Mk8 EGA

Set-Up and Trim Guide

AUTOFLAME®

Mk8 EGA Set-Up and Trim Guide

THE QUEEN'S AWARDS
FOR ENTERPRISE:
INNOVATION
2007

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Important Notes

A knowledge of combustion related procedures and commissioning is essential before embarking work on any of the M.M./E.G.A. systems. This is for safety reasons and effective use of the M.M./ E.G.A. system. Hands on training is required. For details on schedules and fees relating to group training courses and individual instruction, please contact the Autoflame Engineering Ltd. offices at the address listed on the front.

Short Form - General Terms and Conditions

A full statement of our business terms and conditions are printed on the reverse of all invoices. A copy of these can be issued upon application, if requested in writing.

The System equipment and control concepts referred to in this Manual MUST be installed, commissioned and applied by personnel skilled in the various technical disciplines that are inherent to the Autoflame product range, i.e. combustion, electrical and control.

The sale of Autoflame's systems and equipment referred to in this Manual assume that the dealer, purchaser and installer has the necessary skills at his disposal. i.e. A high degree of combustion engineering experience, and a thorough understanding of the local electrical codes of practice concerning boilers, burners and their ancillary systems and equipment.

Autoflame's warranty from point of sale is two years on all electronic systems and components.
One year on all mechanical systems, components and sensors.

The warranty assumes that all equipment supplied will be used for the purpose that it was intended and in strict compliance with our technical recommendations. Autoflame's warranty and guarantee is limited strictly to product build quality, and design. Excluded absolutely are any claims arising from misapplication, incorrect installation and/or incorrect commissioning.

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1 INTRODUCTION

1.1 Overview and Benefits

1.1.1 Features and Benefits

The Mk8 Exhaust Gas Analyser (EGA) monitors the emissions in the flue produced from the burner/boiler system. The EGA can improve combustion, increase efficiency, reduce fuel consumption and improve safety through its 3 parameter trim function and combustion safety limits.

1. Stand-Alone: When in stand-alone mode, the EGA can be used without a Micro-Modulation (MM) module to monitor the combustion gases. The MM trim function and the combustion safety limits are not activated in this stand-alone mode of operation. The emissions levels can be accessed via the full colour EGA touch screen.

2. With MM: When interfaced with an MM, the EGA can monitor emissions or the 3-parameter combustion trim and safety limits can be activated. The emissions levels are monitored by the EGA and the MM makes small adjustments to the air damper to trim the online exhaust gas data back to the commissioned values. The EGA information is accessible through the full colour EGA touch screen, the Data Transfer Interface module (DTI), or 6 x 4-20mA signals.

The main benefits of the EGA include the ability to monitor the exhaust gases and bring them to the safe commissioned levels. Setting the combustion limits on the MM in conjunction with the EGA prevents unsafe combustion scenarios, reducing the fuel consumed in bad combustion.

1.1.2 System Operation

The Mk8 EGA samples the combustion gases via the stack mounted sampling probe (purchased separately from the analyser). The exhaust gases are drawn from the stack by a pump mounted internally within the analyser. Only the supplied sample tubing should be used between the sampling probe and analyser. The internal diameter of the sampling tube is 3mm; if a large diameter tubing is used the sample gas remains resident in the tubing for a longer period. The EGA will then not be able to respond in time to combustion changes, resulting in incorrect operation of the trim function.

Once the exhaust gases have entered the EGA the chiller block reduces their temperature and dries the sample to remove the condensation from the gases prior to entering the cells. The condensate accumulated in the chiller unit is drained every 4 minutes when running, and every 10 minutes when the EGA is in idle mode, automatically through the drain solenoid.

The exhaust gas is then filtered through the dry filter, which is a fine filter used to remove any dust particles carried over from the cooling process. If the burner is firing on heavy or dirty oil, an external particulate filter must be used to remove the excess dirt particles. On leaving the filter, the exhaust gas pressure is checked again to ensure that a vacuum is maintained prior to entering the pump and on exiting the pump, the pressure produced by the pump is checked. Both these pressure sensors modulate the flow rate of the sample into the EGA for consistent operation. Once the exhaust gases have been conditioned, they are ready for an accurate sampling by the cells. After the gases have been sampled by all the cells, the remaining sample is pumped out of the EGA from the clear tubing at the bottom of the EGA casing.

Note: The EGA needs to vent to atmosphere via the drain solenoid on the bottom; this is also where the EGA performs its air calibrations. Care should be taken to ensure the outlet is not restricted or that contamination from exhaust gas occurs.

1.2 3-Parameter Trim

The 3-parameter trim function can be enabled when the Mk8 EGA is used in conjunction with an MM module to manage the combustion. When the EGA detects any differences in the online exhaust gas readings to the original commissioned values, the trim function will make small corrections to the air damper (and channel 5 if optioned for trim), to bring those online values back to the commissioned readings. The trim function controls the combustion of the burner by adding air (air rich) or taking away air (fuel rich) from the commissioned air positions to keep the volume of O_2, CO_2 and CO close to their commissioned values without compromising safety. The air rich and fuel rich limits are set by adding trim data when commissioning the burner or through single point change for 'quick commission.' This trim data is translated into a combustion map, which shows how the burner reacts when air is added or removed from the combustion process during commissioning. The Autoflame system continually monitors 3 parameters O_2, CO_2 and CO to create the safest and most efficient way of trimming the combustion process.

Ingress of tramp air through an ill-fitting boiler or flue section will distort the O_2 reading and show an increase in this value. This results in the EGA reading the tramp air influence in the sample rather than just the actual combustion gases.

Single parameter O_2 trim systems would see both of these conditions as rich (excess air) combustion and start to trim back on the air by closing the air damper. In reality this trim process is not trimming the combustion gases at this point, but is in fact trimming the exhaust gases with the excess O_2. This can potentially lead to the formation of excessive amounts of CO but more importantly this can lead to incomplete combustion with dangerous consequences.

Similarly, single parameter CO_2 trim systems would interpret of air as lower CO_2 levels in the flue, inflicting similar dangerous conditions in the boiler.

Another benefit of the 3 parameter trim is that the EGA is continually measuring the formation of CO compared to its commissioned value. A higher CO reading can be contributed to both lean and rich combustion. A lack of air will produce incomplete combustion and the formation of CO. Also, excess air around the flame envelope can chill the flame edge causing incomplete combustion and higher CO levels.

By referencing all 3 parameters against mapped combustion performance the burner can be trimmed back to the original commissioned values whilst maintaining the highest degree of safety.

When the trim function adds air to bring back the combustion to the commissioned values, as the burner modulates to a new position, the deviation in air damper movement is added to each air position. In this way, optimum combustion is maintained during modulation, through carry forward trim.

As a safety feature, as the air is being taken away, the fuel to air ratio will return back to the commissioned positions when the burner modulates, for every 10 degrees of fuel valve movement. Once this new position is held the system will determine whether the air damper should be closing. This ensures safe combustion at all times without any compromise.

1.3 Continuous Emissions Monitoring System

The Mk8 EGA now has the CEMS function included as standard, logging the exhaust gas and fuel data for up to 2 years. This data includes the gas readings, flue temperature, calculated efficiency and fuel consumption.

When using a standalone Mk8 EGA a direct connection as shown in section 2.2.3 will be required to view and log up to 2 years of data on the Mk7 DTI The DTI will need to be set-up as 'EGA direct' through the 'Edit Boiler' screen and the EGA setup for standalone operation (EGA selects fuel).

Using the EGA in conjunction with the MM module and D.T.I, a data link will be required between the MM and EGA and from the EGA to the DTI (see section 2.2.4). The DTI will need to be setup as 'EGA Direct' **not** 'EGA through MM'

For multiple MMs, each with the EGAs, refer to both sections 2.2.3 and 2.2.4. There will need to be data cable connected as a daisy chain between the EGAs and DTI, a data cable daisy chain between the MMs and DTI, and data cable links between each MM and its corresponding EGA.

2 WIRING AND COMPONENTS

2.1 Flying Lead Wiring Diagram

Data Connector

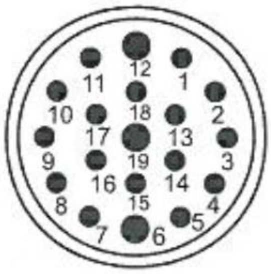


Figure 2.1.i Data Connector – Insert Pin Mating View

1	4-20 mA Output Channel (1+)
2	4-20 mA Output Channel (2+)
3	4-20 mA Output Channel (3+)
4	4-20 mA Output Channel (4+)
5	4-20 mA Output Channel (5+)
6	4-20 mA Output Channel (6+)
7	4-20 mA Output Common (-)
8	Fuel 1 Select Input
9	Fuel 2 Select Input
10	Fuel 3 Select Input
11	Fuel 4 Select Input
12	Fuel Select Input common
13	MM Comms (-)
14	MM Comms (+)
15	DTI Comms (-)
16	DTI Comms (+)
17	4-20mA Input (-)
18	4-20mA Input (+)
19	Not Connected

Note: The data cable should be screened at the MM/DTI end and connected all the way to the EGA plug; the screen from the flying lead provided should be connected to the data cables that connect to the MM/DTI.

Note: Fuel Select Inputs in standalone mode are low voltage. To select a fuel, put a link on the 'Fuel X Select Input' to the Fuel Select Input Common e.g. to select fuel 1, link pin 8 to pin 12 to select fuel 1 in standalone mode.

Mains Connector

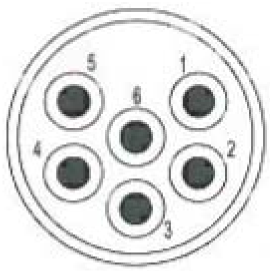


Figure 2.1.ii Mains Connector – Insert Pin Mating View

1	Live
2	Live for HSL
3	Earth for HSL
4	Neutral for HSL
5	Neutral
6	Earth

Auxiliary Connector

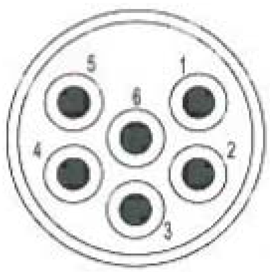
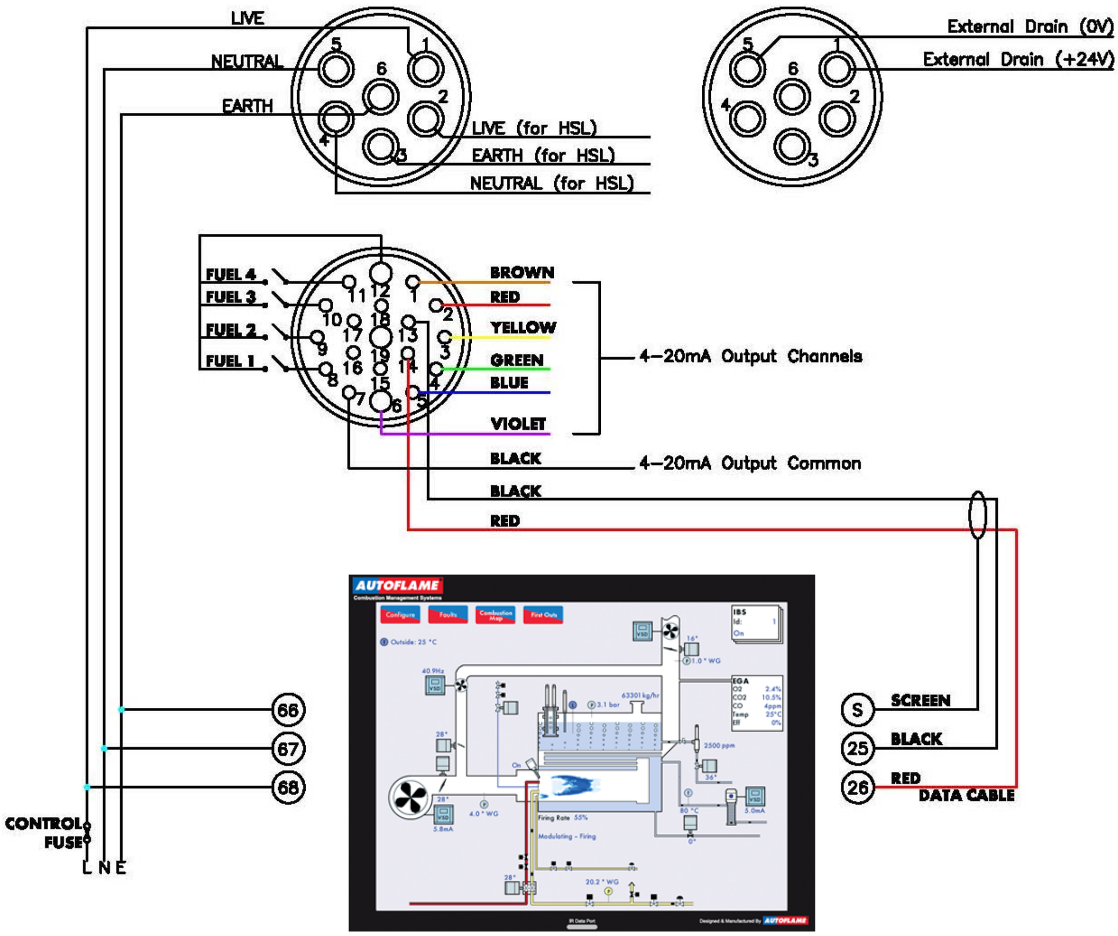


Figure 2.1.iii Auxiliary Connector – Insert Pin Mating View

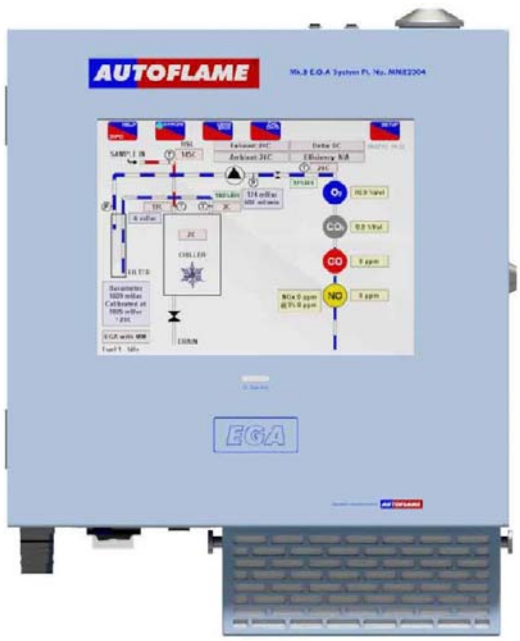
1	External Drain (0V)
2	
3	
4	
5	External Drain (+24V)
6	

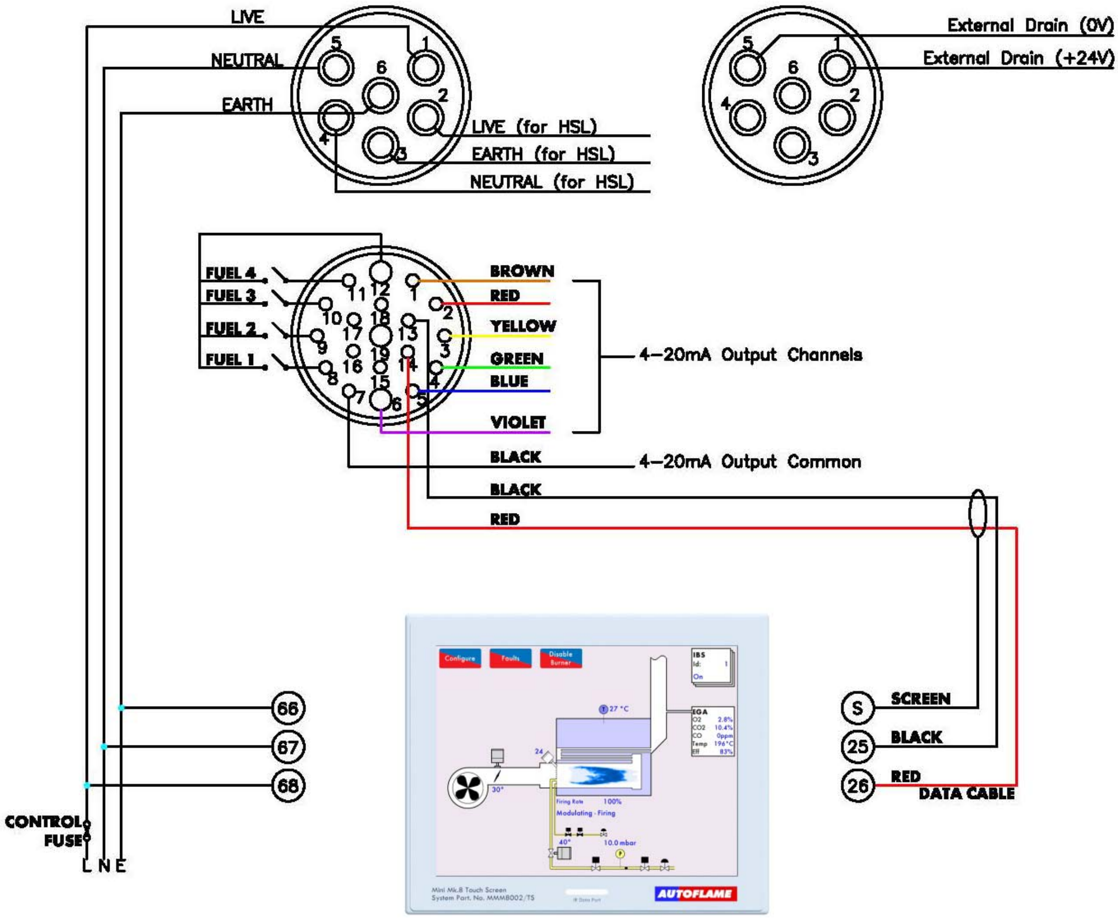
2.2 Electrical Schematics

2.2.1 Interconnection between EGA and Mk8 MM

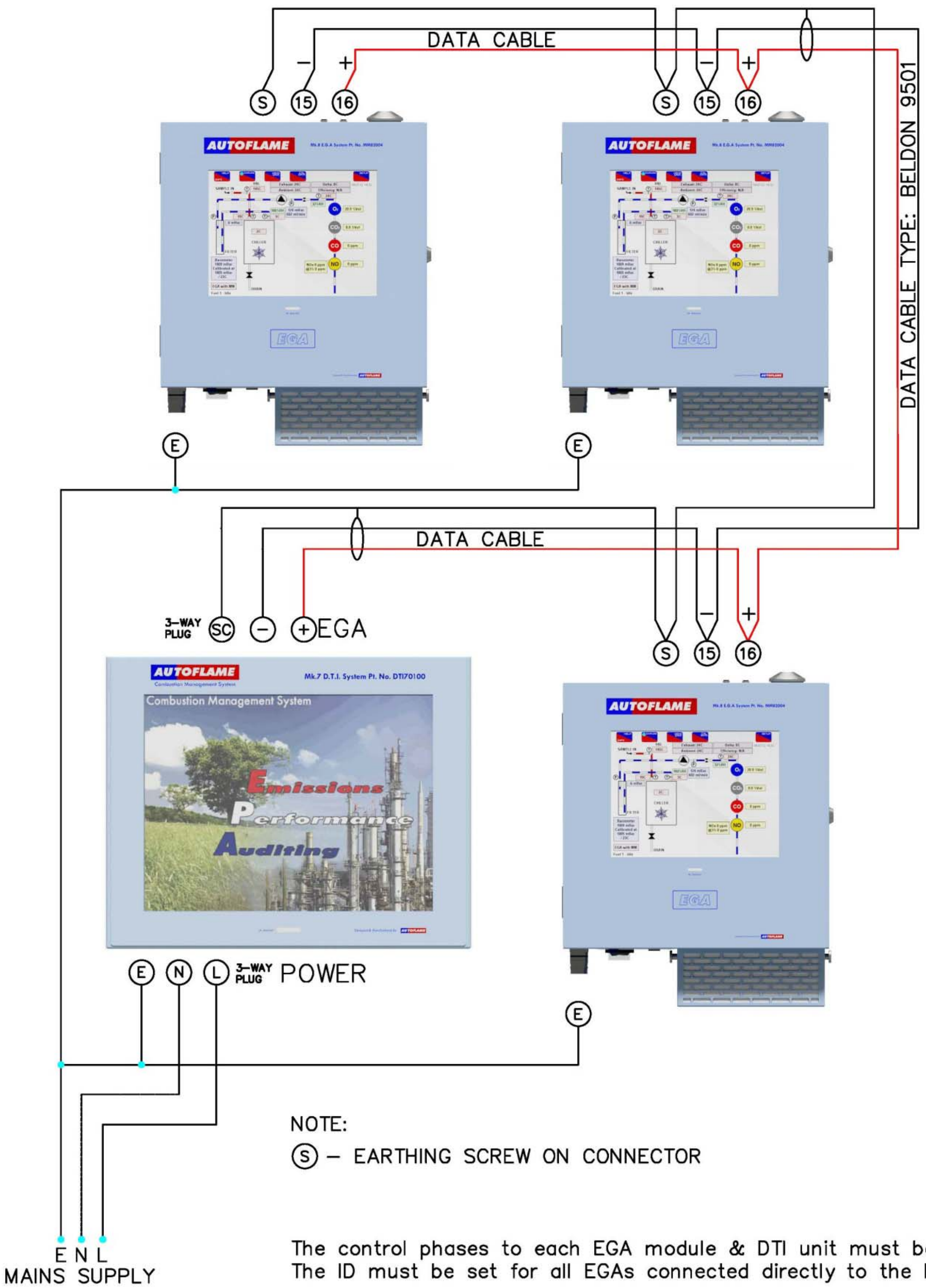


2.2.2 Interconnection between EGA and Mini Mk8 MM Module





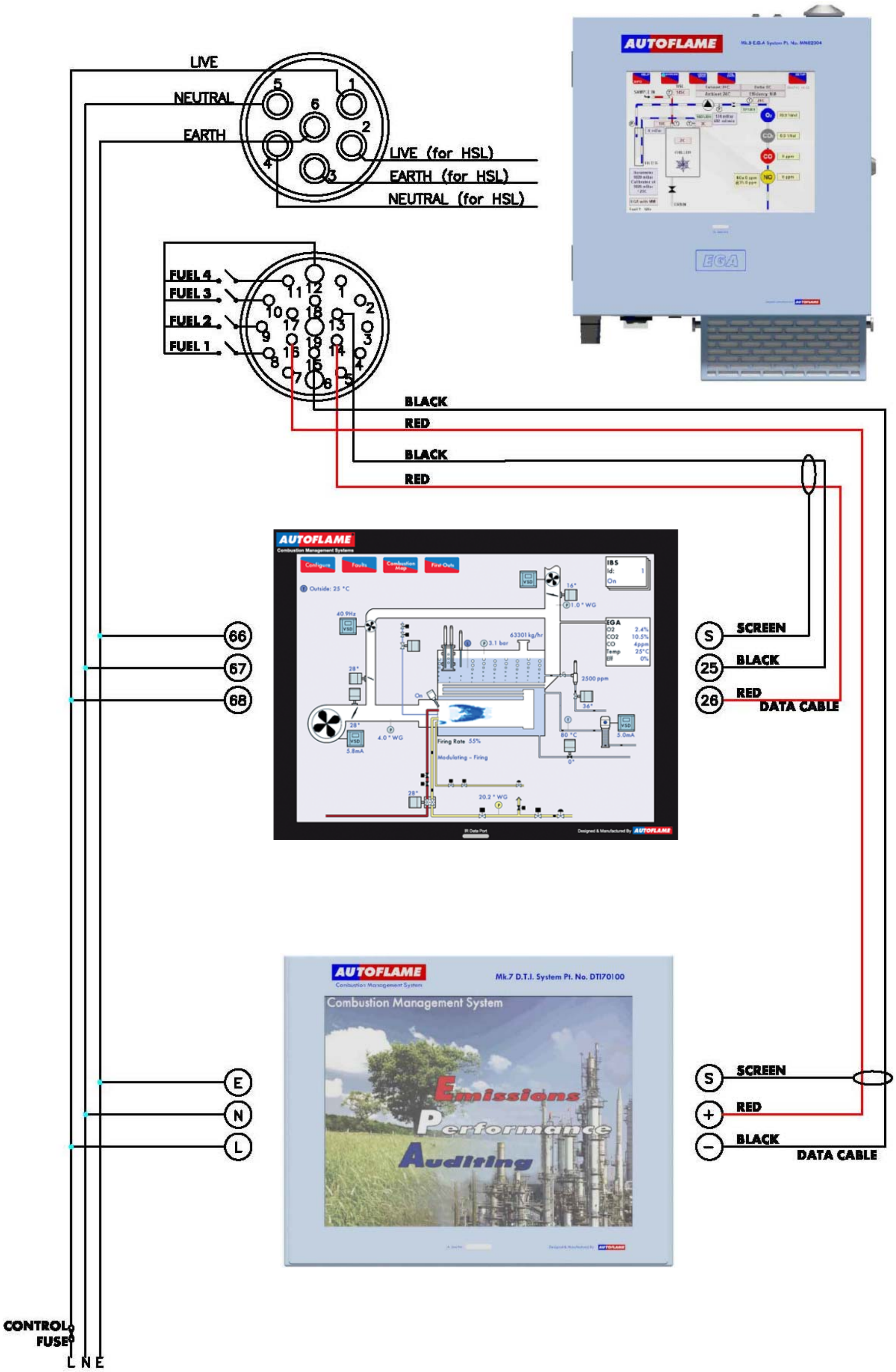
2.2.3 Interconnection between Stand-Alone Mk8 EGA and Mk7 DTI



NOTE:
(S) – EARTHING SCREW ON CONNECTOR

The control phases to each EGA module & DTI unit must be the same.
The ID must be set for all EGAs connected directly to the DTI.

2.2.4 Interconnection between Mk8 MM, Mk8 EGA and Mk7 DTI



2.3 Components

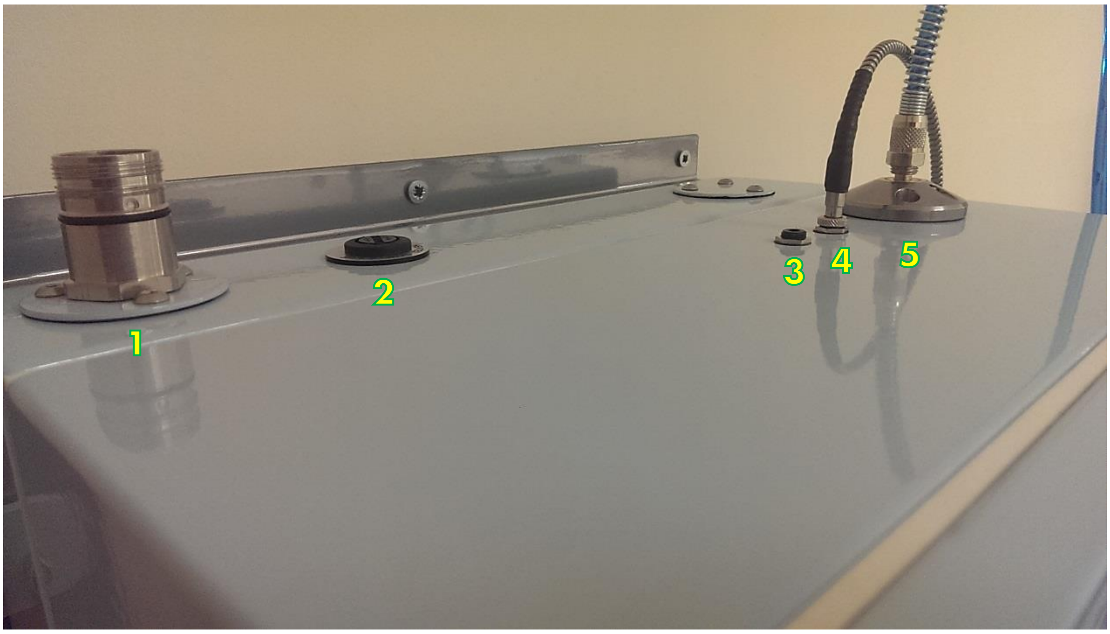
2.3.1 Inside View

Figure 2.3.1.i Inside View

1. Particulate Filter
2. Chiller Block
3. Pinch Valve
4. Drain Solenoid
5. NO Cell
6. CO Cell
7. O_2 Cell
8. CO_2 Cell
9. CR Battery
10. Software Update Jumpers
11. Cell Pump
12. EGA Fan

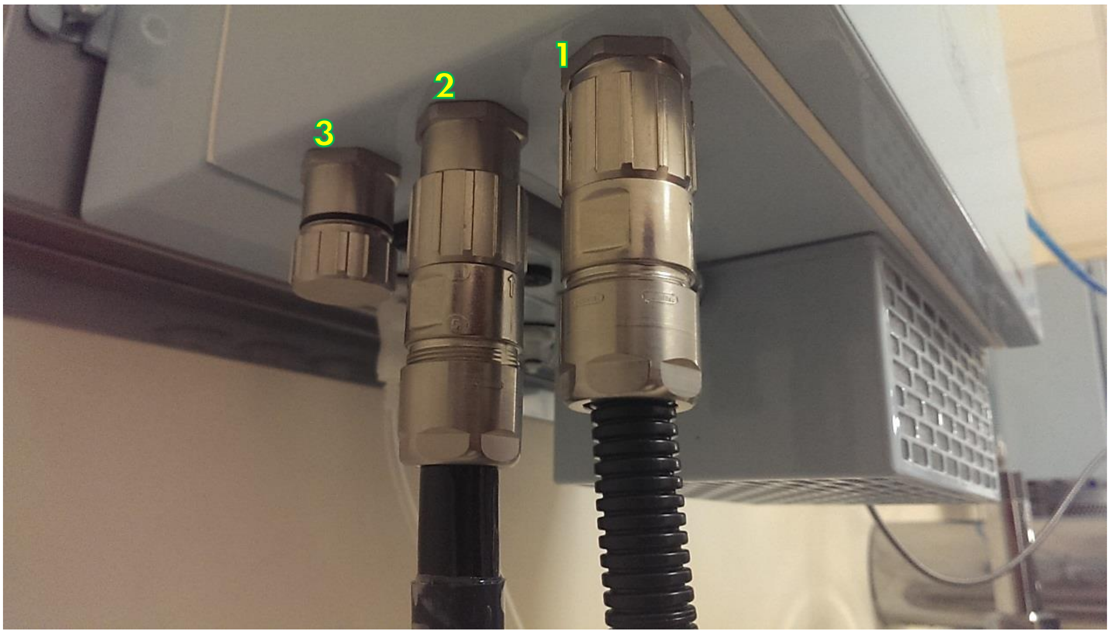
2.3.2 EGA Connections

Top Connections



1. Heated Sample Line (HSL) Power Connection (EPA only)
2. Heated Sample Line Fuse (EPA only)
3. Pre-Heated Air Thermocouple Connection
4. Exhaust Temperature Thermocouple
5. Sample Line connection

Power and Data Connections



1. Power Connector
2. Data Connector
3. External Particulate Filter/ External Drain Connector

2.4 Cell Characteristics

2.4.1 O_2 Cell

This electrochemical cell is used for the detection of oxygen covering a concentration range of 0 to 20.9%. Due to the construction of the cell they offer a long life and a high resistance, even when used with high sulphur content fuels, therefore making it capable of analysis when firing heavy or light fuel oil.

The oxygen cell incorporates a lead oxygen cell with a Lead anode and a Gold cathode, using a specific acid electrolyte. Oxygen molecules which diffuse through a non-porous Teflon membrane into the electromechanical cell are reduced at the Gold electrode. The current flow between the electrodes is proportional to the oxygen concentration in the flue gases measured. The O_2 readings are not influenced from CO, H_2, S, NOX and SOX so there is no cross-sensitivity.

Figure 2.4.1.i O_2 Cell

<u>Operation Ranges:</u>

Detection Range	0 – 23% O2
Accuracy	± 0.3 % Vol O2
Operating Temperature	5°C to 40°C (41°F to 104°F)
Shelf Life	6 months from date of dispatch
Long Term Output Drift	< 1% signal/month typically
	< 10% over operating life

As the O_2, CO, NO, SO_2 and NO_2 cells all have a 6 month shelf-life, it may be better to request for the cells to be shipped when the EGA is being installed on site. Depending on the conditions and environment the EGA is in, the cell's life expectancy can go up to 2 years. It is important to replace the cells when the EGA flags this up on the screen. Cells will need to be changed every 9 to 12 months firing on gas, and 6 to 9 months firing on oil.

2.4.2 CO, NO, NO_2 and SO_2 Cells

The CO, NO, NO_2 and SO_2 electromechanical cells which are specifically managed by the calibration philosophy within the Mk8 EGA unit. The accuracy of these cells is within limits of ± 5% at 100ppm. From experience we would expect to see a drift of ± 10ppm per annum without calibration. In our view, this drift would not be detrimental to the operation or application of the EGA The life of the cells depends on the concentration of the gases measured over time. In order to optimise the life of the CO cell, the electronics will detect when the signal level from the cell reaches or exceeds 500ppm and will stop sampling and purge the system. The sample gas flow to these cells is restored once the O_2 and CO_2 readings are restored to a level within the pre-programmed limits.

Figure 2.4.2.i NO and CO Cells

	Gas (range)	Fuel Oil (range)	Resoltuion at 20°C	Repeatability	Shelf Life
CO	0-1000ppm	Optional	1ppm	1% of signal	6months from dispatch
NO	0-500ppm	Optional	1ppm	2% of signal	6months from dispatch
SO_2	Optional	0-1000ppm	1ppm	1% of signal	6months from dispatch
NO_2	Optional	0-200ppm	0.5ppm	2% of signal	6months from dispatch

2.4.3 CO2 Sensor

The CO_2 sensor is manufactured in-house at Autoflame; the technology used is non-dispersive Infra-red. This sensor has no moving parts and is not an electrochemical cell. The accuracy of the reading is ±0.3% of the reading. The cross-sensitivity is virtually zero to other gases due to the method of calibration within the EGA unit. The lifetime is usually no less than two years of gas firing. The lifetime on oil firing is dependent on the Sulphur content of the fuel.

Figure 2.4.3.i CO_2 Cell

Measurement Range: 0-20%
Shelf-Life: 12months from dispatch
Accuracy of reading: 0.3%

3 SET-UP

3.1 EGA Set-Up

3.1.1 Sampling Screen

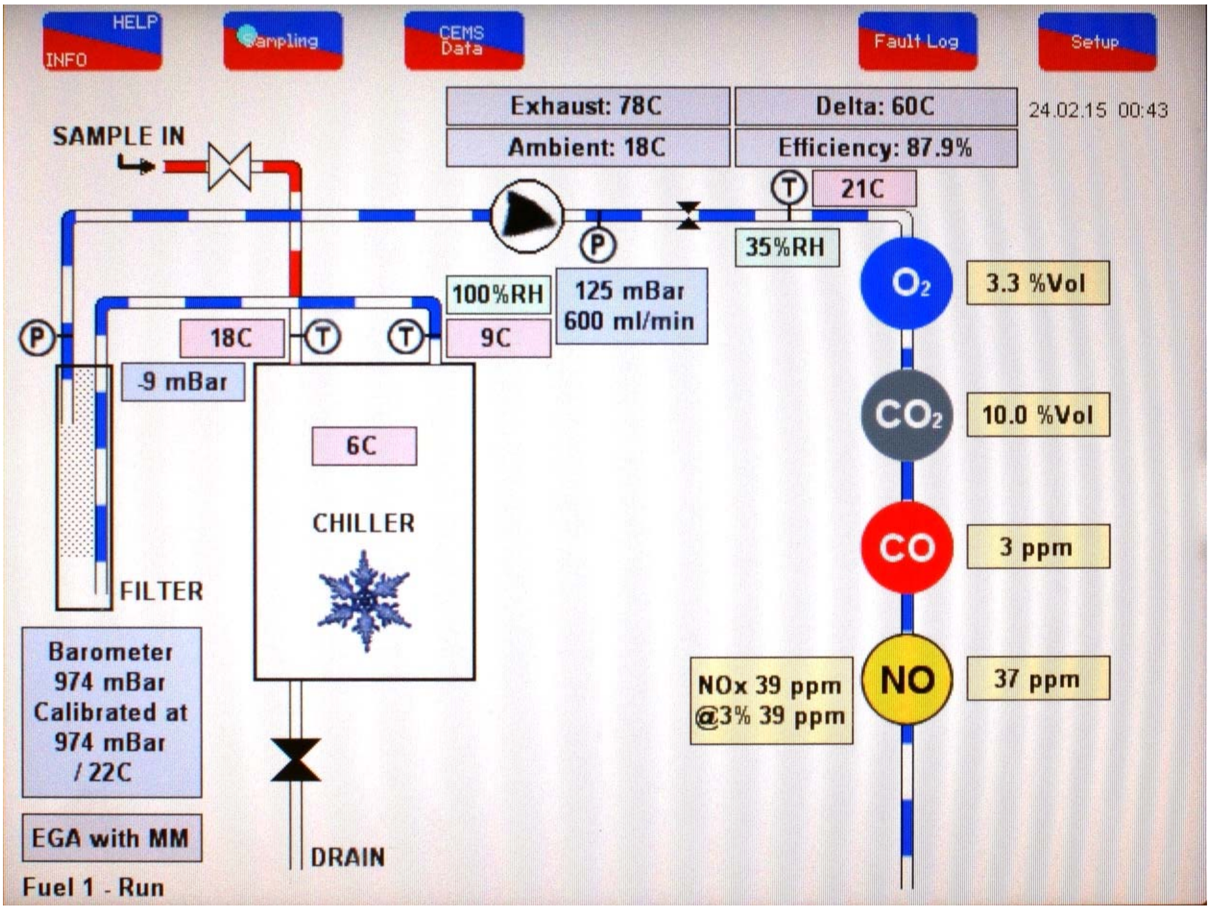


Figure 3.1.1.i. Sampling Screen

The sampling screen presents the user with detailed information about the current operation of the EGA components shown on this screen.

- Fuel being fired and current EGA status (Air calibration, run etc.)
- Exhaust gas temperature
- Ambient air temperature surrounding EGA
- Delta temperature (difference between the exhaust gas and ambient temperatures)
- Current combustion efficiency (see section 3.6.7.)

Cells

CO	Carbon Monoxide	CO_2	Carbon Dioxide
NO	Nitric Oxide	NO_2	Nitrogen Dioxide
O_2	Oxygen	SO_2	Sulphur Dioxide

System Components

- Piping (no flow)
- Piping (gas flowing)
- Piping (water/condensate draining or air sample flowing)
- Pump
- Pinch Valve Open
- Pinch Valve Closed
- Temperature Sensor
- Pressure Sensor
- Chiller Status
- Restrictor

Note: Components that are not ready/malfunctioning are denoted by a .

3.1.2 Mk8 EGA Settings

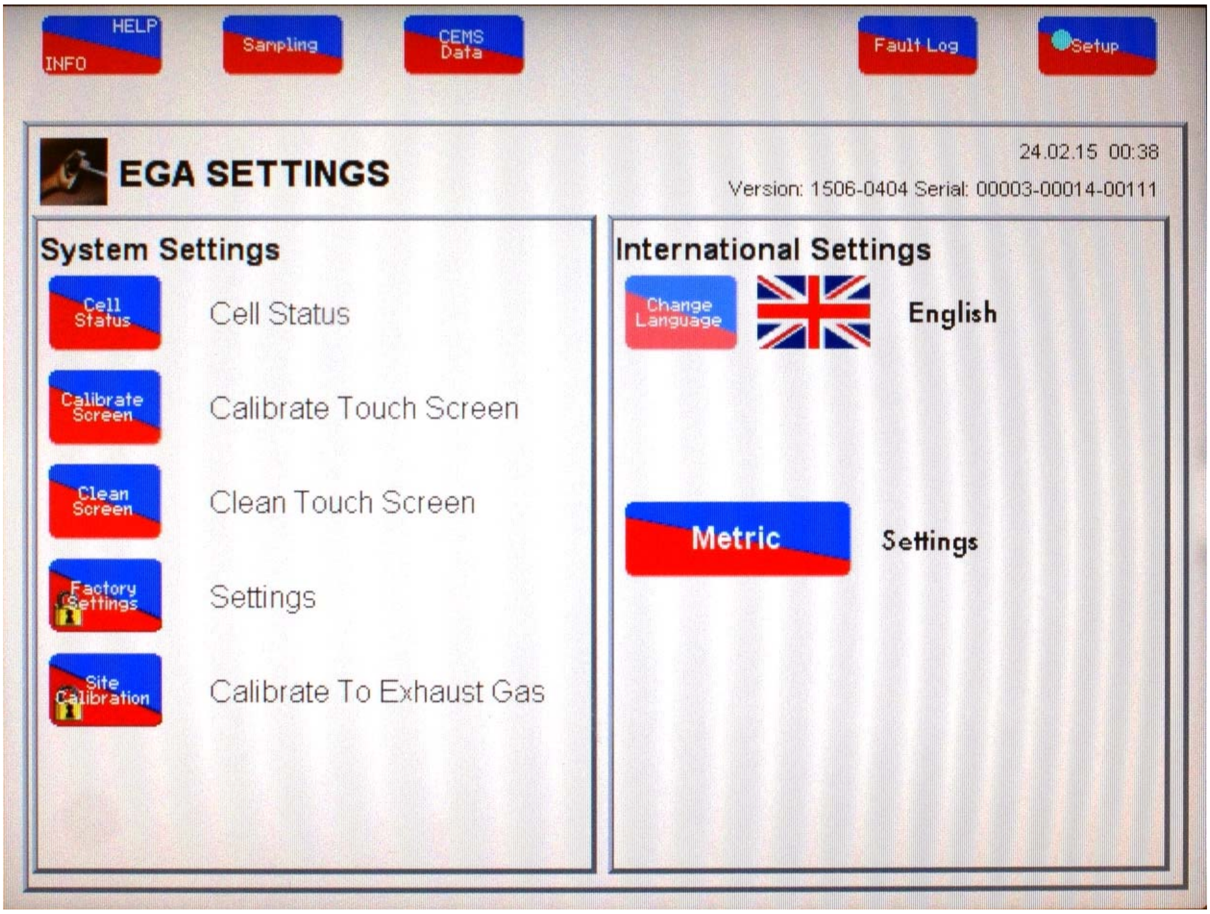


Figure 3.1.2.i. EGA Settings Screen

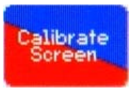
The EGA settings screen is the first of two main settings screens. It displays the following information:

1. Date and time.
2. Software versions.
3. Serial number of the unit.
4. System language.
5. Units being used (Imperial/Metric).

Note: Buttons with the  symbol are password protected.

or


Press either of these buttons to toggle the units used by the system. The text displayed indicates the unit currently selected.



Press here to calibrate the touch screen. Follow the on screen commands to calibrate the touch screen.

Press this button to clean the touch screen. Pressing this button will lock the screen for 30 seconds to allow the screen to be cleaned.

3.1.3 Cell Status Screen

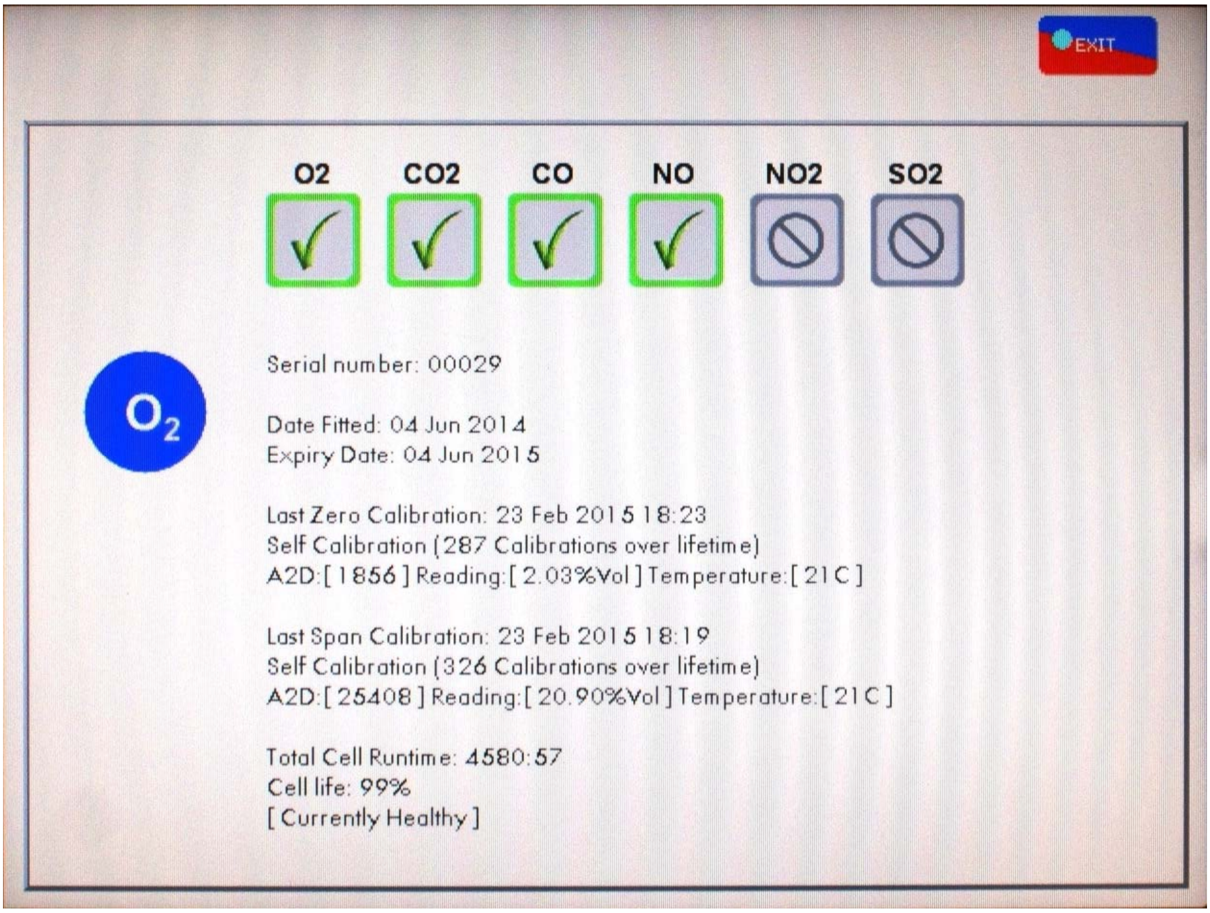


Figure 3.1.3.i Cell Status Screen

The cell status screen displays information of all fitted cells. This information is arranged as follows:

1. Image of the cell currently selected.
2. Detailed information on the cell currently selected.

The status icons are:

OK – Indicates the cell is healthy.

Not Fitted – Indicates the cell is not fitted. Refer to Section 3.1.7 on how to enable cells if they are present.

Error – Indicates there is an error with the cell. Press to get further information.

3.1.4 Fault History

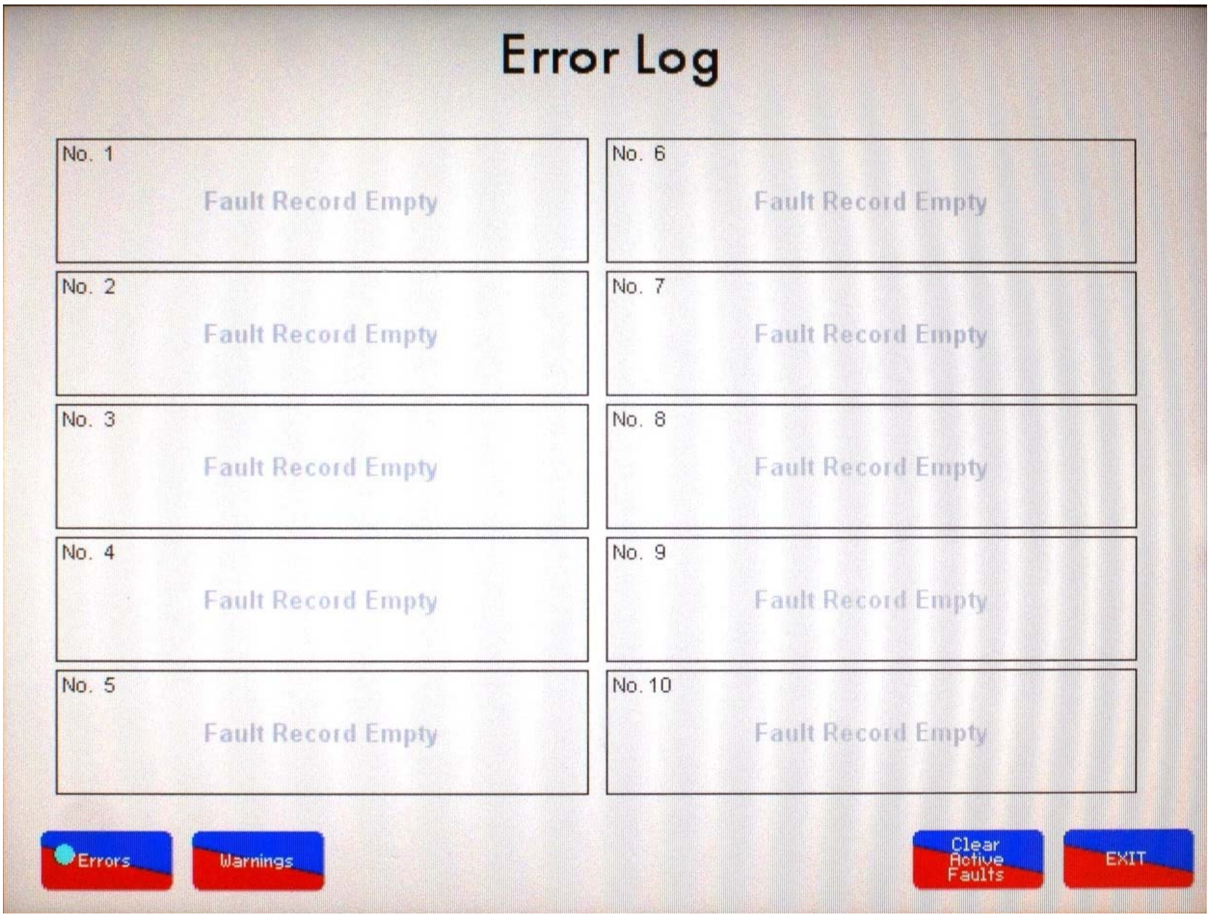


Figure 3.1.4.i Error Log Screen

When an error is detected a popup box will appear with information on the error. This error is then logged onto the Error Log and can be accessed at any time by pressing the 

button on the sampling screen.

The last 10 errors are logged on this record and can be downloaded through an MM (if used). Each error contains the following information:

1. Fault number (in reverse chronological order).
2. Type of fault.
3. Date and time at which the fault occurred.

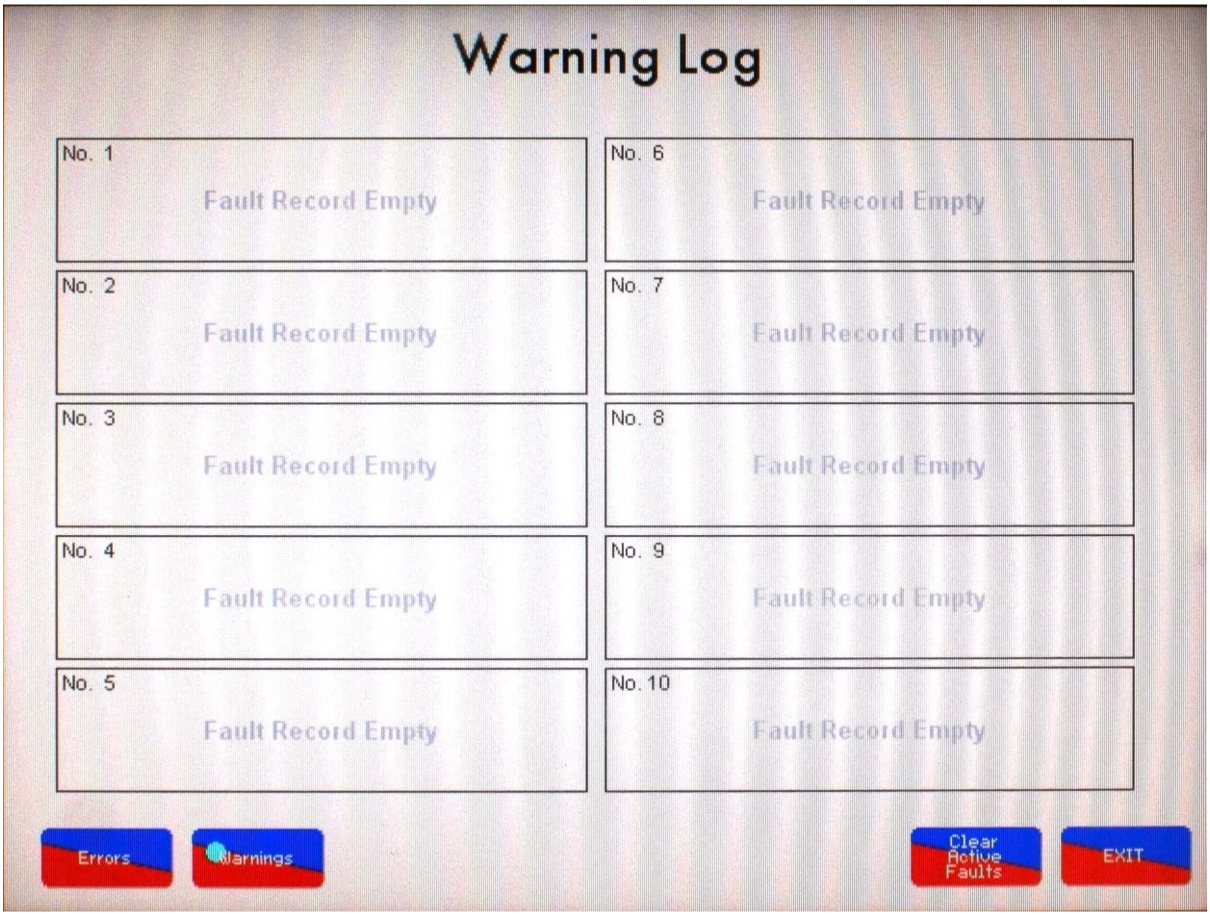


Figure 3.1.4.ii Warning Log Screen

With the Mk8 EGA there are now 2 types of faults, errors and warnings. Any error that occurs will cause the EGA to stop sampling to avoid damage to the unit or inaccurate combustion readings. Errors are more serious/damaging faults than warnings, and would require immediate rectification. Any warnings that occur are less damaging than errors, however they should still be dealt with as soon as possible. When the EGA has a warning, the EGA will continue to operate and sample.

All EGA errors and warning are detailed on the EGA screen, and on the MM screen, they will display as 'Refer to EGA for fault description.'

3.1.5 Factory Settings Screen

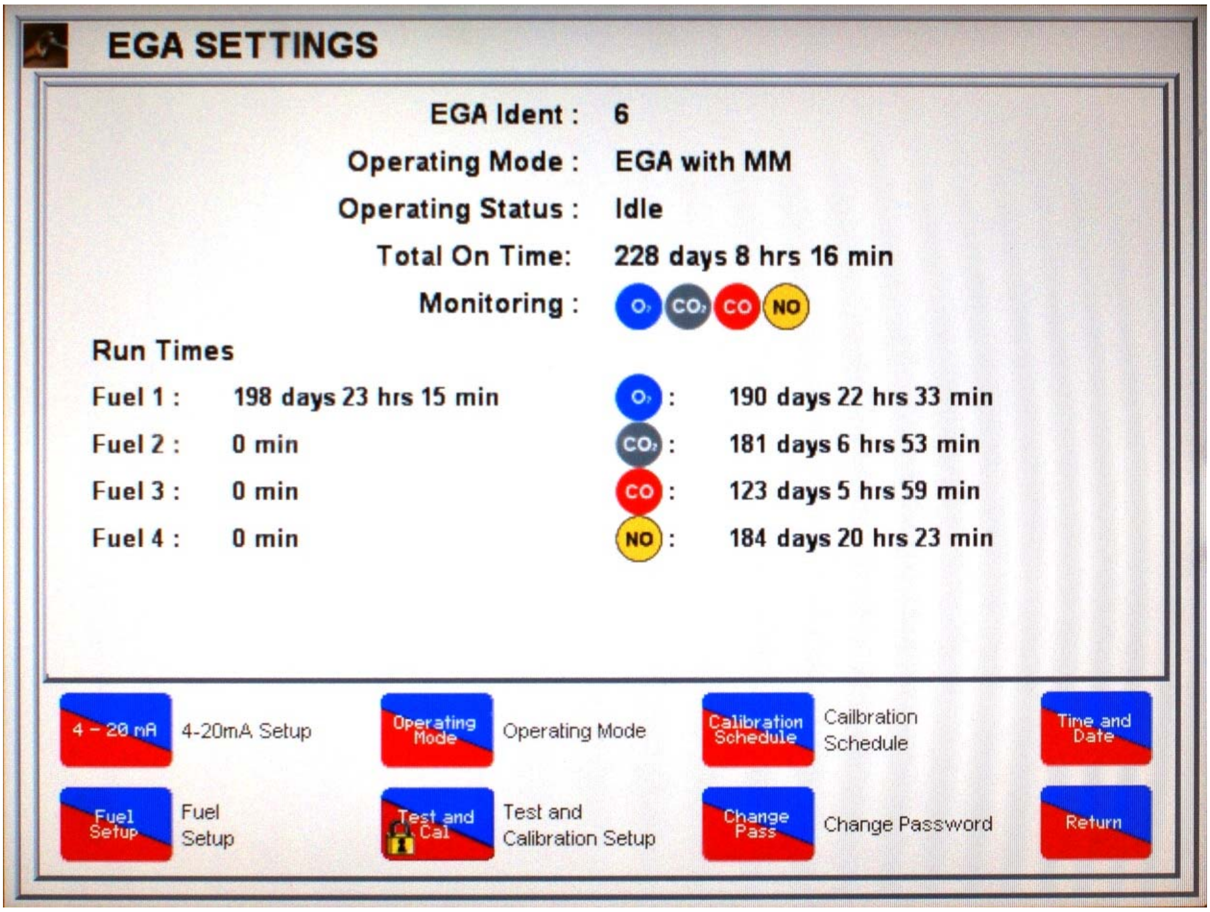


Figure 3.1.5.i Factory Settings Screen

To access this screen press the 

button from Figure 3.2.2.i and enter the password on the keypad displayed.

Upon entering the factory settings screen, an overview of the EGA is displayed:

1. The EGA ID, current operating mode, EGA status and cells selected.
2. The run times for each fuel and totalised run time.
3. Each cells run time.
4. Navigational Keys.

Use the navigational keys to select the following screens.

3.1.6 4-20mA Set-up

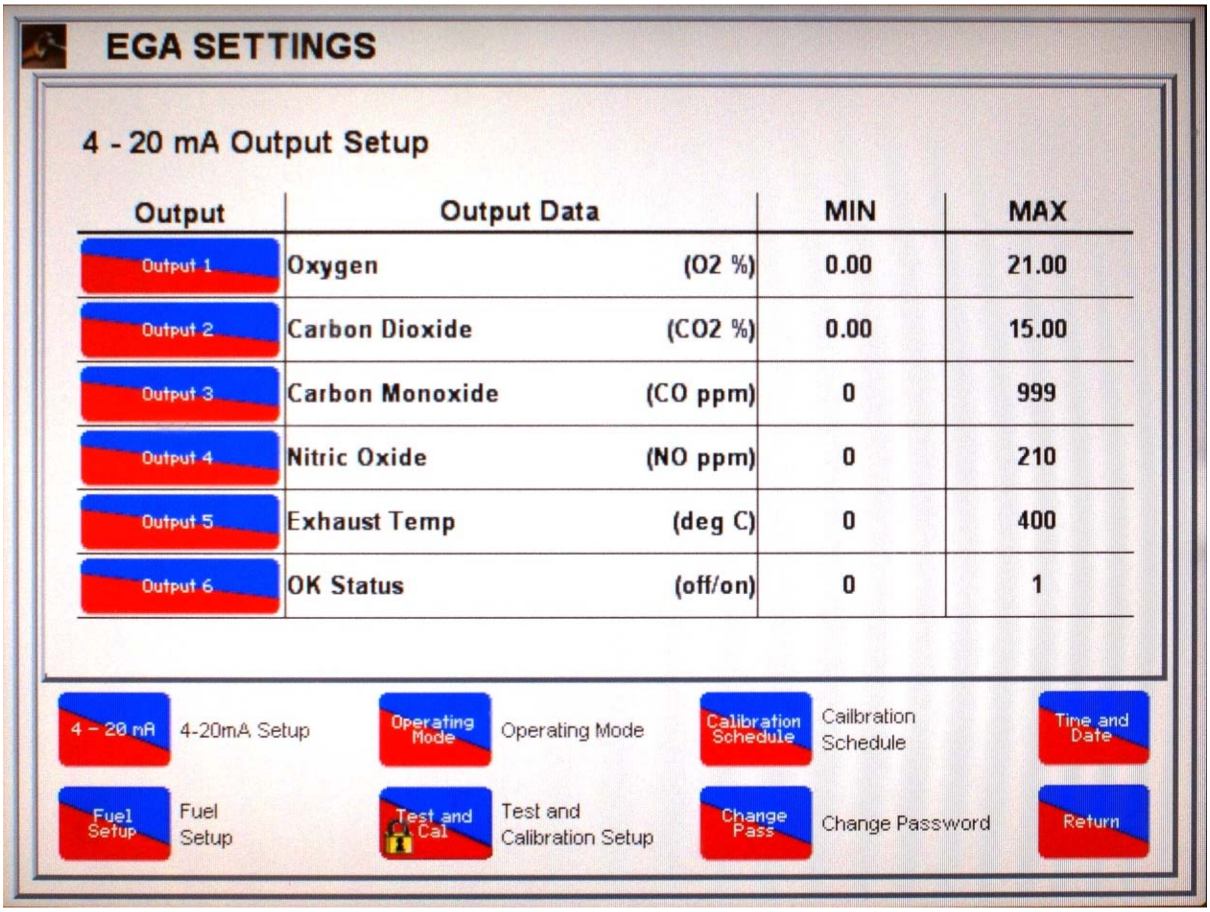


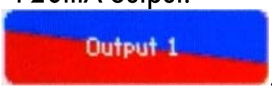
Figure 3.1.6.i 4-20mA Set-up Screen

Press the 

button to display the screen above. The above screen is used to set-up the 4-20 mA outputs. The 4-20mA setup screen has the following layout:

1. Output number.
2. Data to be outputted with units being used.
3. Minimum and maximum value of outputted data (range).

To setup each 4-20mA output:

1. Press 

. This will display a menu showing all possible data types that can be outputted.
2. Select the desired data to be outputted by pressing on the appropriate button from the menu.
3. A number pad will now appear allowing the minimum value of the data selected to be entered.

   Enter the minimum value on the key pad followed by  to confirm. If the value is entered incorrectly press the 

button on the keypad to delete the last number entered. To cancel press the  button.
4. Once the minimum value has been entered the system will require the maximum value for the data to be entered. This is the same procedure as entering the minimum value.
5. Repeat steps 1 to 4 for each output as desired.

Note: All changes will be stored with immediate effect.

3.1.7 Operating Mode Set-up

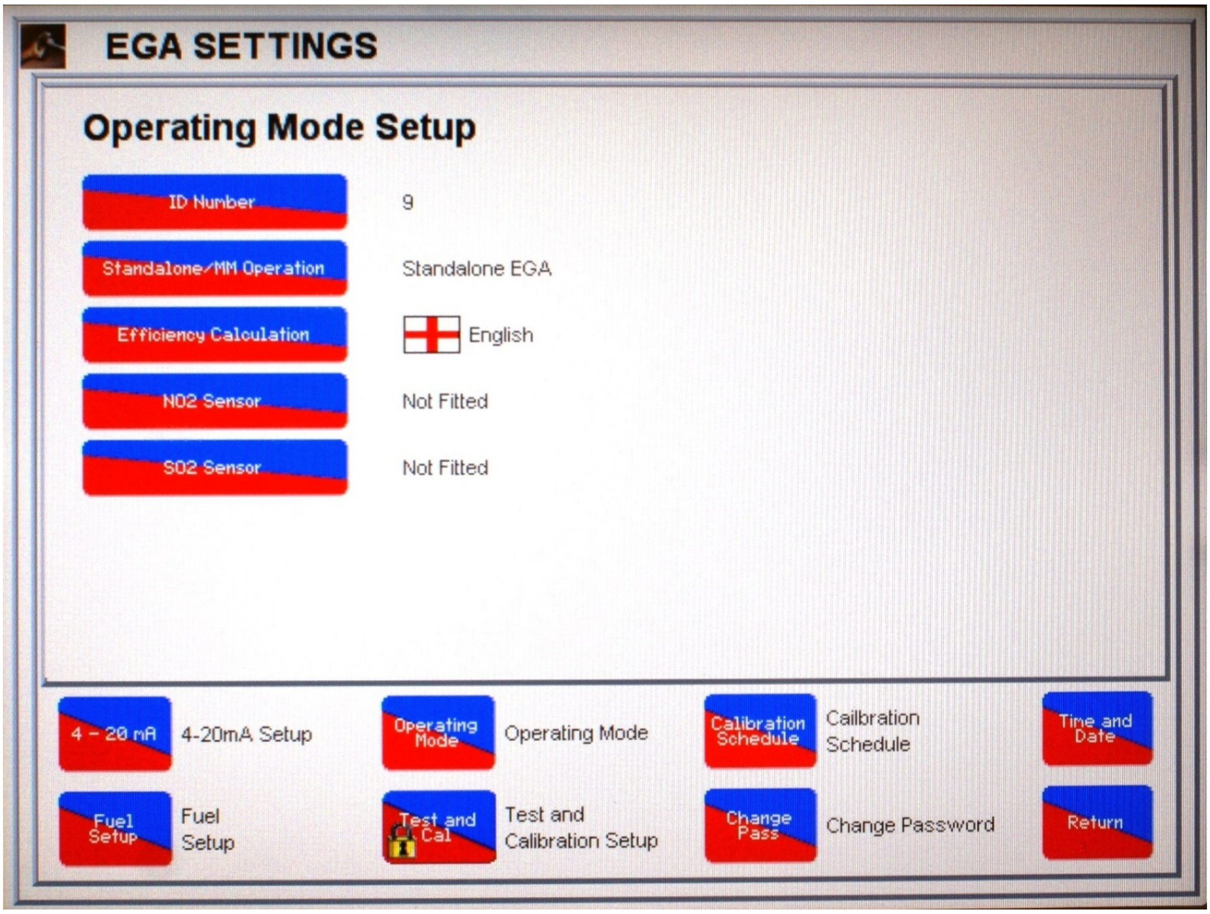


Figure 3.1.7.i Operating Mode Set-up Screen

Pressing the 

mode button will display the above screen. The Operating Mode screen is used to setup the EGA. The following settings can be changed on this screen:

1. ID number (1-10). If using an EGA in standalone mode with a DTI it is necessary to give each EGA a different ID number.
2. Mode of operation (EGA with MM, EGA selects fuel).
3. Efficiency calculation (European, English).
4. Presence of NO_2 and SO_2 cells (Fitted, Not Fitted).

To change any of the settings above, press the corresponding button and select from the available options.

If setting the EGA for standalone operation, the operation mode should be selected as 'EGA selects fuel.' Please see section 2.1 for information on standalone fuel selection.

3.1.8 Time and Date

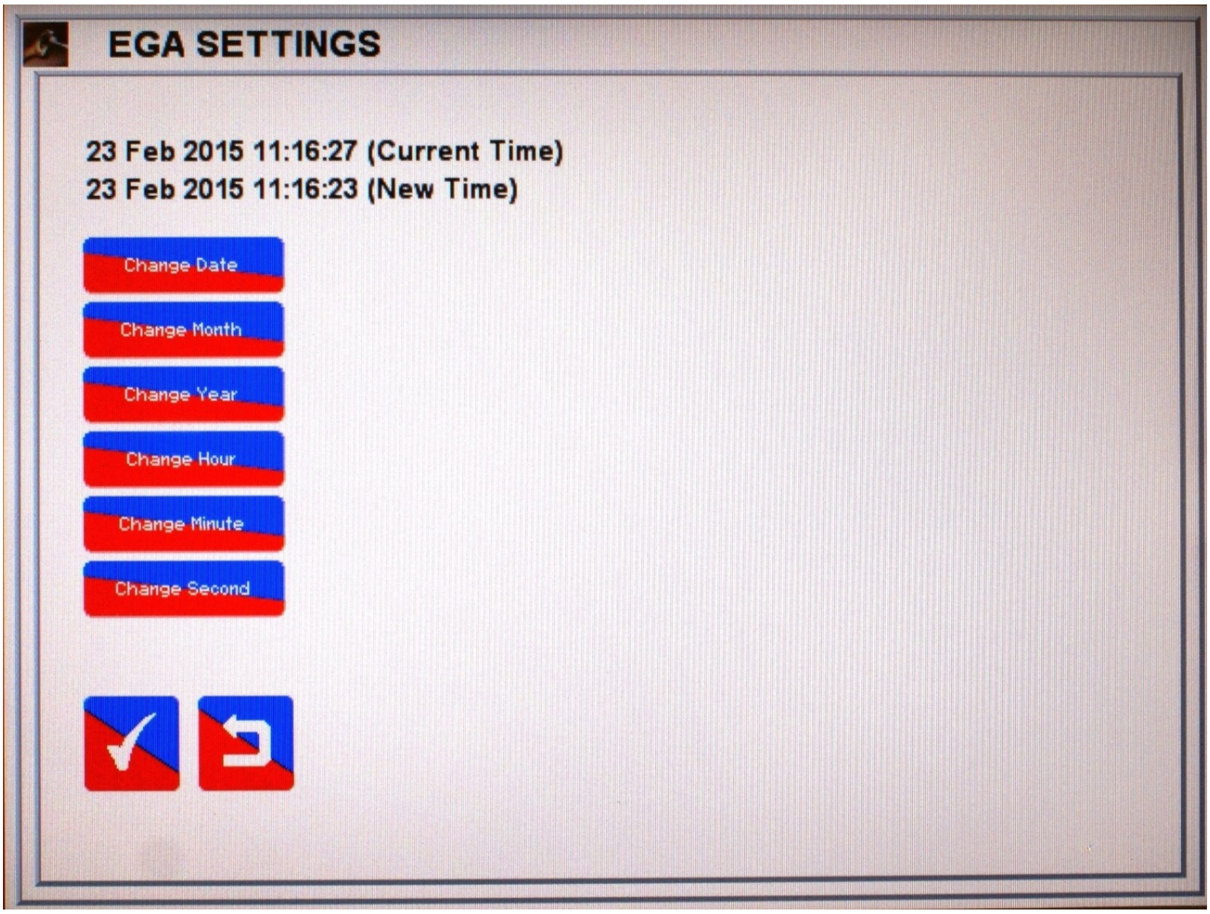


Figure 3.1.8.i Time and Date Screen

Pressing the 

button will display the screen above, where it is possible to change the time and date. The screen displays the following:

1. The currently set time.
2. The currently set date.
3. The new time and date to be set.
4. Buttons to set a new date.
5. Buttons to set a new time.

To change the time or date press the relevant button to what you want to change. Enter the required value into the keypad that appears. Each button has the following ranges:

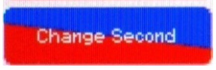
Range: 1 – 31

Choose from the available options.

Range: 0 – 99 (20## is automatically appended upon entering the value).

Range: 0 – 24.

Range: 0 – 59.



Range: 0 - 59.

3.1.9 Change Password

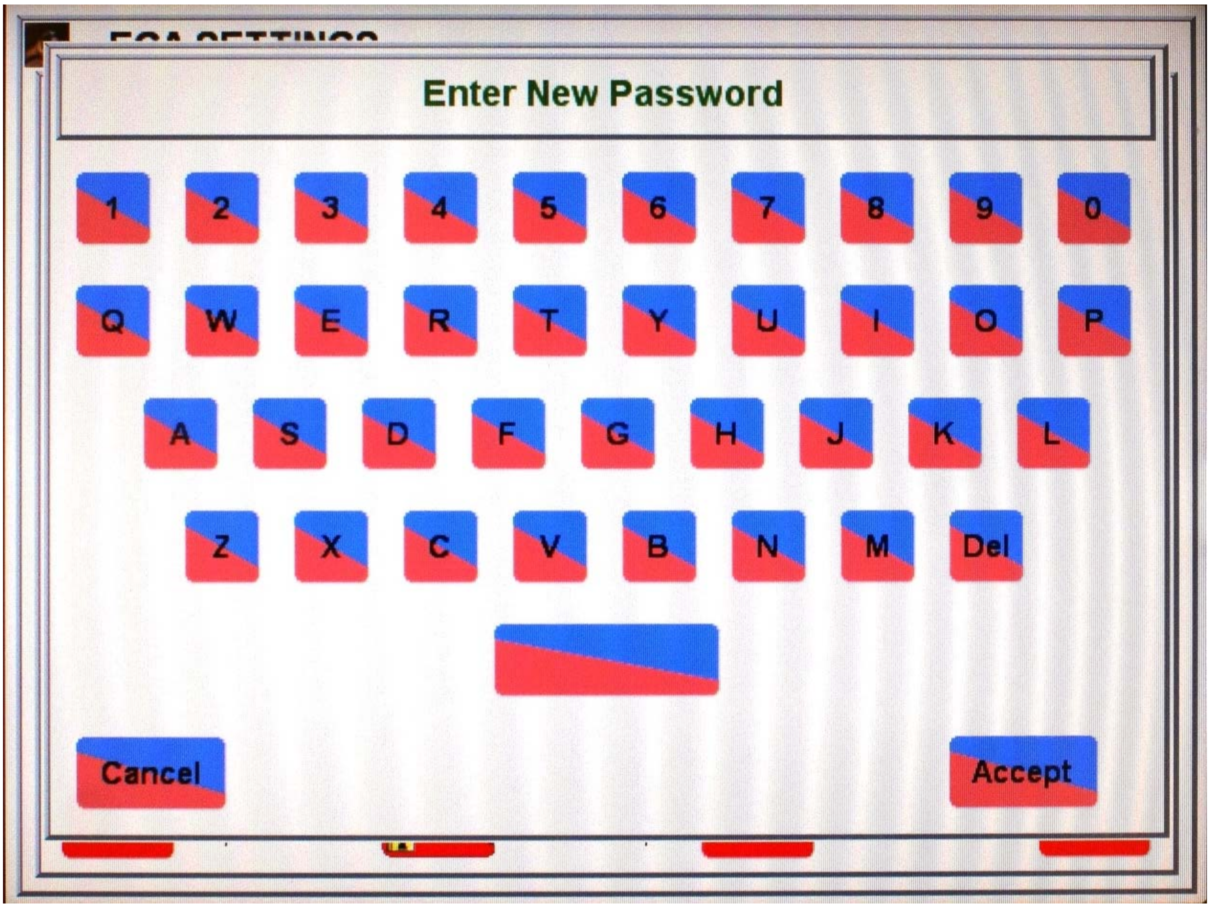
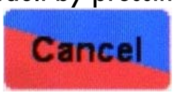
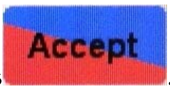


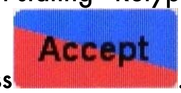
Figure 3.1.9.i Change Password Screen

It is possible to change the password from its default by pressing the 

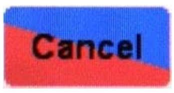
button. To exit this screen without changing the password press the 

button at any time. To proceed with changing the password:

1. Enter the new desired password using the keyboard. Note this password down for future reference.
2. Press 

.
3. A prompt stating "Retype New Password" will appear. Re-enter the password entered in 1 and press 

.

If the passwords entered in steps 1 and 3 are identical a box will appear stating "Password Changed". Should the passwords not match or if the 

button is pressed a box will appear stating "Password Not Changed".

3.2 CEMS Set-Up

3.2.1 Fuel Selection

To access the fuel setup screens, press the 'Setup' button at the top left of the EGA screen, go to the 'Factory Settings'; you will be required to enter the password. Press on the 

button in the bottom left corner of the screen.

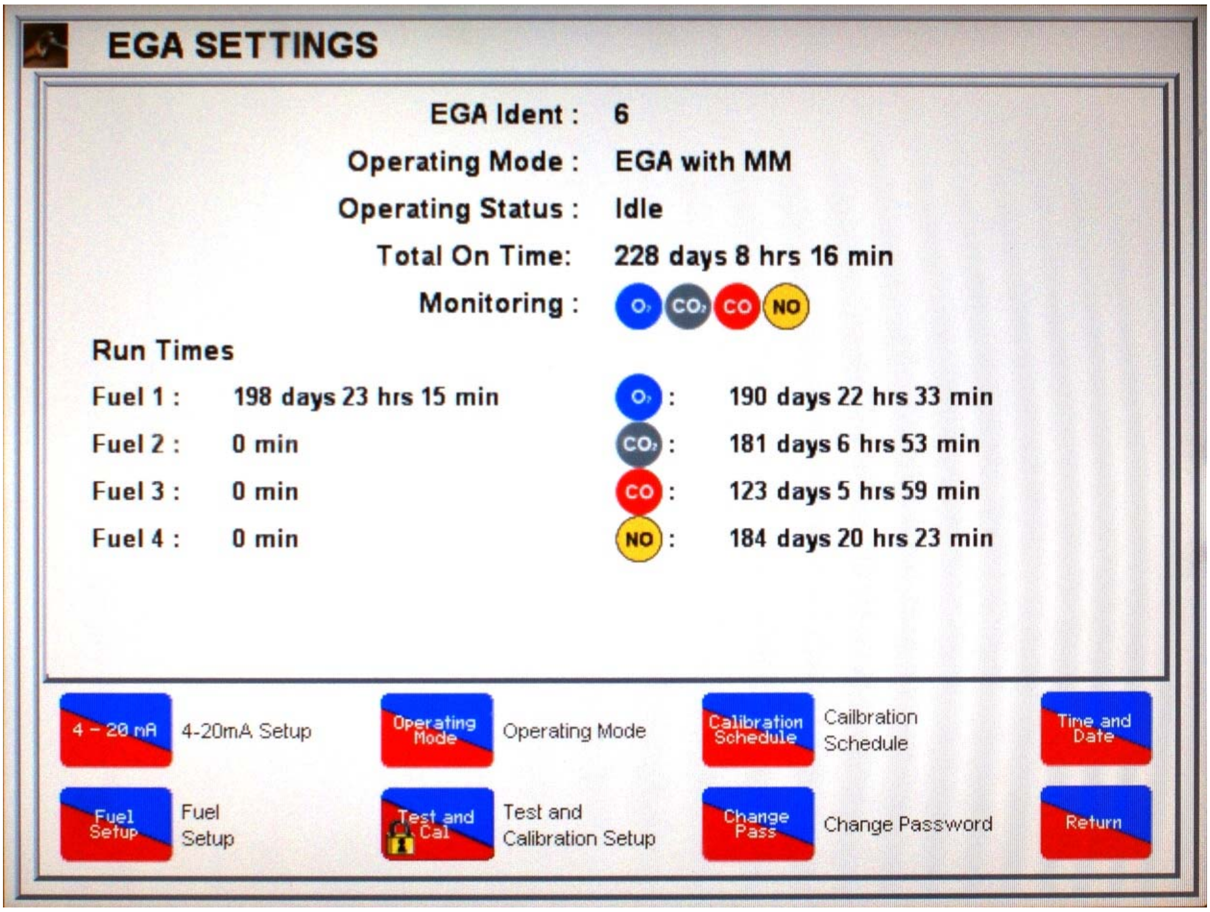
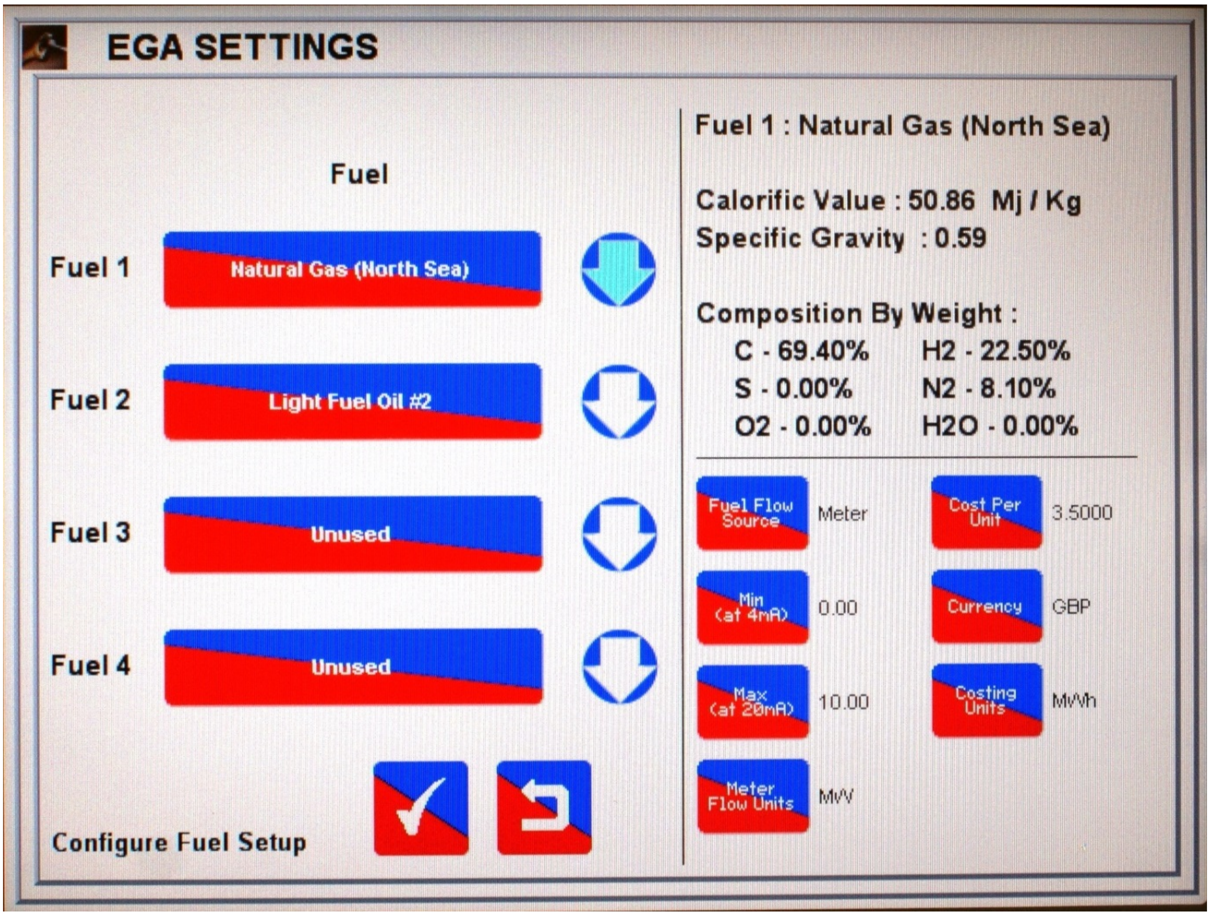


Figure 3.2.1.i EGA Settings – CEMS EGA

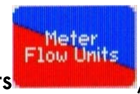
Note: Fuel setup is required for CEMS recording on the EGA and DTI.



3.2.1.ii Fuel Set-up

CEMS fuel data can be entered for up to 4 fuels. There are several pre-set fuels that can be used for each. The calorific values for each are not configurable. If a fuel cannot be found that has similar properties to what is required for accurate CEMS data analysis, please contact Autoflame Technical Support.

For each fuel used in that burner application, the fuel flow source 

, meter units 

, cost per unit 

, currency 

and costing units 

must be set.

3.2.2 Fuel Flow Source

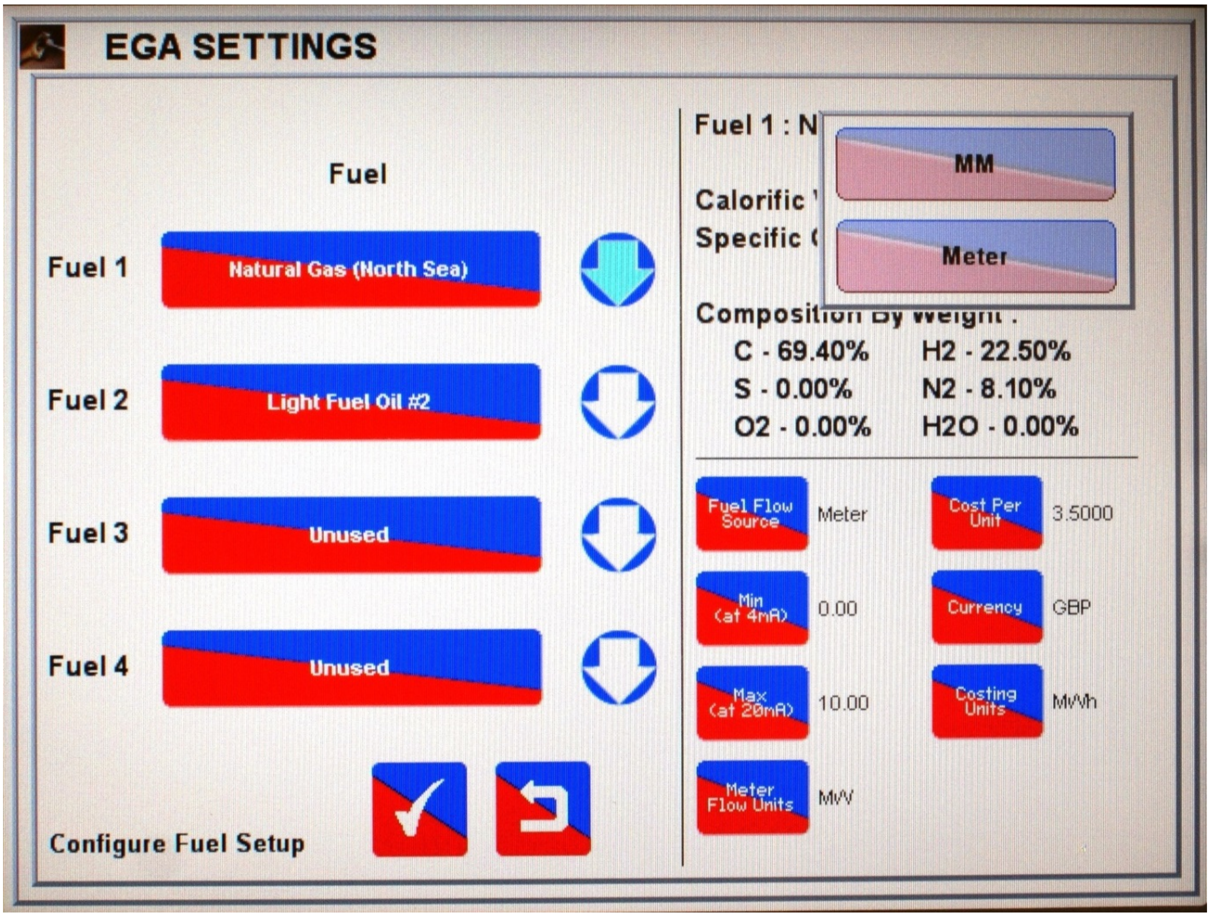


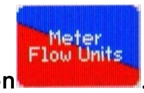
Figure 3.2.2.i Fuel Flow Source

Press 

to enter whether the fuel flow metering data is taken from the MM or a fuel flow meter. If the Mk8 EGA is being used in conjunction with an MM, then the fuel consumption can be determined based on the MM fuel flow metering which is entered through option 57 on the MM. For the MM fuel flow metering based audits, press the 'Fuel Flow Source' button and select MM.

A fuel flow meter can also be used to calculate the fuel consumption. This is done via a fuel flow meter connected to the 4-20mA analogue signals, the minimum flow at 4mA 

and maximum 20mA 

. Units for the flow meter can be changed using the flow units button 

.

3.2.3 Unit Measurement

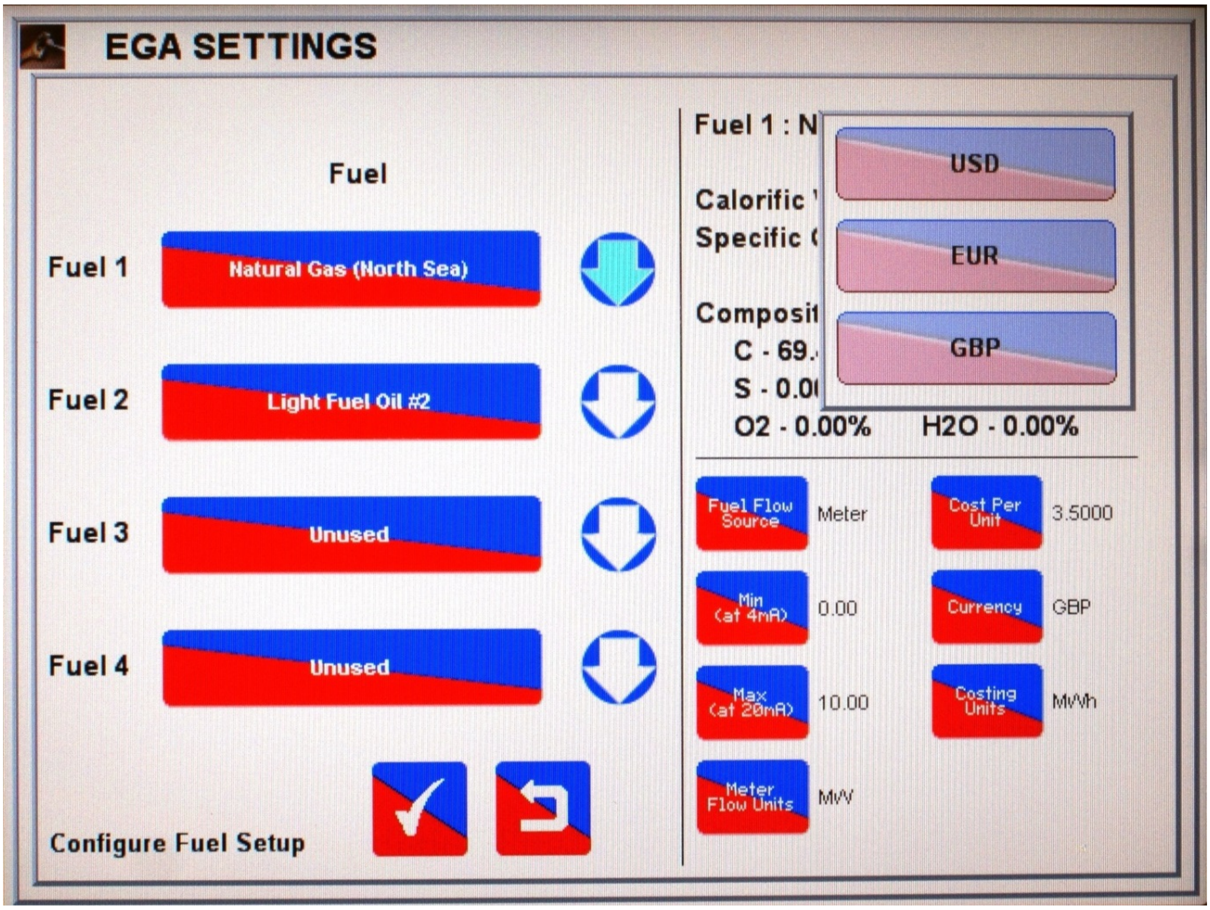


Figure 3.2.3.i Unit Measurement

Press 

, 

and 

to enter the details for the fuel cost and currency.

Once a fuel has been set, accurate CEMS data can be obtained by entering an accurate cost per unit of fuel fired. This is done using the 'Cost per Unit', 'Currency' and 'Costing Units' buttons on the right hand side of the Fuel Set-up screen. If further currencies or unit measurements are required, please contact Autoflame Technical Support.

3.3 CEMS Data Screens

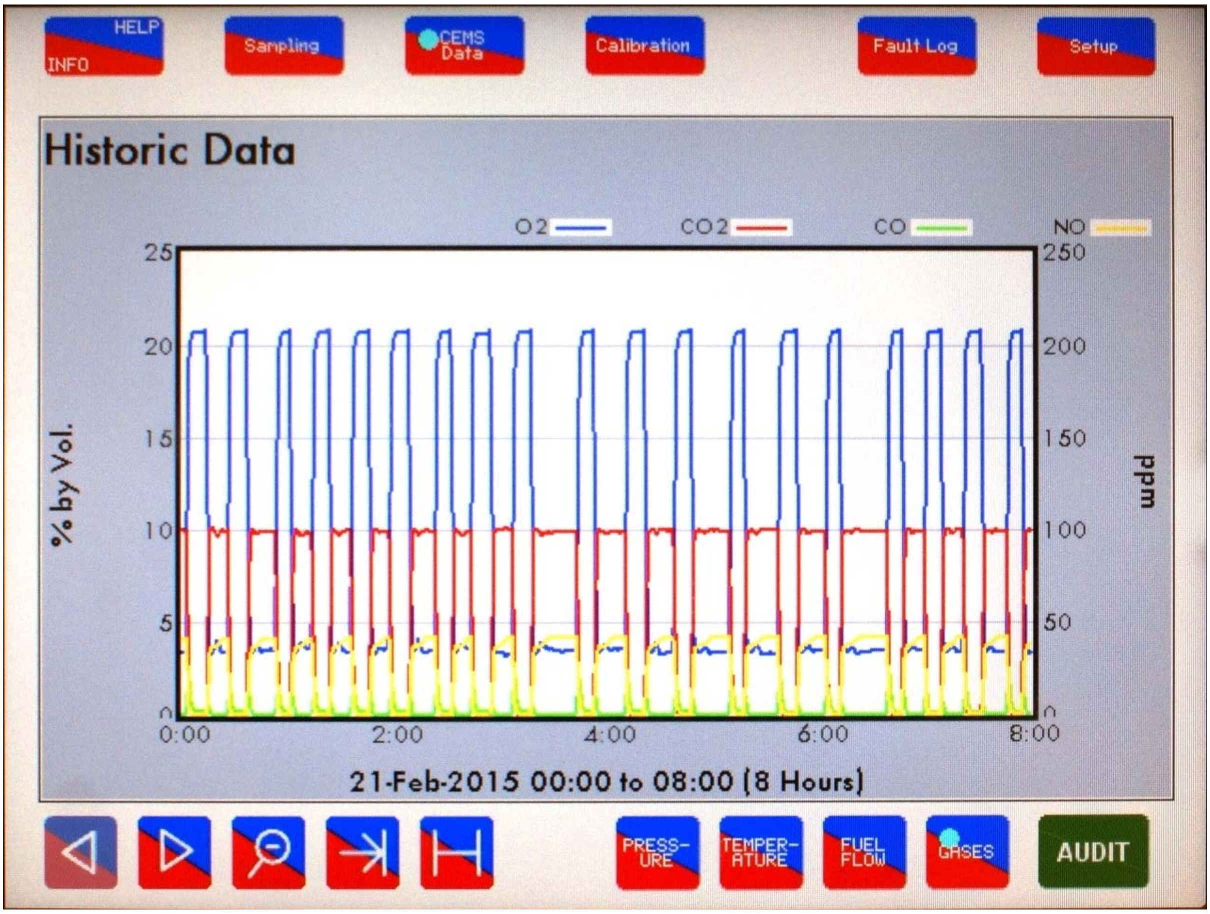


Figure 3.3.i Gas History

Press the  button to view the emissions data logging for up to 2 years.

Press  to view the gas history. The graph can be zoomed in by pressing 2 points on the axis. To view one gas at a time, deselect the other gases above the graph.

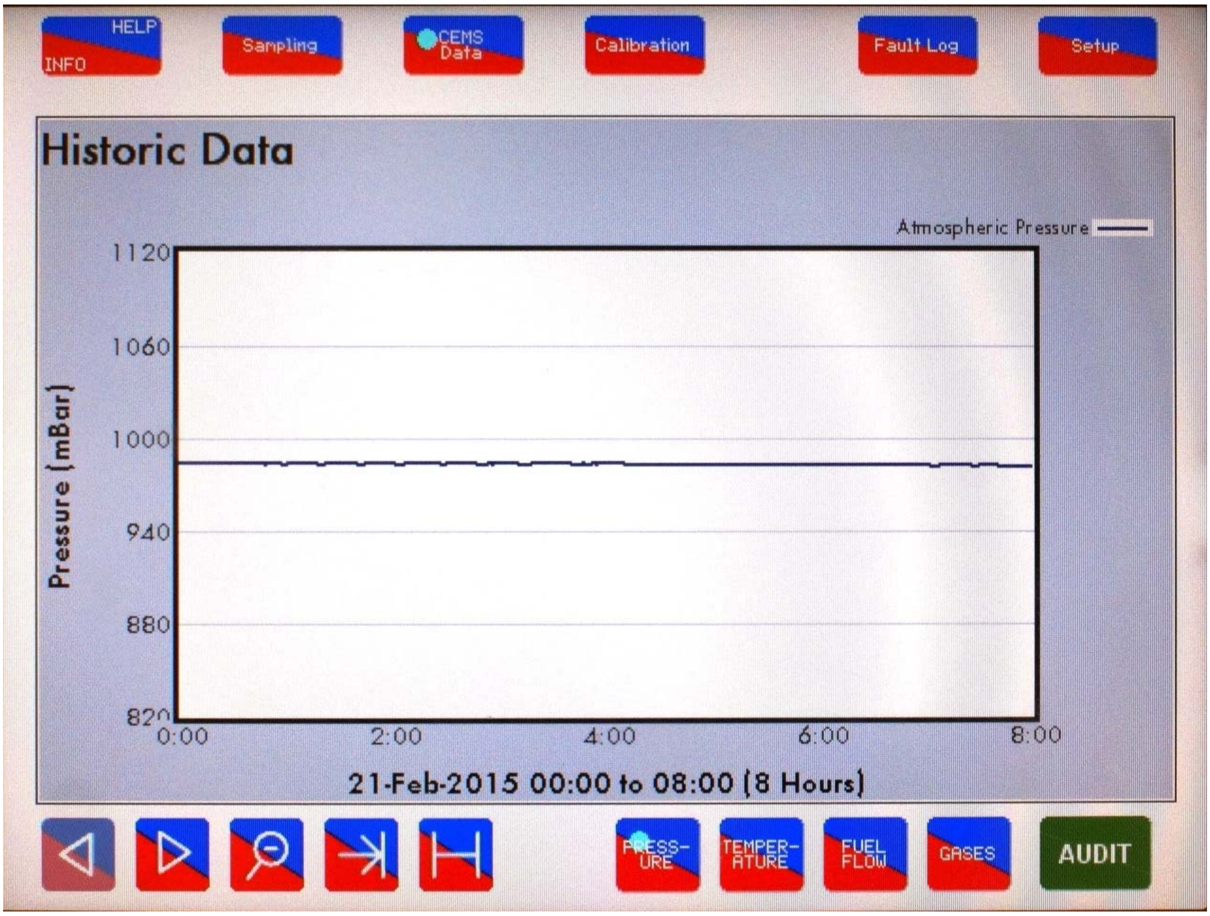


Figure 3.3.ii Pressure History

Press  to view the atmospheric (ambient) pressure history for up to 2 years. The graph can be zoomed by pressing 2 points on the axis.

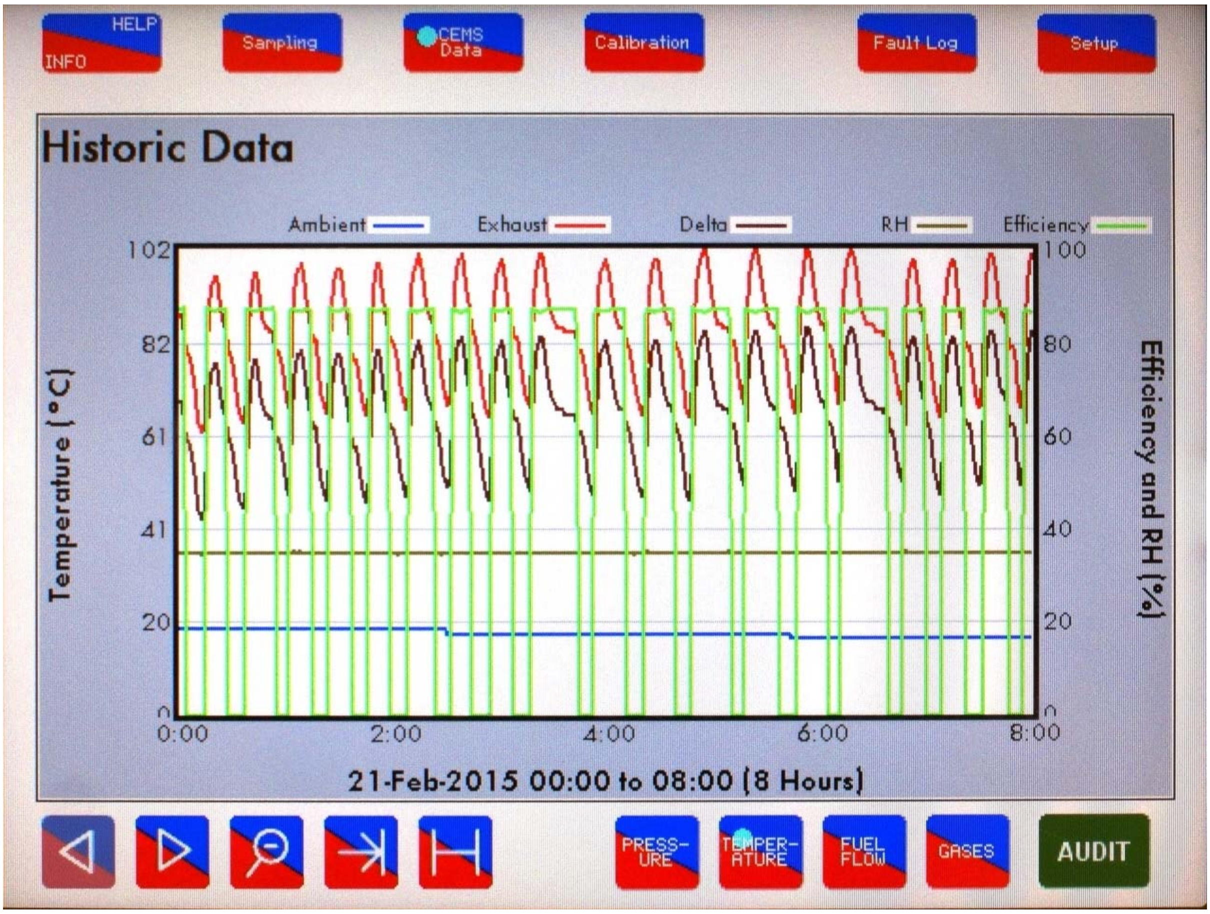
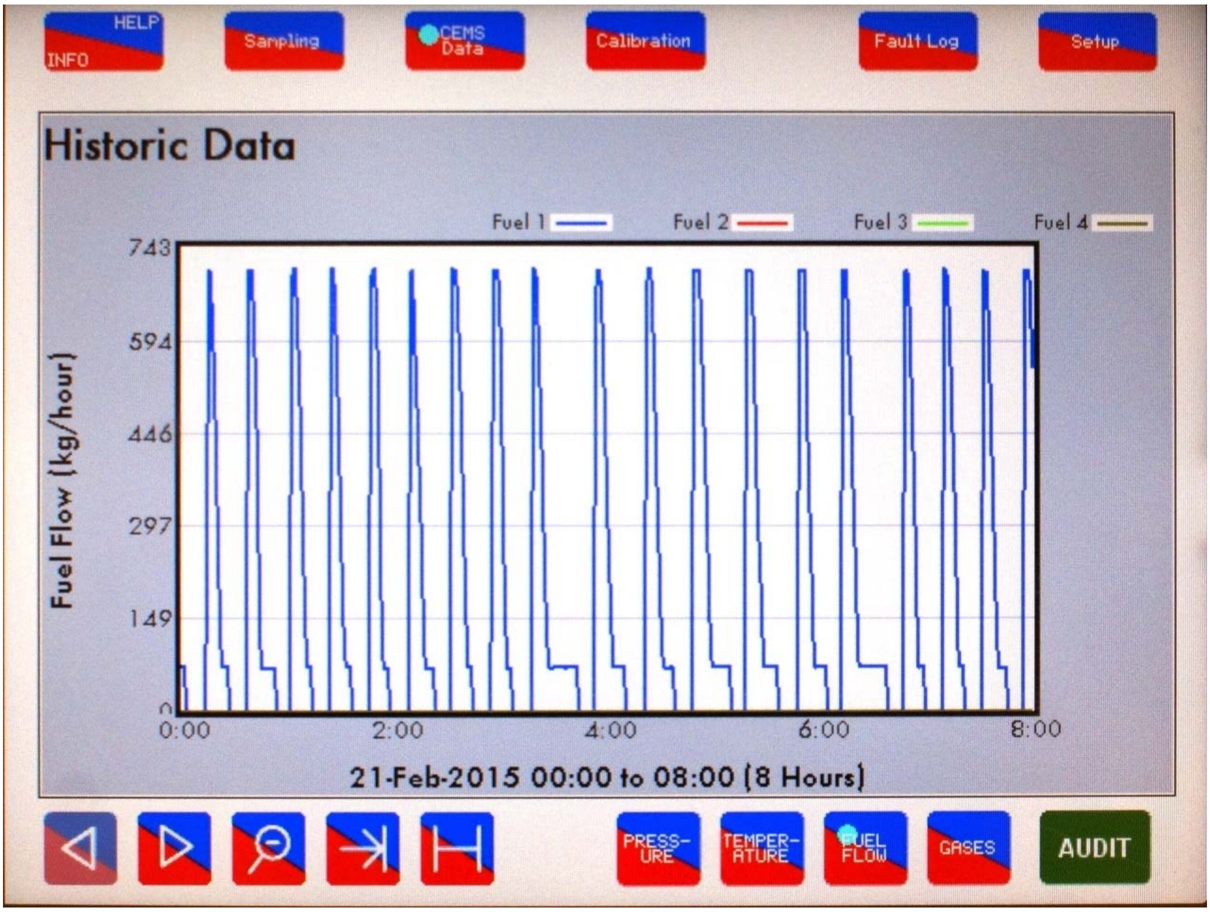


Figure 3.3.iii Temperature History

Press 

to view the temperature history for up to 2 years, for the ambient temperature, exhaust temperature, delta temperature, relative humidity percentage and efficiency percentage. The graph can be zoomed in by pressing 2 points on the axis. To view one temperature graph at a time, deselect the other temperatures above the graph.



3.3.iv Fuel Flow History

Press  to view fuel flow history. The fuel flow data is taken from the MM's fuel flow metering or from a 4-20mA analogue signal. The graph can be zoomed in by pressing 2 points on the axis. To view one fuel graph at a time, deselect the other fuels above the graph.

The left  and right  arrows are used to change the data range (hours, days, months) to the next available one.

The zoom out button  is used to go back to the next available data range.ie from hourly data to daily data.

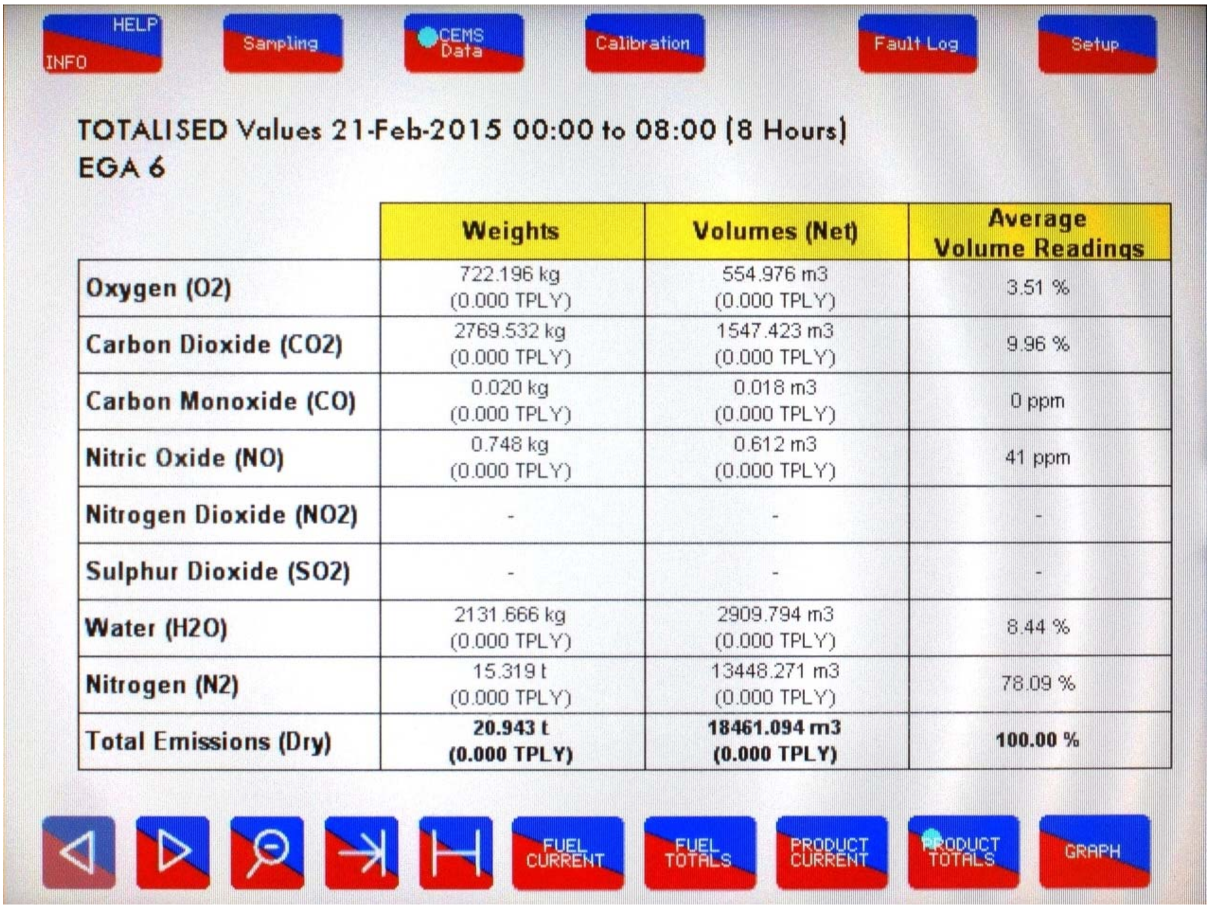
To view the last available data press  .

The full range of data can be seen by pressing  .

To view overnight data, a two day view is required (e.g. from 20:00 on day 1 to 08:00 on day 2). The hourly data for each day is displayed from 00:00 to 24:00.

3.4 CEMS Energy Audits

Once the fuel set-ups have been entered, it is possible on the Mk8 EGA to take fuel consumption audits. Select a time period using the arrow section on the CEMS data for which the fuel consumption will be calculated for.



	Weights	Volumes (Net)	Average Volume Readings
Oxygen (O2)	722.196 kg (0.000 TPLY)	554.976 m3 (0.000 TPLY)	3.51 %
Carbon Dioxide (CO2)	2769.532 kg (0.000 TPLY)	1547.423 m3 (0.000 TPLY)	9.96 %
Carbon Monoxide (CO)	0.020 kg (0.000 TPLY)	0.018 m3 (0.000 TPLY)	0 ppm
Nitric Oxide (NO)	0.748 kg (0.000 TPLY)	0.612 m3 (0.000 TPLY)	41 ppm
Nitrogen Dioxide (NO2)	-	-	-
Sulphur Dioxide (SO2)	-	-	-
Water (H2O)	2131.666 kg (0.000 TPLY)	2909.794 m3 (0.000 TPLY)	8.44 %
Nitrogen (N2)	15.319 t (0.000 TPLY)	13448.271 m3 (0.000 TPLY)	78.09 %
Total Emissions (Dry)	**20.943 t (0.000 TPLY)**	**18461.094 m3 (0.000 TPLY)**	**100.00 %**

Figure 3.4.i Product Totals

Press 

to view the product and fuel totals. The 

and 

buttons allow you to view the consumption at present.

Press 

to view information on the exhaust gas weights, volumes and average volume readings for that time period.

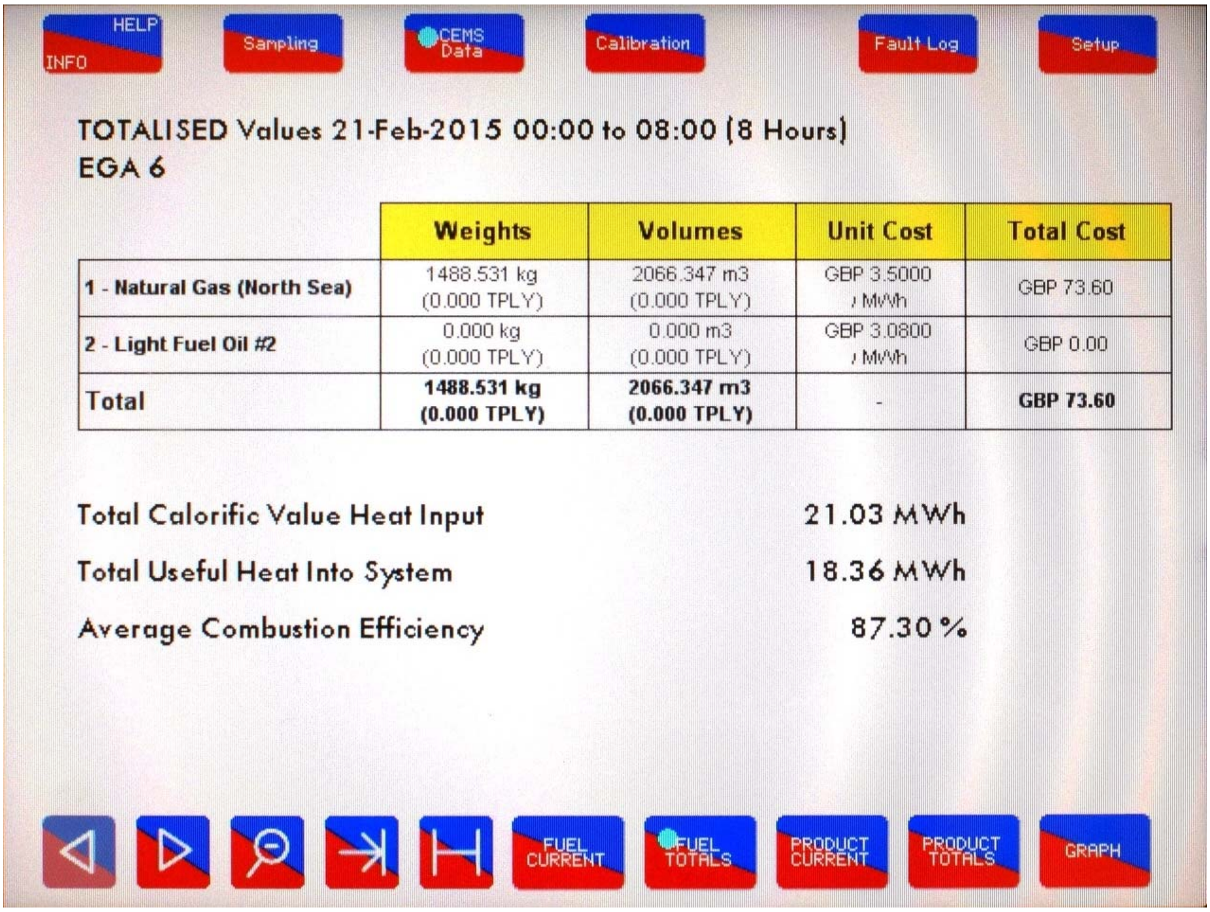


Figure 3.4.ii Fuel Totals

Press 

to view information on the fuel weights, volumes and total costs, as well as the total calorific value heat input, total useful heat into the system and the average combustion efficiency.

As detailed in this section 3.3 the totalised values can be viewed for a particular time period if required.

3.5 Trim Settings

The following table gives all the options in the Mk8 MM and Mini Mk8 MM which are relevant to the EGA settings. When changing the options for the EGA such as the alarm operation, trim threshold and trim delay, it is good practice to adjust one and check the effects on the trim operation before adjusting another.

Option	Description
12	EGA functionality
13	EGA fault response
18	Carry forward of trim
19	O_2 upper limit offset
20	CO_2 upper limit offset
21	CO upper limit offset
22	O_2 lower limit offset
23	CO_2 lower limit offset
25	O_2 absolute limit
26	CO_2 absolute limit
27	CO absolute limit
28	Trim threshold
32	Trim delay
76 (Mk8 MM only)	Trim channel
Parameter	**Description**
4	Delay before EGA commission can be stored
8	Trim delay after drain
10	EGA version
12	CO used for trim on oil
13	Commission fuel-rich trim
14	Trim reset angular rate (negative trim reset angle)
17	Number of trims before limits error generated
18	Maximum trim during run
19	Commission air-rich trim
23	Add air when CO present
26	Trim samples per cycle
94	NO upper limit offset
96	Exhaust temperature upper limit offset
97	Exhaust temperature absolute limit

3.5.1 Commissioning Procedure

Commissioning with the EGA is an extension to commissioning with the MM and is required if the trim function is to be used. The factory trained technician must be completely familiar with the commissioning of the MM unit before commissioning with the EGA For the full commissioning procedure, please refer to the Mk8 MM Installation and Commissioning Guide and Mini Mk8 MM Installation and Commissioning Guide.

The commissioning procedure as described must be strictly adhered to. Anybody commissioning an MM/EGA system must have an adequate understanding of combustion plants and be officially certified by Autoflame Engineering.

In the wrong hands, hazardous conditions could be made to exist that could lead to product damage, critical injury or death.

The fundamental idea of the system is to set a fuel valve position and then set a corresponding air valve position. Care must be taken when adjusting the fuel and air positions so as not to create any unstable or dangerous combustion conditions, e.g. moving the fuel valve to the open position without increasing the air valve correspondingly.

Commissioning a system with an EGA does not require a combustion monitor as the EGA performs all normal exhaust gas measurements. When burning oil, a smoke detection device is required to check that the smoke generated is within government guidelines.

Ideally, to implement commissioning as quickly as possible arrange for a substantial load on the boiler. The commissioning procedure can be interrupted due to excess temperature or pressure, causing the burner to turn off. In these instances the commissioning data accumulated so far is not lost. When the burner is called back on, the system starts up automatically and commissioning can proceed from where it left off.

Once the burner has been fired the maximum fuel position is entered first then descending fuel positions are entered consecutively until finally a minimum fuel position is entered. The CH1 and CH2 positions must always be less than the ones previously entered. However with the remaining channels it is possible to move the position above or below the previously entered points. This is important if these channels are used to control FGR (Flue Gas Recirculation) or atomisation of oil.

On a newly installed system the following procedures should be carried out as listed:

1. Check all interconnecting wiring between the MM and external components are correct.
2. Set the Options and Parameters required (section 3.5)
3. Set up positioning motors.
4. Programme fuel/air positions.

Note: For the safety and operational checks, and the full commissioning procedure of the Mk8 MM Installation and Commissioning Guide and the Mini Mk8 MM Installation and Commissioning Guide.

On the Mk8 MM and Mini Mk8 MM, it is possible to commission the burner with option 12 set to no EGA or monitoring only, then add EGA trim later by setting option 12 to 2 or 3 and adding the trim positions in single point change. Once commissioning is complete and all points are entered, the trim is then set in Single Point Change. Ensure that option 12 is now set to trim. Once in single point change you will then be able to activate the trim by pressing the 'trim' button when on a particular point.

3.6 Mk8 EGA Trim

3.6.1 Trim Operation

With the EGA trim facility it is possible to expand the MM so it will measure and display O_2, CO, CO_2 and exhaust gas temperature, together with boiler temperature or pressure. It is also possible to use these O_2, CO and CO_2 values for 3 parameter trim in order to optimise the burner combustion throughout the firing range of the burner in a safe manner. This means that the safety is never compromised by efficiency, but the best burner/boiler efficiency is maintained. Correct set-up of the 3 parameter trim will maintain optimum combustion efficiency, whilst never compromising safety.

During commissioning, for every paired value of fuel and air, the corresponding values of O_2, CO and CO_2 are stored. During the normal run mode, the on-line sample at any position within the burner's firing rate is compared to the commissioned values. There are 3 individually sampled parameters (O_2, CO, CO_2) in order to verify the combustion performance either side of the commissioned value. The software within the MM unit will inflict minute corrections to the channel 2 air damper positions or the channel 5 variable speed drive in order to maintain the commissioned values. These small changes ensure that the originally entered commissioning data is adhered to, irrespective of variations in stack pressure, ambient temperature/pressure fluctuations, barometric conditions or fuel pressure changes.

The commission time is based on the residence time of the combustion gas. The residence time is measured by looking for a change in the O_2 reading from when the air damper is moved, to a change in combustion of >0.2% O_2. This is the time from the time the gas leaves the burner, to the time it exits the boiler into the flue. This time will vary depending on how the burner is firing and the burner turn down ratios. This residence time is displayed in the combustion map screen. The residence time is typically longer at low fire that at high fire due to the volume of the gases passing through the boiler.

<u>Importance of Measuring 3 Parameters</u>

The Autoflame system trims on O_2, CO_2 and CO, and so is not simply an O_2 trim system. If only O_2 is measured and trimmed on then there is no cross reference to CO, CO_2 or NOx Therefore, even if the O_2 readings are correct, changes in ambient conditions can cause the CO to rise significantly (>>100ppm). Another, more dangerous problem that can occur is oxygen being induced into the boiler through gaskets and small gaps in the boiler flue ways. As the flue gas is measured at the exit of the boiler, this could lead to higher O_2 readings even if the combustion is good, i.e. high CO levels (>>100ppm), low O_2 levels. With a simple O_2 trim system, this potentially dangerous problem would not be accounted for. With the Autoflame EGA, O_2, CO_2 and CO are constantly measured and any changes to these 3 parameters, will result in a trim taking place on the air damper to return the combustion level back to the original commissioned values. Therefore, even if both the O_2 and CO_2 are reading correctly the system will still trim due to changes in the amount of CO produced.

The following table shows a potential problem with using the O_2 analyser.

	O_2 Analyser			3 Parameter Trim (Autoflame)			
State	**O_2**	**CO**		**O_2**	**CO_2**	**CO**	
1	3	0		3	10	0	Commissioned
2	4	0		4	10	0	Trim
3	4.5	100		4.5	10.5	100	Increased Trim
4	5	200		5	10.5	100	No trim
5	4	500		5.5	10	0	Commission position
6	3	1000+		5.5	10.5	50	Trim

Values in red are ones that are not viewable using an O_2 trim system.

State 1 – The burner is operating under normal conditions.

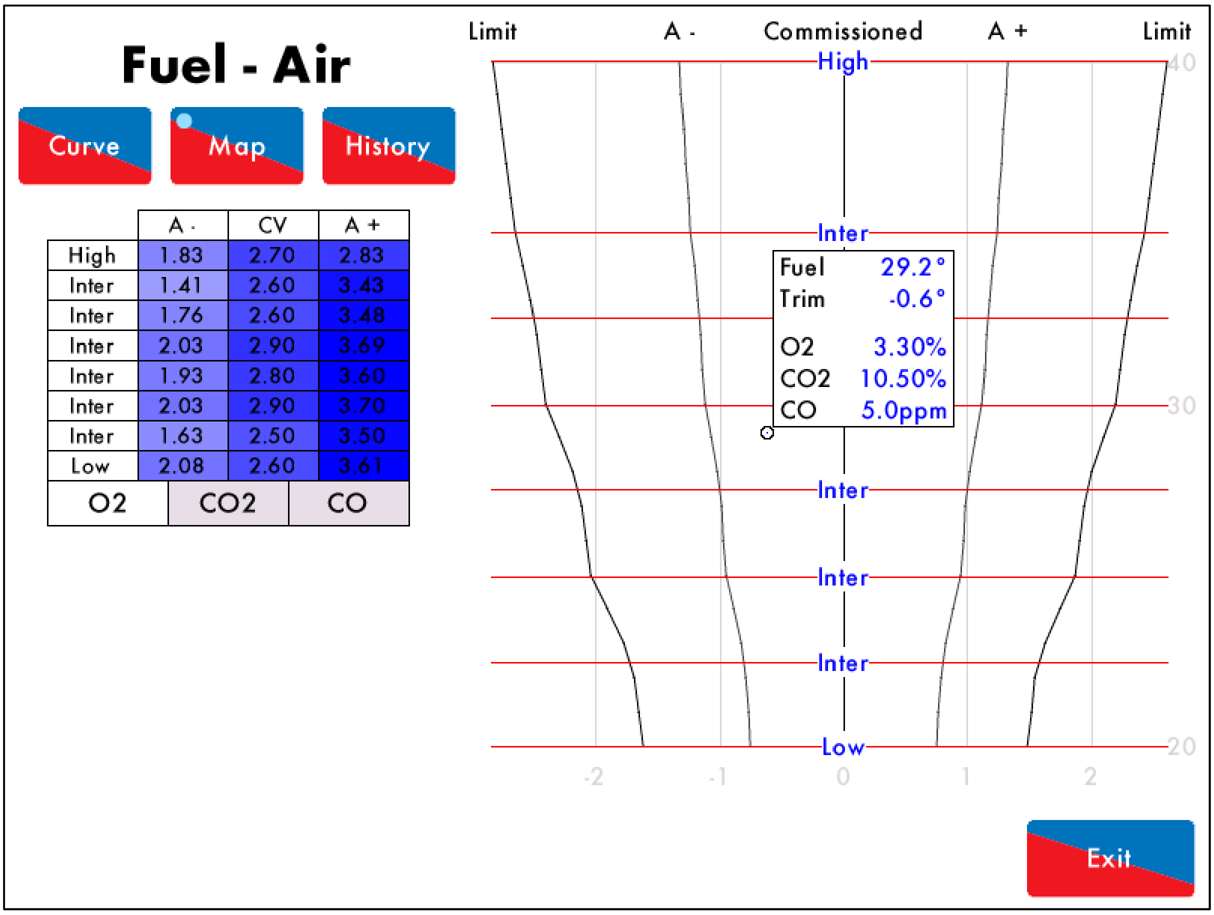
State 2 – Over a period of time, boilers are susceptible to leaks occurring. One of the most likely places that this will occur is on the stack, near to the point where the analyser is measuring the exhaust gases. As a leak occurs at this point, the analyser is not measuring solely the exhaust gases, but is in fact contaminated with 20.9% O_2 from atmosphere. Therefore, the oxygen reading starts to increase.

State 3 – As the amount of oxygen increases so too does the reading. At this point the controller closes the air damper in order to react to the increase in oxygen. The CO begins to rise since the combustion is now not correct.

State 4 – Both analysers still see an increase in the oxygen reading. The O_2 analyser continues to close the air damper in order to reduce the excess air through the system, and so producing CO. The Autoflame analyser measures the increasing CO value and ensures that the air damper does not continue to close.

State 5 – The O_2 analyser continues to trim based on the oxygen readings and so excess CO is produced. The Autoflame analyser has seen this ambiguous case and returns the air damper back to the commissioned value in order to ensure that the O_2, CO_2 and CO levels are returned to the commissioned values (or close to) before further trimming occurs. This, potentially dangerous anomaly has been corrected for.

State 6 – Dangerous combustion occurs on the O_2 analyser, whereas the Autoflame EGA system has taken this ambiguous case into account.



	A -	CV	A +
High	1.83	2.70	2.83
Inter	1.41	2.60	3.43
Inter	1.76	2.60	3.48
Inter	2.03	2.90	3.69
Inter	1.93	2.80	3.60
Inter	2.03	2.90	3.70
Inter	1.63	2.50	3.50
Low	2.08	2.60	3.61

O2 | CO2 | CO

Figure 3.6.1.i Combustion Map Screen

The combustion map (see Figure 3.6.1.i) shows how the trim function works on the system. The combustion map screen can be accessed by pressing the 'combustion map' button on the M.M home screen. The combustion map clearly shows the commissioned EGA values for O_2, CO_2 and CO. The graph on the left of the screen shows the amount of trim being added by the MM to control these emissions values so that they are as close to their commissioned values as possible. The red circle indicates the current position of the trim being applied and the current combustion values are displayed at this point as well.

3.6.2 Trim Timing Operation

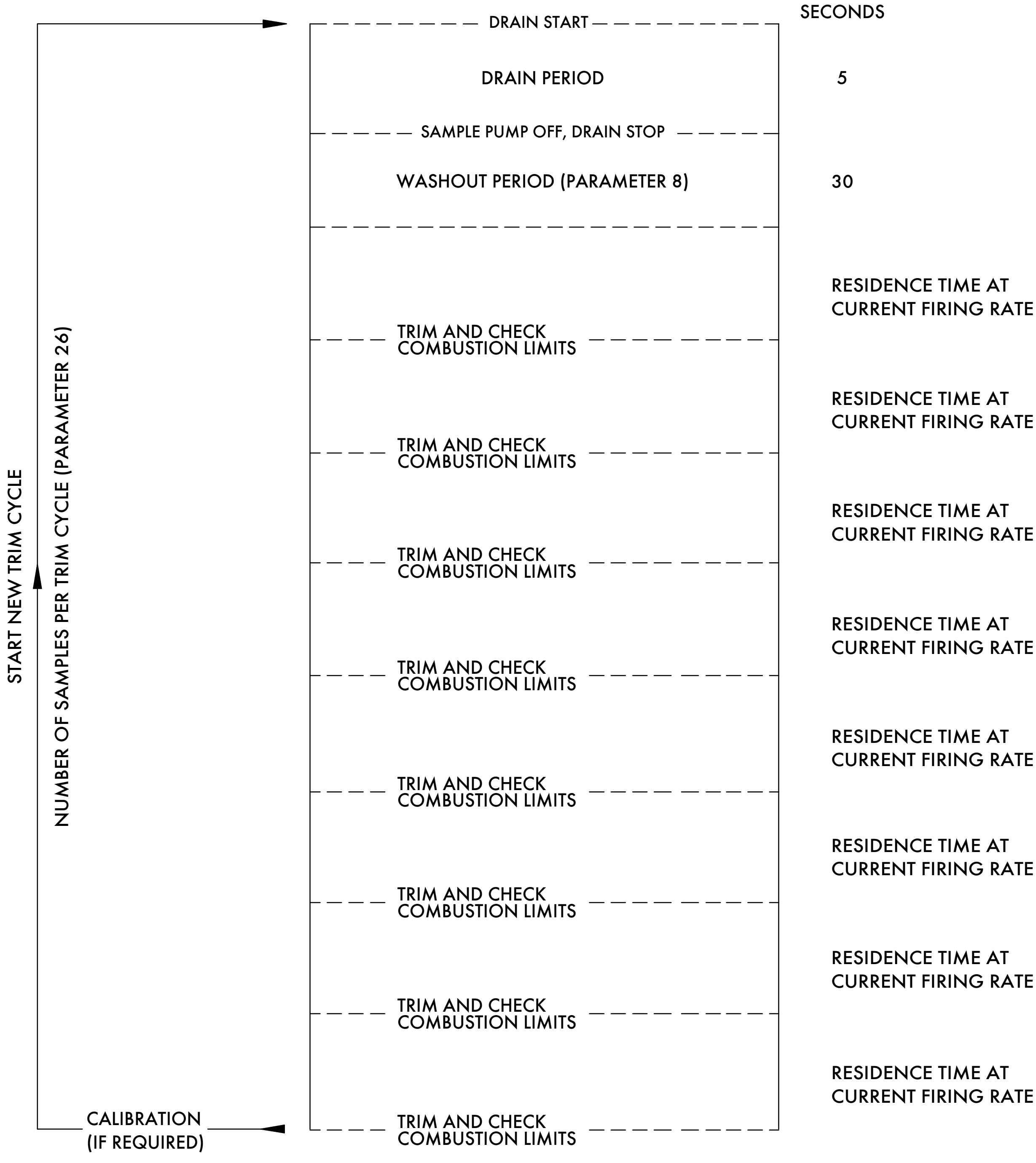


Figure 3.6.2.i Trim Timing Operation

If a calibration is due during the trim cycle, the MM will delay the calibration until the cycle has completed.

3.6.3 Trim Correction Calculation

The additional correction calculated at each trim cycle is the combination of the correction determined for each of the combustion products O_2, CO_2 and CO. The correction for each component is independently calculated. The calculation steps for each combustion product are as follows, "A-" denotes Fuel-rich, "CV" denotes Commissioned Value, "A+" denotes Air-rich:

1. The commissioned values are calculated by interpolation for the current fuel valve position.

2. The current measured O_2 value is determined as air-rich or fuel-rich side of the commissioned value.

3. The adjustment which would give rise to the current reading is calculated by linear interpolation of the commissioned values.

4. Negate this adjustment to produce a correction.

The corrections for each product are then combined with additional weighting given to O_2 (x1.5) over CO_2 and CO (x1). This combined correction is then added to the running total correction and applied to the air channel. The total correction is limited by an option value set by default to ±10% for safety.

Example

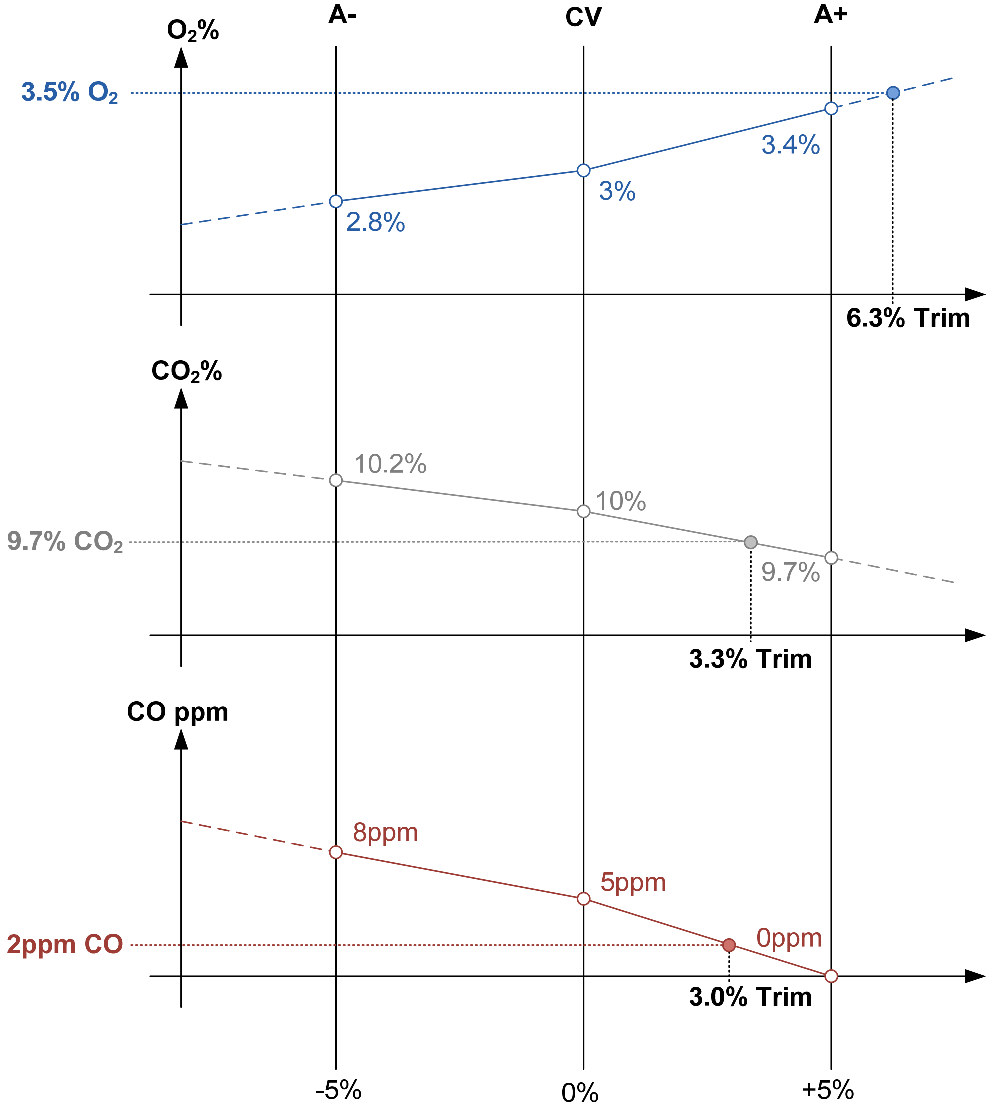
The following shows an example calculation. At the current firing rate the interpolated commissioned values are:

	Fuel Rich (A-)	**Commissioned Value (CV)**	**Air Rich (A+)**
O_2	2.8%	3.0%	3.4%
CO_2	10.2%	10.0%	9.7%
CO	8ppm	5ppm	0ppm

The current measured values are:

	Measured
O_2	3.5%
CO_2	9.7%
CO	2ppm

Using linear interpolation the adjustments that would give rise to these gas concentrations are calculated:



These are negated and combined using their respective weightings:

	Correction	Weighting	Weighted Correction
O_2	-6.3%	1.5	-9.4%
CO_2	-3.3%	1.0	-3.3%
CO	-3.0%	1.0	-3.0%
Total		3.5	-15.7%
Average			-4.5%

Giving an additional trim of -4.5%, which is then added to any existing trim; if for example, there was already +0.5% trim the resultant trim would be -4.0%.

This trim fraction is then applied to the air channel, so if for example the air servo was at 52.0° a correction of -2.1° would be applied resulting in an air servo angle of 49.9°.

3.6.4 Channel 5 Trim

When trim is set on channel 5, changing the MM options will make a difference between errors occurring or not. For the purposes of trim, the Mk8 MM needs to know how the VSD will behave, in terms of a change in the VSD input and its effect on the feedback (output) signal, which is why the VSD Options (90 – 97) must be set exactly – i.e. input/output voltage/current ranges and input/output min/max Hertz. If the system is already commissioned and if any of the VSD drive input/output voltage/current ranges or input/output min/max Hertz are altered then re-commissioning will be necessary as the stored feedback values for each MM entered point will now be incorrect. These stored feedback values are used by the MM as the starting point for working out the expected feedback signal – whether trim on channel 5 is optioned or not.

3.6.5 Combustion Efficiency Calculations

Based on dry gas.

English Calculation:

$$\%\ Combustion\ Efficiency = 100 - (sensible\ heat\ loss + hydrogen\ and\ moisture\ loss)$$

$$\%Combustion\ Efficiency = 100 - \left(\frac{K1(TG - TA)}{\%CO_2} + \left(K2\left(1121.4 + (TG - TA)\right)\right)\right)$$

$K1 = 0.38$ Natural Gas (F1/F4)
$K1 = 0.56$ Fuel Oil (F2/F3)

$K2 = 0.0083$ Natural Gas (F1/F4)
$K2 = 0.0051$ Fuel Oil (F2/F3)

TG Flue Gas Temperature
TA Ambient Air Temperature in Boiler House

Note: To use these equations temperatures must be converted to °C.

European Calculation:

$$\%Combustion\ Efficiency = 100 - sensible\ heat\ loss$$

$$\%Combustion\ Efficiency = 100 - \left((TG - TA) \times \left(\frac{A}{20.9\% - O_2\%} + B\right)\right)$$

$A = 0.66$ Natural Gas (F1/4)
$A = 0.68$ Fuel Oil (F2/F3)

$B = 0.009$ Natural Gas (F1/F4)
$B = 0.007$ Fuel Oil (F2/F3)

3.7 Combustion Limits

3.7.1 Overview of Combustion Limits

The combustion limits are only available when the EGA system is used in conjunction with a MM control module. The system will have improved safety from using the combustion limits, as these ensure that the combustion exhaust gases do not reach dangerous levels for health and safety, and also environmental regulations. The engineer can set limits as an offset value of the commissioned exhaust gases value, or as an absolute value. These can be upper or lower limits, depending on the exhaust gas variable and the application; the combustion limits can be set on 5 combustion variables: O_2, CO_2, CO, NO and exhaust gas temperature.

The limits of combustion can be adjusted through options 19 – 27 and parameters 94 – 97 on the MM module. Before the burner is commissioned, option 12 must be set correctly so that the limits of combustion are checked.

3.7.2 Standard Limits

Standard (offset) limits are a set percentage volume above and below for O_2 and CO_2, ppm above for CO and NO, and temperature above for exhaust gas temperature, for all the commissioned values. If the online exhaust gas values go above this offset of the commissioned value for that point in the firing curve, the burner will lockout or an error will be displayed, depending on how option 12 has been set on the MM. These are values are entered after the commissioning of the EGA system has been completed throughout the firing range of the burner, according to health and safety requirements or environmental regulations.

3.7.3 Absolute Limits

Absolute limits are a specific percentage volume, ppm or temperature. In this form only an ultimate low value may be put on O_2 and exhaust gas temperature in percentage volume and temperature respectively. In the case of CO_2 only an ultimate high value may be entered in percentage volume. For CO and NO an ultimate high in ppm may be entered. These values are entered when commissioning of the EGA system has been completed throughout the load index of the burner to avoid the burner locking out when commissioning.

3.7.4 Combustion Limits Control Functions

Using Option 12 on the MM module it is possible to have two distinct control functions on how the system will react when the limits of combustion are exceeded.

Control Function 1
Once the combustion limits are exceeded the trim function is disabled automatically and the system runs on the fuel-air ratio positions that the MM module was commissioned on. An error will also appear on the MM module, and until the error is reset on the MM, the trim function will remain disabled, even if the combustion limits are no longer exceeded.

Control Function 2
Once the combustion limits are exceeded the MM module will lockout the burner. The MM module will also display an error message, and until the lockout is reset on the MM module, the system will remain in a lockout condition.

The following figures give a graphical presentation of how the standard limits of combustion works.

3.7.5 O_2 Limits Example

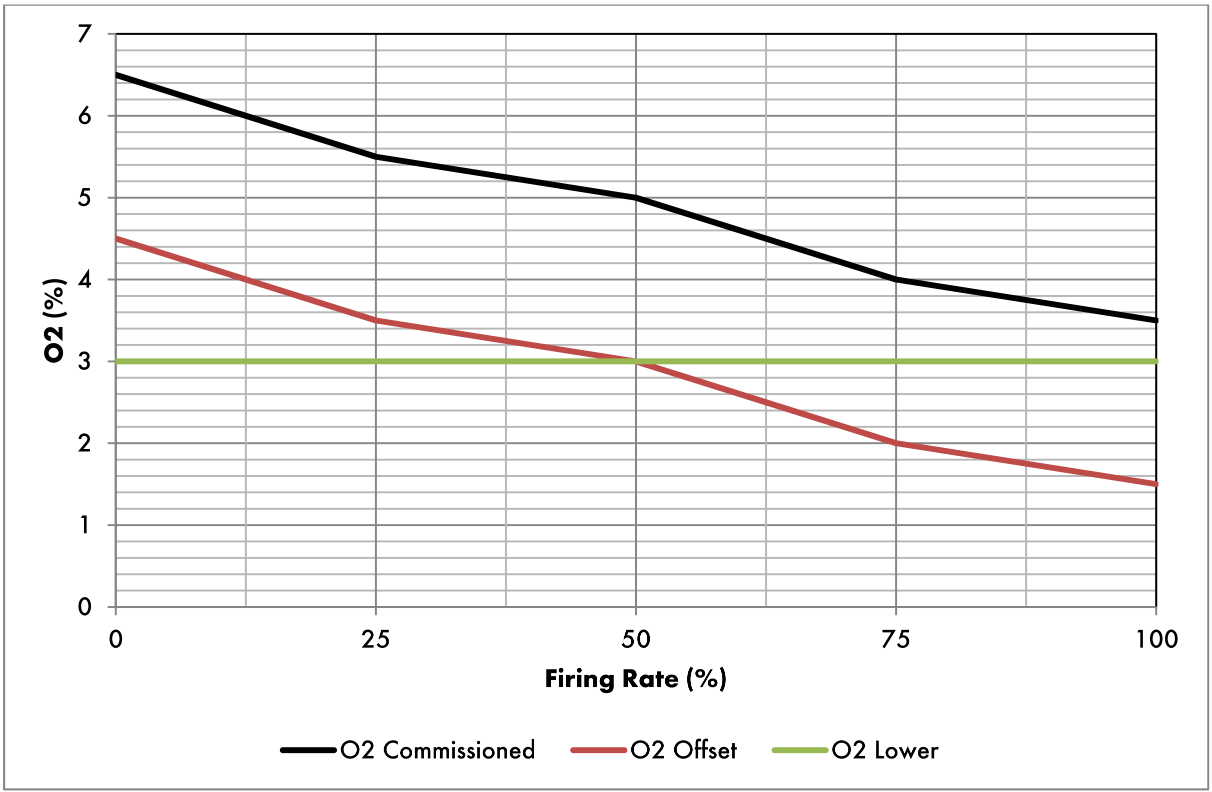


Figure 3.7.5.i O_2 Limits Example

Figure 3.7.5.i shows an example of the O_2 limits. If the offset limit was set to 2%, than the burner would alarm (depending on the terminal 79 operation) when the actual O_2 value dropped below 2% offset from the commissioned value. If the absolute lower limit was set to 3%, the burner would alarm when the actual O_2 value dropped below 3%.

3.7.6 NO Limits Example

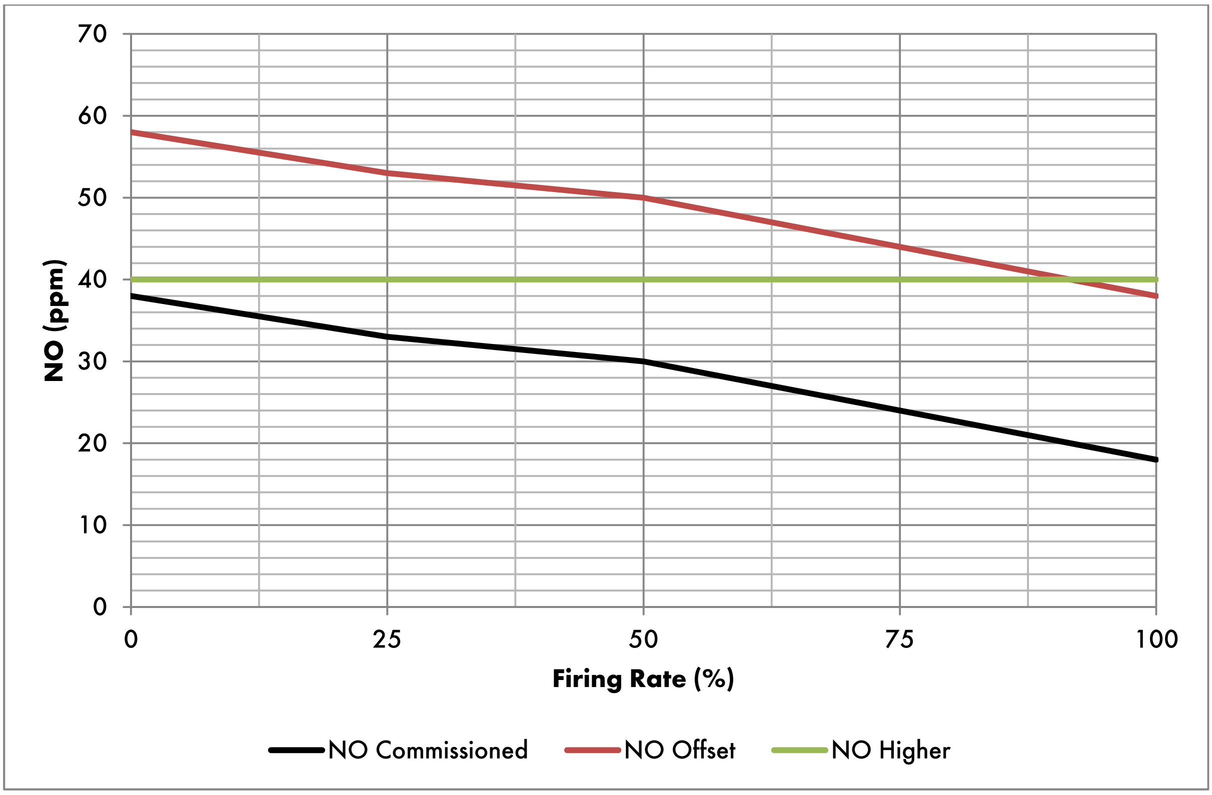


Figure 3.7.6.i NO Limits Example

Figure 3.7.6.i shows an example of the NO limits. If the offset limit was set to 20ppm, than the burner would alarm (depending on the terminal 79 operation) when the actual NO value rose above 20ppm offset from the commissioned value. If the absolute higher limit was set to 40ppm, the burner would alarm when the actual NO value rose above 40ppm.

3.7.7 CO Limit Example

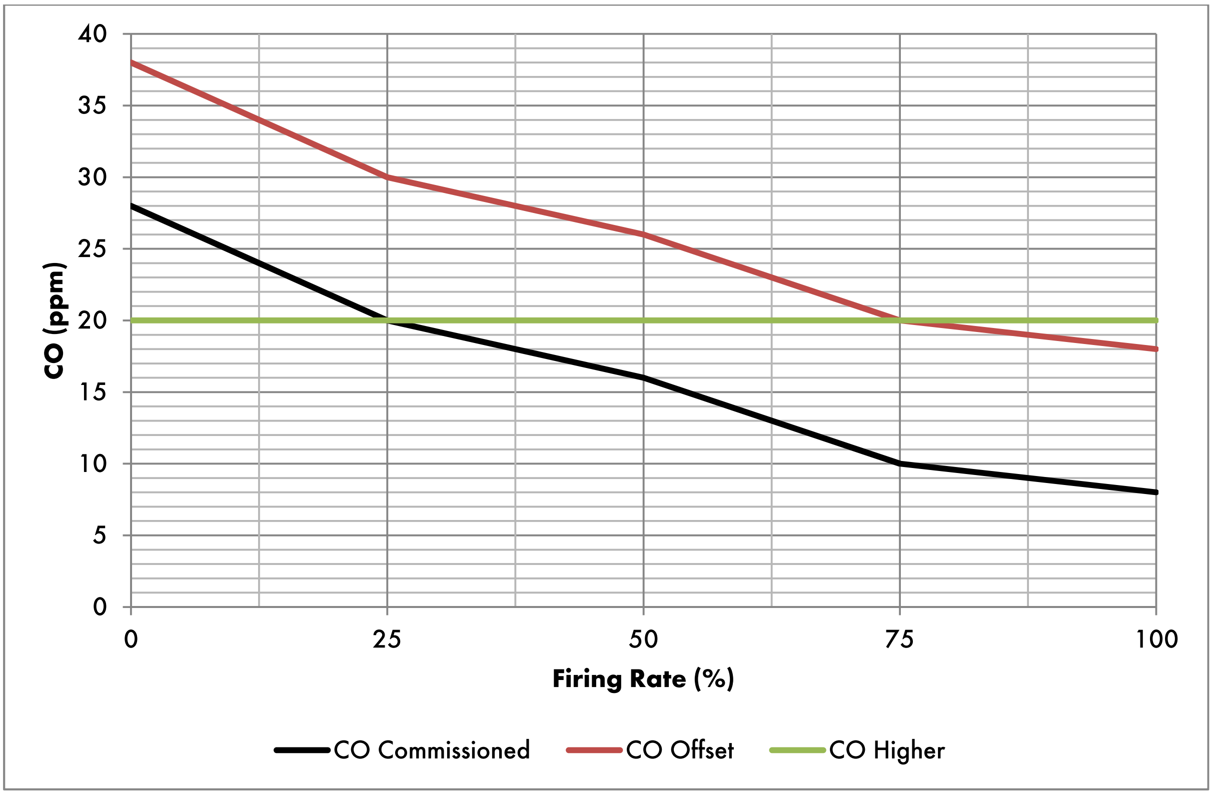


Figure 3.7.7.i CO Limit

Figure 3.7.7.i shows an example of the CO limits. If the offset limit was set to 20ppm, than the burner would alarm (depending on the terminal 79 operation) when the actual CO value rose above 20ppm offset from the commissioned value. If the absolute higher limit was set to 20ppm, the burner would alarm when the actual CO value rose above 20ppm.

3.7.8 Temperature Limits Example

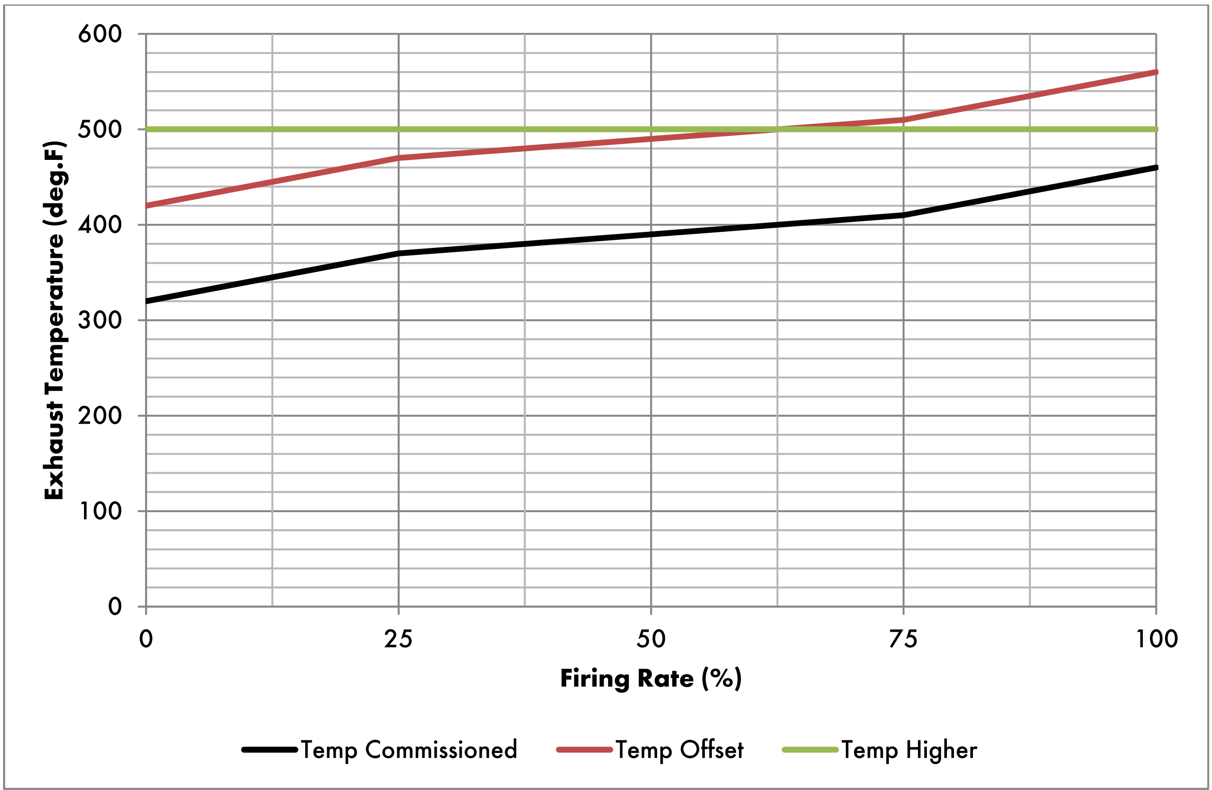


Figure 3.7.8.i Temperature Limits Example

Figure 3.7.8.i shows an example of the exhaust temperature limits. If the offset limit was set to 100deg.F, than the burner would alarm (depending on the terminal 79 operation) when the actual exhaust temperature value rose above 100deg.F offset from the commissioned value. If the absolute higher limit was set to 500deg.F, the burner would alarm when the actual exhaust temperature value rose above 500deg.F.

4 DIMENSIONS AND EQUIPMENT

4.1 Mk8 EGA Dimensions

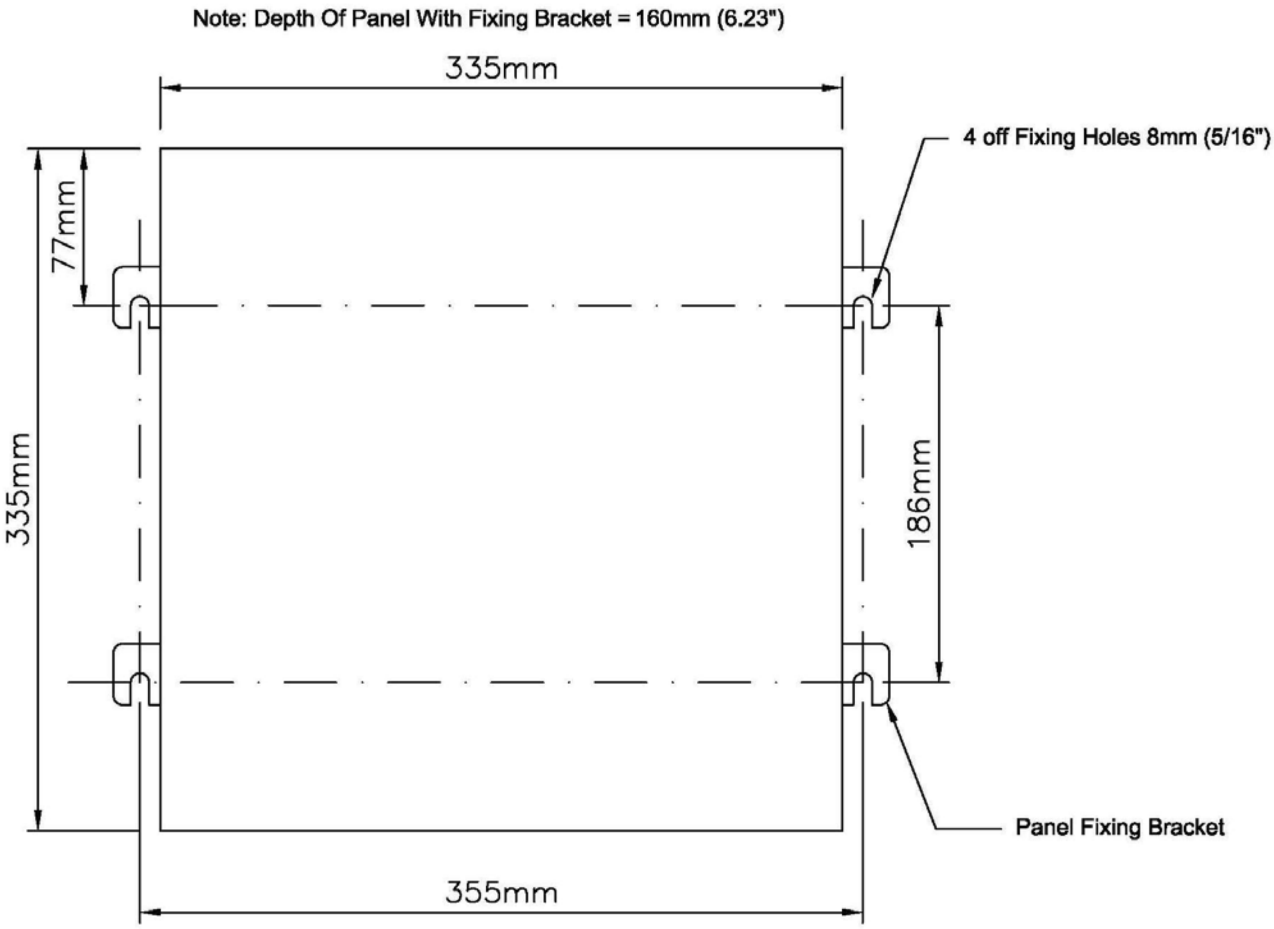


Figure 4.1.i Mk8 EGA Dimensions

4.2 Technical Specifications

Electrical

Electrical Supply	230/110V 50/60 Hz
Power	160W
Max Power Consumption	225W
Fuse Rating	4A
Pump Flow	110 – 120 mBar 600ml/min
Environmental Rating	IP20 NEMA 1

Temperature Range

E.G.A	Min : 5°C (40°F) Max: 40°C (104°F)
K Type Thermocouple	0 - 400°C (32 - 752°F)
Sampling probe tubing	Max: 60°C (140°F)

4.3 Sampling Probe

4.3.1 Installation and Maintenance

EGA Sampling Probe Installation

1. Mount the sampling probe at an angle of approximately 45 degrees into the stack.

2. Install a 1.5" BSP socket on the flue or other point that the sampling probe is to be positioned.

3. Mount the main body of the probe as far in as possible; adjustment is made by loosening the grub screws in the flats of the 1.5" BSP bush supplied on the probe.

4. Keep the thermocouple cable and sample tube away from hot surfaces.

Note: For correct EGA operation the probe must be positioned without air leaks as this will give incorrect readings on all sensors.

EGA Sampling System Unit Installation

1. Push the sample tube onto the inlet tube. Plug the thermocouple connector into the socket and tighten the screw.

2. To obtain optimum performance and reliability do not mount the unit in ambient temperatures above 40°C (104°F) or areas of direct heat radiation. Ensure that the air flow to the intake in the bottom of the EGA unit is not impeded and the air temperature is less than 40°C (104°F).

3. Do not mount the units where excessive vibration occurs.

4. Position the sample tube so that the sample slopes down to the EGA unit at all times. The EGA unit must always be mounted lower than the EGA probe. This helps drain excessive condensate from the flue gases, which may cause blockages in the sample tube.

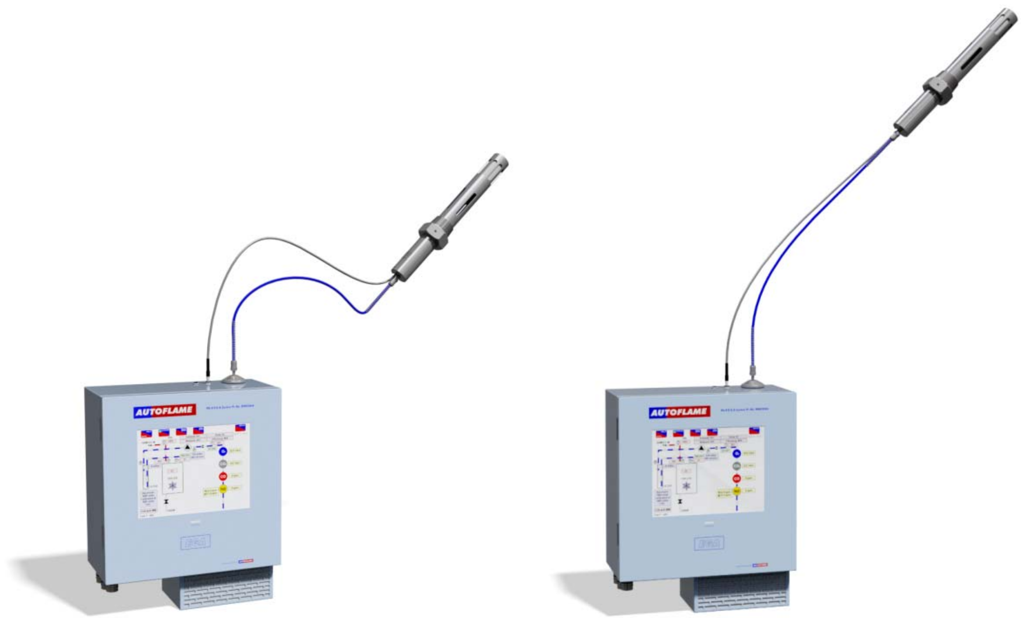


Figure 4.3.1.i Incorrect and Correct Installation of an EGA Unit

4.3.2 Sampling Probe Assembly

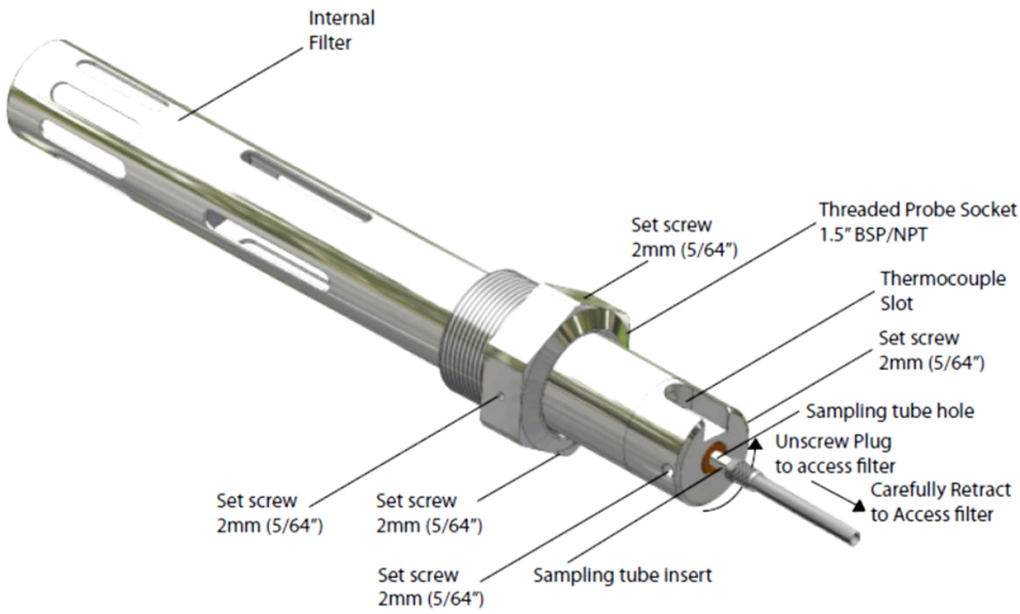


Figure 4.3.2.i Sampling Probe Assembly

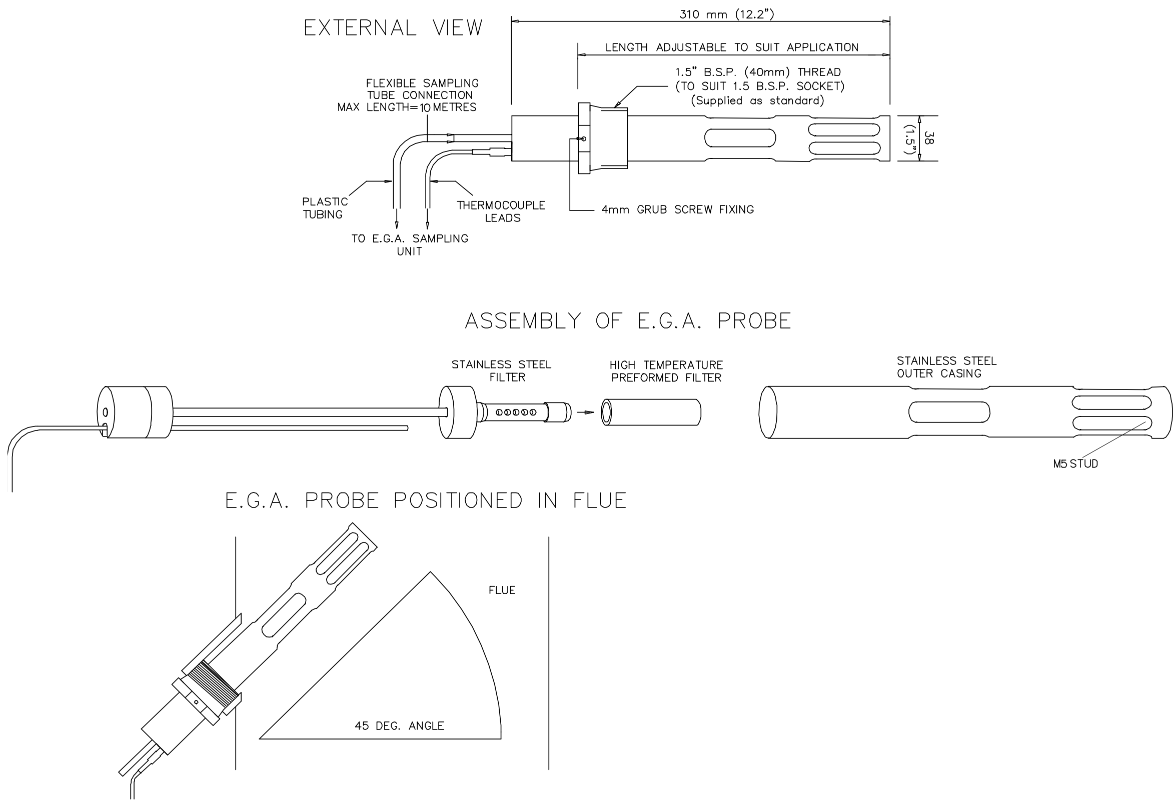


Figure 4.3.2.ii Sampling Probe Dimensions

4.3.3 Sampling Probe Internal Filter

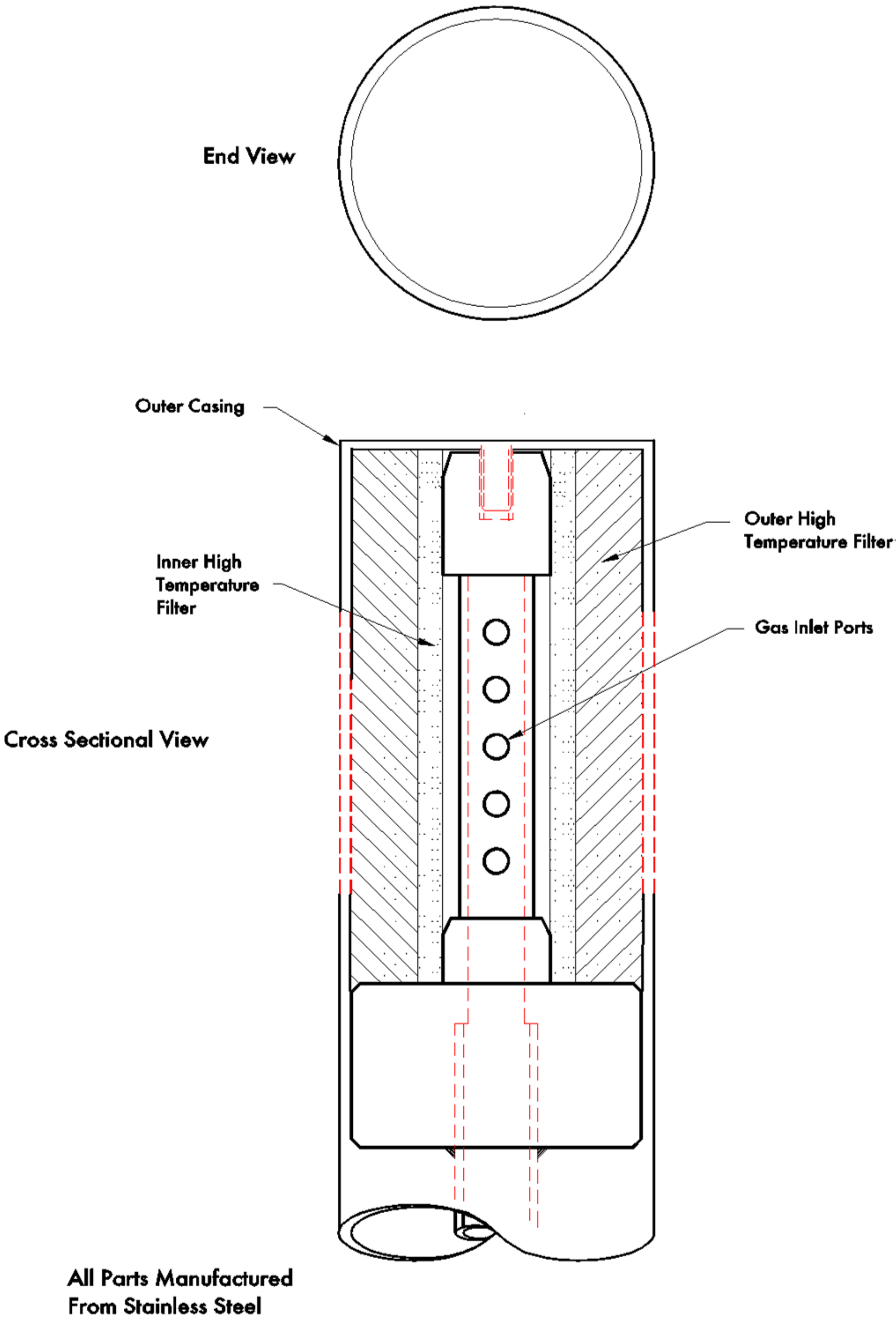


Figure 4.3.3.i Sampling Probe Internal Filter

4.3.4 Sampling Probe Maintenance

On gas only applications it is unlikely that there should be continual maintenance required on the stack mounted probe. It is advised that the probe is checked annually on the gas firing applications in order to ensure that the probe is free of any blockages. On heavy or solid fuel applications, deposits may build up in the outlet part of the tube. If a blockage in the tube occurs an 'O_2 pump fault' will appear on the EGA (See Section 5).

The deposits can be cleared by running a long drill (7mm/0.275") up into the outlet tube by hand. Twist and withdraw the drill often so as to pull out the deposits, otherwise the deposits will be pushed further into the probe assembly.

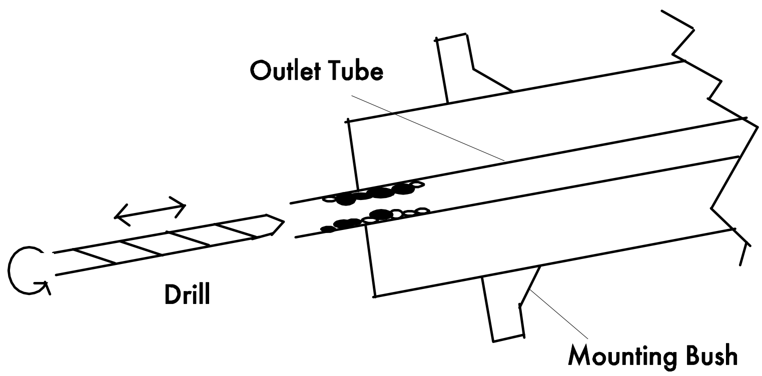


Figure 4.3.4.i Diagram to Show Method of Cleaning a Blocked Outlet Tube

4.3.5 Servicing EGA Sampling Probe

If the filter assembly in the EGA sampling probe is blocked then it is necessary to disassemble the probe and fit a new pre-formed fine filter and coarse filter (Part Number SP70012). To check if the probe is blocked connect the probe to the EGA and allow the EGA to sample. If the pump pressure or flow rate drops below 110mBar or 550 ml/min respectively then the filtering material should be replaced.

To disassemble the probe, unscrew the casing from the base of the probe. See diagram in section 4.3.2. The whole of the internal assembly can now be withdrawn from the sample connection end.

1. Remove the sampling tube and thermocouple from the EGA and unscrew the end cap.
2. Retract the filter and thermocouple from inside the probe at the same angle.
3. Replace the filter on the end of the thermocouple; the thermocouple can also be replaced.
4. Loose the 2mm set screw located above the cap extract the thermocouple.
5. Replace the thermocouple and retighten the set screw.
6. Remove all traces of the filtering materials from the stainless steel filter.
7. Check that the stainless steel filter and inner sample tube are clear inside.
8. Very carefully push the delicate pre-formed filter onto the stainless steel filter.
9. Slide the inner assembly back into the stainless steel outer casing.
10. Pack the void between the fine filter and the outer casing with coarse filtering material.
11. Use a small rod to pack the material down a little at a time.
12. Reassemble by sliding the assembly into the casing and screw together.
13. After reassembly connect the probe to the EGA and check the pump pressure and flow.

4.4 Ancillary Equipment

4.4.1 External Particulate Filter

The external particulate filter (part no. EGA80103/D) is designed to be used when there is excessive moisture from the flue gases, or if there is excess particulates in the flue gases which may cause damage to the EGA The external particulate filter stops excessive moisture from getting into the EGA as it has its own drain solenoid to remove any excess moisture. This drain occurs at the same time intervals as the normal drain solenoid on the EGA The external particulate filter has its own filter, capable of filtering excess particulates from the flue gases. We recommend that this external particulate filter be used for any heavy oil applications. Due to the nature of this product it can only be installed by Autoflame and cannot be fitted on site.

The external particulate filter can be ordered with a new EGA or retrofitted onto an existing E.G.A at our Autoflame London office.

Figure 4.4.1.i External Particulate Filter

Note: For applications firing on heavy or dirty oil, an external particulate filter is highly recommended to be fitted with the Mk8 EGA.

The external particulate filter will need to be changed depending on the amount of particulate carried over from the combustion process. This could be a month or as little as once every 6 months, once the filter starts to discolour. Use the Bacharach scale of 5 as an indication as to when the filters need to be changed.

The filter material is fluorocarbon resin bonded, borosilicate glass microfibre designed to coalesce liquid particles through a two layer construction. The inner layer forms the main filtration and the coarser layer provides drainage. It is a type MCE 95% 25micron high efficiency filter. The filter should be fitted as in the Figure 4.4.1.ii ensuring that the filter operates correctly. Please note that there may be a discharge of liquid from the filter when in use. This is a design feature to drain any excess moisture from the flue before it reaches the EGA.

The inlet from the flue is connected to the horizontal section on the top of the filter. The vertical section is connected directly to the EGA inlet.

4.4.2 Air Inlet Filter

The Mk8 EGA air inlet filter (part no. EGA80106) is designed to protect the EGA from dust and other particles that may cause damage or reduce the performance of the EGA over time. The air inlet filter will fit over the fan that cools the EGA and stop dust and particles from getting inside the EGA. The air inlet filter is easy to maintain with only the air filter material needing replacing once it has become saturated. The time between each change of air filter will depend on the site conditions.

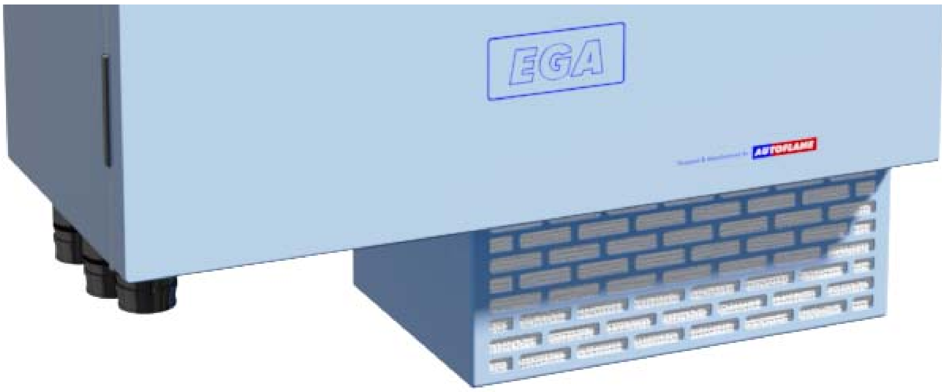


Figure 4.4.2.i Air Inlet Filter

While the EGA can successfully be used to measure combustion exhaust gases when burning HFO, it is very important that the fuel is carefully maintained at a constant and known composition. The fuel temperature and pressure play a major role in the amount of particulate carry-over sampled, before combustion even takes place.

The burner must be regularly maintained to ensure complete combustion of the hydrocarbons. Failure to do so will result in premature failure of the EGA Ensure the oil filter is regularly maintained and the oil nozzle is regularly inspected for fatigue.

It is recommended that when the EGA is used on a dual fuel application where natural gas is the primary fuel and HFO is the secondary fuel, the EGA should not be monitoring the HFO exhaust. This can be achieved by simply isolating the EGA when the HFO fuel is selected to be fired.

4.4.3 Chilled Environmental Enclosure

The exhaust gas is vented into the air stream leaving the EGA unit. This is located on the outside of the EGA enclosure next to the drain solenoid outlet. It is extremely important that the exhaust gas is vented into atmosphere; **do not install an EGA within a sealed enclosure**. Installing the EGA in a sealed enclosure will cause the EGA to calibrate on contaminated gases. The EGA will self-calibrate every 12 hours of running or when the burner starts and stops.

In areas of harsh ambient conditions, or excessive heat, it is necessary to use an environmental enclosure with the EGA module. This protects the EGA from dust and ensures that the EGA is well protected. Using the enclosures allows the EGA to operate under optimal operating conditions.

Autoflame manufacture a chilled environmental enclosure that uses a chiller module and control panel in order to maintain the EGA installed within the enclosure at a set temperature to protect itself from excessive heat. The temperature is user adjustable by means of a thermostat counted on the unit but is nominally set for 35°C (95°F), which ensures ideal operating conditions for the EGA Autoflame also manufacture a heated enclosure for low temperature and for anti-condensing sites.

If you require further information please contact Autoflame Technical Support.

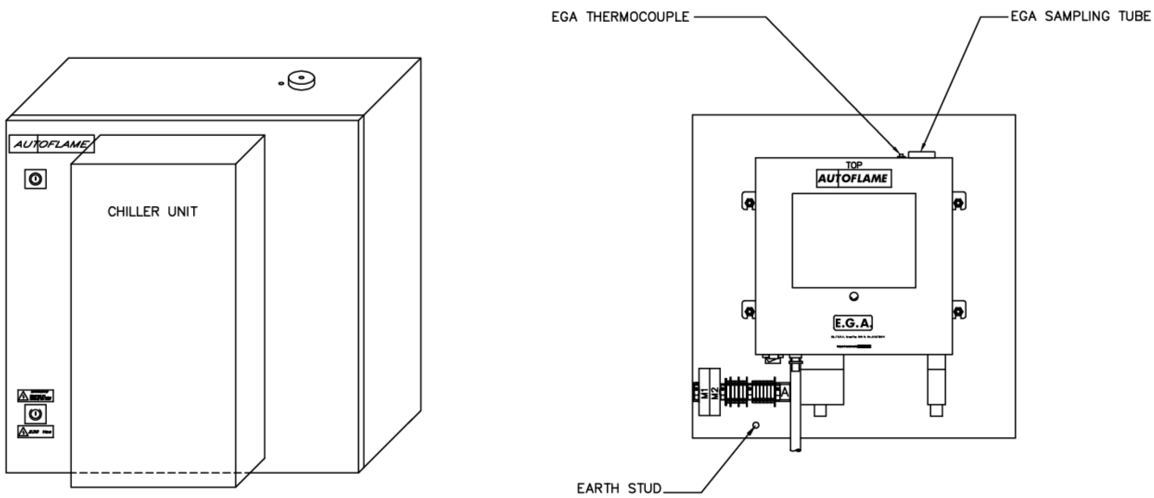
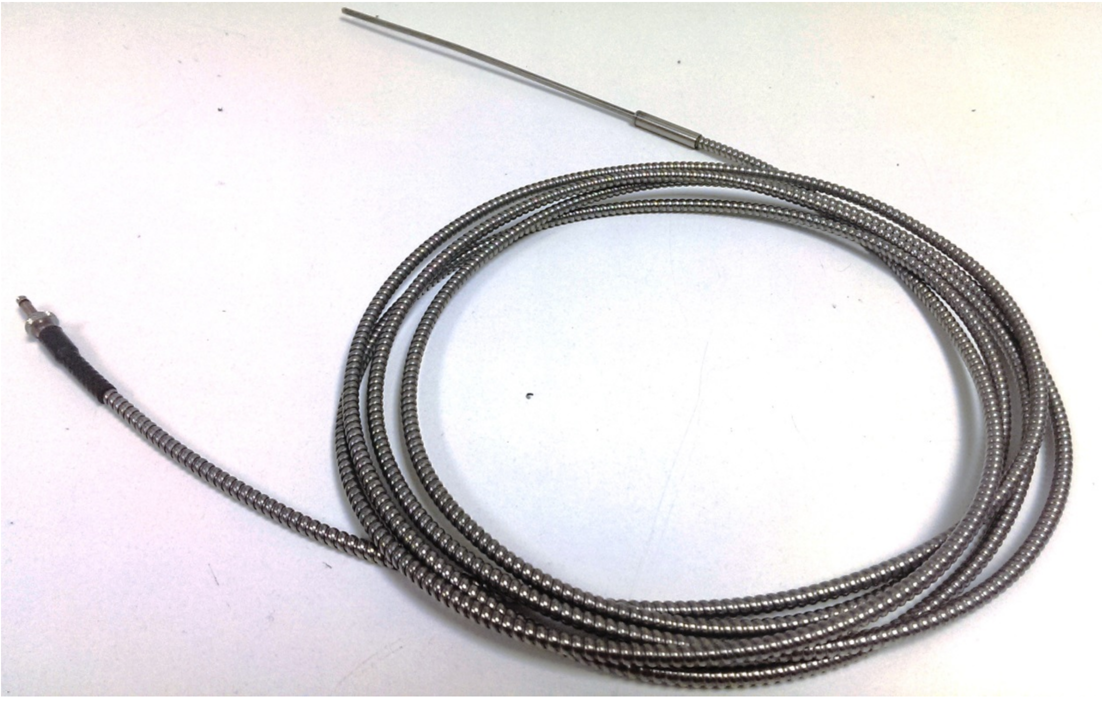


Figure 4.4.3.i Schematic of Chilled Environmental Enclosure

4.4.4 Pre-Heat Air Sensor



A Pre-Heat Air Sensor has been incorporated into the Mk8 EGA to ensure an accurate efficiency calculation when using pre-heated air. This Pre-Heat sensor uses a K-Type Thermocouple.

5 ERROR CHECKING AND SELF-DIAGNOSTICS

5.1 EGA Faults

In the event of an EGA failure, an error will appear on the EGA screen of the MM The MM will show 'See EGA for fault description.' All other screens on the MM are still viewable whilst there is an EGA error. The switched neutral alarm output Terminal 79 can be set to become active or remain inactive in the event of an EGA error (see Option 12). The setting of Option 12 will determine how the burner will operate, i.e. continue to run based on the original commissioned values (trim and limits testing disabled) or lockout the burner until the EGA error is reset and becomes fully operational once again.

Should the fault require the EGA to be returned to Autoflame ensure the EGA sampling system should be carefully packed into the carton in which it was supplied and marked "Fragile – Scientific Instruments" and "Do Not Drop".

It is possible to remove and re-install the EGA at a later date without the burner needing to be re-commissioning if using the trim function with an MM module. After removing the EGA set Option 12 on the MM module to 0. Once the EGA module is ready to be re-installed reset Option 12 back to the required setting, provided the combustion has not been changed either through commissioning mode or single point change the MM module will load up as normal and will not be required to be re-commissioned.

When an error code appears on an MM module it is required that the error is reset on the MM module as well as the EGA If the error is not reset on the MM the EGA and MM will not communicate with each other. This will mean the EGA will display "No Fuel Selected" when in run with MM mode until the error is reset.

When first going into commissioning mode, the MM invokes an EGA calibration. If an error occurs at this stage it will be necessary to investigate and resolve the error before restarting the commissioning procedure.

5.2 Troubleshooting

5.2.1 Ambient Conditions

1. Ambient Temperature – This will read Ok, High or Low. This must be between 5 – 40C (40 – 140 F) or the settings of Parameters 27/28. The temperature is measured by a sensor on the electronics PCB and is cross referenced with the sensor on the side of the CO_2 cell.

2. EGA Trim Threshold – This will be Ok or Low and is looking at the setting of Option 28. This value is an offset from the set point, before which the EGA will not operate. This ensures that the EGA does not pull in high amounts of condensation.

3. Chiller – This will be Ready or Not Ready. There is a temperature sensor on the chiller unit and this chiller must get down to a set temperature before the pump will start to draw a sample from the stack. If the chiller is not decreasing its temperature then check the operation of the fan. If the ambient air in the boiler house is high, it may be necessary to draw cooler air into the EGA In warm environments, an air conditioned enclosure should be used; in cold environments a heated enclosure should be used.

4. Comms – This can read Ok or Not Ok and this is checking for continuity between the EGA and MM Check the wiring between the MM and EGA modules.

5.2.2 Fuses

If the EGA is mounted in an excessively dusty environment a build-up of particles on the terminals can cause arcing. If the particles are corrosive then any attack to the conformal coating on the printed circuit boards can cause tracks to arc and component failure. Any sign of this activity and the unit should be returned to the supplier.

5.2.3 O_2 Reading

If you get a continuous O_2 reading of 20%, this tells you that the Mk8 EGA is sampling fresh air. To troubleshoot this:

- Check all piping is airtight
- Check sample tube is not blocked
- Check that there are no leaks on the flue
- Check the pinch valve tubing for leaks

5.3 Mk8 EGA Faults

Error Code	Description	Type	Troubleshooting
1	Code Cell Invalid	Error – Permanent	Cell is invalid, cell not connected or EEPROM not programmed
2	Cell Data Loaded	Warning – User Clear	Cell commissioning data re-loaded
3	Blocked Input	Error – User Clear	Input is blocked, as detected by input pressure reading
4	Blocked Output	Error – User Clear	Output is blocked, as detected by barometric pressure reading
5	High Humidity	Error – Auto Clear	Cell Humidity is above 95%, leading to erroneous readings
6	Ambient Temperature Low	Error – Auto Clear	Ambient Temperature is too low (<3°C)
7	Ambient Temperature High	Error – Auto Clear	Ambient Temperature is too high (>50°C)
8	Chiller Frozen	Error – Auto Clear	Chiller Temperature has gone below zero
9	Chiller Temperature High	Warning – Auto Clear	Chiller cannot maintain required temperature
10	Chiller Output	Error – Auto Clear	Chiller current sense is detecting incorrect current
11	Flow Out of Range	Error – User/Auto Clear	Pump cannot maintain pressure – for self-cal pump, this auto clears so that the calibration process can continue
12	Self-Cal Low Pressure	Error – User Clear	Self-calibration gas supply pressure is too low
13	Self-Cal High Pressure	Error – User Clear	Self-calibration gas supply pressure is too high
14	HSL Out of Range	Error – Auto Clear	HSL cannot maintain temperature
15	Excessive Calibration Drift	Error – Permanent Fault	Re-calibration resulted in too large value change – only applies to self-cal/MCERTs configured EGAs
16	Temperature Sensor	Error – User Clear	Temperature sensor is faulty – see temperature sensor faults below
17	Pressure Sensor	Error – User Clear	Pressure sensor is faulty

Error Code	Description	Type	Troubleshooting
18	Chemical Sensor	Error – Permanent Fault	Chemical sensor is faulty
19	Optical Sensor	Error – Permanent Fault	Optical sensor is faulty
20	Fan Blocked	Error – Auto Clear	Fan speed too low
21	EEPROM Write Failed	Error – Auto Clear	EEPROM data could not be written after 10 attempts
128	Display Communications	Error – Auto Clear	Communications to the display has been lost
129	Display CEMS Write Fail	Error – User Clear	Display is unable to write CEMS data to the SD card

Temperature Sensor Faults

Error Code	Description	Type	Troubleshooting
0	Temperature Probes	Error/ Warning – User Clear	Thermocouple sensor in exhaust probe has a fault
1	Temperature HSL	Error / Warning – User Clear	Thermocouple sensor in HSL jacket has a fault
2	Temperature Chiller In	Not Used	Thermistor sensor for chiller inlet has a fault
3	Temperature Chiller Out	Warning – Auto Clear	Thermistor sensor for chiller output has a fault
4	Temperature Unused	Not Used	Thermistor sensor has a fault
5	Temperature Cell	Error – User Clear	Thermocouple sensor for pre-heated combustion air temperature has a fault
6	Temperature Pre-Heat	Error – User Clear	Thermocouple sensor for pre-heated combustion air temperature has a fault
7	Temperature Ambient	Error – User Clear	On-board ambient air temperature sensor has a fault
8	Temperature Chiller	Error – User Clear	Thermistor sensor in chiller block has a fault
9	Temperature CO_2	Error – User Clear	Thermistor sensor in CO_2 block has a fault

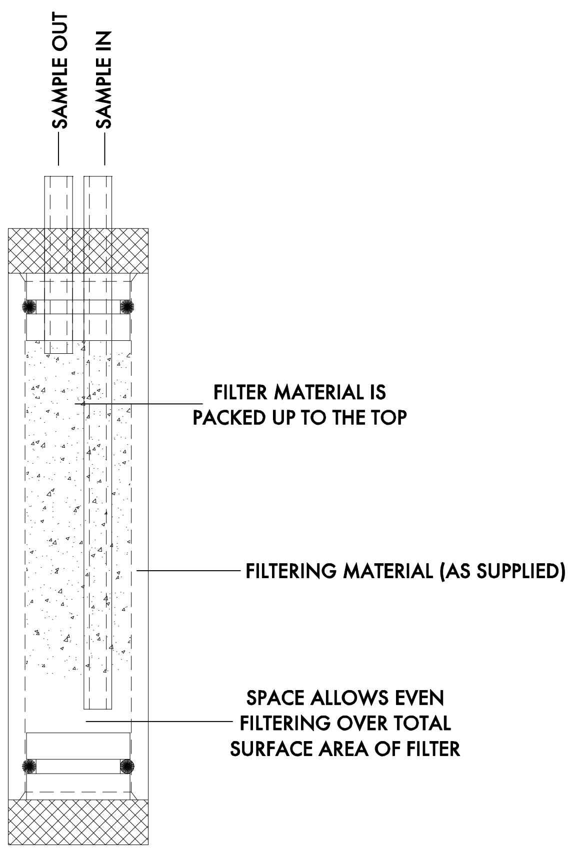
5.3.1 Trim Delay

On burner start-up without calibration the EGA performs a drain and starts sampling at 20.9% O_2 (fresh air), which then reduces to the commissioned value. Enough time must be given before the EGA commences trim, to ensure that it is not correcting the air damper at high O2 values. The total time delay before the EGA starts to trim is based on the boiler's residence time. If the total time delay before trim starts it too short, then a scenario could arise where the EGA reads 5%O2 and over-trims on air damper, reducing the O2 too far.

If calibration on start-up is active, option 32 (trim delay) must be greater than the calibration time (parameter 24). A minimum of 40 seconds should be added. Parameter 24 is set as default to 120 seconds, so option 32 should be set to a minimum time of 160 seconds. The total time before trim is applied is 200 seconds (option 32 + parameter 8); this will also depend on the boilers residence time.

5.3.2 Assembly of Dry Filter

If pump faults are occurring on the EGA it is advised to check the dry filter in the EGA and check for any blockages and make sure that the filter material has not become saturated.



N.B. FREE SPACE MUST BE LEFT AT BOTTOM TO STOP ANY PREMATURE BLOCKAGE
THE SAMPLE IN & OUT PIPES MUST BE CONNECTED CORRECTLY OR BLOCKAGE
WILL OCCUR WITHIN A FEW HOURS.

This filter is specifically used as a dry filter to remove and dust particulate before the dry gas passed into the cells. The filter is carefully packed as a complete replacement part and should be repacked or the filter material changed in the field, as the filter is critically calibrated for a specific pressure drop. The filter should always be dry, if any carryover of liquid or moisture is sent in the filter, please isolate the EGA and contact Autoflame Technical Support.

5.4 EGA Best Practice

The EGA is a sensitive instrument used to analyse the exhaust gases in the flue, so it needs to be serviced regularly to ensure accurate readings are taken for the trim function to maintain safe operation. The following guidelines should be applied to all EGA applications:

- The EGA should be checked before installing it on site. It is advisory that EGA remains upright during any tests and checks. Thereafter the E.G.A should be turned off for a period (couple of hours), and turned back on again to drain out any excess moisture remaining in the EGA

- The Autoflame EGA sampling probe thermocouple is rated at a max temperature of 400°C (752°F). We would recommend the EGA to be fitted into a chilled enclosure when being used in high temperature condition. For environments with high humidity, a chilled enclosure is recommended to avoid corrosion on the board.
- The EGA sample line length is recommended to be 3m.
- Pump Failure
  - A build-up of condensation in the E.G.A could result from incorrect installation installed correctly. Make sure the probe is located at 45° to the stack, and the sampling tube is not wound up.
  - Condensation could also occur from the load demand not being so high at certain times, so it may mean that the back end temperature of the boiler is not high enough. Therefore it will not be warm enough to evaporate the condensation quick enough, causing a large build-up of moisture.
- Cooler not ready
  - There is a temperature sensor in the chiller block and this must read below 12°C(55°F) before the E.G.A, is ready to sample
  - If the unit is started up for the first time, this could take a while for the unit to cool down.
  - If the fan is not working, this could cause the problem. The fan may be running slow or the peltier devices may have failed.
- If extension tubing is attached to the drain solenoid, ensure the end of the tubing is clear of any obstructions or contaminants. When the EGA performs an air calibration, the air is sucked into the EGA through the solenoid.
- If the EGA is placed in an enclosure or cabinet, to avoid the EGA being recalibrated on contaminated gases, ensure that the drain solenoid is taking in fresh air during calibration.
- The EGA O_2, CO, NO, SO_2 and NO_2 cells have a 6 month shelf-life. If ordering an EGA for project that will be installed later we would advise to purchase an EGA without these cells, and then purchase the cells when they are due to be installed. This EGA will come with the CO_2 cell only (patent no: MM72004/NC) as this can only be fitted at Autoflame office. We recommend that the cells are replaced 12-18months for gas firing from manufacturing date and 6-12 months for heavy oil firing applications.
- An external particulate filter should be used for applications:
  - Firing on heavy or dirty oil
  - Environments with dust and particulate
  - Extremely cold conditions
  - High humidity environments
- During commissioning and single point change, the EGA must be given enough time to read an accurate sample of the exhaust gases. This set at 45 seconds to default (parameter 4). Also the time for which the fuel rich and air rich positions are held during commissioning should be set correctly so that the EGA has enough time for the readings to stabilise. This is set to 60s as default on the MM (Parameter 9).

5.4.1 Servicing the EGA

Due to the technology used within the Autoflame E.G.A, to ensure accurate and reliable operation the EGA requires annual servicing. Servicing the EGA and sampling probe is a crucial to maintaining the correct operation of the EGA must be done regularly. For firing on natural gas, the EGA must be sent back every 12-18 months depending on the boiler room conditions. For firing on oil, this would be shortened to 6-12 months. Failure to send back the EGA when it is due for a service will cause the operation and life of the EGA to deteriorate. The cells will need to be replaced as they are calibrated instruments which lose accuracy over time and use. The probe is constantly sampling the gases and can become easily clogged with debris and dirt picked up from the burner, without a service this can result in incorrect readings which affect the reliability of the EGA Further issues such as pump problems, chiller faults and inaccurate trim operation will occur.

5.4.2 Shipping the EGA

The EGA is a scientific instrument with delicate components. Whenever the EGA is shipped it is essential that the EGA is returned using its original packaging.

To avoid any potential damage to the EGA during transit and to stop the PCBs from flexing there are pads between the two PCBs of the Mk8 EGA, and the casing of the EGA and the PCBs. This extra support stops flexing of the PCBs during transit. The top of the cells will be covered in bubble wrap to protect them from damage during transit. Before powering up the EGA, the bubble wrap must be removed from the EGA, however the pads can remain between the PCBS. The pads will affect the operation of the EGA and will help protect the EGA from damage when it is shipped back to Autoflame for its annual service.

Ensure that couriers treat the package appropriately and labelled as containing a delicate scientific instrument. If the EGA is damaged in transit, repair costs will be incurred.

Please contact Autoflame or your local Tech Centre to obtain new Autoflame EGA packaging.

6 STANDARDS

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Notes

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