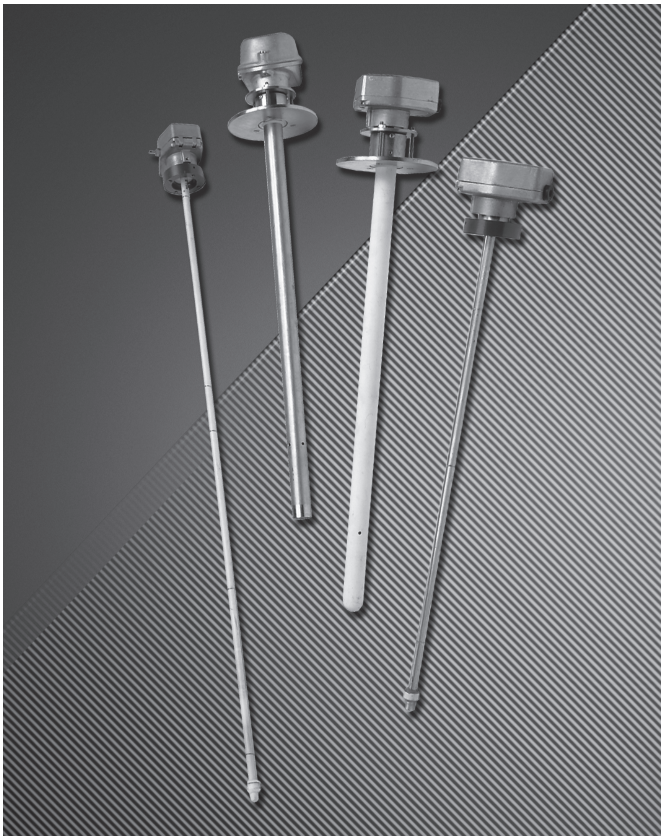
Operating Instructions

# Carbon Sensor

Z-CS2



ABB

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## The Company

We are an established world force in the design and manufacture of instrumentation for industrial process control, flow measurement, gas and liquid analysis and environmental applications.

As a part of ABB, a world leader in process automation technology, we offer customers application expertise, service and support worldwide.

We are committed to teamwork, high quality manufacturing, advanced technology and unrivalled service and support.

The quality, accuracy and performance of the Company's products result from over 100 years experience, combined with a continuous program of innovative design and development to incorporate the latest technology.

The NAMAS Calibration Laboratory No. 0255 is just one of the ten flow calibration plants operated by the Company, and is indicative of our dedication to quality and accuracy.

**EN ISO 9001:1994**

Cert. No. Q05907

**EN 29001 (ISO 9001)**

Lenno, Italy – Cert. No. 9/90A

Stonehouse, U.K.

0255

## Electrical Safety

This instrument complies with the requirements of EN 61010-1:1993 "Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use". If the instrument is used in a manner NOT specified by the Company, the protection provided by the instrument may be impaired.

## Symbols

One or more of the following symbols may appear on the instrument labelling:

| | | | |
|---|---|---|---|
| | **Warning –** Refer to the manual for instructions | | Direct current supply only |
| | **Caution –** Risk of electric shock | | Alternating current supply only |
| | Protective earth (ground) terminal | | Both direct and alternating current supply |
| | Earth (ground) terminal | | The equipment is protected through double insulation |



**Health and Safety**

To ensure that our products are safe and without risk to health, the following points must be noted:

1. The relevant sections of these instructions must be read carefully before proceeding.
2. Warning labels on containers and packages must be observed.
3. Installation, operation, maintenance and servicing must only be carried out by suitably trained personnel and in accordance with the information given.
4. Normal safety precautions must be taken to avoid the possibility of an accident occurring when operating in conditions of high pressure and/or temperature.
5. Chemicals must be stored away from heat, protected from temperature extremes and powders kept dry. Normal safe handling procedures must be used.
6. When disposing of chemicals ensure that no two chemicals are mixed.

Safety advice concerning the use of the equipment described in this manual or any relevant hazard data sheets (where applicable) may be obtained from the Company address on the back cover, together with servicing and spares information.

## CONTENTS



## INTRODUCTION

The Kent Z-CS2 Carbon Sensor is a high-temperature probe with an extremely fast response time, typically less than 0.1 second. The probe produces an output voltage ('oxygen potential') which, in conjunction with the process temperature and atmosphere, can be interpreted in terms of the atmosphere carbon potential in a furnace – see Tables 1 to 4 on pages 8 and 9. Probe voltage can be displayed directly on the Kent P96M digital indicator/controller or monitored on the P100S recorder – see instruction manuals P96M/0011 and P100S/0011, respectively.

The probe is constructed from stabilised zirconium oxide with two electrodes. An outer sheath of aluminous porcelain or Incoloy 800 (as specified at the time of order) protects the probe from excess thermal and mechanical shock. An inlet for a reference air supply, if required, is located in the head of the probe, along with connectors for the electrodes.

The probe head is fitted with external reference air and purge air inlets for use as required. Electrode terminations are made inside the head.

The probe can be mounted via a standard 1in NPT boss or an optional flange fitting (for use when replacing an existing Z-CS1 probe).

## INSTALLATION

**CAUTION.** The probe must be used with the sheath provided. Take care to avoid fracturing the zirconia tube when fitting the sheath. Preferably, install the probe when the furnace etc. is cold; alternatively, in a hot environment, insertion or retraction of the probe must be done gradually.

### Unpacking

The following procedure must be carried out on a clean flat surface.

a) Carefully open the packaging to reveal the contents.

b) Ease the probe, complete with sealing ring, from the packaging freeing the head end first.

  **CAUTION.** Do not use undue force and, in particular, take extreme care with the fragile ceramic insulator which runs the length of the probe.

c) Once the probe is clear of the packaging, place it out of harm's way on a flat surface.

  **Note.** Any slight cracking in the cement collar at the tip of the electrode can be disregarded.

d) Remove the sheath assembly and mounting flange (if supplied) from the packaging.

e) Reassemble the packaging and retain for future use.

### Preparation

The probe can either be mounted directly on to the wall of the furnace or to a support tube (see opposite).

For flange mounting probes drill the fixing flange (see Fig. 1) to suit the chosen mounting, before assembling the probe. Ensure that the orientation of the tapered thread is correct.

Overall dimensions are shown in Fig. 2.

### Assembling the Probe – Fig. 1

① Ensure that the sealing ring is correctly located.

② Carefully slide the protective sheath over the probe assembly.

③ Align the fixing holes in the two flanges and secure with the two ¼in UNF hexagon head captive screws.

④ If using a flange fitting (e.g. when replacing an existing Z-CS1 probe) apply an anti-seize compound (e.g. Rocol J116 or similar) to the threads on the NPT boss. Slide the flange over the sheath, ensuring that the orientation of the tapered thread is correct, and screw it firmly onto the 1in NPT boss.

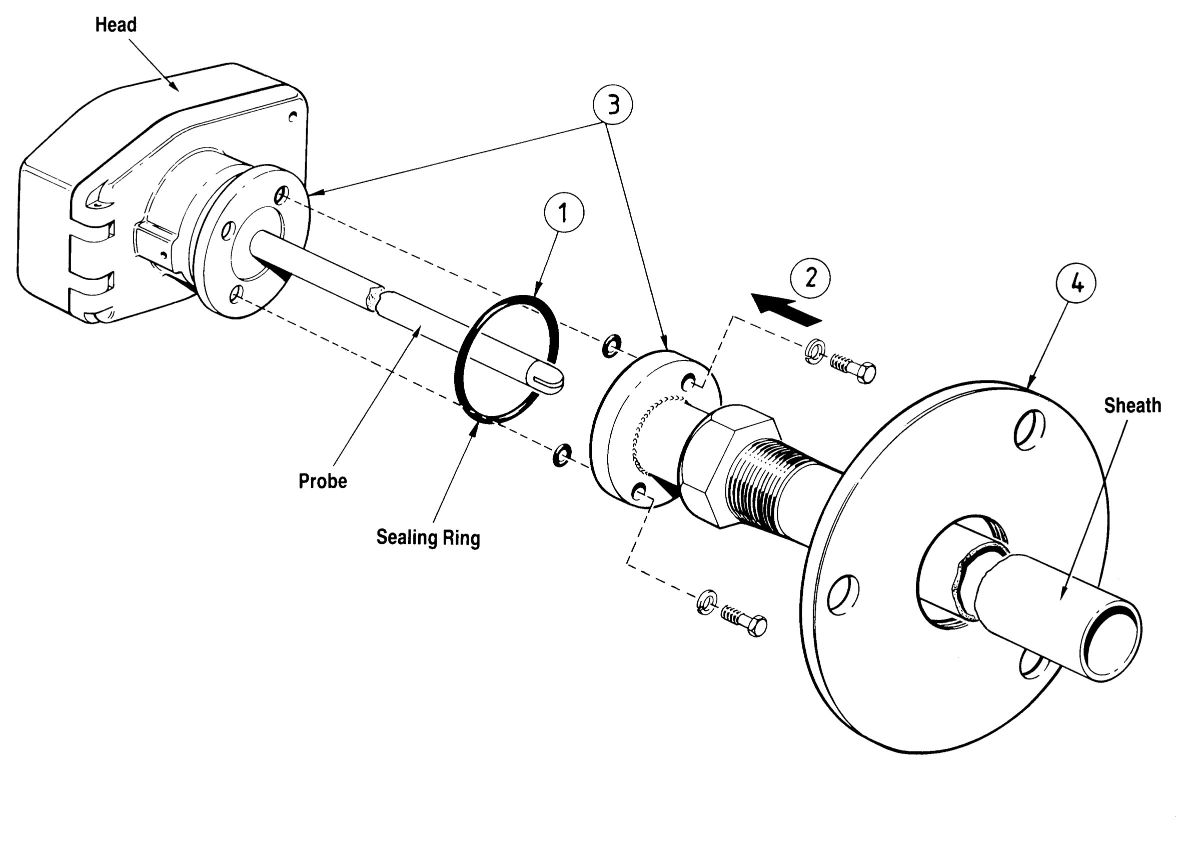



Fig. 1 Assembling the Probe

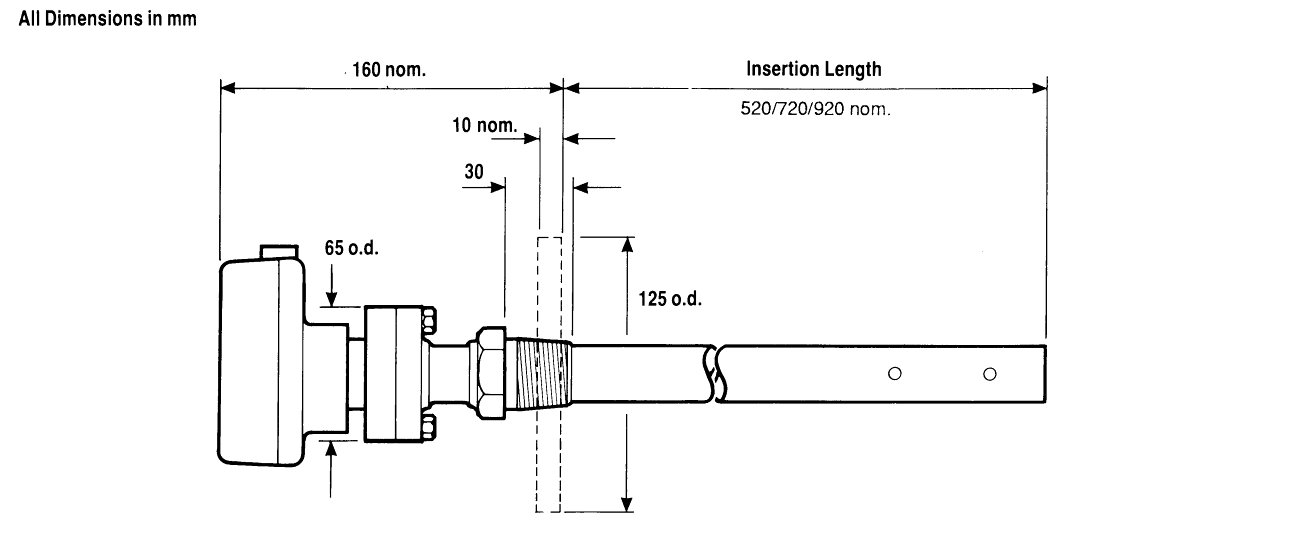



Fig. 2 Overall Dimensions

**Flange Mounting of Probe – Fig. 3**
The flange fitting can be used when replacing an existing Z-CS1 probe. The probe can be mounted vertically or horizontally; vertical mounting being the preferred for prolonged high temperature operation. The diameter of the mounting hole or mounting tube bore should be 42mm minimum. A smaller diameter hole can be used where soft blanket type thermal insulation is used on the furnace.

**Boss Mounting of Probe – Fig. 4**
The probe can be mounted vertically or horizontally; vertical mounting being the preferred for prolonged high temperature operation.

Apply an anti-seize compound (e.g. Rocol J116 or similar) to the threads on the NPT boss. Screw the boss firmly into the female fitting.

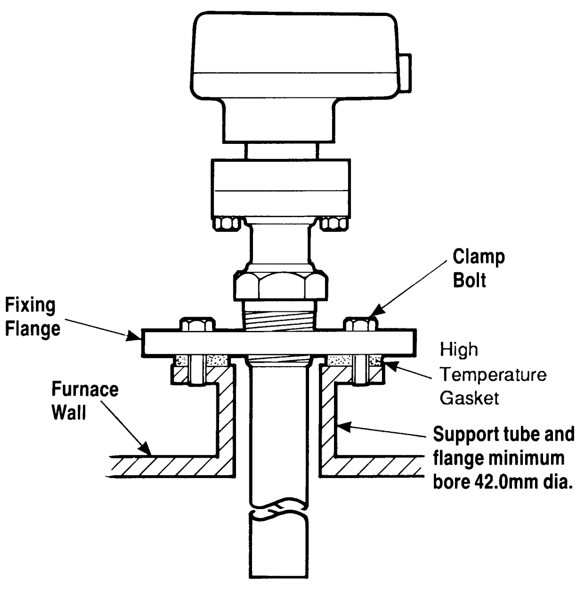



Fig. 3 Flange Mounting

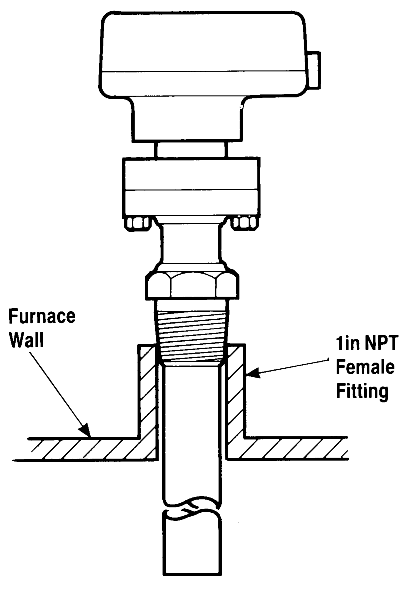



Fig. 4 Boss Mounting

## CONNECTIONS

**Note.** Suitable units for supplying reference purge air, at the required flow rates, are available from the Company:

003000240 is a mains powered pump unit
003000241 is a flow regulator unit

**Reference Air Inlet – Fig. 5**
For the majority of applications it is sufficient to vent the inner electrode to atmosphere via the reference air inlet in the probe head. In contaminated conditions supply clean air through the inlet at a rate of between 100 and 500 ml/minute. The inlet is tapped ⅛in BSP. An adaptor to accept a 3mm bore pipe is provided.

**Purge Air Inlet – Fig 5**
The purge air inlet is utilised when carrying out a probe 'burn-out'. The inlet is fitted with a 6mm diameter spigot for temporary connection of push-on tubing or permanent pipe connection using a compression fitting. For probe 'burn-out' procedure refer to **ROUTINE MAINTENANCE.** The blanking screw and '0' ring seal must be fitted if the purge air inlet is not in use.

If a permanent pipe connection is preferred, all joints must be checked for leaks and a positive seal type valve fitted in the line as close to the probe as is practicable. The valve must always be closed except during probe 'burn out'.

**CAUTION.** If the above instructions are not followed, probe damage and/or spurious readings may result.

**Electrical Connections – Fig. 5**
Between the probe and controller/recorder use 16/0.2mm laid-up twin copper conductor with separate insulation, braid screen and overall insulation, to a maximum length of 100m. High temperature rated cable (e.g. Silicon rubber insulated) is essential for connections to the probe head and for use over any part of the cable run which is subjected to high temperatures. For the remainder of the cable run insulated screened signal lead may be used.

If the thermocouple is included in the probe assembly, the appropriate compensating cable must be used.

With reference to Fig 5:

① Release the two screws in the head cover.

② Swing the cover up.

③ Make connections to the terminal block, via the grommet supplied, in accordance with the label inside the cover.

④ Fit the grommet in the recess.

⑤ Close the cover.

⑥ Tighten the screws.

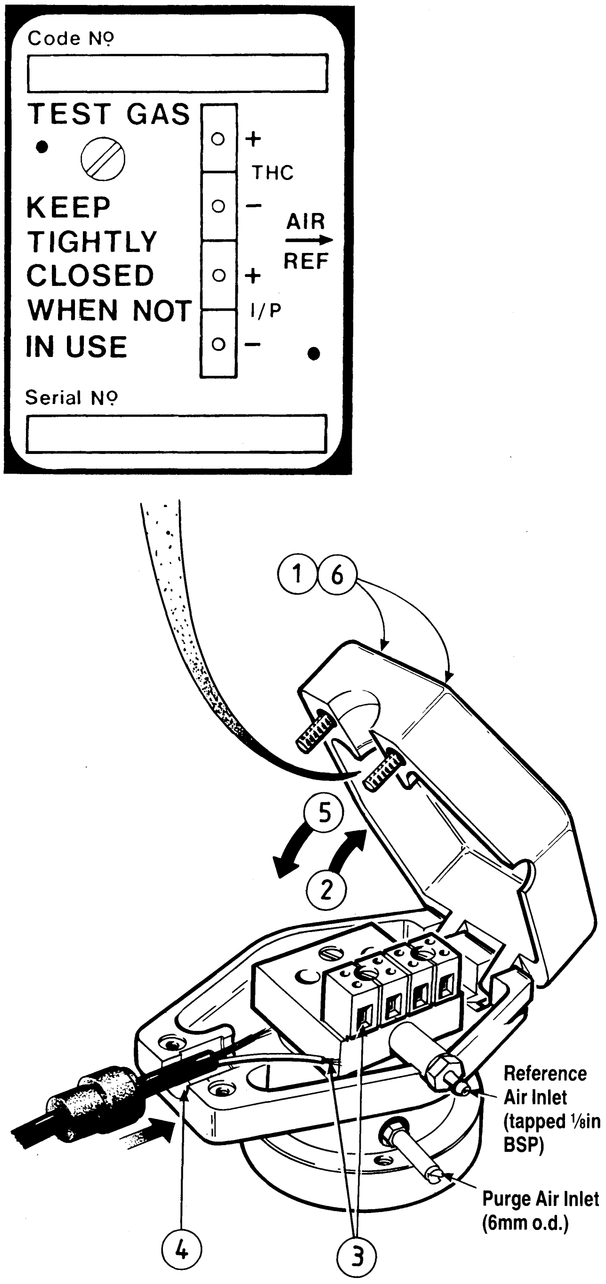



**Fig. 5 Air Inlets and Electrical Connections**

## OPERATION

### Measuring System

A carbon potential control system can be set up using the Z-CS2 probe in conjunction with either a P96M digital indicator/controller (model SP25) or a P100S strip-chart recorder. These instruments can provide a wide range of outputs for control, retransmission or alarms/relays. Temperature compensation of the probe is not required.

Probe operation must not be attempted without the use of a high input impedance instrument ($10^9\Omega$ min.).

### Range of Operation

For optimum life the sensor must be operated within temperature limits 600°C to 1000°C (Fig. 8, page 10). The temperature inside the probe head must not exceed 140°C.

**CAUTION.** Localised high temperatures may be generated when carrying out a probe 'burn-out'. It is important to ensure that these temperatures do not exceed the limitations detailed above.

## ROUTINE MAINTENANCE

### Sensor 'Burn-Out'

Under certain furnace conditions, sooting inside the sensor sheath can modify the atmosphere in the proximity of the sensor and introduce errors to the readings. Severe sooting can also introduce difficulties in removal of the sensor from the sensor sheath.

To overcome these problems it may be desirable to implement a 'burn-out' of this carbon deposit prior to the furnace 'burn-out'.

Since the furnace 'burn-out' removes soot from the immediate vicinity of the probe measuring electrode, it is recommended that probe 'burn-outs' are only carried out when necessary to maintain the accuracy and serviceability of the system.

It is recommended that the probe and furnace 'burn-outs' are conducted at a temperature between 700°C and 760°C. If the temperature exceeds this limit, the air supply must be shut-off until the temperature has dropped back.

Inject a clean air supply at a rate of 100 to 200 ml/minute until all soot has been removed from the sheath. Completion of the sensor 'burn-out' is indicated by a characteristic change in sensor output which is dependent on the type of furnace atmosphere.

**IMPORTANT.** During the sensor 'burn-out' the sensor temperature must be monitored to ensure that it does not exceed 1000°C. At no time must the sensor output be allowed to fall below 700mV during this procedure.

### Note.

The blanking screw and '0' ring seal must be fitted if the purge air inlet is not in use.

### Furnace 'Burn-Out – Fig. 6

Following 'burn-out' of the carbon from the sensor sheath, as described above, the furnace 'burn-out' can be implemented.

The sensor/furnace temperature must be maintained at 700°C to 760°C and monitored to ensure that the localised heating due to the 'burn-out' does not expose the sensor to temperatures in excess of 1000°C.

When the last traces of surface carbon are burning off, the sensor output drops suddenly, indicating completion of the 'burn-out'. The sensor output must not be allowed to fall below 700mV whilst at this temperature.

Continuation of the furnace 'burn-out' beyond this point may 'de-condition' the furnace and introduce errors to the probe output in future.

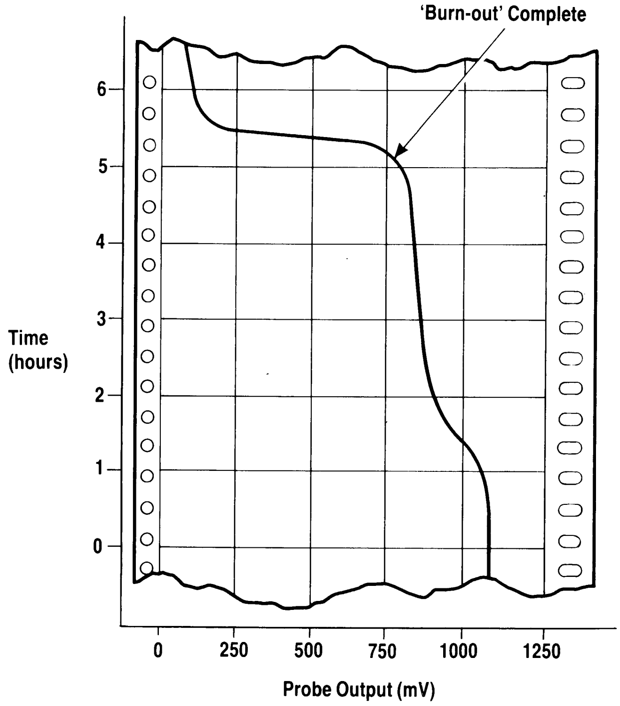



**Fig. 6 Typical Chart Trace for 'Burn-out' of a Batch Carburising Furnace.**

## SENSOR AGEING CHECK

Testing the probe impedance on a regular basis gives an indication of its condition and when replacement may be necessary.

The test circuit required is shown in Fig. 7. The 'Test' switch position enables the sensor condition to be monitored.

**CAUTION.** Before switching to 'Test' ensure that all alarms and controls operated from the recorder or controller are suitably by-passed or disconnected.

**Note.** For comparison purposes, sensor tests must be made at the same operating temperature, and under similar atmosphere conditions.

a) Set the switch to 'Off' and note the probe output reading.

b) Set the switch to 'Test', note the reading and reset the switch to 'Off' as soon as possible.

c) Divide the difference between a) and b) by that obtained in a) and multiply by 100 to obtain the percentage deviation.

**Example**

Reading a) = 1100 mV
Reading b) = 900mV

$$\text{Percentage deviation} = \frac{(1100-900)}{1100} \times 100 = 18\%$$

Plot the percentage deviation and the temperature at which the readings were taken on the record sheet on page 11. Repeat the procedure fortnightly for high utilisation furnaces or monthly for those used intermittently.

Ensure that the operating temperature is the same on each occasion for direct comparison. The deviation may increase slowly with the time under normal conditions, but rises at a much increased rate as the probe approaches the end of its useful life.

The initial deviation varies from sensor to sensor and is not significant in itself. Potential failure of the sensor is usually indicated by a fast increasing deviation with time.

The following Table shows the relationship between the percentage deviation, as conducted in the preceding test, with respect to the sensor impedance. The typical sensor impedance of a new probe is 3kΩ at 900°C.

| % Deviation | Sensor Impedance |
|---|---|
| 9% | 10kΩ |
| 17% | 20kΩ |
| 23% | 30kΩ |
| 29% | 40kΩ |
| 33% | 50kΩ |
| 38% | 60kΩ |
| 41% | 70kΩ |
| 44% | 80kΩ |
| 47% | 90kΩ |
| 50% | 100kΩ |
| 90% | 1MΩ |

## FAULT FINDING

During its working life under normal recommended conditions the probe output remains constant and without drift. Failure, when it does occur, usually results in the appearance of an open circuit condition or an unacceptably high cell impedance.

Site testing of a probe can only be satisfactorily carried out in its working position and at its working temperature. Thus, the following checks are carried out under working conditions. It is recommended that at least one spare probe be carried for replacement or comparison purposes.

If failure of the probe is suspected it can be checked by one or more of the following methods.

**Comparison with Another Probe – Preferred Method**
The probe may be checked by comparison with another probe of known reliability, either by replacing the suspect probe by the known probe or by mounting the known probe in close proximity and monitoring both probes continuously for a short period.

Care must be taken when introducing cold probes into the furnace, to avoid excessive thermal shock.

**Comparison with Other Equipment**
An additional check on the probe may be made by using other equipment to measure an associated condition, e.g. carbon dioxide. Care must be taken to ensure that the sample measured during the check is representative of the gas measured by the probe, a condition sometimes difficult to achieve.

a) **Carburising Furnace Gases (Endothermic Gases)**
In this application a cross check can usually be made by using a portable dew-point or carbon dioxide instrument. It is most important that a ceramic sampling tube is used and that the sample is removed from the furnace as rapidly as possible to minimise any compositional changes in the sample during cooling. Also it is important that the sampling technique used on each occasion is identical.

From experience of such measurements during the life of the probe it is possible to establish a correlation between the oxygen potential reading and the dew-point or carbon dioxide value (it must be borne in mind that the relationship changes with temperature). This correlation enables checks to be carried out readily on the oxygen probe, and any malfunction is detected.

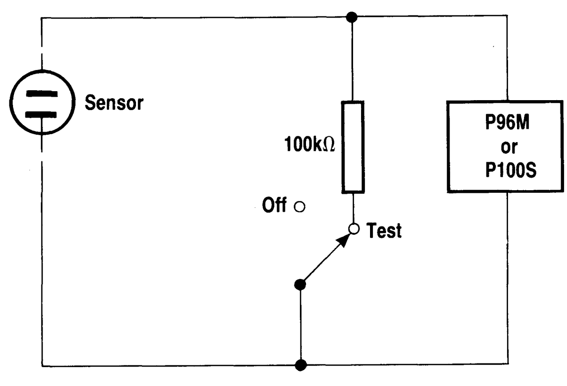



**Fig. 7 Test Circuit**

It is essential that a separate correlation be established for each furnace, since variations may occur because of such items as furnace residence time, the type of generator used and the condition of the generator catalyst; these are factors which influence the degree of equilibrium reached by the gas. It is important to remember that the potential can only be correlated meaningfully with the dew-point or carbon dioxide when the furnace is fully conditioned.

b) **Other Reducing Gases**
Reducing gases such as exothermic gases can usually be checked by Orsat carbon dioxide measurements. The actual method of checking is immaterial provided that some form of correlation is established. The same comments regarding the sampling of endothermic gases also apply.

**Contamination of the Reference Gas**
A possible source of inaccuracy is the presence of furnace gases within the probe. Gases resulting from leaky furnace conditions may enter the probe via the head. As a check for the presence of contamination in a probe an air supply of 100 to 500 ml/minute is required (for test purposes a vibratory 'fish-tank' type compressor could be used).

The probe output must be examined at the moment when the reference air supply is switched on. A small change of reading of up to 2 kilojoules (0.5 kilocalories) or 5mV may occur due to the cooling effect of the reference air on the inner electrode and may be ignored. If a larger change occurs in the upscale direction (i.e to a lower oxygen reading or a numerically greater oxygen potential reading) this indicates that in all probability the reference gas (within the probe) is grossly contaminated. If this condition is confirmed a permanent supply of uncontaminated reference air (see page 4) must be provided or the source of contamination must be removed.

A cracked zirconia tube usually leads to an open circuit condition. In some instances, however, the probe may not show an open circuit condition but gives a low or even zero output because of contamination through the crack to the reference electrode. This condition may be detected by the purging method when a large increase in output is obtained. A probe with a cracked tube must be replaced by a sound one as soon as possible.

**Return to Factory for Checking**
If it is not possible to carry out the above tests on site, and failure or malfunction is suspected, the probe may be returned to Kent repacked in its original packing to ensure safe carriage. The disassembly of a probe and the repacking procedure is the reverse of that described under **Assembling the Probe** and **Unpacking** on page 2. Under no circumstances can repair or replacement under guarantee be carried out unless the above precautions are strictly observed.

## IDENTIFICATION

| Basic Type Number | Sensor Length | | Thermocouple Type | | Sheath Type | | Fitting | |
|---|---|---|---|---|---|---|---|---|
| **Code Digits 1, 2, 3, 4, 5, 6** | **7** | | **8** | | **9** | | **10** | |
| Z-CS2/ | 1 | 600mm | 0 | No thermocouple | 2 | Aluminous porcelain | 1 | 1in NPT |
| High-temperature carbon sensor | 2 | 800mm | 1 | Pt/Pt 13% Rh to BS4937 Type R | 3 | Incoloy 800 | 2 | 125mm o.d. blank flange |
| | 3 | 1000mm | 3 | Pt/Pt 10% Rh to BS4937 Type S | 9 | Special | | |
| | 9 | Special | | | | | | |

**Code Number Example**

**Z-CS2/ 1 3 2 2 00**

Z-CS2 carbon sensor

Sensor length 600mm

Type S thermocouple

Aluminous porcelain sheath

Flange fitting

NA

## DATA TABLES

**Table 1**

Equilibrium* Carbon Sensor Output (mV) for Endothermic Atmospheres Generated from Propane.

| **% Surface Carbon in Steel** | **Temp °C** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **800** | **825** | **850** | **875** | **900** | **925** | **950** | **975** | **1000** | **1025** | **1050** | **1075** | **1100** |
| 0.20 | — | — | 1032 | 1037 | 1041 | 1046 | 1051 | 1055 | 1060 | 1065 | 1069 | 1074 | 1079 |
| 0.25 | — | — | 1043 | 1048 | 1053 | 1058 | 1063 | 1068 | 1073 | 1078 | 1083 | 1088 | 1093 |
| 0.30 | — | — | 1053 | 1058 | 1063 | 1068 | 1074 | 1079 | 1084 | 1089 | 1094 | 1199 | 1104 |
| 0.35 | — | — | 1061 | 1066 | 1072 | 1077 | 1083 | 1088 | 1093 | 1098 | 1104 | 1109 | 1114 |
| 0.40 | — | 1063 | 1068 | 1074 | 1079 | 1085 | 1090 | 1096 | 1101 | 1107 | 1112 | 1118 | 1123 |
| 0.45 | 1063 | 1069 | 1075 | 1080 | 1086 | 1092 | 1097 | 1103 | 1109 | 1114 | 1120 | 1125 | 1131 |
| 0.50 | 1069 | 1075 | 1080 | 1086 | 1092 | 1098 | 1104 | 1109 | 1115 | 1121 | 1127 | 1132 | 1138 |
| 0.55 | 1074 | 1080 | 1086 | 1092 | 1098 | 1104 | 1109 | 1115 | 1121 | 1127 | 1133 | 1139 | 1145 |
| 0.60 | 1079 | 1085 | 1091 | 1097 | 1103 | 1109 | 1115 | 1121 | 1127 | 1133 | 1139 | 1145 | 1151 |
| 0.65 | 1083 | 1089 | 1095 | 1102 | 1108 | 1114 | 1120 | 1126 | 1132 | 1138 | 1144 | 1150 | 1156 |
| 0.70 | 1087 | 1093 | 1100 | 1106 | 1112 | 1118 | 1125 | 1131 | 1137 | 1143 | 1149 | 1156 | 1162 |
| 0.75 | 1091 | 1097 | 1104 | 1110 | 1117 | 1123 | 1129 | 1135 | 1142 | 1148 | 1154 | 1160 | 1167 |
| 0.80 | 1095 | 1101 | 1108 | 1114 | 1121 | 1127 | 1133 | 1140 | 1146 | 1153 | 1159 | 1165 | 1171 |
| 0.85 | 1098 | 1105 | 1112 | 1118 | 1125 | 1131 | 1138 | 1144 | 1150 | 1157 | 1163 | 1170 | 1176 |
| 0.90 | — | 1108 | 1115 | 1122 | 1128 | 1135 | 1141 | 1148 | 1155 | 1161 | 1168 | 1174 | 1180 |
| 0.95 | — | 1112 | 1119 | 1125 | 1132 | 1139 | 1145 | 1152 | 1158 | 1165 | 1172 | 1178 | 1185 |
| 1.00 | — | 1115 | 1122 | 1129 | 1135 | 1142 | 1149 | 1156 | 1162 | 1169 | 1176 | 1182 | 1189 |
| 1.05 | — | — | 1125 | 1132 | 1139 | 1146 | 1152 | 1159 | 1166 | 1173 | 1179 | 1186 | 1193 |
| 1.10 | — | — | 1128 | 1135 | 1142 | 1149 | 1156 | 1163 | 1169 | 1176 | 1183 | 1190 | 1197 |
| 1.15 | — | — | — | — | 1145 | 1152 | 1159 | 1166 | 1173 | 1180 | 1187 | 1193 | 1200 |
| 1.20 | — | — | — | — | 1148 | 1155 | 1162 | 1169 | 1176 | 1183 | 1190 | 1197 | 1204 |
| 1.25 | — | — | — | — | — | — | 1166 | 1173 | 1180 | 1187 | 1194 | 1201 | 1208 |
| 1.30 | — | — | — | — | — | — | 1169 | 1176 | 1183 | 1190 | 1197 | 1204 | 1211 |
| 1.35 | — | — | — | — | — | — | 1172 | 1179 | 1186 | 1193 | 1200 | 1207 | 1214 |
| 1.40 | — | — | — | — | — | — | 1175 | 1182 | 1189 | 1196 | 1204 | 1211 | 1218 |
| 1.45 | — | — | — | — | — | — | 1178 | 1185 | 1192 | 1199 | 1207 | 1214 | 1221 |

**Table 2**

Equilibrium* Carbon Sensor Output (mV) for Endothermic Atmospheres Generated from Natural Gas (assumed 100% Methane).

| **% Surface Carbon in Steel** | **Temp °C** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **800** | **825** | **850** | **875** | **900** | **925** | **950** | **975** | **1000** | **1025** | **1050** | **1075** | **1100** |
| 0.20 | — | — | 1039 | 1044 | 1048 | 1053 | 1058 | 1063 | 1068 | 1073 | 1077 | 1082 | 1087 |
| 0.25 | — | — | 1050 | 1055 | 1060 | 1066 | 1071 | 1076 | 1081 | 1086 | 1091 | 1096 | 1101 |
| 0.30 | — | — | 1060 | 1065 | 1070 | 1076 | 1081 | 1086 | 1092 | 1097 | 1102 | 1107 | 1113 |
| 0.35 | — | — | 1068 | 1073 | 1079 | 1084 | 1090 | 1095 | 1101 | 1106 | 1112 | 1117 | 1123 |
| 0.40 | — | 1069 | 1075 | 1081 | 1086 | 1092 | 1098 | 1103 | 1109 | 1115 | 1120 | 1126 | 1131 |
| 0.45 | 1070 | 1075 | 1081 | 1087 | 1093 | 1099 | 1105 | 1110 | 1116 | 1122 | 1128 | 1133 | 1139 |
| 0.50 | 1075 | 1081 | 1087 | 1093 | 1099 | 1105 | 1111 | 1117 | 1123 | 1129 | 1135 | 1140 | 1146 |
| 0.55 | 1080 | 1086 | 1093 | 1099 | 1105 | 1111 | 1117 | 1123 | 1129 | 1135 | 1141 | 1147 | 1153 |
| 0.60 | 1085 | 1091 | 1097 | 1104 | 1110 | 1116 | 1122 | 1128 | 1135 | 1141 | 1147 | 1153 | 1159 |
| 0.65 | 1089 | 1096 | 1102 | 1108 | 1115 | 1121 | 1127 | 1134 | 1140 | 1146 | 1152 | 1158 | 1165 |
| 0.70 | 1094 | 1100 | 1106 | 1113 | 1119 | 1126 | 1132 | 1138 | 1145 | 1151 | 1157 | 1164 | 1170 |
| 0.75 | 1098 | 1104 | 1111 | 1117 | 1124 | 1130 | 1137 | 1143 | 1149 | 1156 | 1162 | 1169 | 1175 |
| 0.80 | 1101 | 1108 | 1115 | 1121 | 1128 | 1134 | 1141 | 1147 | 1154 | 1160 | 1167 | 1173 | 1180 |
| 0.85 | 1105 | 1112 | 1118 | 1125 | 1132 | 1138 | 1145 | 1152 | 1158 | 1165 | 1171 | 1178 | 1184 |
| 0.90 | — | 1115 | 1122 | 1129 | 1135 | 1142 | 1149 | 1156 | 1162 | 1169 | 1175 | 1182 | 1189 |
| 0.95 | — | 1118 | 1125 | 1132 | 1139 | 1146 | 1153 | 1159 | 1166 | 1173 | 1180 | 1186 | 1193 |
| 1.00 | — | 1122 | 1129 | 1136 | 1142 | 1149 | 1156 | 1163 | 1170 | 1177 | 1184 | 1190 | 1197 |
| 1.05 | — | — | 1132 | 1139 | 1146 | 1153 | 1160 | 1167 | 1174 | 1180 | 1187 | 1194 | 1201 |
| 1.10 | — | — | 1135 | 1142 | 1149 | 1156 | 1163 | 1170 | 1177 | 1184 | 1191 | 1198 | 1205 |
| 1.15 | — | — | — | — | 1152 | 1159 | 1166 | 1174 | 1181 | 1188 | 1195 | 1202 | 1209 |
| 1.20 | — | — | — | — | 1155 | 1163 | 1170 | 1177 | 1184 | 1191 | 1198 | 1205 | 1212 |
| 1.25 | — | — | — | — | — | — | 1173 | 1180 | 1187 | 1194 | 1202 | 1209 | 1216 |
| 1.30 | — | — | — | — | — | — | 1176 | 1183 | 1191 | 1198 | 1205 | 1212 | 1219 |
| 1.35 | — | — | — | — | — | — | 1179 | 1186 | 1194 | 1201 | 1208 | 1215 | 1223 |
| 1.40 | — | — | — | — | — | — | 1182 | 1189 | 1197 | 1204 | 1211 | 1219 | 1226 |
| 1.45 | — | — | — | — | — | — | 1185 | 1192 | 1200 | 1207 | 1215 | 1222 | 1229 |

***Equilibrium between steel surface and atmosphere is assumed. In practice actual control values may be slightly higher, the deviation being a function of treatment time and steel composition.**

**Table 3**
Equilibrium* Carbon Sensor output (mV) for Endothermic Atmospheres Generated from Methanol (CO = 31.5%)

| % Surface Carbon in Steel | Temp °C 800 | 825 | 850 | 875 | 900 | 925 | 950 | 975 | 1000 | 1025 | 1050 | 1075 | 1100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.20 | — | — | 1017 | 1021 | 1026 | 1030 | 1034 | 1039 | 1043 | 1047 | 1052 | 1056 | 1060 |
| 0.25 | — | — | 1028 | 1033 | 1037 | 1042 | 1047 | 1051 | 1056 | 1061 | 1065 | 1070 | 1074 |
| 0.30 | — | — | 1038 | 1043 | 1047 | 1052 | 1057 | 1062 | 1067 | 1072 | 1076 | 1081 | 1086 |
| 0.35 | — | — | 1046 | 1051 | 1056 | 1061 | 1066 | 1071 | 1076 | 1081 | 1086 | 1091 | 1096 |
| 0.40 | — | 1048 | 1053 | 1058 | 1063 | 1069 | 1074 | 1079 | 1084 | 1089 | 1094 | 1099 | 1105 |
| 0.45 | 1049 | 1054 | 1059 | 1065 | 1070 | 1075 | 1081 | 1086 | 1091 | 1097 | 1102 | 1107 | 1112 |
| 0.50 | 1054 | 1060 | 1065 | 1071 | 1076 | 1082 | 1087 | 1093 | 1098 | 1103 | 1109 | 1114 | 1119 |
| 0.55 | 1059 | 1065 | 1071 | 1076 | 1082 | 1087 | 1093 | 1099 | 1104 | 1110 | 1115 | 1121 | 1126 |
| 0.60 | 1064 | 1070 | 1076 | 1081 | 1087 | 1093 | 1098 | 1104 | 1110 | 1115 | 1121 | 1127 | 1132 |
| 0.65 | 1068 | 1074 | 1080 | 1086 | 1092 | 1098 | 1103 | 1109 | 1115 | 1121 | 1126 | 1132 | 1138 |
| 0.70 | 1073 | 1079 | 1085 | 1090 | 1096 | 1102 | 1108 | 1114 | 1120 | 1126 | 1132 | 1137 | 1143 |
| 0.75 | 1077 | 1083 | 1089 | 1095 | 1101 | 1107 | 1113 | 1119 | 1125 | 1130 | 1136 | 1142 | 1148 |
| 0.80 | 1080 | 1086 | 1093 | 1099 | 1105 | 1111 | 1117 | 1123 | 1129 | 1135 | 1141 | 1147 | 1153 |
| 0.85 | 1084 | 1090 | 1096 | 1103 | 1109 | 1115 | 1121 | 1127 | 1133 | 1139 | 1145 | 1151 | 1158 |
| 0.90 | — | 1094 | 1100 | 1106 | 1112 | 1119 | 1125 | 1131 | 1137 | 1143 | 1150 | 1156 | 1162 |
| 0.95 | — | 1097 | 1103 | 1110 | 1116 | 1122 | 1129 | 1135 | 1141 | 1147 | 1154 | 1160 | 1166 |
| 1.00 | — | 1100 | 1107 | 1113 | 1120 | 1126 | 1132 | 1139 | 1145 | 1151 | 1158 | 1164 | 1170 |
| 1.05 | — | — | 1110 | 1116 | 1123 | 1129 | 1136 | 1142 | 1149 | 1155 | 1161 | 1168 | 1174 |
| 1.10 | — | — | 1113 | 1120 | 1126 | 1133 | 1139 | 1146 | 1152 | 1159 | 1165 | 1172 | 1178 |
| 1.15 | — | — | — | — | 1129 | 1136 | 1143 | 1149 | 1156 | 1162 | 1169 | 1175 | 1182 |
| 1.20 | — | — | — | — | 1133 | 1139 | 1146 | 1152 | 1159 | 1166 | 1172 | 1179 | 1185 |
| 1.25 | — | — | — | — | — | — | 1149 | 1156 | 1162 | 1169 | 1176 | 1182 | 1189 |
| 1.30 | — | — | — | — | — | — | 1152 | 1159 | 1166 | 1172 | 1179 | 1186 | 1192 |
| 1.35 | — | — | — | — | — | — | 1155 | 1162 | 1169 | 1176 | 1182 | 1189 | 1196 |
| 1.40 | — | — | — | — | — | — | 1158 | 1165 | 1172 | 1179 | 1186 | 1192 | 1199 |

**Table 4**
Equilibrium* Carbon Sensor output (mV) for Endothermic Atmospheres Generated from Methanol/N2 (CO = 17%)

| % Surface Carbon in Steel | Temp °C 800 | 825 | 850 | 875 | 900 | 925 | 950 | 975 | 1000 | 1025 | 1050 | 1075 | 1100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.20 | — | — | 1047 | 1052 | 1057 | 1062 | 1067 | 1072 | 1077 | 1082 | 1087 | 1092 | 1097 |
| 0.25 | — | — | 1058 | 1063 | 1069 | 1074 | 1079 | 1085 | 1090 | 1095 | 1100 | 1105 | 1111 |
| 0.30 | — | — | 1068 | 1073 | 1079 | 1084 | 1090 | 1095 | 1101 | 1106 | 1111 | 1117 | 1122 |
| 0.35 | — | — | 1076 | 1081 | 1087 | 1093 | 1098 | 1104 | 1110 | 1115 | 1121 | 1127 | 1132 |
| 0.40 | — | 1077 | 1083 | 1089 | 1095 | 1100 | 1106 | 1112 | 1118 | 1124 | 1129 | 1135 | 1141 |
| 0.45 | 1077 | 1083 | 1089 | 1095 | 1101 | 1107 | 1113 | 1119 | 1125 | 1131 | 1137 | 1143 | 1149 |
| 0.50 | 1083 | 1089 | 1095 | 1101 | 1107 | 1114 | 1120 | 1126 | 1132 | 1138 | 1144 | 1150 | 1156 |
| 0.55 | 1088 | 1094 | 1100 | 1107 | 1113 | 1119 | 1125 | 1132 | 1138 | 1144 | 1150 | 1156 | 1163 |
| 0.60 | 1093 | 1099 | 1105 | 1112 | 1118 | 1125 | 1131 | 1137 | 1143 | 1150 | 1156 | 1162 | 1169 |
| 0.65 | 1097 | 1104 | 1110 | 1117 | 1123 | 1129 | 1136 | 1142 | 1149 | 1155 | 1162 | 1168 | 1174 |
| 0.70 | 1101 | 1108 | 1114 | 1121 | 1128 | 1134 | 1141 | 1147 | 1154 | 1160 | 1167 | 1173 | 1180 |
| 0.75 | 1105 | 1112 | 1119 | 1125 | 1132 | 1139 | 1145 | 1152 | 1158 | 1165 | 1172 | 1178 | 1185 |
| 0.80 | 1109 | 1116 | 1122 | 1129 | 1136 | 1143 | 1149 | 1156 | 1163 | 1169 | 1176 | 1183 | 1189 |
| 0.85 | 1112 | 1119 | 1126 | 1133 | 1140 | 1147 | 1154 | 1160 | 1167 | 1174 | 1181 | 1187 | 1194 |
| 0.90 | — | 1123 | 1130 | 1137 | 1144 | 1151 | 1157 | 1164 | 1171 | 1178 | 1185 | 1192 | 1198 |
| 0.95 | — | 1126 | 1133 | 1140 | 1147 | 1154 | 1161 | 1168 | 1175 | 1182 | 1189 | 1196 | 1203 |
| 1.00 | — | 1129 | 1137 | 1144 | 1151 | 1158 | 1165 | 1172 | 1179 | 1186 | 1193 | 1200 | 1207 |
| 1.05 | — | — | 1140 | 1147 | 1154 | 1161 | 1168 | 1175 | 1183 | 1190 | 1197 | 1204 | 1211 |
| 1.10 | — | — | 1143 | 1150 | 1157 | 1165 | 1172 | 1179 | 1186 | 1193 | 1200 | 1207 | 1215 |
| 1.15 | — | — | — | — | 1161 | 1168 | 1175 | 1182 | 1190 | 1197 | 1204 | 1211 | 1218 |
| 1.20 | — | — | — | — | 1164 | 1171 | 1178 | 1186 | 1193 | 1200 | 1207 | 1215 | 1222 |
| 1.25 | — | — | — | — | — | — | 1182 | 1189 | 1196 | 1204 | 1211 | 1218 | 1225 |
| 1.30 | — | — | — | — | — | — | 1185 | 1192 | 1199 | 1207 | 1214 | 1222 | 1229 |
| 1.35 | — | — | — | — | — | — | 1188 | 1195 | 1203 | 1210 | 1218 | 1225 | 1232 |
| 1.40 | — | — | — | — | — | — | 1191 | 1198 | 1206 | 1213 | 1221 | 1228 | 1236 |

***Equilibrium between steel surface and atmosphere is assumed. In practice actual control values may be slightly higher, the deviation being a function of treatment time and steel composition.**

## SPECIFICATION

| | |
|---|---|
| **Operating Range** | The limits of 1.00V to 1.25V shown in Fig. 8 correspond to an operating range of 90 kilocalories to 120 kilocalories. Prolonged operation at either higher oxidising potentials (i.e. below 90 kilocalories) or temperatures above 1000°C reduce the life of the probe.<br><br>Tables 1 to 4 on the previous two pages show the probe coverage of carburising atmospheres. |
| **Accuracy** | ±1 kcal (±10mV approx.) |
| **Response rate** | Estimated to be <0.1 sec. |
| **Air Supplies** | |
| Reference | Clean, dry air at 100 to 500 ml/min. — Can be supplied from reference air units 003000240 or 003000241 |
| Purge | Clean, dry air at 100 to 250 ml/min. — Can be supplied from reference air units 003000240 or 003000241 |
| **Operating Temperature Limits** | 600 to 1000°C |
| **Construction** | |
| Cell | Stabilised zirconium oxide solid electrolyte |
| Protection sheath | Aluminous porcelain or Incoloy 800 |
| **Mechanical Data** | |
| Mounting | 125mm o.d. blank flange or 1in NPT boss |
| Insertion length | 520mm nom., 720mm nom. or 920mm nom. |
| **Weight** | |
| 600mm | 2.5kg net |
| 800mm | 3.1kg net |
| 1000mm | 3.5kg net |

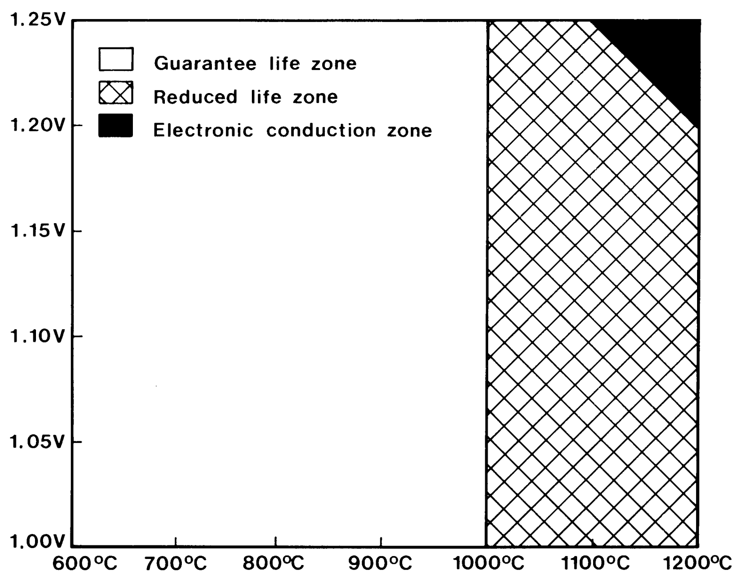



**Fig. 8 Range of Operation**

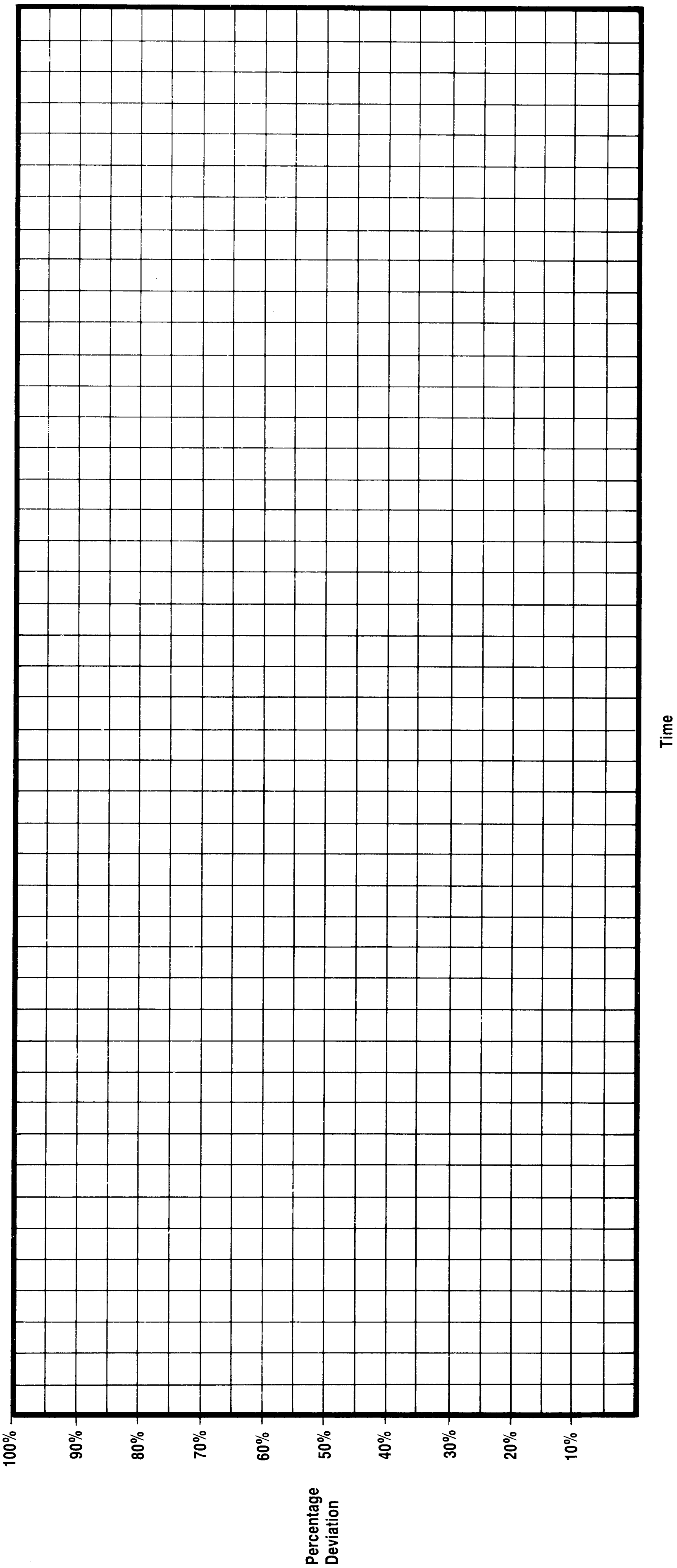
## APPENDIX

### Sensor Ageing Record Sheet

Installation Date:

Sensor No:

Location:




**Standard Operating Conditions**

Operating Temperature:
Sensor Output:

**Fig. A1 Sensor Ageing Record Sheet**

## Notes

# PRODUCTS & CUSTOMER SUPPORT

## Products

### Automation Systems

- ***for the following industries:***
  - Chemical & Pharmaceutical
  - Food & Beverage
  - Manufacturing
  - Metals and Minerals
  - Oil, Gas & Petrochemical
  - Pulp and Paper

### Drives and Motors

- ***AC and DC Drives, AC and DC Machines, AC Motors to 1kV***
- ***Drive Systems***
- ***Force Measurement***
- ***Servo Drives***

### Controllers & Recorders

- ***Single and Multi-loop Controllers***
- ***Circular Chart , Strip Chart and Paperless Recorders***
- ***Paperless Recorders***
- ***Process Indicators***

### Flexible Automation

- ***Industrial Robots and Robot Systems***

### Flow Measurement

- ***Electromagnetic Magnetic Flowmeters***
- ***Mass Flow Meters***
- ***Turbine Flowmeters***
- ***Wedge Flow Elements***

### Marine Systems & Turbochargers

- ***Electrical Systems***
- ***Marine Equipment***
- ***Offshore Retrofit and Refurbishment***

### Process Analytics

- ***Process Gas Analysis***
- ***Systems Integration***

### Transmitters

- ***Pressure***
- ***Temperature***
- ***Level***
- ***Interface Modules***

### Valves, Actuators and Positioners

- ***Control Valves***
- ***Actuators***
- ***Positioners***

### Water, Gas & Industrial Analytics Instrumentation

- ***pH, conductivity, and dissolved oxygen transmitters and sensors***
- ***ammonia, nitrate, phosphate, silica, sodium, chloride, fluoride, dissolved oxygen and hydrazine analyzers.***
- ***Zirconia oxygen analyzers, katharometers, hydrogen purity and purge-gas monitors, thermal conductivity.***

## Customer Support

We provide a comprehensive after sales service via a Worldwide Service Organization. Contact one of the following offices for details on your nearest Service and Repair Centre.

### United Kingdom

ABB Limited
Tel: +44 (0)1453 826661
Fax: +44 (0)1453 827856

### United States of America

ABB Inc.
Tel: +1 (0) 755 883 4366
Fax: +1 (0) 755 883 4373

**Client Warranty**

Prior to installation, the equipment referred to in this manual must be stored in a clean, dry environment, in accordance with the Company's published specification.

Periodic checks must be made on the equipment's condition. In the event of a failure under warranty, the following documentation must be provided as substantiation:

1. A listing evidencing process operation and alarm logs at time of failure.
2. Copies of all storage, installation, operating and maintenance records relating to the alleged faulty unit.

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