CARBON ANALYSER/ TRANSMITTER MODEL 1534

CONTENTS

The product described in this manual and products for use with it, are subject to continuous developments and improvement. All information of a technical nature and particulars of the product and its use (including the information in this manual) are given by Novatech Controls in good faith. However, it is acknowledged that there may be errors or omissions in this manual. A list of details of any amendments or revisions to this manual can be obtained upon request from Novatech Controls Technical Enquiries. Novatech Controls welcome comments and suggestions relating to the product and this manual.

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All maintenance and service on the product should be carried out by Novatech Controls' authorised dealers. Novatech Controls can accept no liability whatsoever for any loss or damage caused by service or maintenance by unauthorised personnel. This manual is intended only to assist the reader in the use of the product, and therefore Novatech Controls shall not be liable for any loss or damage whatsoever arising from the use of any information or particulars in, or any error or omission in, this manual, or any incorrect use of the product.

USING THIS MANUAL

The Novatech 1534 Carbon Analyser/Transmitter has a variety of user-selectable functions.

They are simple to use because each selection is menu driven.

For options you are not sure about, read the manual on that particular item.

Please read the 'Installation' section before connecting power to the analyser.

SPECIFICATIONS 1

SECTION
NUMBER

1.1 MODEL 1534 CARBON ANALYSER

DESCRIPTION

The Novatech model 1534 carbon analyser/transmitter provides in-situ measurement of carbon in gas generators and furnaces with temperatures from ambient up to 1400øC. The analyser provides local indication of carbon plus nine other selectable variables.

Two linearised 4_20 mA output signals are provided. Alarms are displayed at the analyser and relay contacts activate remote alarm devices. The analyser, which is available for heated or unheated zirconia probes, provides automatic on-line filter purging (where necessary). The electronics self-calibrates all inputs every minute.

The 1534 has an internal keyboard for selecting the output range, thermocouple type etc., as well as maintenance and commissioning functions. The instrument is microprocessor based and all adjustments are made using the internal keyboard.

In addition to its use as a local indicator of carbon potential in a furnace, the 1534 may be used in conjunction with an IBM personal computer running the 'Furnace Master' program. This allows complete automation of a furnace from pre-programmed recipes, with a batch report at the end of the job,

- Calculates carbon potential for propane, methane or nitrogen/methanol generators
- Linear 4_20mA output of % carbon
- Interfaces to an IBM PC for completely automatic control
- Simple to install
- Automatic adjustment free calibration
- 11 different alarms with English annotation

SPECIFICATIONS

Inputs

- Zirconia probe_heated or unheated.
- Furnace or auxiliary thermocouple, field selectable as type T, J, K, R, S, N.
- Heater safety interlock (for heated probes only).
- Ambient air temperature sensor.
- Purge and reference air flow switches.

Outputs

- Two linearised 4_20 mA DC outputs (max. load 600 ê).
- Common alarm relay.
- Probe not ready relay (under temperature).
- Auto purge occurring relay (output is frozen when probe purge is occurring).
- Alarm horn driver relay.

Computer

- RS 232-C for connection of a computer terminal for automatic batch control and reports using 'Furnace Master', or printer for diagnostics of the analyser, probe or furnace.

Range of Output 1

Output	Range
Linear	0 - 1.5% carbon

Range of Output 2

Field selectable from the following:

Output	Zero Range	Span Range
Probe EMF	0 - 1100 mV in 100 mV steps	1000 - 1300 mV in 100 mV steps
Auxiliary TC Temperature	0 – 100℃ in 1℃ steps	100 – 1400℃ in 100℃ steps
Log Oxygen	0.1% O_2 Fixed	20% O_2 Fixed
Reducing Oxygen	10^{-1} - 10^{-10} % oxygen in one decade steps, non-overlapping	10^{-1} - 10^{-25} % oxygen in one decade steps. Min span two decades
Linear Oxygen	Fixed	1 - 100%

Range of Indication, Upper Line

- 0.00 - >1.5% carbon. (Calculation accuracy ±0.02 between 0.3 and 1.2%)

Indication Choice, Lower Line

Any or all of the following can be selected for lower line display:

Options:

- Oxygen %
- Auxiliary Temperature
- Ambient Temperature
- Date - time
- Run Hours since last service
- Date of last service
- Probe Impedance
- Probe EMF
- Probe Temperature

Accuracy

- ±0.02% carbon within the range of 0.3 - 1.2%, with a repeatability of ±0.001% carbon.

Relay Contacts

- 4A 240 VAC, 2A 50 VDC

Ambient Temperature

- 0 - 50℃

Power Requirements

- 20 VA (unheated probe)
- 240 or 110V, 50/60 Hz, 150 VA (heated probe)

Weight

- Unheated probe analyser 8.5 kg
- Heated probe analyser 12.5 kg

Mounting

- Suitable for wall or surface mounting.

1.2 SERIES 1230 PROBES

FEATURES

- More consistent and reliable products from heat treating furnaces
- Fuel savings and pollution control in furnaces, boilers and kilns
- Low cost
- Simple to install

DESCRIPTION

Novatech series 1230 probes provide in-situ measurement of the oxygen and carbon level in furnaces, boilers and kilns. In atmosphere control of metal and ceramic heat treatment processes, series 1230 probes provide improved quality control. Series 1230 probes allow major fuel savings in combustion control applications. The selection of probe model depends on the temperature and the constituents of the gas to be measured (Refer to Section 1.5, Specifications).

Novatech series 1230 probes employ state-of-the-art zirconia sensors and advanced materials, which provide the following benefits:

- Improved control due to fast response time - typically less than four seconds
- Cost-efficient design provides improved reliability
- Longer-life probe - greater resistance to corrosion from sulphur and zinc contaminants in furnace gas
- Low-cost maintenance - simplified design allows easy refurbishment
- Reduced probe breakage - greater resistance to thermal shock during installation and start-up

Series 1230 probes are simple to install and maintain. All models provide direct measurement of carbon level. Probes may be used with Novatech carbon analysers and some model analysers from other manufacturers.

All Novatech carbon probes are designed and manufactured to exacting standards of performance and reliability. Series 1230 probes are the result of extensive research and development by Novatech, industry and government agencies, including the CSIRO. Novatech Controls provides application and after-sales support for probes and analysers, world-wide.

Figure 1.1 Series 1230 Probes

ORDERING INFORMATION

Orders may be placed by submitting the following information (please number each item as below):

1. Combustion plant (e.g. furnace, boiler, kiln, etc.).
2. Type and size of plant.
3. Type of fuel(s).
4. Contaminants in gas being measured (e.g. sulphur, zinc, etc.) State percentage of contaminant if known.
5. Probe insertion length (from process end of mounting thread to probe sensing tip).
6. Probe cable (run distance between the probe and the analyser-maximum length 50 metres.)
7. Lagging extension length, if required.
8. Mounting thread (process connection)_BSP or NPT (for size of thread refer to Specifications).
9. Operating temperature range_maximum and minimum temperatures for which probe readings are required.
10. If model 1232 probe, state preferred thermocouple type (Refer to Specifications).
11. If model 1231, state if separate thermocouple is required
    Also state preferred type: T, J, K, R, S or N; insertion length;
    preferred thread_1/2" BSP or NPT; and
    length of lagging extension, if required.

Ask your local Novatech Distributor for assistance in ordering.

STANDARD PROBE 'U' LENGTHS

1231 1232 1233
250 mm (9.8") 300 mm (11.8") 457 mm (18")
500 mm (19.7")500 mm (19.7") 609 mm (24")
750 mm (29.5") 750 mm (29.5") 914 mm (36")
1000 mm (39.4") 1000 mm (39.4") 1160 mm (45.8")
1160 mm (45.8")
Note:
Non standard sizes_within the range of standard lengths_can be specified on request.

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Figure 1.2 Probe Mounting

SPECIFICATIONS

MODEL1231 1232 1233

Application Furnace Furnace gases Furnace gases
gases below above 700øC (1290øF) above 700øC (1290øF)
900øC (1830øF) with no contaminants. with contaminants
refer to Note 1 e.g. natural gas,such as zinc or
light oilssulphur. Refer Note 2.

Temperature Range 0_900øC 700_1400øC 700_1200øC
(32_1830øF) (1290_2550øF) (1290_2190øF)

Length 250_1000 mm 300_1160 mm (12_46 ")300_1160 mm (12_46 ")
(5.5_39 ")

Process 1 1/2" BSP 3/4" BSP 1" BSP
Connection or NPT or NPT or NPT

Heater Yes No No

Furnace Gas Thermocouple Ordering info. 11 R , integral R, integral

Response Time Typically less than 4 secs. Typically less than 1 sec. Typically less than 1 sec.

Head Temperature 150øC (300øF) Max 150øC (300øF) Max 150øC (300øF) Max

Reference Gas Ambient air 50 cc/min approx. Pump supplied with probe

Reference Gas Alarm Piston actuated flow switch

Reference Air Connection 1/8" NPT female Integral air line in probe cable. Barbed fitting to 3/16" ID PVC tube.

Probe Cable Supplied with connector to specified length - maximum 50 m (160 ft)

Calibration Gas 1/8" NPT female 1/16" NPT female 1/16" NPT female

Weight 0.6 kg (1.35 lbs) plus 0.33 kg/ 100 mm (0.75 lbs/in) 0.4 kg (0.9 lbs) plus 0.1 kg/100 mm (0.6 lbs/in) length

Probe M.T.B.F. Typically 1-2 years. -A low cost refurbishing service is available.

Notes: (1) Care must be taken to avoid contact with explosive or inflammable gases with 1231 heated probes when hot. Novatech analysers have built in safety protection.

(2) Please contact factory for corrosives other than sulphur or zinc. We can provide test materials to try in your atmosphere.

CARBON PROBE MODEL SELECTION GUIDE

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1.3 SPECIFICATIONS _ REFERENCE AIR & FILTER PURGE FLOW SWITCHES

Model _ Reference Air LPH_125_0 *
Filter Purge LPH_125_7 *
Range _ Reference Air 50 c.c./minute
Filter Purge 2500 c.c./minute
Dimensions 50 mm high by 14 mm wide
Type Magnetic piston & reed switch, 1 AMP.
Mounting Vertical only

* Suffix 'A' denotes acrylic body with flying leads. (Not suitable for outdoor installation) e.g. LPH_125-0A
Suffix 'B' denotes brass body with conduit thread entry for leads. Suitable for outdoor installation.

DESCRIPTION
2

SECTION
NUMBER

DESCRIPTION

2.1 The Zirconia Sensor

The analyser input is provided from a solid electrolyte carbon probe which contains a zirconia element and thermocouple. The probe is designed to be inserted into the furnace or boiler gas flue. Sampling lines and filters are not required. A reference air supply or pump is required for probes with insertion length 250 mm and above.

The probe sensing end construction is shown in Figure 2.1.

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Figure 2.1 Schematic View of a Sensor Assembly

The heater control is a time proportioning temperature controller and triac so that the thermocouple junction is controlled to approximately 720øC. Probes operating in a combustion environment above 700øC do not require a heater.
When exposed to different oxygen partial pressures at the outside and inside of the sensor, an EMF (E) is developed which obeys the Nernst equation:

E (millivolts) = _F(RT,4F) loge _B(_F((PO2) INSIDE,(PO2) OUTSIDE))

Where T is the temperature (K) at the pellet (> 650øC), R is the gas constant, F is the Faraday constant and (PO2) INSIDE and (PO2) OUTSIDE are the oxygen partial pressures at the inner and outer electrodes, respectively, with the higher oxygen partial pressure electrode being positive.

If dry air at atmospheric pressure, (21% oxygen) is used as a reference gas at the inner electrode, the following equations are obtained:
E (millivolts) = 2.154 x 10-2 T loge _F(0.21,(PO2) OUTSIDE)

Transposing this equation
(%O2) OUTSIDE (ATM) = 0.21 EXP _F(-46.421E,T)
The 1534 transmitter solves this equation which is valid above 650øC for oxygen, from which it then calculates the carbon potential of the atmosphere. The probe heater, or the process maintains the sensor temperature at this level.

2.2 The CARBON Probe

The probe assembly provides a means of exposing the sensor to the atmosphere to be measured with sensor, thermocouple and heater wires connected via a weatherproof plug to the analyser lead. Reference air is fed via the plug for unheated probes and via a separate gas thread connection for heated probes.

A cleaning purge of air can be admitted via the cal. gas entry. The outer sheath can be metal or ceramic, depending on the application.

2.3 The ANALYSER

The 1534 analyser is a transmitter with two 4_20 mA outputs. One output is % carbon. The second output can be selected as auxiliary probe temperature, oxygen, probe emf, or a reducing oxygen range. Four alarm relays are provided. Refer to the specifications section for more details.

The 1534 analyser is designed to operate with either a heated or unheated, zirconia probe. The analyser maintains the temperature of heated probes at 720øC. If the furnace gas temperature is above 730øC, the probe heater cuts out completely and the process provides probe heating. The analyser solves the Nernst equation and will provide accurate carbon measurements up to 1500øC (2730øF), although most probes are suitable only to 1400øC (2250øF) and some are limited to 900øC (1650øF), with an accuracy of ñ0.02% between 0.3 and 1.2% carbon.

A block diagram of the analyser is shown in Figure 2.2 and details on its functions are given in the remainder of this section.

2.4 Alarms

Inside the 1534 analyser is a complete alarm annunciator panel. There are 12 alarms that will operate the alarm and horn relay. The alarm button is used to display the alarm message. Refer to Operator Functions Section 4 for details on alarm functions.

2.5 Heater Supply (HEATED PROBES ONLY)

CAUTION

The probe heater is supplied with 110 VAC at 1 A (cold). This supply has electrical shock danger to maintenance personnel. Always isolate the analyser before working with the probe. For maximum safety the heater supply is transformer isolated.

2.6 Applications Where Sensing Point Is Not At Atmospheric Pressure

To apply the 1534 analyser to processes which have pressure at the point of measurement significantly above or below atmospheric pressure, then a compensation must be applied. (Refer to Set-up Steps 11 and 12 in Section 5.5).

2.7 Probe Impedance

The probe impedance is a basic measurement of the reliability of the carbon reading. A probe with a high impedance reading will eventually produce erroneous signals. The analyser checks the probe impedance every five minutes, and if the impedance is above the maximum level for a specific temperature then the impedance alarm will be activated. Typical probe impedance is less than 5000ê.

2.8 Auto Calibration - Electronics

The analyser input section is self calibrating. There are no adjustments. The analog to digital converter input stages are checked against a precision reference source and calibrated once every minute. Should the input electronics drift slightly then the drift will be automatically compensated for within the microprocessor. If a large error occurs due to an electronic fault then an 'A/D CAL ERROR' alarm will occur.

A one-off calibration procedure of the precision reference sources should never need to be repeated for the instrument life unless the instrument undergoes a 'COLD START' (Refer to Section 3.13). If there is any doubt about the accuracy of the instrument readings, then refer to Maintenance Section 6.5, items 6, 7, 8 and 9 for a full description of this simple calibration procedure.

The D/A sections are recalibrated in one second by pressing the 'AUTO CAL' button on the technicians keyboard. All output signals will drop to 0 mA for the one second period. If they are found to have an error then a 'D/A CAL ERROR' alarm will occur.

It is suggested that a D/A recalibration be performed after the instrument has stabilised, approximately 30 minutes after first switching on and the ambient temperature has stabilised, and after Maintenance Section 6.5, items 6, 7, 8 and 9 have been completed, and then annually. If a 'D/A CAL ERROR' alarm occurs during normal operation, then a hardware fault should be suspected.

2.9 Auto Purge

If the probe is fitted with a sintered filter, it is possible for it to become blocked. An automatic purge cycle can be set up so that a blast of air, maximum 100 kPa, will automatically back-flush the probe filter on a timed basis. Refer to set-up steps 13 to 17 in Section 5.5.

A purge flow switch will sense that there is sufficient flow to clear the filter during the purge cycle, otherwise a 'FILTER BLOCKED' alarm will occur.
The probe can be manually purged from the keyboard while in 'RUN' mode. The analyser output is not frozen during or after the pressing of this button.

2.10 RS 485/RS 232C Port

The RS 485/RS 232C port is normally used for two way communication between the 1534 analyser and the PC running the 'Furnace Master' software. In this way the PC can use the measured values of probe emf, temperature and carbon to provide temperature and carbon profiles for automatic batch operations in your furnace. Set-up step 24 must have the option 'YES' selected. (Contact Novatech Controls for more information about 'Furnace Master' software).

If the set up step 24 option 'NO ' is selected, the serial port can be connected to a printer, data logger or any computer. It can then be used to monitor the 1534 analyser or process by logging the values of functions selected in step 18 of the set up menu in section 5.5.
The protocol for the serial port is eight data bits, one stop bit, no parity.

2.11 Other Inputs, _ Ambient Temperature & AUXILIARY Temperature

The safe maximum ambient operating temperature for the 1534 is specified at 50øC. If it is required to read the temperature of the inside of the 1534 cabinet, select ambient temperature in step 10 of the set up menu.

An auxiliary temperature input is provided to enable an additional temperature to be logged out the serial port, transmitted on the 4_20 mA channel number two, or displayed on the LCD. The thermocouple type is selected in set-up step 3, and may be either K, R, S, N, T or J.

If it is desired to re-transmit the furnace temperature on the 4_20 mA output channel number two, interconnect terminals 3 to 5 and 4 to 6, and select 'AUX TEMP' in set-up step 6. The temperature range may be selected in set-up steps 7 and 8. A minimum of 100øC span must be used with a maximum of 1400øC.

2.12 Watchdog Timer

The watchdog timer is started if the microprocessor fails to pulse it within any three second period, (i.e. fails to run its normal program).

The microprocessor will then be repeatedly reset until normal operation is resumed. Reset cycles are displayed by the RESET light on the internal keyboard. A steady 'ON' light indicates normal operation.

If the program has not resumed normal operation after three attempts to reset, the common alarm relay will be activated, and the ERROR light will be lit. A single flash of the RESET light would probably be caused by a strong burst of interference (e.g. arc welding close by). Continuous flashing means a fault on the 1530_1 printed circuit board, perhaps the RAM, IC2.

2.13 Back-Up Battery

The transmitter's RAM and real-time clock are backed up by a lithium battery in the event of power failure. All set-up and maintenance variables are saved and the clock is kept running for approximately ten years with the power off. The average life of the battery with the power on is 38 years.

Figure 2.2 1534 Analyser Block Diagram

INSTALLATION &
COMMISSIONING
3

SECTION
NUMBER INSTALLATION

COMMISSIONING

INSTALLATION
3.1 Mounting the ANALYSER

Surface mount the transmitter case on to a flat surface or bracket, using the four holes provided. Refer to Figure 3.1. If the hole layout provided is not suitable then the circuit boards may be removed and additional holes drilled in the rear of the case. Mounting screws should not come into contact with the printed circuit boards. All wiring should comply with local electrical codes. The lead between the probe and transmitter should be ordered with the probe. It has an integral weatherproof connector to plug into the probe head.

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Figure 3.1 Case Mounting Dimensions

3.2 HEATER INTERLOCK RELAYS
CAUTION

Explosion protection for heated probes is achieved by switching the power to the probe heater off whenever the main fuel valve is closed.

The principle of safety is that if the main fuel valve is open then main flame has been established. With this primary source of ignition on, the probe heater can be safely switched on. The most dangerous situation is if fuel leaks into the combustion appliance when the fuel valve is closed. When power is removed from the main fuel valve the heater should also be switched off.

To achieve this protection, connect the main fuel valve power to the 'BURNER ON I/P' terminals and check that relay RL7 coil is compatible with the voltage connected e.g. 110 or 240 VAC. For

Installation where there is no risk of explosion, connect a constant mains supply to terminals number 39 & 40. Refer to Figure 3.2.

3.3 Earth, Shield & Power Connections

All external wiring should be shielded. The printed circuit boards are fully floating above earth. All earth and shield connections should be connected to the earth terminal number 44.

The mains earth should be connected to a sound electrical earth.
Do not connect shields at the field end. Simply clip off and insulate. An extra terminal strip may be required to connect all shields together. This should be supplied by the installer.

Before connection of mains power check that the correct solder links are installed as shown in Figure 3.3.

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Figure 3.2 Heater Supply Interlock Connection For Heated Probes

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Figure 3.3 Earth, Shield and Power Connections

3.4 Connecting the Probe Cable

Connect the probe lead supplied as shown in Figures 3.4a and 3.4b. Unheated probe leads have integral reference air tube. An adaptor has been supplied to connect this tube to quarter inch flexible PVC tubing, from the air pump or reference air supply.

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Figure 3.4a Connection of Probe Cable for Unheated
Probes Model 1232 and 1233.

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Figure 3.4b Connection of Probe Cable for Heated
Probe Model 1231.

3.5 Connecting the AUXILIARY Thermocouple

An additional thermocouple input has been provided on the 1534 analyser on terminals 5 and 6 of the screw terminal board. The temperature of a thermocouple on this input may be either displayed on the LCD, logged on the RS 232C serial port, or transmitted on channel number two, 4_20 mA output. The thermocouple may be a type T, J, K, R, S or N.

It may be useful to transmit the furnace temperature on channel number two,
4_20 mA. In this case, interconnect terminals 3 and 4 to terminals 5 and 6.

For unheated probes the probe TC can also serve as a furnace TC. For this option, jumper in copper wire from terminal 3 and 4 to terminals 5 and 6 respectively. Remove link LK2 when connecting in this way. In this way the furnace temperature may be re-transmitted on channel number two. (See set-up step 6).

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Figure 3.5 Auxiliary Thermocouple Connection

3.6 Connecting the Output Channels

The two 4_20 mA DC output channels are capable of driving into a 600ê load. Refer to Figure 3.6.

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Figure 3.6 Connections for Transmitter Output Channels.

3.7 Connecting the Alarms

The alarm relay functions are described in detail in Sections 4.2 and 4.3. Each relay, except for the horn relay, has normally closed contacts. The contacts will open in alarm condition or if power is removed from the 1534 analyser. The horn relay has normally open contacts. All systems should have the alarm relay RL5 connected to Terminals 26 and 27, and the probe low temperature relay RL3 connected. The probe calibration and horn relays are optional. Alarm wiring should be shielded.

3.8 Connecting THE Horn Relay

The horn relay operates as a true alarm system and can be connected directly to a horn. The horn relay is latching and can be re-set by pressing the alarm button. Refer to Figure 3.7.

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Figure 3.7 Connections for Alarm Horn

3.9 Connecting the Automatic Purge System

The on-line auto purge system is optional. It will normally only be necessary for heated probes that are more likely to need a probe end filter. For details on its operation refer to Sections 1.1 and 2.9. Typical connection details are shown in Figure 3.8.

After installation, the purge system should be tested thoroughly for leaks. Any leaks can cause significant errors if the furnace is at negative pressure. If the furnace is at positive pressure, an outward leak can cause corrosion in the purge system piping and fittings.

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Figure 3.8 Automatic Purge System Wiring Schematic

3.10 Connecting Reference Air

A reference air supply is required for the probe. Reference air must be clean and dry. If there is any doubt about plant instrument air quality, it is better to use a separate diaphragm pump. Connect as shown in Figure 3.9.

A reference air flow switch is required. The flow switch causes an alarm if the reference air flow is insufficient. Failure of reference air can cause indeterminate errors which may result in a dangerous combustion situation.

The reference air flow switch is also checked by the 1534 analyser. Every five minutes the power to the reference air pump is turned off for seven seconds. During this time the flow switch change-over is checked. If the switch does not operate correctly, a 'FLOW SWCH FAIL' alarm is generated.

Reference air pressure should be regulated to around 20 mm W.G. As a guide, if the end of the air supply tube is held 12 mm under water, then you should see several bubbles per second. The flow should be sufficient to actuate the reference air flow switch. Cooling effect errors will occur if the reference air flow is too high. This can be checked by turning the flow on and off while reducing the flow until no difference in oxygen reading is noticed between flow and no-flow.

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Figure 3.9 Reference Air Connection

3.11 Connecting the Printer

The RS 485/RS 232C port is available at the connector on the lower right hand side of the main circuit board. This port operates at 9600 baud (see set-up step 20), seven data bits, one stop bit, no parity.

A printer with a serial port, or a data logger, or a computer terminal may be connected to the port.

Data is logged out of the port as arranged in set-up steps 18 and 19. The baud rate is selectable in step 20. (Refer to Section 2.10). Connection details are shown in Figure 3.10.

Note: For the RS 485/RS 232C port to work as an RS 232C port, there must be no other connection from the external device back to the transmitter, (including an earth return).

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Figure 3.10 Serial Port Connections

3.12 INSTALLING THE CARBON PROBE

Weld a BSP or NPT socket to the furnace in a suitable position for furnace gas sensing. For the correct size of socket, refer to probe data in Section 1. Try to place the carbon probe in a position where it is sensing a representative gas in the furnace. (i.e. Not too close to the endo injection port).

COMMISSIONING

3.13 Connecting Power - Cold Start

Check that the mains supply voltage link is in the correct place for the supply voltage. To locate this link refer to Section 3.3

It is recommended that, prior to commissioning, a 'COLD START' be performed. This resets all 'Set-up' and 'Maintenance' mode entries to their normal default values. 'COLD START' will show on the display for a second prior to a microprocessor initialising sequence, which takes about seven seconds.

After a 'COLD START', it is necessary to set all new variables in 'MAINTENANCE' and 'SET-UP' modes, including calibration voltages and time and date.

To perform a 'COLD START', apply power to the transmitter while at the same time holding down one of the nine internal keyboard buttons.

A 'WARM START', which is performed by applying power without holding down an internal keyboard button, will retain all data previously entered in Maintenance and Set-up modes.

3.14 Reference Air Flow Switch

It is important that a reference air flow switch be installed in the reference air line to the probe. The reference air flow switch normally provided trips to close a contact when the flow is greater than 50 cc/min.

When this flow switch is installed, ensure also that the reference air flow switch alarm is enabled by selecting 'YES' in set-up step 21. The flow switch wires should be connected to terminals 16 and 17 (REF AIR) or to connector CN12 (SWITCH).

3.15 Commissioning - Maintenance Mode

Switch the mode switch to 'MAINT'. Enter the date and time. If the analyser has performed a 'COLD START', then the reference voltage calibration will have to be performed. If a 'COLD START' has been performed or a new probe installed, then the probe offset will need to be set. Refer to Section 6 for full details on calibration.

3.16 Commissioning - Set-Up Mode

Switch the mode switch to 'SET-UP' and enter all set-up functions as listed in Section 5.

3.17 Run Mode

Switch the mode switch to 'RUN'. The upper line of the display will now read 'CARBON %' if the probe temperature is above 650øC and the calculated carbon value is between 0.3 and 1.2% carbon, otherwise the word 'INVALID' will be displayed. The probe temperature can be checked on the lower line of the display. Refer to Section 6.6 for calibration of the D/A section of the analyser.

3.18 Heater By-Pass Switch

Heated probes can have the heater supply interlocked with the furnace using RL7, and terminals 39 and 40. (See Figure 3.2). This will enable the heater in the probe to come on only when it is safe to do so.

To commission a heated carbon probe wired with this facility, it is possible to enable the heater by using the heater by-pass switch. This switch will then by-pass the interlock system, and as this may cause a dangerous situation, will also raise an alarm. After commissioning is completed, if the interlock is again required, switch the heater by-pass switch to the 'UP' position.

3.19 Checking the Alarms

If any alarms are present the alarm LED should be lit, either flashing or steady. To interpret the alarms, press the alarm button until all alarm functions have been displayed. Rectify the cause of each alarm until no further alarms appear on the display. For details on the operation of the alarm button and the alarm functions refer to Section 4.

3.20 Probe Calibration

The zirconia sensor in the probe provides an absolute measurement of carbon potential. There are no calibration adjustments, apart from 'PROBE OFFSET', for the probe. The probe EMF is either correct or the probe is faulty.

To check that the probe is functioning correctly, firstly check that the high probe impedance alarm is not activated. The display would show 'SENSOR FAIL'. The actual impedance can be displayed on the lower line. It should be less than 5000 ê.

Once it has been established that the probe impedance is normal, the probe offset may be tested and set. (Refer to Section 5.5). A small flow of air must be admitted to both the 'REF' and 'CAL' ports when testing probe offset.

3.21 FILTER PURGE SET-UP PROCEDURE

Before setting up probe calibration gases, the filter purge should be set up. If filter purge is not installed, proceed to the calibration gas set-up described in the following paragraph.

Set up the probe outside the furnace so that the filter can be viewed whilst running purge air, (controlled from the 'PURGE' button on the analyser when in 'RUN' mode). Gradually adjust the purge air supply regulator, increasing the pressure until sufficient flow is obtained to clear the filter.

This is best checked with a dirty filter after a period of operation, by withdrawing the probe from service and watching any build up on the filter being blown off at the set pressure. Normally 30 kPa (5 psi) is adequate but the air pressure may be set as high as 100 kPa (15 psi).

The time between purges, purge duration and purge freeze time may be set in set-up steps 15 to 17 if 'YES' is selected in set-up step 14, (Automatic Purge).

3.22 SOOTING in the FURNACE

For unheated probes with no filter, carbon build up in the end of the probe does not present a problem unless the carbon, when settled, is not porous. Allow the carbon in the process to build up on the probe. It will form a porous layer, slowing the response time. To avoid mechanical abrasion of the electrode material, pack 'SAFFIL' or equivalent alumina based ceramic fibre in the sensing holes to protect the electrode. Do not use silica based ceramic fibres such as 'KAOWOOL', which can attack the electrode at high temperatures. Once the carbon has built up the response time of the probe will be slower.

For heated probes the preferred method of mounting is facing vertically downwards with the filter removed.

Probes can also be mounted horizontally with no filter. An occasional automatic back purge is helpful in this case.

Normally, heated probes are supplied with filters. The probe response time should be tested when the probe is first installed, and then regularly until it remains constant for a significant period. Filter purging should be set up on the time periods determined by these tests. To test the probe response time, use a stop watch to obtain the time for a probe to achieve a 63% change from one reading to another.

If a probe filter blocks completely in a short period of time, then there is no option but to use the probe without the filter. A trial probe with filter is available to test whether filter blockage is likely to occur.

OPERATOR
FUNCTIONS
4

SECTION
NUMBER

OPERATOR FUNCTIONS (RUN MODE)

4.1 Display Button

The upper line on the display will always read carbon %. The following are available for display on the lower line.

1. DATE _TIME

2. RUN HOURS SINCE LAST SERVICE

3. DATE OF LAST SERVICE

4 PROBE IMPEDANCE, a measure of integrity of the sensor's electrode, the part of the probe that normally wears out first.

5. PROBE EMF (millivolts)

6. PROBE TEMPERATURE

7. OXYGEN %, a measure of the oxygen level that is used in the carbon calculation.

8. AUXILIARY TEMPERATURE

9. AMBIENT TEMPERATURE

10. The lower line may be set to be 'BLANK'

Any number of these variables can be displayed sequentially by pressing the 'DISPLAY' button. Items can be selected for display or deleted in set-up step 10 on the technicians keyboard. In addition to the above lower line displays, the analyser will automatically display:

11. PROBE UNDERTEMP, when the probe is below 650øC

12. PROBE PURGE occurring

NOTE:
The run time will be the period of time the furnace interlock contact is closed (i.e. furnace atmosphere being generated). If no explosion protection is required, a permanent bridge between the 'BRNR ON I/P' terminals to mains power will register run time whenever the analyser is powered.

This timer can be used as a probe replacement or a service schedule aid. The start time is re-set by changing the 'SERVICE DAY' in Maintenance mode on the technicians keyboard.

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Figure 4.1 Operator's Panel

4.2 Alarm Button

Repeatedly pressing the operators 'ALARM' button will produce alarm displays in sequence on the lower line of the LCD display. If an alarm has cleared prior to pressing the 'ALARM' button, it will not re-appear on a second run through the alarms. Active alarms which have been previously displayed will have 'ACC' (accepted), displayed alongside. New alarms will not have 'ACC' displayed until a second press of the 'ALARM' button. After the last active alarm is indicated, the lower line of the display will return to the last displayed lower line variable.

The alarm 'LED' will flash on alarm. Pressing the 'ALARM' button will cause the LED to go steady if any alarms are still active, or extinguish if there are no active alarms. The horn relay will operate when an alarm occurs. Pressing 'ALARM' will mute the horn relay which will re-initiate on any new alarms.

4.3 Alarm Schedule

4.3.1 Summary of Alarms

ALARM DESCRIPTION

'SENSOR FAIL' Oxygen cell or electrode failure (high impedance), (inhibited under 650øC).

'PROBE HEATER FAILURE' For heated probes, in the first 20 minutes of power being applied to the heater after being switched on, this alarm will not occur, but a 'PROBE UNDER_TEMPERATURE' display will occur and relay RL3 will be activated. Refer to Section 6.13.

'PROBE TC O/C' Probe thermocouple is open circuit. The heater in heated probes will switch off.

'REF AIR FAIL' Low reference air flow to probe.

'FLOW SWITCH' The reference air flow switch has failed. This is tested by automatically switching off the reference air pump once every ten minutes for seven seconds to check the operation of the flow switch. The alarm can be removed by either correcting the flow switch failure or selecting 'NO' in set-up step 21.

'A/D CAL ERROR' The analog to digital converter has been found to fall outside the normal calibration specifications. This is an electronic fault.

'A/D MAINS ERROR' Total failure of the analog to digital converter (IC15) or of the mains frequency signal (50/60 Hz) from the power supply used to synchronise the A/D converter.

'D/A CAL ERROR' The digital to analog and voltage isolator circuit has been found to fall outside the normal calibration specifications. This check is only performed when the 'AUTO CAL' button is pressed. Refer to Section 6.6.

'FILTER BLOCKED' Blocked probe filter, low purge flow. This test is only performed when automatic purging of the probe is requested. Refer to step 26 in the set-up menu Section 5.5.

'HEATER BY-PASS' The safety interlock relay has been by-passed by turning on the 'BURNER BY-PASS' switch on the terminal printed circuit board. Refer to Section 3.2 and 3.18.

'REM ALARM' This alarm is instigated by the 'Furnace Master' program through the serial port of the 1534 analyser.(Remote Alarm).

'COMMS ALARM' This alarm is only instigated when 'YES' is selected in set-up step 25 (Remote communications?), and if there has been no communication from the 'Furnace Master' program in the last minute. (Communications Alarm).

'WATCHDOG TIMER' This alarm will not appear on the display. The 'ERROR' LED on the front door will illuminate. (See Sections 2.12 and 4.5).

4.3.2 Summary of Alarm Relays

ALARM	RELAY	FUNCTION	LATCHING	NOTES
'PROBE LOW TEMP'	RL3	Probe reading is invalid (under 650øC)	No	For heated probes if the probe heater has been on for more than 20 minutes and the temperature is less than 650øC, a heater fail alarm will occur.
'CAL IN PROG'	RL4	Purge check in progress	No	
'ALARM'	RL5	Alarm condition present	No	
'HORN'	RL6	Horn Driver	Yes	Press the 'ALARM' button twice for any one alarm to reset the horn relay.

Note:
The 'Probe Not Ready' relay is used with unheated probes to indicate carbon reading is invalid (the probe is below 650øC), in case the process temperature falls below this level. For heated probes this relay will be energised while the probe is heating up from ambient.

4.4 Power Lamp

Illuminates when power is connected to the analyser.

4.5 RE-SET LAMP

The reset lamp is on the internal keyboard of the 1534 analyser. This lamp is normally 'ON', however if the microprocessor fails to complete its normal tasks, the watchdog timer will turn this lamp off and re-set the microprocessor. If re-setting the microprocessor is successful, then the lamp will come back on and stay on. (i.e. There may have been a temporary burst of high interference level).

If this lamp is flashing on and off with approximately one second cycle time, it means there has been a catastrophic failure on the hardware and the 1530_1 printed circuit board should be changed.

4.6 Error Lamp

If the microprocessor's software fails, then the 'ERROR' LED will be lit and the common alarm relay activated.

SETTING UP THE ANALYSER
5

SECTION
NUMBER

SET-UP MODE SUMMARY

5.1 Set-Up Mode Functions

1. Sensor Type

2. Probe Thermocouple Type

3. Auxiliary Thermocouple Type

4. Generator Gas

5. Furnace CO%

6. Transmitter Output Channel 2

7. Transmitter Zero Channel 2

8. Transmitter Span Channel 2

9. Centigrade/Fahrenheit Selection

10. Lower Line Display Functions

11. Furnace Pressure mm/inches/kilopascals

12. Furnace Pressure Value

13. Purge Time

14. Automatic Purge

Set-up steps 15 to 17 will be skipped automatically if 'NO' is selected in set-up step 14.

15. Time Between Purges

16. Purge Duration

17. Purge Freeze Time

18. Data to Print

19. Print Log Period

20. Printer Baud Rate

21. Switched Reference Air Supply

22. Damping Factor

23. 4_20 mA Span Correction Factor

24. Remote Communications

5.2 Set-Up/Maintenance/Run Switch

For the 'Set-up' mode keyboard to operate, move the toggle switch to 'SET-UP'. The outputs will be frozen when in set-up mode. If purges or auto calibration occur while the mode switch is in 'SET-UP' mode, they will be delayed until the mode switch is returned to 'RUN'. To cancel a purge or calibration cycle, press 'ENTER' while in 'RUN' mode.

5.3 Function Select

When the 'SET-UP/MAINTENANCE/RUN' switch is moved to 'SET-UP', the display will automatically read the last set-up function selected.

To select other functions, operate the 'FUNCTION □ ' button to increment to the next function, or 'FUNCTION _' to decrement to the previous function.

5.4 Enter Option or Value

A. Options.
To step through the available options for each function press the 'OPTION □ ' or 'OPTION _' buttons.

When the required option is selected press the 'ENTER' button. An asterisk will then appear alongside the option selected. When stepping through the set-up functions, the display will always first indicate the last options entered. The 'Lower Line Select' and 'Data To Print' functions 10 and 46 are multiple options. One or more options may be selected for these functions.

B. Values
To set a value for a particular function press the 'OPTION ' button to increase the value and the 'OPTION _' button to decrease the value. A momentary press will change the value one digit. Holding the button will change the value more quickly. Once the correct option or value is displayed it can be entered into the analyser's memory by pressing the 'ENTER' button. When a value has been entered an asterisk will appear at the R.H.S. of the lower line.

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Figure 5.1 Internal Technicians Keyboard

5.5 Set-Up Function Details

1. SENSOR TYPE

Options
Model No. Enter the probe in use
1. 1231 Heated Probe
2. 1232 Unheated Probe
3. 1233 Unheated Probe for high sulphur applications (cermet sheath)

2. PROBE THERMOCOUPLE TYPE

The probe can have either a type K, R, or N thermocouple as a sensor temperature detector.

Options
1. K Check in the manual Section 1
2. R for the probe model number.
3. N Enter the correct TC type.

3. AUXILIARY THERMOCOUPLE TYPE

Select the auxiliary thermocouple type.

Options
1. T
2. J
3. K
4. R
5. S
6. N
7. Nil

4. GENERATOR GAS

Select the source of the gas in the furnace.

Options:
1. Methane
2. Propane
3. Nitrogen/Methanol

Note
If option 3, nitrogen/methanol is not selected, set-up step 5 will be skipped.

5. FURNACE CO%

Enter the value of carbon monoxide present in the furnace. This may be measured by another instrument, or may be estimated.

Default Value
23.0%

6. TRANSMITTER OUTPUT CHANNEL 2

Select transmitter output for output Channel 2.

Options
1. Probe EMF (0 _1300 millivolts)
2. Auxiliary temperature øC
3. 0.1 _20 % oxygen logarithmic
4. 1 x 10 -1_ 10-25 % oxygen (for reducing conditions)

7. TRANSMITTER ZERO CHANNEL 2

The output zero and span of Channel 2 is set in set-up steps 7 and 8. Range limits are shown in 5.5.8.

8. TRANSMITTER SPAN CHANNEL 2

OUTPUT	ZERO RANGE	SPAN RANGE
PROBE EMF	0 _1100 mV in 100 mV steps	100 _1300 mV in 100 mV steps
AUXILIARY TEMP.	0 _100øC in 1øC steps	100 _1400øC in 100øC steps
LOG OXYGEN (see Note 1)	0.1 % oxygen fixed	20 % oxygen fixed
REDUCING OXYGEN (see Note 2)	10 -1 _10 -10 % oxygen in one decade steps, non o/lapping	10 -1 _10 -25 % oxygen in one decade steps. Min span two decades

NOTE

1. For log oxygen scale details, refer to Appendix 3.
2. Note that the reducing oxygen span is shown on the display as the exponent only. -1 represents 10 -1 % oxygen.

9. CENTIGRADE/FAHRENHEIT SELECTION

Select whether displays and outputs are to be in øCelsius or Fahrenheit

Options
1. Celsius (centigrade)
2. Fahrenheit

10. LOWER LINE DISPLAY FUNCTIONS

In the run mode the upper line on the LCD display will always read % carbon. The lower line can be set to read one or more of the following. Select as many as are required to be displayed by pressing the 'ENTER' button. Those selected will have an asterisk displayed alongside.

Options
1. Date _ time
2. Run hours since last service
3. Date of last service
4. Probe impedance
5. Probe EMF
6. Probe temperature
7. Oxygen
8. Auxiliary temperature
9. Ambient temperature

If no lower line options are required then do not enter any. If options already selected are required to be deleted, select the required option and press the 'ENTER' button. The asterisk will be removed.

11. FURNACE PRESSURE
Enter furnace pressure, e.g. 3 mm W.G.
Options
MM W.G.
Kilopascals
Inches W.G.

12. FURNACE PRESSURE VALUE

Enter furnace pressure e.g. 3 mm W.G.

Limits
_200 to +200 mm W.G.
_9 to +9 inches W.G.
_200 to +200 kPa.

13. PURGE/CAL TIME

Set the purge time to occur at the correct time-of-day. If purging is not required, ignore the time setting.

Range
0_23 hours in one hour steps.

14. AUTOMATIC PURGE

If heavy sooting of the probe sensor is found to be a problem, sensor filters may be necessary and should be back-purged with sufficient frequency to avoid blocked filters. The output will be frozen during purging. If no purge is required, set-up steps 15, 16 and 17 will be skipped.

Options
Yes
No

15. TIME BETWEEN PURGES

Set the time between purges. e.g. A two hourly purge or a 100 hourly purge.

Range
1 _199 hours

16. PURGE DURATION

Set up purge duration to a number between three and ten seconds. The filter is actually purged in less than one second, but three seconds are required for the purge flow switch to check that the filter is not blocked.

Range
0 _10 seconds

17. PURGE FREEZE TIME

After the purge period the transmitter output will remain fixed (frozen) for an adjustable period to allow the probe reading to return to the correct process level and avoid output 'bumps'. The freeze period time required will depend on the probe response time and thus its design, and whether it has a filter or not. To determine the required freeze time, manually perform a purge while the plant is in operation and note the time required for the reading to return to the correct process level within approximately 0.5 % oxygen.

Range
100 _1000 seconds in ten second steps

18. DATA TO PRINT

Any or all of the following values may be printed on a printer or computer connected to the RS 232C port. They may be selected or de-selected using the 'ENTER' buttons as in set-up step 10. The log period and RS 232C protocol follows in set-up steps 19 and 20. A sample of a print-out from the port is contained in Appendix 4.

Options
1. Date _Time
2. Run Hours Since Last Service
3. Date of Last Service
4. Probe Impedance
5. Probe EMF
6. Probe Temperature
7. Oxygen %
8. Auxiliary Temperature
9. Ambient Temperature

19. PRINT LOG PERIOD

Select the time interval between data print outs on the printer.

Range:
1 _2000 minutes

20. PRINTER BAUD RATE

Select the correct baud rate of data to be transmitted out of the RS 232C port to the printer.

Options
300
1200
2400
4800
9600

21. SWITCHED REFERENCE AIR SUPPLY

It is recommended that the reference air supply for the carbon probe is supplied to the probe through a flow sensor (See Section 3.10, Connecting Reference Air). The power lead of the pump is connected to terminals 35 and 36 (See Figure 3.2) The flow switch contacts are connected to terminals 16 and 17. (See Figure 3.8).

The flow switch would be on all the time, with the possibility that the float in the sensor may stick. To exercise the switch and to actually check its reaction to a break in reference air flow, the power to terminals 35 and 36 (Ref air pump) is interrupted for about seven seconds, every ten minutes.

If a plant air supply is being used, a mains voltage solenoid valve may be used to switch the reference air supply off. Connect the coil of the solenoid to terminals 35 and 36 (Reference air pump). If a switched reference air supply is not being used, select 'NO' to inhibit the 'FLOW SWITCH' alarm.

Options
1. Yes
2. No.

22. DAMPING FACTOR

Each time a new reading is read from the carbon probe, the new reading is averaged with the last readings taken, before the new average is either displayed on the LCD, or sent to the 4_20 mA output.

The number of readings that are averaged together is adjustable by the user in this function. A value of five for example, means that the new reading from the probe, and the previous four readings are averaged together before being displayed.

A value of one entered here will mean that every new reading from the probe will be sent to the display unaltered.

23. 4_20 mA SPAN CORRECTION FACTOR

To calibrate the 4_20 mA output channels, the AUTOCAL button is pressed. However, to 'fine tune' the calibration for a particular analyser, a correction factor, usually of about ñ1% may be entered.

After pressing the AUTOCAL button, check the calibration of the output 4_20 mA channel, using a 3 1/2 digit digital multimeter at about 19 mA. If the calibration is out by more than ñ 0.2 mA, enter a new correction value, and re-calibrate using the AUTOCAL button. (A lower correction value will bring down the output current). Re-check the calibration using the DMM until satisfied with the accuracy.

24. REMOTE COMMUNICATIONS

If the 1534 analyser is to be used in conjunction with a personal computer running 'Furnace Master', select 'YES'. This will inhibit all the printer output messages such as periodic data logs, or alarm messages. If 'YES' is selected, the 'REM COM' alarm will appear if no remote communication is received within 20 minutes. If you wish to use a printer, or computer for data logging, select 'NO'.

Options:
1. Yes
2. No

MAINTENANCE
6

SECTION
NUMBER

TRANSMITTER MAINTENANCE

PROBE MAINTENANCE

TRANSMITTER MAINTENANCE

6.1 Maintenance Mode Summary

1. Enter date, year

2. Enter date, month

3. Enter date, day

4. Enter time, hours

5. Enter time, minutes

6. Set 20 mV reference (calibration)

7. Set 70 mv reference (calibration)

8. Set 1200 mv reference (calibration)

9. SET 2500 mv reference (calibration)

10. Set probe offset (probe calibration)

11. Enter service year

12. Enter service month

13. Enter service day

6.2 Set-Up/Maintenance/Run/Switch

For the 'MAINTENANCE' mode on the keyboard to operate, move the toggle switch to 'MAINT'. The outputs will be frozen when in 'MAINTENANCE' mode.

If purges or auto calibration occur while the mode switch is in 'MAINT', they will be delayed until the mode switch is returned to 'RUN'.

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Figure 6.1 Internal Technicians Keyboard

6.3 Function Switch

When the 'SET_UP/MAINTENANCE/RUN SWITCH' is moved to 'MAINT', the display will automatically read the last 'MAINTENANCE' function selected. To select other functions, operate the 'FUNCTION ' button to increment to the next function or the 'FUNCTION _' to decrement to the previous function.

6.4 Enter Values

To set a value for a particular function press the 'OPTION ' button to increase the value, and the 'OPTION _' button to decrease the value. A momentary press will change the value one digit. Holding the button will change the value more quickly. Once the correct option or value is displayed it can be entered into the analyser's memory by pressing the 'ENTER' button. When a value has been accepted an asterisk will appear at the R.H.S. of the lower line (except for calendar date and time values).

6.5 MAINTENANCE FUNCTIONS DETAIL

1. ENTER DATE DD/MM/YR

Enter year e.g. 04-08-91 =4th August, 1991.

2. ENTER DATE

Enter month.

3. ENTER DAY

Enter day.

4. ENTER HOURS

Enter hours e.g. 22:04 = 10.04 pm.

5. ENTER TIME

Enter minutes.

6. SET 20 mV REF.

Enter the 20 mV reference voltage to calibrate the transmitter.

7. SET 70 mV REF.

Enter the 70 mV reference voltage.

8. SET 1200 mV REF

Enter the 1200 mV reference voltage.

9. SET 2500 mV REF

Enter the 2500 mV reference voltage.

Functions 6 to 9 are used to calibrate the A/D of the instrument. This should be done 30 minutes or more after the instrument has been on, approximately once every year. The calibration constants are retained in battery-backed memory unless a 'COLD START' is performed. Refer to Section 3.13.

Connect a 3 1/2 digit multimeter negative lead to the terminal marked 'COMMON' to the left of the internal keyboard. Measure the four test point voltages on the test pins marked 1 to 4 below the common test pin with the positive lead. Refer to Figure 6.2. These voltages should be approximately:

1) 2481 mV
2) 1159 mV
3) 66.6 mV
4) 18.8 mV

Enter the measured values in functions 6 to 9. Whenever new values are entered the D/A section should be re-calibrated, Refer to Section 6.6.

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Figure 6.2 Location of Calibration Test Points

10. SET PROBE OFFSET

When the oxygen level in operation is as low as it is when measuring carbon potentials, this adjustment has very little effect on the calibration, and may be left at zero. (Refer to tables in Appendix 1). A new EMF offset must be entered whenever a new carbon probe is installed to calibrate for any offset an individual probe may have. Each probe will have an offset value noted on a removable tag. Enter the 'PROBE OFFSET' value with opposite polarity, e.g. if offset value is -1.2 mV. enter 1.2 mV. The typical maximum is 2 mV.

To check a probe offset on site, the probe must be sensing air with reference air connected and allowed to settle at the probe operating temperature for 30 minutes. Read the offset in 'RUN' mode in millivolts on the lower line. Offset errors can occur if the sensor does not have some air passing over it. A gentle flow of air in the calibration port can be provided by a reference air pump or similar.

For heated probes, if the furnace is not operational and the probe heater is interlocked with the 'FUEL ON' signal, the 'HEATER LOCKOUT BYPASS' switch should be set to 'BYPASS' to power the probe heater after removing the probe from the furnace.

CAUTION DANGER

Return the 'HEATER LOCKOUT BYPASS' switch to normal before installing the probe in the furnace.

For unheated probes, the probe sensing tip must be raised to at least 700øC with a portable furnace. (Available as an accessory).

Determine the probe offset in 'RUN' mode. Select 'PROBE EMF' on the lower line. With the probe in air, stabilised at temperature for 30 minutes, read the 'PROBE EMF'. Switch back to 'MAINTENANCE' mode and enter 'PROBE OFFSET' of equal value and opposite polarity. e.g.,if 'PROBE OFFSET' was 0.8 mV. enter -0.8 mV.

When reading the EMF offset the furnace pressure compensation must be set. If the probe has been removed from the furnace, set the furnace pressure compensation to 0 in set-up step 12.

11. ENTER SERVICE YEAR

For a new 'DATE OF LAST SERVICE', enter the service 'YEAR'. This can represent the last time the probe was serviced or the last time the furnace was serviced. It is recommended that probes be refurbished every two years

12. ENTER SERVICE MONTH

Enter the current 'MONTH'.

13 ENTER SERVICE DAY

End the current 'DAY' of the month. Altering these values will reset the 'RUN TIME'.

6.6 D/A Calibration

If a 'COLD START' is performed (Section 3.13), then the D/A section of the analyser will be automatically calibrated after a 30 second delay. The D/A section should be manually re-calibrated after the instrument has been switched on for 30 minutes and stabilised. This is achieved by pressing the 'AUTO CAL' button. This button should be pressed annually, or if the reference voltages are altered in 'MAINT'. Refer to Section 6.5, items 6, 7, 8 or 9 to re-calibrate the D/A converter and isolated output section. An 'AUTO CAL' will be performed for one second after pressing the button. The transmitter outputs will fall to 0 mA. for this one second period.

If a 'D/A CAL' error occurs during normal operation, then a hardware fault should be suspected.

6.7 Back-Up Battery Replacement

The back-up battery is contained within the module, plugged into socket IC2. It is rated for an average service life of 38 years with power on, and for ten years with the power off. The battery is not re-chargeable and should be replaced every three years with stored transmitters with power off or every ten years with transmitters which have had the power on.

After replacing the battery, re-enter all maintenance and set-up mode functions.

6.8 Electronic Repairs

Electronic schematics are included in Appendix 5. A competent electronic technician could perform trouble shooting with these schematics, aided by the analyser self-diagnostic alarms.

It is recommended that service be performed on a change-over circuit board basis. A fast turn-around or replacement service is available from Novatech or accredited service agents.

Other service aids, including a firmware diagnostics package and input probe simulator are also available from Novatech.

PROBE MAINTENANCE

6.9 Test Equipment Required

All measurements are simplified if an analyser is connected to the probe. Readings can then be easily taken of probe impedance, EMF, temperature and carbon percent. The analyser also provides proper heater control for heated probes.

The following tests are described using readily available workshop equipment where an analyser is not available. If an analyser is available the same test procedures will apply. First check all alarms on the analyser, allowing time for the probe to heat up after switch on.

An instrument to measure probe EMF and temperature is required. A 3 1/2 or 4 1/2 digit multimeter will perform both measurements. A separate temperature indicator to suit the probe thermocouple type is also useful, although not necessary.

A reference air pump is required and a cylinder of calibration gas e.g. 2% oxygen in nitrogen. The cylinder should have a pressure and flow regulator. Both of these are inexpensive devices available from gas supply companies. The calibration gas should be chromatograph tested to an accuracy of 0.1% oxygen.

Unheated Probes

A small test furnace capable of raising the probe tip temperature to 720øC is required. The furnace should have a uniform temperature for about 50 mm either side of the sensor tip.

Heated Probes

If a 1534 analyser is available at the test location then no other equipment will be required. If not, then a controllable power source for the heater is required. A Variac (variable transformer), set to approximately 100 volts will regulate the probe temperature to 720øC approximately.

6.10 Testing A Probe

With the probe tip heated to approximately 720øC, either from a small test furnace or its own internal heater, connect a digital multimeter to the probe electrode conductors. Connect the multimeter positive to the internal electrode conductor. Connect reference air to probes longer than 140 mm and apply a gentle purge of air to the probe calibration port. Reference air flow should be the smallest flow available (less than 50 cc per minute). The multimeter should read zero millivolts + two millivolts. If not, then there is a problem with the probe electrodes and the sensor needs refurbishing. Normally a faulty probe electrode is indicated with a high source impedance.

To test the source impedance, set the multimeter to read ohms and take a measurement, within a couple of seconds, of the probe impedance. Reverse the multimeter and repeat the reading. Take the average of the two readings for an approximate measurement of impedance. If the impedance is above 5000ê, then the electrode needs refurbishing. The probe must be at 720øC or above for this measurement.

The reason that impedance measurements need to be performed quickly, is that the zirconia sensor polarises with the DC voltage from the multimeter across it. Where a probe electrode requires refurbishing it is suggested that they should be returned to Novatech or an accredited service organisation.

If the probe tests reveal less than 3 mV offset and a good impedance reading, the next step is to apply a calibration gas. The calibration gas should be inserted in the calibration port. With the calibration gas flowing, the probe should develop an EMF according to the tables in Appendix 2. If the EMF reading is low then there may be insufficient calibration gas flow. Increase the calibration gas flow until the reading is correct. An excessive calibration gas flow will cause cooling on one surface of the sensor, giving temperature differential errors on the sensor.

If the calibration gas flow is high and it is left to flow on a probe at a high temperature for more than about 15 seconds, the ceramic parts of the sensor and probe sheath can be cooled to the point where, when the flow is removed, they can break due to thermal shock.

If the flow is kept on for a long time it should be reduced slowly to allow the ceramic surfaces to heat at a rate of not more than 50øC per minute. i.e.To remove a flow which has been running for some time on a probe at 1100øC, the time taken should be about 22 minutes.

The sensor accuracy should be within 0.5 mV with the same offset which was measured with air on both sides of the sensor. If the probe EMF is not within this tolerance, then it will require the electrodes to be refurbished.

As an alternative, using the reference air port, the calibration gas can be inserted into the inside of the sensor. This requires a lower flow rate, and thus lower usage of calibration gas. The flow rate should be similar to that of the reference air, which should be removed for internal calibration. The probe EMF reading will be identical but negative in polarity. A small flow of air should be flowing over the outside of the sensor when testing in this way.

Occasionally, a sensor can develop offset with a polluted electrode caused by contaminants in the furnace gas stream. In this case, the old electrode material must be completely cleaned off before re-applying the fresh electrode material. Again, return the probe or sensor to Novatech or an accredited service organisation.

6.11 Sensor Impedance

If the sensor impedance is found to be high in the test described in Section 6.10, it is occasionally necessary to cause a small movement of the inner electrode conductor to re-establish contact. This is achieved by gently pulling the four bore ceramic tube against its spring loading for approximately 1 mm and releasing. This procedure is normally only required with a probe which has been sitting cold for many months.

With some probes it is possible to view the sensor electrode material from outside the outer sheath. The electrode material should be either grey or green and should fully cover the end of the sensor. If any cream coloured ceramic material is visible at the sensor end, then the electrode has been degraded and will require refurbishment.

6.12 Probe Thermocouple

Although some unheated probes are specified without a thermocouple, most probes, both heated and unheated, have an integral thermocouple which is fitted into the four bore insulator. The analyser has an alarm function which will advise the operator of an open circuit probe thermocouple, however bench testing can be performed by simply measuring the thermocouple continuity. If the thermocouple requires replacement, care should be taken not to physically damage the inner electrode material during removal and replacement of the thermocouple and insulator.

6.13 Heater Failure

For heated probes, a heater failure will cause a 'PROBE UNDER TEMPERATURE' or 'HEATER FAILURE' alarm. Heaters can be tested from the probe head with a continuity test.

The heater impedance should be approximately 120 ê. Should the heater be open circuit, contact Novatech or an accredited service agent.

6.14 Filter Blockage

For carbon probes in installations with entrained solids in the furnace gas, it is sometimes necessary to replace the filter. Filters are normally cleared with back purging. However fine carbon, or other particles can ultimately completely block a filter, necessitating filter replacement. A new probe filter can be fitted by Novatech or an accredited service agent.

6.15 Packing

To return a probe for refurbishment to our factory, please ensure that it is properly packed. We recommend a cardboard box which is normally dropped with less force than a heavy wooden box. Use polystyrene beads for internal packing and some cardboard to inhibit end travel of the probe.

Due to the delicate ceramic inner components of the probe, probes improperly packed are normally broken by the time they arrive at our factory.

Refurbishment is normally an inexpensive operation that can be made expensive with improper packing.

APPENDICES

1. PROBE EMF TABLES FOR ENDOTHERMIC ATMOSPHERES
2. Probe EMF Tables FOR OXYGEN
3. % OXYGEN SCALE _ LOGARITHMIC
4. Sample Log Print Out
5. Circuit Schematics

APPENDIX 1

PROBE EMF TABLES
FOR ENDOTHERMIC ATMOSPHERES

APPENDIX 2

PROBE EMF TABLES
FOR OXYGEN

ZIRCONIA OXYGEN PROBE OUTPUT (mV), PROBE TYPE 1231

% OXYGEN	mV at 720 ø C
20.0	0.99
19.5	1.53
19.0	2.09
18.5	2.66
18.0	3.25
17.0	4.47
16.5	5.11
16.0	5.77
15.5	6.45
15.0	7.15
14.5	7.87
14.0	8.62
13.5	9.40
12.5	11.05
12.0	11.92
11.5	12.83
11.0	13.78
10.5	14.78
10.0	15.82
9.5	16.92
9.0	18.08
8.5	19.30
8.0	20.60
7.5	21.98
7.0	23.45
6.5	25.04
6.0	26.75
5.5	28.61
5.0	30.65
4.5	32.90
4.0	35.42
3.5	38.28
3.0	41.58
2.5	45.48
2.0	50.25
1.5	56.41
1.0	65.08
0.5	79.91
0.2	99.51

Using air as a reference,
the probe e.m.f. is calculated using
the Nernst equation:

e.m.f. = 0.02154 x T x ln (21/ % Oxygen)/ % Oxygen), where
T = øK (øC +273)

'K' TC mV 29.965

ZIRCONIA OXYGEN PROBE OUTPUT (mV), PROBE TYPE 1232

	TEMPERATURE								
% O2	600	700	800	900	1000	1100	1200	1300	1400
20	0.917	1.023	1.128	1.233	1.338	1.443	1.548	1.653	1.758
19.5	1.394	1.553	1.713	1.872	2.032	2.192	2.351	2.511	2.671
19	1.882	2.098	2.313	2.529	2.744	2.960	3.175	3.391	3.607
18.5	2.383	2.657	2.930	3.203	3.476	3.749	4.022	4.295	4.568
18	2.899	3.231	3.563	3.895	4.227	4.559	4.891	5.223	5.555
17.5	3.428	3.821	4.214	4.607	4.999	5.392	5.795	6.177	6.570
17	3.974	4.429	4.884	5.339	5.794	6.249	6.705	7.160	7.615
16.5	4.535	5.054	5.574	6.093	6.613	7.132	7.652	8.171	8.691
16	5.114	5.699	6.285	6.871	7.457	8.042	8.628	9.214	9.800
15.5	5.711	6.365	7.019	7.673	8.327	8.981	9.635	10.289	10.944
15	6.327	7.052	7.777	8.501	9.226	9.951	10.676	11.400	12.125
14.5	6.965	7.762	8.560	9.358	10.156	10.954	11.751	12.549	13.347
14	7.625	8.498	9.371	10.245	11.118	11.991	12.865	13.738	14.612
13.5	8.308	9.260	10.212	11.164	12.115	13.067	14.019	14.970	15.922
13	9.018	10.051	11.084	12.117	13.150	14.183	15.216	16.249	17.282
12.5	9.756	10.873	11.991	13.108	14.226	15.343	16.461	17.578	18.695
12	10.523	11.729	12.934	14.139	15.345	16.550	17.756	18.961	20.167
11.5	11.324	12.621	13.918	15.215	16.512	17.809	19.106	20.403	21.700
11	12.159	13.552	14.945	16.338	17.731	19.124	20.516	21.909	23.302
10.5	13.034	14.527	16.020	17.513	19.006	20.499	21.992	23.486	24.979
10	13.952	15.550	17.148	18.746	20.344	21.942	23.540	25.139	26.737
9.5	14.916	16.625	18.333	20.042	21.751	23.459	25.168	26.877	28.585
9	15.933	17.758	19.583	21.408	23.233	25.058	26.883	28.709	30.534
8.5	17.008	18.956	20.904	22.852	24.801	26.749	28.697	30.645	32.593
8	18.148	20.227	22.305	24.384	26.463	28.542	30.620	32.669	34.778
7.5	19.361	21.579	23.797	26.015	28.223	30.450	32.668	34.886	37.104
7	20.659	23.025	25.392	27.758	30.124	32.491	34.857	37.224	39.590
6.5	22.052	24.578	27.104	29.630	32.156	34.683	37.209	39.735	42.261
6	23.557	26.256	28.954	31.653	34.351	37.050	39.748	42.447	45.145
5.5	25.194	28.080	30.965	33.851	36.737	39.623	42.509	45.395	48.281
5	26.986	30.077	33.168	36.259	39.351	42.442	45.533	48.624	51.715
4.5	28.967	32.285	35.603	38.922	42.240	45.558	48.876	52.194	55.512
4	31.182	34.754	38.326	41.897	45.469	49.041	52.613	56.185	59.757
3.5	33.693	37.552	41.412	45.271	49.131	52.990	56.850	60.709	64.569
3	36.592	40.783	44.975	49.166	53.358	57.549	61.741	65.932	70.124
2.5	40.020	44.604	49.189	53.773	58.357	62.941	67.525	72.110	76.694
2	44.216	49.281	54.346	59.411	64.476	69.541	74.605	79.670	84.735
1.5	49.626	55.310	60.995	66.680	72.364	78.049	83.733	89.418	95.102
1	57.250	63.808	70.366	76.924	83.482	90.040	96.598	103.156	109.714
0.5	70.285	78.336	86.387	94.438	102.488	110.539	118.590	126.641	134.692
0.2	87.515	97.540	107.564	117.589	127.614	137.638	147.663	157.687	167.712
TC mV									
'R'	5.582	6.741	7.949	9.203	10.503	11.846	13.224	14.624	16.035
'K'	24.902	29.128	33.277	37.325	41.269	45.108	48.828	_	_

'N' 20.609 24.526 28.456 32.370 36.248 40.076 43.836 47.502 _

These tables are based on the Nernst equation:
Probe e.m.f.= 0.02154 x T x 1n x 21/% oxygen
Where T = ø K (ø C + 273)

ZIRCONIA OXYGEN PROBE OUTPUT (mV), PROBE TYPE 1233

	TEMPERATURE									
% O2	600	700	800	900	1000	1100	1200	1300	1400	
20	-14.310	-15.346	-19.380	-22.511	-25.760	-29.120	-32.570	-36.077	-39.612	
19.5	-13.008	-15.776	-18.795	-21.872	-25.066	-28.371	-31.767	-35.219	-38.699	
19	-12.520	-15.294	-18.195	-21.215	-24.354	-27.603	-30.943	-34.339	-37.763	
18.5	-12.019	-14.735	-17.578	-20.541	-23.622	-26.814	-30.096	-33.435	-36.802	
18	-11.503	-14.161	-16.945	-19.849	-22.871	-26.004	-29.227	-32.507	-35.815	
17.5	-10.974	-13.571	-16.294	-19.137	-22.099	-25.171	-28.323	-31.553	-34.800	
17	-10.428	-12.963	-15.624	-18.345	-21.304	-24.314	-27.403	-30.570	-33.755	
16.5	-9.867		-12.338	-14.934	-17.651	-20.485	-23.431	-26.466	-29.559	-32.679
16	-9.288	-11.693	-14.223	-16.873	-19.641	-22.521	-25.490	-28.516	-31.570	
15.5	-8.691	-11.027	-13.489	-16.071	-18.771	-21.582	-24.483	-27.441	-30.426	
15	-8.075	-10.340	-12.731	-15.243	-17.872	-20.612	-23.442	-26.330	-29.245	
14.5	-7.437	-9.630	-11.948	-14.386	-16.942	-19.609	-22.367	-25.181	-28.023	
14	-6.777	-8.894	-11.137	-13.499	-15.980	-18.572	-21.253	-23.992	-26.758	
13.5	-6.094	-8.132	-10.296	-12.580	-14.983	-17.496	-20.099	-22.760	-25.448	
13	-5.384	-7.341	-9.424	-11.627	-13.948	-16.380	-18.902	-21.481	-24.088	
12.5	-4.646	-6.519	-8.517	-10.636	-12.872	-15.220	-17.657	-20.152	-22.675	
12	-3.879	-5.663	-7.574	-9.605	-11.753	-14.013	-16.362	-18.769	-21.203	
11.5	-3.078	-4.771	-6.590	-8.529	-10.586	-12.754	-15.012	-17.327	-19.670	
11	-2.243	-3.840	-5.563	-7.406	-9.367	-11.439	-13.602	-15.821	-18.068	
10.5	-1.368	-2.865	-4.488	-6.231	-8.092	-10.064	-12.126	-14.244	-16.391	
10	-0.450	-1.842	-3.360	-4.998	-6.754	-8.621	-10.578	-12.591	-14.633	
9.5	0.514	-0.767	-2.175	-3.702	-5.347	-7.104	-8.950	-10.853	-12.785	
9	1.531	0.366	-0.925	-2.336	-3.865	-5.505	-7.235	-9.021	-10.836	
8.5	2.606	1.564	0.396	-0.892	-2.297	-3.814	-5.421	-7.085	-8.777	
8	3.746	2.835	1.797	0.640	-0.635	-2.021	-3.498	-5.061	-6.592	
7.5	4.959	4.187	3.289	2.271	1.135	-0.113	-1.450	-2.844	-4.266	
7	6.257	5.633	4.884	4.014	3.026	1.928	0.739	-0.506	-1.780	
6.5	7.650	7.186	6.596	5.888	5.058	4.120	3.091	2.005	0.891	
6	9.155	8.864	8.446	7.909	7.253	6.487	5.630	4.717	3.775	
5.5	10.792	10.688	10.457	10.107	9.639	9.060	8.391	7.665	6.911	
5	12.584	12.685	12.660	12.515	12.253	11.879	11.415	10.894	10.345	
4.5	14.565	14.893	15.095	15.178	15.142	14.995	14.758	14.464	14.142	
4	16.780	17.362	17.818	18.153	18.371	18.478	18.495	18.455	18.387	
3.5	19.291	20.160	20.904	21.527	22.033	22.427	22.732	22.979	23.199	
3	22.190	23.391	24.467	25.422	26.260	26.986	27.623	28.202	28.754	
2.5	25.618	27.212	28.681	29.989	31.259	32.378	33.407	34.380	35.324	
2	29.814	31.889	33.838	35.667	37.378	38.978	40.487	41.940	43.365	
1.5	35.224	37.918	40.487	42.936	45.266	47.486	49.615	51.688	55.732	
1	42.848	46.416	49.858	53.180	56.384	59.477	62.480	65.426	68.344	
0.5	55.883	60.944	65.879	70.694	75.390	79.976	84.472	88.911	93.322	
0.2	73.113	80.148	87.056	93.845	100.516	107.075	113.545	119.957	126.342	

TC mV

'R' x 2.58	5.582	6.741	7.949	9.203	10.503	11.846	13.224	14.624	16.035

1233 Probes use the same Nernst equation as 1232 probes, minus 2.58 x TC e.m.f. (mV).

APPENDIX 3

% OXYGEN SCALE _ LOGARITHMIC

% OXYGEN	% FULL SCALE
0.1	0
0.15	7.66
0.2	13.1
0.3	20.7
0.4	26.2
0.6	33.8
0.8	39.2
1	43.5
1.5	51.1
2	56.5
3	64.2
4	69.6
6	77.3
8	82.7
10	86.9
12	90.8
14	93.3
16	95.8
18	98
20	100

APPENDIX 4

SAMPLE LOG PRINT OUT

12.07: 20/06/912

CARBON% 0.91
OXYGEN% 1.13
EMF mV 61.8
OFFSET 0.0
PRB TEMP 925 C
AUX TEMP 850 C
AMBNT TEMP 25 C
PROBE IMP 1.0K
RUN TIME 1435:21
SRVCD 6/06/91
PURGE 1433 MINS, PRINT LOG 13 MINS,

12:09:55 20/06/91 REF AIR FAIL   SELF CLEARED
12:10:29 20/06/91 HTR BYPASS   ACCEPTED
12:14:43 20/06/91 PROBE TC O/C
12:17:46 20/06/91 PROBE TC O/C   SELF CLEARED

APPENDIX 5

CIRCUIT SCHEMATICS