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 **TELEDYNE ANALYTICAL
INSTRUMENTS**

**Oxygen Transmitter
Model 9060Z
Technical Manual**



M9060Z

8/15/14

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This manual describes the transmitter firmware version 1.24, September 2012

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Important Notice Regarding 9060 Probe Option - FIL-3

WARNING: The only identifiable standard for flame arresters for general use is British Standard BS EN 12874:2001. British Standard BS EN 12874:2001 refers to an operating environment up to 150 Degrees Centigrade.

The FIL-3 device optionally fitted to 9060 Heated Zirconia Probes (the "Probes" or "Probe") operate in an environment considerably greater than 150 Degrees Centigrade.

Therefore, we know of no Australian, British, European or USA standard applicable to flame arresters or their testing above 150 degrees Centigrade. Consequently, the FIL-3 device cannot be certified as a safety device.

The probe is only on probes during the start up processes of a combustion appliance.

The Teledyne Analytical Instruments Burner Interlock Relay facility, which is a standard part of the Teledyne Analytical Instruments transmitter, is designed to be wired to the main safety shut-off fuel valves in a way that can shutdown the probe heater when the fuel valves are closed.

The risk of ignition of flammable gas mixture at the hot end of the Probe can only be minimized by correct use, maintenance and operation of the FIL-3 device. The user of the FIL-3 device is responsible for verification and maintenance and correct use and operation of the FIL-3 device.

THE USER AGREES THAT IT USES THE PROBE AND THE FIL-3 DEVICE AT ITS SOLE RISK. TELEDYNE ANALYTICAL INSTRUMENTS TO THE FULL EXTENT PERMITTED BY LAW, GIVES NO WARRANTIES OR ASSURANCES AND EXCLUDES ALL LIABILITY (INCLUDING LIABILITY FOR NEGLIGENCE) IN RELATION TO THE PROBE AND THE FIL-3 DEVICE.

The user must ensure that it correctly follows all instructions in relation to the Probe and FIL-3 device, correctly understands the specifications of the Probe and FIL-3 device and ensures that the Probe and FIL-3 device are regularly inspected and maintained.

FIL-3 equipped Probes should be inspected at least once a year for corrosion and more frequently if there is any reason to suspect that corrosion may have occurred.

1. IMPORTANT NOTICES

This manual is intended as a supplement to the 9060Z Operators Manual. It is intended to be used by technical personnel that are qualified to install, commission, service and calibrate electronic industrial control equipment.

Please read the safety information below before connecting power to the transmitter.

CAUTION 1

The probe heater is supplied with mains voltage. This supply has electrical shock danger to maintenance personnel. Always isolate the transmitter before working with the probe. The EARTH wires (green/yellow) from a heated probe must ALWAYS be connected to earth.

CAUTION 2

Combustion or atmosphere control systems can be dangerous. Burners must be mechanically set up so that in the case of equipment failure the system cannot generate explosive atmospheres. This danger is normally avoided with flue gas trim systems by adjustment so that in the case of failure the appliance will not generate CO in excess of 400 ppm in the flue. The CO level in the flue should be measured with a separate CO instrument normally an infrared or fuel cell type.

CAUTION 3

The oxygen probe is heated to over 700°C (1300°F) and is a source of ignition. Since raw fuel leaks can occur during burner shutdown, the transmitter has an interlocking relay that 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 9060Z transmitter with a heated probe will not be safe in your application. An unheated probe can be utilized in such applications, however the oxygen readings are valid only above 650°C (1200°F).

CAUTION 4

The reducing oxygen signal from the transmitter and the associated alarm relay can be used as an explosive warning or trip. This measurement assumes complete combustion. If incomplete combustion is possible then this signal will read less reducing and should not be used as an alarm or trip. A true excess combustibles analyzer, normally incorporating a catalyst or thermal conductivity bridge, would be more appropriate where incomplete combustion is possible. Also read the probe electrical shock caution in the probe heater interlock caution in chapter 4.7

CAUTION 5

FIL-3 filter. If the optional FIL-3 has been fitted to the 9060H probe in this installation, please read the Important Notice regarding probe option FIL-3 on the previous page.

CAUTION 6

The heater is supplied from the mains power directly, and the temperature is controlled at 720°C (1330°F). The outside of the process end of the probe can get to temperatures that are dangerous to touch. Wear insulating gloves when handling a probe that has been on.

CAUTION 7

Please note that if this equipment is not installed and used in the manner described in this manual then the safety protection provided by the equipment may be impaired.

2. INTRODUCTION

2.1 9060Z TRANSMITTER

The Teledyne Analytical Instruments 9060Z oxygen transmitter is designed to measure the oxygen gas concentration in combustion applications such as power stations and industrial boilers. The measurement is used to control the air / fuel ration in the burner to maintain efficiency and safe operation conditions.

The transmitter is designed to be used in conjunction with a Teledyne Analytical Instruments probe model 9060H or 9060UL/UH. These two probes use a zirconia sensor that must operate at $>650^{\circ}\text{C}$. The 9060H probe has an integrated heater, and the 9060UL/UH probe uses the process heat to heat the sensor. There is a unique cable connection between the 9060Z transmitter and the 9060H/9060UL/UH probe.

The model 9060Z oxygen transmitter is based on the well known model 9060H transmitter. It includes a number of hardware and software improvements such as a graphic display, larger characters, faster microprocessor, simplified set up menu, alarm logging, faster probe heater control and more calculated values such as burner efficiency.

The 9060Z Oxygen 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 in chapter 6, Setup Mode.

Features include:-

Inputs

Two zirconia oxygen probes, heated or unheated

Oxygen read 0-1% to 0-100%

Furnace, kiln or flue thermocouple, field selectable as type K, J, R or S

Main flame established safety interlock (for heated probes only)

Purge pressure or flow switch

Outputs

Two linearised 4-20mA or 0-20mA DC isolated outputs, max. load 1000Ω

The output function and the range are field selectable

Common alarm relay

Three other alarm relays with selectable functions

Digital Interface

RS-232 or two wire RS-485 MODBUS[®] for connection to a computer/DCS/PCL for diagnostics of the transmitter, probe or combustion process.

Display

Multi font graphical display

Large font characters for the oxygen on the top line

Selectable lower line items for the secondary display functions. ie Probe temperature, Oxygen second probe Alarm display mode that shows the time of the alarm, the acceptance time and the time that the alarm was cleared of up to 4000 alarm events

2.2 SERIES 9060H OXYGEN PROBES & SENSORS

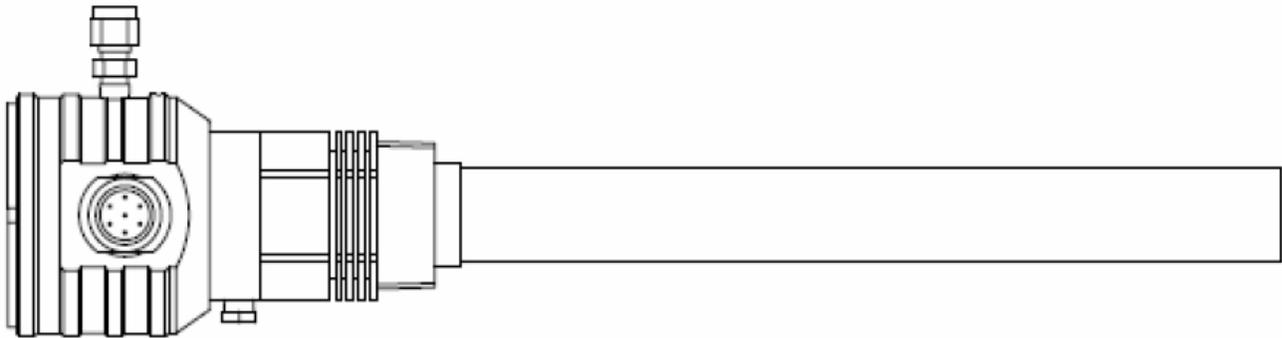
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Teledyne Analytical Instruments series 9060H oxygen probes and sensors employ state-of-the-art zirconia sensors and advanced materials, which provide the following benefits:

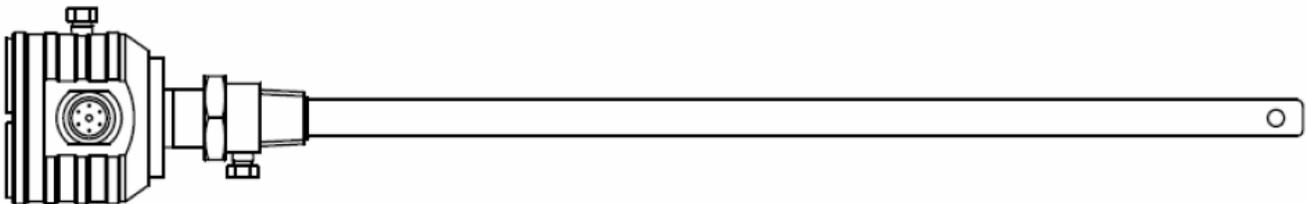
- Improved control due to fast response time to typically less than four seconds
- Cost-efficient design provides improved reliability
- Longer-life probes with greater resistance to corrosion from sulfur and zinc contaminants in flue gas
- Low cost allows maintenance by replacement
- Reduced probe breakage due to greater resistance to thermal shock and mechanical damage during installation and start-up

Series 9060H probe or sensors are simple to install and maintain. All models provide direct measurement of oxygen level. On-line automatic calibration check is available if required. Probes or sensors may be used with Teledyne Analytical Instruments oxygen transmitters and some model transmitters from other manufacturers.

All Teledyne Analytical Instruments oxygen probe or sensors are designed and manufactured to exacting standards of performance and reliability. Series 9060H probe or sensors are the result of extensive research and development by Teledyne Analytical Instruments, industry and government agencies. Teledyne Analytical Instruments provides application and after sales support for oxygen probes, sensors and transmitters, worldwide.



Model 9060H Heated Oxygen Probe



Model 9060UL/UH Unheated Oxygen Probe

2.3 Warning Symbols



Danger, high voltage. Risk of electrical shock.



Caution hot surface.

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Caution, risk of danger. See additional information in the manual.

3.1 HARDWARE SPECIFICATIONS

3.1.1 TRANSMITTER SPECIFICATIONS

Number of oxygen probes:	2 maximum
Oxygen range:	0-1% to 0-100%
Oxygen accuracy:	±1% of actual measured oxygen value with a repeatability of ±0.5% of the measured value
Thermocouple types:	Type K, J, R and S
Temperature accuracy:	±2°C
Analogue outputs:	0-20mA or 4-20mA field selectable Active outputs (Do NOT loop power these outputs)
Output load:	1000 ohm max
Alarm relays:	4
Alarm relay contacts:	2A/240VAC, 2A/30VDC

(WARNING: Do not use both mains voltage and low voltage connections to adjacent alarm contacts)

Mains voltage supply:	100 to 240VAC, -6 +10%, 50/60 Hz
Overvoltage:	Category II (IEC60364-4-443)
Power:	5W for controller plus probe power 530W max., 25% duty cycle each probe on 240VAC 110W max., 100% duty cycle each probe on 110VAC 2.5A max
Fuses:	3A, fast blow, 250v, 20x5mm (heater fuses, 2 of) 1A, slow blow, 250v, microfuse (PCB mtg fuse, 1 of)
Environmental Rating:	Operating Temperature -25°C to 55°C Relative Humidity 5% to 95% (non-condensing)
Altitude	2000m maximum
Degree of Protection:	IP65 IP54 with internal reference air pump
Case Size:	260mm (10.2") wide, 160mm (6.3") high, 90mm (3.5") deep
Weight:	3 Kg (6.6 lbs.)

WARNING: All signal level connections onto the transmitter must be treated as safety extra-low voltage (SELV) as defined in the standard IEC61140. Double insulation must be used when connecting these terminals to systems that might carry high voltage.

3.1.2 STANDARD 'U' LENGTHS

9060H	9060UL/UH
250 mm (10")	500 mm (20")
350 mm (14")	750 mm (30")
500 mm (20")	1000 mm (40")
750 mm (30")	1500 mm (60")
1000 mm (40")	
1500 mm (60")	
2000 mm (80")	

Ordering Information

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Probe insertion length (from process end of mounting thread to probe sensing tip).

3.1.3 SERIES 9060H PROBES SPECIFICATIONS

MODEL	9060H	9060UL/UH
Application	Combustion flue gases below 900°C (1650°F)	Combustion flue gases above 700°C (1290°F) with no contaminants.
	Refer to note 1	eg. natural gas, light oils
Temperature Range	0 to 900°C. Refer to note 2 (32 to 1650°F)	700 to 1400°C (1470 to 2550°F)
Length	250 to 2000 mm (10" to 80")	500 to 1500 mm (20" to 60")
Process Connection	1 ½ BSP " or NPT	¾ BSP " or NPT
Electrical Connection	Weatherproof plug-in connector or optional screw terminals. The plug connector can be supplied with the cable.	
Cable	Order a specific length with the transmitter	
Heater	Yes	No
Thermocouple	K, integral	R, integral
Response Time	Typically < 4 secs.	Typically < 1 sec
Head Temperature	-25 to 100°C (-15 to 210°F) with weatherproof connector -25 to 150°C (-15 to 300°F) with screw terminals	
Reference Gas	Ambient air, 50 to 150 cc/min (3 to 9 scim). Pump can be supplied with transmitter.	
Ref Air Connection	1/4 NPT "	Integral air line in probe cable. Barbed fitting to 3/16" ID PVC tube.
Filter	Removable sintered titanium alloy particulate filter, 30 micron standard, optional 15 micron available. Refer to note 2	
Calibration Check Gas Connection	1/8 NPT female "	1/8 NPT female "
Weight	2 kg (4.4 lb) plus 165 g (5.8 oz) / 100 mm (4") length	1 kg (2.2 lb) plus 100 g (3.5 oz) / 100 mm (4") length

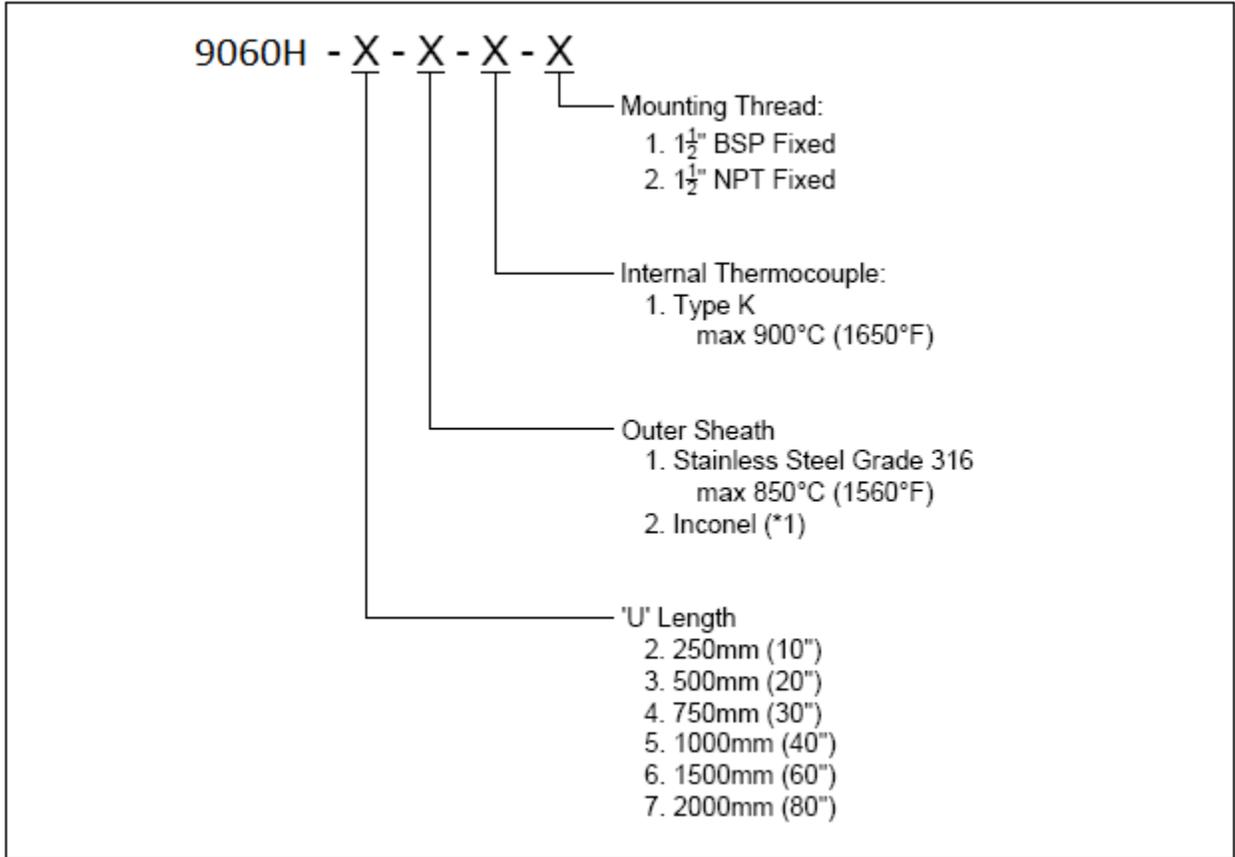
Notes: 1. Care must be taken to avoid contact with explosive or inflammable gases with 9060H heated probes when hot. Teledyne Analytical Instruments transmitters have built in safety protection.

2. Process gas temperature must be below 800°C if the filters are fitted.

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

3.1.4 OXYGEN PROBE MODEL SELECTION GUIDE

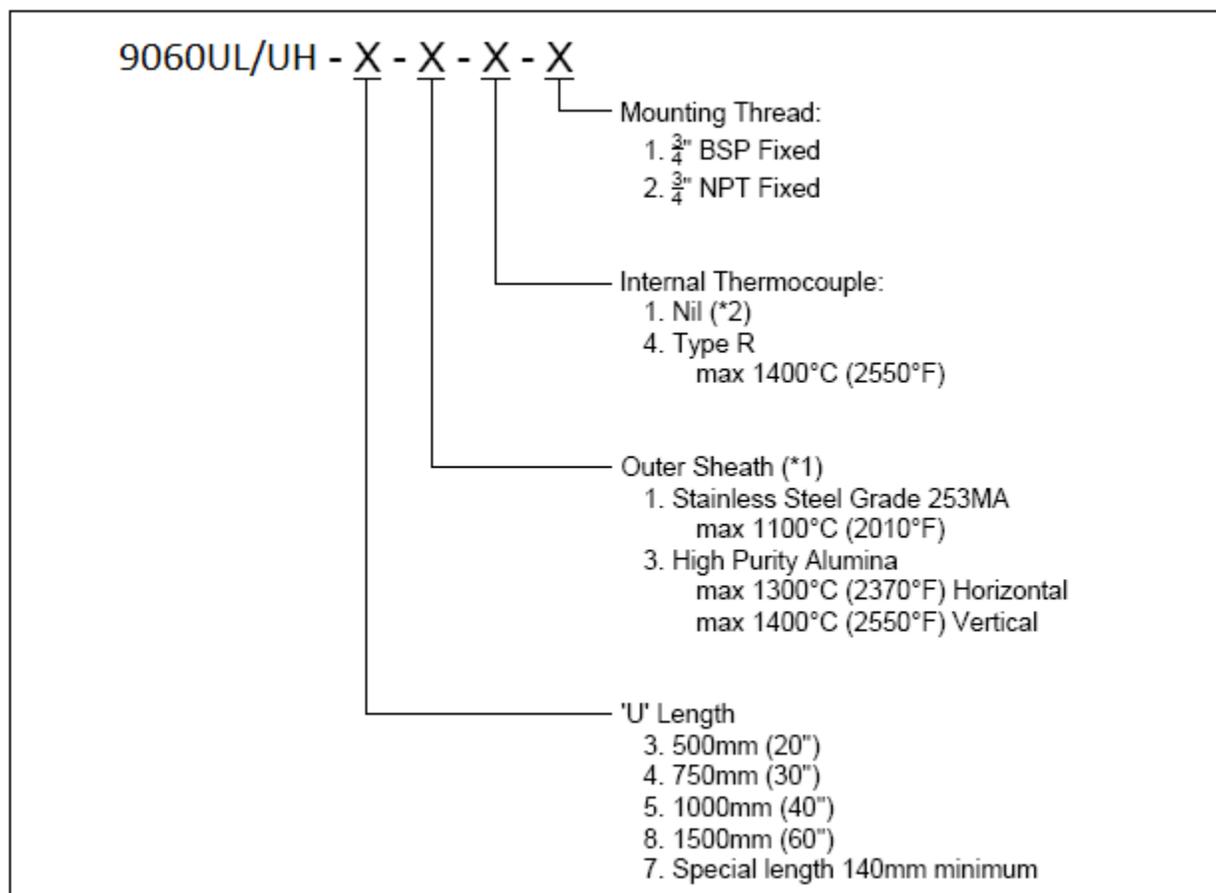
Heated probes-temperature range 0-900°C (1650°F).



*Note: (1) The Inconel option has all inconel wetted parts except for the ceramic sensor and viton 'o' rings.

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Unheated probes for clean gases-temperature range 700-1400°C (1290-2550°F).



*Note: (2) A standard oxygen probe for carburising furnaces, has a 253 MA sheath.

3.2 OPERATIONAL SPECIFICATIONS

Range of outputs:

Function	Minimum	Maximum
Linear oxygen #1	0 to 1%	0 to 100% (**)
Very low oxygen #1	0 to 0.001%	0 to 2.000% (**)
Linear oxygen #2	0 to 1%	0 to 100% (**)
Very low oxygen #2	0 to 0.001%	0 to 2.000% (**)
Average oxygen	0 to 1%	0 to 100% (**)
Logarithmic oxygen	0.1 to 20%	Fixed range
Reducing oxygen	0 to 1x10 ⁻³⁰ %	0 to 100% (**)
Oxygen deficiency	-10 to 0%	-10 to 20% (**)
Aux temperature	0 to 100°C	0 to 1600°C
Combustibles	0 to 0.5%	0 to 2.0% (**)
Carbon dioxide	0 to 5%	0 to 100% (**)
Probe #1 sensor EMF	0 to 100mV	0 to 1500mV (Fixed zero)
Probe #2 sensor EMF	0 to 100mV	0 to 1500mV (Fixed zero)
Burner efficiency	0 to 20.0%	0 to 100.0% (**)
No output	Disables the output	
** (Adjustable zero)		
Range of local indication:	0-1% to 0-100% 0.01 to 10,000ppm, automatically defaults to % range above 10,000ppm (1%)	

Local display, lower line secondary display items:

Function	Range
Probe #1	temperature Up to 1760°C (3200°F)
Probe #2	temperature Up to 1760°C (3200°F)
Probe #1	EMF -30 to 1350mV
Probe #2	EMF -30 to 1350mV
Probe #1	sensor impedance 0 to 300k Ω
Probe #2	sensor impedance 0 to 300k Ω
Oxygen probe #2	0-1% to 0-100%
Average oxygen, probe #1 and probe #2	0-1% to 0-100%
Aux temperature	Up to 1760°C (3200°F)
Ambient temperature	-20° to 70°C (-5° to 125°F)
Ambient RH	5 to 95%
Carbon dioxide	0 to 2.0%
Combustibles	0 to 2.0%
Oxygen deficiency	-10.0 to 20.0%
Burner efficiency	0 to 100.0%

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The oxygen deficiency output can be used in the same way as a combustibles analyzer to signal the extent of reducing conditions of combustion processes.

4. INSTALLATION AND COMMISSIONING

4.1 MOUNTING THE TRANSMITTER

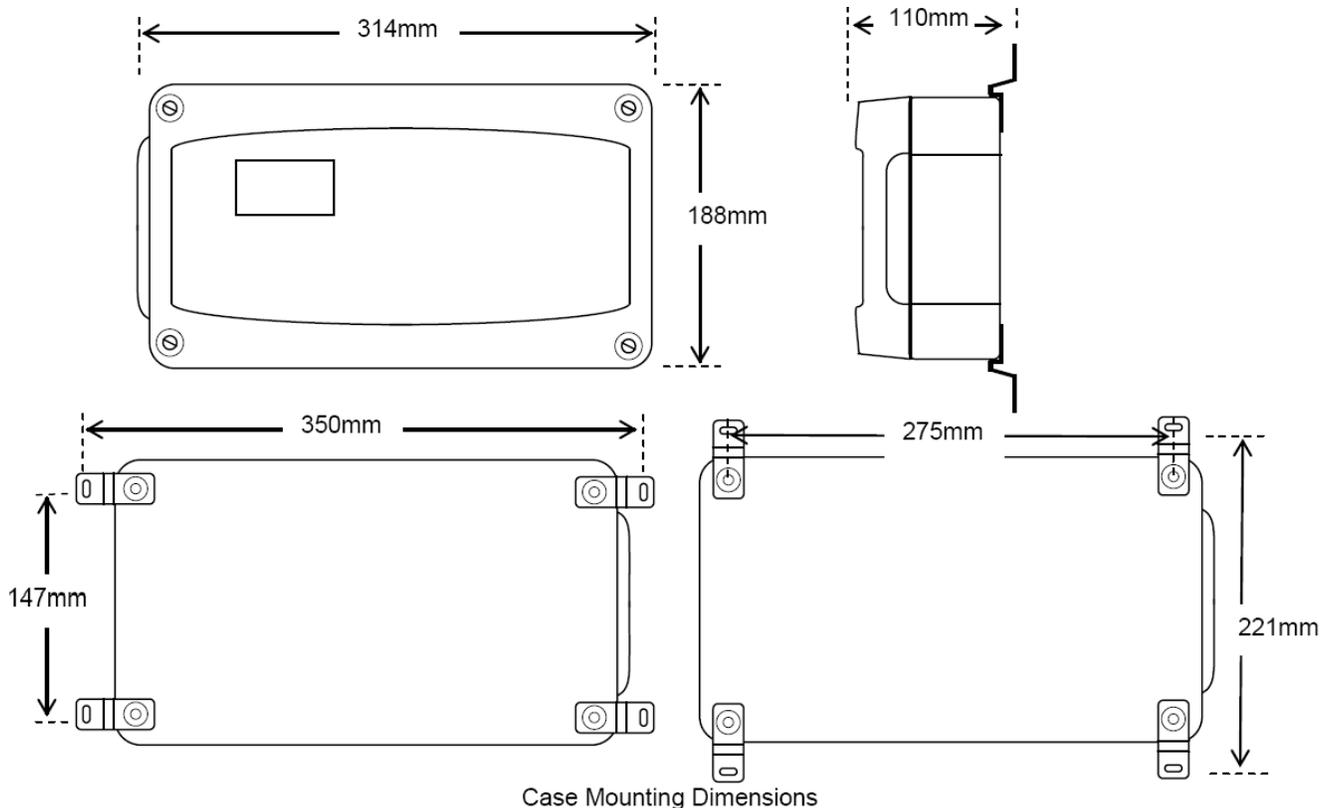
Surface mount the transmitter case on to a flat surface or bracket, using the four mounting brackets provided. The transmitter should never be mounted so that it is directly exposed to the sun or rain. Always leave at least 10cm of clearance around the four sides of the case.

Make sure the temperature of the case is below 55°C, and that the radiated heat from furnaces and boilers is kept to a minimum. There should be adequate ventilation to maintain ambient temperature.

Install the cables through cable glands. There are 4 holes cut in the base of the transmitter case; 2x 17mm & 2x 21mm. Use a sharp knife to cut away the covering film for only the glands that are needed.

NOTE: ALWAYS LEAVE THE UNUSED GLAND HOLES SEALED.

Ensure that the electrical connection complies with the local electrical requirements. (see chapter 4.6, Electrical Connections)



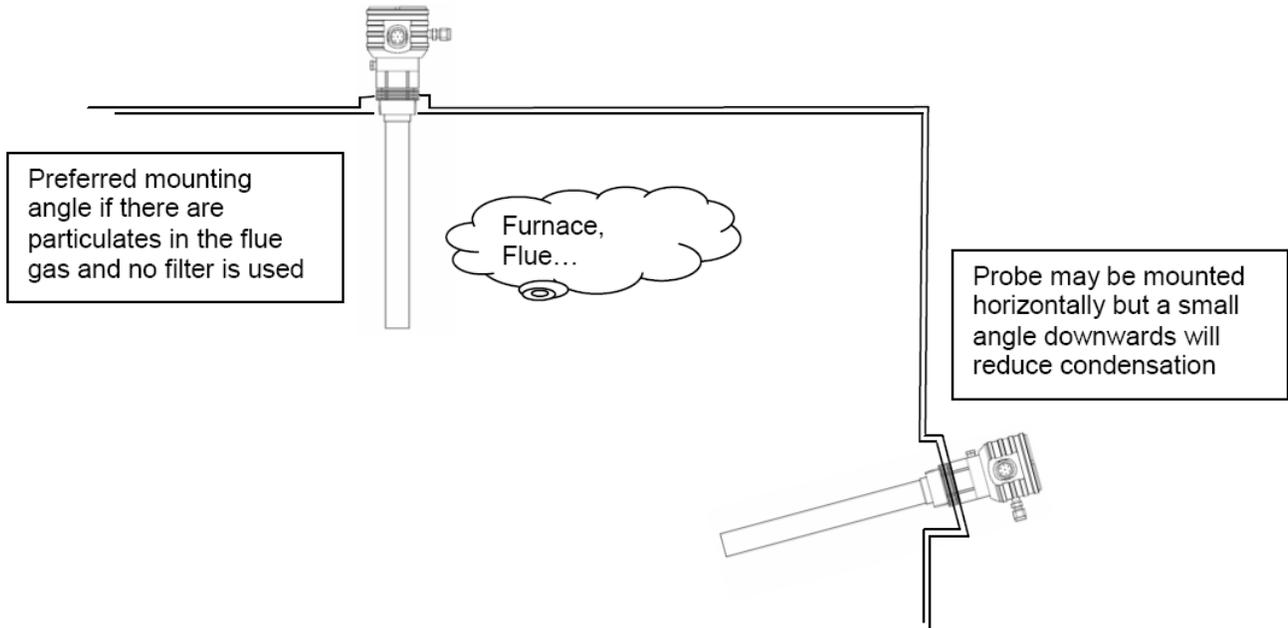
4.2 INSTALLING A 9060H OXYGEN PROBE

Weld a BSP or NPT socket to the flue in a suitable position for flue gas sensing. For the correct size of socket refer to probe data in chapter 3.1.3. The closer to the source of combustion the smaller will be 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 combustion to the point of sensing.

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Probes can be mounted at any angle. However, if the probe is to be mounted on a vertical duct wall, it is better to angle the probe (approx. 15°) down to avoid process condensation inside the cold end of the probe. If there are any particulates in the flue gas, a filter can be omitted by pointing the probe vertically downwards. Otherwise the transmitter can be configured to automatically purge the filters, or they can be replaced periodically.



Oxygen Probe Mounting

CAUTION

It is important that there is no air in leakage upstream of the oxygen sensing point otherwise there will be a high oxygen reading.

If the probe is to be installed on a bend in the flue, it is best located on the outer circumference of the bend to avoid dead pockets of flue gas flow. While the standard 9060 probe with a 'U' length of 250 mm (10") will suit most low temperature flue applications, it is occasionally necessary to have a longer probe with the sensing tip in the centre of the flue gas stream.

Although it is rare, occasionally a probe may sense oxygen vastly differently from the average reading in the flue gas. If it occurs, then the probe should be moved, or a longer probe installed. This phenomenon is normally caused by stratification of the flue gas.

4.3 INSTALLING THE AUXILIARY THERMOCOUPLE

Weld a 1/2 inch BSP mounting socket to the flue within about 300 mm (12"), and upstream of the oxygen probe. The thermocouple should be of similar length to the oxygen probe to prevent flue temperature distribution errors.

The thermocouple should be connected to terminals 7 & 8. These terminals will not be available for an auxiliary thermocouple if a second probe has been installed.

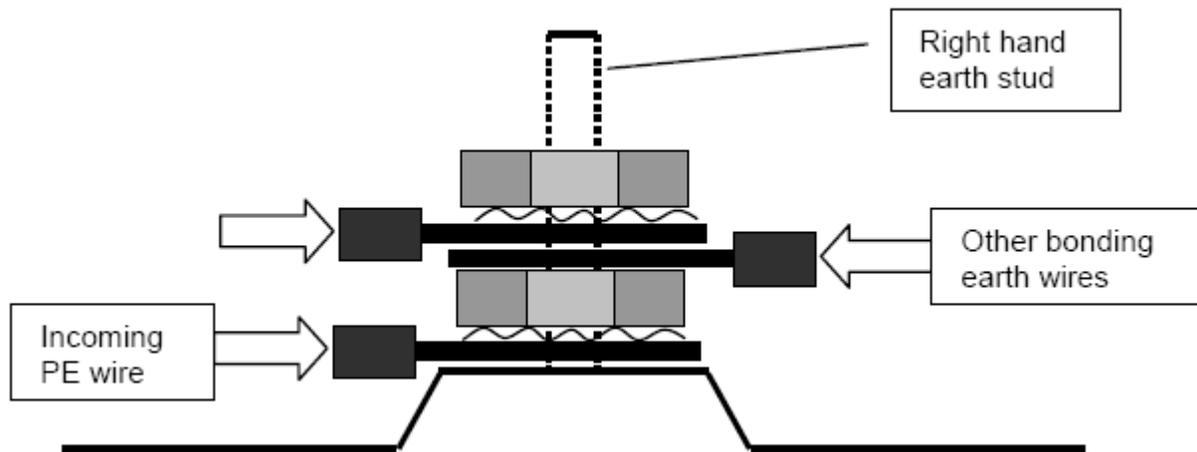
4.4A SHIELD CONNECTIONS

All external wiring to the 9060Z transmitter should be shielded. Do not connect shields at the field end. Simply clip off and insulate. There are two M4 earth screw terminals available in the 9060Z transmitter. An extra terminal strip may be required to connect all shields together. This should be supplied by the installer.

4.4B EARTH CONNECTION (PE)

The PE (protective earth) input connection must be made to the earth stud on the right hand side of cabinet. The PE input connection must be the first connection onto the earth stud and it must be secured by a separate nut and spring washer. All other earth connections (bonding connections) can be made on either of the two earth studs in the base of the cabinet.

The transmitter MUST be securely earthed.



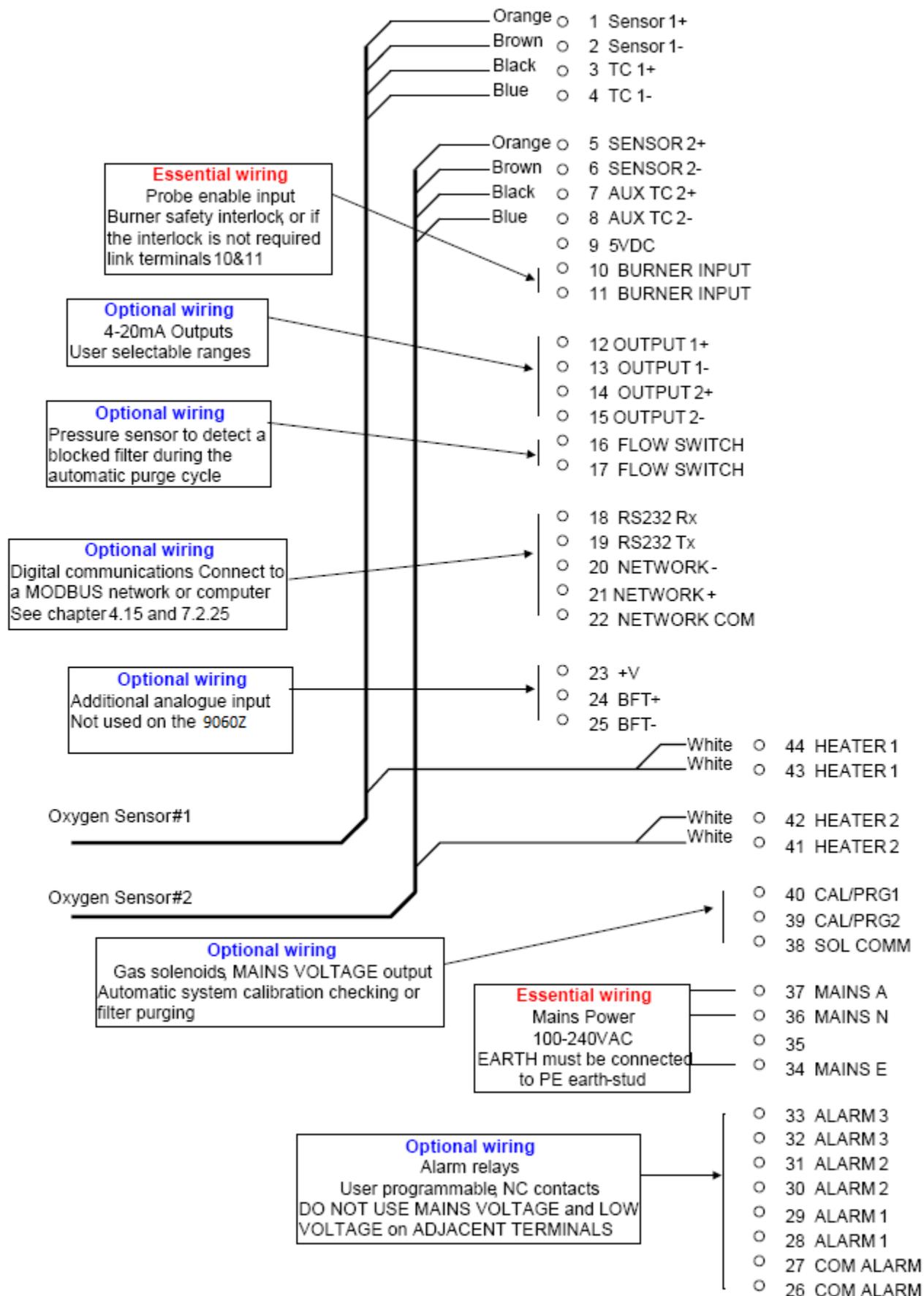
Assembly of the PE and bonding connections on the earth stud

4.5 ELECTRICAL CONNECTIONS

All wiring should comply with local electrical codes. The printed circuit boards are fully floating above earth. The incoming safety earth (PE) must be connected to the primary earth stud in the right hand side of the base cabinet.

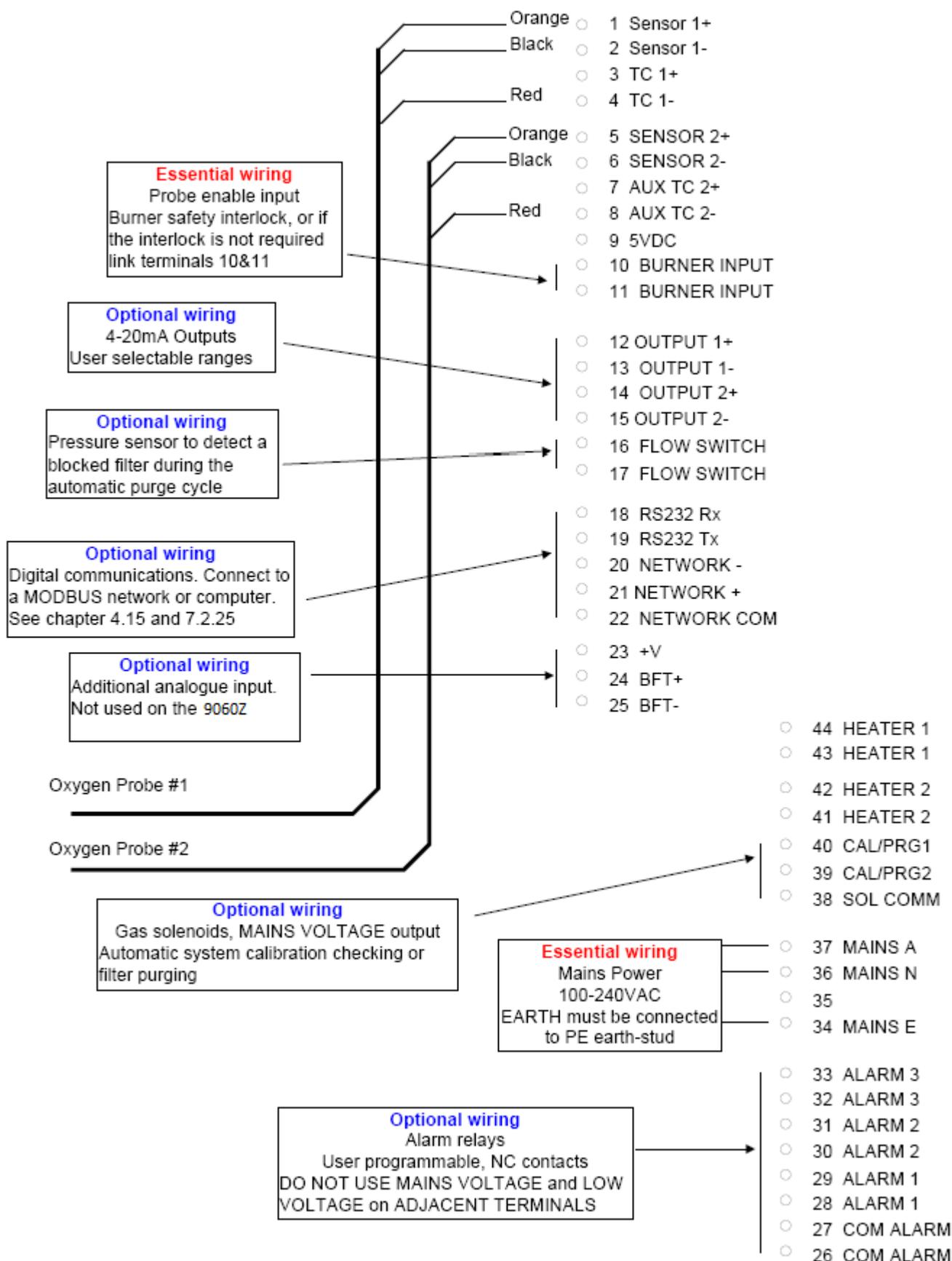
The local fuse for the mains power supply, the isolation switch and the supply wiring must all comply with the electrical safety codes and must only be installed by qualified technicians. All earth and shield connections should be connected to the earth screws inside the case.

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Connection Diagram for 9060Z Transmitter and one or two 9060H Heated Sensors

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Connection Diagram for 9060Z Transmitter and one or two 9060UL/UH Unheated Probes

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- The mains power must be either 100/110VAC or 220/240VAC with a mains frequency of 50 or 60Hz
- The supply circuit must be fused to at least 10Amps and have a dual pole isolation switch within easy access of the oxygen transmitter. The isolation switch must be marked as the isolation switch for this equipment. It is recommended that a separate isolation switch be used for each transmitter so that a transmitter can be serviced individually.
- The power supply cables must be supplied and installed according to local regulations
- The earth connection must comply with the local regulations must have a current carrying capability
 - equal or greater than the supply fuse current rating
- The earth connection must be connected to the primary earth stud inside the transmitter on the right hand side
- All other bonded earth connections from the external wiring must be connected to the primary earth stud.

All operations relating the electrical wiring and installation must be carried out by qualified persons in accordance with the safety regulations and the wiring rules.

NOTE: The power switch in the transmitter can be used to turn off the transmitter. There must be an approved isolation device installed to provide complete isolation of the mains power to the transmitter. The mains wiring terminal must not be used as an disconnect device.

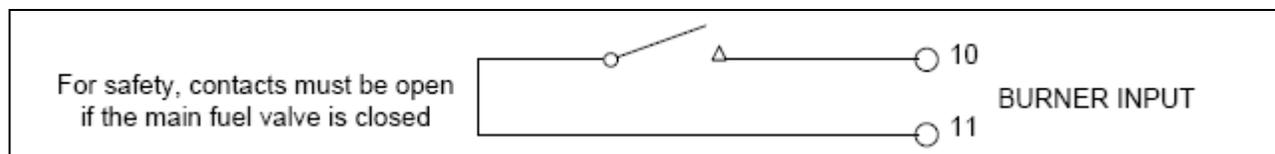
4.6 HEATER INTERLOCK RELAYS

CAUTION

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

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

To achieve this protection, connect a main fuel valve voltage free contact to the 'BURNER INPUT' terminals 10 & 11. When the main fuel valve is open, the voltage free contact should be closed. For installations where there is no risk of explosion, connect a link between terminals number 10 & 11.



Heater Supply Interlock Connection for Heated Probes

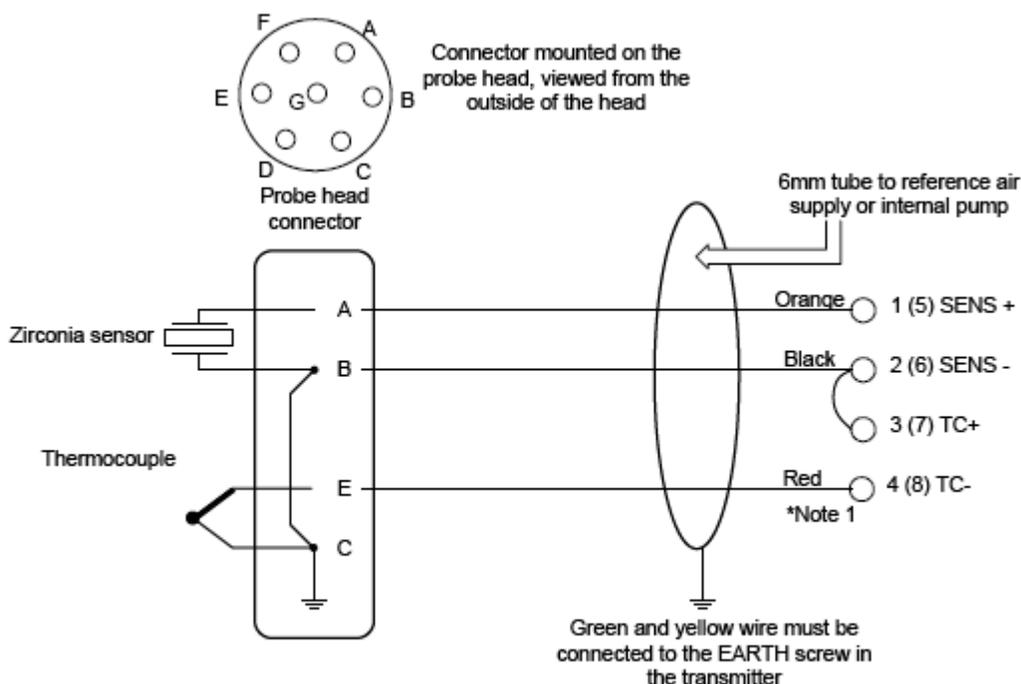
If a safety interlock is not required, a wire must be connected between terminals 10 & 11 to enable –

- The heaters on heated probes
- Process alarms
- Auto-purge and auto-cal checking
- Run time timer

4.7 CONNECTING AN OXYGEN PROBE CABLE

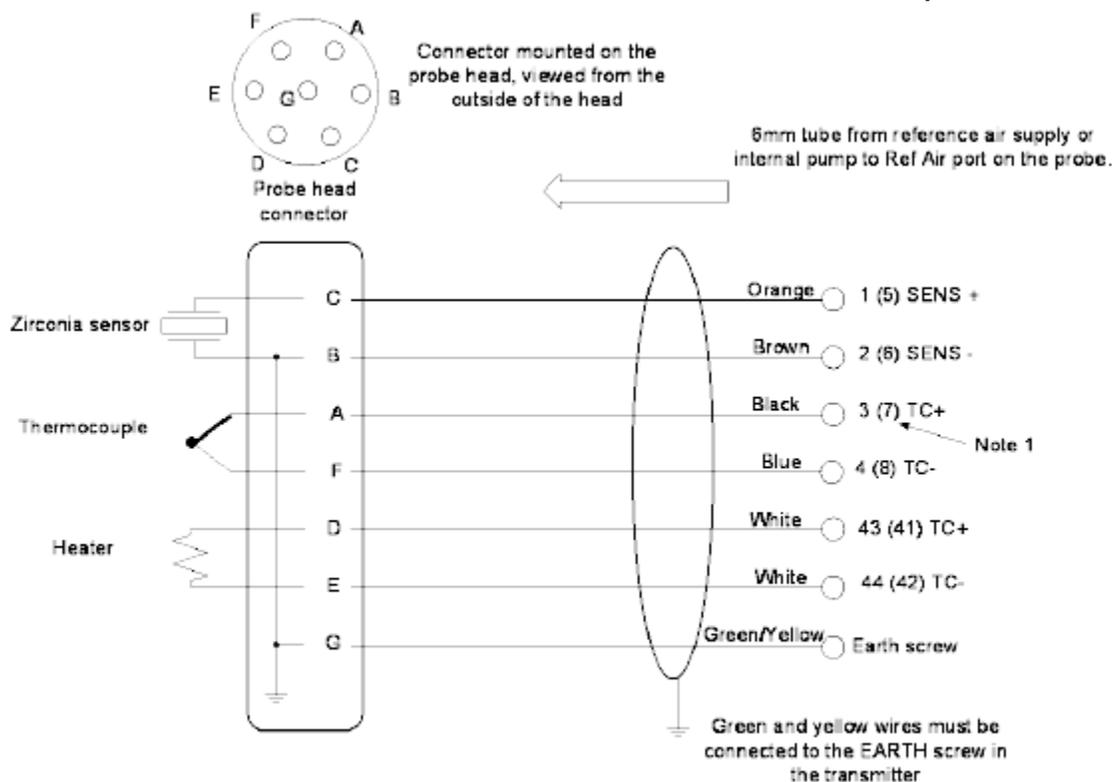
Connect the probe lead as shown in the following drawings. Unheated probe leads have integral reference air tube. An adaptor has been supplied to connect this tube to quarter inch flexible PVC tubing, from the air pump or reference air supply.

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Note 1: Jumper terminal 4 to 8 if efficiency or flue temperature display is required.
Use copper wire.

Connection of Probe Cable for Unheated Probes Models 9060UL/UH.



Note 1: Numbers in the brackets are the connector numbers if the probe is to be connected as probe #2.

Connection of Probe Cable for Heated Probes Model 9060H .

4.8 CONNECTING THE AUXILIARY THERMOCOUPLE (OPTIONAL)

For 9060H 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 either a K, J, R or S type thermocouple. It is optional. If the auxiliary temperature or combustion efficiency is not to be displayed or transmitted, then an auxiliary thermocouple is not necessary. The thermocouple should be connected to terminals 7 & 8. These terminals will not be available for an auxiliary thermocouple if a second probe has been installed.

4.9 CONNECTING THE OUTPUT CHANNELS

The two 4 to 20 mA DC output channels are capable of driving into a 1000Ω load. The output terminals are 12 & 13 for channel 1, and 14 & 15 for channel 2.

4.10 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 chapter 9.2. Each relay has normally open contacts. The contacts will open in alarm condition. Relays are connected as follows:

Relay Common Alarm	Terminal Numbers 26 & 27	
Alarm 1	28 & 29	
Alarm 2	30 & 31	
Alarm 3	32 & 33	
Common Alarms All of the following conditions will cause a common alarm -		
Probe 1 (2) Heater Fail	Ref Air Pump Fail	Heater 1 (2) SSR Failure
Probe 1 (2) High Impedance	ADC Calibration Fail	Heater SSR Leakage
Probe 1 (2) TC Open Circuit	Alarm Log Fail	Probe 1 (2) Filter Blocked
Aux TC Open Circuit	Output 1 (2) Failure	Gas 1 (2) Calibration Error
		BGRAM Fail

The watchdog timer is a special alarm. There will not be an alarm message displayed, but the transmitter will reset.

Alarms can be accepted by pressing the alarm button (viewing the alarm messages).

Alarm relay 2 to 4 Select any one or all of the following for each relay. Refer chapter 9.

In addition, any of the selections that are removed from the common alarm relay can be added to relays two to four.

High oxygen 1 (2)

Probe 1 (2) temperature low

Low oxygen 1 (2)

Calibration check 1 (2) in progress

Very low oxygen 1 (2)

Probe 1 (2) purge in progress

Oxygen deviation

4.11 CONNECTING THE AUTOMATIC PURGE AND 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 transmitter before working with the purge and calibration solenoid valves.

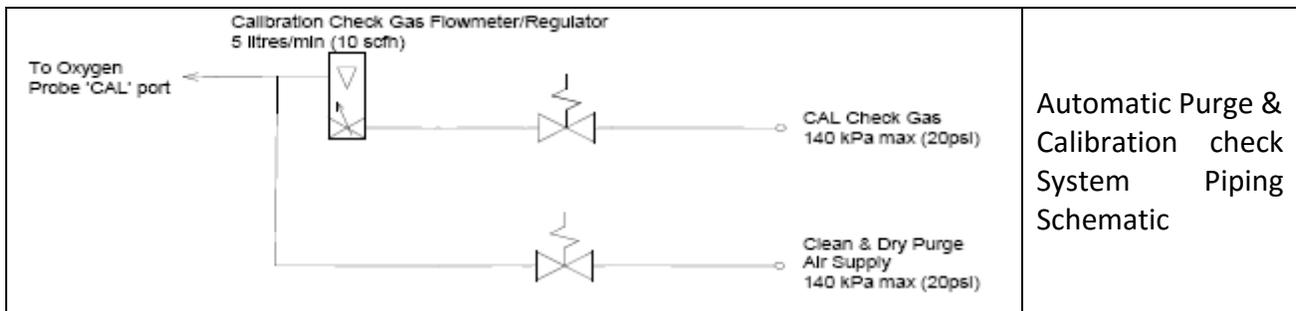
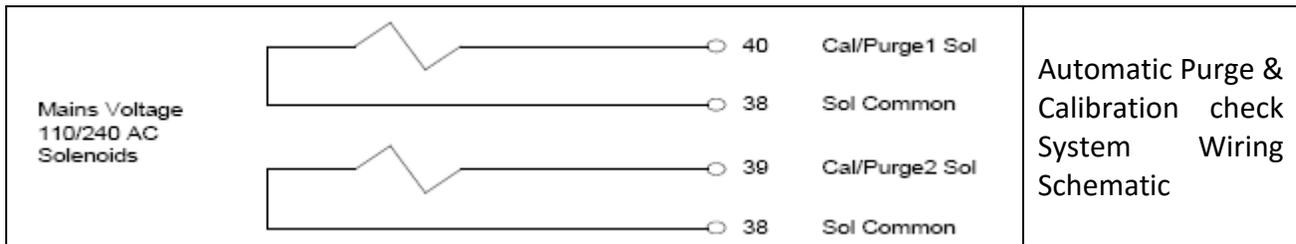
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The on-line auto purge and calibration check system is optional. For details on its operation see chapters 4.24, 4.25 and chapter 11.

To automatically sense a blocked probe filter, a flow switch should be installed in the 'purge' line to the probe 'CAL' port. It should be adjusted so that it energizes just below the purge flow with new or clean filters installed. The flow switch contacts should be connected to terminals 16 & 17 (FLOW SW). If the filter is still blocked or partly blocked after an auto purge cycle, the flow switch will not energize and will therefore cause a 'Probe1 (2) Filter Blocked' alarm.

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

If probe/filter purging is required but a "Probe1 (2) Filter Blocked" alarm is not required, do not install the flow switch but link terminals 16 & 17.



4.12 CONNECTING REFERENCE AIR

For oxygen probes, a 1/4" tube connector on the transmitter 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" fitting must be supplied to provide reference air supply to both probes.

4.13 CONNECTING THE TRANSMITTER TO A MODBUS™ NETWORK

The transmitter can be networked to other transmitters and to a network master. The network uses the transmitter's RS485 port. Up to 31 transmitters can be connected to the network, and can be interrogated by the Network Master.

NOTE: Hardware Protocol Selection The communications port of the 9060Z can be configured to communicate on either RS232 or RS485. If the transmitter is to be used on a MODBUS network, the 9060Z transmitter must be set to RS485. For further details see chapter 7.2.25, Communication Port Options.

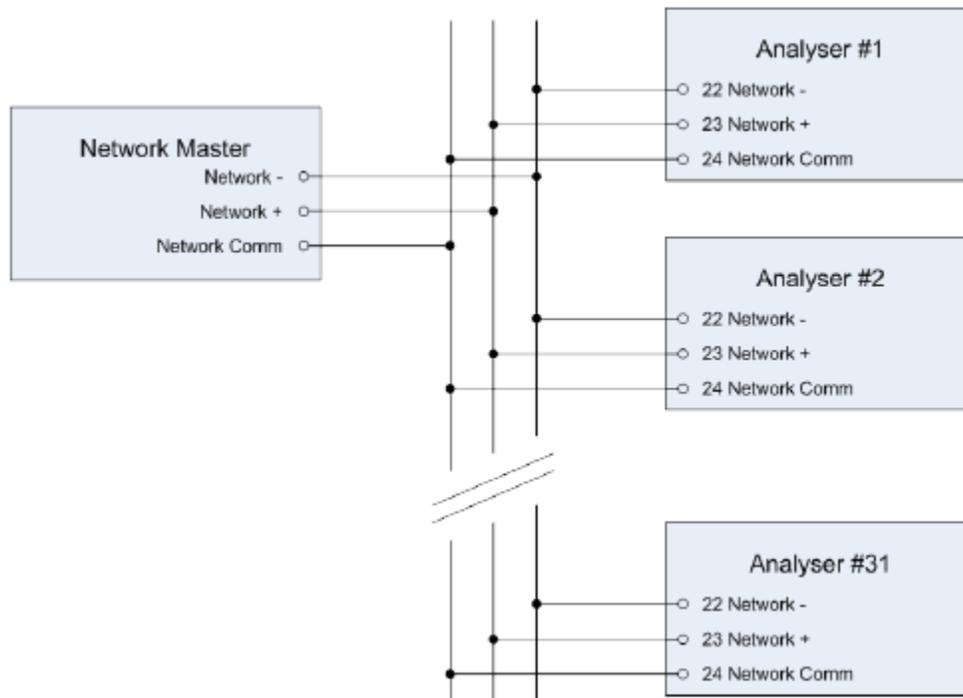
NOTE: Terminating Resistor There is a terminating 100 ohm resistor fitted to the 1732-1 PCB. Link LK3 (TERM), in the bottom left-hand corner of the PCB, is used to connect the terminating resistor. Link LK3 must be removed on all transmitters except the transmitter on the end of the network line. If the

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network line from the transmitters is taken from the middle of the transmitter network string, a terminating resistor should be enabled with LK3 at each end of the network line.

The MODBUS™ protocol of the network is –	
Baud Rate	19,200
Parity	Even
Stop Bits	1
RS485	2-wire (half duplex)
Mode	RTU (binary mode)

For more details see Appendix 5.



4.14 ONNECTING POWER

Before commissioning the probe, sensor or transmitter, read the CAUTION paragraphs at the front of this manual. The green & yellow EARTH wire MUST be connected to earth.

4.15 COMMISSIONING - RUN MODE

When the transmitter 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 '% OXYGEN'. If the probe or sensor temperature is not above 650°C (1200°F), a "Probe Low Temperature" message is flashed on the lower line. The probe or sensor temperature can be checked on the lower line of the display.

4.16 PROBE OR SENSOR CALIBRATION

The zirconia sensor provides an absolute measurement of oxygen partial pressure. There are no calibration adjustments, apart from 'Probe 1 Offset', for the probe. The zirconia sensor EMF is either correct or it needs to be replaced. To check that the probe is functioning correctly, first check that the

high impedance alarm, 'Probe 1 (2) High Impedance', is not active. The actual impedance can be displayed on the lower line. It should be less than 9 K Ω at 720°C (1320°F).

Once it has been established that the impedance is normal, the offset may be set using the millivolt value marked on the oxygen probe. See chapter 6.3.1, Probe Offset. 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 offset. If the probe is in the process, the air must fully purge the probe sensor without interference from the process gas sample. Teledyne Analytical Instruments probes can easily achieve this with or without a probe filter and a gas flow of only 1 to 5 SLPM (2 to 10 SCFH) for a 9060H probe and up to 20 SLPM (40 SCFH) for an unheated probe. When a stable oxygen reading has been achieved, read the 'Probe EMF'. Enter this value into the set-up menu #1 for the probe 1 (set-up #2 for the second probe if it is installed).

4.17 FILTER PURGING

Purging probe filters is controlled from the 'GAS/PURGE' buttons on the transmitter when in 'RUN' mode. If 'Automatic' has been selected in either 'Sol. 1 Auto/Man' or 'Sol. 2 Auto/Man' in Commissioning Menus 21 or 30, pressing the GAS/PURGE button will start the automatic cycle. Pressing the button again will cancel the auto purge cycle. If 'Automatic' was not enabled, the solenoid will only stay open for as long as the button is pressed. 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).

4.18 CALIBRATION GAS CHECK

If the installation has a filter purge facility, set this up first. Refer to the previous paragraph. Press the 'GAS/PURGE 1' or 'GAS/PURGE 2' 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 airflow. The flow required is 1 to 5 SLPM (2 to 10 SCFH) for a 9060H probe and up to 20 SLPM (40 SCFH) for an unheated probe.

Air is not the best gas for calibration checking on a zirconia sensor. The output of a zirconia sensor with air on both sides of the sensor 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 2% oxygen in nitrogen is a commonly used calibration gas. The maximum pressure on the calibration check gas cylinder regulators is 100 kPa (15 psi).

Note: If 'Dual probe' was selected in commissioning menu 4, 'Cal Gas 2' must be connected to probe 2.

4.19 DUST IN THE FLUE GAS

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

For heated probes the preferred method of mounting for dust-laden applications is facing vertically

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

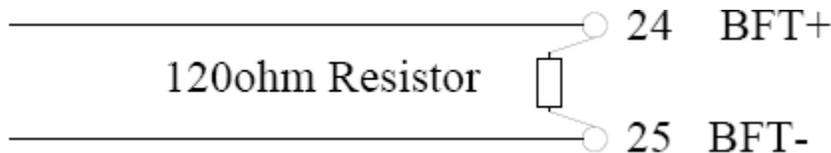
Normally heated probes are supplied with filters for applications with particulates in the flue gas. The probe response time should be tested when the probe is first installed, and then regularly until it remains constant for a significant period. Filter purging should be set up on the time periods determined by these tests. To test the probe response time, use a stopwatch to obtain the time for a probe to achieve a 63 % change from one reading to another. If a probe filter blocks completely in a short period of time, then there is no option but to use the probe without the filter. A trial probe with filter can be installed to test whether a filter blockage is likely to occur.

4.20 STRATIFICATION

If the transmitter and probe have been fully tested and the oxygen readings in the flue gas are incorrect, gas stratification may be occurring. The phenomena cannot be anticipated for any particular installation. Generally, large flues have oxygen differences of approximately one percent across the flue. Occasionally an oxygen error of several percent may occur in a flue of any size. Moving the probe to a new location normally solves this problem. The effects of stratification can be reduced by using two probes and averaging the two oxygen readings. This can be achieved within a Teledyne Analytical Instruments 9060Z transmitter controlling two probes.

4.21 CONNECTING A PRESSURE TRANSDUCER

If the process gas pressure varies more than 4" WG and therefore requires automatic compensation, connect a pressure transducer as shown below. Place a link across LK2, near to the input terminals 24 & 25. If the link is not populated, you can achieve the same thing connecting a 120Ω resistor across the two terminals. A pressure change of 4" WG will cause a change in the calculated oxygen reading of approximately 1%.



There are no calibration adjustments for the zero or span of the pressure transducer input. Set the transducer scale range in the commissioning menu - See Section 7.2.8. The pressure can be displayed on the lower line by enabling the corresponding option. See Section 6.3.2.

5. DISPLAY AND KEYPAD

Operator interaction with the oxygen transmitter is done through a graphical display and 8 keys on the front of the case. The five LED indicators are used to show the status of the transmitter and to alert the operator of any errors.

Each of the keys has a dual function;

The BLACK text printed on the key is the function while the transmitter is in the RUN mode

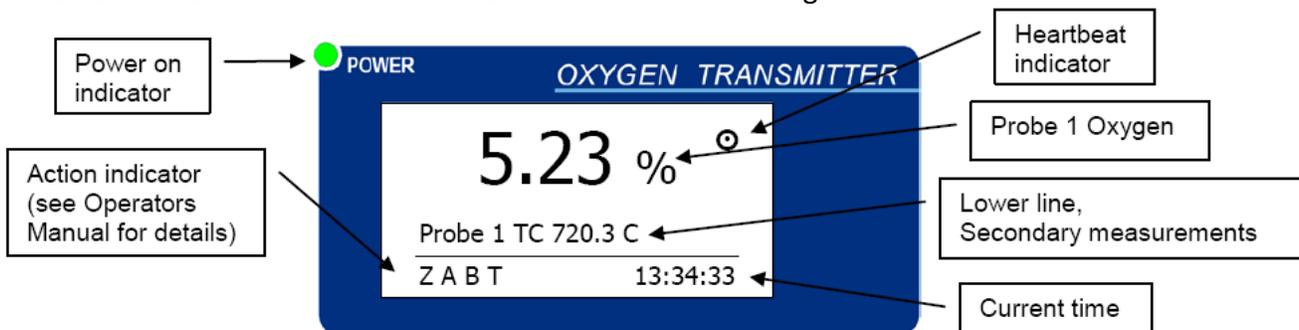
The WHITE text printed on the key is the function in one of the three configuring menus, (SETUP, COMMISSIONING and CALIBRATION)

The menu driven modes are accessed by pressing, and in some cases holding down, the SETUP key (see chapters 6, 7 and 8 for details of these modes). The transmitter will return to the RUN mode when the SETUP key is pressed again, or if 60 seconds has elapsed since the last key was pressed.



5.1 Graphical Display

In RUN mode the 9060Z shows the first oxygen probe measurement in large characters at the top of the display and a user selectable lower line in smaller characters below. Other items on the display include the activity heartbeat indicator in the top right corner, a row of single letter action indicators in the bottom left corner and the current time in the bottom right corner.



In SETUP mode the RUN display is replaced with a menu driven interface. All other functions of the transmitter (reading, calculating and transmitting etc) aside from the keypad and display will continue to operate as normal.

5.2 OXYGEN DISPLAY UNITS

The measured oxygen content displayed on the top line of the transmitter for probe 1 and on the lower line for probe 2 can be shown in either % or parts per million (ppm). See chapter 6.3.3 Oxygen Display Units for how to change the oxygen display.

The format of the oxygen display changes to maintain the best resolution for the measurement.

If 'Oxygen %' is selected the transmitter will display oxygen in the following format:

Range	Display format
30.0 to 100.0%	##.##%
1.00 to 29.99%	##.###%
0.100 to 0.999%	#.####%
< 0.100%	scientific notation (#.## x 10 - ## %)

If 'Oxygen ppm' is selected the transmitter will show the oxygen in ppm format between 10 and 9,999ppm. Outside of this range the oxygen will be shown in % format described above.

Display format for 'Oxygen ppm':

Range	Display format
> 10,000ppm (1%)	% format (see 'Oxygen %' section above)
1,000 to 9,999ppm	#,### ppm
100.0 to 999.9ppm	###.# ppm
10.00 to 99.99ppm	##.## ppm
< 10ppm	scientific notation (#.## x 10 - ## %)

5.3 KEYPAD

There are eight keys built into the decal on the outside of the door of the 9060Z transmitter. The key functions are written in BLACK and WHITE to identify the function of the key in either RUN mode or SETUP mode.

Key text	RUN mode (WHITE text)	SETUP mode (BLACK text)
SETUP / RUN	Enter SETUP mode	Return to RUN mode
DISPLAY / FUNCTION UP	Display Next Lower Line Item	Next Function
DISPLAY / FUNCTION DOWN	Display Prev. Lower Line Item	Previous Function
ALARM / OPTION UP	Next Alarm	Next / Increment Option
ALARM / OPTION DOWN	Previous Alarm	Previous / Decrement Option
ALARM ACCEPT / ENTER	Acknowledge Displayed Alarm	Save Current Option
GAS 1 PURGE 1 / SENS IMP	Gas 1 / Purge 1 manual activate	Check Probe impedance
GAS 2 PURGE 2 / AUTO CAL	Gas 2 / Purge 2 manual activate	Manually Activate Output Calibration

5.3.1 Keypad in RUN mode

When the transmitter is turned on and has completed its start-up procedure, it will enter RUN mode and enable the keypad. The key functions in this mode are as follows;

SETUP / RUN key

Pressing this key will put the transmitter into one of the menu-driven SETUP, COMMISSIONING or CALIBRATION modes (see chapters 6, 7 and 8 for details). The function of all the keys will then change to the functions that they have in the SETUP mode.

DISPLAY UP / DOWN keys

The display keys are used to scroll the lower line up and down through the variety of measurements that are available on the lower line. For a complete list of options see chapter 6.3.2, Lower Line Items.

ALARM UP key

If there is either a new alarm or an active alarm the ALARM UP key can be pressed to examine the alarm status. The alarm light will be flashing if there is a new alarm or steady if there is an existing alarm. For more details on the alarm mode and keys see chapter 9, Alarms. The SETUP light will flash slowly to show that the transmitter is now in the alarm display mode.

ALARM DOWN key

When the transmitter is displaying active alarms (the ALARM UP key has been pressed), the ALARM DOWN key and the ALARM UP key allow the operator to examine the date / time of the alarm and the date / time that the alarm was acknowledged.

If the transmitter was in RUN mode when this key is pressed it will go into the alarm log display mode. See chapter 9 for more details.

ALARM ACCEPT key

The ALARM ACCEPT key is used to accept a new alarm (see chapter 9, Alarms).

GAS 1 / PURGE 1 and GAS 2 / PURGE 2 keys

These two keys are used to turn on the gas / purge solenoids. When the transmitter is in the manual cal / purge mode (Commissioning functions #21 and 30) the solenoid will be activated for as long as the key is pressed. When the transmitter is in the auto cal / purge mode the automatic cal / purge cycle is started. The cycle can be stopped by pressing the same key again.

5.3.2 Keypad in SETUP / COMMISSIONING / CALIBRATION modes

<p>NOTE: In order to enter either COMMISSIONING or CALIBRATION modes, the corresponding DIP switch on the 1732-1 PCB must be turned on.</p>
--

From RUN mode, if the SETUP / RUN key is pressed once, the transmitter will go into the SETUP mode.

From RUN mode, if the SETUP / RUN key is pressed and held for 2 seconds, the transmitter will go into the COMMISSIONING mode.

From RUN mode, if the SETUP / RUN key is pressed and held for 4 seconds, the transmitter will go into the CALIBRATION mode.

The following key functions are then available in all of the above modes.

SETUP / RUN key

Pressing the SETUP / RUN key while in any of the set up modes will return the transmitter to the RUN mode.

FUNCTION up and FUNCTION down keys

These two keys allow for the selection of the setup function. A function summary table is found at the start of the relevant SETUP, COMMISSIONING or CALIBRATION mode chapter.

OPTION up and OPTION down keys

These two keys allow for changing the option for the selected function. A list/range of options for each function is found in the function summary table at the start of the relevant SETUP, COMMISSIONING or CALIBRATION mode chapter.

ENTER key

The ENTER key sets the currently displayed option and stores the value in non-volatile memory to be retrieved on device start up. If the ENTER key is not pressed when a new option is chosen, the previous option will be retained.

Probe impedance key

When this key is pressed the transmitter will measure the impedance of oxygen sensor(s) attached to the transmitter. If the burner is not enabled (terminals 10 & 11) or the probe temperature is below 700°C (1292°F) impedance checking will not be performed. A 'Z' will be seen in the bottom left hand corner of the display as the test is performed.

Auto calibrate key

When this key is pressed the transmitter will calibrate the analogue output channels that are set to auto calibration (see chapter 10). This is performed by directing the output current away from the output terminals (terminals 12&13 and 14&15) back to an analogue input to the transmitter in order to calculate a zero and span calibration factor for each of the output channels.

During this process normal output to the analogue channels will be interrupted sending the outputs to zero mA.

6. SETUP MODE

The SETUP mode is mode is accessed by pressing the SETUP key momentarily so the words 'Setup Mode' appear at the bottom of the display. The transmitter will return to the RUN mode when the SETUP key is pressed again or 60 seconds after the last key press.

6.1 FUNCTION SUMMARY TABLE

When the transmitter is in the SETUP mode the SETUP light will be on and the words "Setup Menu" will be shown at the bottom of the display.

The following table shows the SETUP functions:

Menu #	Function name	Range	Default value
1	Probe 1 Offset	-6.0 to +6.0mV	0.0mV
2	Probe 2 Offset	-6.0 to +6.0mV	0.0mV
3	Lower Line Items	See Chapter 6.3.2	
4	Oxygen Display Units	Oxygen % / Oxygen ppm	Oxygen %
5	Damping Factor	No Damping to 10 Samples	5 Samples
6	Process Alarms	Enabled / Disabled	Disabled

6.2 CHANGING OPTIONS

The purpose of having a menu driven SETUP mode is to allow for configuration of the transmitter using the graphical display and keypad.

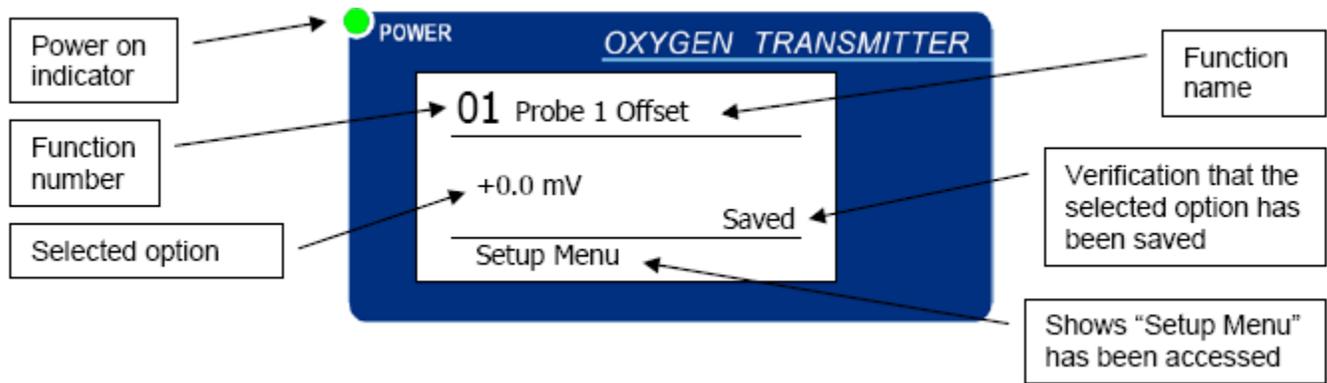
Once an option is changed and entered using the ENTER key that value immediately becomes active. It is also stored into the non-volatile memory within the BBRAM and will be loaded again at device start-up. To reset the transmitter configuration defaults see chapter 10.2, Cold Start.

To change an option in the SETUP menu system:

1. Select the SETUP mode by pressing the SETUP / RUN key once. The SETUP light will come on and the display will have the format shown below. The operations of the keys are now the operations written in WHITE on the keypad. The menu name is written at the bottom of the display.
2. When the SETUP mode has been selected the required function can be found by using the FUNCTION UP and FUNCTION DOWN keys.
The options available for that function can be seen by using the OPTION UP & OPTION DOWN keys.
3. When the required option is on the display press the ENTER key to save that value.

When finished, press the SETUP / RUN key to return to the RUN mode.

6.3 SETUP MODE FUNCTIONS



6.3.1 Probe 1 Offset

Each Teledyne Analytical Instruments probe has an offset calibration value printed on a tag that is attached to the probe when it is dispatched. To achieve accurate measurement the offset value must be entered with the same polarity as it is printed on this label. The offset value should be within $\pm 1.0\text{mV}$

NOTE: An offset of 1.0mV will change the oxygen reading by approximately 1% oxygen when the probe is in ambient air. However, as the process oxygen measurement drops, this offset will have a reduced affect. At a process gas oxygen concentration of 2%, the 1.0mV offset error will only change the reading by 0.1% oxygen.

If in any doubt about the correct offset value, set it to 0.0mV.

The function 'Probe 2 Offset' will only appear if the transmitter has been configured for 2 probes. (see chapter 7.2.3 Number of Probes)

6.3.2 Lower Line Items

This function allows the operator to change the items that are available to be displayed on the lower line of the transmitter in RUN mode. If the word "Enabled" appears on the display for a selected lower line option, the measurement will be available to be shown on the display in the RUN mode by scrolling through the list using the DISPLAY UP and DISPLAY DOWN keys.

A lower line measurement can be "Enabled" or disabled by pressing the ENTER key.

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OPTIONS:	Enabled as Default
1	Temperature, probe #1 *
2	Temperature, probe #2 *
3	Sensor EMF, probe #1 *
4	Sensor EMF, probe #2 *
5	Sensor impedance, probe #1 *
6	Sensor impedance, probe #2 *
7	Oxygen, probe #2 *
8	Oxygen, Average probe 1 and probe 2 *
9	Auxiliary thermocouple temperature
10	Ambient temperature *
11	Ambient relative humidity
12	Oxygen deficiency, probe #1
13	Oxygen deficiency, probe #2
14	Combustibles, probe #1
15	Combustibles, probe #2
16	Maximum theoretical dry CO, probe #1
17	Maximum theoretical dry CO, probe #2
18	Combustion efficiency (requires "Single probe" and "Aux TC Type" to be set)
19	Flue Pressure
20	Burner run time
21	Service date
22	Analog Output 1 4-20mA
23	Analog Output 2 4-20mA

NOTE: An asterisk (*) on the end of the line identifies the item is enabled by default after a COLD-START.

6.3.3 Oxygen Display Units

The top line of the display that shows the oxygen measurement can be displayed in either % or ppm (see chapter 5.2 Oxygen Display Units)

6.3.4 Damping Factor

The oxygen measurement can be damped by averaging successive readings from the probe. This will smooth out fluctuations in the process gas level and will slow down the reaction time of the transmitter. The larger the number selected here, the more successive readings are averaged and the smoother the measurement will be. The damped oxygen value is also used in the calculation of all other parameters that are based on the oxygen value.

6.3.5 Process Alarms

This function allows the operator to enable and disable process alarms. The process alarm menu functions will also be hidden if the process alarms are disabled. (See also chapter 7.2.19, Process Alarms)

7. COMMISSIONING MODE

This chapter describes the functions available when the COMMISSIONING mode is entered on the transmitter.

The COMMISSIONING mode is accessed by pressing and holding the SETUP key for approximately 2 seconds until the words “Commissioning Menu” appears at the bottom of the display. The transmitter will return to the RUN mode when the SETUP key is pressed again or 60 seconds after the last key press.

Changing options in the COMMISSIONING mode is the same as the SETUP mode. See chapter 6.2, Changing Options.

7.1 FUNCTION SUMMARY TABLE

When the transmitter is in the COMMISSIONING mode the SETUP light will be on and the words “Commissioning Menu” will be shown the bottom of the display.

The following table shows the COMMISSIONING menu functions:

Menu #	Function name	Range	Default value
01	Internal Clock Date	-	
02	Internal Clock Time	-	
03	Service Date	-	
04	Number of Probes	Single / Dual Probe	Single Probe
05	Probe 1 Type	9060H	9060H Heated
06	Probe 2 Type	OR 9060UL/UH	9060H Heated
07	Probe 1 TC Type	K, J, R or S Types	K-Type
08	Probe 2 TC Type	K, J, R or S Types	K-Type
09	Auxiliary TC Type	K, J, R or S Types, Disabled	Disabled
10	Transmitter Output Channel 1		Linear oxygen
11	Transmitter Zero Channel 1		
12	Transmitter Span Channel 1	See chapter 7.2.7 Transmitter	
13	Transmitter Output Channel 1	Output Channel	Linear oxygen
14	Transmitter Zero Channel 2		
15	Transmitter Span Channel 2		
16	Flue Pressure Units	Inches WG, mm WG, kPa, PSI	Inches WG
17	Flow Pressure Input	Fixed / Variable	Fixed
18	Flue Pressure Value (Fixed)		0 Inches WG
19	Flue Input Zero	-1 to 3 Atm	0 Inches WG
20	Flue Input Span		100 Inches WG
21	Temperature Units	Celsius / Fahrenheit	Celsius
22	Cal Freezes Outputs	Enabled / Disabled	Enabled
23	Solenoid 1 Operation	Calibration Gas / Purge	Calibration Gas
24	Solenoid 1 Auto / Manual	Automatic / Manual	Manual
25	Solenoid 1 Start Time	00:00 to 23:45	00:00 (midnight)

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26	Solenoid 1 Period	1 minute – 7 days	1 hour
27	Solenoid 1 Duration	1 – 90 seconds	30 seconds
28	Solenoid 1 Post Freeze	5 – 300 seconds	60 seconds
29	Oxygen Content Cal Gas 1	0.1 – 20.9%	8.0%
30	Max Cal Gas 1 Positive Error	0.1% to 3.0%	0.5%
31	Max Cal Gas 1 Negative Error	0.1% to 3.0%	0.2%
32	Solenoid 2 Operation	Calibration Gas / Purge	Calibration Gas
33	Solenoid 2 Auto / Manual	Automatic / Manual	Manual
34	Solenoid 2 Start Time	00:00 – 23:45	00:00 (midnight)
35	Solenoid 2 Period	1 minute – 7 days	1 hour
36	Solenoid 2 Duration	1 – 90 seconds	30 seconds
37	Solenoid 2 Post Freeze	5 – 300 seconds	60 seconds
38	O2 Content Calibration Gas 2	0.1% to 20.9%	8.0%
39	Max Cal Gas 2 Positive Error	0.1% to 3.0%	0.5%
40	Max Cal Gas 2 Negative Error	0.1% to 3.0%	0.2%
41	Very Low Oxygen Alarm	0.1ppm to 100%	0.500% (5000 ppm)
42	Very Low Oxygen Alarm Delay	0 to 200 seconds	2 seconds
43	Low Oxygen Alarm	0.1ppm to 100%	2.5%
44	Low Oxygen Alarm Delay	0 to 200 seconds	10 seconds
45	High Oxygen Alarm	0.1ppm to 100%	10.0%
46	High Oxygen Alarm Delay	0 to 200 seconds	60 seconds
47	Oxygen Deviation Alarm	0.1ppm to 100%	2.0%
48	Oxygen Deviation Alarm Delay	0 to 200 seconds	30 seconds
49	Alarm Relay 1 Function	See chapter 9	
50	Alarm Relay 2 Function	See chapter 9	
51	Alarm Relay 3 Function	See chapter 9	
52	Common Relay Function	See chapter 9	
53	Accept Relay Hold	Enabled / Disabled	Enabled
54	Fuel Type Select	See chapter 7.2.23	
55	Fuel Heat / gram C	0.00 to 300.00	209.90
56	Fuel H / C atom ratio	0.00 to 10.00	3.86
57	Fuel O / C atom ratio	0.00 to 10.00	0.00
58	Fuel N / C atom ratio	0.00 to 10.00	0.10
59	Fuel S / C atom ratio	0.00 to 10.00	0.00
60	H2O Mol / C atom ratio	0.00 to 10.00	0.00
61	Reference Air Pump	Internal / External	Internal
62	Internal Pump Voltage	1.5 to 5.0v	5.0v
63	Reference Air RH %	0 to 80%	55%
64	Serial Interface	RS-232 / RS-485 / Disabled	RS-232
65	Serial Baud Rate	9600 – 57600 bps	19200bps
66	Serial Parity	Even / Odd / No Parity	Even Parity
67	MODBUS Address	1 – 246	Disabled (0)
68	Clear Alarm Log	Clear / Don't Clear	Don't Clear

7.2 COMMISSIONING MODE FUNCTIONS

7.2.1 Internal Date / Time

The date and time are used in the transmitter to run time based operations such as impedance readings and gas calibration checks. The correct date and time should be entered by pressing and holding the OPTION UP & DOWN keys. The date and time will change faster the longer the OPTION key is held.

7.2.2 Service Date

The service date can be used to keep a record of when a probe was changed. The RUNTIME timer which keeps a track of the hours and minutes that the transmitter and probe has been operating is reset when the service date is changed.

The service date and the runtime timer can be displayed as lower line items in RUN mode.

7.2.3 Number of Probes

The 9060Z transmitter can operate in single or dual probe mode. By selecting single probe, all dual probe options and alarms will be disabled and second probe options hidden from the user.

If you are using the transmitter as a single probe device you should set the number of probes to 'single probe' to disable all probe 2 alarms and display items.

7.2.4 Probe 1 & 2 Type

The probe type function allows a selection between a heated probe and an unheated probe types. Heater control and alarms will be disabled if unheated probe type is selected.

7.2.5 Probe 1 & 2 Thermocouple Type

The thermocouple type can be set to K, J, R or S. The thermocouple in the Teledyne Analytical Instruments 9060H heated probes are always K type. 9060UL/UH unheated probes are available in R type or S type. Other thermocouple options are made available for special installations.

7.2.6 Auxiliary Thermocouple Type

When the transmitter is operating as a single probe mode, the probe 2 thermocouple input (terminals 7&8) is used as an auxiliary thermocouple input. In dual probe mode this option is unavailable.

Use of an auxiliary thermocouple allows for basic monitoring of temperature as well as enabling the calculation of combustion efficiency. The thermocouple type can be set to K, J, R or S.

7.2.7 Transmitter Output Channel 1 & 2

The 9060Z transmitter has two fully configurable 4-20mA analogue outputs. The channels can be configured independently to output one of several calculated values.

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The following outputs are available on channel #1:

Output	Zero	Span	Step	Min Span	Default
Linear Oxygen	0 to 99%	1 to 100%	1%	1%	0 to 10%
Linear Oxygen Average **	0 to 99%	1 to 100%	1%	1%	0 to 10%
Very Low Oxygen	0 to 19,900ppm	100 to 20,000ppm	10ppm	100ppm	0 to 2%
Logarithmic Oxygen	0.1% fixed	20% fixed	-	-	0.1 to 20%
Reducing Oxygen exp.	+2 to -28	0 to -30	1	2 decades	-1 to 30
Oxygen Deficiency	-10 to 0%	0 to 20%	1%	5%	-5 to 10%
Combustion efficiency *	0 to 80%	20 to 100%	10%	20%	0 to 100%
Combustibles %	0% fixed	0.5 to 2%	0.1%	0.5%	0 to 2%
Max Dry CO %	0 to 10%	5 to 100%	5%	5%	0 to 100%
Probe EMF	0 to 1,400mV	100 to 1,500mV	100mV	100mV	0 to 100mV
Aux TC Temperature *	0 to 1500C	100 to 1600°C	100°C	100°C	0 to 1300°C
No Output	-	-	-	-	-

** Only available in dual probe mode. * Only available in single probe mode.

The following outputs are available on channel #2:

Output	Zero	Span	Step	Min Span	Default
Linear Oxygen	0 to 99%	1 to 100%	1%	1%	0 to 10%
Linear Oxygen Average **	0 to 99%	1 to 100%	1%	1%	0 to 10%
Very Low Oxygen	0 to 19900ppm	100 to 20000ppm	10ppm	100ppm	0 to 2%
Logarithmic Oxygen	0.1% fixed	20% fixed	-	-	0.1 to 20%
Reducing Oxygen 1 e ^x	+2 to -28	0 to -30	1	2 decades	-1 to 30
Oxygen Deficiency	-10 to 0%	0 to 20%	1%	5%	-5 to 10%
Combustion efficiency *	0 to 80%	20 to 100%	10%	20%	0 to 100%
Combustibles %	0% fixed	0.5 to 2%	0.1%	0.5%	0 to 2.0%
Max Dry CO %	0 to 10%	5 to 100%	5%	5%	0 to 100%
Probe EMF	0 to 1400mV	100 to 1500mV	100mV	100mV	0 to 100mV
Aux TC Temperature *	0 to 1500C	100 to 1600°C	100°C	100°C	0 to 1300°C
No Output	-	-	-	-	-

** Only available in dual probe mode. * Only available in single probe mode.

The zero and span of the selected output are set in the following two menus (functions 11&12 and 14&15).

NOTE:

Regarding channel output configuration; both 4-20mA channels are separately isolated and output variables and scaling are individually configured for each channel.

In single probe mode both channel 1 and 2 have identical options, however when the analyzer is configured as dual probe then channel 1 will output process variables relative to probe 1 and channel 2 will output process variables relative to probe 2.

7.2.8 Flue Pressure Units and Value

The 9060Z transmitter is capable of fixed or variable input pressure compensation in the calculation of oxygen from -1 Atm to +3 Atm. If the probe is running in a pressurized environment this value should be set to allow for accurate oxygen measurement. If the flue pressure is constant select 'Fixed' in this function and set the pressure units and value in the proceeding menus. If the pressure varies, select "Variable", and connect a pressure transducer to terminals 24 & 25. (See section 4.23). Set the range of the transducer using a zero and span value in the commissioning menus.

7.2.9 Temperature Units

The display on the transmitter can be changed to show temperature in either Celsius or Fahrenheit scales.

7.2.10 Calibration Freezes Outputs

During gas calibration checks it may be required that the analogue outputs remain frozen at their last reading. When cal freezes is enabled both analogue outputs remain frozen until the entire calibration cycle has completed.

7.2.11 Solenoid 1 & 2 Operation

The two solenoid outputs can be individually configured to perform gas calibration check or probe purge.

Some of the menus between functions 22 to 28 (31 to 37) will not appear depending on what has been selected in function #20 and #21 (29 and 30).

7.2.12 Solenoid 1 & 2 Automatic / Manual

When set to automatic the solenoid will perform a pre-programmed gas calibration or purge cycle. When set to manual the solenoid is controlled directly from the corresponding key on the front of the case. When set to automatic the calibration check or the purge cycle can be started by pressing the corresponding key on the front of the case. It can be stopped by pressing the same key again.

7.2.13 Solenoid 1 & 2 Start Time

For automatic gas calibration checking or purge events a start time is specified to allow precise control over the timing of such events. Starting at this specified time, the next gas calibration or purge event will occur in successive intervals from this time.

7.2.14 Solenoid 1 & 2 Period

This option specifies the period between automatic gas calibration or purge events. For periods less than 24 hours the period is divisible into 24 hours forcing scheduling of events to occur at the same time each day between 1 minute and 7 days.

The 'No Timed Operation' option accessible by scrolling the option below 1 minute allows for pre-configured solenoid cycles to be triggered manually via the keypad, but without the automatic scheduling.

7.2.15 Solenoid 1 & 2 Duration

Duration of time that an automatic gas calibration or purge event energizes the solenoid

7.2.16 Solenoid 1 & 2 Post Freeze

Duration of time the transmitter waits before resuming live readings following a gas calibration or purge event. (See also chapter 7.2.10)

7.2.17 Oxygen Content Calibration Gas 1 & 2

When configured as a gas calibration check solenoid this value specifies the oxygen content of the calibration gas.

7.2.18 Maximum Calibration Gas 1 & 2 Positive / Negative Error

Specifies the maximum positive & negative error levels used during the gas calibration check. If the difference between the specified oxygen content and the measured process gas exceed these thresholds, a gas calibration error alarm will be triggered immediately.

7.2.19 Process Alarms

The oxygen measurements are continuously monitored by the transmitter for process alarm conditions (Process alarms must be enabled in the Set up menu). The limits and the alarm time delays are configurable for the Very Low Oxygen alarm, Low Oxygen alarm, High Oxygen alarm and the Oxygen Deviation alarm.

7.2.20 Alarm Relay 1, 2 and 3 Function

There are 3 user configurable alarm relays. Any of the 3 relays can be configured to be triggered on the following alarm conditions. In addition, any of the alarm conditions that are disabled from the common alarm relay can also be configured to trigger these 3 relays. Multiple selections can be made.

Process Alarms	
Oxygen 1 Low	Probe 1 Temperature Low
Oxygen 2 Low **	Probe 2 Temperature Low **
Oxygen 1 Very Low	Calibration 1 In Progress
Oxygen 2 Very Low **	Calibration 2 In Progress **
Oxygen 1 High	Purge 1 In Progress
Oxygen 2 High **	Purge 2 In Progress **
Oxygen Deviation	

7.2.21 Common Alarm Relay Function

The common alarm relay can be configured to be triggered on any of the following:

Instrument Alarms		
Probe 1 Heater Fail	Reference Air Pump Fail	Heater SSR Leakage
Probe 2 Heater Fail **	Reference Air Pump Overload	Probe 1 Filter Blocked
Probe 1 High Impedance	Alarm Log Fail	Probe 2 Filter Blocked **
Probe 2 High Impedance **	Output 1 Fail	Gas 1 Calibration Error
Probe 1 Thermocouple Open Circuit	Output 2 Fail	Gas 2 Calibration Error **
Probe 2 Thermocouple Open Circuit **	Heater 1 SSR Fail	
Auxiliary Thermocouple Open Circuit	Heater 2 SSR Fail	

**** Are only available in dual probe mode.**

All of the items in this list are selected as the default setting. Any of these items can be disabled from the common alarm by pressing the ENTER key, and they will then appear on the list in the other alarm relays.

7.2.22 Operation of the Alarm Relays when an Alarm is Accepted

An option is available to in the commissioning menu to change the operation of the alarm relay when an alarm has been accepted. The states for the alarm relay contacts are shown in the following table –

Alarm state	Accepted Relay hold setting- Enabled	Accepted Relay hold setting- Disabled
No alarm condition	Closed circuit	Closed circuit
New alarm	Open circuit	Open circuit
All alarms accepted	Open circuit	Closed circuit
Alarms self cleared	Closed circuit	Closed circuit

The default setting is 'Enabled' after a cold start.

7.2.23 Selecting the Correct Fuel

The 9060Z transmitter can calculate several measurements that are based on the oxygen reading and the temperature of the process gas. These calculations also require some details about the chemical makeup of the fuel. The additional calculations are:

Oxygen deficiency	The volume of oxygen required to bring the combustion back to stoichiometry
Combustibles	This theoretical scale is equivalent to a combustibles analyzer
Carbon dioxide (maximum dry)	The calculated maximum level of CO ₂ in the combustion gas
Combustion efficiency	Requires a stack thermocouple and so is only available in single probe mode

Select the required fuel in function 50 by using the OPTION keys and then press the ENTER key. The table of values in the next 6 functions will be updated for that fuel.

7.2.24 Reference Air Pump Options

Normally the reference air is supplied from the transmitter using the internal pump. The default option is 5.00v.

	Function	Options
57	Reference Air Pump	External or Internal
58	Internal Pump Voltage	Pump voltage setting, between 2.5 and 5.00 in 0.25v steps
59	Reference Air RH%	If external is selected, set the RH level. (5% if instrument air is used)

7.2.25 Communications Port Options

The 9060Z transmitter has a serial communications port available at terminals 18 to 22. The default protocol is for RS-232 running at 19,200 baud rate with 8 bits, Even parity and 1 stop bit.

	Function	Options
60	Serial Interface	RS-232 or RS-485 (Use RS-485 for MODBUS)
61	Serial Baud Rate	9600, 19200, 38400, 57600 (RS-232 up to 19200 only)
62	Serial Parity	Even, Odd or No Parity
63	MODBUS Address	Set the MODBUS address for this device between 1 and 246. 0 is to disable the MODBUS

7.2.26 Alarm Log Clearing

Every alarm that is instigated internally in the transmitter or as a process level is recorded in the alarm log with the activation time, accepted time and the cleared time. The last 4000 events will be recorded and then the oldest alarms will be dropped off as new ones occur. If you would like to delete the log recording select CLEAR in SETUP step 64 by using the OPTION keys and press the ENTER key. The message "Alarm Log Cleared" will be displayed.

8. CALIBRATION MODE

This chapter describes the functions available when the CALIBRATION mode is selected on the transmitter.

For specific information about calibrating the transmitter see chapter 10, Instrument Calibration.

The CALIBRATION mode is accessed by pressing and holding the SETUP key for approximately 4 seconds until the words “Calibration Menu” appears at the bottom of the display. The transmitter will return to the RUN mode when the SETUP key is pressed again or 60 seconds after the last key press. Changing options in the CALIBRATION mode is the same as the SETUP mode. See chapter 6.2 Changing Options.

8.1 FUNCTION SUMMARY TABLE

When the transmitter is in the CALIBRATION mode the SETUP light will be on and the words “Commissioning Menu” will be at the bottom of the display. The following table shows the CALIBRATION menu functions:

Menu #	Function name	Range	Default value
1	Reference Voltage 1, 50mV	40.00 to 60.00mV	47.14mV
2	Reference Voltage 2, 200mV	180.00 to 210.00mV	182.24mV
3	Reference Voltage 3, 1200mV	1150.0 to 1250.0mV	1221.8mV
4	Reference Voltage 4, 2500mV	2400.0 to 2550.0mV	2489.2mV
5	Output Channel 1, Calibration	Auto Calibrated Manual Calibrated Set 4mA Set 20mA	Auto Calibrated
6	Output Channel 1, 4mA Trim	3.00 to 5.00mA	4.00mA
7	Output Channel 1, 20mA Trim	19.00 to 21.00mA	20.00mA
8	Output Channel 2, Calibration	Auto Calibrated Manual Calibrated Set 4mA Set 20mA	Auto Calibrated
9	Output Channel 2, 4mA Trim	3.00 to 5.00mA	4.00mA
10	Output Channel 2, 20mA Trim	19.00 to 21.00mA	20.00mA
11	Ambient Temperature Sensor Offset	-10.0°C to 10.0°C	0.0°C
12	Low Oxygen Cal 1	80.0% to 120.0%	100.00%
13	Low Oxygen Cal 2	80.0% to 120.0%	100.00%
14	Transmitter Output Select	4-20mA / 0-20mA / 4-20mA over- scale limit / 0-20mA over scale limit	4-20mA
15	Transmitter Output Limiting	Disabled / Hold 0mA / Hold 4mA / Hold 20mA	Hold 0mA
16	Mains Voltage Detection Override	Automatic / 220/240 / 10/120	Automatic
17	Mains Frequency Detection Override	Automatic / 50Hz / 60Hz	Automatic
18	Heater SSR Selection Normal	Heater1 <-> Heater2 Heaters <-> Cal Purge	Normal
19	SSR Fail Protection	Enabled / Disabled	Enabled

8.2 CALIBRATION MODE FUNCTIONS

8.2.1 REFERENCE VOLTAGES

The calibration of the analogue inputs is based on the voltage of a temperature compensated voltage reference integrated circuit. There are 4 voltages generated from the standard reference voltage. They will vary by about 1% from one transmitter to another but can be trimmed by setting the actual voltages into CALIBRATION menu functions #1 to 4. These voltages should be measured and the reference voltage entries in the menu checked every year.

8.2.2 OUTPUT CHANNEL 1 AND 2 CALIBRATION

The output 4-20mA calibration can be set either AUTOMATICALLY (default) or MANUALLY. If Auto Calibrated is selected the transmitter will go through an output calibration cycle when the power is turned on or when the AUTO CAL button is pressed in SETUP mode. This will divert the outputs back to the input and automatically set the 4mA and 20mA calibration.

If Manually Calibrated is selected then the 4mA and 20mA calibration must be set in the next two functions. For the full explanation see chapter 10.1.2.

8.2.3 AMBIENT TEMPERATURE CALIBRATION

The ambient temperature measurement is used as the cold junction temperature for the thermocouple measurements. Use an independent temperature sensor to measure the temperature inside the transmitter case near the screw terminal #1. Enter this temperature into the calibration function 11 by using the OPTION keys and then the ENTER key.

8.2.4 LOW OXYGEN CALIBRATION

The low oxygen calibration factors can be used to fine tune the oxygen calculation at low oxygen readings. It will not affect the measurement at 20.9%. They are included to allow oxygen probes made by other manufacturers to be used on a Teledyne Analytical Instruments transmitter. The default is 100% but can be set to between 80 and 120%.

8.2.5 TRANSMITTER OUTPUT SCALE

The transmitter outputs can be configured to either 4-20mA or 0-20mA. The two scaled outputs are capable of outputting 0-24mA and will transmit over-scale unless the over-scale limit option is selected.

8.2.6 TRANSMITTER OUTPUT LIMITING

If the oxygen reading is invalid the output can be made to be set to 0mA, 4mA or 20mA. An invalid reading is when the probe temperature is below 650°C (1200°F) or the probe thermocouple has been detected as open circuit. The default is to set the output to 20mA but the function can also be disabled.

8.2.7 MAINS VOLTAGE DETECTION

The default setting for the 9060Z transmitter is that it will automatically detect the mains voltage and frequency in order to correctly drive the probe heaters. If there is any uncertainty in this detection system the voltage can be forced to 220-240 or 100-127, and the frequency can be set to 50 or 60Hz.

8.2.8 HEATER SSR FAULT CORRECTION

In the event of one of the heater solid state relays (SSR) failing in single probe mode, the heater drive output can be swapped to the HEATER 2 output. Select “Heater 1<-> Heater 2”.

If you are running in dual probe mode but not using the calibration gas or purge solenoid outputs the solenoid outputs can be swapped to the 2 heater outputs. Select “Heaters <-> CalPurge”. The default setting is “Normal”.

8.2.9 SSR FAIL PROTECTION

The transmitter continuously monitors the high voltage outputs on the solid state relays that power the probe and purge/cal solenoids. If it detects that any solenoids are not switching off correctly then it mechanically isolates all high voltage outputs in order to protect the instrument. This feature can be switched off by setting the SSR fail protection to disabled.

9. ALARMS

The 9060Z has 4 alarm relays and a built in alarm annunciator. If an alarm occurs, the ALARM light will flash. To find out what the alarm is, press the ALARM up key.

When the ALARM up key has been pressed, the transmitter goes into the alarm display mode. In this mode some of the keys take on a special function.

Key text	RUN mode	ALARM mode
SETUP / RUN	*	Return to RUN mode
DISPLAY / FUNCTION up	*	Next alarm
DISPLAY / FUNCTION down	*	Last alarm
ALARM / OPTION up	Enter ALARM display mode	Alarm activated time
ALARM / OPTION down	Enter ALARM log mode	Alarm acknowledged time
ALARM ACCEPT / ENTER	*	Acknowledge alarm
GAS 1 PURGE 1 / SENS IMP	*	*
GAS 2 PURGE 2 / AUTO CAL	*	*
* This key is not used in the ALARM mode		

The common alarm relay is used to monitor faults within the transmitter and the probe. The other three alarm relays relate to the process gas. All relays have user defined actions.

If one of the alarm events is removed from the common alarm using COMMISSIONING menu function #49, then this alarm event can be programmed for one of the other 3 alarm relays.

When the alarm mode has been entered, the SETUP light flashes once a second until the SETUP key is pressed to return the transmitter to RUN mode.

All relays have fail-safe alarm contacts. That is –

When the transmitter is turned off the contacts are open circuit

When the transmitter is on but there are no alarms the contacts will be closed

When there is a current unaccepted alarm event the contacts will be open circuit

When there is a current accepted alarm event the state of the contacts will depend on the selection in the commissioning menu #50. See chapter 7.2.22, Operation of the alarm relay when an alarm is accepted.

All alarms drive the alarm light on the front door.

The light will be off if there are no alarms current

The light will flash if there is a current alarm that has not been acknowledged

The light will be on steady if there are current alarm(s) that have not been cleared

The light will flash faster as more alarms occur

9.1 COMMON ALARMS

The events that drive the common alarm are –

1. 'Probe 1 Heater Fail'

2. 'Probe 2 Heater Fail'

A heated probe (model 9060H) has been turned on for more than 20 minutes but is still not up to 650°C (1200°F) or the probe temperature falls below 650°C.

3. 'Probe 1 High Impedance'

4. 'Probe 2 High Impedance'

Oxygen probe or electrode failure. The sensor has a high impedance measurement. Replace the probe. This alarm is inhibited when the probes are less than 650°C (1200°F).

5. 'Probe 1 TC Open Circuit'

6. 'Probe 2 TC Open Circuit'

Probe thermocouple is open circuit. The heater in heated probes will switch off.

7. 'Aux TC Open Circuit'

The AUX thermocouple is open circuit. If the thermocouple is not needed, select "Disabled" in COMMISSIONING menu function #9, "Aux TC Type" or place a short circuit between terminals 7 & 8.

8. 'Ref Air Pump Fail'

The reference air pump in the transmitter has been either unplugged or has gone open circuit (<20mA). Replace the reference air pump.

9. 'Ref Air Pump Overload'

The reference air pump in the transmitter has stalled and is drawing in excess of 300mA. The transmitter will attempt to restart the pump every minute for 1 second. Replace the reference air pump.

10. 'ADC Calibration Fail'

The analogue to digital converter has been found to fall outside the normal calibration specifications. In this case the probe heater will automatically be turned off.

11. 'Alarm Log Fail'

The alarm history is kept in an EEROM. This alarm will be raised if this memory device fails.

12. 'Output 1 Failure'

13. 'Output 2 Failure'

The digital to analogue 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. See chapter 10.1.2.

14. 'Heater 1 SSR Failure'

15. 'Heater 2 SSR Failure'

One of the heater power control devices (SSR) has been found to have failed. See chapter 8.2.8, Heater SSR fault correction.

16. 'Heater SSR Leakage'

One of the heater power control devices (SSR) has been found to have failed but the transmitter cannot determine which one(s) has failed.

17. 'Probe 1 Filter Blocked'

18. 'Probe 2 Filter Blocked'

Blocked probe filter. This test is only performed when automatic purging of the probe is selected. See chapter 11. This alarm will not reset until the next purge cycle. The cycle can be initiated manually or automatically.

19. 'Gas 1 Calibration Error'

20. 'Gas 2 Calibration Error'

At the end of an automatic gas calibration check cycle the oxygen reading was outside the values set in the COMMISSIONING menu #26 to 28 (#35 to 37). This alarm will not reset until the next calibration check cycle. The cycle can be initiated manually or automatically.

21. 'BBRAM Fail'

All of the setup options are held in the battery backed memory (BBRAM). This is the battery shaped device at the bottom centre of the 1732-1 PCB labeled MEM1. This alarm will occur when this device fails and will need to be replaced.

9.2 SELECTABLE PROCESS ALARMS

The alarm relays 1, 2 and 3 are generally used to transmit a gas related alarm event. Any or all of the following functions can be selected for each relay.

The trip levels and the delay times are set in the COMMISSIONING menu.

<p>NOTE: The process alarms will only be activated if they are enabled in the SETUP function 6. See chapter 6.3.5.</p>

21. 'Oxygen 1 Very Low'

22. 'Oxygen 2 Very Low'

The measured oxygen level on the indicated probe has been below the trip level shown in COMMISSIONING menu function #38 for longer than the delay time shown in function #39.

23. 'Oxygen 1 Low'

24. 'Oxygen 2 Low'

The measured oxygen level on the indicated probe has been below the trip level shown in COMMISSIONING menu function #40 for longer than the delay time shown in function #41.

25. 'Oxygen 1 High'

26. 'Oxygen 2 High'

The measured oxygen level on the indicated probe has been above the trip level shown in COMMISSIONING menu function #42 for longer than the delay time shown in function #43.

27. 'Oxygen Deviation'

The difference between the oxygen level measured on probe #1 and the oxygen level measured on probe #2 is greater than the trip level shown in COMMISSIONING menu function #44 for longer than the delay time shown in function #45.

28. 'Probe 1 Temperature Low'

29. 'Probe 2 Temperature Low'

The probe temperature is under 650°C (1200°F). 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 (1200°F) a 'Probe # Heater Fail' alarm will occur.

NOTE: The 'Probe # Temperature Low' relay function is used with unheated probes to indicate oxygen reading is invalid (the probe is below 650°C (1200°F)), in case the process temperature falls below this

level. With heated probes this relay will be de-energised while the probe is heating up from ambient, making the contacts open circuit.

30. 'Cal 1 in Progress'

31. 'Cal 2 in Progress'

A calibration check is occurring, either manual or automatic mode.

32. 'Purge 1 in Progress'

33. 'Purge 2 in Progress'

A probe purge is occurring, either manual or automatic mode.

9.3 ALARM RELAY OPTIONS

The three process alarm relays (relays 1 to 3) are user defined. The relay action will depend on the selections made in the COMMISSIONING menu functions #45 to #48.

The relay contacts are all designed to be "Fail Safe". That is, they are

- open when the transmitter power is off
- closed when there is NOT an alarm condition
- open when an alarm occurs

The contact will close circuit again (relay energised) when the alarm condition is acknowledged.

Choose to have the relays react to any or all of the following alarms or warnings –

Oxygen on probe 1 Low	Alarm
Oxygen on probe 2 Low	Alarm
Oxygen on probe 1 Very Low	Alarm
Oxygen on probe 2 Very Low	Alarm
Oxygen on probe 1 High	Alarm
Oxygen on probe 2 High	Alarm
Oxygen Deviation High	Alarm
Probe 1 Temperature Low	Warning
Probe 2 Temperature Low	Warning
Calibration check on probe 1 in Progress	Warning
Calibration check on probe 2 in Progress	Warning
Purge on probe 1 in Progress	Warning
Purge on probe 2 in Progress	Warning

In addition to the above process alarms that can activate the process alarm relays, any of the common alarm relay events that have been taken off the common alarm list in COMMISSIONING menu function #49 will appear on the process alarm relay lists in function #46 to #48.

10. INSTRUMENT CALIBRATION

10.1 CALIBRATION SUMMARY

The 9060Z oxygen transmitter has a self calibration and diagnostic system built into the hardware and software. Once the reference voltages have been set into memory the self calibration system maintains the calibration of the transmitter. An automatic update of the zero and span is done every minute.

The 4-20mA outputs can be automatically calibrated with the press of the AUTO CAL key or manually fine tuned.

One entry for each probe offset is required to optimise the calibration of the oxygen measurement although an automatic system calibration check can be programmed into the transmitter using certified gasses.

10.1.1 CALIBRATION OF THE INPUTS

The calibration of the analogue inputs is based on the voltage of a temperature compensated voltage reference integrated circuit. There are 4 voltages generated from the standard reference voltage. They will vary by about 1% from one transmitter to another but can be trimmed by setting the actual voltages into CALIBRATION menu functions #1 to 4.

The calibration 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. See chapter 10.2, Cold Start.

Connect a 3 1/2 digit multimeter negative lead to the test point marked 'COM' in the centre of the 1732-1 PCB (labeled 'V-REFS'). Measure the four voltages on the test point marked 1 to 4 with the positive lead of the multimeter. Enter the measured values in the CALIBRATION menu functions #1 to 4. Whenever new values are entered, the D/A Section should be re-calibrated. See chapter 10.1.2.

10.1.2 CALIBRATION OF THE OUTPUTS

The easiest way to calibrate the outputs is to select 'Auto Calibrated' in CALIBRATION menu functions #5 and 8. If this is selected the outputs will be directed away from the output terminals and back into an analogue input of the transmitter. The outputs are then tested and a zero and span calibration factor is recorded. If a more accurate calibration is required select 'Manually Calibrated' in CALIBRATION menu functions #5 and 8. This will inhibit the automatic calibration system overwriting the calibration factors. However, the zero and span factors will need to be manually set. To set the calibration factors use the following steps for each output:

1. Select CALIBRATION menu function #5 (8) and set the option to 'Calibrate 4mA'.
2. Use the FUNCTION up key to go to function #6 (9).
3. Set this to 4.00mA and press the ENTER key.
4. Measure the actual output current with a digital multimeter.
5. Use the OPTION keys to set the option to the value read on the digital multimeter and press ENTER.
6. The output should go to 4.00mA. The value in function #6 (9) can be fine tuned if necessary.
7. Go back to function #5 (8) and select 'Calibrate 20mA'.
8. Go up to function #7 (10) and set the option value to 20.00mA.
9. Measure the actual output current with a digital multimeter.
10. Use the OPTION keys to set the option to the value read on the digital multimeter and press ENTER.

11. The output should go 20.00mA. The value in function #7 (10) can be fine tuned if necessary.
12. Go back to function #5 (8) and select 'Calibrate 4mA' again and check that the output is still set to 4.00mA. If it is not exactly 4.00mA the value in function #6 (9) can be trimmed again.
13. Go back to function #5 (8) and select 'Manually Calibrated'.

10.1.3 PROBE CALIBRATION

There is only one calibration factor for the calibration of the oxygen probe. This is the sensor offset, and it is written on a tag attached to every probe.

Use the FUNCTION keys to go to SETUP menu #1 (2) and then use the OPTION keys to set the value to the value written on the tag. If in doubt the best option is to set the offset to 0.0mV because this will only produce an error of around 0.1% oxygen in a combustion application for a 1mV error in the offset value.

For information on checking the probe and transmitter system with a certified gas see chapter 11.

10.2 COLD START

The intention of the cold start function of the transmitter is to return all of the configuration set up back to the default values. There are 3 parts to the cold start:

1. If a software upgrade is installed and the changes require a change to the menu functions then the transmitter will automatically do a cold start. The transmitter will also do a cold start when the power is turned on and the configuration / calibration factors are found to be corrupted. It will only reset either the configuration values or the calibration values if either of them is found to be corrupted.
2. A cold start can be forced if the operator wants to reset the transmitter back to the default set up. See chapter 10.2.1, Forcing a Cold Start.
3. Resetting the calibration factors back to the default values. See chapter 10.2.2, Resetting the Calibration Factors.

10.2.1 FORCING A COLD START

The cold start can be initiated by following these steps:

1. Turn the transmitter power off.
2. Use a fine point or screw driver to turn the COLD START switch on. The switch is at the bottom of the 1732-1 PCB, accessible through the window in the shield.
3. Turn the transmitter back on.
4. You will be prompted to select 'Reset' or 'Cancel' to the prompt 'Reset Calibration Data?'. Press the DISPLAY up key to reset the calibration factors and the configuration data or the ALARM up key to only reset the configuration of the transmitter.
5. Turn off the cold start switch when prompted by 'Turn off C/Start Switch'.

If the calibration factors have been reset, follow the instructions in chapter 10.1 to recalibrate the transmitter. If only the configuration has been reset it is also important to check items that will affect the transmitter outputs, number of probes, the serial communications, the solenoid configuration and other items.

10.2.2 RESETTING THE CALIBRATION FACTORS

If it is required to reset the calibration factors, follow the instructions in the previous section and select 'Reset' when prompted to 'Reset Calibration Data?'.

11. GAS CALIBRATION CHECK AND PURGE

The oxygen sensor that is used in the Teledyne Analytical Instruments oxygen probe is extremely predictable, stable and reliable. For this reason, the calibration of a Teledyne Analytical Instruments oxygen system does not require the use of calibration gases. However, all Teledyne Analytical Instruments oxygen probes have a built in gas connection that does allow the accuracy of the probe to be checked in-situ. This chapter describes the operation of this gas checking system.

The 9060Z has a timer and solenoid driving system that can be configured to admit a certified calibration gas into the probe or an air supply to purge the probe filters through the gas connection. Both the calibration gas and the filter purge gas must be piped to the port on the probe labeled “CAL”. There are two solenoids drivers in the 9060Z transmitter. They can be used for any combinations of gas checking and probe filter purging. The only limitation is that if the transmitter is in dual probe mode, then solenoid #1 must be wired and plumbed to the probe #1 and solenoid #2 must be wired and plumbed to probe #2.

The transmitter can also be configured to be in a MANUAL or AUTOMATIC purge and gas check mode.

Function #	Function Description	Options			
20 (29)	Solenoid 1 (2) Operation	Calibration Gas / Purge	√	√	√
21 (30)	Solenoid 1 (2) Auto / Manual	Automatic / Manual	√	√	√
22 (31)	Solenoid 1 (2) Start Time	00:00 to 23:45		√	√
23 (32)	Solenoid 1 (2) Period	1 hour – 7 days		√	√
24 (33)	Solenoid 1 (2) Duration	1 – 90 seconds		√	√
25 (34)	Solenoid 1 (2) Post Freeze	5 – 300 seconds		√	√
26 (35)	Oxygen Content Cal Gas 1 (2)	0.1 – 20.9%			√
27 (36)	Max Cal Gas 1 (2) Positive Error	0.1% to 3.0%			√
28 (37)	Max Cal Gas 1 (2) Negative Error	0.1% to 3.0%			√

Functions available if either Calibration Gas or Purge and Manual are selected

Functions available if Purge and Automatic are selected

Functions available if Calibration Gas and Automatic are selected

11.1 PURGE

For processes that have particulate present in the gas stream, probe filters are necessary and should be back-purged with sufficient frequency to avoid blocked filters. Select ‘Purge’ in function #20 (29) and ‘Automatic’ in function #30 and then set the times in function #22 (31) to #25 (34) The outputs can be frozen during purging if selected in COMMISSIONING menu function #19. A flow switch can be wired to terminals 16 and 17. If the flow is not sufficient at the end of the purge cycle to close the contacts of the flow switch a ‘Probe 1 (2) Filter Blocked’ alarm is generated. If a flow switch is not being used a short circuit should be placed across terminals 16 and 17 to suppress the ‘Probe 1 (2) Filter Blocked’ alarm.

11.2 CALIBRATION GAS

If it is required to automatically check the oxygen probe and transmitter on line, select ‘Calibration Gas’ in function #20 (29) and ‘Automatic’ in function #30 and then set the times in function #22 (31) to #25 (34) and the gas levels in function #26 (35) to 28 (37). If the transmitter measurement does not fall within the limits set in function #26 (35) to 28 (37) a ‘Gas1 (2) Calibration Error’ alarm will be generated. If the transmitter has ‘Automatic’ selected in function #21 (30) and one of the GAS/PURGE keys is pressed in RUN mode, the automatic cycle will be started and the alarms will be checked. The cycle can be stopped at any time by pressing the same key during the cycle.

12. SOFTWARE UPGRADES

The software for the 9060Z series transmitters is contained in memory inside the microprocessor integrated circuit (IC). The transmitter therefore does not require an external memory IC for the software. Provision has been made to enable the software to be upgraded in the field without the use of a computer. If an upgrade is to be made to the software it will be supplied in a 32 pin EEROM IC type 29F010B. To do the upgrade, use the following steps:

1. Turn the power off to the transmitter at the power switch
2. Remove the hose from the reference air pump (if fitted)
3. Unplug the reference air DC power lead (if fitted)
4. Undo the two M4 screws at the top and bottom of the main shield
5. Remove the earth screw from the main shield on the right hand side of the cabinet
6. Lift out the main shield around the cable glands
7. Fold out the two wings of the blue socket labeled "FIRMWARE UPGRADE SOCKET". Plug the 29F010B into the socket. Carefully note the direction of the IC. Pin 1 is identified on the PCB and pin 1 on the IC has a small round indentation next to the pin.
8. Hold down the DISPLAY down and the ALARM LOG keys and then turn on the power
9. Release the keys when the message "Verifying the EEROM" will be shown. The transmitter is confirming that the new firmware is valid.
10. After the EEROM has been read and confirmed this message will be shown:

Upgrade Firmware?
Model 9060Z
New Version: 1.##
Upgrade Cancel

11. Press the DISPLAY up key to 'Upgrade' the firmware.
12. Press the ALARM up key to cancel the upgrade and continue the start up of the current firmware.
13. When the transmitter has upgraded the firmware it will start up the normal initialization. The version of the firmware is shown on the startup screen.

Upgrading Firmware.
Analyser will reset itself in approx. 15 seconds.
Do not turn off the power

NOTE: While the firmware is being upgraded it is essential that the power is not turned off otherwise the programme will be corrupted and will not be recoverable.

14. Turn the transmitter power off.
15. Unplug the EEROM by pressing out the wings of the blue upgrade socket. Keep the EEROM in a safe place. It can be used to upgrade any number of transmitters as required.
16. Replace the main shield and secure it with the three screws.
17. Reconnect the reference air pump hose and plug (if fitted).
18. Turn the power back on.

NOTE: The transmitter may do an automatic COLD START after the upgrade. The words 'Cold Start' will be shown on the display in step 14 if the cold start has been performed. The calibration will NOT be changed but the configuration may have been changed.

13. TROUBLESHOOTING

The Teledyne Analytical Instruments oxygen transmitter has proved an extremely reliable instrument. The trouble shooting guide here is based on an analysis of the potential problem that may occur after many years of operation in the field. A current list of problems and solutions can be found on the Teledyne Analytical Instruments web site at www.teledyne-ai.com when any are identified.

13.1 FIRST APPROACH

The probe will not heat up.

Turn the power off, remove and check 2 x 20mm glass fuses. If either of them is blown, check the probe heater resistance between the two white wires that come from the probe. It should be 110 +/- 15 ohms, and both wires should be open circuit to earth. If not, replace the probe.

Is the 'B' shown on the bottom left hand corner of the display? If not, check that the burner is enabled with either a link between terminals 10&11, BURNER INPUT, or is enabled with a connection to a voltage-free contact from the main fuel valve to these terminals.

The display is blank and there is no backlight on.

Measure the power supply voltages at the test points labeled COMM and +5v at the right hand side of the main PCB 1732-1. It should be 5 +/- 0.15v.

Turn off the power and remove the main shield. Check that the plug-in fuse FS1 has not blown. It should only be replaced with a 1A, 250v fuse if it has blown.

Is the mains power being supplied to terminals 36&37 and is it between 100 and 240VAC? If may be necessary to replace the switch mode power supply, PS5, APC-5S.

An 'ADC Calibration Fail' alarm has occurred.

Turn the transmitter off and remove the main shield. Turn the transmitter back on and measure the voltages on the 'Acom' test points. With the negative lead on the centre terminal the other 2 terminals should measure 12 +/-0.3v. If not, replace the small DC-DC converter PS4.

An 'Output 1 (2) Failure' alarm has occurred.

Turn the transmitter off and remove the main shield. Turn the transmitter back on and measure the voltages on the 'D1com' test points. With the negative lead on the centre terminal the other 2 terminals should measure 12 +/-0.3v. If not, replace the small DC-DC converter PS4.

A 'Heater 1 (2) Failure' alarm has occurred.

The software has found that the SSR4 has failed. If only one probe is being used and you need to get the transmitter back working quickly, use the CALIBRATION menu function 18, Heater SSR Select, to change the heater output terminals. See chapter 8.2.8, Heater SSR fault correction.

A 'BBRAM Fail' alarm has occurred

Replace the BBRAM, MEM1 on the 1732-1 main PCB.

13.2 DETAILED FAULT ANALYSIS

The 9060Z transmitter has a diagnostics mode built into the software. This mode allows detailed analysis of the hardware of the transmitter, but does require a level of competence in electronics.

The diagnostics mode is selectable by turning the 'Diagnostics' DIP switch to ON and then turn on the power. There is a separate Diagnostics Mode Manual available that describes its use. Ask Teledyne Analytical Instruments for more details.

14. MAINTENANCE

14.1 TRANSMITTER MAINTENANCE

The 9060Z transmitter has several hardware checking systems that confirm the correct operation of the transmitter and raise an alarm if there is a fault detected. Because of this system, the transmitter only requires periodic maintenance. Teledyne Analytical Instruments recommends an annual check of the transmitter.

The annual check should include the following items –

1. Measure and record the reference voltages, and check that the correct voltages are set in the calibration menu
2. Check that the reference air flow from the port on the bottom of the transmitter case is between 100 and 300cc/m
3. Check for contamination and potential blockage of the reference air filter that is mounted on the bottom of the transmitter case
4. If an external burner interlock has been connected (terminals 10 & 11), check that if one of the wires is disconnected the probe heater is disabled (9060H probes only)
5. Check the integrity of the cable. Particularly check the main power supply cable and the probe cable for any damage.
6. Check the integrity of the earth connections in the transmitter

14.2 CLEANING

The 9060Z transmitter is made in an IP65 / IP54 rated diecast case. It is painted with a tough ripple finish power coating to maintain a clean look. However, if it is necessary to clean the case use either a warm soapy water solution or an isopropyl alcohol.

A build up of dust on or around the transmitter should be removed before the cabinet door is opened. If there is a buildup of dust inside the cabinet check the door o-ring seal for damage and replace it if necessary.

Take care when wiping the display window to avoid scratching the surface.

If the filters of the probe (if fitted) become blocked, use an ultrasonic cleaner with a few drops of household detergent. If the filters cannot be cleaned this way replace the sintered filters.

The filter in the base of the analyzer may become blocked if the analyzer is operating in a dusty environment. It is available as a field replacement item.

14.3 REPLACEMENT PARTS

The following list identifies field replaceable parts –

Stock number	Description
18020	1732-1 Main PCB
18021	1732-2 Display PCB
15039	MP-24E Reference air pump
14105	Fuse -M205 3.15A 250V fuse (pack of 5)
14093	Instruction manual
18064	EEROM 9060x firmware
11040	FIL-230 Titanium sintered filter, 30um
11041	FIL-215 Titanium sintered filter, 15um
14123	Filter – analyzer bulkhead

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APPENDIX 1, CONSTITUENT VALUES FOR VARIOUS FUELS

If the transmitter is set up to have readout or output of combustibles, oxygen deficiency, maximum carbon dioxide or combustion efficiency, then the fuel constituents must be entered. Any or all of the variables can be modified and entered in COMMISSIONING menu functions #50 to 56. (See chapter 7.2.23). Your fuel supplier or chemist should be able to give you all these values.

A	is the heat of combustion of the fuel per gram atom of contained carbon.
H	is the H/C atom ratio in the fuel.
O	is the O/C atom ratio in the fuel.
N	is the N/C atom ratio in the fuel.
S	is the S/C atom ratio in the fuel.
M	is the ratio of H ₂ O molecules to C atoms in the fuel

FUEL	A	H	O	N	S	M
Blast Furnace Gas	50.55	0.08	1.3	3.08	b	a
Coke Oven Gas	256.88	5.6	0.25	0.23	b	a
Producer Gas	101.98	1.18	1.02	2.9	b	a
Natural Gas	209.9	3.86	0	0.1	0	0
Propane, Natural	176.4	2.69	0	0	0	0
Butane, Refinery	166.1	2.34	0	0	0	0
Methanol	172.59	3.97	1	-	-	-
Gasoline, Motor	157.58	2.01	0	0	0	0
No 1 Distillate Oil	149.65	1.83	0	-	0	-
No 2 Distillate Oil	145.18	1.71	-	-	0	-
No 4 Fuel Oil	145.54	1.6	-	-	0.01	0
No 5 Residual Oil	142.25	1.44	-	0	0	0
No 6 Residual Oil	136.52	1.25	0.01	0	0	0
Wood, Non-Resinous	110.91	2.26	1.07	0	0	c
Coal, Bituminous	116.88	0.74	0.05	0	0	0.03
Coal, Anthracite	104.98	0.35	0.05	0	0.01	0.04
Coke	99.63	0.11	0.01	0.01	0	0.01

- a. The moisture level varies depending on the process details. The calculated values assume M = 0.
- b. The sulfur level varies depending on the process details. The calculated values assume S = 0.
- c. Variable.

Values calculated from the North American Combustion Handbook, Tables 2.1a and 2.1b.

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APPENDIX 2, PROBE EMF TABLES

ZIRCONIA OXYGEN SENSOR OUTPUT (mV) PROBE TYPE 9060H, SENSOR

OXYGEN %	Probe EMF @ 720°C (1320°F)	OXYGEN %	Probe EMF @ 720°C (1320°F)
20.95	0	10	15.93
20.5	0.517	9.5	17.033
20	1.046	9	18.196
19.5	1.589	8.5	19.426
19	2.147	8	20.73
18.5	2.719	7.5	22.12
18	3.306	7	23.607
17.5	3.911	6.5	25.204
17	4.533	6	26.93
16.5	5.173	5.5	28.808
16	5.834	5	30.867
15.5	6.515	4.5	33.145
15	7.219	4	35.695
14.5	7.947	3.5	38.59
14	8.7	3	41.94
13.5	9.481	2.5	45.913
13	10.292	2	50.797
12.5	11.134	1.5	57.135
12	12.011	0.9	66.182
11.5	12.925	0.4	82.168
11	13.881	0.2	99.518
10.5	14.881	0.1	114.347

'K' Type TC 29.965 mV @ 720°C (1320°F)

These tables are based on the Nernst equation: O₂

$$EMF = \frac{T \log_e \left(\frac{O_2}{20.95} \right)}{-46.421} \text{ Where T is temperature}^\circ \text{ K}$$

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ZIRCONIA OXYGEN PROBE OUTPUT (mV) PROBE TYPE 9060UL/UH

OXYGEN %	TEMPERATURE °C (°F)								
	600 (1110)	700 (1290)	800 (1470)	900 (1650)	1000 (1830)	1100 (2010)	1200 (2190)	1300 (2370)	1400 (2550)
20	0.873	0.973	1.073	1.173	1.273	1.373	1.473	1.573	1.673
19.5	1.349	1.504	1.658	1.813	1.967	2.122	2.276	2.431	2.585
19	1.838	2.048	2.259	2.469	2.680	2.890	3.100	3.311	3.521
18.5	2.339	2.607	2.875	3.143	3.411	3.679	3.947	4.215	4.483
18	2.855	3.182	3.509	3.835	4.162	4.489	4.816	5.143	5.470
17.5	3.385	3.772	4.160	4.547	4.935	5.323	5.710	6.098	6.485
17	3.930	4.380	4.830	5.280	5.730	6.180	6.630	7.080	7.530
16.5	4.491	5.006	5.520	6.034	6.549	7.063	7.578	8.092	8.606
16	5.070	5.651	6.231	6.812	7.393	7.973	8.554	9.135	9.715
15.5	5.667	6.316	6.965	7.614	8.263	8.913	9.562	10.211	10.860
15	6.284	7.004	7.723	8.443	9.163	9.882	10.602	11.322	12.042
14.5	6.922	7.714	8.507	9.300	10.093	10.885	11.678	12.471	13.263
14	7.582	8.450	9.318	10.187	11.055	11.923	12.792	13.660	14.528
13.5	8.266	9.212	10.159	11.106	12.052	12.999	13.946	14.892	15.839
13	8.976	10.004	11.032	12.060	13.087	14.115	15.143	16.171	17.199
12.5	9.713	10.826	11.938	13.051	14.163	15.276	16.388	17.500	18.613
12	10.481	11.682	12.882	14.082	15.283	16.483	17.684	18.884	20.084
11.5	11.282	12.574	13.866	15.158	16.450	17.742	19.034	20.326	21.618
11	12.118	13.506	14.893	16.281	17.669	19.057	20.445	21.833	23.220
10.5	12.993	14.481	15.969	17.457	18.945	20.433	21.921	23.409	24.897
10	13.911	15.504	17.097	18.690	20.283	21.876	23.469	25.063	26.656
9.5	14.875	16.579	18.283	19.986	21.690	23.394	25.097	26.801	28.504
9	15.892	17.712	19.533	21.353	23.173	24.993	26.813	28.633	30.453
8.5	16.967	18.911	20.854	22.797	24.740	26.684	28.627	30.570	32.513
8	18.108	20.182	22.255	24.329	26.403	28.477	30.551	32.625	34.698
7.5	19.322	21.535	23.747	25.960	28.173	30.386	32.599	34.812	37.025
7	20.619	22.981	25.342	27.704	30.065	32.427	34.788	37.150	39.511
6.5	22.013	24.534	27.056	29.577	32.098	34.619	37.140	39.661	42.182
6	23.519	26.212	28.906	31.600	34.293	36.987	39.680	42.374	45.067
5.5	25.155	28.036	30.917	33.798	36.679	39.560	42.442	45.323	48.204
5	26.948	30.035	33.121	36.207	39.293	42.380	45.466	48.552	51.639
4.5	28.930	32.243	35.557	38.870	42.183	45.496	48.810	52.123	55.436
4	31.145	34.712	38.279	41.846	45.413	48.980	52.547	56.115	59.682
3.5	33.657	37.512	41.366	45.221	49.076	52.930	56.785	60.640	64.494
3	36.557	40.743	44.930	49.117	53.303	57.490	61.677	65.864	70.050
2.5	39.986	44.565	49.145	53.724	58.304	62.883	67.463	72.042	76.622
2	44.183	49.243	54.303	59.364	64.424	69.484	74.544	79.604	84.665
1.5	49.594	55.274	60.954	66.634	72.314	77.994	83.674	89.354	95.034
1	57.221	63.774	70.327	76.881	83.434	89.988	96.541	103.094	109.648
0.5	70.258	78.305	86.351	94.398	102.445	110.491	118.538	126.584	134.631
0.2	87.493	97.514	107.534	117.554	127.575	137.595	147.616	157.636	167.657
Thermocouple mV									
'K' Type	24.905	29.129	33.275	37.326	41.276	45.119	48.838	52.410	-
'J' Type	33.102	39.132	45.494	51.877	57.953	63.792	69.553	-	-
'R' Type	5.583	6.743	7.950	9.205	10.506	11.850	13.228	14.629	16.040
'S' Type	5.239	6.275	7.345	8.449	9.587	10.757	11.951	13.159	14.373
'N' Type	20.613	24.527	28.455	32.371	36.256	40.087	43.846	47.513	-

These tables are based on the Nernst equation:

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$$\text{EMF} = \frac{T \log_e \left(\frac{O_2}{20.95} \right)}{-46.421}$$

Where T is temperature° K

Thermocouple information from NIST ITS-90 data tables

APPENDIX 3, % OXYGEN SCALE TO LOGARITHMIC

OXYGEN %	FULL SCALE %
0.1	0
0.15	7.65
0.2	13.1
0.3	20.7
0.4	26.2
0.6	33.8
0.8	39.2
1	43.5
1.5	51.1
2	56.5
3	64.2
4	69.6
6	77.3
8	82.7
10	86.9
12	90.4
14	93.3
16	95.8
18	98
20	100

APPENDIX 4, MODBUS™

The Teledyne Analytical Instruments 9060Z transmitter has the ability to work as a Modbus slave node on serial RS-232 or 3-wire RS-485 via RTU mode transmissions. By accessing information stored in the input and holding registers it is possible to access runtime variables, alarm conditions and modify the device configuration.

The implementation of the Modbus protocol is limited to the specific command set relevant to reading and writing register variables. Attempting to send unrecognised commands will result in appropriate error responses

MODBUS™ Functions Supported:-

0x03: Read Holding Registers	0x16: Mask Write Holding Register
0x04: Read Input Registers	0x17: Read/Write Multiple Holding Registers
0x06: Write Single Holding Register	0x2B: Encapsulated Interface (read device information)
0x08: (return query data – for loopback testing)	0x41: Special Instruction Function
0x10: Write Multiple Holding Registers	

Serial Configuration

The serial configuration for the slave device is accessed in the Commissioning menu of the transmitter. Default settings are highlighted in bold.

Baud Rate	9600, 19200, 38400, 57600
Parity	Even, Odd, None
Stop Bits	1
Interface	RS-485, RS-232

All holding register addresses contain a single 16 bit value, however some variables span multiple holding registers to yield a single 32 bit variable.

When reading register values be aware that the byte order of data within registers may differ from that of the target system.

Modbus Protocol

The modbus over serial line protocol defines a messaging system for master/slave communications. Only one master device may be connected to any network with one or several slave nodes.

In unicast mode, the master initiates communication with a specific slave node by sending a request message. The slave processes the request and returns a reply message containing the requested information or a confirmation that the request was fulfilled.

Modbus requests are transmitted as a formed request frame with a CRC for data integrity checking. The frame for each request and reply type will vary somewhat, but will always have the basic structure described below:

1 byte	1 byte	up to 255 bytes	2 bytes
slave address	function code	data	checksum

Internal Representation of Dates & Alarm Status

The transmitter stores all dates as an unsigned 32bit count of seconds elapsed since 1-Jan 2004.

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Alarm status is stored as an integer value:

0	clear	2	active
1	self cleared	3	acknowledged

9060Z Transmitter Modbus Input Register Table for firmware v1.16 and newer

	Reg	Description	Bits	Type
Probe 1 Runtime Data	0	Oxygen %	32	floating point
	2	EMF mV	32	floating point
	4	Temperature degC	32	floating point
	6	Thermocouple Open Ct Flag	16	boolean
	7	Temperature Low Flag	16	boolean
	8	Impedance kOhms	32	floating point
	10	Oxygen Deficiency	32	floating point
	12	% Combustibles	32	floating point
	14	Maximum Theoretical CO	32	floating point
	16	Heater 1 Output	16	unsigned integer
Probe 2 Runtime Data	17	Oxygen %	32	floating point
	19	EMF mV	32	floating point
	21	Temperature degC	32	floating point
	23	Thermocouple Open Ct Flag	16	boolean
	24	Temperature Low Flag	16	boolean
	25	Impedance kOhms	32	floating point
	27	Oxygen Deficiency	32	floating point
	29	% Combustibles	32	floating point
	31	Maximum Theoretical CO	32	floating point
	33	Heater 2 Output	16	unsigned integer
Analyser Runtime Data	34	Auxilliary TC Temperature degC	32	floating point
	36	Auxilliary TC Open Ct Flag	16	boolean
	37	4-20mA Outputs Frozen	16	boolean
	38	Ambient Temperature	16	signed integer
	39	Maximum Ambient Temperature	16	signed integer
	40	Average Oxygen	32	floating point
	42	Reference Air Oxygen	32	floating point
	44	Boiler Efficiency %	32	floating point
	46	Burner Runtime Minutes	32	unsigned integer
	48	Burner On Time Minutes	32	unsigned integer
Event Times	50	Current Date & Time	32	unsigned integer
	52	Next Purge/Cal 1 Time	32	unsigned integer
	54	Next Purge/Cal 2 Time	32	unsigned integer
	56	Next Probe Impedance Check	32	unsigned integer
Relay Status	58	Relay 1 Status	16	unsigned integer
	59	Relay 2 Status	16	unsigned integer
	60	Relay 3 Status	16	unsigned integer
	61	Common Relay Status	16	unsigned integer
	62	Mains Power	16	unsigned integer
	63	Mains Frequency	16	unsigned integer
	92	DAC Output 1 mA	16	unsigned integer
	93	DAC Output 2 mA	16	unsigned integer

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	Reg	Description	Bits	Type
Current Alarm Status	64	Heater 1 Fail Alarm	16	unsigned integer
	65	Heater 2 Fail Alarm	16	unsigned integer
	66	Probe 1 Hi Impedance	16	unsigned integer
	67	Probe 2 Hi Impedance	16	unsigned integer
	68	Probe 1 Thermocouple Open Ct	16	unsigned integer
	69	Probe 2 Thermocouple Open Ct	16	unsigned integer
	70	Auxilliary Thermocouple Open Ct	16	unsigned integer
	71	Reference Air Pump Fail	16	unsigned integer
	72	Reference Air Pump Overload	16	unsigned integer
	73	Battery Backup RAM Failure	16	unsigned integer
	74	Internal Alarm Log Memory Failure	16	unsigned integer
	75	Internal ADC Fail	16	unsigned integer
	76	Internal DAC Output 1 Fail	16	unsigned integer
	77	Internal DAC Output 2 Fail	16	unsigned integer
	78	Heater 1 SSR Relay Fail	16	unsigned integer
	79	Heater 2 SSR Relay Fail	16	unsigned integer
	80	Heater SSR Leaking	16	unsigned integer
	81	Probe 1 Blocked	16	unsigned integer
	82	Probe 2 Blocked	16	unsigned integer
	83	Gas 1 Calibration Error	16	unsigned integer
	84	Gas 2 Calibration Error	16	unsigned integer
85	Oxygen 1 Low	16	unsigned integer	
86	Oxygen 2 Low	16	unsigned integer	
87	Oxygen 1 Very Low	16	unsigned integer	
88	Oxygen 2 Very Low	16	unsigned integer	
89	Oxygen 1 High	16	unsigned integer	
90	Oxygen 2 High	16	unsigned integer	
91	Oxygen Deviation	16	unsigned integer	
Last Alarm Active Time	94	Heater 1 Fail Alarm	32	unsigned integer
	96	Heater 2 Fail Alarm	32	unsigned integer
	98	Probe 1 Hi Impedance	32	unsigned integer
	100	Probe 2 Hi Impedance	32	unsigned integer
	102	Probe 1 Thermocouple Open Ct	32	unsigned integer
	104	Probe 2 Thermocouple Open Ct	32	unsigned integer
	106	Auxilliary Thermocouple Open Ct	32	unsigned integer
	108	Reference Air Pump Fail	32	unsigned integer
	110	Reference Air Pump Overload	32	unsigned integer
	112	Battery Backup RAM Failure	32	unsigned integer
	114	Internal Alarm Log Memory Failure	32	unsigned integer
	116	Internal ADC Fail	32	unsigned integer
	118	Internal DAC Output 1 Fail	32	unsigned integer
120	Internal DAC Output 2 Fail	32	unsigned integer	
122	Heater 1 SSR Relay Fail	32	unsigned integer	
124	Heater 2 SSR Relay Fail	32	unsigned integer	

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	Reg	Description	Bits	Type
Last Alarm Active Time	126	Heater SSR Leaking	32	unsigned integer
	128	Probe 1 Blocked	32	unsigned integer
	130	Probe 2 Blocked	32	unsigned integer
	132	Gas 1 Calibration Error	32	unsigned integer
	134	Gas 2 Calibration Error	32	unsigned integer
	136	Oxygen 1 Low	32	unsigned integer
	138	Oxygen 2 Low	32	unsigned integer
	140	Oxygen 1 Very Low	32	unsigned integer
	142	Oxygen 2 Very Low	32	unsigned integer
	144	Oxygen 1 High	32	unsigned integer
146	Oxygen 2 High	32	unsigned integer	
148	Oxygen Deviation	32	unsigned integer	
Last Alarm State Cleared Time	206	Heater 1 Fail Alarm	32	unsigned integer
	208	Heater 2 Fail Alarm	32	unsigned integer
	210	Probe 1 Hi Impedance	32	unsigned integer
	212	Probe 2 Hi Impedance	32	unsigned integer
	214	Probe 1 Thermocouple Open Ct	32	unsigned integer
	216	Probe 2 Thermocouple Open Ct	32	unsigned integer
	218	Auxilliary Thermocouple Open Ct	32	unsigned integer
	220	Reference Air Pump Fail	32	unsigned integer
	222	Reference Air Pump Overload	32	unsigned integer
	224	Battery Backup RAM Failure	32	unsigned integer
	226	Internal Alarm Log Memory Failure	32	unsigned integer
	228	Internal ADC Fail	32	unsigned integer
	230	Internal DAC Output 1 Fail	32	unsigned integer
	232	Internal DAC Output 2 Fail	32	unsigned integer
	234	Heater 1 SSR Relay Fail	32	unsigned integer
	236	Heater 2 SSR Relay Fail	32	unsigned integer
	238	Heater SSR Leaking	32	unsigned integer
	240	Probe 1 Blocked	32	unsigned integer
	242	Probe 2 Blockd	32	unsigned integer
	244	Gas 1 Calibration Error	32	unsigned integer
	246	Gas 2 Calibration Error	32	unsigned integer
	248	Oxygen 1 Low	32	unsigned integer
	250	Oxygen 2 Low	32	unsigned integer
	252	Oxygen 1 Very Low	32	unsigned integer
	254	Oxygen 2 Very Low	32	unsigned integer
	256	Oxygen 1 High	32	unsigned integer
	258	Oxygen 2 High	32	unsigned integer
	260	Oxygen Deviation	32	unsigned integer

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9060Z Transmitter Modbus Holding Register Table for firmware v1.16 and newer

	Reg	Description	Bits	Type		
Analyser Calibration & Configuration	0	00	50mV Reference Voltage	32	unsigned integer	
	2	02	200mV Reference Voltage	32	unsigned integer	
	4	04	1200mV Reference Voltage	32	unsigned integer	
	6	06	2500mV Reference Voltage	32	unsigned integer	
	8	08	Single/Dual Probe	16	boolean	
	9	09	Service Date	16	unsigned integer	
	10	0A	Probe 1 Type	16	unsigned integer	
	11	0B	Probe 1 TC Type	16	unsigned integer	
	12	0C	Probe 1 Offset	16	signed integer	
	13	0D	Probe 2 Type	16	unsigned integer	
	14	0E	Probe 2 TC Type	16	unsigned integer	
	15	0F	Probe 2 Offset	16	signed integer	
	16	10	Aux TC Type	16	unsigned integer	
	17	11	Flue Pressure Units	16	unsigned integer	
	18	12	Flue Pressure Value	16	signed integer	
	19	13	Temperature Units	16	unsigned integer	
	20	14	Oxygen Display Units	16	unsigned integer	
	21	15	Lower Line Items	64	bitmask	
	25	19	Reference Air Pump	16	unsigned integer	
	26	1A	Reference Air Pump Voltage	16	unsigned integer	
	27	1B	Reference Air RH%	16	unsigned integer	
	28	1C	Oxygen Damping Factor	16	unsigned integer	
	29	1D	Ambient Temperature Offset	16	signed integer	
	30	1E	Transmitter 4-20mA / 0-20mA Select	16	unsigned integer	
	31	1F	Transmitter Output Limiting for Low Ten	16	unsigned integer	
	32	20	Manual Mains Voltage Select	16	unsigned integer	
	33	21	Manual Mains Frequency Select	16	unsigned integer	
	Transmitter 1 Configuration	34	22	Transmitter 1 Output	16	unsigned integer
		35	23	Transmitter 1 Zero (Linear Oxygen 1)	16	unsigned integer
		36	24	Transmitter 1 Zero (Linear Oxygen Avg)	16	unsigned integer
		37	25	Transmitter 1 Zero (Very Low O2 1)	16	unsigned integer
		38	26	Transmitter 1 Zero (Reducing O2)	16	unsigned integer
		39	27	Transmitter 1 Zero (Oxygen Deficiency 1)	16	unsigned integer
40		28	Transmitter 1 Zero (Boiler Efficiency)	16	unsigned integer	
41		29	Transmitter 1 Zero (Dry CO2)	16	unsigned integer	
42		2A	Transmitter 1 Zero (Probe 1 EMF)	16	unsigned integer	
43		2B	Transmitter 1 Zero (Aux TC Temp)	16	unsigned integer	
44		2C	Transmitter 1 Span (Linear Oxygen 1)	16	unsigned integer	
45		2D	Transmitter 1 Span (Linear Oxygen Avg)	16	unsigned integer	
46		2E	Transmitter 1 Span (Very Low O2 1)	16	unsigned integer	
47		2F	Transmitter 1 Span (Reducing O2 1)	16	unsigned integer	
48		30	Transmitter 1 Span (Oxygen Deficiency 1)	16	unsigned integer	
49		31	Transmitter 1 Span (Boiler Efficiency)	16	unsigned integer	
50		32	Transmitter 1 Span (Combustibles % 1)	16	unsigned integer	
51		33	Transmitter 1 Span (Dry CO2 % 1)	16	unsigned integer	
52		34	Transmitter 1 Span (Probe 1 EMF)	16	unsigned integer	
53		35	Transmitter 1 Span (Aux TC Temp)	16	unsigned integer	
54		36	Transmitter 1 4-20mA Cal Mode	16	unsigned integer	
55		37	Transmitter 1 4mA Trim	16	unsigned integer	
56		38	Transmitter 1 20mA Trim	16	unsigned integer	

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	Reg	Description	Bits	Type	
Transmitter 2 Configuration	57	39	Transmitter 2 Output	16	unsigned integer
	58	3A	Transmitter 2 Zero (Linear Oxygen 1)	16	unsigned integer
	59	3B	Transmitter 2 Zero (Linear Oxygen Avg)	16	unsigned integer
	60	3C	Transmitter 2 Zero (Very Low O2 1)	16	unsigned integer
	61	3D	Transmitter 2 Zero (Reducing O2 1)	16	unsigned integer
	62	3E	Transmitter 2 Zero (Oxygen Deficiency 1)	16	unsigned integer
	63	3F	Transmitter 2 Zero (Boiler Efficiency)	16	unsigned integer
	64	40	Transmitter 2 Zero (Combustibles % 1)	16	unsigned integer
	65	41	Transmitter 2 Zero (Probe 1 EMF)	16	unsigned integer
	66	42	Transmitter 2 Zero (Aux TC Temp)	16	unsigned integer
	67	43	Transmitter 2 Span (Linear Oxygen 1)	16	unsigned integer
	68	44	Transmitter 2 Span (Linear Oxygen Avg)	16	unsigned integer
	69	45	Transmitter 2 Span (Very Low O2 1)	16	unsigned integer
	70	46	Transmitter 2 Span (Reducing O2 1)	16	unsigned integer
	71	47	Transmitter 2 Span (Oxygen Deficiency 1)	16	unsigned integer
	72	48	Transmitter 2 Span (Boiler Efficiency)	16	unsigned integer
	73	49	Transmitter 2 Span (Combustibles % 1)	16	unsigned integer
	74	4A	Transmitter 2 Span (Dry CO2 % 1)	16	unsigned integer
	75	4B	Transmitter 2 Span (Probe 1 EMF)	16	unsigned integer
76	4C	Transmitter 2 Span (Aux TC Temp)	16	unsigned integer	
77	4D	Transmitter 2 4-20mA Cal Mode	16	unsigned integer	
78	4E	Transmitter 2 4mA Trim	16	unsigned integer	
79	4F	Transmitter 2 20mA Trim	16	unsigned integer	
Process Alarms Configuration	80	50	Enable Process Alarms	16	boolean
	81	51	High Oxygen Alarm	32	unsigned integer
	83	53	High Oxygen Alarm Delay	16	unsigned integer
	84	54	Low Oxygen Alarm	32	unsigned integer
	86	56	Low Oxygen Alarm Delay	16	unsigned integer
	87	57	Very Low Oxygen Alarm	32	unsigned integer
89	59	Very Low Oxygen Alarm Delay	16	unsigned integer	
90	5A	Oxygen Deviation Alarm	32	unsigned integer	
92	5C	Oxygen Deviation Alarm Delay	16	unsigned integer	
Alarm Relays	93	5D	Alarm Relay 1 Options	64	bitmask
	97	61	Alarm Relay 2 Options	64	bitmask
	101	65	Alarm Relay 3 Options	64	bitmask
	105	69	Common Relay Options	64	bitmask
Fuel Characteristics	109	6D	Fuel Heat of combustion per gram atom C	16	unsigned integer
	110	6E	Fuel Hydrogen/Carbon atom ratio	16	unsigned integer
	111	6F	Fuel Oxygen/Carbon atom ratio	16	unsigned integer
	112	70	Fuel Nitrogen/Carbon atom ratio	16	unsigned integer
	113	71	Fuel Sulphur/Carbon atom ratio	16	unsigned integer
	114	72	Fuel H2O molecules/Carbon atom ratio	16	unsigned integer

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	Reg	Description	Bits	Type
Solenoid 1 Configuration	115	73 Solenoid 1 Operation (Cal/Purge)	16	unsigned integer
	116	74 Solenoid 1 Auto/Man	16	unsigned integer
	117	75 Solenoid 1 Start Time	16	unsigned integer
	118	76 Solenoid 1 Period	16	unsigned integer
	119	77 Solenoid 1 Purge/Cal Duration	16	unsigned integer
	120	78 Solenoid 1 Post P/C Freeze	16	unsigned integer
	121	79 Solenoid 1 Calibration Gas Content	16	unsigned integer
	122	7A Solenoid 1 Calibration Gas Positive Error	16	unsigned integer
	123	7B Solenoid 1 Calibration Gas Negative Error	16	unsigned integer
Solenoid 2 Configuration	124	7C Solenoid 2 Operation (Cal/Purge)	16	unsigned integer
	125	7D Solenoid 2 Auto/Man	16	unsigned integer
	126	7E Solenoid 2 Start Time	16	unsigned integer
	127	7F Solenoid 2 Period	16	unsigned integer
	128	80 Solenoid 2 Purge/Cal Duration	16	unsigned integer
	129	81 Solenoid 2 Post P/C Freeze	16	unsigned integer
	130	82 Solenoid 2 Calibration Gas Content	16	unsigned integer
	131	83 Solenoid 2 Calibration Gas Positive Error	16	unsigned integer
	132	84 Solenoid 2 Calibration Gas Negative Error	16	unsigned integer

0x41 Special Instruction Function

This command allows you to interact with the transmitter allowing access to functionality that would otherwise only be accessible via the keypad. The request length will vary from one command to the next depending on what arguments are required. Requests are formed the same as other modbus requests:

1 byte	1 byte	1 byte	0 -4 bytes	2 bytes
slave address	command code	function code	arguments	checksum

Function Code	Command	Arguments
0x01	Accept All Active Alarms	none
0x02	remote set key down	1 byte keymask
0x03	remote reset key down	1 byte keymask
0x04	Initiate Probe Impedance Check	none
0x05	Set Internal Clock	4 byte rtc*
* date expressed as seconds since 1-Jan 2004		