Novatech CONTROLS PTY. LTD.

Water Vapour Analyser

Model 1635

August 2007

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Note: This manual includes software modifications up to Version 5.18, 12th July 2007

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USING THIS MANUAL

The Novatech 1635 Percent Water Vapour Analyser has a variety of user-selectable functions.

Each selection is menu driven, designed for simplicity. For options you are unsure about, read the manual.

Please read the safety information below and the 'Installation' section, before connecting power to the analyser.

CAUTION FOR DIRECT FIRED DRYERS OR OVENS

CAUTION 1

The sensing probe is heated to above 700°C and can be a source of ignition. With direct fixed dryers, raw fuel leaks can occur during burner shutdown, the analyser has an interlocking relay which removes power from the probe heater when the main fuel shut-off valve power is off. If this configuration does not suit or if it is possible for raw fuel to come into contact with a hot oxygen probe then the Model 1635 analyser with its heated probe may be unsuitable for your application. Also read the probe heater interlock caution in section 2.7.

CAUTION 2

The probe heater is supplied with mains voltage, either 240 or 110 VAC. This supply has electrical shock danger to maintenance personnel. Always isolate the analyser before working with the probe.

DESCRIPTION & SPECIFICATIONS

1

SECTION
NUMBER

1.1 DESCRIPTION

The Novatech 1635 Percent Water Vapour Analyser is designed for measuring water vapour in drying and baking applications, where the drying temperature is above the maximum limit of conventional relative humidity sensors (typically 130-150°C) or a more robust sensor is preferred. The analyser signal can be used with a conventional controller to improve the efficiency of industrial drying or baking applications, as well as to optimise the quality of the product being dried or baked. There are seven basic types of installation for the 1635 analyser (see table below)

2	Indirectly fired, 2 zones	2 sensors	Indirect 2 Zone	n/a	n/a
3	Directly Fired, Constant Combustion	1 sensor	Direct, Fixed O2	0.1 - 21.0% 0.1% interval	n/a
4	Directly Fired, Ambient Cooled/Refrigerated Process gas on Probe Reference	1 sensor	Direct Ref'g O2	n/a	Ambient Cooled/ Refrig'd Dry
5	Directly Fired, Constant/Auto Operation of Sensor 2	2 sensors	Direct Fired	n/a	n/a
6	Directly Fired, Auto Operation of Cal 2 Solenoid	1 sensor	Switched Dry O2	n/a	Ambient Cooled/ Refrig'd Dry
7	Directly Fired, External Dry O2 Input	1 sensor	External Dry O2	n/a	n/a
8	Directly Fired, External Drier Temperature, 0-400 Deg C	2 sensor	Direct Fired c/w RH	n/a	n/a

	Setup Step 27 Dry O2 Upd' Mode	***Setup Step 28 Update Period***	***Setup Step 29 Update Duration***	***Setup Step 30 Update Freeze***	***Setup Step 31 Update Deviation***
1	n/a	n/a	n/a	n/a	n/a
2	n/a	n/a	n/a	n/a	n/a
3	n/a	n/a	n/a	n/a	n/a
4	n/a	n/a	n/a	n/a	n/a
5	Constant/Auto	0.1 - 99.9 hours [1] 0.1 hour interval	5-300 minutes 1 minute interval	1-60 minutes 1 minute interval	0.1 - 21.0% [1] 0.1% interval
6	Timed/Auto	0.1 - 99.9 hours 0.1 hour interval	5-300 minutes 1 minute interval	1-60 minutes 1 minute interval	0.1 - 21.0% [1] 0.1% interval
7	n/a	n/a	n/a	n/a	n/a
8	n/a	n/a	n/a	n/a	n/a

1. Indirectly Heated Dryers and Ovens, 1 Zone

The in-situ probe measures the oxygen content within the drying chamber and calculations are performed to determine how much of the air space is taken up by water vapour. For indirectly heated dryers or ovens, an oxygen probe and analyser are all that is required. The oxygen probe uses ambient air as a reference gas.

2. Indirectly Heated Dryers and Ovens, 2 Zones

If the dryer or oven has two zones that you would like to measure the humidity level in, a 1635 analyser can be configured to read both zones and independently display and transmit the for each zone on independent channels.

3. Directly Heated Dryers and Ovens with Constant Combustion

If the dryer or oven has a fixed combustion system (fixed firing rate), where the reduction of oxygen due to combustion is constant, then a reference gas sensor may not be necessary to condition reference gas from within the dryer. The dryer or oven oxygen level can be entered on the analyser keyboard. The percent water vapour can be measured by gravimetric methods to calculate the correct reading.

4. Directly Heated Dryers and Ovens with Single Probe and RGS thermocouple

In a system where water vapour % is measured using a single probe, process gas is extracted from the system and cooled to ambient (RGS thermocouple) temperature or refrigerated to drop out most of the water vapour. The probe then measures the oxygen difference between the dry cooled process gas and wet process gas to calculate water vapour %. For ambient cooling the RGS thermocouple must be present for compensation.

5. Directly Heated Dryers and Ovens with Dual Sensors

Where dryers or ovens use direct fired combustion, the oxygen level in the dryer or oven is measured after removing some or all of the water vapour. The oxygen level of the dried sample is compared to the oxygen level in the wet measurement in the oven and the amount of water vapour is calculated. The 1231 oxygen probe in the dryer or oven performs the wet measurement. The dry measurement is performed by the RGS-01, reference gas sensor which draws a gas sample from the dryer of oven. In this mode, the RGS-01 sensor can be operated in continuous sampling mode, or auto mode with a solenoid on terminals 45 & 46 controlling flow of sample gas to the probe when the change in measured wet oxygen exceeds the deviation threshold.

6. Directly Heated Dryers and Ovens with Single Probe with Switched Regference Gas

This mode extends *Mode 4* by calculating wet & dry oxygen as well as measuring water vapour using the difference in wet/dry oxygen. It achieves this by switching the reference gas to the probe between dry process oxygen and reference air using a solenoid connected to terminals 45 & 46. Switching can be configured to occur automatically when the change in wet process gas exceeds the deviation threshold, or at set timed intervals. It then uses the wet oxygen reading and water vapour to calculate the dry process gas oxygen content.

7. Directly Heated Dryers and Ovens with Single Probe and Dry Process Gas on External 4-20mA Input

For systems that have external dry process gas oxygen reading, this measurement can be sent back to the analyser via the BFT input in the form of a 4-20mA signal as linear scaled 0-25% oxygen dry process gas. In this mode the analyser calculates water vapour % the same as in *Mode 5*, using the external input as the dry oxygen measurement instead of an RGS-01 sensor.

8. Directly Heated Dryers and Ovens with Dual Sensors and the Drier Temperature on External 4-20mA Input

For systems that require a reading of RH but are using in insitu probe and a sampling oxygen sensor to measure the water vapour, the drier temperature must be fed into the analyser on the terminals 55&56. This signal must be a 4-20mA signal ranged for 0-400°C.

What Measuring Units to Use:

The water vapour can be displayed or transmitted in 4 different engineering units.

Water Vapour Percent
Absolute Humidity Kg/Kg
Dew Point Temperature Centigrade / Fahrenheit
Mass Fraction g/Kg
Relative Humidity %

Most industrial processes operate at high temperatures resulting in low RH levels. For this reason it is normally best to use a reading of % Water Vapour or g/kg of moisture or Dew Point. A dryer or oven temperature thermocouple is only necessary if Relative Humidity percent is to be displayed or transmitted.

Features

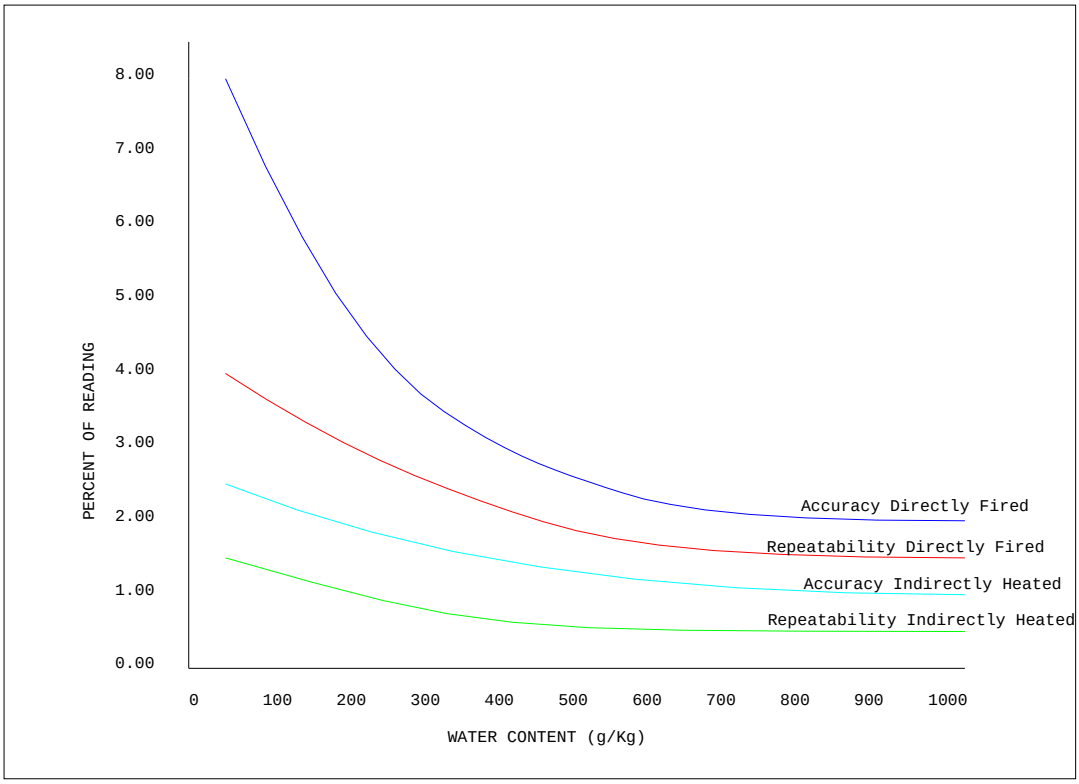
1. The probe can be operated in dryer atmosphere temperatures up to 900°C or higher

2. The output signal is continuous and proportional to the percentage volume of water vapour

3. Various engineering units Selectable from the keyboard -
   Water vapour %
   Relative Humidity %
   g/Kg or lb/lb of moisture
   Dew point

4. Fast response, typically 20 seconds

5. Long- term continuous and reliable measurement



Accuracy & Repeatability of 1635 Water Vapour % Analyer Readings

1.2 SPECIFICATIONS

1.2.1 SPECIFICATIONS - ANALYSER

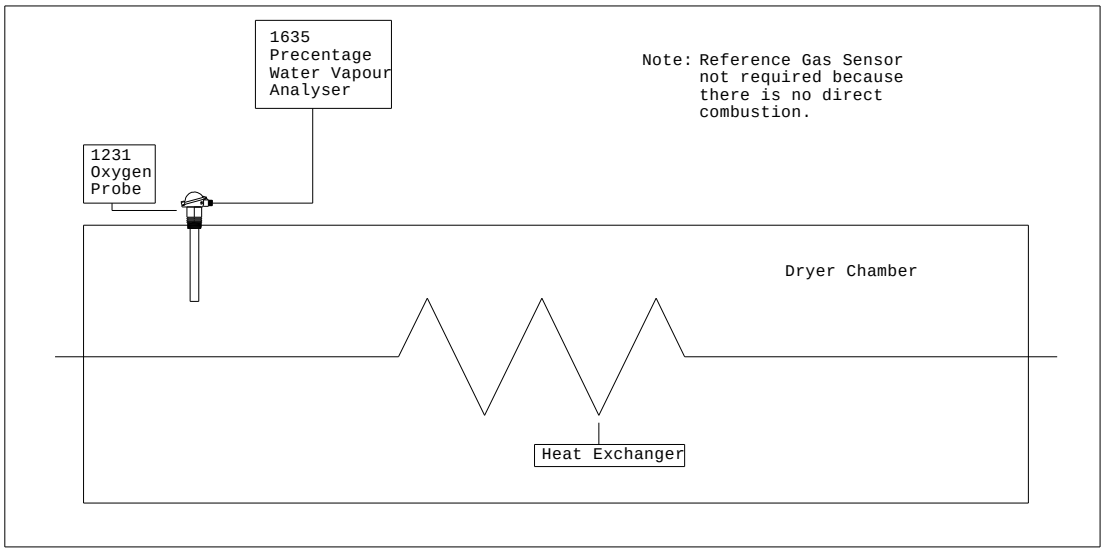
Model:	1635
Range:	Keyboard selectable for the following ranges: - 0–100% volume of water vapour 0-100% Relative humidity (RH) 0-10,000 g/Kg -50-+100 °C Dew point all with adjustable span and zero.
Output:	Isolated 4–20 mA DC linear
Displays:	Various, Refer Section 3.1
Alarms:	Various, Refer Section 3.3.1 & 3.3.2
Speed of response:	Typically 20 seconds
Accuracy:	See graph above
Power Supply:	110/240 VAC, 50/60 Hz 105VA
Environmental Rating	Operating Temperature: -25 to 55°C (-15 to 130°F) Relative Humidity: 5 to 95% (non-condensing) Vibration: 10 to 150Hz (2g peak)
Degree of Protection	IP65 without reference air pump IP54 with reference air pump

1.2.2 SPECIFICATIONS – PROBE

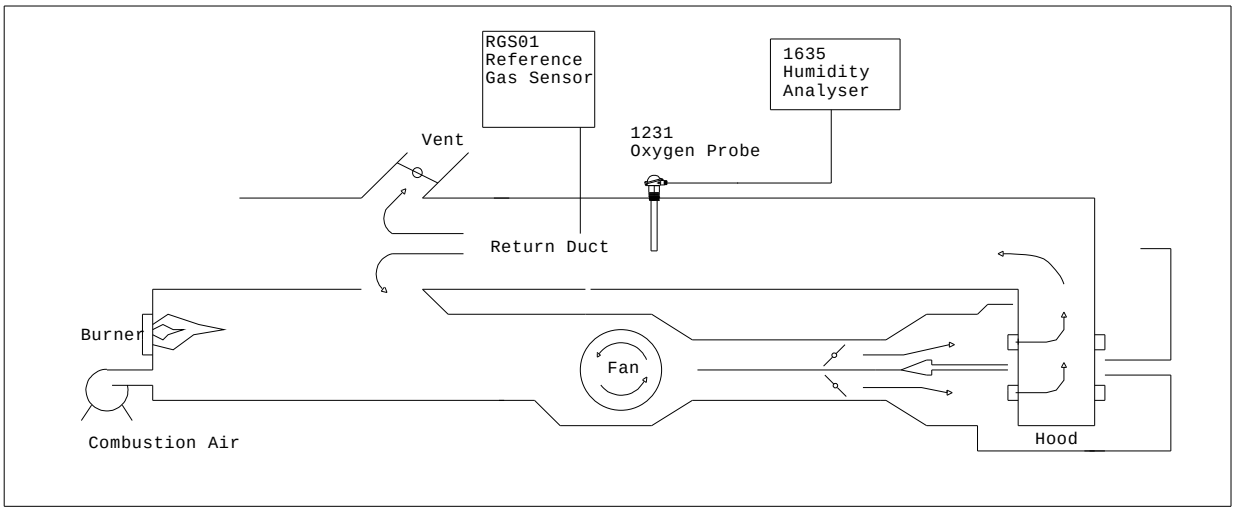
Model:	1231
Length:	250–1000 mm.
Temperature Range:	0 to 900°C
Process Connection:	1.5" BSP or NPT
Filter:	Sintered titanium alloy particulate filter, removable, 30 or 15 micron
Response Time:	Typically less than 4 seconds
Operating Temperature:	720°C with integral heater
Heater Voltage:	240 (25% duty cycle) / 110 VAC, 100 watts
Maximum Head Temperature:	150°C with screw terminals / 100°C with weatherproof connector
Reference Gas Connection:	1/8" NPTF.
Probe Cable:	Supplied with weatherproof connector to specified length, maximum 100 metres
Probe Life:	Typically 2 to 3 years.

1.2.3 SPECIFICATIONS – REFERENCE GAS SENSOR

Model	RGS-01
Pump:	Integral electric sampling pump
Size	300 H x 125 W x 88 D
Weight	3 Kg
Heater Voltage:	240 (25% duty cycle) / 110 VAC, 100 watts
Maximum ambient air temperature	100°C
Minimum process moisture content	2000 g/Kg



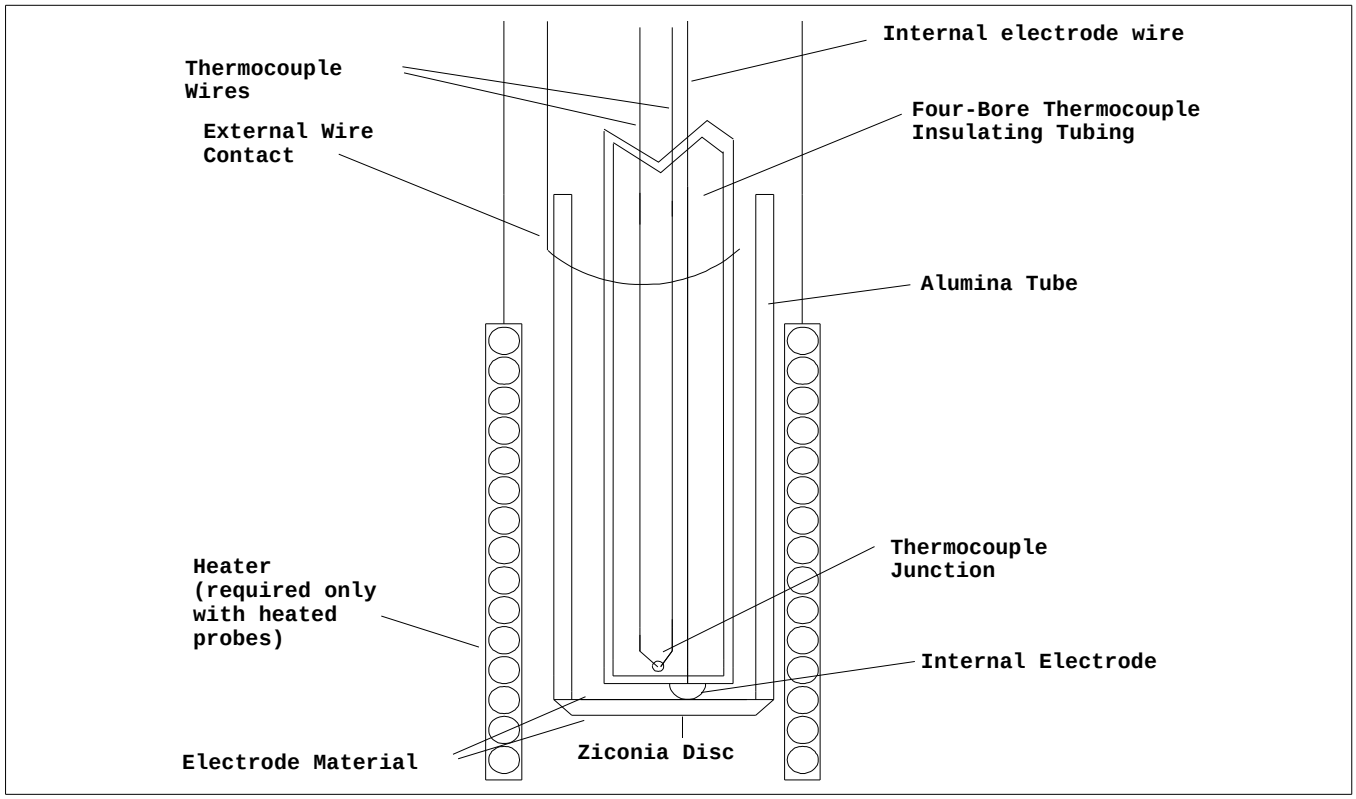
Percent Water vapour Measurement in Indirectly Heated Dryer or Oven



Percent Water vapour Measurement in Directly Heated Dryer or Oven (Paper Machine Hood Example)

1.3 THE ZIRCONIA SENSOR

The analyser input is provided from one or two (two where an RGS-01 is required) zirconia oxygen sensors and thermocouples. The probe is designed to be inserted into the dryer or oven. A reference air supply is required for the probe. A reference air pump is integral with the 1635 analyser. The RGS-01 withdraws a sample from the dryer of oven. It uses air as a reference but a pump is not required. The sensor construction is shown below.



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 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:

$$E(\text{millivolts}) = \frac{RT}{4F} \ln\left(\frac{(\%O_2)\,\text{INSIDE}}{(\%O_2)\,\text{OUTSIDE}}\right)$$

Where T is the temperature (° K) at the sensor (> 650°C), 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:

$$E(\text{millivolts}) = 2.154\times10^{-2} T \ln\frac{0.21}{(\%O_2)\,\text{OUTSIDE}}$$

Transposing this equation

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

The 1635 analyser solves this equation which is valid above 650°C.

A 1231 probe can measure the oxygen in the dryer or oven, and in direct fired ovens and dryers the RGS-01 can measures the oxygen in the dried oven atmosphere. The 1635 uses both these readings to calculate the moisture content in the oven or dryer. The 1635 can then use the moisture content to calculate the dew point, g/Kg and relative humidity.

1.4 THE OXYGEN PROBE

The probe assembly provides a means of exposing the zirconia 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 a gas thread connection. Connections are provided for an in-situ gas calibration check. A cleaning purge of air can be admitted via the calibration gas entry.

1.5 THE REFERENCE GAS SENSOR (RGS-01)

A sample of gas must be drawn from the dryer or oven and the moisture condensed over about two metres of upward sloping, 1/2" stainless steel tube. The sensor measures the amount of oxygen that the combustion is using from the dryer or oven atmosphere in direct heated processes.

1.6 ALARMS

Refer to OPERATOR FUNCTIONS Section 3.3 for details on alarm functions.

1.7 HEATER SUPPLY

CAUTION

The probe heater and the RGS-01 heater are supplied with 240 / 110 VAC. This supply has electrical shock danger to maintenance personnel. Always isolate the analyser before working with the probe or the RGS-01.

1.8 APPLICATIONS WHERE THE SENSING POINT IS NOT AT ATMOSPHERIC PRESSURE

To apply the 1635 analyser to processes that have pressure at the point of measurement significantly above or below atmospheric pressure, then compensation must be applied. Refer to set-up step 41 & 42 in section 4.5.
The pressure compensation only applies to probe #1, as the sensor #2 is usually an RGS-01, which is always subject to atmospheric pressure.

1.9 SENSOR IMPEDANCE

The probe or sensor impedance is a basic measurement of the reliability of the oxygen reading. A probe or sensor with a high impedance reading will eventually produce erroneous signals. The analyser checks the probe or sensor impedance daily and if the impedance is above the maximum level for a specific temperature then the impedance alarm "Sensor Fail" will be activated. The analyser will activate the "Sensor Fail" alarm at 9 kΩ @ 720°C, the reading will still be valid but you should arrange to replace the probe or have it serviced.

1.10 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 three seconds. Should the input electronics drift slightly then the drift will be automatically compensated for within the microprocessor. If the calibration factors are found to be have been changed more than expected, an 'ADC Warning' alarm is generated. If a large error occurs due to an electronic fault then an 'ADC CAL FAIL' alarm will occur.

A check of the precision reference source voltages should be performed annually or if the instrument has been repaired. For a description of the calibration procedure, refer to 'Setting Up The Analyser' Section 4.5, items 7, 8, 9 and 10.

The digital to analog converters or output section of the analyser are tested for accuracy when the 'AUTOCAL' button is pressed, and when the analyser goes through the start up procedure. If the output calibration factors are found to have changed more than expected, the 'DAC Warning' alarm will occur. If either output has a fault, the 'DAC CAL FAIL' alarm will occur. The D/A sections are re-calibrated by pressing the 'AUTO CAL' button on the keyboard while in 'SET-UP' mode. Each of the output channels has three menu items that provide manual calibration (set-up 15 and 18). If manual is selected in set-up step 15 or 18, the 'AUTO CAL' will be skipped and the manual calibration factors will be retained. See section 4.5 set-up 15, and section 5.3 for more details.

1.11 AUTO CALIBRATION CHECKING - PROBES

On-line automatic gas calibration check is not normally required. Where it is required however, the probe can be checked for accuracy in-situ and on-line. Solenoid valves can admit a calibrated gas mixture into the probe under microprocessor control on a timed basis. For details on installation refer Section 2.13. For details on setting up this facility refer to Set-up steps 49 to 54 in Section 4.5.

During probe auto calibration checking, the analyser output will freeze and remain frozen for a further adjustable period, allowing the probe time to recover and continue reading the water vapour level.

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

1.12 PURGE & CALIBRATION CHECK ACCESSORIES

Due to the absolute measurement characteristics of zirconia sensors and the self-calibration features of Novatech analysers, probe calibration checks with calibrated gas are not normally required. In some installations however, automatic gas calibration checks are required by Environmental Protection Authorities and by engineering management in Power Stations, Oil Refineries and similar large fuel users.

Novatech probes and analysers provide a ready method of connecting on-line calibration check gases. They provide on-line automatic checking of probe and analyser calibration, as well as a probe purge facility.

The absolute characteristics of zirconia sensors require only one calibration check gas to properly check the probe's performance.

Dirty flue gas applications often require the back purge facility to keep a probe filter free from blockage. (In these applications, it is more reliable to install probes pointing vertically downwards with no filter). Purge and calibration check solenoid valves can be operated manually or automatically from a 1635 analyser.

The external components required for automatic / manual gas calibration checking are:

- A calibration check gas flow meter / regulator
- A mains voltage (240 or 110 VAC) solenoid valve for calibration check gas

The external components required for automatic / manual purging are:

- A mains voltage (240 or 110 VAC) purge solenoid valve
- A purge pressure switch, 0 to 35 kPa (0 to 5 psi), to test for filter blockage.

The user should supply:

- Span gas cylinder, typically 8 % oxygen in nitrogen or a similar percentage of O2 close to the normal level in the gas stream being measured, to ensure fast recovery.
- A 100 kPa (15 psi) clean and dry instrument air supply when filter purging is required.

1.13 FILTER PURGE PRESSURE SWITCH

To automatically sense a blocked probe filter, a pressure sensor should be connected to the 'purge' line to the probe 'cal' port. It should be adjusted so that it energises just above the purge pressure with a new or clean filter installed. The switch contacts should be connected to terminals 12 & 13 (PURGE FL SWITCH).
If the filter is still blocked or partly blocked after an auto purge cycle, the pressure switch will energise and cause a 'Probe Filter Blocked' alarm. The contacts must be normally closed.

The pressure switch should have an adjustable range of 0 to 100 kPa (0 to 15 psi).

1.14 RS 485 NETWORK (MODBUS™) AND RS 232C PORT

The serial port has two functions. -

- It can be configured to connect up to 31 analysers together on a MODBUS™ RS485 network.

Each individual analyser can be interrogated by a computer or PLC. The values of oxygen, sensor EMF, sensor temperature, sensor impedance for both oxygen sensors (if two sensors are being used on one analyser) can be read over the network, as well as calculated values such as water vapour %, dew point etc.
The alarm status can also be checked over the network.
For the connection details, see Section 2.15 and Appendix 3.

- It can be used to log the analyser readings by connecting the analyser to a printer, a data logger, or any computer using an RS232-C port.

To configure the data logging capabilities of the device, use set-up step 58 to select the items to be logged. The log period may be selected in set-up step 59, and the baud rate may be set in set-up step 60. Alarms, including the time they occurred are transmitted to the printer and computer whenever they are first initiated, accepted and cleared. The protocol for the serial port is eight data bits, one stop bit, no parity.

1.15 DRYER OR OVEN TEMPERATURE (AUX) THERMOCOUPLE

A type K dryer or oven thermocouple should be installed and connected only when relative humidity display is required. This is an unlikely requirement for high temperature drying or baking processes because the relative humidity is very low. Greater resolution is achieved with % water vapour, moisture or dewpoint measurement.

The auxiliary thermocouple input is not available when an RGS-01 is being used in direct fired systems.

1.16 MODES WITH SWITCHING CAL 2 SOLENOID

When operating the device in dryer heater type *Mode 5Auto* and *Mode 6 Timed & Auto*, terminals 45 & 46 (cal 2 sol) serve as an output to control an external solenoid critical to these modes of operation. In *Mode 5 Auto*, this solenoid relay is energised when the device is sampling from the RGS-01 sensor and could be used as an indicator/solenoid controller to enable gas flow to the sensor.
In *Mode 6* theis relay controls a solenoid which switches reference air / dry process gas to the reference input on the sensor. The solenoid should be configured so that when it is energised the probe reference should be plumbed to the dry process gas, and when de-energised it should be reference air.

1.17 WATCHDOG TIMER

The watchdog timer is started if the microprocessor fails to pulse it within any one second period, (i.e. fails to run its normal program). The microprocessor will then be reset up to three times 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. The reset function will continue repeatedly after the alarm. If a successful reset is achieved, the alarm will be cancelled and the analyser will continue to run normally.

1.18 BACK-UP BATTERY

The analyser's RAM and real-time clock are backed up by a lithium battery in the event of power failure.

INSTALLATION & COMMISSIONING

2

SECTION NUMBER

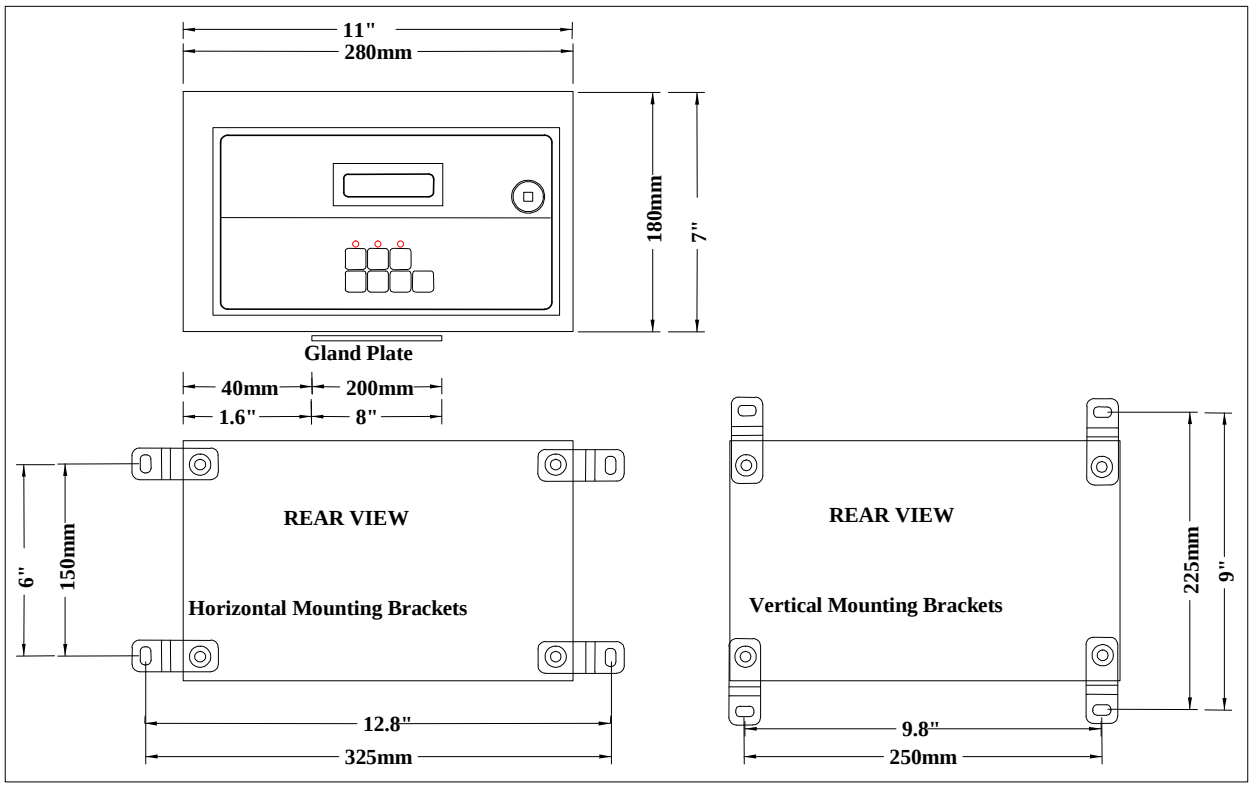
INSTALLATION

COMMISSIONING

INSTALLATION

2.1 MOUNTING THE ANALYSER

Surface mount the analyser case on a flat surface or bracket, using the four mounting brackets provided.



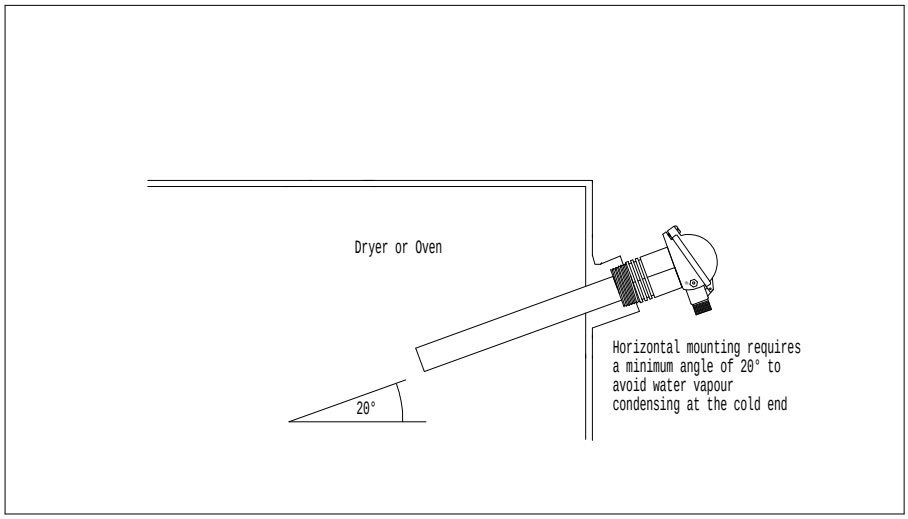
Enclosure Mounting Dimensions

2.2 INSTALLING THE OXYGEN PROBE

Weld a 1.5” BSP or NPT socket to the dryer or oven in a suitable position for sensing the water vapour level. The closer to the source of moisture the smaller will be a sensing lag time, allowing better control.

The probe has a typical response time of less than four seconds, so most of the delay time is normally the transit time of the gas from the point of moisture emission to the point of sensing.

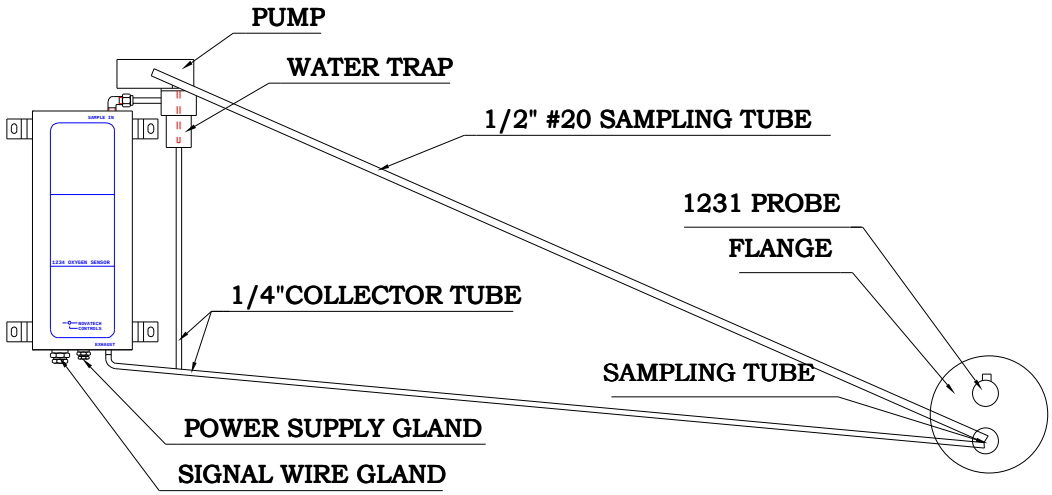
It is necessary to angle the probe downward at about 20° minimum angle from horizontal, to avoid water vapour building up in the probe housing. The sensing tip should be lower than the head.



Installing an Oxygen Probe in the Dryer of Oven

2.3 Installing The RGS-01, Reference Gas Sensor

Screw the RGS-01 to a wall or similar surface with the piping connections at the bottom. Connect the gas sample piping to the "sample in" port. The gas sample piping should be thin wall, 1/2" OD, stainless steel tube approximately two metres long. It should rise vertically or at an angle of at least 20° from the horizontal.



Installation of the reference gas sensor

2.4 Installing The Dryer Or Oven Thermocouple

Weld a 1/2 inch BSP mounting socket to the dryer or oven within about 300 mm, and upstream of the oxygen probe. The thermocouple should be of similar length to the oxygen probe to prevent temperature distribution errors. The thermocouple can be type 'K', 'T', or 'J'.

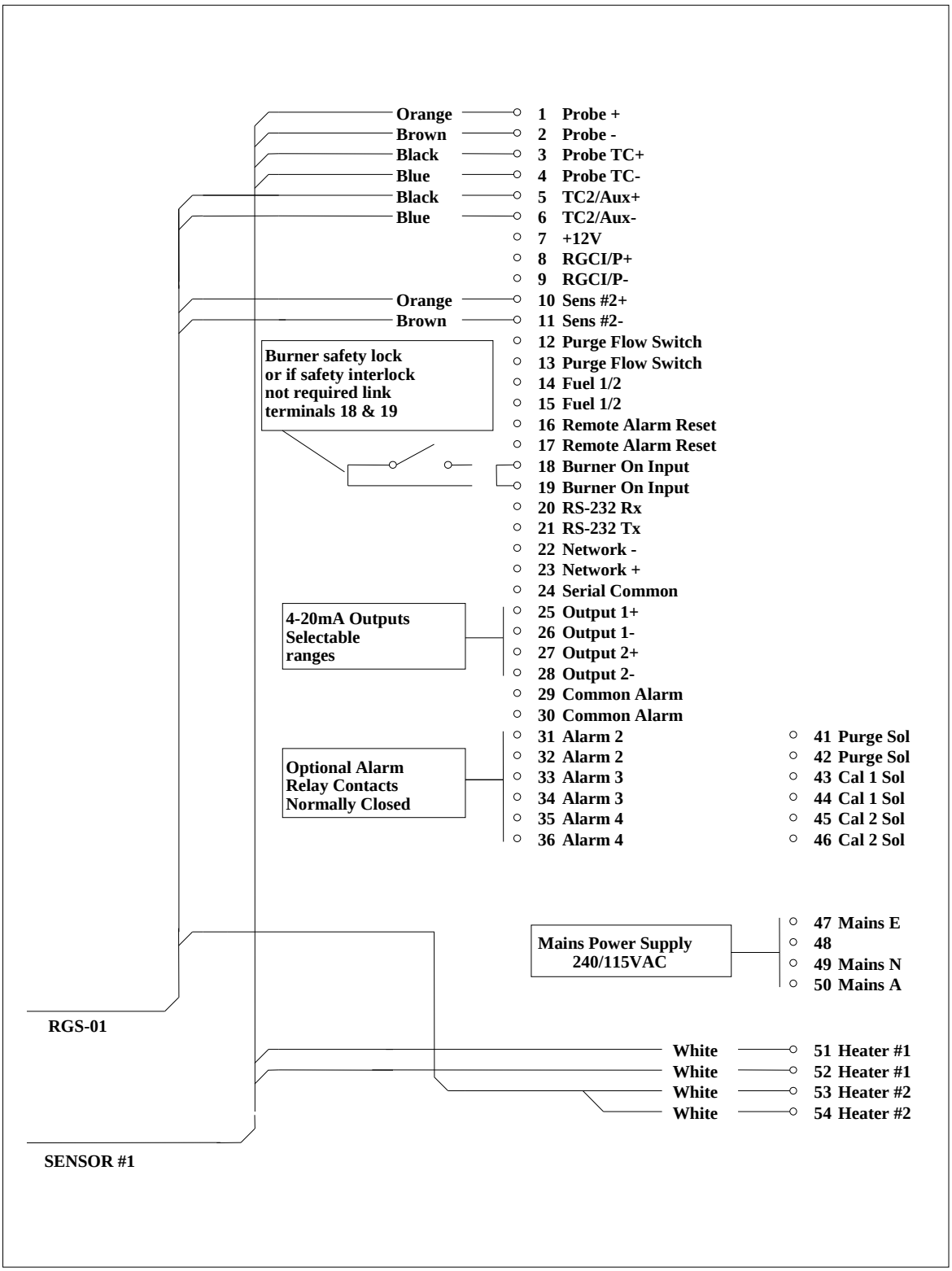
This thermocouple is optional. It is only necessary when it is required to read the moisture content in % relative humidity. This is not possible in direct fired applications using an RGS-01.

2.5 Shield Connections

All external wiring to the 1635 analyser should be shielded. 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.

2.6 ELECTRICAL CONNECTIONS

All wiring should comply with local electrical codes. The printed circuit boards are fully floating above earth. All earth and shield connections should be connected to the earth stud on the LHS inside the case. Before connection of mains power check that the 115 / 230 volt power selector switch is set to the correct voltage.



Connection Diagram for a 1635 Analyser, a 1231 Heated Probe and on optional RGS-01

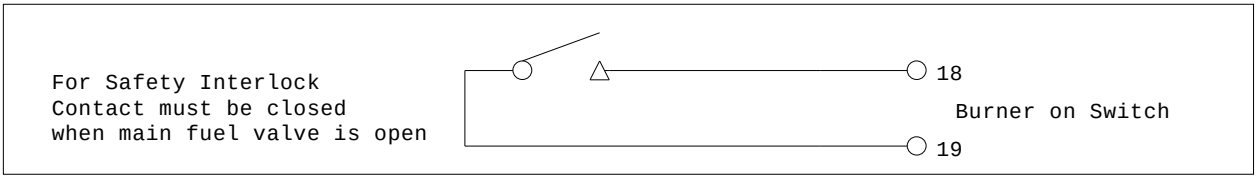
2.7 HEATER INTERLOCK RELAYS

CAUTION

For direct fired dryers or ovens, explosion protection for heated probes is achieved by switching the power to the probe heater off whenever the main fuel valve is closed. For indirectly heated ovens, connect a jumper bridge to terminals 18 and 19.

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.

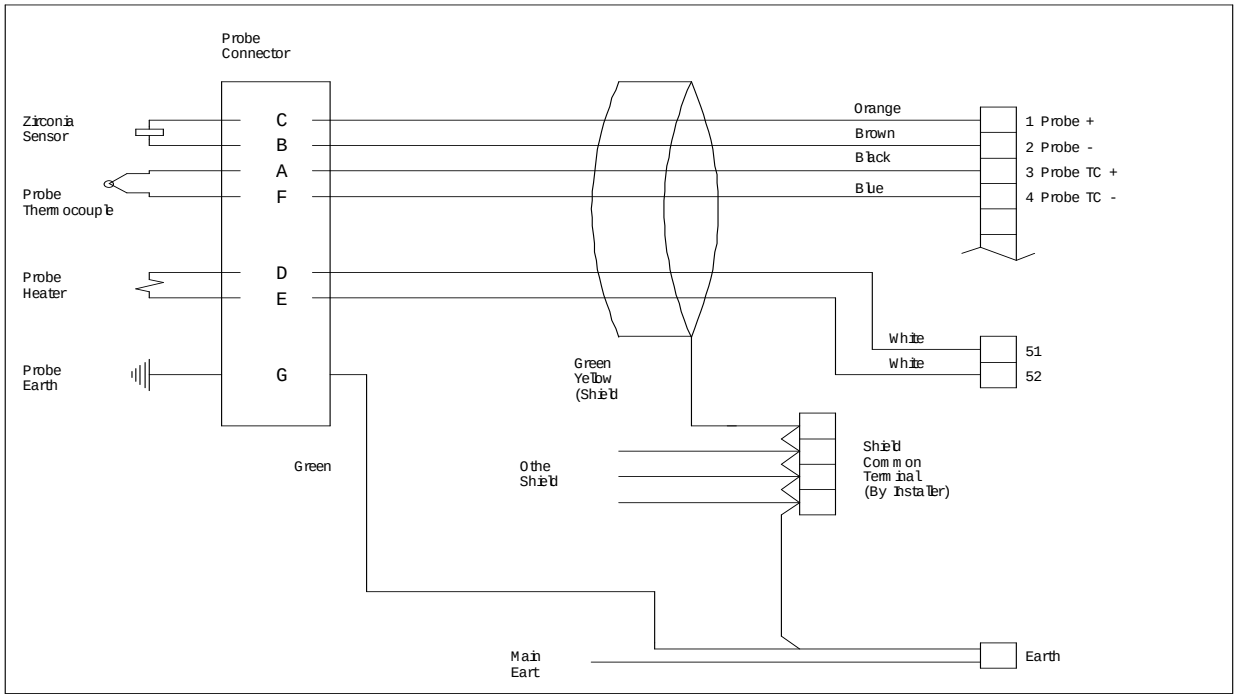
To achieve this protection, connect a main fuel valve voltage free contact to the 'BURNER ON SWITCH' terminals. The contacts must be closed when the main fuel valve is open.
For installations where there is no risk of explosion, connect a jumper bridge to terminals number 18 & 19.



Heater Supply Interlock Connection

2.8 CONNECTING THE OXYGEN PROBE CABLE

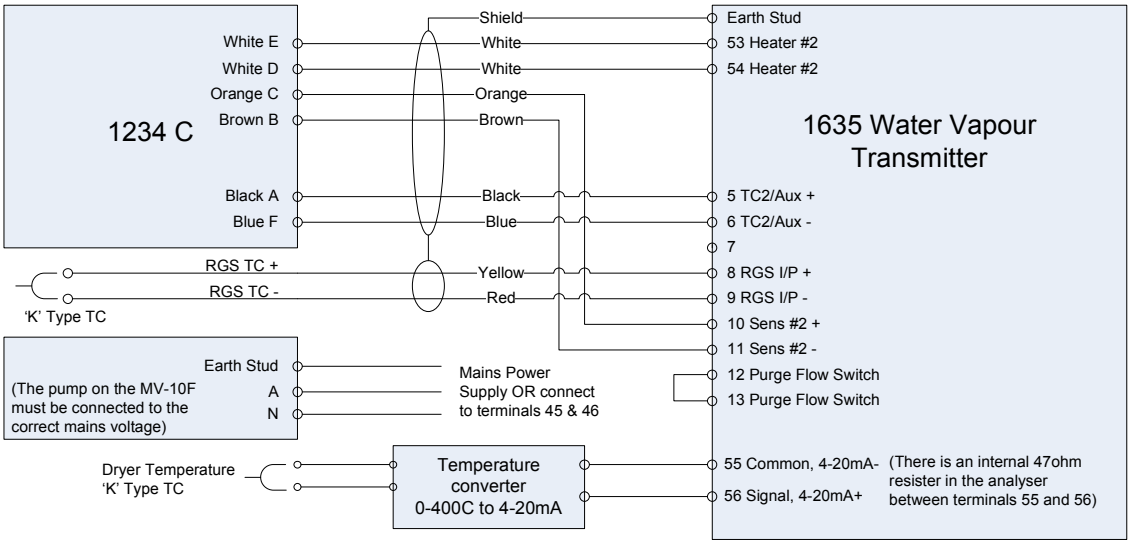
Connect the oxygen probe lead supplied as shown. Connect a 1/4" reference air tube from the analyser to the probe 'ref' connection.



Connection of Probe Cable for 1231 Model Heated Probes

2.9 CONNECTING THE REFERENCE GAS SENSOR (RGS-01) CABLE

Connect the RGS-01 lead supplied. The oxygen probe and the RGS-01 leads are identical but they may be different lengths. The RGS-01 also requires a mains (240 or 115 VAC) power supply, a pair a mains voltage wires from the 1635 analyser to activate the RGS-01 pump and a type 'K' thermocouple compensation lead.



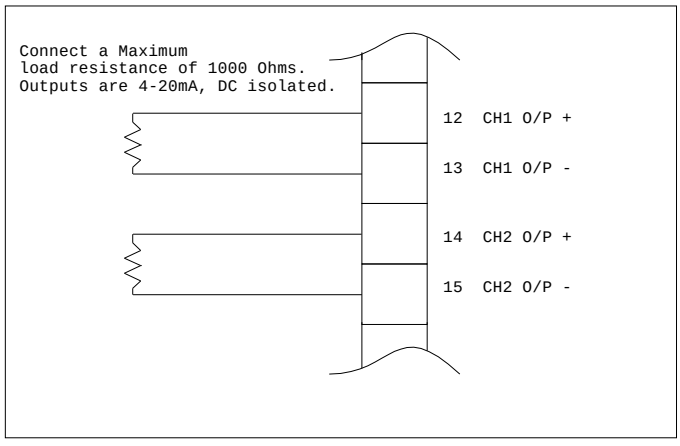
Connections for a Reference Gas Sensor (RGS) to a 1635 Analyser

2.10 CONNECTING THE DRYER OR OVEN (AUX) TEMPERATURE THERMOCOUPLE

The dryer or oven temperature thermocouple is only required if the dryer relative humidity is to be calculated. For 1231 heated probes, the auxiliary thermocouple must be a separate TC with the junction isolated from earth, mounted near to and upstream of the oxygen probe. It can be any one of the types 'K', 'T', or 'J'. If relative humidity or auxiliary temperature for display or transmitted signals are not required, then an auxiliary TC is not required.
If relative humidity is required in a direct fired application, the drier temperature must be connected to terminals 55&56. This is a 4-20mA input scaled to 0-400°C. R55, just above CN16, must be 47 ohms, or an external 47 can be placed across terminals 55&56.

2.11 CONNECTING THE OUTPUT CHANNELS

The two 4 to 20 mA DC output channels are capable of driving into a 1000Ω load.



Connections for Analyser Output Channels

2.12 CONNECTING THE ALARMS

A common alarm, which should be connected for all installations initiates on alarm functions described below. Three additional alarm relays are available for selectable functions as listed in Section 4.5, steps 39 to 41. Each relay has normally closed contacts. The contacts will open in alarm condition except for the optional horn function which operates with normally open contacts. Relays are connected as follows:

Relay	Terminal Numbers
Common Alarm	29 & 30
Alarm 2	31 & 32
Alarm 3	33 & 34
Alarm 4	35 & 36

Alarm Conditions

Common Alarms All of the following conditions will cause a common alarm -

ADC Calibration Fail
DAC Calibration Fail
ADC Calibration Warning
DAC Calibration Warning
Sensor 1 Fail
Sensor 2 Fail
Heater 1 Fail
Heater 2 Fail
Sensor 1 TC Open
Sensor 2 TC Open
Sensor 2/Auxiliary/Dryer TC Open
Reference Air Pump Fail
Mains Frequency Check Fail
Probe Filter Blocked
Gas1 Calibration Check Error
Burner bypass Switch on
Watchdog Timer *

* The watchdog timer is a special alarm. It will force the common alarm to activate in the event of a microprocessor failure. There will not be an alarm message displayed, but the analyser will reset.

Alarm 2 to 4 Select any one or all of the following for each relay. Refer Section 4.5.39 to 41

Sensor under temperature
Calibration check in progress
Alarm horn function (Alarm Relay 4 only)

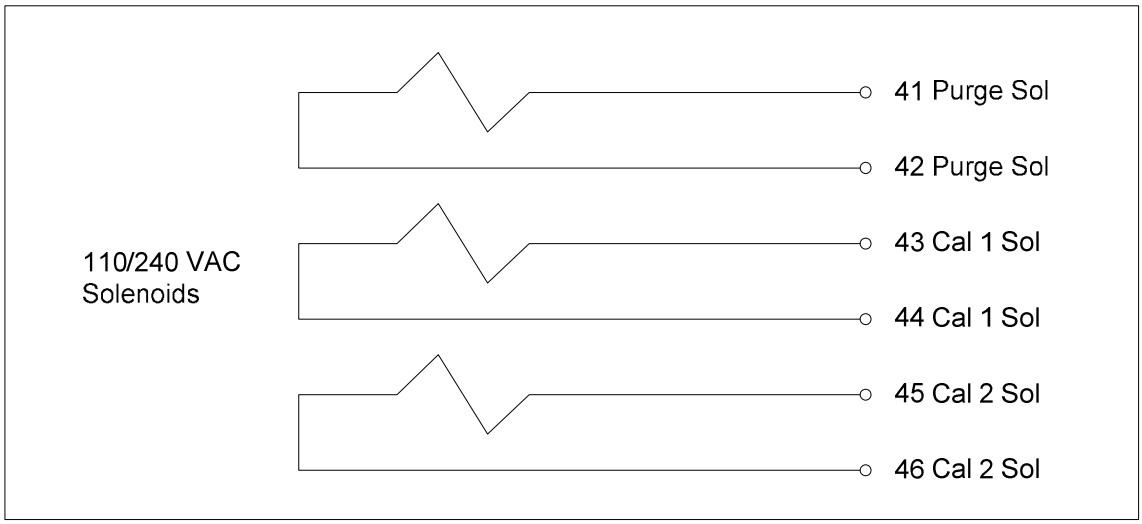
2.13 CONNECTING THE AUTOMATIC CALIBRATION CHECK SYSTEM

CAUTION

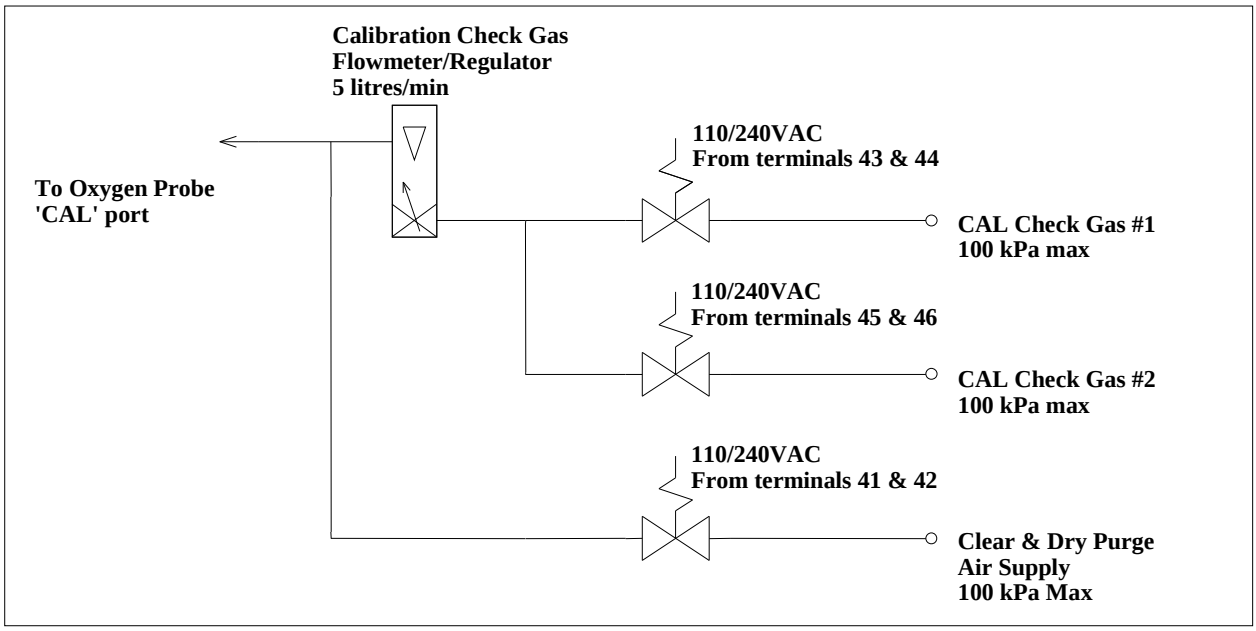
The purge and calibration solenoid valves are supplied with mains voltage. This supply has electrical shock danger to maintenance personnel. Always isolate the analyser before working with the purge and calibration solenoid valves.

The on-line auto calibration check system is optional. For details on its operation refer to Sections 1.1. Typical connection details are shown in Figures 3.10 (a) and (b).

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



Automatic Purge & Calibration check System Wiring



Automatic Purge & Calibration check System Piping

2.14 CONNECTING REFERENCE AIR TO 1231 PROBE

For the oxygen probe, a 1/4" tube connector on the analyser should be connected via a nylon, copper or stainless steel tube to the 'REF' connector on the probe.
If two probes are being used, a "T" union must be supplied to provide reference air supply to both probes.

2.15 CONNECTING TO A MODBUS™ NETWORK

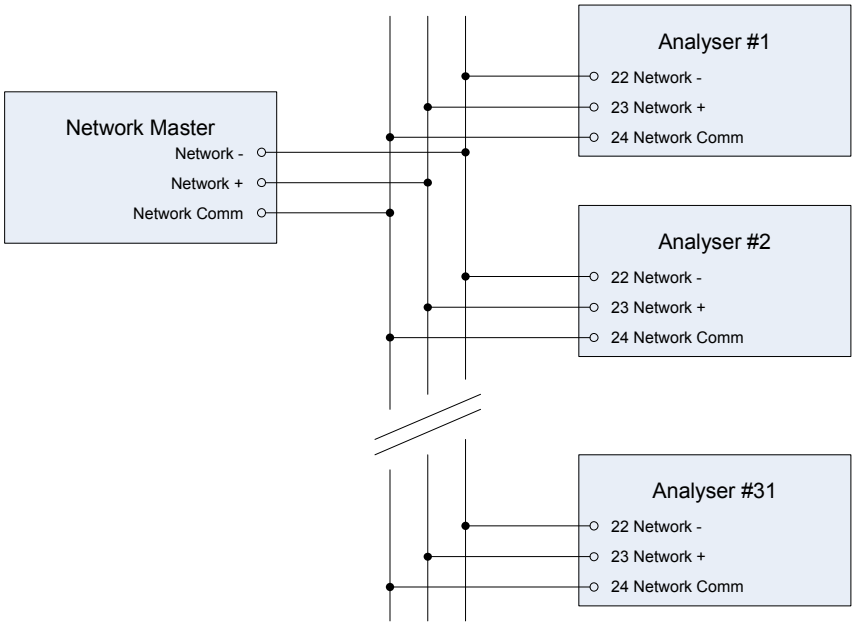
The analyser can be networked to other analysers and to a network master. The network uses the analyser RS485 port. Up to 31 analysers can be connected to the network, and can be interrogated by the Network Master.

NOTE: Hardware Protocol Selection
For the RS485 port on the analyser to operate, the link LK3 on the 1630-1 printed circuit board (mounted on the door of the analyser) must be set to the RS485 position. The LK3 is accessed by removing the cover from the door PCB. It is located at the bottom of the circuit board.
NOTE: Terminating Resistor
There is a terminating 100 ohm resistor fitted to the 1630-1 PCB. Link LK2, in the bottom left-hand corner of the PCB on the door, is used to connect the terminating resistor. Link LK2 must be removed on all analysers except the analyser on the end of the network line. If the network line from the analysers is taken from the middle of the analyser network string, a terminating resistor should be enabled with LK2 at each end if the network line.

The protocol of the network is –

```
Baud Rate   9600
Parity      none
Stop Bits   1
RS485       Half Duplex
Mode        RTU (binary mode)
```

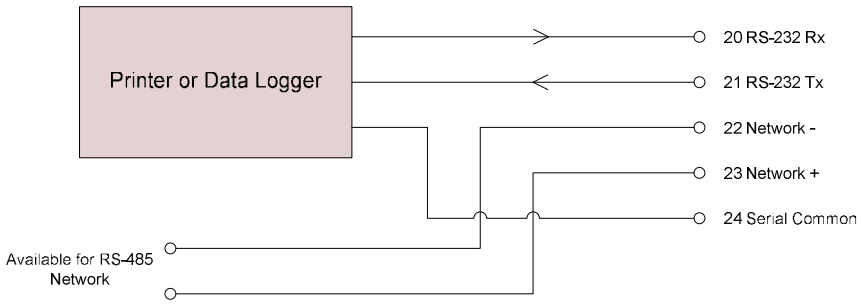
For more details see Section 1.14 and Appendix 3.



Network Connections

2.16 CONNECTING THE PRINTER

A printer with a serial port, or a data logger, or a computer terminal may be connected to RS 232-C or the network port. Data is logged out of the port as arranged in Set-up steps 58 and 59. The baud rate is selectable in set-up step 60. The RS-232 protocol for the serial port is eight data bits, one stop bit, no parity.



Serial Port Connections

COMMISSIONING

2.17 CONNECTING POWER

Before commissioning the probe, sensor or analyser, read the two **CAUTION** paragraphs at the front of this manual. Check that the mains supply voltage switch is set for the correct supply voltage.

2.18 COMMISSIONING - SET-UP MODE

Press the SET-UP button to select the 'SET-UP' mode. Most of the default settings of the functions will be correct, or will have been pre-set at the factory. Refer to Section 4.5 for more details.

Check the following set-up functions -

1	Number of sensors
2 to 6	Date /time
7 to 10	Reference voltages
11 & 12	Probe/sensor offset(s)
13 & 14	Output channel mode (4-20, 0-20)
15 & 20	Output calibration
24	Dryer type
29 & 30	Sensor type(s)
49 to 54	Auto gas calibration checking
551 to 57	Alarm set-up

2.19 COMMISSIONING - RUN MODE

When the analyser is turned on it will go to RUN mode. The SET-UP/RUN button will toggle between the two modes. The upper line of the display will now read '% Water Vapour'. If the probe or sensor temperature is not above 650 °C, a "Probe Low Temperature" message will be flashed on the lower line. The probe or sensor temperature can be checked on the lower line of the display.

2.20 BURNER BYPASS SWITCH

Heated probes and sensors should have their heater supply interlocked if the 1231 probe is to be installed into a dryer / oven which is directly heated with combustion flame, or if the probe heater is likely to be a source of ignition in the appliance (See CAUTION 1 at the front of this manual). If the combustion appliance is not running, then power will not be supplied to the heater. To commission an oxygen probe or sensor when the main burner is turned off, switch power off the analyser, remove the probe from the dryer or oven or the dryer or oven pipe connection from the sensor.

Re-apply power to the analyser, press the burner bypass switch into the 'DOWN' or 'ON' position. This will apply power to the probe or sensor heaters even when the plant is not running. The offset can now be set and calibration checked with appropriate calibration check gases (typically 2% oxygen in nitrogen).

Ensure that the BURNER BYPASS switch and the power are turned off before the probe or sensor is re-installed. An alarm will occur if the BURNER BYPASS switch is turned on (down) during normal operation.

2.21 CHECKING THE ALARMS

If any alarms are present the alarm LED will 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 3.

2.22 PROBE OR SENSOR CALIBRATION

The zirconia sensor provides an absolute measurement of oxygen partial pressure. There are no calibration adjustments, apart from 'SENSOR OFFSET', for the probe or RGS-01 sensor. The sensor EMF is either correct or a replacement is required. To check that the probe or sensor is functioning correctly, firstly check that the high impedance alarm is not activated ('Sensor Fail' alarm). The actual impedance can be displayed on the lower line. It should be less than 9,000Ω at 720°C.

Once it has been established that the impedance is normal, the offset may be set using the millivolt level marked on the oxygen probe or sensor. Refer to Section 4.5. The probe offset can be tested on site. A small flow of air must be admitted to both the 'REF' and 'CAL' ports when testing the probe or sensor offset. If the probe is in the process, the air must fully purge the probe sensor without interference from the process gas sample.

2.23 CALIBRATION GAS CHECK

If the installation has a filter purge facility, set this up first. Refer to the previous paragraph. Press the 'CAL 1' button while in 'SET-UP' mode to obtain a reasonable flow through the calibration check gas flow meter. If air is being used as a calibration check gas, use the air from the regulator for filter purge. Then, when setting up a gas for calibration checking, set the pressure from the calibration gas cylinder so that it is the same as the pressure set on the air regulator. Then the setting on the rotameter / flow regulator will be the same as that for the air flow. The flow requirements vary depending upon the length of the probe and whether or not the probe has a filter. Required flows normally range from 5 to 20 litres per minute. Too high a flow will cause cooling of the sensor, creating errors. If the flow is too low, gas equilibrium will not be achieved and the reading will fall short.

Air is not the best gas for calibration checking on a zirconia sensor. The output of a zirconia sensor with reference air is zero millivolts. It is better to choose a gas value which provides a reasonable output from the sensor and which is near to the process oxygen level. A cylinder with 8% oxygen in nitrogen is a commonly used calibration gas. The maximum pressure on the calibration check gas cylinder regulators is 100 kPa (15 psi).

OPERATOR FUNCTIONS

3

SECTION
NUMBER

OPERATOR FUNCTIONS (RUN MODE)

DISPLAY

TOP LINE

The top line of the display will read '% Water Vapour' after a COLD START.
The top line can be configured to also read -

Dew Point1	++
Absolute Humidity Kg/Kg 1	++
Mass Fraction g/Kg 1	++
Relative Humidity	++
Oxygen % 1	++

++ Note that these readings are of the zone 1 if 'Indirect, 2 Zone" is selected in set-up step 24.
This can be changed by selecting one of the above to be transmitted on channel 1 output, using set-up step 33.
Whichever parameter is chosen to be transmitted on channel 1 will also be displayed on the top line of the display.

The top line indicator (far right column) is also used to show running status of the analyser.
The symbols that will appear are –

'*' Flashes every 2 seconds, showing that the analyser is running normal calculations.
'Z' The analyser is calculating the impedance of the oxygen sensor(s)
'#' The analyser is doing an automatic calibration of the analog inputs
'+' The analyser is checking automatic timed events such as gas calibration and purge

BOTTOM LINE

The bottom line has selectable items available. See section 3.1 (below) and section 4.5, set-up step 40 (lower line display set up).

3.1 DISPLAY BUTTON

The upper line on the display will read '% Water Vapour'
The following are available for display on the lower line:-

1. Dew Point Temperature
2. Dryer Absolute Humidity Kg/Kg / Mass Fraction g/Kg

The diplay of absolute humidity / mass fraction is selectable using the extended setup options

3. Relative Humidity %
4. Probe 1 Oxygen %, as read by the 1231 probe
5. Probe 2 Oxygen %, as read by the 1234 probe, RGS / External Dry Oxygen %
6. Probe 1 EMF (millivolts)
7. Probe 2 EMF (millivolts)
8. Probe 1 temperature
9. Probe 2 temperature / Dryer Thermocouple temperature
10. Probe 1 Impedance.
11. Probe 2 impedance

The probe impedance will show 'n/a', until the probe reaches 800°C, approximately 5 minutes from switch on.

12. Ambient Temperature (Inside the analyser)
13. Water Vapour 2 %* / Ambient relative humidity
14. Dew Point 2 / Dryer temperature
15. Dryer Absolute Humidity 2 Kg/Kg* / Mass Fraction 2 g/Kg* / Reference Gas Temperature
16. Run hours

* These options become available when the analyser is set to 2 zones, see section 1.1

These variables can be displayed sequentially by pressing the 'DISPLAY' button. In addition to the above, the analyser will automatically display the following lower line messages:

17. "Probe Temp Low", when the probe is below 800°C
18. "Gas 1 ON" for Calibration check Gas
19. "Purging Probe"
20. "Probe Thermocouple Wrong Polarity"
21. "Aux Thermocouple Wrong Polarity"

Items 17, 18 and 19 will only display as they are occurring.

3.2 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.

3.3 ALARM SCHEDULE

3.3.1 SUMMARY OF ALARMS

1. 'Sensor 1 Hi Z'
Oxygen cell or electrode failure in the 1231 probe (high impedance); (inhibited under 650°C).

2. 'Sensor 2 Hi Z'
Oxygen cell or electrode failure in the 1234 RGS (high impedance); (inhibited under 650°C).

3. 'Heater 1 Fail'
The heater in the 1231 probe has failed to reach 650°C in 20 minutes.
In the first 20 minutes of power being applied to the heater after being switched on, this alarm will not occur, but a 'Probe Temperature' display will occur and one of the alarm relays may be activated if 'PROBE TEMP' was selected in Section 4.5.55 to 57.

4. 'Heater 2 Fail'
The heater in the 1234 RGS has failed to reach 650°C in 20 minutes.

5. 'Probe 1 TC Open'
Probe thermocouple in the 1231 probe is open circuit. The heater in heated probes will switch off.

6. 'Probe 2 TC Open'
Sensor thermocouple in the 1234 RGS is open circuit. The heater in heated probes will switch off.

7. 'Dryer TC Open'
Dryer (Aux) thermocouple is open circuit. If the thermocouple is not needed, place a short circuit between terminals 5 & 6.

8. 'Ref Pump Fail'
The reference air pump in the analyser has failed.

9. 'Prbe 1 Filter'
The filters are blocked on the dryer / oven in-situ probe.

10. 'ADC Warning'
The analog to digital converter has been found to fall outside the normal calibration specifications. The analyser will still be operating accurately because of the auto calibration system, but it is an abnormal condition.

11. 'ADC Cal Fail'

The analog to digital converter has been found to fall *well* outside the normal calibration specifications.

12. 'Mains Freq'
The sample of the mains frequency has failed.

13. 'DAC Warning'
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 2.21.

14. 'DAC Cal Fail'
The digital to analog and voltage isolator circuit has been found to fall *well* outside the normal calibration specifications. Default calibration constants have been used to keep the output channels working if at all possible. This check is only performed when the 'AUTO CAL' button is pressed.

15. 'Gas Cal Err'
Probe does not correctly calibrate to calibration check gas1.

16. 'Burner bypass'
The safety interlock relay has been bypassed by turning on the 'BURNER BYPASS' switch on the PSU / terminal printed circuit board. Refer to Section 2.20.

17. 'Watchdog Timer'
Microprocessor error. This alarm will not appear on the display. The common alarm relay will be forced open circuit. If the watchdog timer senses a malfunction in the microprocessor, it will attempt to reset the analyser every 2 seconds. After two resets the alarm relay contacts will go open circuit.

3.3.2 SUMMARY OF ALARMS - SELECTABLE ALARMS
There are three user configurable alarm relays. Any or all of the following functions can be selected for each relay.

18. 'Probe Temperature'
The probe temperature is under 650°C. The oxygen reading is therefore invalid. If the probe heater has been on for more than 20 minutes and the temperature is less than 650°C a 'heater fail' alarm will occur.
Note: The 'Probe Temp' relay function is used with unheated probes to indicate oxygen reading is invalid (the probe is below 650°C), 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.

19. 'Cal in Progress'
A calibration check is occurring, either manual (in RUN mode) or automatic.

20. Alarm Horn
This is not an alarm condition. If one of the three user configurable alarm relays have 'Alarm Horn' enabled, the relay will have closed contacts only when there is an unaccepted alarm on the analyser. Press the alarm button twice to accept any new alarm to cancel the horn relay.

3.3.3 ALARM RELAYS
The alarm relays are fail safe. That is, the contacts will be closed during normal operation, and will be open circuit if there is an alarm or if the power is removed from the analyser.

3.4 POWER LAMP
Illuminates when power is connected to the analyser. If the lamp is flashing, the watchdog timer is attempting to reset the microprocessor. Replace the 1630-1 microprocessor PCB.

3.5 BURNER BYPASS SWITCH
This switch is mounted on the terminal PCB near the POWER switch.
There are two ways of enabling the heaters and alarms for the probes and sensors: -
Use the safety interlock on terminals 18 & 19 (BURNER ON switch), or turn the BURNER BYPASS switch to the ON position.
While the BURNER BYPASS switch is on there will be an alarm, "Burner Bypass".
If it is not needed to have the analyser interlocked with the combustion appliance terminals 18 & 19 can be bridged together.

SETTING UP THE ANALYSER

4

SECTION
NUMBER

4.1 SET-UP MODE FUNCTIONS

1. Number of Sensors
2. Calender Year
3. Calender Month
4. Calender Day
5. Real Time Clock Hour
6. Real Time Clock Minutes
7. Reference Voltage #1
8. Reference Voltage #2
9. Reference Voltage #3
10. Reference Voltage #4
11. Sensor 1 Offset
12. Sensor 2 Offset
13. Output Channel Number 1, 4-20 or 0-20mA Mode
14. Output Channel Number 2, 4-20 or 0-20mA Mode
15. Output Channel Number 1 Calibration
16. Output Channel Number 1 Calibration, 4mA Trim
17. Output Channel Number 1 Calibration, 20mA Trim
18. Output Channel Number 2 Calibration
19. Output Channel Number 2 Calibration, 4mA Trim
20. Output Channel Number 2 Calibration, 20mA Trim
21. Service Record Year
22. Service Record Month
23. Service Record Day
24. Dryer Heating Type

See Section 1.1 for details on heater type selection menus

25. Dryer Combustion O_2 %
26. Sensor Reference Gas
27. Dry Oxygen Update Mode
28. Dry Oxygen Update Period
29. Dry Oxygen Update Duration
30. Dry Oxgeyn Update Freeze
31. Update Oxygen Deviation Trigger
32. Sensor 1 Type
33. Sensor 2 Type
34. Probe 1 Thermocouple Type
35. Probe 2 / Dryer Thermocouple Type
36. Analyser Output Channel 1 function
37. Analyser Zero Channel 1
38. Analyser Span Channel 1
39. Analyser Output Channel 2 function
40. Analyser Zero Channel 2
41. Analyser Span Channel 2
42. Centigrade/Fahrenheit Selection
43. Lower Line Display Functions
44. Dryer Pressure kPa / InWg / mmWg
45. Dryer Pressure Value
46. Water Vapour 1 % Trim Factor
47. Water Vapour 2 % Trim Factor
48. Alarm relay number 2 function select
49. Alarm relay number 3 function select
50. Alarm relay number 4 function select
51. Data Logger Data to Print
52. Data Logger Print Period
53. Data Logger Printer Baud Rate
54. MODBUS™ Address
55. Damping Factor

Note: If the Set-up menu does not match the functions in your instrument, check the software version number -

- On Page 2 of this manual and
- On the EPROM in the socket labelled IC12 (In the window, top centre of the door PCB)

4.2 SET-UP & RUN MODES

For the SET-UP mode keyboard to operate, press the SET-UP/RUN button. The SET-UP light will come on when the SET-UP mode has been entered.

SET-UP mode cannot be entered if the keyboard lock switch on the inside of the analyser is in the UP position. The keyboard lock switch can be found on the door PCB (1630-2), on the lock side, at the top. If access is attempted while the keyboard is locked, the message **'Illegal Access'** will be displayed.

The temperature of a heated probe may fall if the set-up mode is used for more than 2 minutes.

While the analyser is in SET-UP mode the outputs will be frozen. Key functionality while in setup mode is indicated on the keypad by the BLUE labels. If no buttons are pressed for 1 minute, the analyser will automatically revert to RUN mode.

If an auto-calibration check is scheduled to occur while the analyser is in SET-UP mode, it will be delayed until the analyser returnes to RUN mode.

To cancel an automatic calibration check cycle, press AUTO CAL button while in RUN mode.

4.3 FUNCTION SELECT

When returning to SET-UP mode, the analyser will return to the last selected set-up set-up function.

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

4.4 ENTER OPTION OR VALUE

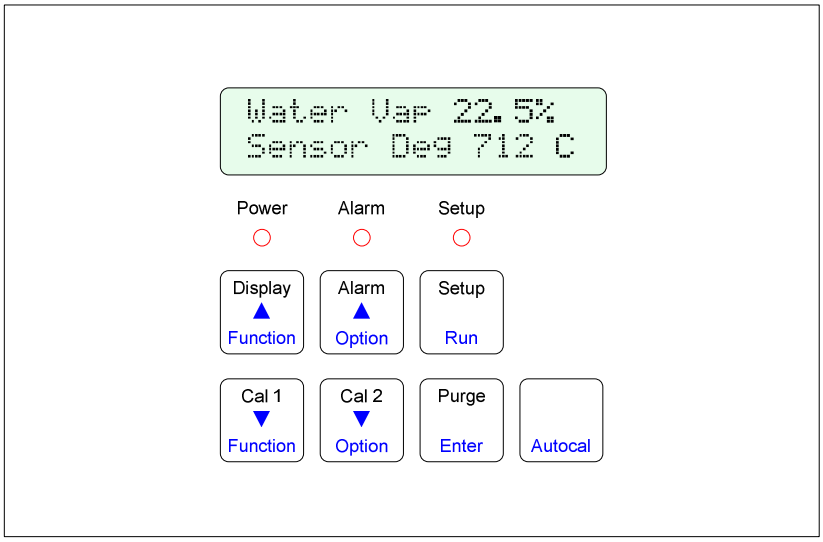
A. Options.

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' Set-up 40 and 58 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.



1635 Analyser Keyboard

4.5 SET-UP FUNCTION DETAILS

1. NUMBER OF SENSORS

Options

Select the number of oxygen probes or sensors being used.

1 Sensor *

2 Sensors

2. CALENDER YEAR

Options

Select the current year for the real time clock/calendar.

The cold start default sets the date and time to the software version date.

3. CALENDER MONTH

Options

Select the current month for the real time clock/calendar.

4. CALENDER DAY

Options

Select the current day for the real time clock/calendar.

5. REAL TIME CLOCK HOUR

Options

Select the current hour for the real time clock. (24 hour format)

6. REAL TIME CLOCK MINUTES

Options

Select the current minutes for the real time clock.

7. REFERENCE VOLTAGE # 1 (~27.5MV)

Options

Set the value of the reference voltage as read on a 3 1/2 digit multimeter (See SET-UP 10 for further details).

27.55 mV *

8. REFERENCE VOLTAGE # 2 (~19MV)

Options

Set the value of the reference voltage as read on a 3 1/2 digit multimeter (See SET-UP 10 for further details).
193.60 mV *

9. REFERENCE VOLTAGE # 3 (~1200MV)

Options

Set the value of the reference voltage as read on a 3 1/2 digit multimeter (See SET-UP 10 for further details).
1202.00 mV *

10. REFERENCE VOLTAGE # 4 (~2500MV)

Options

Set the value of the reference voltage as read on a 3 1/2 digit multimeter.
2479.00 mV *

Functions 7 to 10 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 5.1 in the 1635 manual.
Connect a 3 1/2 digit multimeter negative lead to the test point marked 'C' to the right of the PCB on the inside of the door (labelled 'REF VOLTS'). Measure the four voltages on the test point marked 1 to 4 with the positive lead. Refer to Figure 6.2 in the 1635 manual.
Enter the measured values in functions 7 to 10. Whenever new values are entered the D/A section should be re-calibrated, Refer to Section 1.10 in this manual.

11. SET PROBE 1 OR SENSOR 1 OFFSET

A new EMF offset must be entered whenever a new oxygen probe or sensor is installed to calibrate for any offset an individual probe or sensor may have. Each probe or sensor will have an offset value noted on a removable tag. Enter the 'SENSOR OFFSET' value with the same polarity,
eg. if offset value is -1.2 mV. enter -1.2 mV. The typical maximum is 2mV.

To check a probe or sensor offset on site, the probe or sensor must be sensing air with reference air and allowed to settle at the 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 check port can be provided by a reference air pump or similar.

For heated probes or sensors, if the dryer / oven is not operational and the probe or sensor heater is interlocked with the 'FUEL ON' signal, the 'BURNER BYPASS' switch should be set to 'ON' to power the probe or sensor heater after removing the probe from the dryer/oven.

CAUTION DANGER

Return the 'BURNER BYPASS' switch to normal before installing the probe in the dryer or oven.

Determine the probe or sensor offset in 'RUN' mode. Select 'Sensor EMF' on the lower line. With the probe in air and stabilised at the operating temperature for 30 minutes, read the 'Sensor EMF'. Switch back to 'SET-UP' mode and enter 'SENSOR OFFSET' of equal value and the same polarity. For example, if the measured 'SENSOR OFFSET' was -1.2 mV, enter -1.2 mV.

When reading the EMF offset, the dryer / oven pressure compensation must be considered. If the sensor #1 has been removed from the dryer / oven, set the dryer pressure compensation to 0 in set-up step 42.

12. SET PROBE 2 OR SENSOR 2 OFFSET

Follow the same procedure as the previous step.

13. OUTPUT CHANNEL #1, 0-20MA OR 4-20MA

The 2 output channels can be selected to drive a full scale of either 0 to 20 mA or 4 to 20 mA to represent the parameter that is selected in set-up functions 33.

Options:

1. 0-20 mA
2. 4-20 mA *

14. OUTPUT CHANNEL #2, 0-20MA OR 4-20MA

The 2 output channels can be selected to drive a full scale of either 0 to 20 mA or 4 to 20 mA to represent the parameter that is selected in set-up 36.

Options:

1. 0-20 mA
2. 4-20 mA *

15. 4-20 MA CHANNEL #1 CALIBRATION OPTIONS

Select the calibration method for the 4-20mA output channel #1.
The output channels can be either calibrated by simply pressing the 'AUTO CAL' button, or can be trimmed at both the 4mA and 20mA ends of the scale using an external multimeter.

Options:

1. Auto Calibration *
2. Manual Calibration
3. Set 4mA Trim
4. Set 20mA Trim

If 'AUTO CAL' is selected, the output channel is calibrated when 'Auto Cal' is initiated from the keyboard (See section 5.3).
If 'MAN CAL' is selected, it is necessary to trim both ends of the 4-20mA output range using the 4mA and 20mA options in this menu item. Selecting 'MAN CAL' inhibits the 'Auto Cal' process of this channel.
Always do the 4mA trim first, and then the 20mA trim. After trimming both ends of the scale, return the 'CALIBRATION OPTIONS' menu option back to 'MAN CAL' (not 'AUTO CAL'), or the calibration factors will be over written by the next 'AUTO CAL'.

For more details on calibrating the output channels, see section 5.3.

NOTE: The analyser will only stay in either '4mA TRIM' or '20mA TRIM' modes for 30 minutes before it automatically returns to 'MAN CAL'.

16. CALIBRATE 4MA, CHANNEL #1

This menu item only appears if 'Set 4mA Trim' is selected in Set-up 13.
Range: 0 to 25mA, Default is 4.00mA
For full details on the calibration of the 4-20mA output channels, see section 5.3.

17. CALIBRATE 20MA, CHANNEL #1

This menu item only appears if 'Set 20mA Trim' is selected in Set-up 13.
Range: 0 to 25mA, Default is 20.00mA

18. 4-20 MA CHANNEL #2 CALIBRATION OPTIONS

Select the calibration method for the 4-20mA output channel #1.
For more details, see Set-up 16 and section 4.5.

Options:

1. Auto Calibration *
2. Manual Calibration
3. Set 4mA Trim
4. Set 20mA Trim

19. CALIBRATE 4MA, CHANNEL #2

This menu item only appears if 'Set 4mA Trim' is selected in Set-up 16.
Range: 0 to 25mA, Default is 4.00mA
For full details on the calibration of the 4-20mA output channels, see section 5
.3.

20. CALIBRATE 20MA, CHANNEL #2

This menu item only appears if 'Set 20mA Trim' is selected in Set-up 16.
Range: 0 to 25mA, Default is 20.00mA

21. ENTER SERVICE YEAR

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

22. ENTER SERVICE MONTH

Enter the current 'MONTH'.

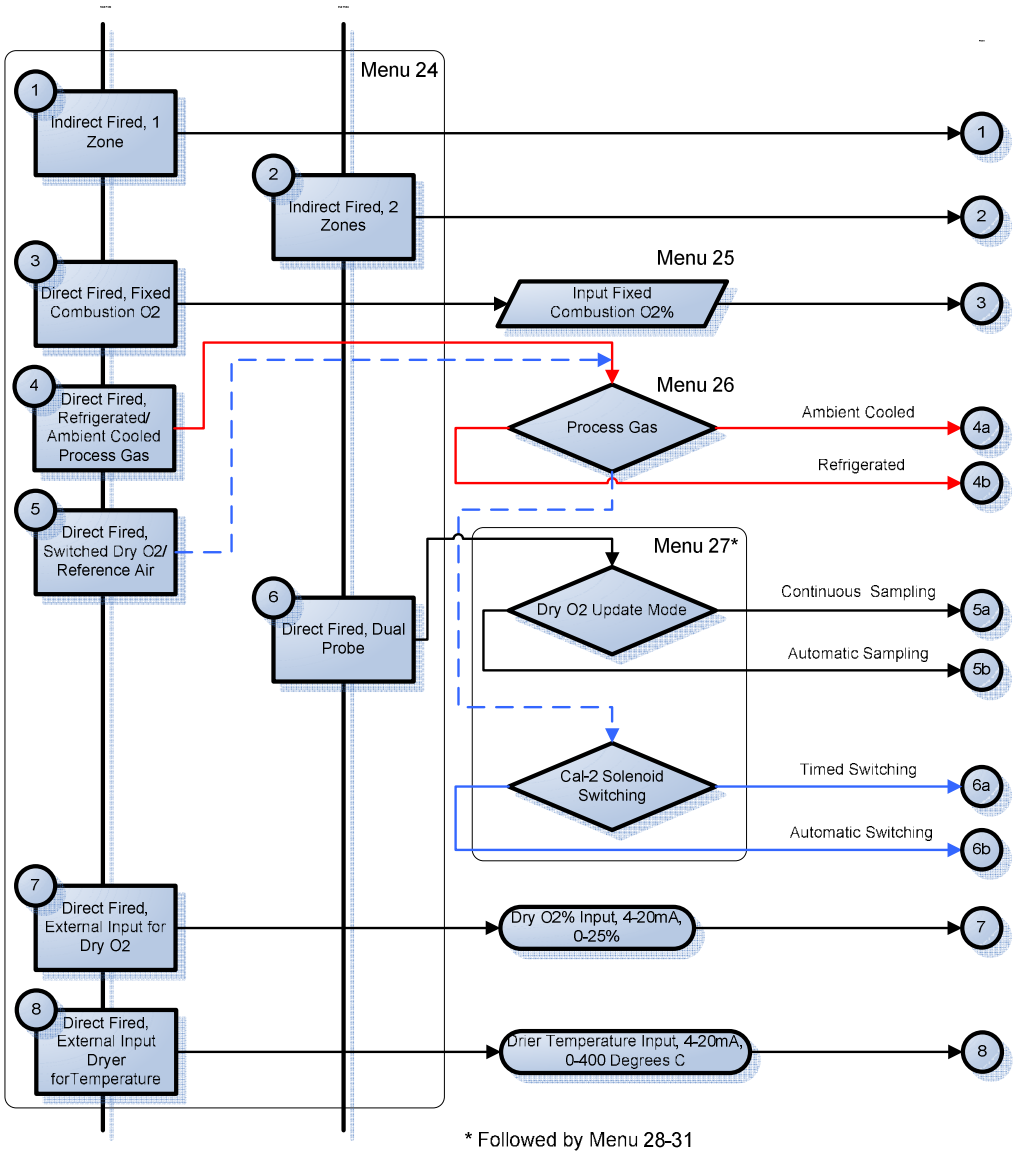
23. ENTER SERVICE DAY

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

24. DRYER HEATER TYPE (SEE SECTION 1.1 FOR MORE DETAILS)

Options:

1. Indirect Fired, 1 Zone, Single oxygen sensor (heat exchanger)
2. Indirect Fired, 2 Zone, Dual Oxygen Sensor
3. Direct Fired, Fixed Combustion O2
4. Direct Fired, Ambient Cooled/Refrigerated Process Gas
5. Direct Fired with RGS, Constant/Auto Sampling
6. Direct Fired, Switched Reference Dry Process/Reference Gas Timed/Auto Switching
7. Direct Fired, External Dry O_2 on 4-20mA Input
8. Direct Fired, External Dryer Temperature, 0-400°C



Set-Up Mode Selection Steps 24 to 31

For *Modes 4, 5 & 6* there are options that will affect the calculations and in some cases functions of these modes;
Mode 4 has the option of ambient cooled or refrigerated process gas as sensor reference and
Mode 5 has the option of continuous sampling or automatic sampling on the RGS-01 sensor. In addition to the selection of dry process gas in set-up 25,
Mode 6 must also configure the operation of a solenoid on terminals 45&46 (cal 2 sol) described in se-up 27.
Mode 7 requires an external input 4-20mA scaled 0-25% on the AUX INPUT, CN16.
Mode 8 requires an external input 4-20mA scaled 0-400°C on the AUX INPUT, CN16.

25. FIXED COMBUSTION O_2 %

In dryers where the reduction of oxygen due to the combustion is constant, it is not necessary to use an RGS-01, reference gas sensor. The value of oxygen to be entered is determined by removing any wet product from the dryer, and having the combustion at the normal level. Read the oxygen on the lower line of the display. Alternatively, a gravimetric test of the dryer of oven water vapour level will allow the operator to set the 'Combustion O_2' level so that the percent water vapour reading is correct. Ambient air must already have been supplied to the 'Ref. Air' input to the probe.

Range: 0.1 –21 % oxygen in 0.1 % steps.

26. DRY PROCESS GAS

For measurement of water vapour using a single probe system process gas must be dried and recirculated into the reference gas port of the probe. When wet high temperature process gas is cooled the absolute humidity of the resulting gas can be calculated and factored out of the equation making it possible to calculate water vapour. It is important to place an RGS thermocouple close to the reference port of the sensor if using the ambient cooled option.

Options:

1. Ambient Cooled *
2. Refrigerated Dry

27. DRY O_2 UPDATE MODE

Available only in *Mode 5 & 6*

Options:

1. Constant Sampling (*Mode 5*) / Timed Sampling (*Mode 6*) *
2. Automatic Sampling

This option controls timing of the sampling from the RGS-01 sensor in *Mode 4* and solenoid switching in *Mode 5*. For Auto sampling, the deviation trigger in set-up 31 should also be set.

Set-up 28 – 30 are only available in Mode 5 Timed & Mode 6

28. SAMPLE PERIOD

This is the period between sampling for *Mode 5 Timed* or switching of the solenoid on terminals 45 & 46 in *Mode 6*. In *Mode 5/6 Auto*, if a change in oxygen does not exceed the deviation trigger after this period of time then it will schedule a sample/switch to occur.

Range: 0.1 – 99.9 hours in 0.1 hour steps. Default is 2.4 hours.

29. SAMPLE DURATION

The duration of a triggered sample or switch before operation returns to its previous state.

Range: 5 – 300 minutes in 1 minute steps. Default is 20 minutes

30. SAMPLE FREEZE

The period of time after initiating the start of sampling in *Mode 4* or switching the solenoid on terminals 45&46 in *Mode 6* where the readings are frozen, allowing the system readings to stabalise before sampling. Depending on the response time of the system, this freeze time may vary and should be set accordingly.

Range: 1 – 60 minutes in 1 minute steps. Default is 2 minutes.

Set-up 31 only available in Mode 5 Auto & Mode 6 Auto

31. SAMPLE O_2 TRIGGER DEVIATION

This is the absolute value of the change that must occur in the wet oxygen reading from the oven or dryer to cause the system to register a change and start sampling the new dry oxygen value from the RGS-01 sensor in *Mode 5*, or to switch the relay inputting reference gas in *Mode 6* to measure water vapour.

Range: 0.1 – 21.0% oxygen in 0.1% steps. Default is 2.0%.

32. SENSOR 1 TYPE

Options

Model No. Enter the probe or sensor model number in use

1. 1231/1234 Heated Probe at 720°C
2. 1232 Unheated Probe

33. SENSOR 2 TYPE

Options

Model No.	Enter the probe or sensor model number in use	
1. 1231/1234		Heated Sensor at 720°C
2. 1232		Unheated Probe

34. SENSOR 1 THERMOCOUPLE TYPE

The probe can have a type K, T, or J thermocouple as a sensor temperature detector. A 1231 probe or a 1234 sensor will always have a K thermocouple, and a 1232 will usually have an R thermocouple.

Options

1. K	*	Check in the manual Section 1
2. R		for the probe or sensor model number.

35. SENSOR 2 / DRYER THERMOCOUPLE TYPE

The 1234 sensor will always have a K thermocouple. In single probe operation this will be dryer tc.

Options

1. K *
2. R
3. No T/C (only available for Dryer TC Option)

36. ANALYSER 4-20MA OUTPUT CHANNEL 1 FUNCTION

Select the type of output required.

Options:

1. Water Vapour 1 % *
2. Dew Point Temperature
3. Dryer Absolute Humidity Kg/Kg
4. Dryer Mass Fraction g/Kg
5. Dryer Relative Humidity (if available)
6. Sensor 1 Oxygen %
7. No Output

NOTE :

The item that is selected here also determines the function of the top line of the display. If no output is selected, top line will display water vapour %.

37. ANALYSER OUTPUT CHANNEL 1 ZERO

38. ANALYSER OUTPUT CHANNEL 1 FULL SCALE

	Zero	Full Scale	Minimum Range
Water Vapour %	0 - 80	20 - 100	20%
Dew Point ºC	-50 - +80	-30 - +100	20 ºC
Dew Point ºF	-50 - +200	0 - +250	50 ºF
Absolute Humidity Kg/Kg	0 - 18	2 - 20	2 Kg/Kg
Mass Fraction g/Kg	0 - 900	100 - 1000	100 g/Kg
Relative Humidity %	0 - 90	10 - 100	10%
Oxygen %	0 - 99	1 - 100	1%

Output Scaling Channel 1

39. ANALYSER 4-20MA OUTPUT CHANNEL 2 FUNCTION

Select the type of output required.

Options:

1. Sensor 1 Oxygen % *
2. Sensor 2 Oxygen %
3. Dryer (Aux) Temperature (not available if 2 probes are selected in set-up 1)
4. Water Vapour 2 %[1]
5. Dew Point Temperature 2[1]
6. Dryer Absolute Humidity Kg/Kg[1]
7. Dryer Mass Fraction g/Kg[1]
8. No Output

40. ANALYSER OUTPUT CHANNEL 2 ZERO

41. ANALYSER OUTPUT CHANNEL 2 FULL SCALE

	Zero	Full Scale	Minimum Range
Sensor 1 Oxygen %	0	1 - 100	1%
Sensor 2 Oxygen %	0	1 - 100	1%
Dryer (Aux) Temperature	0 - 1000	100 - 1300	100 ºC/ºF
RGS Temperature	0 - 300	100 - 400	100 ºC/ºF
Water Vapour 2 %	0 - 80	20 - 100	20%
Dew Point 2 ºC	-50 - +80	-30 - +100	20 ºC
Dew Point 2 ºF	-50 - +200	0 - +250	50 ºF
Dryer Abs Humidity 2 Kg/Kg	0 - 18	2 - 20	2 Kg/Kg
Dryer Mass Fraction 2 g/Kg	0 - 900	100 - 1000	100 g/Kg

Output Scaling Channel 2

42. CENTIGRADE / FAHREHHEIT SELECTION

Select whether displays and outputs are to be in degrees Celsius or degrees Fahrenheit

Options:

1. Celsius (Centigrade) *
2. Fahrenheit

43. LOWER LINE DISPLAY FUNCTIONS

In the run mode the upper line on the LCD display will always read whatever is selected in set-up step 33. 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. Dew Point Temperature 1
2. Dryer 1 Absolute Humidity Kg/Kg / Mass Fraction g/Kg 1
3. Dryer 1 Relative Humidity % (if Dryer TC is present)
4. Sensor 1 Oxygen
5. Sensor 2 Oxygen / External Dry Oxygen
6. Sensor 1 EMF
7. Sensor 2 EMF
8. Sensor 1 Temperature
9. Sensor 2 Temperature / Dryer TC Temperature
10. Sensor 1 Impedance
11. Sensor 2 Impedance
12. Ambient Temperature
13. Ambient Relative Humidity %[2] / Water Vapour 2 %[1]
14. Dryer (Aux) Temperature / Dew Point Temperature 2[1]
15. Dryer 2 Absolute Humidity Kg/Kg / Mass Fraction g/Kg[1] / RGS Temperature / External Dry O2
16. Run Hours since Last Service

---

[1] Only available in 2 zone mode, see section 1.1

[2] A Dryer / Oven type 'K' thermocouple must be connected to Terminals 5 & 6 to obtain readings

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.

44. DRYER OR OVEN PRESSURE UNITS

Enter dryer/oven pressure, e.g. 3 mm W.G.
If the pressure at the point where the probe #1 is inserted is below atmospheric pressure, the oxygen will appear to the probe as lower than it really is. Enter the correct pressure in this menu item and the next item and the analyser will show the correct oxygen percentage.
Options:
mm W.G. *
Kilopascals
Inches W.G.

45. DRYER OF OVEN PRESSURE VALUE

Enter dryer/oven pressure e.g. 3 mm WG. The default setting is 0
Limits :
-200 to +200 mm W.G.
-9 to +9 inches W.G.
-200 to +200 kpa.

46. WATER VAPOUR 1 TRIM FACTOR

Independent verification of the water vapour level in your process can be obtained from testing agencies. They will use a sampling method called a gravimetric test. If there is a difference between the gravimetric test results and the display of water vapour on the 1635 analyser, this factor can be used to fine-tune the reading on the analyser display.
If the display units of the water content of the process has been chosen to be Dew Point, g/Kg or relative humidity, the trim factor will still operate numerically on the water vapour, but will be reflected in the displayed or transmitted units.
Range: 90.0 –110.0 % in 0.1 % steps.

47. WATER VAPOUR 2 TRIM FACTOR

This function is the same as set up step 21, but for the second water vapour zone, if "Indirect, 2 Zone" is selected in set up step 18.

48. ALARM RELAY #2

Any or all of the following alarm functions may be used to activate the alarm relay. They may be selected or de-selected using the 'ENTER' buttons as in set-up step 40.
Options :
1. Probe or sensor under temperature
2. Calibration check in progress
3. Alarm horn function (Only available for Alarm 4)

49. ALARM RELAY #3

Alarm relay #3 has the same functions available as alarm relay #2. See SET-UP 48

50. ALARM RELAY #4

Alarm relay #4 has the same functions available as alarm relay #2. See SET-UP 48
If 'Horn' is selected it will override any other selections. A relay selected as a 'Horn' driver will have the relay contacts open circuit if there is an accepted alarm, and closed when a new alarm occurs.

51. DATA TO PRINT / LOG

Any or all of the following values may be printed on a printer or computer connected to port 2. They may be selected or de-selected using the 'ENTER' buttons as in set-up step 40. The log period follows in set-up steps 59. RS to 232C protocol is :

Data word length	8
Stop bits	1
Parity	None

Oxygen is always printed, plus any of the following

Options:
1. Dew Point Temperature 1
2. Dryer Absolute Humidity 1 Kg/Kg / Mass Fraction 1 g/Kg
3. Dryer Relative Humidity 1 % (if Dryer TC is present)
4. Sensor 1 Oxygen
5. Sensor 2 Oxygen
6. Sensor 1 EMF
7. Sensor 2 EMF
8. Sensor 1 Temperature
9. Sensor 2 Temperature / Dryer TC Temperature
10. Sensor 1 Impedance
11. Sensor 2 Impedance
12. Ambient Temperature
13. Ambient Relative Humidity % / Water Vapour % 2[3]
14. Dryer (Aux) Temperature / Dew Point Temperature 2[3]
15. Dryer 2 Absolute Humidity Kg/Kg / Mass Fraction g/Kg[3] / RGS Temperature / External Dry O2
16. Run Hours since Last Service

52. PRINT LOG PERIOD
Select the time interval between data print outs on the printer.

Range:
1 to 2000 minutes

53. PRINTER BAUD RATE
Select the correct BAUD rate for data to be transmitted out of the port to the printer.
Options:
300
1200
2400
4800
9600 *

54. MODBUS™ ADDRESS
This function is used when networking one or more analyser back to a master computer or data acquisition system. For more details on the functions of the MODBUS see Section 2.15, and Appendix 3.
The valid range of MODBUS addresses is from 1 to 31. Any analyser with zero selected as the MODBUS address will have the MODBUS disabled, and the data log function enabled.
For the connection details, see Section 2.15.
NOTE: If the MODBUS address is changed, the analyser must be turned off and back on for the address change to take effect.
Range:
0-31, where 0 = MODBUS OFF, Default setting is MODBUS Off.

55. DAMPING FACTOR
Each time a new reading is read from the oxygen probe or sensor, 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 with this function.

A value of five for example, means that the new reading from the probe or sensor 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 or sensor will be sent to the display unaltered. The damping factor is used for humidity measurements in both zones is “Indirect, 2 Zone” is selected in set up step 18.
Range: 1 to 20

[3] Only available in 2 zone mode, see section 1.1

MAINTENANCE

5

SECTION
NUMBER

ANALYSER MAINTENANCE

5.1 COLD START

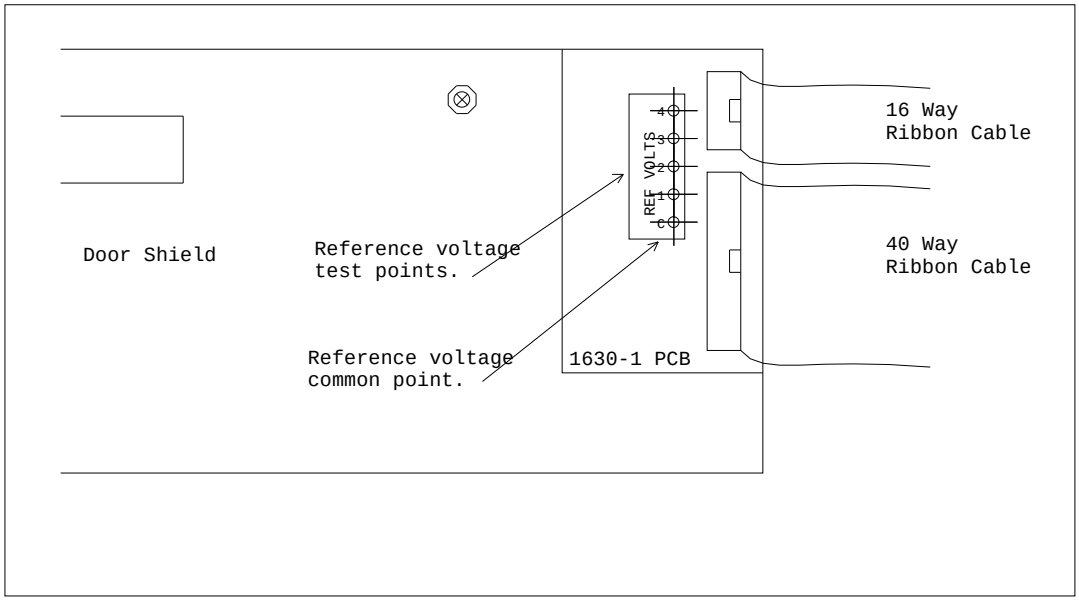
A 'COLD START' will reset all 'Set-up' mode entries to their factory default values. 'COLD START' will show on the display for a second prior to a microprocessor initialising sequence, which takes about seven seconds. After a 'COLD START', it is necessary to set all new variables in the 'SET-UP' mode, including calibration voltages and time and date.

To initiate a 'COLD START' -
Turn the mains power off
Remove the 'COLD START LINK' (this is located on the door PCB, next to the keyboard lock switch, behind the shield)
Turn the mains power on. The message "Cold Start..." will be displayed on the lower line of the display.
Leave the LINK off until the message "Replace c/s Link" is displayed. Replace the LINK.
The date and version number of the software will be displayed.

A 'WARM START', which is performed by applying power with the COLD START LINK in its place, will retain all data previously entered in the Set-up mode.

5.2 A/D CALIBRATION

The analyser maintains its accuracy over a long time by continuously checking itself against internal stabilised references. The only calibration required is to set the actual values of these references into battery backed memory. The analyser will read these references every minute and update its zero and span correction factors. See Section 4.5, 7 to 10.
These references should be checked every 12 months. An AUTOCAL of the analog output section should always be performed if these references are altered. See Section 5.3.



Location of Calibration Test Points

5.3 D/A (4-20mA Output Channels) CALIBRATION

The calibration can be done using the 'Auto Cal' or 'Manual Cal'.

Auto Cal

The 'Auto Cal' mode is selected in set-up 15 (and 18 for channel 2).

The analyser will automatically divert the output back to the input, measure the offset and span, and record the calibration factors for each channel.

If either of the channels are selected to be calibrated manually, the factors will not be changed by an 'Auto Cal'.

Manual Cal

The 'Manual Cal' mode is selected in set-up 15 (and 18).

Set the 4mA calibration first and then the 20mA calibration.

1. Select 'Set 4mA Trim' in set-up 15 (or 18).
2. Return to RUN mode.
3. Measure the output on the channel to be calibrated with a digital multimeter. If the current is not exactly 4.00mA, return to set-up mode and change the 4mA calibration factor in set-up 16 (or 19).
4. Re-measure the current while back in RUN mode until the current is within 3.9 to 4.1mA.
5. Return to set-up mode and select 'Manual Cal' in set-up 15 (or 18).

Set the 20mA calibration factor.

6. Select 'Set 20mA Trim' in set-up 15 (or 18).
7. Return to RUN mode.
8. Measure the output on the channel to be calibrated with a digital multimeter. If the current is not exactly 20.00mA, return to set-up mode and change the 20mA calibration factor in set-up 17 (or 20).
9. Re-measure the current while back in RUN mode until the current is within 19.9 to 20.1mA.
10. Return to set-up mode and select 'Manual Cal' in set-up 15 (or 18).

This calibration is now saved in battery backed memory until

The factors are changed in the manual calibration

The analyser is forced into a COLD-START (see section 6.1)

The calibration mode in set-up 15 (or 18) is changed to Auto Cal and an Auto Cal is initiated.

NOTE: The 4mA or the 20mA trim mode will only be held on the output channels for 30 minutes before automatically returning to 'Manual Cal' mode in set-up 15 (or 18).

5.4 Pump Replacement

The reference air pump is mounted on the 1630-2 PCB in the base of the analyser. The operation of the pump is monitored by the analyser and a "Pump Fail" alarm will be shown if a fault occurs.

To replace the pump loosen the top pump retaining screw (do not remove), remove the bottom pump retaining screw, unplug it's electrical connector, and remove the pump.

5.5 Back-Up Battery Replacement

The back-up battery is contained within the battery-like real time clock / memory module, plugged into socket M2. It is rated for an average service life of greater than ten years. The module is not re-chargeable and should be replaced every three years with a stored analysers with power off or every eight years with a analysers which have had the power on. After replacing the battery, re-enter all set-up mode functions.

5.6 Electronic Repairs

Electronic schematics are included in Appendix 5. A competent electronic technician could perform troubleshooting 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 test EPROM firmware package and probe or sensor input simulator is also available.

PROBE & SENSOR MAINTENANCE

5.7 INSTALLING A NEW PROBE OR SENSOR

Whenever a new oxygen probe or sensor is installed, the millivolt offset(s) value should be entered. To achieve this, refer to Section 4.5, 11 & 12.

The probe or sensor offset is noted on a tag or label attached to probe or sensor. To check an offset on site, the probe or sensor must be sensing air with reference air connected and allowed to settle at the 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 check port can be provided by a reference air pump or similar. If a probe is in a process with the process running, the air purge on the sensing side of the sensor will only be successful if the probe has a filter or small sensing hole. Probes with open sensing ends or with large sensing holes allow the process gas to mix with the calibration gas, giving a false reading.

For heated probes or sensors, if the combustion appliance is not operational and the probe or sensor heater is interlocked with the 'FUEL ON' signal, the 'HEATER LOCKOUT BYPASS' switch should be set to 'BYPASS' to power the probe or sensor heater after removing the probe from the flue. For unheated probes, the sensing tip must be raised to at least 700°C with a portable furnace.

CAUTION DANGER
Return the 'HEATER LOCKOUT BYPASS' switch to normal before installing the probe or sensor in the dryer or oven.

5.8 TEST EQUIPMENT REQUIRED

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

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 or sensor to heat up after switch on.
An instrument to measure probe or 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 probe or sensor thermocouple type is also useful, although not necessary.

A reference air pump is required and a cylinder of calibration check gas e.g. 8 % 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 check 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 720 °C is required. The furnace should have a uniform temperature for about 50mm either side of the sensor's tip.

HEATED PROBES OR SENSORS

If a 1635 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 or sensor temperature to 720°C approximately.

5.9 TESTING A PROBE OR SENSOR

With the probe or sensor heated to approximately 720 °C, either from a small test furnace or its own internal heater, connect a digital multimeter to the probe or sensor electrode conductors. Connect the multimeter positive to the internal electrode conductor. Connect reference air to and apply a gentle purge of air to the probe calibration check port. Reference air flow should be the smallest flow available (less than 50 cc per minute). The multimeter should read zero millivolts $\pm$ 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. 1234 sensors do not require reference air but a gentle flow of air should be admitted into the sample connection.

To test the source impedance, set the multimeter to read ohms and take a measurement, within a couple of seconds, of the sensor impendence. 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 10kΩ, then the probe or sensor needs to be replaced. The probe or sensor must be at 720 °C 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.

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

As an alternative, using the reference air port, the calibration check gas can be inserted into the inside of a probe sensor. This requires a lower flow rate, and thus lower usage of calibration check gas. The flow rate should be similar to that of the reference air, which should be removed for internal calibration check. The probe or sensor 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 gas stream. In this case the impedance may be OK but the output incorrect. This phenomenon is rare.

5.11 PROBE OR SENSOR THERMOCOUPLE

Although some unheated probes are specified without a thermocouple, most probes, both heated and unheated, have an integral thermocouple which is fitted in to the four bore insulator. The analyser has an alarm function which will advise the operator of an open circuit thermocouple, however bench testing can be performed by simply measuring the thermocouple continuity.

5.12 HEATER FAILURE

For heated probe or sensors, a heater failure will cause a ‘Probe Temp’ or ‘HEATER FAILURE’ alarm. Heaters can be tested with a continuity test. The heater impedance should be approximately 110Ω. Should the heater be open or short circuited, replace the probe or sensor.

5.13 FILTER BLOCKAGE

For oxygen probes with filters in installations with entrained solids in the gas, it is sometimes necessary to replace the filter. Filters are normally cleared with back purging. However particles can ultimately completely block a filter necessitating filter replacement. A new probe filter can be fitted.

APPENDICES

1. PROBE EMF TABLES
2. CIRCUIT SCHEMATIC'S
3. MODBUS™ REGISTER MAP & APPLICATION NOTES

APPENDIX 1

PROBE EMF TABLES

ZIRCONIA OXYGEN SENSOR OUTPUT (mV)
PROBE TYPE 1231, SENSOR TYPE 1234

% OXYGEN	mV at 720° C
21.0	0.00
20.5	0.46
20.0	0.99
19.5	1.53
19.0	2.09
18.5	2.66
18.0	3.25
17.5	3.85
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
13.0	10.21
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

'K' TC mV **29.212 at 720°C**

These tables are based on the Nernst equation:

Sensor e.m.f. = 0.02154 x T x 1n x 20.95 / % oxygen, where T = ° K (° C + 273), e.m.f. is in mV's

APPENDIX 2

CIRCUIT SCHEMATICS

APPENDIX 3

Modbus™ Register Map and Application Notes

Modbus Functions Supported are:-

```
ReadHolding  Register  Function 3
WriteHolding Register  Function 6  ( for allowable addresses only )
```

Introduction.

The 1635 Analyser implements a subset of the modbus slave protocol, it is intended to work in conjunction with a modbus master.

This is accomplished by setting the Modbus address to some non-zero value in the range 1-31, setting the jumper positions to select the RS485 half duplex configuration, and re-starting the analyser.

The master must be configured as follows.

Baud Rate	9600
Parity	none
Stop Bits	1
RS485	Half Duplex
Mode	RTU (binary mode)

A typical transaction would be to read the current value of a variable from the analyser.
The master send a ReadHoldingRegister packet, with the appropriate address and the analyser responds with data at that address.

The Register Addresses are as follows, to convert to Schneider addresses for earlier model PLC's address space, add 40001 to each address.
For later model PLC's with linear address space the address co-responds directly to %MW XXXX address.

For Example, to read dryer absolute humidity 1 -
Read %MW2064 which is equivalent to holding register 42065 = 40001 + 2064

Some data is 32 bit data (double) which requires some care to ensure that the word order is correctly interpreted.
For Example, OXYGEN32, (dual probe) which is at address 2052 is interpreted as follows.

2052 contains the high 16 bits for probe 1 oxygen
2053 contains the low 16 bits for probe 1 oxygen

2054 contains the high 16 bits for probe 2 oxygen
2055 contains the low 16 bits for probe 2 oxygen

Configuration and Setup Addresses

Holding Reg.	Function	Description
716	Probe #1 offset	10 = 1.0mV
717	Probe #2 offset	10 = 1.0mV

Calibration checking gas related variables

2048	Probe #1 EMF	100,000 = 100.000 mV
2050	Probe #2 EMF	100,000 = 100.000 mV
2052	Probe #1 OXYGEN	100,000,000 = 100.0%
2054	Probe #2 OXYGEN	100,000,000 = 100.0%
2056	Water Vapour #1 %	100,000 = 100.0%
2058	Water Vapour #2 %	100,000 = 100.0%
2060	Dew Point 1 degC	1,000 = 100.0 ºC
2062	Dew Point 2 degC	1,000 = 100.0 ºC
2064	Dryer Absolute Humidity 1	200,000 = 20.0 Kg/Kg
2066	Dryer Absolute Humidity 2	200,000 = 20.0 Kg/Kg
2068	Mass Fraction 1	100,000 = 1000.0 g/Kg
2070	Mass Fraction 2	100,000 = 1000.0 g/Kg
2072	Probe #1 Impedance	1,000 = 1 kΩ
2074	Probe #2 Impedance	1,000 = 1 kΩ
2076	Probe #1 TC mV	100,000 = 100.000 mV
2078	Probe #2 TC mV	100,000 = 100.000 mV
2080	Probe #1 temperature	7,000 = 700.0 ºC
2082	Probe #2 temperature	7,000 = 700.0 ºC
2088	ALRM-ARRAY	Array of Current Alarm Status. See below
2104	ALRM-TIMES	Array of Timestamp of Alarms

Alarm Array:

There are 30 alarms and states in the 1635 analyser which can be individually read from the alarm array. Each alarm uses a single byte, so in reading the alarm array each 16-bit holding register contains two alarm states.

1	Sensor 1 High Impedance	16	ADC Calibration Fail
2	Heater 1 Fail	17	Burner Bypass Switch On
3	Probe 1 TC Open Circuit	18	Gas 2 Calibration Error
4	Probe 1 Filter Blocked	19	RGS TC Open Circuit
5	Battery Backed RAM Fail	20	Dryer TC Open Circuit
6	Reference Air Pump Fail	21	Probe Cal Error
7	ADC Warning	22	4-20mA Output 1 Fail
8	Mains Frequency Error	23	Sensor 2 High Impedance
9	Oxygen % Low	24	Probe 2 Heater Fail
10	4-20mA Output 2 Fail	25	Probe Temp
11	Oxygen % Very Low	26	Probe 2 TC Open Circuit
12	Oxygen % High	27	Probe Purge in Progress
13	Heater SSR Relay Fail	28	Calibration in Progress
14	Oxygen% Deviation	29	Probe Temperature High
15	Gas 1 Calibration Error	30	Alarm Horn

In each alarm byte is stored a number 0-4 specifying the alarm state:

0,1 Not Active
2 Active
3 Cleared
4 Self-Cleared

The not active state represented by both 0 & 1 should be treated the same.

Declaration of Conformity

Application of Council Directives:

89/336/EEC (92/31/EEC)
72/23/EEC

Standards to which conformity is declared:

EN550011.1:1995 (ISM, Group 1, Class B)
EN55014:1995 (Clause 4.2)
EN50082-2 (Industrial)
EN61010-1
AS61000.4.5:1999
IEC-68-2-2
IEC-68-2-3
AS1099.2.6

Manufacturer's name: **Novatech Controls Pty Ltd**
MANUFACTURER'S ADDRESS: 309 RESERVE ROAD
Cheltenham VIC 3192
AUSTRALIA

Type of equipment: Oxygen Transmitter
Equipment Class: ISM, Group 1, Class B
MODEL NUMBER: 1630 SERIES TRANSMITTER
1231 Oxygen Probe
1234 Oxygen Sensor

I hereby declare that the equipment specified herein conforms to the above directive(s) and standards(s).

Full Name: **Fraser Chapman**
Position: **R & D Manager**