken to keep the sensor 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.
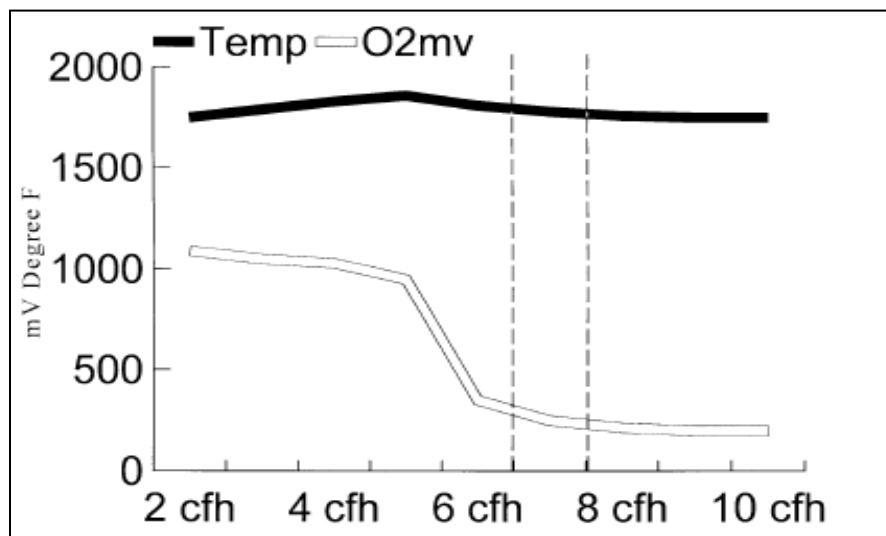

Figure 2

Figure 2 shows a typical example of data used to determine the flow rate of air required for burnoff. In this situation, a flow rate of 7 – 8 SCFH would be selected because this provides a lower temperature as well as some free oxygen at the sensor tip. If the amount of air required is found to be so high that interference with product processing is

anticipated, the sensor should be relocated to a spot that will offer less impingement from the atmosphere circulation system.

Burnoff duration should be between 60-180 seconds (1 – 3 minutes). Do not let the sensor temperature rise above its maximum allowable temperature. The frequency of the operation depends upon the rate at which carbon is being accumulated.   In continuous furnace applications, the burnoff process is ran 3-6 times daily, while in batch applications, the burnoff should be done at the start and end of each cycle. To verify the effectiveness of the burnoff procedure, simply remove the sensor after a burnoff and examine it.

Note: The Quicksilver sheath is made out of ½" schedule 40 material (¾" schedule 40 for the Carbonseer-M). The burn-off frequency must be enough to overcome carbon build up in the region around the substrate (see Figure 3), inside of the sheath. If carbon fills this space, and condenses, the sensor will fail prematurely.

Adjust burnoff frequency to prevent carbon buildup in this region around the substrate
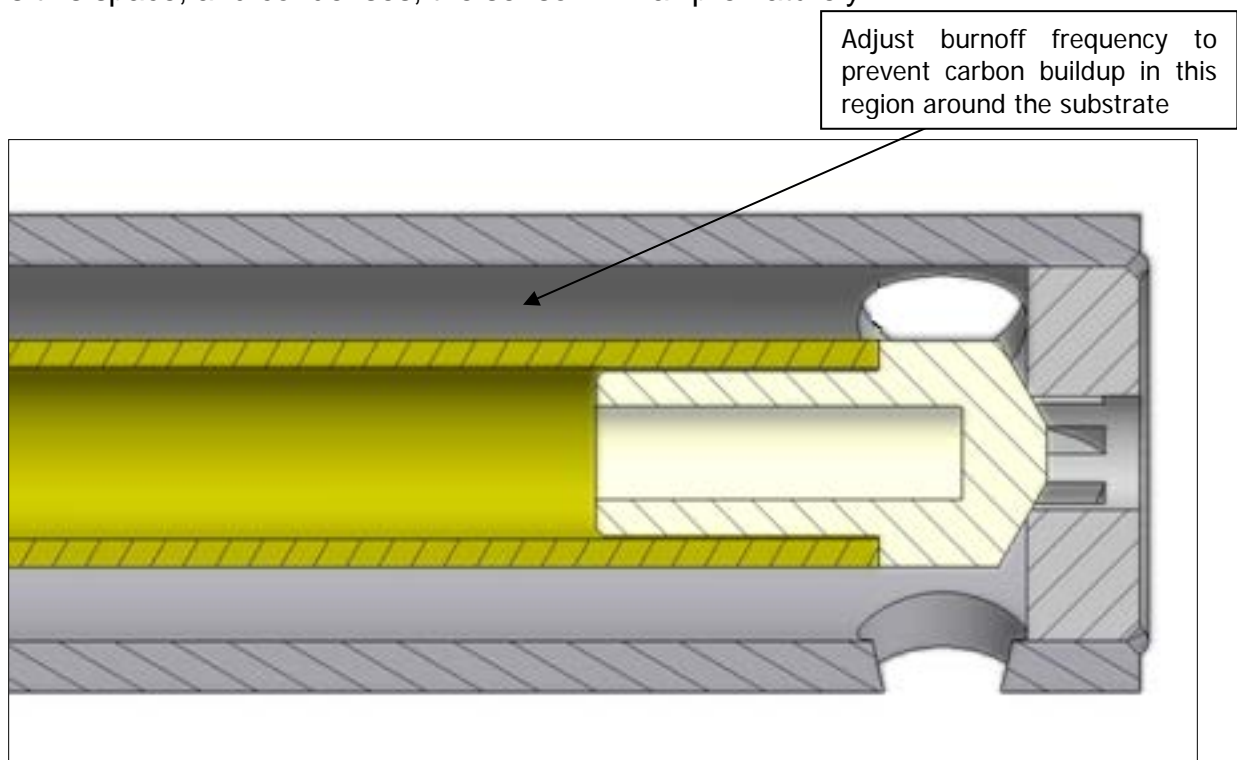
Figure 3

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" furnace burnouts be conducted to avoid the cumulative effects of deposited carbon on furnace components. "Gentle" burnouts are normally conducted at 1500°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 kΩ) indicates that the electrode contact on the sensor's zirconia has deteriorated to a level that warrants replacement.

High sensor impedance results in erratic 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 sensor's performance.

Typical impedance readings for a new sensor are less than 1 kΩ. As the sensor starts to age, the impedance will increase. Once past 20 kΩ, the sensor should be monitored more closely and above 50 kΩ, 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 UPC for information on rebuilding your sensor.

An impedance test can only be performed if the sensor 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 kΩ resistor is shunted across the sensor output. The sensor impedance is calculated using Formula 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 kΩ)	**For mula** $$R_X := \left(\frac{E_O}{E_S} - 1 \right) \cdot R_S$$ **1**

APPENDIX A: TROUBLESHOOTING YOUR SENSOR

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 sensor. In all cases, the last resort is to replace the sensor, 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 sensor.

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 and/or Dew Point temperatures are too low/high and/or do not change.	Go to Reference Air Check. Go to Furnace Check.
Carbon readings are erratic or carbon level keeps oscillating.	Go to Signal Level Check. Go to 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 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.

Table 2

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 pressure regulated at 1.0 – 3.0 inH$_2$O. If in doubt about the reference air source, try an alternative source.
2. If reference airflow is not between 0.2 – 0.5 SCFH on a flow meter, ensure that airflow is getting to the sensor. Disconnect the reference air tube at the sensor 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 sensor. If there is no

flow when the tube is reattached to the sensor, the reference air tubing in the sensor is blocked. Replace the sensor.

3. The reference air flow must be between 0.2 – 0.5 SCFH with a reference air pressure (P_R) of 1.0 – 3.0 inH$_2$O and equal to or less than the process pressure (P_P).
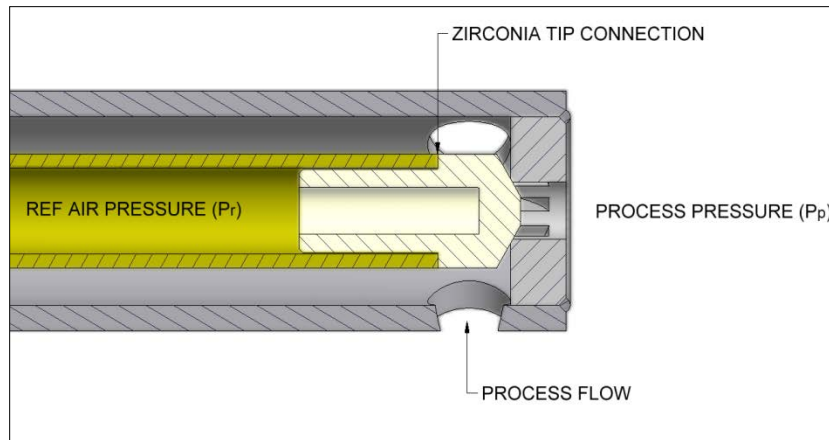
4. The process pressure (P_p) must match the ref air pressure (P_r) or be slightly greater in order to prevent false High levels of O$_2$ in the process. High levels of O$_2$ will correlate to low C_p levels and high Dew Point temperatures.

BURNOFF CHECK

1. Perform a burnoff with the sensor at 1500°F minimum. The sensor temperature should increase slightly (100°F) above the ambient furnace temperature and the sensor mV 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 sensor by doing the bubble test as described in "Reference Air Check."
3. If all of the above is correct but the sensor mV still does not drop, repeat the burnoff procedure at a more frequent interval. If after a minimum of five burn offs there is no change in the mV reading and proper response to carbon changes, remove the sensor and inspect for heavy sooting. See Sensor Replacement.

IMPEDANCE CHECK

1. Check the sensor's impedance with a minimum temperature of 1500°F. A good sensor's impedance should be between 0.1-20 kΩ. If the impedance is above 20 kΩ, the sensor electrodes are degrading and the sensor should be monitored more closely. If the levels reach 50 kΩ, the sensor should be replaced. If the impedance is good, check Process Factor or see Furnace Checks.

2. If the sensor impedance is high during one test and low or normal during another test, check the connections between the instrument and the sensor. If the impedance readings are still intermittent, see Sensor Replacement.

SIGNAL LEVEL CHECK

1. If the carbon sensor measurement system does, in fact, disagree with alternative measurement technique (e.g. FDPRO IR analyzer, shim stock analysis), check the sensor temperature and mV readings with the Percent Carbon chart (in the back of this manual) and see Process Factor Check. If these values agree then go to the Furnace Checks.
2. If sensor 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 mV 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 MΩ 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 sensor lead wires. When the positive sensor lead wire is disconnected from the sensor 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 sensor signal. Connect the sensor 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 sensor mV terminals for 15 seconds. If the sensor mV 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 sensor 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 dependent 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 (>300) 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, carbon fluctuations may correspond to gas-fired burners coming on during the early part of the heat cycle. This would indicate that there is a hole in a burner tube, leaking 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.

SENSOR REPLACEMENT

- If your sensor is not working properly, please contact your Local UPC representative before removing the sensor. There may be trouble shooting technique only accomplished while the sensor is still installed
- Insert/remove the sensor at ½" per second MAX if furnace is hot and place into an insulated blanket until complete dissipation. The modularity of the Carbonseer-M makes possible to rebuild a faulty sensor.
- Ensure that the sensor sheath shows no significant accumulation of soot or other deposits.
- Make sure that the main ceramic tube of the sensor is physically intact.
- Be sure that the sensor sheath is not is not warped.
- Note the above conditions and the sensor's serial number. Call UPC for an RMA to test and possibly rebuild the sensor.

CARBON POTENTIAL VS. SENSOR MV OUTPUT @ TEMPERATURE(S) GRAPH
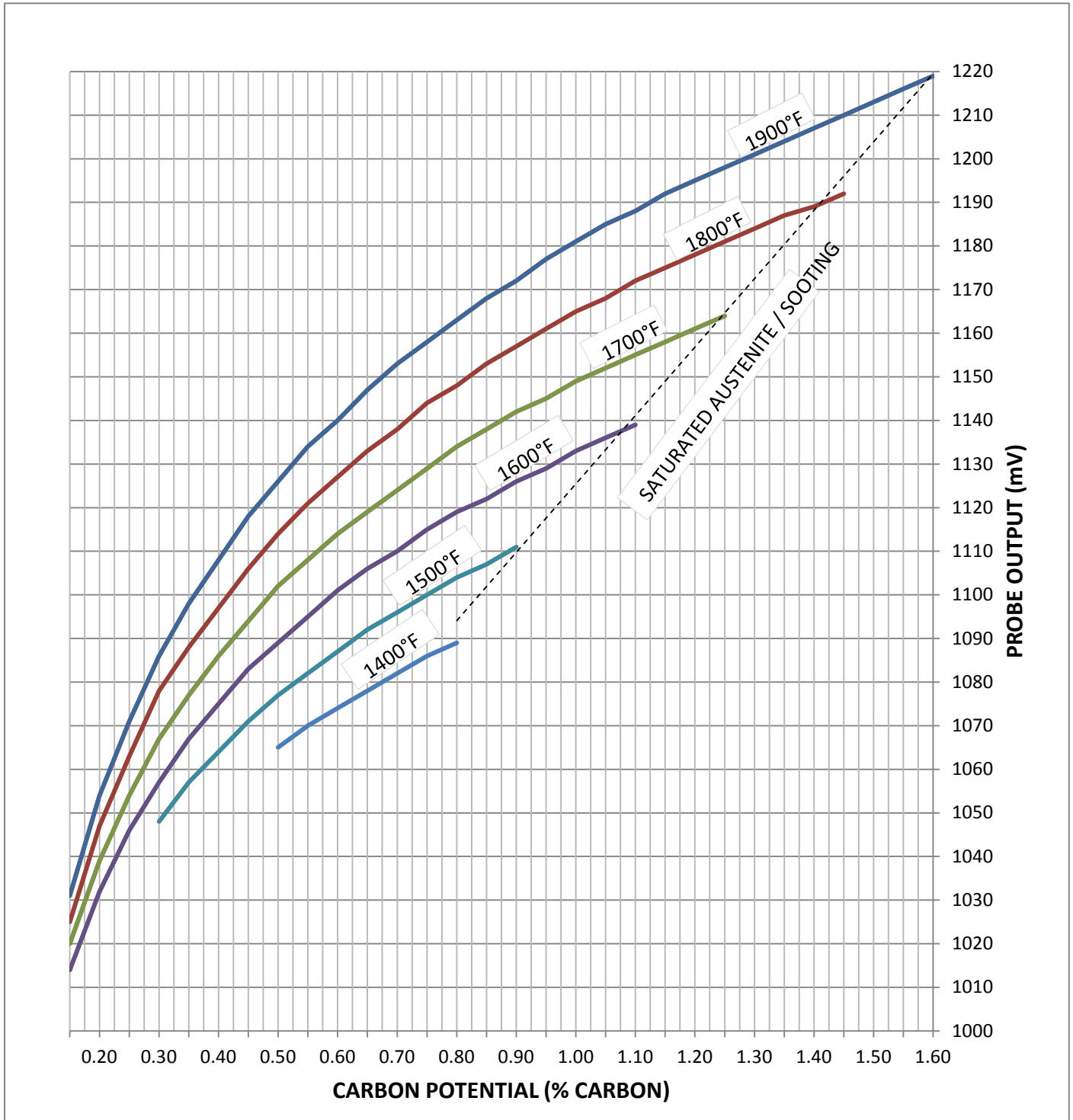
CARBON POTENTIAL VS. SENSOR MV OUTPUT @ TEMPERATURE(S) DATA

CARBON POTENTIAL (%C)

|	1400	1425	1450	1475	1500	1525	1550	1575	1600	1625	1650	1675	1700	1725	1750	1775	1800	1825	1850	1875	1900
1.60																					
1.55																					1219
1.50																				1212	1216
1.45																			1204	1209	1213
1.40																	1192	1197	1201	1206	1210
1.35																	1189	1194	1198	1203	1207
1.30																1182	1187	1191	1195	1200	1204
1.25															1175	1179	1184	1168	1193	1197	1201
1.20													1164	1168	1172	1177	1181	1186	1190	1194	1198
1.15												1157	1161	1165	1170	1174	1178	1182	1187	1191	1195
1.10										1146	1150	1154	1158	1162	1167	1171	1175	1179	1183	1187	1192
1.05									1139	1143	1147	1151	1155	1159	1163	1167	1172	1176	1180	1184	1188
1.00									1136	1140	1144	1148	1152	1156	1160	1164	1168	1172	1176	1180	1185
0.95								1129	1133	1137	1141	1145	1149	1153	1157	1161	1165	1169	1173	1177	1181
0.90							1122	1125	1129	1133	1137	1141	1145	1149	1153	1157	1161	1165	1169	1173	1177
0.85					1111	1114	1118	1122	1126	1130	1134	1138	1142	1145	1149	1153	1157	1161	1165	1169	1172
0.80			1100	1104	1107	1111	1115	1119	1122	1126	1130	1134	1138	1141	1145	1149	1153	1156	1160	1164	1168
0.75	1089	1093	1097	1100	1104	1107	1111	1115	1119	1122	1126	1130	1134	1137	1141	1144	1148	1152	1156	1159	1163
0.70	1086	1089	1093	1098	1100	1104	1108	1111	1115	1116	1122	1125	1129	1133	1136	1140	1144	1147	1151	1154	1158
0.65	1082	1085	1089	1092	1096	1100	1103	1107	1110	1114	1117	1121	1124	1128	1131	1135	1138	1142	1145	1149	1153
0.60	1078	1081	1085	1088	1092	1095	1099	1102	1106	1109	1112	1116	1119	1123	1126	1129	1133	1136	1140	1143	1147
0.55	1074	1077	1081	1084	1087	1091	1094	1097	1101	1104	1107	1110	1114	1117	1120	1124	1127	1130	1134	1137	1140
0.50	1070	1073	1076	1079	1082	1086	1089	1092	1095	1098	1102	1105	1108	1111	1114	1118	1121	1124	1127	1130	1134
0.45	1065	1068	1071	1074	1077	1080	1083	1088	1089	1092	1095	1098	1102	1105	1108	1111	1114	1117	1120	1123	1126
0.40		1062	1065	1068	1071	1074	1077	1080	1083	1088	1088	1091	1094	1097	1100	1103	1106	1109	1112	1115	1118
0.35			1058	1061	1064	1067	1070	1073	1075	1078	1081	1084	1086	1089	1092	1095	1097	1100	1103	1106	1108
0.30				1054	1057	1059	1062	1064	1067	1069	1072	1074	1077	1080	1082	1085	1088	1090	1092	1096	1098
0.25					1048	1050	1052	1055	1057	1060	1062	1064	1067	1069	1071	1074	1078	1079	1081	1083	1086
0.20						1039	1041	1044	1046	1048	1050	1052	1054	1057	1059	1061	1063	1065	1067	1069	1071
0.15							1028	1030	1032	1034	1035	1037	1039	1041	1043	1045	1047	1048	1050	1052	1054

* Data only valid with carrier gas composition $CO + CO_2 = 20\%$ and AISI 1010 Steel

DEW POINT VS. SENSOR MV OUTPUT @ TEMPERATURE(S) GRAPH
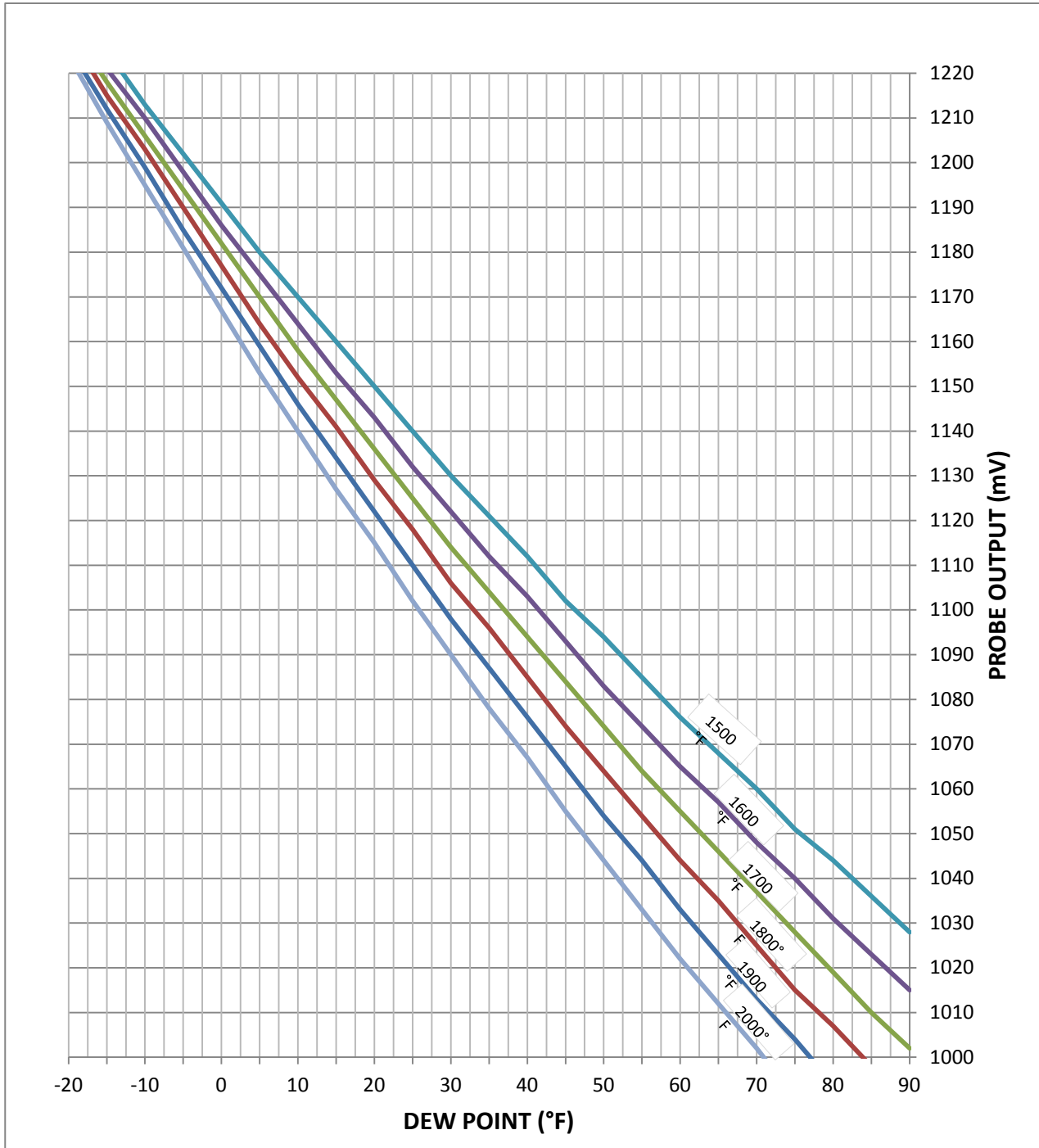
DEW POINT VS. SENSOR MV OUTPUT @ TEMPERATURE(S) DATA

		TEMPERATURE (°F)															
		1400	1450	1500	1550	1600	1650	1700	1750	1800	1850	1900	1950	2000	2050	2100	2150
	90	1041	1035	1028	1021	1015	1008	1002	995	989	982	976	969	962	955	949	942
	85	1048	1042	1036	1029	1023	1017	1010	1004	998	991	985	978	972	965	959	952
	80	1055	1049	1044	1037	1031	1025	1019	1013	1007	1000	994	988	981	975	969	962
	75	1063	1057	1051	1045	1040	1034	1028	1022	1015	1009	1004	997	991	985	979	973
	70	1071	1065	1060	1054	1048	1042	1037	1031	1025	1019	1013	1007	1002	996	990	984
	65	1078	1073	1068	1062	1057	1051	1046	1040	1035	1029	1023	1018	1012	1006	1000	995
	60	1086	1081	1076	1071	1065	1060	1055	1050	1044	1039	1033	1028	1022	1017	1011	1006
	55	1094	1090	1085	1080	1074	1069	1064	1059	1054	1049	1044	1038	1033	1028	1022	1017
	50	1103	1098	1094	1089	1083	1079	1074	1069	1064	1059	1054	1049	1044	1039	1034	1029
	45	1111	1107	1102	1098	1093	1088	1084	1079	1074	1070	1065	1060	1055	1050	1045	1041
Dew Point (°F)	40	1120	1116	1112	1107	1103	1098	1094	1089	1085	1080	1076	1071	1067	1062	1058	1053
	35	1129	1125	1121	1116	1112	1108	1104	1100	1096	1091	1087	1083	1078	1074	1070	1065
	30	1137	1134	1130	1126	1122	1118	1114	1110	1106	1102	1098	1094	1090	1086	1082	1077
	25	1147	1143	1140	1136	1132	1129	1125	1121	1118	1114	1110	1106	1102	1098	1094	1090
	20	1156	1153	1150	1146	1143	1139	1136	1132	1129	1125	1122	1118	1115	1111	1107	1104
	15	1166	1163	1160	1156	1153	1150	1147	1144	1141	1137	1134	1131	1127	1124	1120	1117
	10	1175	1172	1170	1167	1164	1161	1158	1155	1152	1149	1146	1143	1140	1137	1134	1130
	5	1185	1183	1180	1176	1175	1172	1170	1167	1164	1161	1159	1156	1153	1150	1147	1144
	0	1195	1193	1191	1189	1186	1184	1182	1179	1177	1174	1172	1169	1167	1164	1161	1159
	-5	1206	1204	1202	1200	1198	1196	1194	1191	1190	1187	1185	1183	1181	1178	1176	1173
	-10	1217	1215	1213	1211	1210	1208	1206	1204	1203	1201	1199	1197	1195	1193	1191	1189
	-15	1227	1226	1225	1223	1221	1220	1218	1217	1215	1214	1212	1210	1209	1207	1205	1203
	-20	1238	1237	1236	1235	1234	1233	1231	1230	1229	1227	1226	1225	1224	1222	1221	1219

* Data only valid with gas composition $H_2 + H_2O = 40\%$

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