NOVATECH

RELATIVE HUMIDITY TRANSMITTER MODEL 1535

RELATIVE HUMIDITY % WATER VAPOUR DEW POINT g/kg

CONTENTS

NOTE: This manual includes software modifications up to -
Version 027, 2nd September 1994.

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 Enquires. Novatech Controls welcome comments and suggestions relating to the product and this manual.

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USING THIS MANUAL

The Novatech 1535 Humidity 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 transmitter.

CAUTION FOR DIRECT FIRED DRYERS

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 transmitter 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 1535 transmitter with its heated probe may be unsuitable for your application.

Also read the probe heater interlock caution in section 5.5.10.

CAUTION
2

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

DESCRIPTION & SPECIFICATIONS 1

SECTION
NUMBER

NOVATECH 1535 HIGH TEMPERATURE, PERCENT WATER VAPOUR TRANSMITTER

1.1 DESCRIPTION

The Novatech 1535 Humidity Transmitter is designed for measuring humidity in hot air drying applications, where the drying temperature is above the maximum limit of relative humidity sensors (typically 100°C). The transmitter signal can be used with a conventional controller to improve the efficiency of industrial drying applications, as well as to optimise the quality of the product being dried. Industrial baking can particularly take advantage of measurement and control of the moisture in the oven to produce consistent browning of the product.

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.

In the case of indirectly heated dryers, air is drawn from the atmosphere as a reference. To improve the accuracy, the humidity of this air can be measured and the ambient water vapour pressure is entered into the calculations.

Where the dryers use direct fired combustion, the drier atmosphere can be used as a reference after removing some or all of the water vapours. In this case, the reference gas oxygen level is the same as the process except that it has been dried. If the drier has a fixed combustion system (fixed firing rate), where the reduction of oxygen due to combustion is constant, then a reference gas drier system may not be necessary to condition reference gas from within the drier. The accuracy of the transmitter is further improved if the combustion gas is a small percentage of the recirculating drier air.

WHAT MEASUREMENT TO USE

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

Relative Humidity Percent
Water Vapour Percent
g/Kg
Dew Point degrees Centigrade

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

FEATURES

- The probe can be operated in drier air temperatures up to 600°C
- The output signal is continuous and proportional to the percentage volume of water vapour
- 4 different engineering units Selectable from the keyboard -
  - Water vapour %
  - Relative Humidity %
  - g/Kg
  - Dew point
- Fast response (less than 10 seconds)
- Long- term continuous and reliable measurement

1.2 SPECIFICATIONS – TRANSMITTER

Model	1535
Range	Keyboard setable in the range of :- 0–100% volume of water vapour 0-100% Relative humidity (RH) 0-10,000 g/Kg -50-100 °C Dew point with adjustable span and zero.
Output	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 3 seconds.

Accuracy

i) In Indirectly Heated Dryers

a) With an ambient RH sensor connected: ± 2% RH

b) With no ambient RH sensor connected: ± 3% RH

ii) In Directly Fired Dryers

a) With dried reference gas from the process: ± 2% RH

b) With the mean process oxygen entered and an actual variation of 2% oxygen:

± 3% RH with ambient RH sensor connected.

± 4% RH with no ambient RH sensor connected.

Reproduce ability	±1% RH
Ambient RH sensor	Lee Integer CH15, 0 –1 VDC = 0 –100% RH (optional if indirectly heated drier or directly heated drier with reference gas from ambient air)
Power Supply	110/240 VAC 50/60 Hz

SPECIFICATIONS – PROBE

Model	1231
Length	140–1000 mm.
Temperature Range	100–600°C
Process Connection	1.5" BSPT.
Thermocouple	Type K (for probe heater control. Use a separate thermocouple for drier temperature measurement).
Response Time	For indirectly heated & directly fired appliances with fixed oxygen level - (a) with filter on probe 15 seconds (b) with no filter on probe 4 seconds For directly fired appliances with reference gas cooler (A filter is required on the probe for this application). 15 seconds

Typically less than 4 seconds

Operating Temperature	720°C with integral heater

Heater Voltage	110 VAC, 1.2 amps
Head Temperature	150°C max.
Reference Gas Connection	1/8" NPTF.
Probe Cable	Supplied with weatherproof connector to specified length, maximum 100 metres
Probe Life	Typically 1 –2 years. Low cost refurbishing service available.
Reference Gas Fail Alarm	Piston actuated flow switch type: LPH–125–OA
Reference Gas Flow	Less than 50 c.c./min approx.

SPECIFICATIONS – REFERENCE GAS COOLER/DRIER

Ambient air cooled -

Model	**RGC-01**
Size	300 W x 500 H x 135 D
Weight	7.5 Kg
Maximum ambient air temperature	45°C
Minimum process moisture content	200 g/Kg
Minium process gas temperature	80°C

SPECIFICATIONS – AMBIENT HUMIDITY PROBE

(Required for indirectly heated dryers only, for improved accuracy)

Model	CH15
Humidity Range	0–100% RH
Temperature	–20 to +90°C
Output	0–1 VDC , linearly proportional to 0–100% RH

SPECIFICATIONS – REFERENCE GAS & FILTER PURGE FLOW SWITCHES

Model	
Reference Gas	LPH–125–0 *
Filter Purge	LPH–125–7 *
Range	
Reference Gas	50 c.c./minute
Filter Purge	2500 c.c./minute
Dimensions	50 mm high by 14 mm wide
Type	Magnetic piston & reed switch, 1 AMP.
Mounting	Vertical only

* Suffix ‘A’ denotes acrylic body with flying leads. (Not suitable for outdoor installation) eg. LPH–125-0A
Suffix ‘B’ denotes brass body with conduit thread entry for leads. Suitable for outdoor installation.

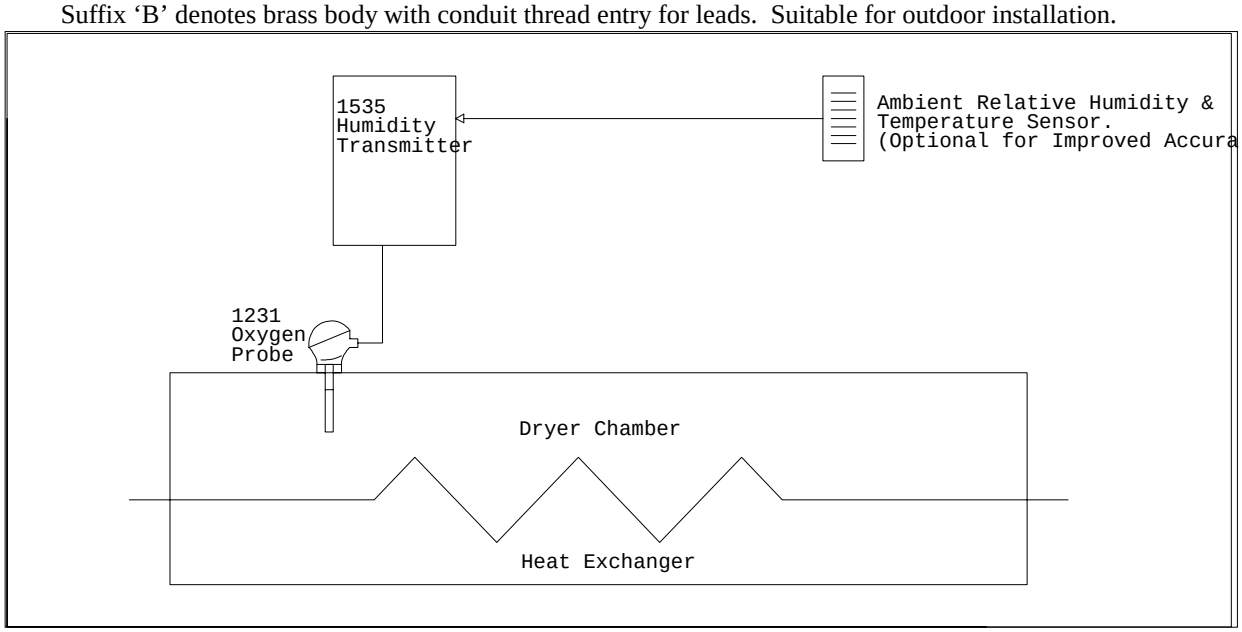


Figure 1.1 Indirectly Heated Drier Humidity Measurement

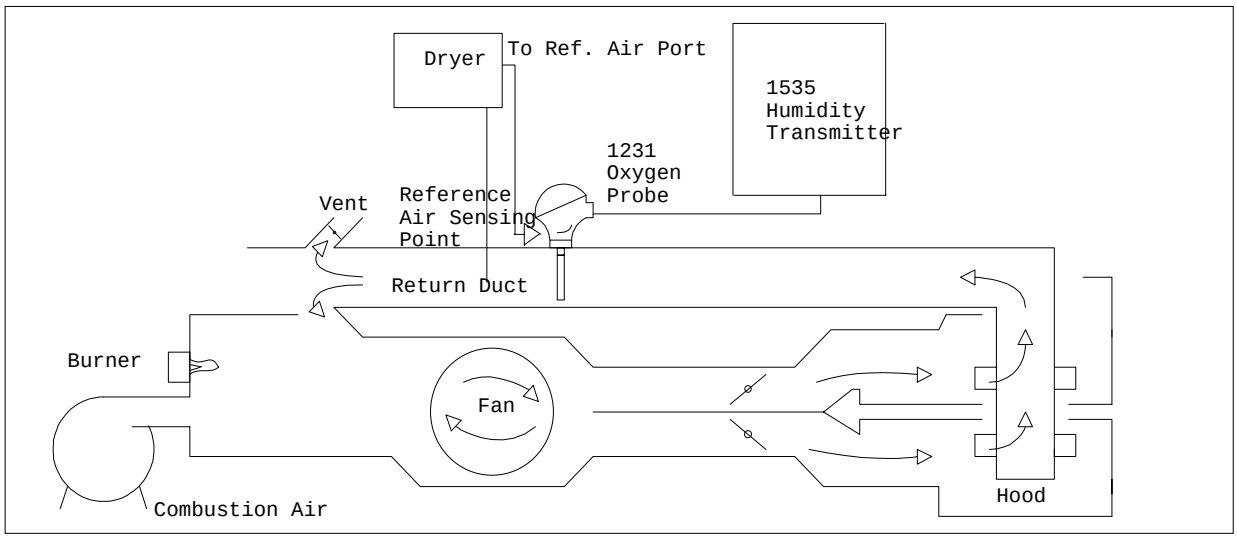


Figure 1.2 Paper Machine Hood Water Vapour Measurement

1.3 PURGE/CALIBRATION PANELS

Due to the absolute measurement characteristics of zirconia sensors and the self calibration features of Novatech analysers, probe calibration checks with calibrated gases are not normally required. In some installations however, automatic gas calibration checks are required by production engineering management. Novatech Purge/Calibration Panels provide a ready method of connecting on-line calibration gases, and have a probe zero off-set check facility. They provide on-line automatic checking of probe and analyser calibration, as well as a probe purge facility and a reference gas facility. The absolute characteristics of zirconia sensors require only one calibration gas to properly check the probe's performance. Where required however, Purge/Cal Panels are available to handle two calibration gases. The purge and calibration solenoid valves can be operated manually or automatically from a model 1535 series transmitter.

Each panel is supplied with:

- A reference gas flow meter/regulator
- A reference gas flow switch
- A hand valve for zero off-set calibration
- A calibration gas flow meter/regulator
- A 24 VAC solenoid valve for each span (calibration) gas

Panels with filter purge include:

- A 24 VAC purge solenoid valve
- A purge flow switch to test for filter blockage

The customer should supply:

- Span gas cylinder(s), typically 2% oxygen in nitrogen or a similar percentage of oxygen 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. If purging is not required and instrument air is not available, an electric pump should be used for reference gas and zero off-set calibration air.

Purge/Cal Panel Model Selections

MODEL NUMBER	NO. OF SPAN GASES	FILTER PURGE	FOR CLASS 1 HAZARDOUS AREA
1536–1	1	NO	NO
1536–3	1	YES	NO
1536–5	1	NO	YES
1536–7	1	YES	YES

Accessories:

- Calibration cylinder regulator and pressure gauge. (Customer to supply).
- Electric air pump in weatherproof enclosure, 110–250 VAC.

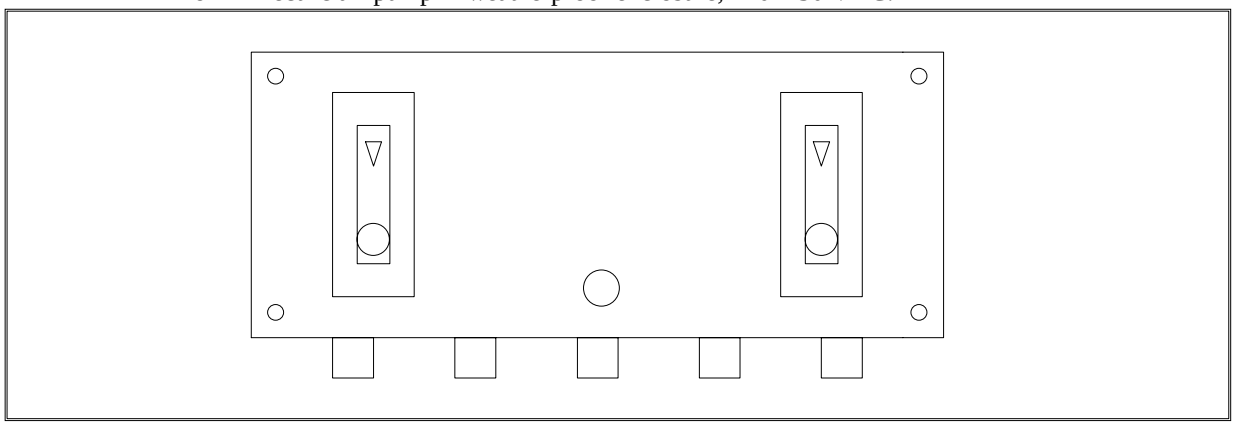


Figure 1.3 Model 1536-3 Purge/Cal Panel

1.4 THE ZIRCONIA SENSOR

The transmitter input is provided from a solid electrolyte oxygen probe which contains a zirconia element and thermocouple. The probe is designed to be inserted into the drier. Sampling lines and filters are not required. A reference gas or gas supply is required for the probe. Refer to section 2.11 for more details on reference gas. The probe sensing end construction is shown in Figure 1.4.

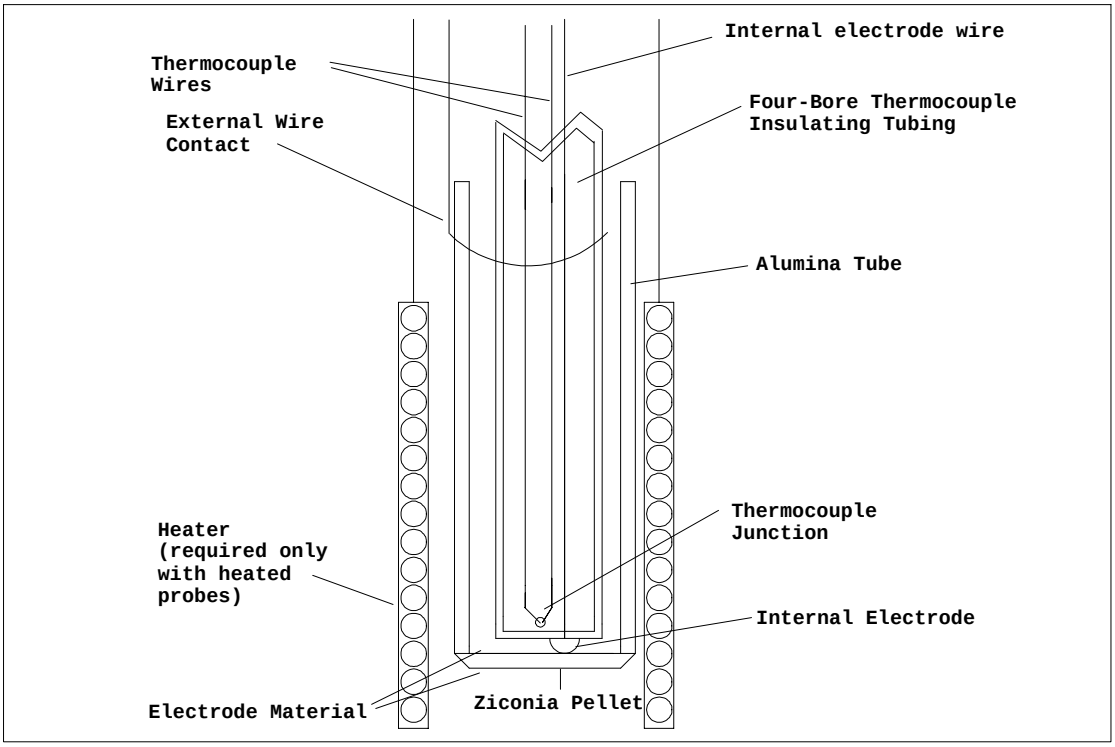


Figure 1.4 Schematic View of a Sensor Assembly

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:

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

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

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

Transposing this equation

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

The 1535 transmitter solves this equation which is valid above 650°C.

1.5 THE OXYGEN PROBE

The probe assembly provides a means of exposing the sensor to the atmosphere to be measured with sensor, thermocouple and heater wires connected via a weatherproof plug to the transmitter lead. Reference gas 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 cal. gas entry.

1.6 REFERENCE GAS DRIER

A cooler is ***essential*** if the installation is for a direct fired drier or oven, because the level of oxygen in the oven is reduced by the combustion.

A sample of gas must be drawn from the drier and dried sufficiently to be used in the oxygen probe without any moisture condensing in the probe. The calculations in the transmitter will compensate for the remaining water content.

Reference Gas Summary

Answering these questions will help to determine the equipment required for your installation. Refer also to the flow chart in Figure 4.3, Set-up Mode Selection Steps, 4 to 7.

Q1. How is the drier fired ?

Direct fired (flame direct into the drier)	Go to Q2.
Indirect fired (electric or heat exchanger)	Got to Q3.

Direct fired

Q2. Does the flame get changed in intensity to regulate the temperature ?
ie. The oxygen reduction caused by the combustion in the drier is not constant.

No. Constant flame, constant oxygen reduction.	Go to A1.
Yes. Variable oxygen level in the drier.	Go to A2.

Indirect fired

Q3. Do you require the highest possible accuracy of the humidity calculation ?
ie. Do you require compensation for the variation of moisture in the ambient air ?
This improves the calculated accuracy of the calculated RH value by about 1%..

No. No ambient RH probe.	Go to A3.
Yes. Ambient RH probe required.	Go to A4.

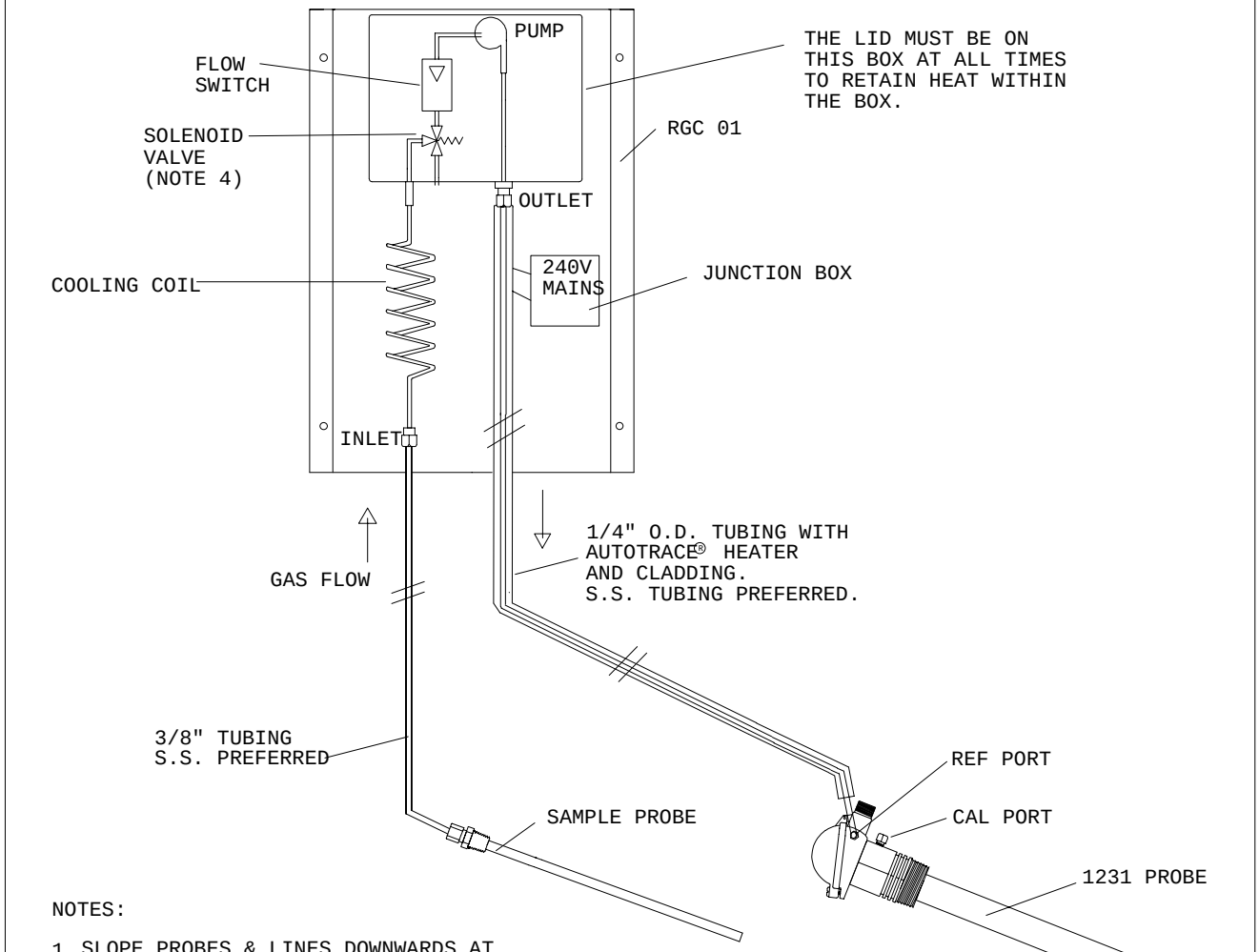
Answers

A1. A reference gas cooler is not required.
Select 'Direct Fired' in Set-up function #4.
Select 'Ambient Air' in Set-up function #5.
Set the level of oxygen in to the menu with Set-up function #6.
(See Section 4.5.4, Drier Heating Type
and Section 1.2, 'Specifications – Reference gas Cooler/Drier' for further details)

A2. It is necessary to have a reference gas cooler to remove the majority of the water vapour.
The simplest way to dry the gas is to use the Novatech model RGC-01.
Select 'Direct Fired' in Set-up function #4.
Select 'Dried Process Gas' in Set-up function #5.
The reference gas temperature sensor must be used.
(See section 2.6, Connecting the Reference Gas Temperature Sensor)

A3. A reference gas cooler or an ambient RH probe are not required.
Use ambient air to the 'REF' port on the oxygen probe.
Select 'Indirect Fired' in Set-up function #4.
Select 'No' in Set-up function #7. (External RH probe)

A4. A reference gas cooler is not required, but an ambient RH probe is required.
Use ambient air to the 'REF' port on the oxygen probe.
Select 'Indirect Fired' in Set-up function #4.
Select 'Yes' in Set-up function #7. (External RH probe)



NOTES:

1. SLOPE PROBES & LINES DOWNWARDS AT AN ANGLE OF 10ø MINIMUM.
2. COOLING COIL REQUIRES FREE AIR CIRCULATION.
3. AUTOTRACE HEATER NOT REQUIRED IF RGC OUTLET LINE DOES NOT COOL BELOW THE TEMPERATURE OF THE RGC COIL OUTLET. IF IN DOUBT INSTALL THE HEATER.
4. THE SOLENOID VALVE IS (OPTIONAL) IS REQUIRED FOR ANALYSERS WHICH DISPLAY BOTH % WATER VAPOUR & % OXYGEN.
5. DISTANCE BETWEEN RGC 01 & PROBE SHOULD BE MINIMISED. TYPICALLY 1.5M.
6. THE RGC 01 SHOULD BE INSTALLED IN AN AMBIENT TEMPERATURE OF LESS THAN 50øC.

NOVATECH CONTROLS (AUST) PTY LTD.			
Description: INSTALLATION OF RGC 01 REFERENCE GAS CONDITIONER			
Drawing Name: M:ATEAM\DRAWINGS\RGC\INSTALL			
Scale: NTS	Date:8/8/94	General Revision	Rev.1 09/01/95

FIGURE 1.6

Figure 1.6 How to Install the reference gas cooler

1.7 ALARMS

Refer to OPERATOR FUNCTIONS Section for details on alarm functions.

1.8 HEATER SUPPLY

CAUTION

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

1.9 APPLICATIONS WHERE SENSING POINT IS NOT AT ATMOSPHERIC PRESSURE

To apply the 1535 transmitter to processes which have pressure at the point of measurement significantly above or below atmospheric pressure, then compensation must be applied. Refer to set-up step 4.5.10.

1.10 PROBE IMPEDANCE

The probe impedance is a basic measurement of the reliability of the oxygen reading. A probe with a high impedance reading will eventually produce erroneous signals. The transmitter checks the probe impedance once per minute and if the impedance is above the maximum level then the impedance alarm will be activated. Typical probe impedance is 800–2000 °C at 720°C.

1.11 AUTO CALIBRATION–ELECTRONICS

The transmitter input section is self calibrating. There are no adjustments. The analog to digital (A/D) 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 a large error occurs due to an electronic fault, then an ‘A/D CAL ERROR’ alarm will occur.

The calibration procedure of the precision reference sources should be repeated about every two years or if the instrument undergoes a cold start (refer section 2.14). If there is any doubt about the accuracy of the instrument readings, then refer Maintenance Section 5.5 items 6, 7, 8 and 9 for a full description of this simple calibration procedure.

The digital to analog converters or output sections of the transmitter are tested for accuracy only when the 'AUTO CAL' button is pressed. 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 3 seconds by pressing the ‘AUTO CAL’ button on the technicians keyboard. All output signals will drop to 0 mA for the 3 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 the A/D calibration has been completed.
It should be repeated annually. If a ‘D/A CAL ERROR’ alarm occurs during normal operation then a hardware fault should be suspected.

1.12 AUTO CALIBRATION CHECKING–PROBE

As stated in Section 1.3, on-line automatic gas calibration 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 up to two calibrated gas mixtures into the probe via the calibration port, under microprocessor control, on a timed basis. For details on installation refer Section 2.10. For details on setting up this facility refer to set-up steps 11 to 23 Section 4.5.

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

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

1.13 AUTO PURGE

In oil and coal fired plants, or in dryers with high dust loadings, it is possible for the probe sensing filter to become blocked. An automatic purge cycle can be set up so that a blast of air, maximum 100 kPa, will automatically back-flush the probe filter on a timed basis. Refer to set-up steps 11 to 15 Section 4.5.

A purge flow switch senses that there is sufficient flow to clear the filter during the purge cycle otherwise a 'FILTER BLOCKED' alarm will occur.

The probe can be manually purged from the keyboard while in 'RUN' mode. The transmitter output is not frozen during or after the pressing of this button.

1.14 RS 485 –232C PORTS

The serial port is for connecting a printer, a data logger, or any computer with an RS485 –232-C port.

It can be used to monitor the transmitter and process by logging the values of functions selected in step 29 of the set-up menu.

The log period may be selected in step 30 for 1–2000 minutes, and the baud rate may be set up in step 31.

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

1.15 OTHER INPUTS–Humidity, Ambient Temperature and Drier Temperature

The connection of a Lee Integer CH15 or similar sensor/transmitter with a range of 0–100 % RH and output of 0–1 volt is optional for dryers with indirect heating. In this case the probe reference gas comes from the ambient atmosphere, and compensating for RH and temperature variations of this reference gas improves the accuracy by 1% RH.

Dryers with direct fired combustion processes normally use a sample of atmosphere from within the drier as probe reference gas and do not require an RH or ambient air temperature sensor. In this case, the reference gas must be dried to remove all water vapour before entering the probe reference port.

If the drier has a fixed combustion system (fixed firing rate), where the reduction of oxygen due to combustion is constant, then an ambient/water cooled drier may not be necessary to condition reference gas from within the drier. The accuracy of the transmitter is further improved if the combustion gas is a small percentage of the recirculating drier air. In this case the CH15 sensor can optionally be installed for a 1 % RH improvement in accuracy

In order to calculate the % RH of the drier, the temperature of the drier gas must be known. A K type thermocouple is used for this purpose. This thermocouple is not necessary if the transmitter is set to display % Water Vapour, g/Kg or dew point temperature only.

1.16 WATCHDOG TIMER

The watchdog timer is started if the microprocessor fails to pulse it within any three 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 three attempts to reset, the common alarm relay will be activated.

1.17 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.

INSTALLATION & COMMISSIONING 2

SECTION NUMBER

INSTALLATION

COMMISSIONING

INSTALLATION

2.1 MOUNTING THE TRANSMITTER

Surface mount the transmitter case on to a flat surface or bracket, using the four holes provided. Refer to Figure 2.1. If the hole layout provided is not suitable then the circuit boards may be removed and additional holes drilled in the rear of the case. Mounting screws should not come into contact with the printed circuit boards.
All wiring should comply with local electrical codes. The lead between the probe and transmitter should be ordered with the probe. It has an integral weatherproof connector to plug into the probe head.

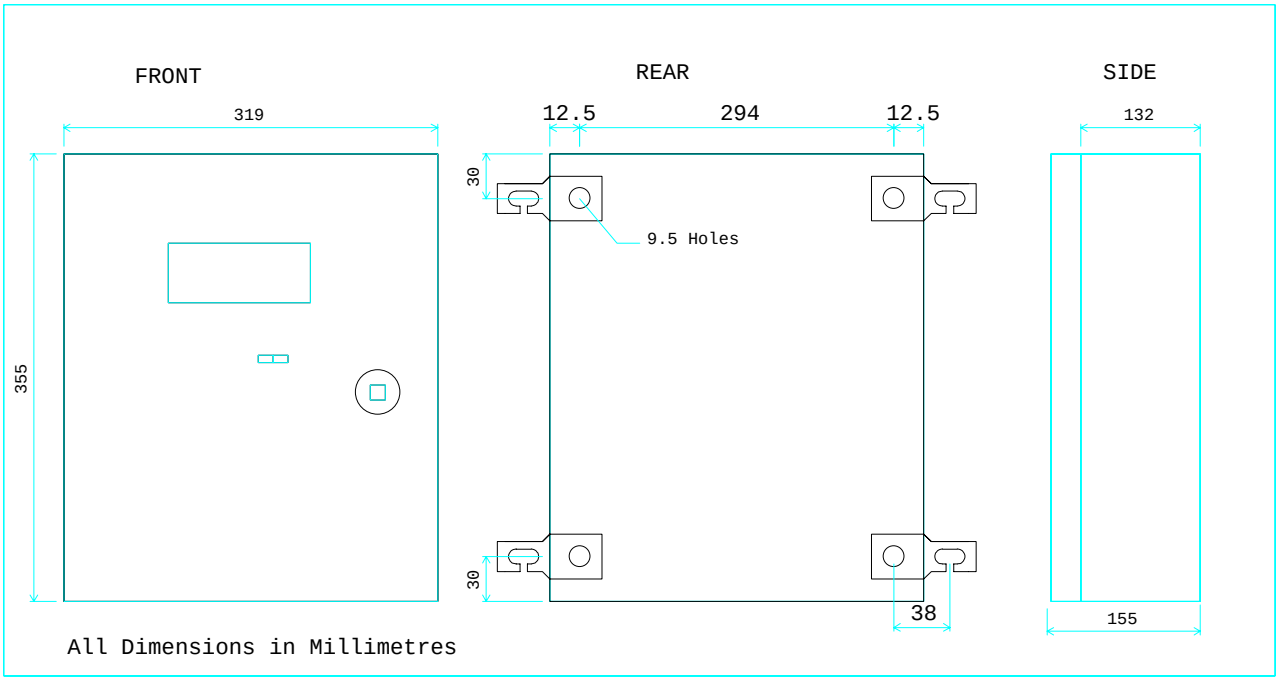


Figure 2.1

Enclosure Mounting Dimensions

2.2 HEATER INTERLOCK RELAYS

CAUTION

On direct fired dryers, explosion protection for heated probes is achieved by switching the power to the probe heater off whenever the main fuel valve is closed.

The principle is that if the main fuel valve is open then the 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 drier when the fuel valve is closed. When power is removed from the main fuel valve the heater must also be switched off.

To achieve this protection, connect the main fuel valve power to the ‘burner on I/P’ terminals and check that relay RL 7 coil is compatible with the voltage connected eg. 110 or 240 VAC. Refer to Figure 2.2.

For installations where there is no risk of explosion, connect a constant mains supply to terminals number 39 and 40.

Figure 2.2 Probe Heater Safety Interlock Connections

2.3 EARTH, SHIELD & POWER CONNECTIONS

All external earthing should be shielded. The printed circuit boards are fully floating above earth. All earth and shield connections should be connected to the earth terminal No. 44.

The mains earth should be connected to a sound electrical earth.

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

Before connection of mains power check that the correct solder links are installed as shown in Figure 2.3.

Figure 2.3 Earth, Shield and Power Connections

2.4 CONNECTING THE PROBE CABLE

Connect the probe lead supplied as shown in Figure 2.4.

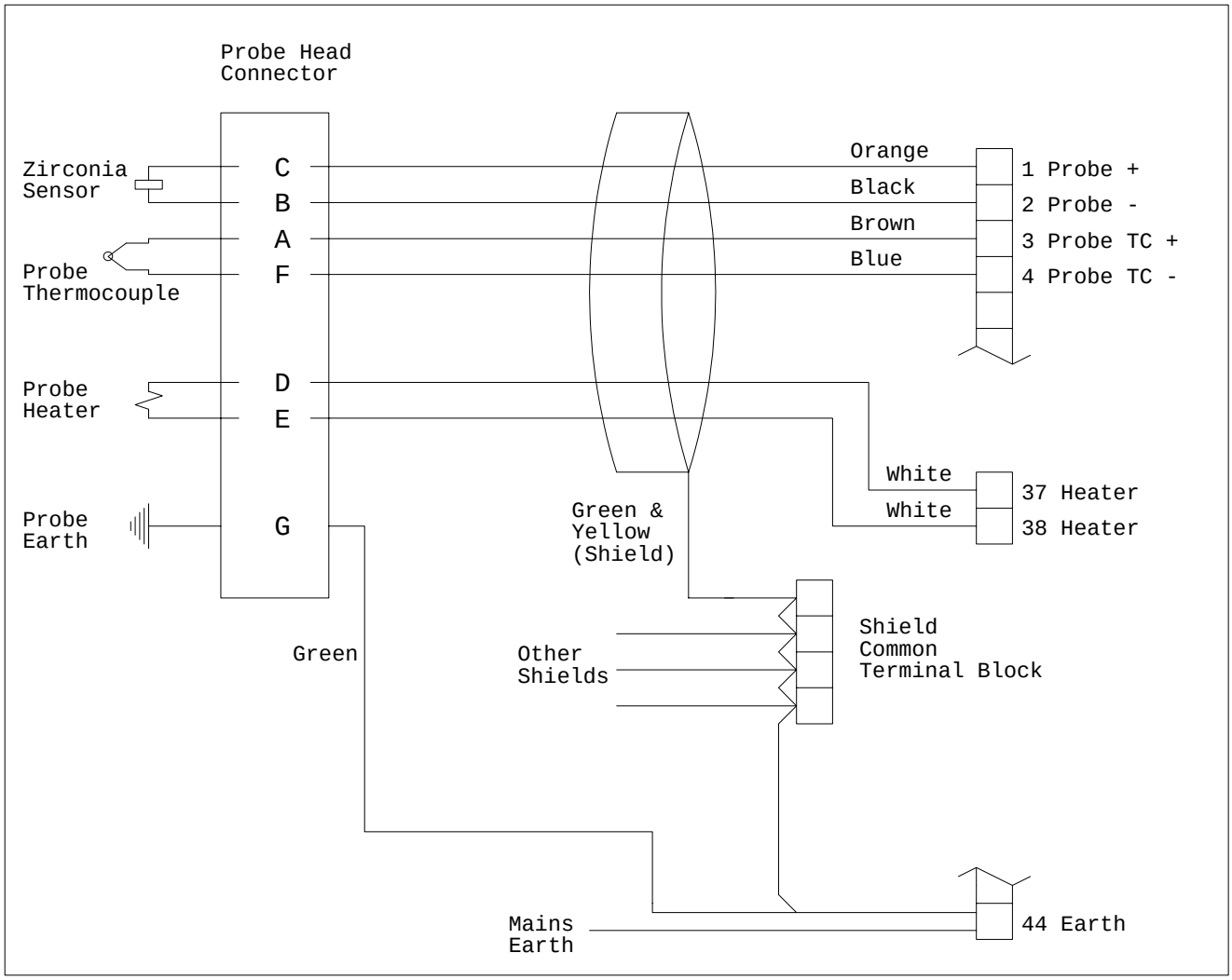


Figure 2.4 Connection of Probe Cable

2.5 CONNECTING THE RELATIVE HUMIDITY SENSOR

This input is only required for indirectly heated dryers or directly heated dryers with fixed combustion where probes can use ambient air as a reference. Refer to Section 1.15 for details on this optional input. Mount the relative humidity sensor enclosure in a position to sense ambient air RH . For connection details refer Figure 2.5.

Figure 2.5 Connections for Relative Humidity Sensor

2.6 CONNECTING THE REFERENCE GAS (AMBIENT) TEMPERATURE AND DRIER TEMPERATURE SENSORS

The ambient temperature sensor is optional for indirectly heated dryers or for directly heated dryers where ambient air is used as a reference. It is essential if the installation is on a directly heated drier with process gas used for a reference gas to the oxygen probe.

For simply monitoring air temperature, mount the ambient temperature sensor in a protected position with plenty of exposure to the air. The sensor is supplied within the relative humidity sensing enclosure. Refer to Figure 2.6a for connection details.

Figure 2.6a Connection of Ambient Temperature Sensor, AD590

When used with a directly heated drier with process gas used for a reference gas to the probe, the installation must have a reference gas cooler. This sensor is then used to measure the reference gas temperature after the cooler. The reference gas sensor will be included in the cooler.
The cooler will be fitted with a PT100 RTD sensor. It is necessary to use shielded, low resistance cable for this sensor (18 gauge or lower resistance). Compensation can be made for lead resistance. See section 5.5.15.

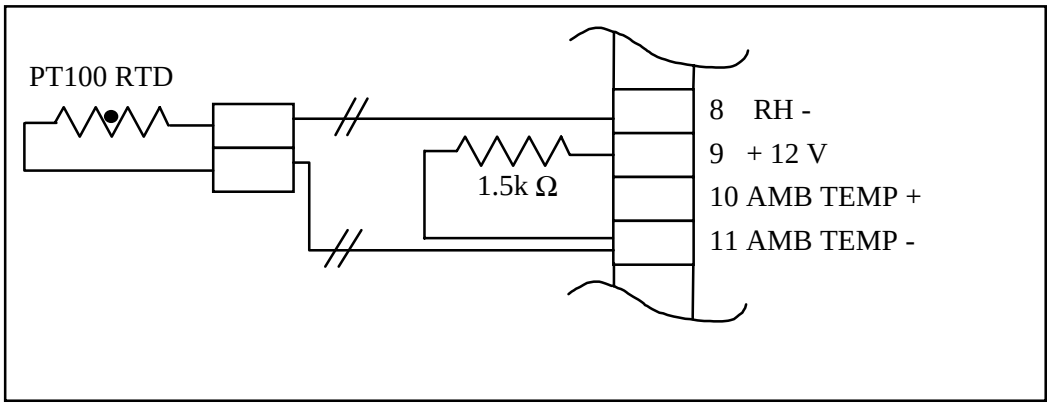


Figure 2.6b Connection of Ambient Temperature Sensor, PT100 RTD

The Drier Temperature sensor is only required for transmitters displaying and/or transmitting % RH. It is not required for the calculation of % Water Vapour, g/Kg or dew point.
The sensor must be a 'K' type thermocouple mounted in the drier, in a position close to where the % RH is being measured.

Figure 2.6c Connection of the Drier Temperature Sensor

2.7 CONNECTING THE TRANSMITTER OUTPUT

The 4 –20 mA DC output channel is capable of driving into a maximum 600 Ω load. It is fully isolated. Refer to Figure 2.7.

Figure 2.7 Connections the for Transmitter Output Channel

2.8 CONNECTING THE ALARMS

The alarm relay functions are described in detail in Sections 3.2 and 3.3. 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. All systems should have the common alarm relay RL5 and the probe low temperature relay RL3 connected. The probe calibration and horn relays are optional. Alarm wiring should be shielded.

2.9 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. Refer to Figure 2.8.

Figure 2.8 Connections for Alarm Horn

2.10 CONNECTING THE AUTOMATIC PURGE AND CALIBRATION SYSTEM

The on-line auto purge and calibration system is optional. For details on its operation refer to Sections 1.3, 1.12 and 1.13. Typical connection details are shown in Figures 2.9 (a) and (b).

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

Figure 2.9a Automatic Purge & Calibration System Wiring Schematic

Figure 2.9b Automatic Purge & Calibration System Piping Schematic

2.11 CONNECTING REFERENCE GAS

A reference gas supply is required for the oxygen probe. Connect as shown in Figure 2.10. If the drier is indirectly heated, the reference gas should be pumped from ambient air with a simple diaphragm pump. A good quality aquarium pump is adequate.

If the drier air is heated by direct firing burners; gas, oil, or other fuel; the reference gas can be drawn from a sampling point within the drier near to the oxygen probe sensing tip. It then needs to be dried completely with a refrigerated or desiccant drier. If the drier has a fixed combustion system (fixed firing rate) where the reduction of oxygen due to combustion is constant, then a refrigerated drier system may not be necessary to condition reference gas from within the drier. The accuracy of the transmitter is further improved if the combustion gas is a small percentage of the recirculating drier air.

A reference gas flow switch is required. Connection details are shown in Figure 2.9b. The flow switch causes an alarm if the reference gas flow is insufficient. Failure of reference gas can cause indeterminate errors.

Reference gas pressure should be about 20mm WG to provide a flow of approximately 50 cc/min. As a guide, if the end of the air supply tube is held 12 mm under water, then you should see several bubbles per second. The flow should be sufficient to actuate the reference gas flow switch.

Cooling effect errors will occur if the reference gas flow is too high. This can be checked by turning the flow on and off while reducing the flow until no difference in oxygen reading is noticed between flow and no-flow.

Figure 2.10 Reference gas Connection

2.12 CONNECTING THE PRINTER AND TERMINAL PORTS

The RS 485–232-C port is available at the connector CN7 on the lower right hand side of the main circuit board.

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

Data is logged out of the port as arranged in set-up steps 29 and 30. The baud rate is selectable in step 31. Refer to Section 1.14.
Connection details are shown in Figure 2.11.
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).

Figure 2.11 Serial Port Connections

2.13 INSTALLING THE OXYGEN PROBE

Weld a 1 1/2" BSP or NPT socket to the flue in a suitable position on the drier.
It is necessary to angle the probe downwards, at about 30° minimum angle from the horizontal, to avoid water vapour building up in the probe housing. The sensing tip should be lower than the head.
If installing a probe with a hot environment, slide the probe in slowly to avoid thermal shock to the internal ceramic parts.

CAUTION

It is important that there is no air in leakage near to the oxygen sensing point otherwise there will be a high oxygen reading.
Although it is rare, occasionally a probe may sense oxygen vastly differently from the actual. If this occurs then the probe should be moved, or a longer probe installed. This phenomenon is caused by stratification of gases in the drier.

COMMISSIONING

2.14 CONNECTING POWER–COLD START

In direct fired dryers, before commissioning the probe or 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 2.3

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

After a ‘COLD START’, it is necessary to set all new variables in Maintenance and Set-up modes, including calibration voltages and time and date.

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

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

2.15 REFERENCE GAS FLOW SWITCH

Ensure that the reference gas is flowing and that the reference gas flow switch is closed by pressing the alarm button to ensure a 'REF AIR FAIL' alarm is not occurring.

2.16 COMMISSIONING–MAINTENANCE MODE

Switch the mode switch to 'MAINT'. Enter the date and time. If the transmitter has performed a 'COLD START', the reference voltage and D/A calibrations will have to be performed. If a 'COLD START' has been performed or a new probe installed then the probe offset will need to be set. Refer to Section 5 for full details on calibration. Refer to Section 5.5.10 and 2.21 for details on probe offset calibration.

2.17 COMMISSIONING–SET UP MODE

Switch the mode switch to 'SET-UP' and enter all set up functions as listed in Section 4.

2.18 RUN MODE

Switch the mode switch to 'RUN'. The upper line of the display will now read '% RELATIVE HUMIDITY' or '% WATER VAPOUR'. The probe temperature can be checked on the lower line of the display. % Relative Humidity or % Water Vapour readings are not valid when the probe is below 650°C.

2.19 HEATER BYPASS SWITCH (DIRECT FIRED DRYERS ONLY)

In indirectly heated dryers, leave the heater by-pass switch in the 'off' position and RL7 permanently linked to the mains supply. See Section 2.2

In directly heated dryers, heated probes should have their heater supply interlocked with RL 7. If the drier combustion is off, then power will not be supplied to the heater.

With direct fired dryers, to commission an oxygen probe when the main burner is turned off, switch power off the transmitter, remove the probe from the mounting point and connect the lead with the probe laying on a metal or ceramic surface external to the flue and capable of withstanding 750°C.

Re-apply power to the transmitter and press the burner by-pass switch into the 'down' position. This will apply power to the probe heater even when the plant is not running. The probe offset can now be set and calibration checked with appropriate calibration gases (typically 2 % oxygen in nitrogen).

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

2.20 CHECKING THE ALARMS

If any alarms are present the alarm LED should be lit, either flashing or steady. To interpret the alarms, repeatedly 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.

2.21 PROBE CALIBRATION

The zirconia sensor in the probe provides an absolute measurement of oxygen partial pressure. There are no calibration adjustments, apart from 'PROBE OFFSET', for the probe. Refer to Section 5.5.10. The probe EMF is either correct or the probe is faulty.

To check that the probe is functioning correctly, firstly check that the high probe impedance alarm is not activated. The display would show 'SENSOR FAIL'. The actual impedance can be displayed on the lower line. For a probe with less than one year of non-corrosive service, it will be less than 4000 Ω. Once it is established that the probe impedance is normal, the probe offset may be tested and set. Refer to Section 5.5.10. A small flow of air must be admitted to both the 'REF' and 'CAL 'ports when testing probe offset. Gas calibration tests can then be carried out. Refer to Section 2.23.

2.22 FILTER PURGE SET-UP PROCEDURE

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

Set up the probe outside the drier so that the filter can be viewed whilst running purge air, (controlled from the 'PURGE' button on the analyser when in 'RUN' mode). Gradually adjust the purge air supply regulator, increasing the pressure until sufficient flow is obtained to clear the filter. This is best checked with a dirty filter after a period of operation, by withdrawing the probe from service and watching any build up on the filter being blown off at the set pressure. Normally 30 kPa (5 psi) is adequate but the air pressure may be set as high as 100 kPa (15 psi).
With filter purge set up, the air pressure has been determined and the calibration gas system can be set to an equal pressure.

2.23 CALIBRATION GAS SET-UP PROCEDURE

If the installation has a filter purge facility, set this up first. Refer to the previous paragraph. Press the zero offset valve to obtain a reasonable flow through the calibration gas flow meter. Leave the pressure set on the air regulator for filter purge and adjust the flow on the rotameter flow regulator. 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 –20 1itres per minute.

Probes without filters will require a higher flow to achieve an accurate calibration gas reading and sometimes may not exactly read the calibration gas due to equilibration of the calibration gas with the process gas near the sensor. So long as the reading is reasonably close, accuracy is guaranteed, because the sensor is an absolute device. With the probe removed from service, a filter can be temporarily held over the sensing end of the probe to obtain an accurate check of oxygen readings. It is mainly for probes with no filters that acceptable accuracy's can be entered in set-up mode. Too high a flow will cause cooling of the sensor creating errors.

With heated probes that have no filter, a compromise flow rate may be required. For this reason an acceptable accuracy level can be set in the instrument to avoid nuisance 'GAS CAL ERROR' alarms. Once this flow has been set, the calibration gas solenoids should be manually operated from the instrument keyboard by pressing the 'CAL 1' button whilst in 'RUN' mode. The calibration gas cylinder pressure should be gradually increased to achieve exactly the same flow reading on the flow metre as the zero offset flow without adjusting the rotameter flow regulator. Calibration gas flow and the zero offset flow should be identical.

Some adjustments may be required to obtain satisfactory results with calibration gas flow. The maximum pressure on the calibration gas cylinders is 100 kPa (15 psi). 30 kPa (5 psi) is sufficient, particularly when no purge option is installed. Use a calibration gas close to the normal drier oxygen level to avoid a long recovery time. A typical gas would be 14% oxygen in nitrogen in a drier normally operating at 30% water vapour. Check this oxygen level by reading '% Oxygen' on the lower line of the display while the drier is in operation.

2.24 DUST IN THE DRIER

The preferred method of mounting an oxygen probe for dust laden applications is facing vertically downwards with the filter removed. With no filter some errors in gas calibration can occur when the gas sample has an oxygen content significantly different from that of the flue gas. Allow for this when setting auto-calibration tolerances in the set-up mode. An occasional automatic back purge is helpful with probes mounted at 30° downwards with or without a filter.

Normally heated probes are supplied with filters for dusty applications. The probe response time should be tested when the probe is first installed and then regularly until it remains constant for a significant period. A partially blocked filter will slow the response of the probe. Many probes in the field operate continuously in this way for many years with an occasional filter purge. To test the probe response time, use a stop watch to obtain the time for a probe to achieve a 63% change from one reading to another.

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

2.25 STRATIFICATION

If the transmitter and probe have been fully tested and the oxygen readings in the drier are incorrect, gas stratification may be occurring.

The phenomenon cannot be anticipated for any particular installation. The problem is normally solved by moving the probe to a new location.

OPERATOR FUNCTIONS

3

SECTION NUMBER

OPERATOR FUNCTIONS (RUN MODE)

3.1 DISPLAY BUTTON

The upper line on the display will read:- '% Relative Humidity'
'% Water Vapour'
g/Kg
Dew point temperature
whichever is selected as an output. The following are available for display on the lower line:-

1. % RELATIVE HUMIDITY (if it is not selected on the upper line).
2. % WATER VAPOUR (if it is not selected on the upper line).
3. DEW POINT TEMPERATURE (if it is not selected on the upper line).
4. g/Kg (if it is not selected on the upper line).
5. PROBE TEMPERATURE
6. DRIER TEMPERATURE
7. REFERENCE GAS TEMPERATURE
8. AMBIENT HUMIDITY, will read correctly only if a sensor is connected.
9. PROBE IMPEDANCE, a measure of integrity of the sensor's electrode, the part of the probe that normally wears out first. The reading should be less than 2 KΩ at 720°C. The probe impedance is measured every five minutes. In the first five minutes after being switched on, the probe impedance display will show '- -', or until the probe reaches 650°C.
10. OXYGEN %, as read by the probe.
11. PROBE EMF (millivolts)

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:

12. PROBE UNDERTEMP, when the probe heater is on but the temperature is below 650°C.
13. PROBE CALIBRATION, occurring for Cal Gas check.
14. PROBE PURGE occurring.

Items 12, 13 and 14 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.

Figure 3.1 Operator's Panel

3.3 ALARM SCHEDULE

3.3.1 SUMMARY OF ALARMS

ALARM	DESCRIPTION
'SENSOR FAIL'	Oxygen cell or electrode failure (high impedance); (inhibited under 650°C).
'PROBE HEATER FAILURE'	In the first 20 minutes of power being applied to the heater after being switched on, this alarm will not occur, but a 'PROBE UNDER- TEMPERATURE' display will occur and relay RL8 will be activated. Refer to Section 5.13.
'PROBE TC O/C'	Probe thermocouple is open circuit. The heater in heated probes will switch off.
'REF AIR FAIL'	Low reference gas flow to probe.
'FLOW SWITCH'	The reference gas flow switch has failed. This is tested by automatically switching off the reference gas pump once every ten minutes for three seconds to check the operation of the flow switch.
'A/D CAL ERROR'	The analog to digital converter has been found to fall outside the normal calibration specifications. This is an electronic fault.
'D/A CAL ERROR'	The digital to analog and voltage isolator circuit has been found to fall outside the normal calibration specifications. This check is only performed when the 'AUTO CAL' button is pressed. Refer to Section 5.6.6.
'FILTER BLOCKED'	Blocked probe filter, low purge flow. This test is only performed when automatic purging of the probe is requested. Refer to step 12 in the set up menu.
'GAS-1 CAL ERROR'	Probe does not correctly calibrate to calibration gas 1.
'HEATER BY-PASS'	The safety interlock relay has been bypassed by turning on the 'BURNER BY-PASS' switch on the terminal printed circuit board. Refer to Section 2.2 and 2.19.
'WATCHDOG TIMER'	Software error. This alarm will not appear on the display. The 'ERROR' LED on the front door will illuminate.

3.3.2 SUMMARY OF ALARM RELAYS

ALARM	RELAY	FUNCTION	LATCHING	NOTES
'PROBE LOW TEMP'	RL3	Probe reading is invalid (under 650°C).	No	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.
'CAL IN PROG'	RL4	Probe calibration /purge check in progress	No	
'ALARM'	RL5	Alarm condition present	No	
'HORN'	RL6	Horn Driver	Yes	Press the 'ALARM' button twice for any one alarm to reset the horn relay.

3.4 POWER LAMP

Illuminated when power is connected to the transmitter.

3.5 ERROR LAMP

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

SETTING UP THE TRANSMITTER 4

SECTION NUMBER

SET-UP MODE SUMMARY

4.1 SET-UP MODE FUNCTION'S

1. Output Signal/Display Top Line
2. Transmitter Zero Set
3. Transmitter Full scale Set
4. Drier Heating Type
5. Reference gas Selection
6. Combustion Oxygen %
7. Ambient RH Sensor
8. Temperature Units
9. Drier Pressure Units
10. Drier Pressure
11. Purge/Cal Time
12. Automatic Purge
13. Time Between Purges
14. Purge Duration
15. Purge Freeze Time
16. Number of Cal Gases
17. Oxygen Content Cal Gas
18. Maximum Acceptable Positive Error Cal Gas
19. Maximum Acceptable Negative Error Cal Gas
20. Period Between Gas Autocals
21. Duration of Autocal
22. Cal Gas Freeze Time
23. Data to Print
24. RS 232 Log
25. Printer Baud Rate
26. 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
On the EPROM in the socket labelled IC3 (top left hand corner of the main PCB)

4.2 SET-UP/MAINTENANCE/RUN SWITCH

To enter the ‘set-up’ mode via the keyboard, move the toggle switch to ‘SET-UP’. The outputs will be frozen when in set-up mode.

If purges or auto calibration occur while the mode switch is in ‘SET-UP’ mode, they will be delayed until the mode switch is returned to ‘RUN’.

To cancel a purge or calibration cycle, press ‘ENTER’ while in ‘RUN’ mode.

4.3 FUNCTION SELECT

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

To select other function's, 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 function's the display will always first indicate the last options entered. The 'data to print' function number 23 has multiple options. One or more options may be selected for this function.

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 transmitters memory by pressing the 'ENTER' button. When a value has been entered an asterisk will appear at the right-hand-side of the lower line.

Figure 4.1 Internal Technician's Keyboard

4.5 SET-UP FUNCTION DETAIL'S

1. OUTPUT SIGNAL VARIABLE — **Options**
1. % Relative Humidity
2. % Water Vapour
3. Dew Point °C or °F (selectable in Setup #8)
4. g/Kg

2. TRANSMITTER ZERO SET — Range: See the table below, fig 4.2

3. TRANSMITTER FULL SCALE — Range: See the table below, fig 4.2

	Zero	Span	Minimum Range
Relative Humidity	0	100	20
Water Vapour %	0	100	20
Dew Point °C	-50	+100	20
Dew Point °F	-50	+250	50
g/Kg	0	10,000	1,000

Figure 4.2 Output Scaling

4. DRIER HEATING TYPE

Options:
1. Indirect (heat exchanger)
2. Direct Fired Combustion

If (1) is selected, the next set-up step is 7.
If (2) is selected go to step 5.

Figure 4.3 Set-Up Mode Selection Steps 4 to 7

5. PROBE REFERENCE GAS

This set-up function will appear only if 'direct fired' is selected in set-up #4. If 'indirectly' is selected, this step will not appear on the set-up menu.
Choose 'Ambient Air' if the drier has a fixed combustion system (fixed firing rate) where the reduction of oxygen due to combustion is constant. A refrigerated or ambient drier system will not be necessary to condition reference gas from within the drier. The accuracy of the transmitter is further improved if the combustion gas is a small percentage of the recirculating drier air.
If the reduction of oxygen due to the combustion is not constant, then choose 'Process Gas'. A refrigerated or ambient cooler will now be required. See Novatech Controls or their agent for details of availability.

Options:
1. Ambient air
2. Dried process gas from within the drier

If (1) is selected the next set-up step is 6. If (2) is selected the next set-up step is 8.

6. COMBUSTION 0_2 %

In dryers where the reduction of oxygen due to the combustion is constant, it is not necessary to use a refrigerated or ambient cooler.
The value of oxygen to be entered is determined by removing any wet product from the drier, and having the combustion at the normal level. Read the oxygen on the lower line of the display. Ambient air must already have been supplied to the 'Ref. Air' input to the probe.
The next set up is step 8..

Range: 0 –21 % oxygen in 0.1 % steps.

7. AMBIENT RH SENSOR CONNECTED

Depending on the level of accuracy required, an ambient RH sensor is optional. If no RH sensor is connected, the transmitter will default to 50% RH. Compensation for ambient reference gas oxygen content with this sensor will improve the accuracy of the calculated value of RH by about 1%.

Options:
1. Yes—RH sensor connected
2. No—RH sensor not connected.

8. TEMPERATURE UNIT

Select whether displays are to be in ° Celsius or Fahrenheit.

Options:
1. Celsius (Centigrade)
2. Fahrenheit

9. DRIER PRESSURE UNITS

The average drier operating pressure must be entered. Select whether to enter in inches or mm WG or kilopascals.

Options:
mm WG
kilopascals
Inches WG

10. DRIER PRESSURE

Enter drier pressure eg. 3 mm WG

Limits:
-200 – +200 mm WG
-9 – +9 inches WG
-200 – +200 kPa

11. PURGE/CAL TIME

Set the purge time to occur at the correct time-of-day. If purging is not required but on-line auto gas calibration is required, enter a time-of-day value suitable for the auto calibrations. Cal gas 1 will be tested 10 minutes after the purge/cal time and cal gas 2, 20 minutes after. If neither purge nor auto calibration is required, ignore the time setting.

Range:
0–23 hrs in one hour steps, representing midnight to 11pm

12. AUTOMATIC PURGE

For oil and coal fired plant, probe filters may be used. These should be back purged with sufficient frequency to avoid blockage. The output will be frozen during purging. If no purge is required steps 13, 14 and 15 will be skipped.

Options:
YES
NO

13. TIME BETWEEN PURGES

Set the time between purges
eg. a two hourly purge or a 100 hourly purge.

Range:
1–199 hours

14. PURGE DURATION

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

Range:
3–10 seconds

15. PURGE FREEZE TIME

After the purge period, the transmitter output will remain fixed (frozen) for an adjustable period. To allow the probe reading to return to the correct process level and avoid output 'bumps'. The freeze period time required will depend on the probe response time and thus its design and whether it has a filter or not. To determine the required freeze time, manually perform a purge while the plant is in operation and note the time required for the reading to return to the correct process level within a reasonable tolerance.
Refer to section 2.23, 'Calibration Gas Set-up Procedure'.

Range:
100–1000 sec. in 10 second steps

16. CAL GAS

Select 'Cal Gas' to have automatic system calibration checking. For example a check gas of 8 % could be used to test a large scale signal calibration, and alarm if the result is out of the tolerance values in set-up #18 & 19.

Options:
No Cal Gas
Cal Gas

During the timed calibration periods, the transmitter outputs will be frozen and the transmitter will alarm if readings are not within the accuracy limits set in set-up 17 and 18 If autocal is not required enter 'No Cal Gas' and the transmitter will step to set-up step 23.

17. OXYGEN CONTENT OF CAL GAS

Enter value of Cal Gas 1 (to one decimal place).

Range:
0.0–20.9 % oxygen

18 MAX. ACCEPTABLE POSITIVE ERROR

Maximum positive error above which the 'AUTOCAL ERROR HIGH' alarm will be initiated after timed period in set-up 21.

Range:
0.1–3.0 % oxygen

19. MAX. ACCEPTABLE NEGATIVE ERROR

Maximum negative error below which the 'AUTOCAL ERROR LOW' alarm will be initiated after timed period in set-up 21.

Range:
0.1–3.0 % oxygen

20. PERIOD BETWEEN GAS AUTOCALS

Set number of hours between autocal gas 1 from 1–1999. A typical time would be 24 –168 hours. (Daily or weekly)

Range:
1–1999 hours

21. DURATION OF AUTOCAL

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, an AUTOCAL ERROR will initiate. To determine the minimum time required for a particular length or design of probe to settle, manually admit cal gas from the internal keyboard while observing the oxygen reading in 'RUN' mode. Typical minimum times vary from 15 seconds to 60 seconds depending on the probe length and gas plumbing arrangement. See section 2.23, 'Calibration Gas Set-up Procedure'.

Range:
0–90 seconds

22. CAL GAS FREEZE

After the cal gas 1 period, the transmitter output will remain fixed (frozen) for an adjustable period to allow the probe reading to return to the correct process level and avoid output 'bumps'. The freeze period time required will depend on the probe response time. This is dependant on its length and whether or not it has a filter.

Range:
10–100 seconds in 10 second steps

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

NOTE: If an automatic purge or cal period occurs when the transmitter is switched to 'SET-UP' or 'MAINT' mode, they will be delayed until run mode is selected. They will initiate immediately the mode selector is switched to 'RUN'.

23. DATA TO PRINT

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' button.

Options :
1. Probe Temperature
2. Drier Temperature
3. Reference gas Temperature
4. Ambient Relative Humidity
5. Probe Impedance
6. % Oxygen
7. Probe EMF
8. % Water Vapour
9. Dew Point

24. PRINT LOG PERIOD

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

Range:
1–2000 minutes

25. PRINTER BAUD RATE Select the correct BAUD rate for data to be transmitted out of the serial port to the printer.

Options:
300
1200
2400
4800
9600

26. DAMPING FACTOR Each time a new reading is read from the oxygen 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 4-20mA output. The number of readings that are averaged together is adjustable by the user in this function. A value of 5, for example means that the new reading from the probe, and the previous 4 readings are averaged together before being displayed/output. A value of 0 entered her will mean that every new reading from the sensor will be sent to the display/output un-altered.

Range:
0–25

MAINTENANCE 5

TRANSMITTER MAINTENANCE

5.1 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 20MV REFERENCE (CALIBRATION)
7. SET 70MV REFERENCE (CALIBRATION)
8. SET 1200MV REFERENCE (CALIBRATION)
9. SET 2500MV REFERENCE (CALIBRATION)
10. SET PROBE OFFSET (PROBE CALIBRATION)
11. 4-20mA OUTPUT CALIBRATION
12. ENTER SERVICE YEAR
13. ENTER SERVICE MONTH
14. ENTER SERVICE DAY
15. REFERENCE GAS TEMPERATURE SENSOR CALIBRATION

Note: If the Maintenance menu does not match the functions in your instrument, check the software version number -
On Page 2 of this manual
On the EPROM in the socket labelled IC3 (top left hand corner of the main PCB)

5.2 SET-UP/MAINTENANCE/RUN SWITCH

To enter the MAINTENANCE mode via the keyboard, move the toggle switch to ‘MAINT’. The output will be frozen when in MAINTENANCE mode.

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

5.3 FUNCTION SWITCH

When the ‘SET-UP/MAINTENANCE/RUN’ SWITCH is moved to ‘MAINT’ the display will automatically read the last MAINTENANCE function selected. To select other function's operate the ‘FUNCTION ⇓’ button to increment to the next function or the ‘FUNCTION ⇑ ’ to decrement to the previous function.

Figure 5.1 Internal Technician's Keyboard

5.4 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 transmitters memory by pressing the 'ENTER' button. When a value has been accepted an asterisk will appear at the right-hand side of the lower line (except for calendar date and time values).

5.5 MAINTENANCE FUNCTION'S

1.	**ENTER YEAR**	Set the clock/calender year eg. 04-08-92 = 4th August, 1992.
2.	**ENTER MONTH**	Set the month.
3.	**ENTER DAY**	Set the day.
4.	**ENTER HOUR**	Set time, hours (24 hour format).
5.	**ENTER MINUTES**	Set 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.

Function's 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 2.14.
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 5.2 These voltages should be approximately:

1) 2484 mV
2) 1163 mV
3) 64.1 mV
4) 19.0 mV

Enter the measured values in function's 6 to 9. Whenever new values are entered the D/A section should be re-calibrated, Refer to Section 5.6.

Figure 5.2 Location of Calibration Test Points

10. SET PROBE OFFSET

A new EMF offset must be entered whenever a new oxygen probe is installed to calibrate for any offset an individual probe may have. Each probe will have an offset value noted on a removable tag. Enter the 'PROBE OFFSET' value with opposite polarity eg. if offset value is -1.2 mV enter 1.2 mV. The Typical Maximum is 2 mV.

To check a probe offset on-site the probe must be sensing air with reference gas connected (to both the 'CAL' and 'REF' ports) and allowed to settle at the probe operating temperature for 30 minutes. Read the offset in 'RUN' mode in millivolts on the lower line.

Offset errors can occur if the sensor does not have some air passing over it. A gentle flow of air in the calibration port can be provided by a reference gas pump or by pressing the 'PROBE OFFSET TEST' button on a 1536 Purge/Cal panel. For heated probes, if the combustion appliance is not operational and the probe heater is interlocked with the "FUEL ON' signal the 'heater lockout by-pass switch should be set to 'BY-PASS' to power the probe heater after removing the probe from the drier.

CAUTION DANGER:

Return the 'heater lockout by-pass' switch to normal before installing the probe in the drier.

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

When reading the EMF offset, the flue pressure compensation must be set. If the probe has been removed from the flue, set the flue pressure compensation to 0 in set-up step 10.

11. 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 5 and 6 were set for a full scale output of 10% oxygen, then generate input signals until the top line of the display reads 10% 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.
ie. 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 10, 4–20 mA #1 CAL, and press 'AUTOCAL' before leaving the maintenance 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.

12. ENTER SERVICE YEAR

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

13. ENTER SERVICE MONTH

Enter the current 'MONTH'.

14. ENTER SERVICE Enter the current 'DAY' of the month. Altering these DAY values will reset the 'RUN TIME'.

15. SET RTD COMPENSATION

This only needs to checked if an RTD is being used on terminals 10 &11. The input terminals number 10 &11 can be used for either an AD590 solid state temperature sensor or an PT100 RTD temperature sensor.
If an RTD temperature sensor is being used, the sensor calibration must be checked.

Measure the voltage between the screw terminals 2 & 9. Enter this value on the keypad using the Option buttons.
The accuracy of RTD sensor can be further improved by compensating for lead resistance. Add 0.01 volts to the value entered here for every 0.1Ω total lead resistance. (typically add 0.04 volts)
The calibration should be checked after the installation, by comparing the displayed 'REF AIR' temperature with a calibrated temperature indicator.

NOTE:
The calibration must always be checked when using either the RGC-01 or RGC-02 reference air coolers because they are supplied with an RTD installed.

NOTE: If an automatic purge or cal period occurs when the transmitter is switched to 'SET-UP' or 'MAINT' mode, they will be delayed until run mode is selected. They will initiate immediately the mode selector is switched to 'RUN'.

5.6 D/A CALIBRATION

If a cold start is performed (Section 2.14) then the D/A section of the transmitter 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 'AUTO CAL' button. This button should be pressed annually, or if the reference voltages are altered in 'MAINT', 5.5 items 6, 7,8 or 9. An 'AUTO CAL' will be performed in one second after pressing the button. The transmitter outputs will fall to 0 mA for this one second period. If a 'D/A CAL' error occurs during normal operation then a hardware fault should be suspected.

5.7 BACK-UP BATTERY REPLACEMENT

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

After replacing the battery, re-enter all maintenance and set-up mode function's.

5.8 ELECTRONIC REPAIRS

Electronic schematics are included in Appendix 2. It is recommended that service be performed on a change-over circuit board basis. A fast turn around or replacement service is available from accredited service agents. Other service aids, including a test ROM and input simulator are also available .

PROBE MAINTENANCE

5.9 TEST EQUIPMENT REQUIRED

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

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

An instrument to measure probe EMF and temperature is required. A 3 1/2 or 4 1/2 digit multimeter will perform both measurements.

A separate temperature indicator to suit a type 'K' thermocouple is also useful, although not necessary.

A reference gas pump is required and a cylinder of calibration gas 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 chromatography tested to an accuracy of 0.1% oxygen.

If a 1535 transmitter 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 set to approximately 100 volts will regulate the probe temperature to approximately 720°C.

5.10 TESTING A PROBE

With the probe tip heated to approximately 720°C, either from a small test furnace or its own internal heater, connect a digital multimeter to the probe electrode conductors. Connect the multimeter positive to the internal electrode conductor. Connect reference gas to the probe and apply a gentle purge of air to the probe calibration port. Reference gas 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 sensor impedance.

To measure the probe sensor impedance, and therefore get a measure of the sensor integrity, use the 'DISPLAY' button to scroll the lower line of the display until the probe impedance value is shown. This will only be a valid reading if the sensor is up to the operating temperature (720°C).

If an analyser is not available, use a multimeter switched to read ohms and take a measurement, within a couple of seconds, of the probe impedance. Reverse the multimeter and repeat the reading. Take the average of the two readings for an approximate measurement of impedance. If the impedance is above 4000Ω, then the electrode needs refurbishing. The probe 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. Where a probe electrode requires refurbishing, it is suggested that they should be returned to an accredited service organisation.

If the probe tests reveal less than 2 mV offset and a good impedance reading, the next step is to apply a calibration gas. The calibration gas should be inserted in the calibration port. With the calibration gas flowing, the probe should develop an EMF according to the tables in Appendix 2. If the EMF reading is low, then there may be insufficient calibration gas flow. Increase the calibration gas 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.

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

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

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

5.11 SENSOR IMPEDANCE

If the sensor impedance is found to be high in the test described in Section 5.10, it may be necessary to move the inner electrode slightly to re-establish contact. This is achieved by gently pulling the four bore ceramic tube against its spring loading for approximately 1 mm and releasing. This procedure is normally only required with a probe which has been sitting cold for many months.

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

5.12 PROBE THERMOCOUPLE

The transmitter has an alarm function which will advise the operator of an open circuit probe thermocouple, however, bench testing can be performed by simply measuring the thermocouple continuity. If the thermocouple requires replacement, care should be taken not to physically damage the inner electrode material during removal and replacement of the thermocouple and insulator.

5.13 HEATER FAILURE

A heater failure will cause a ‘HEATER FAILURE’ alarm. Heaters can be tested from the probe head with a continuity test.

The heater impedance should be approximately 110_. Should the heater be open circuit, contact an accredited service agent for replacement.

5.14 FILTER BLOCKAGE

For oxygen probes or flow guide tubes with filters in installations with entrained solids in the flue gas, it is sometimes necessary to replace the filter. Filters are normally cleared with back purging. However fine fly-ash, or other particles can ultimately completely block a filter necessitating filter replacement. A new probe filter can be fitted by an accredited service agent. Flow guide tube filters are field replaceable.

5.15 PACKING

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

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

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

APPENDICES

1. **PROBE EMF TABLES**
2. **CIRCUIT SCHEMATIC'S**

APPENDIX 1

PROBE EMF TABLES

MILLIVOLT TABLE WITH AIR REFERENCE

% OXYGEN	mV at 720°C
20.0	0.99
19.5	1.53
19.0	2.09
18.5	2.66
18.0	3.25
17.0	4.47
16.5	5.11
16.0	5.77
15.5	6.45
15.0	7.15
14.5	7.87
14.0	8.62
13.5	9.40
12.5	11.05
12.0	11.92
11.5	12.83
11.0	13.78
10.5	14.78
10.0	15.82
9.5	16.92
9.0	18.08
8.5	19.30
8.0	20.60
7.5	21.98
7.0	23.45
6.5	25.04
6.0	26.75
5.5	28.61
5.0	30.65
4.5	32.90
4.0	35.42
3.5	38.28
3.0	41.58
2.5	45.48
2.0	50.25
1.5	56.41
1.0	65.08
0.5	79.91
0.2	99.51
'K' TC mV	29.965

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

e.m.f. = 0.02154 x T x ln (21/ % Oxygen)/ % Oxygen)

Using drier combustion gas as a reference, the Nernst equation becomes:

e.m.f.= 0.02154 x T x ln (Drier % Oxygen Dried/Drier % Oxygen Undried)

T= the probe temperature in °K

APPENDIX 2

CIRCUIT SCHEMATICS