NOVATECH

OXYGEN /CARBON DIOXIDE ANALYSER /TRANSMITTER MODEL 1537

CONTENTS

NOTE: This manual includes software modifications up to -
Version 6.30, 18th October 1998.

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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USING THIS MANUAL

The Novatech 1537 Oxygen/Carbon Dioxide 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 safety information below and the ‘Installation’ section before connecting power to the analyser.

CAUTION 1

The oxygen sensor will be heated to above 700°C in this instrument, and can be a source of ignition in applications where fuel gases or very high oxygen percentages (above 50%) are present. For these applications, it will be necessary to provide a sampling line made of flame proof material, with adequate flashback arresters. If this configuration does not suit or if it is possible for raw fuel to come into contact with a hot oxygen sensor then the Model 1537 analyser with a heated sensor may be unsuitable for your application.
An unheated probe can be utilised in applications where the gas temperatures are already high, however the oxygen readings are valid only above 650°C.

CAUTION 2

The reducing oxygen signal from the analyser and the associated alarm relay can be used as an explosive warning or trip. This measurement assumes complete combustion. If incomplete combustion is possible then this signal will read less reducing and should not be used as an alarm or trip. A true excess combustibles analyser, normally incorporating a catalyst and thermal conductivity bridge, would be more appropriate where incomplete combustion is possible. If you are uncertain about your application, please contact the factory for more details.

SPECIFICATIONS

1

SECTION
NUMBER

SPECIFICATIONS

1.1 DESCRIPTION

The Novatech model 1537 oxygen/carbon dioxide analyser/transmitter provides an integrated instrument for measurement of oxygen and carbon dioxide for food packaging and gas monitoring. The analyser provides local indication of oxygen/carbon dioxide, plus eight other selectable variables, including minimum sample hold level.

Two linearised 4–20 mA output signals are provided. Alarms are displayed at the analyser and relay contacts activate remote alarm devices. The analyser provides automatic on-line gas calibration check of the oxygen sensor when used with the 1537 auto–cal check optional configuration (1537–3 or 1537–4). The electronics self-calibrates all inputs every minute.

The 1537 has an internal keyboard for selecting the output range, display options, alarm levels, etc., as well as maintenance and commissioning functions. The instrument is microprocessor based and all adjustments are made using the internal keyboard.

- Used for continuous gas sampling, food pack testing
- Simple to use
- Sensitive down to 20 ppm oxygen
- Displays 0.1% carbon dioxide resolution
- Automatic minimum sample detection, display and output to printer and 4–20 mA signal
- Automatic calibration of oxygen and carbon dioxide offset
- Linear output of % oxygen and carbon dioxide for recording or control
- Built in safety features
- 12 different alarm functions warn the operator of gas composition, sensor or analyser problems
- RS 232C/RS 485 printer/computer interface

1.2 DETAILED SPECIFICATIONS

Measuring Range

- 20 ppm to 100% oxygen
- 0 to 10, 0 to 20, 0 to 100 % carbon dioxide

Response Time

- Less than two seconds with a gas flow of 400 cc per minute, oxygen
- Less than ten seconds with a gas flow of 400 cc per minute, carbon dioxide

Accuracy

- Oxygen ±3% of actual reading (not valid between 19% and 23% oxygen) See Note.

- Carbon dioxide ±3%

Warm Up Time

o Fifteen minutes approximately for maximum accuracy. Useful readings are possible within 7 minutes after switching the instrument on.

Outputs

- o Two isolated linearised 4–20 mA DC outputs into 600Ω load (max).
- o RS232/485 computer/printer interface for peak oxygen/carbon dioxide value report and alarm functions.
- o Four alarm relays for self diagnostic alarms, 'NOT READY' and horn.

Power

- o 240/110VAC, 50/60 Hz, 115W

Gas Connection

- o 1/8'' Swagelok tube connector

Flow Rate Range

- o 150–500 cc per minute

Environmental

- o 0–55°C ambient temperature
- o 0–45°C ambient temperature when CO_2 sensor fitted

Weight

- o 15 Kg

Dimensions

- o 320 x 355 x 210 mm

Range of Output 1

- o Field selectable from the following:

Output Selection	**Range**
Linear	0–0.1% oxygen to 0–100% oxygen
Log	0.1 to 20% oxygen
Reducing	As described under Output 2

Range of Output 2

- o Field selectable from the following:

Output		**Zero Range**	**Span Range**	
Carbon Dioxide,	0-10%	0% Fixed	10% Fixed	
	0-20%	0% Fixed	20% Fixed	
	0-100%	0–90%	10–100%	Min span 10%
Sample Oxygen		0–1000 ppm	100–20,000 ppm	Min span 100 ppm
Low Oxygen		0–1000 ppm	100–20,000 ppm	Min span 100 ppm
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} % Min span five decades oxygen in one decade steps.	
Sensor EMF		0–1100 mV in 100 mV steps	1000–1300 mV in 100 mV steps	

Range of Indication, Upper Line

- Oxygen selectable either % O_2 or ppm, and Carbon Dioxide
- Oxygen, auto ranging from 0.1 ppm to 100% O_2 (always ppm below 0.1% oxygen (if selected as %O_2 in set-up #2)
- Carbon Dioxide, 0.1 to 10% for the 0-10% range
  0.1 to 20% for the 0-20% range
  1 to 100% for the 0-100% range

Indication Choice, Lower Line

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

Options:

- Oxygen Sensor EMF
- Oxygen Sensor Temperature
- Oxygen Sensor Impedance
- Sample Oxygen/Carbon Dioxide
- Ambient Temperature
- Balance gas (Remaining gas after the O_2 and CO_2 have been removed)
- Date - time
- Run Hours since last service
- Date of last service

Relay Contacts

- 4A 240 VAC, 2A 50 VDC

Mounting

- Suitable for wall or surface mounting.

Note

Talk to the factory for improved accuracy reading near ambient oxygen levels (19–23%).

1.3 ORDERING INFORMATION

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

1. State if carbon dioxide measurement is required and over what full scale range
2. Minimum and maximum expected oxygen in sample (particularly the minimum value)
3. Other gas constituents (Any combustibles will consume oxygen as they are burnt on the surface of the sensor)
4. If the gas is under pressure or if the gas must be drawn out into the 1537 analyser.
5. Gas connection required (1/8'' Swagelok is standard)
6. Supply voltage (240 or 110VAC)
7. If auto/manual on-line oxygen gas calibration checking is required.
8. If surface mounting of the instrument is required or if free standing on rubber feet is adequate.

Ask your local Novatech Distributor for assistance in ordering

1.4 MODEL SELECTION GUIDE

1.5 GAS FLOW SWITCH SPECIFICATIONS

Model	LPH–125–1A
Range	120 cc/minute
Dimensions	50 mm high by 28 mm wide
Type	Magnetic piston & reed switch
Mounting	Vertical only

Figure 1.1 Sensor Configurations Available

DESCRIPTION

2

SECTION
NUMBER

DESCRIPTION

2.1 THE ZIRCONIA OXYGEN SENSOR

The oxygen analyser input is provided from a solid electrolyte oxygen sensor which contains a zirconia element and thermocouple. The sensor is designed to have a small sample of the unknown gas passed into the inside of the sensor tube, and air (20.95% oxygen) around the outside. A heater is mounted around the sensor to keep the sensor hot. The sensor construction is shown in Figure 2.1.

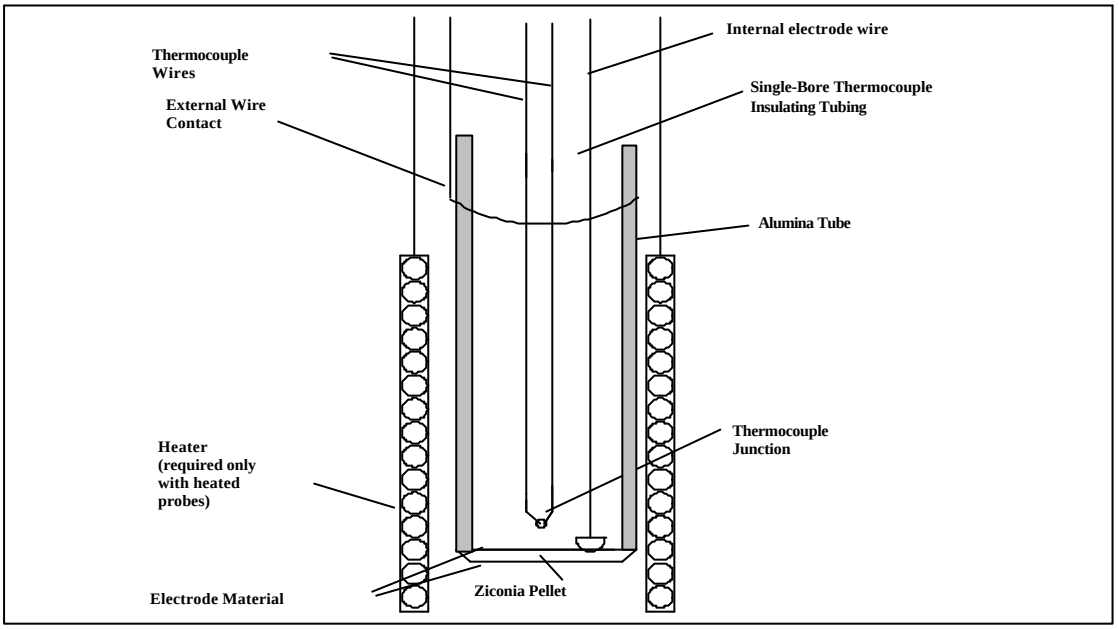

Figure 2.1 Schematic View of an oxygen Sensor Assembly

The heater control is a time proportioning temperature controller and triac so that the thermocouple junction is controlled to approximately 720°C.

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:

$$E\ (\text{millivolts}) = \frac{RT}{4F} \log_e \left(\frac{(PO_2)\ \text{INSIDE}}{(PO_2)\ \text{OUTSIDE}} \right)$$

Where T is the temperature (K) at the pellet (> 650°C), R is the gas constant, F is the Faraday constant and (PO_2) INSIDE and (PO_2) 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 outer electrode, the following equations are obtained:

$$E\ (\text{millivolts}) = 2.154 \times 10^{-2}\ T \log_e \frac{0.21}{(PO_2)\ \text{INSIDE}}$$

Transposing this equation

$$(\%O_2)\ \text{INSIDE (ATM)} = 0.21\ \text{EXP}\ \frac{46.421E}{T}$$

The 1537 transmitter solves this equation which is valid above 650°C. The sensor heater maintains the sensor temperature at this level.

2.2 THE OXYGEN SENSOR ASSEMBLY

The oxygen sensor assembly provides a means of exposing the zirconia sensor to the atmosphere to be measured on the inside of the sensor, and maintain air as a reference gas on the outside of the sensor. A small volume, (from as little as 150 cc/min) of the gas to be sampled is either pumped through the assembly at a known rate by the internal pump, or the flow rate may be set on a rotameter. The gas flow rate may also be monitored by a flow rate switch, which will cause an alarm if the rate falls below 120 cc/min.

The sensor assembly also provides the means of maintaining the temperature of the sensor at 720°C by surrounding the sensor tube with a heater element, and measuring the temperature of the sensor with a thermocouple inside the sensor. (See Figure 2.1)

2.3 THE CARBON DIOXIDE SENSOR ASSEMBLY

The carbon dioxide sensor assembly is mounted on a circuit board in the 1537 cabinet. It has been designed to read carbon dioxide concentrations within the temperature range of 5 to 45°C, with ambient humidity not exceeding 85% RH. The full scale range must be chosen before purchase of the instrument. The standard ranges are 0 to 10%, 0 to 20%, and 0 to 100%. (contact the factory for other ranges)

The principle of operation is that of absorption of the infra red light source which is passed through an analysis cell and a thin film filter into a solid state detector. The filter is selective and transmits radiation only in the carbon dioxide wave band. The detector output is amplified and rectified and, with no carbon dioxide present in the cell, is balanced against a reference voltage to give a zero output voltage. This zero output voltage can be nulled, either automatically or manually, by using 'MAINT' Section 6.5.13, (Set CO_2 Sensor Offset). See also Section 2.10, Carbon Dioxide Sensor Calibration.

Absorption gas in the cell reduces the detector signal, leading to a positive voltage appearing at the sensor output. The gain of the amplifier is adjusted automatically in proportion with the offset, such that a 1 VDC signal output is obtained for 100% carbon dioxide being measured. Span calibration can also be trimmed from the internal keyboard, or by means of the span potentiometer on the CO_2 circuit board.
The voltage appearing out of this circuit board is non linear with respect to carbon dioxide percentage, but is linearised within the microprocessor of the 1537.

2.4 THE ANALYSER

The 1537 analyser is a microprocessor based, auto–calibrating instrument with a liquid crystal display, two 4–20 mA output signals, a printer/computer port and four alarm relays with a total of 11 alarm functions.

The display will read in either % oxygen or ppm, as selected in set–up step 1. It is capable of calculating the oxygen volume from less than one ppm to 100%. The top line of the LCD is used to display the oxygen and the carbon dioxide content.

The lower line is used to display nine other variables such as sensor temperature, sensor impedance, date/time etc. The lower line is also used to display alarm messages such as sensor 'OXYGEN NOT READY' and 'A/D CAL ERROR', 'HIGH O_2' etc.

Many of the functions are user variable (such as 4–20 mA output channel ranging), and are changed using a menu system from an internal keyboard. 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. Even the one–time calibration is performed using the keypad. (See Section 2.7). The changes are then all stored in a battery-backed RAM integrated circuit.

2.5 ALARMS

Refer to OPERATOR FUNCTIONS Section 4 for details on alarm functions.

2.6 HEATER SUPPLY

CAUTION

The sensor heater is supplied with 110 VAC at 1 Amp. This supply has electrical shock danger to maintenance personnel. Always isolate the analyser before working with the sensor.

2.7 SENSOR IMPEDANCE

The sensor impedance is a basic measurement of the reliability of the oxygen reading. A sensor with a high impedance reading will eventually produce erroneous signals. The analyser checks the sensor impedance once every five minutes and if the impedance is above the maximum level for a specific temperature then the impedance alarm will be activated. Typical sensor impedance is 800 to 3000Ω at 720°C. Typical sensor life is at least two years.

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.

The 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 3.7). If there is any doubt about the accuracy of the instrument readings, then refer to ‘MAINT’ Section 6.5, items 6, 7, 8 and 9 for a full description of this simple calibration procedure.

The digital to analog converters or output section of the analyser are tested and calibrated when the AUTOCAL button is pressed, and if they are found to have an error then a ‘D/A CAL ERROR’ alarm will occur. The D/A sections are re-calibrated in three seconds by pressing the ‘AUTOCAL’ button on the technicians keyboard. Both output signals will go to 0 mA , then 20 mA for the three second period.

It is suggested that a D/A re-calibration be performed after the instrument has stabilised, approximately 30 minutes after first switching on and after ‘MAINT’ Section 6.5, items 6, 7, 8 and 9 have been completed, and then annually. If a ‘D/A CAL ERROR’ alarm occurs after AUTOCAL has been pressed, then check the reference voltage settings (see Section 6.5.6 to 6.5.9), or a hardware fault should be suspected.

2.9 AUTO CALIBRATION CHECKING– OXYGEN SENSOR

The calibration of the oxygen sensor is done automatically at the 20.9% (zero sensor mV), and can be checked with the on-line automatic gas calibration using a span gas.

Air, 20.9%. While the analyser is not doing a process gas measurement (the sample inlet pipe is sucking in air), the analyser can automatically trim the calibration to read 20.9% oxygen. For more details see the 'MAINT' section 6.5, number 10 & 11.

Span gas. On-line automatic gas calibration checking is not normally required, particularly if a gas sampling is being used. Where it is required however, when continuous gas monitoring is being used, the sensor can be checked for accuracy on-line. A solenoid valve can admit calibrated gas mixtures into the oxygen sensor via the solenoid valve under microprocessor control on a timed basis. For details refer to Section 3.7, (Connecting the Automatic Calibration System). For details on setting up this facility, refer to set-up steps 10 to 17 in Section 5.5.

During sensor auto calibration checking, the analyser output will freeze and remain frozen for a further adjustable period, allowing the sensor time to recover and continue reading the sample gas oxygen level.

Calibration gas may be manually admitted by pressing the 'CAL 1' button on the keyboard while in 'RUN' mode. The analyser output is frozen during the pressing of this button and immediately becomes active when the button is released.

When using automatic calibration checking, it is important that the flow rate of both the sample gas and the calibration gas be approximately the same. To achieve this, the sample gas should first be set using the rotameter to between 300 and 500 cc/min, then the calibration gas flow must be adjusted by using a needle valve after the gas pressure regulator to the same value as the sample gas.

2.10 CARBON DIOXIDE SENSOR CALIBRATION

Integrated into the 1537 analyser is a self checking and calibrating system for the CO_2 cell.
The offset and span can be manually calibrated by entering values from the internal keyboard.
In addition, there is an automatic process that uses the oxygen signal to enable an offset for the CO_2 cell to be read and saved. This system ensures that the CO_2 cell will always read zero when air is flowing in the cell.

2.11 RS 485/RS 232–C PORTS

The serial port is for connecting a printer, a data logger, or any computer with an RS 485/ 232-C port. It can be used to monitor the transmitter and process by logging the values of functions selected in step 19 of the set-up menu in Section 5.5.

The log period may be selected in step 20 for 1 to 2000 minutes, and the baud rate may be set up in step 21.

The protocol for the serial port is eight data bits, one stop bit, no parity.

Alarms, including the time they occurred, will be transmitted to the printer and computer whenever they are first initiated, accepted and cleared.

If 'Valley Hold' or 'Display Update' is selected in set-up step 1, each time a new minimum rate of oxygen is detected, this value plus date/time, will also be printed.

2.12 AMBIENT TEMPERATURE INPUT

An additional input is provided for an external temperature sensor. The sensor used is of the two wire semiconductor type (Analog Devices AD 590), which is capable of operating over the temperature range of –55 to +150°C. It must be connected to terminals 10 and 11. If there is no sensor connected to these terminals, the analyser will automatically select the internal ambient temperature sensor.

This temperature may be displayed on the lower line of the LCD (see set-up step 10), or may be logged to the printer/computer port (see set-up step 19).

2.13 WATCHDOG TIMER

The watchdog timer is started if the microprocessor fails to pulse it within any one second period, (ie. 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 two attempts to reset, the common alarm relay will be activated, and the 'ERROR' light on the internal keyboard will come on.

2.14 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 1537 Analyser Block Diagram

INSTALLATION & COMMISSIONING

3

INSTALLATION

3.1 ANALYSER DIMENSIONS

The analyser is supplied with rubber feet on the base, and a handle on the top. Optionally, the 1537 may be supplied with side mountings. The analyser has a removable rear cover and should remain accessible and clear for ventilation.

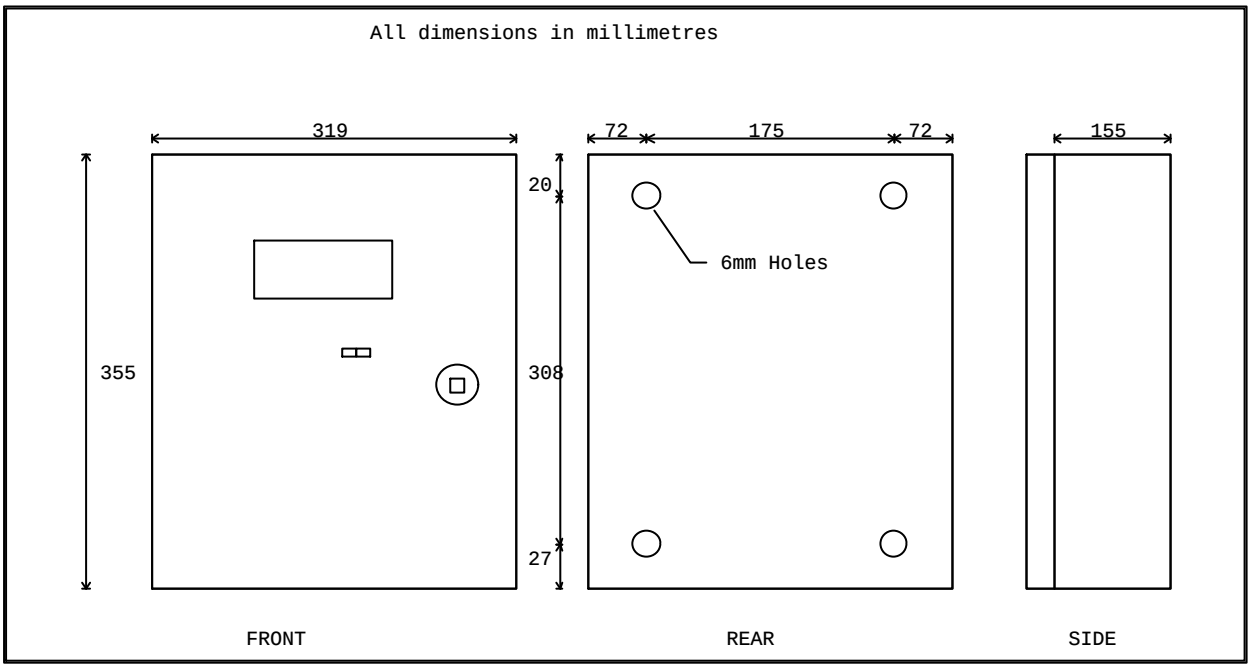

Figure 3.1 Case Dimensions

3.2 EARTH, SHIELD & POWER CONNECTIONS

All external wiring for the 4–20 mA outputs, alarm relays and printer/computer port 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, and the cabinet earth stud.

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.

IMPORTANT

Before connection of mains power check that the correct solder links are installed as shown in Figure 3.2.

Figure 3.2 Earth, Shield and Power Connections

3.3 CONNECTING THE AMBIENT TEMPERATURE SENSOR

This input is only required if an ambient temperature, or the temperature of another gas or part of the machinery is required to be displayed or logged to the printer/computer port. Refer to Figure 3.3.

Figure 3.3 Connection of Ambient Temperature Sensor

3.4 CONNECTING THE OUTPUT CHANNELS

The two 4–20 mA DC output channels are capable of driving into a 600Ω load. Refer to Figure 3.4.

Figure 3.4 Connections for Transmitter Output Channels.

3.5 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. The horn relay has normally open contacts. Continuous monitoring systems should have the 'alarm' relay RL5 (terminals 26 and 27), and the 'sensor low temperature', relay RL3 (terminals 22 and 23) connected to an external alarm system. The sensor calibration and horn relays are optional. Alarm wiring should be shielded.

3.6 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 reset by pressing the alarm button. The contacts (terminals 28 and 29) will be closed whenever the alarm light is flashing. Refer to Figure 3.5.

3.7 CONNECTING THE AUTOMATIC OXYGEN CHECK SYSTEM

The on-line oxygen calibration system is optional, available with the -3 and -4 options (see figure 1.1, Sensor Configurations). The gas change-over solenoid is mounted in the rear of the cabinet. Typical connection details are shown in Figure 3.6.
For details on its operation refer to Section 2.8.

3.8 CONNECTING THE GAS FLOW SWITCH

On the 1537–4 configuration of the analyser, a sample gas flow monitor switch is used to activate an alarm if the sample gas flow drops below 120 cc/min. The connection for the switch is shown in Figure 3.7.

Failure to maintain sufficient flow will cause the response time to lengthen, and may cause extreme errors in the readings.

Care must also be taken not to increase the flow to a point where the inside of the zirconia cell is cooled. This can be monitored by the display of ‘SENS TEMP’ on the lower line of the display.

Figure 3.5 Connections for Alarm Horn

Figure 3.6 Automatic Oxygen Check System Wiring Schematic

Figure 3.7 Sample Gas Flow

3.9 CONNECTING THE DUAL OXYGEN ALARM INPUT

The 1537 analyser has provision for automatic change over between two oxygen alarm trip point levels. These levels are set in set-up steps 24 and 25. A voltage free contact may then be connected to the 1537 to determine which trip point is used. When the contact is open circuit, alarm level #1 is used. Set-up step 23 allows the option of alarm #1 to be a high or low oxygen alarm.

Figure 3.8 Alarm Trip Level Contacts Connections

3.10 CONNECTING THE PRINTER

The RS 485/232-C port is available at the connector on the lower right hand side of the main circuit board. A printer with a serial port, 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 19 and 20. The baud rate is selectable in step 21. Refer to Section 2.11. The protocol for the serial port is eight data bits, one stop bit, no parity.

Connection details are shown in Figure 3.9.

NOTE

For the RS 485/232-C port to work as an RS 232-C port, there must be no other connection from the external device back to the transmitter, (including an earth return). An integrated optical isolator is available if required.

Figure 3.9 Serial Port Connections

COMMISSIONING

3.11 CONNECTING POWER - COLD START

Before commissioning the transmitter, read the two Caution paragraphs at the front of this manual.

Check that the mains supply voltage link is in the correct place for the supply voltage. To locate this link refer to Section 3.2

It is recommended that prior to commissioning, the date in the battery backed real time clock be checked. Switch the mode switch to 'MAINT' position. Use the 'FUNCT' buttons to locate the year, month or day entry function. If the date displayed is not correct, perform a 'COLD START'. This resets all 'Set-up' and ''MAINT'' mode entries to their 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 ''MAINT'' and 'SET-UP' modes, including calibration voltages, time and date.

To perform a 'COLD START', apply power to the transmitter while holding down the display button on the internal keyboard.

3.12 CONNECTING POWER –WARM START

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

3.13 COMMISSIONING - MAINTENANCE MODE

Switch the mode switch to 'MAINT'. If the date and time are not correct, it will be necessary to also check the reference voltages. If the analyser has performed a 'COLD START', then a reference voltage calibration will have to be performed.

3.14 COMMISSIONING - SET-UP MODE

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

3.15 RUN MODE

Switch the mode switch to 'RUN'. The upper line of the display will now read 'OXYGEN', or 'OXYGEN and CO_2 ', if O_2 / CO_2 is selected in set-up step 2 (Display). The oxygen reading will be valid if the sensor temperature is above 650°C. The sensor temperature can be checked on the lower line of the display. Refer to Section 4 for the lower line functions.

3.16 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 4.2.

3.17 THE OXYGEN SENSOR

The zirconia oxygen sensor provides an absolute measurement of oxygen partial pressure. There are no calibration adjustments, apart from 'SENSOR OFFSET', which can be selected to be trimmed automatically (See Section 65, #10 & 11). The sensor EMF for a span gas is either correct or the sensor is faulty.

To check that the sensor is functioning correctly, firstly check that the high sensor impedance alarm is not activated by pressing the alarm button if the alarm LED is flashing. The display would show 'SENSOR FAIL'. The actual impedance can be displayed on the lower line. It should be less than 3000Ω .

Once it has been established that the sensor impedance is normal, the sensor offset may be tested and set. Refer to Section 6.5.10 & 6.5.11. A normal flow of air must be in the gas sample line when testing sensor offset. Refer to Section 3.19.

3.18 SENSOR CALIBRATION – CARBON DIOXIDE

After power has been applied to the 1537, the carbon dioxide transducer will function almost immediately, however it is recommended that it is allowed to stabilise for about an hour before making any adjustments. Make sure that the environmental temperature has stabilised within this period.

Calibration of the carbon dioxide cell has two values set from the keyboard.

Offset
Span

The set-up for the calibration of the carbon dioxide cell is to -

1. Set the option 'AUTO CO_2 CAL' in 'MAINT' step 12 to 'YES'.
2. Press the 'AUTOCAL' button while in 'RUN' mode, with air passing through the CO_2 cell.
3. Use a span gas to read the accuracy of the cell at a point between 50 and 100% of the full scale of the CO_2 cell.
4. Check that the CO_2 reading on the top line of the display reads zero when air is passed through the CO_2 cell.

(The cell will automatically be kept reading zero as long as the oxygen is more than 20%, and the CO_2 cell output is close to the currently recorded CO_2 offset)

5. Use 'MAINT' step 14 (SET CO2 SPAN), to trim the CO_2 reading on the display top line, until the analyser reads the true gas percentage.
6. Re-check items 4 and 5 until you are satisfied with the accuracy at both zero and span.

To display the CO_2 level on the 1537, switch the mode switch to ‘SETUP’ and use the function keys to get to step 2, ‘DISPLAY’, then use the OPTION keys to select ‘o_2/Co_2’ or ‘o_2/Co_2 only’ , and switch back to ‘RUN’ mode.

MANUAL CO_2 OFFSET CALIBRATION

The greatest variation in the calibration as the CO_2 sensor warms up is from the offset. The offset value is the reading of voltage from the CO_2 cell while the cell has air (0.03 % CO_2) being passed through it. The value can be manually set by pressing the 'AUTOCAL' button while in 'RUN' mode.

NOTE: The oxygen level must be above 20% for the offset value to be set.

The value set for you by pressing the 'AUTOCAL' button can be read by switching to the 'MAINT' mode step 13 (SET CO2 OFFSET), and can also be trimmed with the option buttons.

AUTOMATIC CO_2 OFFSET CALIBRATION

The effect of pressing the 'AUTOCAL' button as above, can be achieved automatically by setting 'MAINT' step 12 (AUTO CO2 CAL) to 'YES'. This will automatically trim the CO_2 offset between samples of gas.

NOTE: The oxygen level must be above 20%
and The CO_2 cell output must be close to the currently recorded CO_2 offset (within 20mV's)

CO_2 free air may be produced by passing air over soda lime, however if this, or a certified bottle of CO_2 free gas is **not** available, ambient air may be used to set the zero. In this case, a level of 0.0% CO_2 can be assumed. (Outside air contains about 0.033% CO_2).

CO_2 SPAN CALIBRATION

The span should be checked periodically with the use of certified calibration gas.
Make sure that the CO_2 offset is set correctly.
ie. The analyser reads zero CO_2 when air is passing through the CO_2 cell.

Read the calibration gas and note the CO_2 value on the top line of the display.
If analyser reads less than the certified value of the calibration gas, increase the value in 'MAINT' step 14 (SET CO2 SPAN).
If analyser reads more than the certified value of the calibration gas, decrease the value in 'MAINT' step 14 (SET CO2 SPAN).

Trim the 'SET CO2 SPAN' value until the analyser reads the true gas percentage. The span value will normally need to be set between 97 and 103%.

NOTE: It is important that the gas flow rate is the same when using the calibration gas and the sampling gas.

3.19 SENSOR CALIBRATION – OXYGEN

There is only one calibration adjustment necessary for the 1537 oxygen sensor. This is the PROBE OFFSET. An incorrect value for the PROBE OFFSET will affect an oxygen reading at 21% by about 1% oxygen in every 1 mV of offset, but will have very little effect on oxygen readings below 2% oxygen.

To remove this error, ensure that the normal volume of gas is passing through the gas sample line (approximately 450 cc/min). In this condition, the zirconia sensor should have no oxygen partial pressure difference across the cell. (Air is also used as reference gas all the time).
NOTE:
If 'YES' has been selected in 'MAINT' step 10, the offset will be automatically trimmed to keep the analyser reading 20.9%.
If 'NO' has been selected in 'MAINT' step 10, the offset can been entered manually by reading the sensor 'EMF mV' from the lower line of the display while in 'RUN' mode.

A manual gas calibration check may also be performed. In the 1537– 3 and the 1537– 4, this may be performed simply by pressing the 'CAL 1' button on the inside keyboard. The analyser electronics should also be calibrated according to Section 6.5, Maintenance Functions Details.

On the 1537– 1 and 1537– 2, a known calibration gas may be sampled to check the accuracy of both the oxygen and the carbon dioxide sensors.

OPERATOR FUNCTIONS

4

SECTION
NUMBER

OPERATOR FUNCTIONS (RUN MODE)

4.1 DISPLAY BUTTON

The upper line on the display will always read oxygen % or ppm, or oxygen % and carbon dioxide.

The following are available for display on the lower line.

1 OXYGEN SENSOR EMF (millivolts)
2 OXYGEN SENSOR TEMPERATURE
4 OXYGEN SENSOR IMPEDANCE, a measure of integrity of the oxygen sensor's electrode, the part of the sensor that normally wears out first.
4 SAMPLE OXYGEN (AND CARBON DIOXIDE)
5 AMBIENT TEMPERATURE
6 DATE –TIME
7 RUN HOURS SINCE LAST SERVICE
8 DATE OF LAST SERVICE
9 BALANCE GAS (%). A calculation of the balance of the volume of gas being sampled. Oxygen and carbon dioxide are subtracted from 100% if 'O2/CO2' is selected in set-up 2. If 'Display Update' or 'Valley Hold' is selected in set-up 1, the BALANCE GAS is calculated from the SAMPLE values of oxygen and carbon dioxide.

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 technician's keyboard. In addition to the above lower line displays, the analyser will automatically display:

10 OXYGEN NOT READY, until the sensor is over 650°C for the required time which will be less than 1 minute. If the heater does not get the sensor up to 650°C within 40 minutes, the "OXYGEN NOT READY" message will be replaced by a "HEATER FAIL" alarm.
11 SENSOR CALIBRATION, occurring for Cal Gas

NOTE

The run time will be the period of time the analyser is powered. This timer can be used as a sensor replacement and/or gas generator service schedule aid. The start time is reset by changing the 'SERVICE DAY' in Maintenance mode on the technicians keyboard.

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 650°C).
'HEATER FAIL'	In the first 40 minutes of power being applied to the heater after being switched on, this alarm will not occur, but an 'OXYGEN NOT READY' display will occur and relay RL8 will be activated. Refer to Section 6.12.
'SENSOR TC O/C'	Oxygen sensor thermocouple is open circuit. The heater will switch off.
'A/D CAL ERR'	The analog to digital converter has been found to fall outside the normal calibration specifications. This is an electronic fault.
'D/A CAL ERR'	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.
'GAS CAL ERROR'	The oxygen sensor does not correctly calibrate to calibration gas.
'LOW GAS FLOW'	The flow switch on terminals 16 and 17 or the flow switch terminals on CN10 (top right hand corner) of the terminal PCB is open circuit, indicating a low gas sample flow.

‘HIGH OXYGEN’	a) Set-up step 1 SAMPLING TYPE = Valley hold. The sample oxygen found to be the valley point is higher than the selected high oxygen trip level. b) Set-up step 1 SAMPLING TYPE = Continuous. The current oxygen level is higher than the selected high oxygen trip level. Refer also to Section 3.9, Connecting the dual high oxygen alarm input.
‘LOW OXYGEN’	Refer to 'HIGH OXYGEN', except that the alarm is raised because the oxygen is low. Refer to set-up step 23, section 5.5.23.
‘AD/MAINS ERR’	Either the A/D converter (IC15) has failed to convert, or the A/D converter mains frequency signal from the power supply printed circuit board (1530-2) has failed. (Call the factory for advice).
‘WATCHDOG TIMER’	Software error or total hardware failure. This alarm will not appear on the display. The ‘ERROR’ LED on the front door and on the inside keyboard will illuminate.

4.3.2 SUMMARY OF ALARM RELAYS

ALARM	RELAY	FUNCTION	LATCHING	NOTES
'OXYGEN NOT READY'	RL3	Oxygen sensor reading is invalid (under 650°C), and the CO_2 is still stabilising.	No	If the oxygen sensor heater has been on for more than 40 minutes and the temperature is less than 650°C, a heater fail alarm will occur.
'CAL IN PROG'	RL4	Oxygen sensor calibration 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.

4.4 POWER LAMP

Illuminates when power is connected to the analyser. It will flash if the microprocessor is resetting. This will indicate a hardware failure.

4.5 ERROR LAMP

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

SETTING UP THE ANALYSER

5

SECTION
NUMBER

⇓’ to decrement to the previous function.

⇓’ 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.

Figure 5.1 Internal Technicians Keyboard

5.5 SET-UP FUNCTION DETAILS

5.5.1. SAMPLING TYPE

Options
1. Valley Hold
2. Display update
3. Continuous

Select the option, either ‘Valley Hold’, ‘Display update’ or ‘Continuous’ to suit the application.
If a continuous stream to the sample gas is available, then ‘Continuous’ will allow the alarms to trip on the steady state oxygen level. Set-up step 22 (Reset Level), will be skipped if ‘Continuous’ is selected here.

If however, the gas is coming from a short duration sample, (eg. food packaging sample withdrawn through hypodermic needle), the minimum value of oxygen may be retained until another sample is read by selecting 'Valley Hold' or 'Display update'. When the valley figure has been confirmed by five further values above the minimum, the date/time and minimum oxygen value, and the CO_2 value as the oxygen minimum was taken, will be sent to the printer port. The high oxygen alarm will be activated by a high sample level.
'Display update' mode is very similar to 'Valley Hold', except the readings are only taken once per second (10 per second for Valley Hold). This means for small head space packets (<100cc) the true valley may be missed.
The 'Valley Hold' mode is the more precise mode of operation but will not update the display until the valley and peak values have been found.

5.5.2. DISPLAY

Options
1. Oxygen %
2. ppm
3. o2/co2
4. o2/co2 % only

The top line of the LCD always shows the oxygen content, but the user may select whether the oxygen will be displayed as a percentage or in parts per million form. If the CO_2 option has been installed, both O_2 and CO_2 may be displayed. If option 1 (Oxygen %) is chosen, below 0.1% the display will revert to the ppm form automatically. This selection also affects other displays such as the 4–20 mA output ranges, gas cal checking, reset level and alarm trip levels.

If 'O_2/CO_2' or 'O_2/CO_2 only' is selected here in set-up step 2, and 'Valley Hold' or 'Display Update' was selected in set-up step 1, the SAMPLE on the lower line of the display will also show the peak level of CO_2.

Using 'O_2/CO_2 only' option restricts the display to the percentage form only. The display will not go into the ppm mode automatically.

5.5.3. TRANSMITTER OUTPUT CHANNEL 1

Select the type of output from Channel 1. Linear is the most common output required. The logarithmic output is often used where analog indicators give an exploded view of the oxygen range near 1%. You can draw your own scale using data in Appendix 2.

Options
1. Linear
2. Logarithmic
3. Reducing

The reducing output is for special applications requiring extreme reducing conditions eg. ceramic surface treatment.

Linear output spans are adjustable in set-up step 4 and 5. The logarithmic output is fixed at 0.1 to 20 % oxygen and the reducing output is fixed at 10^{-1} to 10^{-25} % oxygen. If either of the latter two are selected, then set-up step 4 and 5 will be skipped.

5.5.4. TRANSMITTER ZERO CHANNEL 1

Applicable only to linear output. Select transmitter zero for output Channel 1.
Range
0 to 95, minimum channel 1 range is 5% oxygen.

5.5.5. TRANSMITTER SPAN CHANNEL 1

Applicable only to linear output. Select transmitter span for output Channel 1.
Range
5 to 100, minimum channel 1 range is 5% oxygen.

5.5.6. TRANSMITTER OUTPUT CHANNEL 2

Select transmitter output for output Channel 2.

Options
1. Oxygen sensor EMF
2. Sample oxygen
3. Low oxygen
4. 0.1 to 20 % oxygen, logarithmic
5. co2, 1-100%
6. co2, 1-10%
7 co2, 1-20%
8. 1 x 10^{-1} to 10^{-25} % oxygen (for reducing conditions)

5.5.7. TRANSMITTER ZERO CHANNEL 2

The output zero and span of Channel 2 is set in set-up steps 6 and 7. Range limits are shown below.

5.5.8. TRANSMITTER SPAN CHANNEL 2

OUTPUT	ZERO RANGE	SPAN RANGE
SENSOR EMF	0 –1100 mV in 100 mV steps	100 –1300 mV in 100 mV steps
SAMPLE OXYGEN	0–1000 ppm in 100 ppm steps 0–0.1% in 0.01% steps	100–20000 ppm in 100 ppm steps 0.01–2.00% in 0.01% steps
LOW OXYGEN	0–1000 ppm in 100 ppm steps 0–0.1% in 0.01% steps	100–20000 ppm in 100 ppm steps 0.01–2.00% in 0.01 % steps
LOG OXYGEN (see Note 1)	0.1 % oxygen fixed	20 % oxygen fixed
CARBON DIOXIDE 0-100%	0–90%	10–100% Min span 10%

CARBON DIOXIDE 0-10%	0% Fixed	10% Fixed
CARBON DIOXIDE 0-20%	0% Fixed	20% Fixed
REDUCING OXYGEN (see Note 2)	10^{-1} –10^{-10} % oxygen in one decade steps, non overlapping	10^{-1} –10^{-25} % oxygen in one decade steps. Min span two decades

NOTES

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.
3 The sample range is updated as a new valley is detected. It therefore draws a graph of all the lowest oxygen values. It is only available if 'VALLEY elected in set-up step 1.
4 The LOW range is meant as a complimentary range to SAMPLE if CONTINUOUS is selected in set-up step 1. It is updated continuously and covers the low values of oxygen.

5.5.9. CENTIGRADE/FAHRENHEIT SELECTION

Select whether displays of sensor and ambient temperatures are to be in ° Celsius or ° Fahrenheit

Options
1. Celsius (Centigrade)
2. Fahrenheit

5.5.10. LOWER LINE DISPLAY FUNCTIONS

In the run mode the upper line on the LCD display will always read % oxygen. 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 Oxygen sensor EMF
2 Oxygen sensor temperature
3 Oxygen sensor impedance
4 Sample oxygen (and carbon dioxide)
6 Ambient temperature
6 Date – time
7 Run hours since last service
8 Date of last service
9 Balance gas

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.

NOTE
Carbon dioxide is displayed on the top line only if 'o2/co2' is selected in set up step 2.

5.5.11. OXYGEN CALIBRATION CHECK GAS

Select whether or not a timed automatic gas check of the system is required. 'GAS CAL ERR' is generated if the measured gas is outside the set limits. Refer to set-up steps 12 to 14.

Options
No Cal Gas
Cal Gas

During the timed calibration periods the transmitter outputs will be frozen. If autocal is not required enter 'NO CAL GAS' and the transmitter will step to set-up 19.

5.5.12. FIRST CALIBRATION CHECK

Set the time of day that best suits to start the auto cal gas check.

Range
0 to 23 hours in one hour stops

5.5.13. OXYGEN CONTENT OF CAL GAS

Enter value of Calibration Gas (to one decimal point).

Range
0.1 to 30.0% oxygen or
1,000 to 300,000 ppm

5.5.14. MAXIMUM ACCEPTABLE POSITIVE GAS ERROR

Set the maximum positive error above which the 'GAS CAL ERR' alarm will be initiated after the timed period set in set-up step 16.

Range

0.1to 3.0 % oxygen
1,000 to 30,000 ppm

5.5.15. MAXIMUM ACCEPTABLE NEGATIVE GAS ERROR

Set the maximum negative error below which the 'GAS CAL ERR ' alarm will be initiated after the timed period set in set-up step 16.

Range

0.1 to 3.0 % oxygen
1,000 to 30,000 ppm

5.5.16. PERIOD BETWEEN GAS AUTOCALS

Set the number of hours between autocals. A typical time would be 24 to 168 hours. (Daily or weekly).

Range

1 to 1999 hours

5.5.17. DURATION OF AUTOCAL GAS

Set the number of seconds that the autocal gas solenoid will be open. At the end of this period, if the oxygen level measured is not within the limits set for Cal Gas, a 'GAS CAL ERR' will initiate. To determine the minimum time required for a particular configuration of analyser to settle, manually admit cal gas while observing the oxygen reading in 'RUN' mode by pressing the 'CAL 1' button. Typical minimum times vary from 5 to 15 seconds.

Range

1 to 90 seconds

5.5.18. GAS FREEZE TIME

After the Cal Gas period, the transmitter output will remain fixed, (frozen) for an adjustable period to allow the sensor reading to return to the correct process level and avoid output 'bumps'. The freeze period time required will depend on the sensor response time.

Range

10 to 100 seconds in ten second steps

To determine the required freeze time, manually perform a calibration while the plant is in operation and note the time required for the reading to return to the correct process level.

5.5.19. DATA TO PRINT

Any or all of the following values may be printed on a printer or computer. They may be selected or de-selected using the 'ENTER' buttons as in set-up step 9. The log period and RS 232-C protocol follows in set-up steps 19 and 20. A sample of a print-out is contained in Appendix 4.

Options

1. Date of Last Service
2. Oxygen Sensor EMF
3. Oxygen Sensor Temperature
4. Oxygen Sensor Impedance
5. Sample Oxygen
6. Ambient Temperature
7. Date –Time
8. Run Hours Since Last Service

5.5.20. PRINT LOG PERIOD

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

Range

1 to 2000 minutes

5.5.21. PRINTER BAUD RATE

Select the correct baud rate of data to be transmitted to the printer.

Options

300
1200
2400
4800
9600

5.5.22. RESET LEVEL

In order to detect a new ‘SAMPLE’ oxygen or carbon dioxide level, the reset threshold must be set below the normal idle oxygen level (non sampling level), but well above the level expected in the sample period.

5.5.23. HIGH / LOW ALARM #1

Select whether the alarm # 1 is to alarm when the measured oxygen level is above the trip point set in step 24 (high) or below the trip level (low).

Options
High or Low

5.5.24. HIGH / LOW ALARM #1 LEVEL

Enter high/low oxygen alarm trip level.

Range
0.0001 to 30% oxygen
100 to 300,000 ppm

If ‘CONTINUOUS’ is selected in set-up step 1, this alarm will be activated by the top line oxygen value going above/below this value. If ‘VALLEY HOLD’ or ‘DISPLAY UPDATE’ is selected in set-up step 1, this alarm will be activated by the lower line ‘SAMPLE’ value being detected above the ‘HI–ALARM’ value. See also Section 3.9, Connecting the Dual High Oxygen Alarm.

Figure 5.2 Sampling Reset Level

5.5.25. HI–ALARM #2

Set dual alarm #2. See set-up step 24. This alarm is always a high alarm.

MAINTENANCE

6

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. AUTOMATIC O_2 SENSOR OFFSET (O_2 SENSOR CALIBRATION)
11. SET O_2 SENSOR OFFSET (O_2 SENSOR CALIBRATION)
12. AUTOMATIC/MANUAL CO_2 SENSOR CALIBRATION
13. SET CO_2 SENSOR OFFSET (CO_2 SENSOR CALIBRATION)
14. SET CO_2 SENSOR SPAN (CO_2 SENSOR CALIBRATION)
15. 4-20mA OUTPUT CALIBRATION CHANNEL #1
16. 4-20mA OUTPUT CALIBRATION CHANNEL #2
17. ENTER SERVICE YEAR
18. ENTER SERVICE MONTH
19. ENTER SERVICE DAY
20. REVERSE INPUT POLARITY, O_2 TEST/RUN

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 ‘‘MAINT’’ mode. If auto calibrations occur while the mode switch is in ‘MAINT’, they will be delayed until the mode switch is returned to ‘RUN’.

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 ‘‘MAINT’’ 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 eg. 04-08-91 =4th August, 1991.

2. **ENTER DATE**
   Enter month.

3. **ENTER DAY**
   Enter day.

4. **ENTER HOURS**
   Enter hours eg. 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 3.11. 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) 2480 mV
2) 1164 mV
3) 63.3 mV
4) 18.9 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.

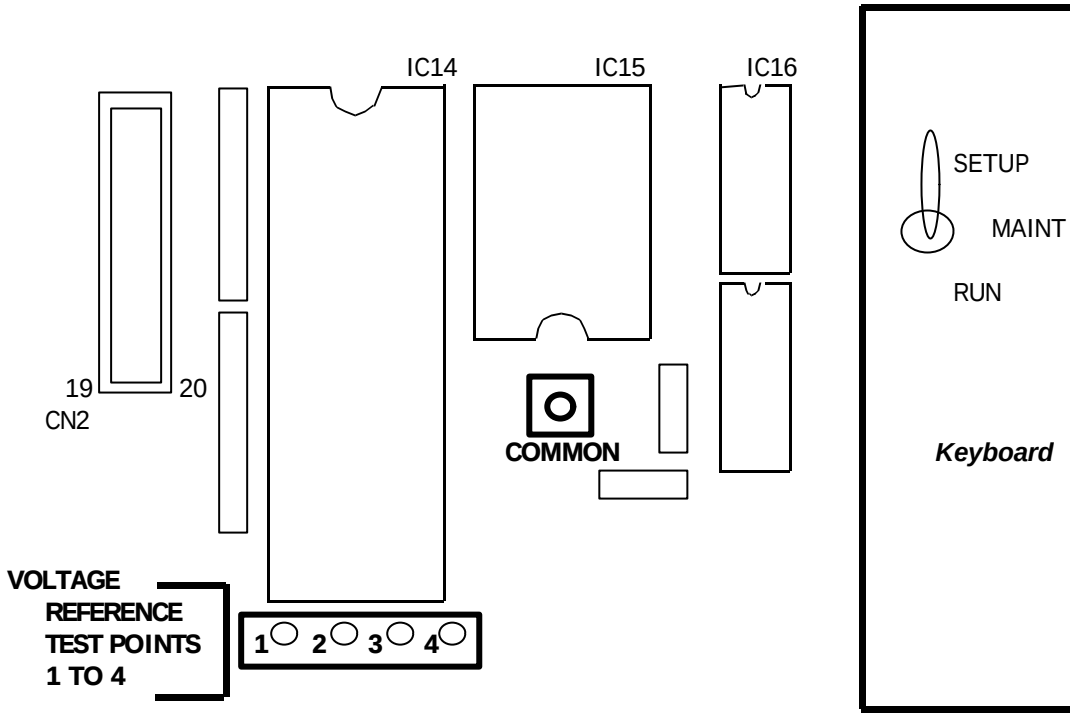

Figure 6.2 Location of Calibration Test Points

10. SET O_2 SENSOR OFFSET

The sensor offset voltage is produced by small temperature differences within the oxygen sensor. The voltage is normally between +3 to -3mV. This error can be automatically removed by selecting 'YES'.

The only time 'NO' should be selected is when the analyser is being used to measure gasses with between 16 and 26% oxygen. The oxygen sensor offset should then be manually entered using 'MAINT' step 11.

11. SET O_2 SENSOR OFFSET - MANUAL

The offset only needs to be set manually when the analyser is being used to measure gasses with between 16 and 26% oxygen.

To check a sensor offset on site, the sensor must be sensing air and allowed to settle at the sensor operating temperature for 30 minutes. Read the offset in 'RUN' mode in millivolts on the lower line. Enter the 'SENSOR OFFSET' value eg. if offset value is -1.2 mV, enter -1.2 mV. The typical maximum is +/-3 mV.

If the manual entry method is being used, make sure that 'NO' to automatic entry is selected in 'MAINT step 10 or the manual value will be over written.

A new EMF offset must be entered whenever a new oxygen sensor is installed to calibrate for any offset an individual sensor may have. This will have been set at the factory for a new or serviced instrument.

12. SELECT AUTO CO_2 SENSOR OFFSET CALIBRATION

If 'YES' is selected, the CO_2 offset is automatically measured and saved whenever the oxygen reading is above 20% and the current reading of the CO_2 cell is near the current CO_2 offset.
If 'NO' is selected, the CO2 offset can be either set by pressing the 'AUTOCAL' button while in 'RUN' mode, or using the 'OPTION' buttons while displaying the CO_2 offset in 'MAINT' step 11. See also section 3.18, SENSOR CALIBRATION - CARBON DIOXIDE.

13. SET CO_2 SENSOR OFFSET

This figure is used in the calculation of both the zero and span calibration factors for CO_2 before displaying or transmitting CO_2 on channel two (4–20 mA output).

To check this value, press the 'AUTOCAL' button while in 'RUN' mode. After 5 seconds return to 'MAINT' mode, step 12 to display the value that has been saved. The value can also be trimmed manually by using the option keys.
For details of calibration of the carbon dioxide cell, refer to section 3.18, SENSOR CALIBRATION - CARBON DIOXIDE.
It is also recommended that the 1537 be turned on for at least one hour before setting this level.

14. SET CO_2 SPAN

This figure is used in the calculation of the span calibration factor only for CO_2 before displaying or transmitting CO_2 on channel two (4–20 mA output).

Adjusting this value (usually only +/- 3%) allows the CO_2 calculation to be trimmed for the best accuracy.

For details of calibration of the carbon dioxide cell, refer to section 3.18, SENSOR CALIBRATION - CARBON DIOXIDE.

15. SET CALIBRATION FACTOR FOR 4–20 CHANNEL #1

The calibration of the 4–20 mA outputs is done by reading back the output into the input and calibrating this against a known standard. The standard however, may vary from analyser to analyser. To allow for this a trim factor has been provided to set the calibration of each channel for your particular analyser. These two values should only have to be entered once for the life of the instrument, then the only calibration of the outputs should be to press the ‘AUTOCAL’ button every six months.

To determine the factors, generate a full scale value to be sent to the output. eg. For Channel #1, if set up steps 3 to 5 were set for a full scale output of 20% oxygen, then generate input signals until the top line of the display reads 20% oxygen. This is best done with the use of a Novatech probe simulator test box, but can also be achieved with a millivolt generator.

Read the output of channel #1 with a three and a half digit multimeter.
i.e. The output should be 20mA.
If your meter reads 19.65mA.
20.00 – 19.65 = 0.35
(0.35/19.65 *100% = 1.78% error.

Enter the value of 101.8 into ‘MAINT’ step 15, 4–20 mA #1 CAL, and press ‘AUTOCAL’ after returning to the RUN mode.

NOTE :
The accuracy of the output channels without trimming these factors is generally within 2% after using the ‘ AUTOCAL’ procedure. In most cases the instrument can be used without this further trimming of the calibration.

16. SET CALIBRATION FACTOR FOR 4–20 CHANNEL #2

Follow the procedure set in step 15 for Channel #2.

17. ENTER SERVICE YEAR

For a new ‘DATE OF LAST SERVICE’, enter the service ‘YEAR’. This can represent the last time the sensor was serviced or the last time the boiler was serviced. It is recommended that sensors be refurbished every two years

18. ENTER SERVICE MONTH

Enter the current ‘MONTH’.

19. ENTER SERVICE DAY

Enter the current ‘DAY’ of the month. Altering this value will reset the ‘RUN TIME’ counter.

20. REVERSE INPUT POLARITY

When using an oxygen sensor simulator to test the analyser, the mV's from the box must have the polarity reversed within the analyser calculation. Select 'NO' for normal use, or select 'YES' when using the test box simulator.

6.6 D/A CALIBRATION

If a 'COLD START' is performed , then the D/A section of the analyser will be automatically calibrated after a thirty 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 'AUTOCAL' button. This button should be pressed every 6 months, 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 converters and isolated output sections refer to section 6.5, items 15 & 16.

An 'AUTOCAL' will be performed for two seconds after pressing the button. The transmitter outputs will go to 0 mA and 20 mA for these three seconds.

If a 'D/A CAL' error occurs after an 'AUTOCAL', 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 most of the time.

After replacing the battery, all maintenance and set-up mode functions will have to be re entered.

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 firm ware package and input simulator are also available from Novatech.

OXYGEN SENSOR MAINTENANCE

6.9 TEST EQUIPMENT REQUIRED

All measurements are simplified if a 1537 analyser is connected to the oxygen sensor. Readings can then be easily taken of sensor impedance, EMF, temperature and percent oxygen. The analyser also provides proper heater control for heated sensors.

First check all alarms on the analyser, allowing time for the sensor to heat up after switch on.

An instrument to measure sensor 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 sensor 'K' type thermocouple is also useful, although not necessary.

A cylinder of calibration gas is required, eg. 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.

6.10 TESTING AN OXYGEN SENSOR

With the sensor tip heated to approximately 720°C, connect a digital multimeter to the sensor electrode conductors, terminals 1 and 2. Polarity displayed will be the reverse of that displayed on the analyser. If a multimeter is not available, the EMF reading may be taken from the lower line of the display. Apply approximately 500 cc/minute of air to the analyser. The multimeter should read zero millivolts $\pm$ 4.0 millivolts.

If not, then there is a problem with the sensor electrodes and the sensor needs refurbishing. Normally a faulty sensor electrode is indicated with a high source impedance. This can be measured on the lower line of the 1537 display

To test the source impedance, use the sensor impedance display on the lower line. Refer to Section 5.5.9, Lower Line Display Functions. If the impedance is above 3000_, then the electrode needs refurbishing. The sensor must be at 720°C or above for this measurement.

Where a sensor electrode requires refurbishing it is suggested that they should be returned to Novatech or an accredited service organisation.

If the sensor tests reveal less than 4 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. (1537–3 and 1537–4) With the calibration gas flowing at 500 cc/minute, the sensor 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 slightly 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 sensor at a high temperature for more than about 15 seconds, the ceramic parts of the sensor and sensor 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 50°C per minute.

The sensor accuracy should be within 1% of the EMF according to the tables, with the same offset which was measured with air on both sides of the sensor. If the sensor EMF is not within this tolerance, then it will require the electrodes to be refurbished.

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

6.11 SENSOR THERMOCOUPLE

The analyser has an alarm function which will advise the operator of an open circuit sensor thermocouple, however bench testing can be performed by simply measuring the thermocouple continuity. The sensor 'K' type thermocouple connections are on terminals 3 and 4 of the 1530–3 PCB.

6.12 HEATER FAILURE

A heater failure will cause a 'OXYGEN NOT READY' or 'HEATER FAILURE' alarm. Heaters can be tested from the terminals marked 'HEATER' with a continuity test, with power off.
The heater impedance should be approximately 120Ω. Should the heater be open circuit, contact Novatech or an accredited service agent.

6.13 CO_2 OPTICAL SERVICE

Faults in the optical part of the sensor assembly are generally shown by a greater than full scale output caused by a loss of signal. This could be due to source failure, dirt or water droplets in the transmission path, or excessive CO_2 concentration in the cell. After replacing a source, the zero offset for the CO_2 cell should be re-set as per 'MAINT' Section 6.5.11 (Set CO_2 sensor offset) and section 3.18, SENSOR CALIBRATION - CARBON DIOXIDE..

To clean the analysis cell, the sensor assembly should first be disconnected and then unscrewed from the circuit board. To separate the analysis cell from the sensor assembly, both the source and detector ends should be carefully removed.

The bore of the analysis cell (gold plated unless it is very short), should be carefully cleaned and polished using cotton wool and alcohol or acetone. Great care must be taken with the detector assembly and the parts should be re-assembled in the same order. After cleaning the cell, normally the zero will need to be re-set, as per 'MAINT' Section 6.5.11.

The printed circuit board for the CO_2 sensor is not user serviceable and no attempt should be made to adjust or modify any of its components.
If a fault is suspected on this circuit board, please contact Novatech Controls or their agents.

6.14 PACKING

To return an analyser for refurbishment of the sensor 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. Due to the delicate ceramic inner components of the sensor, sensors 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. SENSOR EMF TABLES
2. % OXYGEN SCALE – LOGARITHMIC
3. SAMPLE LOG PRINT OUT
4. CIRCUIT SCHEMATICS

APPENDIX 1

ZIRCONIA OXYGEN SENSOR OUTPUT (mV)

% OXYGEN	mV at 720 ° C	PPM OXYGEN	mV at 720 °C
20.0	0.99	(1000ppm = 0.1%)	
19.5	1.53	1000	114.4
19.0	2.09	950	115.5
18.5	2.66	900	116.6
18.0	3.25	850	117.9
17.0	4.47	800	119.2
16.5	5.11	750	120.5
16.0	5.77	700	122.0
15.5	6.45	650	123.6
15.0	7.15	600	125.3
14.5	7.87	550	127.2
14.0	8.62	500	129.2
13.5	9.40	450	131.5
12.5	11.05	400	134.0
12.0	11.92	350	136.9
11.5	12.83	300	140.2
11.0	13.78	250	144.1
10.5	14.78	200	148.8
10.0	15.82	150	155.0
9.5	16.92	100	163.7
9.0	18.08	50	178.5
8.5	19.30	40	183.3
8.0	20.60	30	189.4
7.5	21.98	20	198.1
7.0	23.45	10	212.9
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		
0.1	114.39		
'K' TC mV	**29.965**		

These tables are based on the Nernst equation:

Sensor e.m.f. = 0.02154 x T x 1n (20.95/% oxygen), where T = ° K (° C + 273).

APPENDIX 2

% 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 3

SAMPLE LOG PRINT OUT

12.07: 12/10/90

O2 18.2%
EMF mV 2.9
SENS TEMP 693 C
PRB IMP 0.0K
SAMPLE 0.123%
AMBIENT TEMP 26 C
RUN TIME 0 :05
SRVCD 12/10/90

GAS CAL 1431 MINS, PRINT LOG 23 MINS,

12:12:41 12/10/90 SAMPLE 1.17%
12:12:41 12/10/90 HIGH OXYGEN

12:14:16 12/10/90 LOW GAS FLOW
12:16:07 12/10/90 LOW GAS FLOW CLEARED

APPENDIX 4

CIRCUIT SCHEMATICS