AUTOFLAME®

Combustion Management Systems



MK8 MM MANUAL
MM80001

23.02.2026

Autoflame Engineering Ltd.
Unit 1-2 Concorde Business Centre
Airport Industrial Estate
Wireless Road, Biggin Hill
Kent TN16 3YN
United Kingdom

Tel: +44 (0)1959 578 820
Email: technicalsupport@autoflame.com
Web: www.autoflame.com

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23 FEB 2026

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Important Notes

A knowledge of combustion related procedures and commissioning is essential before embarking work on any of the MM / EGA systems. This is for safety reasons and effective use of the MM / EGA 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 herein.

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

- 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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VERY IMPORTANT SAFETY NOTES



Please fully read and understand the following notes before commencing with any work related to the Mk8 MM. Failing to do so can result in serious injury or even death, and can cause serious equipment and substantial property damage.

Any person working on a boiler must be adequately trained and have a thorough understanding and appreciation of the boiler plant.

It is the responsibility of the technician working on the plant to ensure that the system operation meets all local codes and regulations.

Options, Parameters and Expansion Options must only be changed by an Autoflame-trained and certified technician who has thorough understanding of the Autoflame combustion control systems and boiler/combustion control in general. Any person changing these settings without undergoing the necessary training and gaining an understanding of the boiler plant may place themselves and others in a potentially dangerous situation or cause permanent equipment damage.

Modification to the Autoflame system settings should only ever be carried out by qualified combustion engineers. Changes to the Autoflame control system setup has the potential to make the controller operate in an unstable and potentially unsafe manner.

Commissioning or burner start-up must only be carried out by a an Autoflame- trained and certified technician.

The commissioning procedure as described must be strictly adhered to. Anybody commissioning an Autoflame system must be trained in operating combustion equipment safely.

Autoflame products must only be installed, set up, commissioned and adjusted by an Autoflame certified technician.

The fundamental idea of the system is to set a fuel valve position and then set a corresponding air damper position. Care must be taken when adjusting the fuel and air positions so as not to create any unstable or hazardous combustion conditions, e.g. moving the fuel valve to the open position without increasing the air damper position. Improper use may result in property damage, serious physical injury or death.

Electrical connections are live, make sure to fully and safely isolate the mains power before carrying out any work related to the wiring connections, failure to do so may result in serious physical injury or death.

If you are unclear about anything related to the Autoflame system, please contact Autoflame for technical advice.

1 MK8 MM OVERVIEW, SPECIFICATIONS AND WIRING

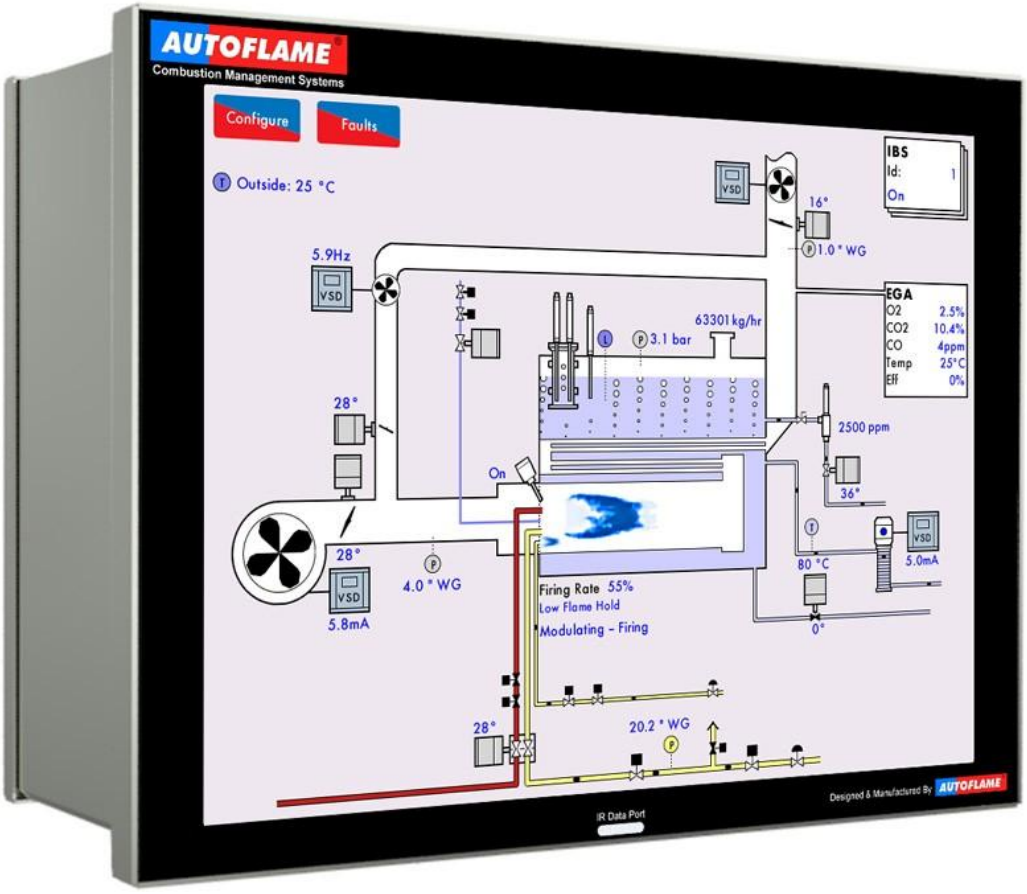
1.1 Mk8 MM Overview

The Mk8 MM Controller is a Micro-Modulating system that offers comprehensive control of industrial and commercial boiler/burners.

With the Mk8 MM, it is possible to control all boiler processes from a single 12.1” multi-touch screen interface without any added module. It is ideal for steam and water boilers (watertube or firetube), kilns and steam generators. Designed for oil or gas with the capability of running dual fuels, the MM features a linkageless servomotor system and automated flame safeguard to safely and reliably control an unmanned boiler house.

Additional expansion features include:

- Autoflame water level management.
- Analogue water level using third party water level detection system.
- TDS/Top blowdown.
- Bottom blowdown.
- Draught control.
- Direct Modbus connectivity.
- First out annunciation.
- Fully metered, cross-limited control.
- Steam flow & hot water flow metering.
- Modbus connectivity allows for remote monitoring and management.
- Setpoint scheduling.
- Fuel change on the fly.



1.1.1 Mk8 MM Main Features

- Fuel/Air ratio control.
- 12.1” Full colour touch screen.
- 120V or 230V standard operation 50/60Hz.
- Controls up to 5 servomotors and 2 variable speed drives (VSD/VFD).
- 4 independent fuel programmes.
- Fully adjustable PID load control for temperature or pressure.
- Internal flame safeguard – full flame supervision with self-check UV or IR.
- Dual flame scanner operation (IR and UV scanners).
- Gas valve train leak supervision and high/low gas pressure monitoring.
- Air pressure proving and monitoring.
- 128 lockouts, errors, alarms and warnings stored with date, time, phase and reset.
- 1000 entry system log stored with date, time and status.
- Online diagnostics showing system electronics information.
- Single point change for adding, removing and adjusting fuel/air positions on fuel-air curve.
- Golden start position for optimum ignition position.
- Flue gas recirculation start position.
- Variable servomotor travel speed.
- Burner control safety times user selectable.
- External voltage/current load control and setpoint adjustment.
- Outside temperature compensation of boiler setpoint.
- Second setpoint and run times scheduling.
- Hand/auto/low flame hold firing modes.
- Various boiler load detectors available.
- Fuel flow metering capability – instantaneous and totalised.
- Fuel flow feedback.
- Multi-burner capability with synchronised firing rate up to 10 MMs.
- 4-20mA (0-20mA) / 0-10V (2-10V) input for external modulation.
- 4-20mA (0-20mA) / 0-10V (2-10V) output confirming firing rate.
- Fully metered combustion control for commissioning based on equivalence ratio and excess air.
- Draft control to maintain stack pressure.
- Password protection of all safety related functions.
- Infra-red port for upload/download of commission data.
- First out annunciation inputs.
- 4 fuel commission curves possible.
- 24-hour history graphical information on MM when powered on.
- Custom boiler display configuration.
- Download/upload all commissioning data and controller settings from MM module to a PC viaBluetooth or IR.
- System will sequence hot water boilers or steam boilers via lead/lag distribution.
- Fully adjustable user options within the system to tailor sequencing operation to the application.
- System control for isolation of valves or pumps (2 port valve operation).
- Standby setpoint and warming for lag boilers via a standby pressure and timing sequence.
- Lead boiler and lag boiler warming modes selection.
- Return to pilot allows the main flame to turn off and the pilot flame can continue.
- Fully modulating feed water control with servomotor and VSD as well pump on/off.
- Capacitance probes for patented wave signature level detection.
- Water level alarms 2nd low, 1st low, high water and optional pre 1st low and pre-high water.
- Conductivity probe for auxiliary 2nd low alarm.
- Automatic bottom blowdown with time reduction for blowdown savings.
- Continuous modulating top blowdown control to maintain TDS level in water.
- Steam/hot water flow metering to calculate flow rates based on temperature sensor.
- Direct Modbus communications from MM including remote setpoint and firing rate adjustment, burner enable/disable (without DTI or intelligent boiler sequencing).
- Fuel Changeover on the Fly (COF) which allows fuel change without turning off the burner.
- Flame Safeguard mode, which allows the MM to operate as a standard Flame Safeguard.

1.1.2 Overview of Micro-Modulation (MM)

To ensure maximum efficiency and reliability of the boiler plant operation, two requirements are of paramount importance, the air to fuel ratio and the target temperature or pressure:

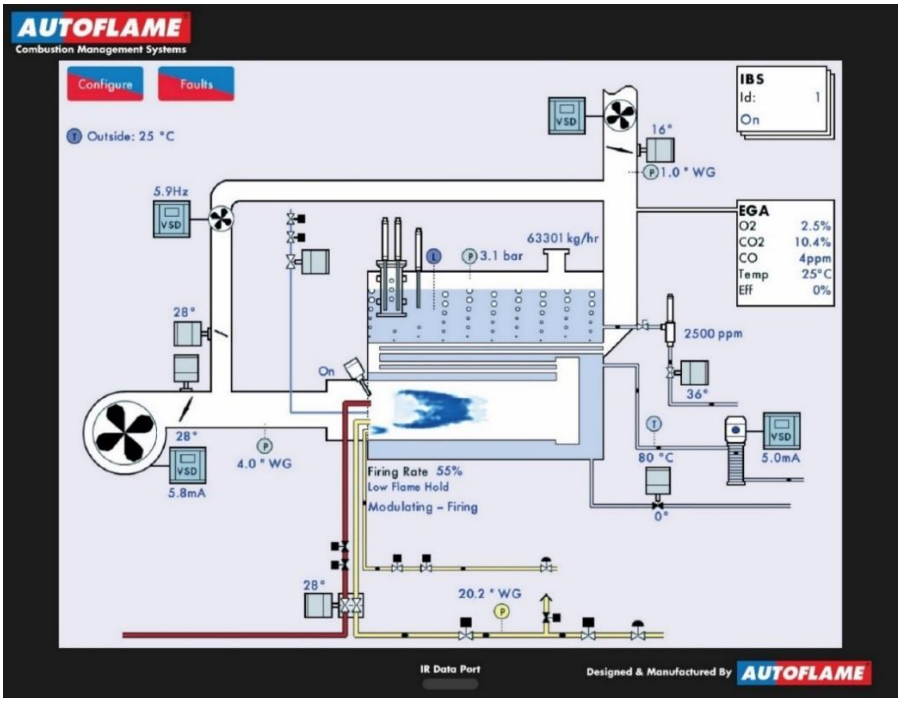
- The air to fuel ratio must be kept to the minimum to ensure complete combustion within the limitations of the combustion head design. A very high air to fuel ratio will be an indication of high excess air, which decreases the overall efficiency of the boiler. The fuel valve and air damper positions set for this minimum air to fuel ratio along the whole commission curve must be infinitely repeatable to an incredibly high degree of accuracy.

- The target temperature or pressure of the boiler must be monitored by the combustion system at all times, with exactly the right amount of fuel and air fired to achieve this target value. Irrespective of load changes, the burner/boiler system should be able to meet the target temperature or pressure.

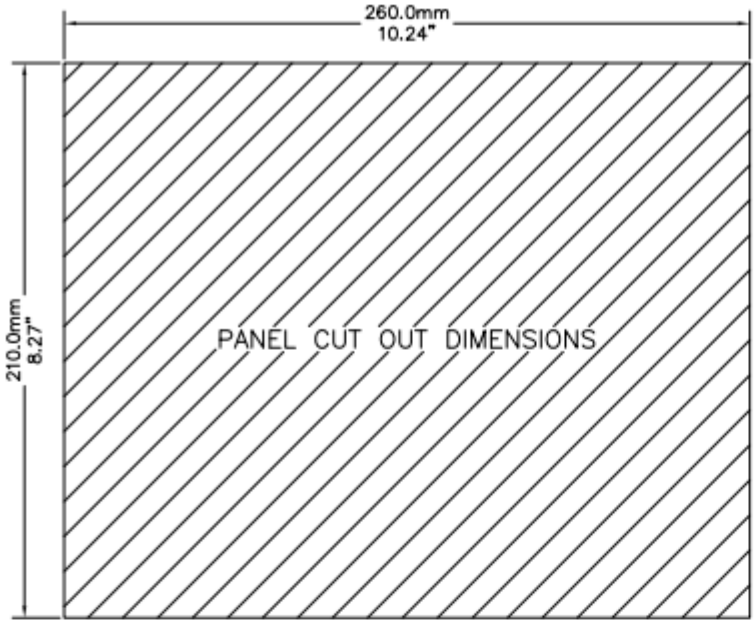
The burner's fuel to air ratio was traditionally governed by mechanical systems which involved multiple cams, shafts and linkages controlled by one motor. An inherent hysteresis in this system design allowed components to become loose, which made it impossible to achieve the required level of accuracy. With this poor accuracy, the response of the fuel input to the monitored temperature/ pressure of the boiler meant that the set target value at most times would overshoot or fall short.

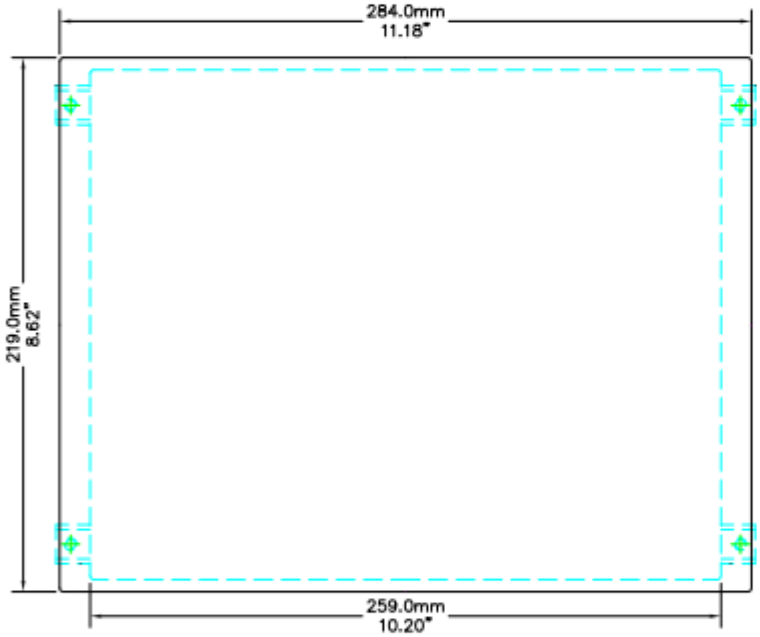
The Micro-Modulation module is the basic building block of the Autoflame System. The Autoflame MM provides an easily programmable and flexible means of optimising combustion quality throughout the load requirement range of the burner/boiler unit whilst ensuring the temperature is accurate to within 1°C (°F) and pressure to within 1 PSI (0.1Bar). Using direct drive motors to individually control the air damper and fuel valve(s), gives the optimum combustion of the burner at every point along the firing range. The allowed error in angular degrees of rotation between the two servomotors at any position in the load range is 0.1°.

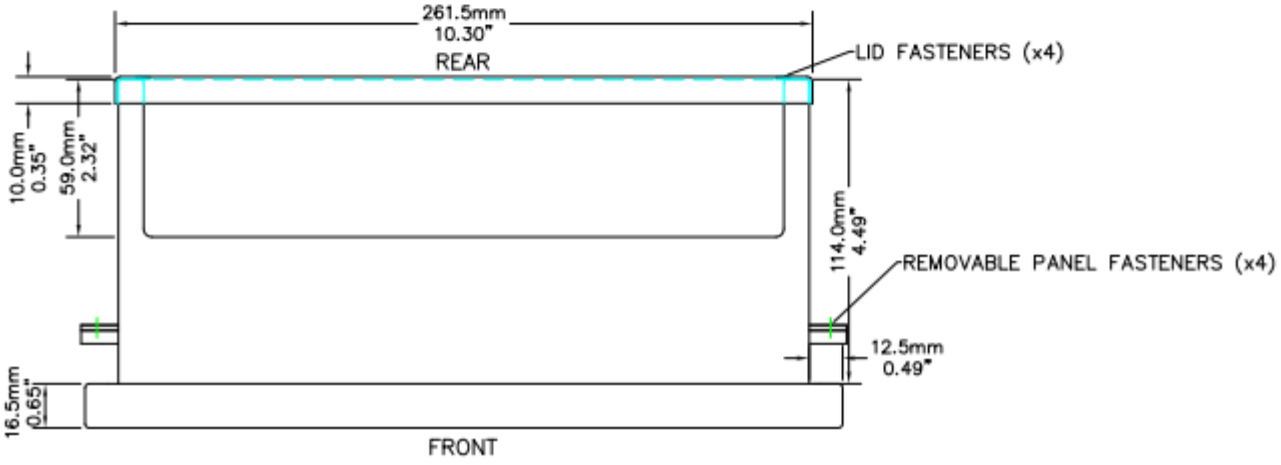
This automated system of burner control can achieve 'locked on' near stoichiometric air to fuel mixing throughout the fuel input range of the boiler while maintaining exact temperature or pressure target values. The load control incorporates user-variable Proportional Integral Derivative control. The PID control is infinitely adjustable to match any boiler room requirements.



1.1.3 Fixing Holes and Dimensions

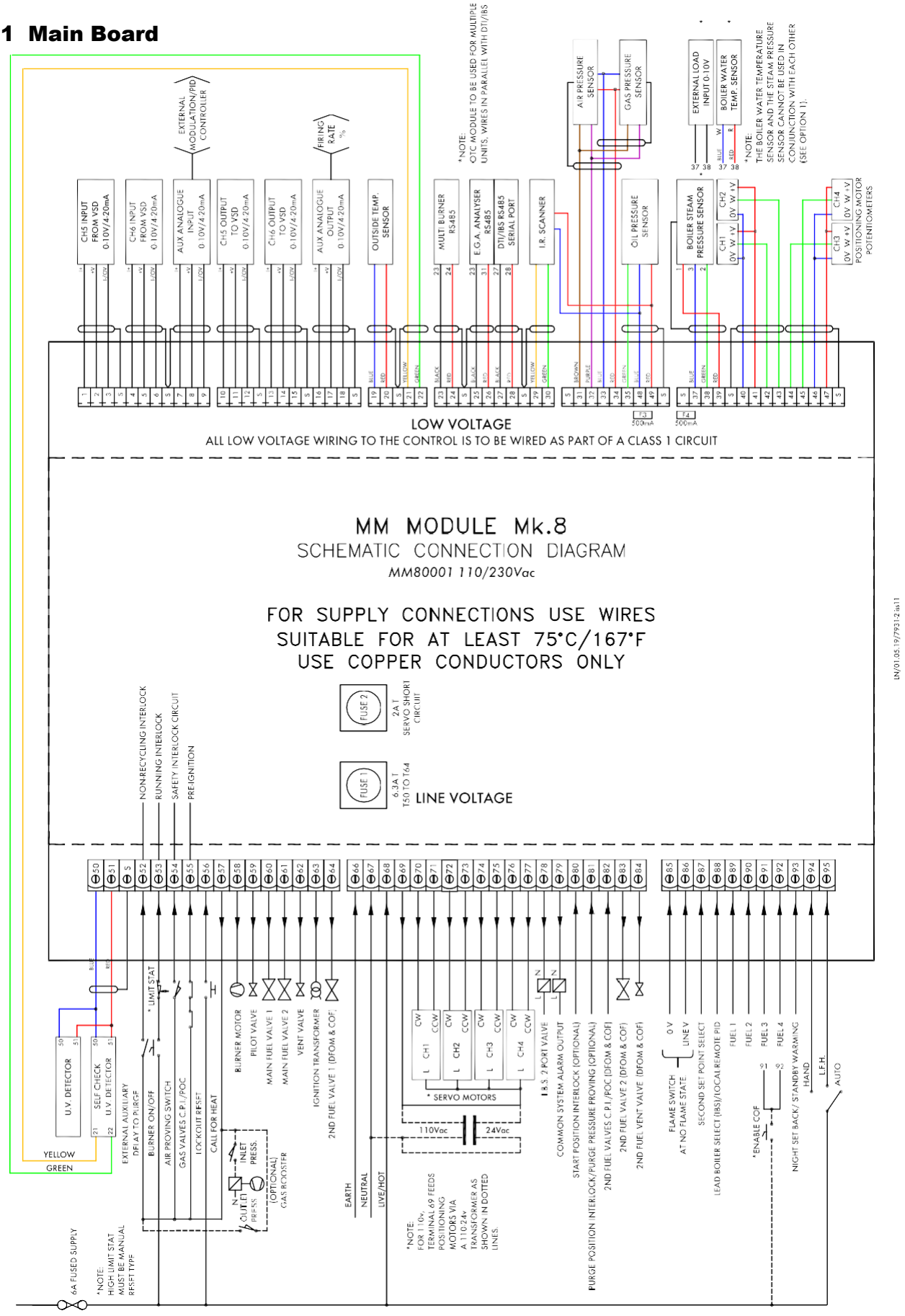




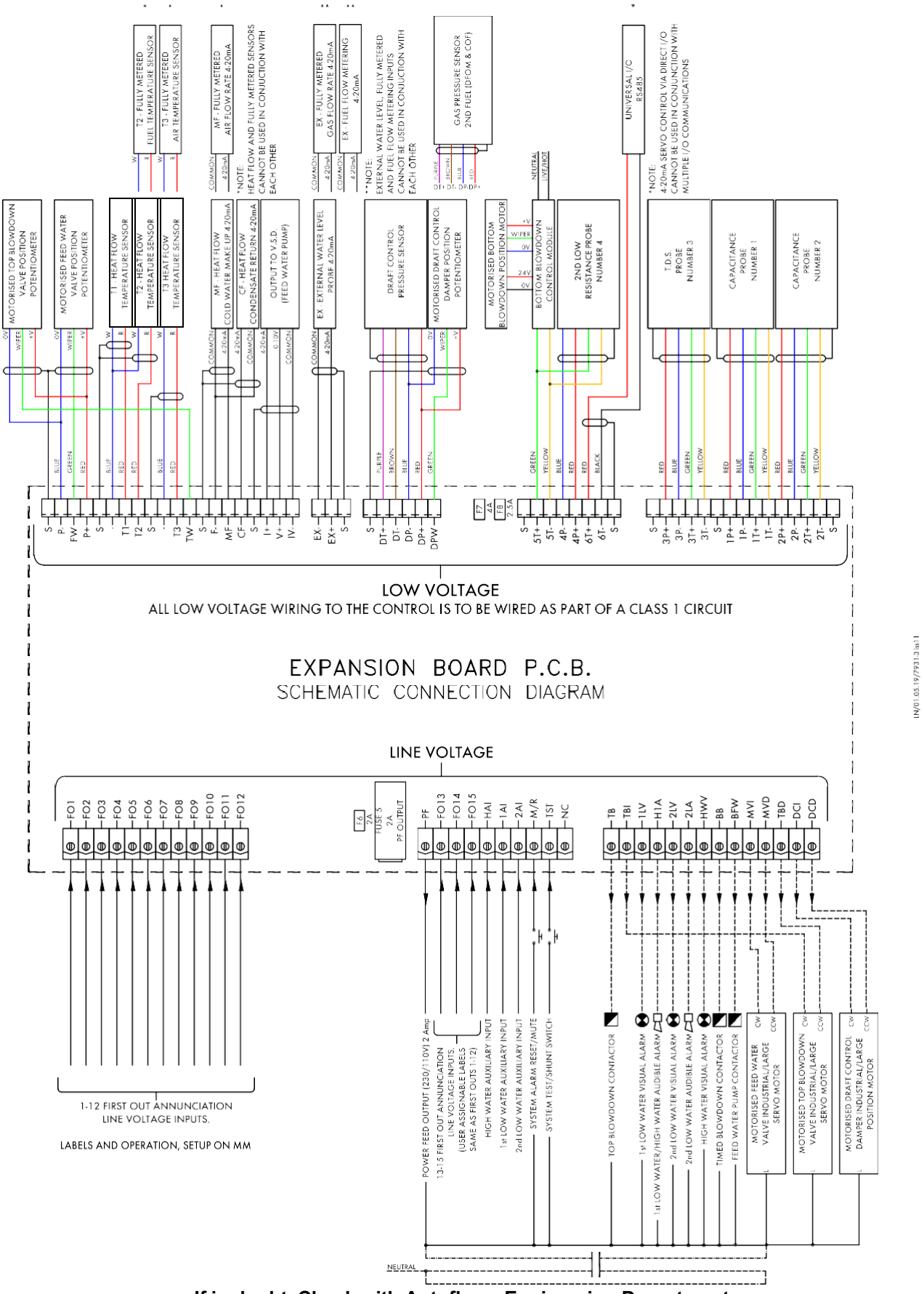


1.2 Wiring Schematic

1.2.1 Main Board



1.2.2 Expansion Board



If in doubt, Check with Autoflame Engineering Department

1.2.3 Fuse Ratings

Fuse	Rating	Spare Part Number
1	6.3A (T)	FU10026
Fuse 1 protects the mains input to the MM, including the mains output terminals 50 – 64.		
2	2A (T)	FU10034
Fuse 2 protects the power supply (terminal 69) for the servomotors, alarm and 2 port valve. If this fuse blows, error 'Triac Power Supply Error (Check F2)' will occur.		
3	500mA	FU10040
Fuse 3 protects the 13.5V power supply to the oil pressure sensor and IR scanner on terminal 49. If this fuse blows, error 'Fused 13.5V Supply Error (Check F3)' will occur.		
4	500mA	FU10040
Fuse 4 protects the 12V power supply to the gas/air pressure sensor and steam pressure detector on terminals 34 and 39. If this fuse blows, error 'Fused 12V Supply Error (Check F4)' will occur.		
5	2A (T)	FU10034
Fuse 5 protects the power supply (terminal PF) for the expansion servos and alarm outputs. If fuse 5 blows, error 'Expansion PF Output (Check F5)' will occur.		
6	2A	FU10027
Fuse 6 protects the DC circuits. If this fuse blows, the display will be off and both LEDs adjacent to fuse 7 and 8 will be off.		
7	4A	FU10050
Fuse 7 protects the internal 5V supply. If this fuse blows the display will be off and the LED adjacent to the fuse will be off.		
8	2.5A	FU10042
Fuse 8 protects the internal 12V supply. If this fuse blows the display will be off and the LED adjacent to the fuse will be off.		

1.3 Electrical Specifications

Classification according to BS EN298:2012

Mains Supply:	Single phase 230V, +10%/-15%} Single phase 120V, +10%/-15%}	47-63 Hz, unit max. consumption 140W
Climate:	Min. Operation Temperature Recommended Temperature Max. Operation Temperature Humidity	0°C (32°F) Less than 40°C (104°F) 60°C (140°F) 0 to 90% non-condensing
Storage:	Temperature	-20 to 85°C (-4 to 185°F)
Protection Rating:	The unit is designed to be panel mounted in any orientation and the front facia is IP65, NEMA4. The back of the unit is IP20, NEMA1.	

1.3.1 MM Inputs and Outputs

Output Terminal	Rating (230V)	Rating (120V)	Notes
57	250mA	250mA	Must be connected through contactor
58	250mA	250mA	Must be connected through contactor
59	1A	2A	0.6 power factor
60	1A	2A	0.6 power factor
61	1A	2A	0.6 power factor
62	1A	2A	0.6 power factor
63	1A	2A	0.6 power factor
64	1A	2A	0.6 power factor
78	100mA	100mA	To drive relay only – switched neutral
79	100mA	100mA	To drive relay/lamp only – switched neutral
83	1A	2A	0.6 power factor
84	1A	2A	0.6 power factor
Max. Load	6A	6A	



Note:

1. The high and low voltage connections are not safe to touch. Protection against electric shock is provided by correct installation. **CAUTION – ELECTRIC SHOCK HAZARD.**
2. Control voltage cabling should be maximum 10m, screened (if not screened then less than 1m, howeverservomotors can be unscreened up to 10m)
3. Any cabling over 10m must have additional surge protection.
4. Low voltage cables should be screened cable as specified in section 1.3.3.
5. The burner 'High Limit Stat' must be a manual reset type.
6. All external safety devices that require manual reset must be reset external to the Autoflame system and prior to completing the recycling interlock.

Note: The cover (back plate) of the MM must always be re-fitted after the wiring is completed to prevent unauthorised wiring modifications or fuse replacement.

1.3.2 Expansion Board Inputs and Outputs

Outputs:	120/230 V	All outputs with the exception of PF are switched neutrals
BFW	250mA	Must be connected through contactor.
BB	250mA	Must be connected through contactor.
HWV	100mA	(alarm indicator).
2LA	100mA	(alarm indicator).
2LV	100mA	(alarm indicator).
H1A	100mA	(alarm indicator).
1LV	100mA	(alarm indicator).
79	100mA	(alarm indicator on MM board).
TB	250mA	Solenoid only, must be connected through contactor.
PF	Maximum 2A	(load currents for above terminals).
Note:	Max number of alarm indicators on at any time is 3 (1LV, 2LA, 2LV).	

Main Voltage Signal Inputs:

At 120V current loading is approximately maximum 0.7mA per input.
At 230V current loading is approximately maximum 1.5mA per input.

Analogue Output Terminals

4-20mA Output Terminals	Maximum Voltage Drop Supported
10, 12	12V
13, 15	12V
16, 18	12V
I+, IV-	12V

1.3.3 Cable Specifications

Low Voltage

The screened cable used for low voltage wiring from the MM to the servomotors, detectors and variable speed drive must conform to the following specification:

UV scanner cable length should not exceed 25m, all other screened cables should not exceed 50m.

- 16/0.2mm PVC insulated overall braid, screened, PVC sheathed.
- Sixteen wires per core.
- Diameter of wires in each core 0.2mm.
- Rated at 440V AC rms at 1600Hz.
- DEF 61-12 current rating per core 2.5A.
- Maximum operating temperature 70°C (158°F).
- Nominal conductor area 0.5sq mm per core.
- Nominal insulation radial thickness on core 0.45mm.
- Nominal conductor diameter per core 0.93mm.
- Nominal core resistance at 20°C. 40.1Ω/1000m.
- Nominal overall diameter per core 1.83mm.
- Fill factor of braid screen 0.7.
- Equivalent imperial conductor sizes 14/0.0076.

Use the number of cores suitable for the application. A universal part numbering system appears to havebeen adopted for this type of cable as follows:

- 16-2-2C 2 Core.
- 16-2-3C 3 Core.
- 16-2-4C 4 Core.
- 16-2-6C 6 Core.
- 16-2-8C 8 Core.

(5 Core not readily available).

Note: If using 4 Core cable and interference is detected, use 2 sets of 2 Core.

Data Cable

Data cable must be used for communication connections between MMs for sequencing applications as well as between MMs to EGAs, MMs to a DTI and DTI to BMS systems.

Communication cable should not exceed 1km.

Types of data cable that can be used:

- Belden 9501 for 2-core shielded cable (1 twisted pair).
- Belden 9502 for 4-core shielded cable (2 twisted pairs).
- STC OS1P24.

Samples are available upon request. Low voltage and data cable can be ordered directly from Autoflame Engineering, please contact Autoflame Sales.

When using a VSD, please review the manufacturer’s guidelines on installations to prevent EMC including the recommendations for reactors and filters.

1.3.4 MM Terminals Description

S	All terminals marked S are internally connected. They are provided for connections to the various screened cables.
1	Current Input, 0-20mA/ 4-20mA. For channel 5 only. Can be connected to the current output of a VSD or tachometer system or 4-20mA servomotor feedback.
2	Voltage Input, 0-10V. For channel 5 only. Can be connected to the voltage output of a VSD or tachometer system.
3	0V common for Terminals 1 or 2.
4	Current Input, 0-20mA/ 4-20mA. For channel 6 only. Can be connected to the current output of a VSD or tachometer system or 4-20mA servomotor feedback.
5	Voltage Input, 0-10V. For channel 6 only. Can be connected to the voltage output of a VSD or tachometer system.
6	0V common for Terminals 4 or 5.
7	Current Input, 4-20mA. Used for external modulation or external required setpoint.
8	Voltage Input, 2-10V. Used for external modulation or external required setpoint.
9	0V common for Terminals 7 or 8.
10	Current Output, 0-20mA/ 4-20mA. For channel 5 only. Can be connected to the current input of a VSD or tachometer system or 4-20mA servomotor feedback.
11	Voltage Output, 0-10V. For channel 5 only. Can be connected to the voltage input of a VSD or tachometer system.
12	0V common for Terminals 10 or 11.
13	Current Output, 0-20mA/ 4-20mA. For channel 6 only. Can be connected to the current input of a VSD or tachometer system or 4-20mA servomotor feedback.
14	Voltage Output, 0-10V. For channel 6 only. Can be connected to the voltage input of a VSD or tachometer system.
15	0V common for Terminals 13 or 14.
16	Current Output, 4-20mA/ 0-20mA. Varies in accordance with firing rate.
17	Voltage Output, 0-10V/ 2-10V. Varies in accordance with firing rate.
18	0V common for Terminals 16 or 17.
19, 20	Connections to an Autoflame outside temperature sensor.
21, 22	Connections to an Autoflame self-check UV sensor.
23, 24	Communications port connections for multi-burner operation.
25, 26	Communications port connections to an Exhaust Gas Analyser (EGA).
27, 28	Communications port connections for DTI and/or IBS.
29, 30	Digital communications connections to an Autoflame IR scanner.
31, 32	Digital communications connections to an Autoflame air pressure sensor and/or Autoflame gas pressure sensor.
33	0V supply to an Autoflame air pressure sensor and/or Autoflame gas pressure sensor.

34	+12V supply to an Autoflame air pressure sensor and/or Autoflame gas pressure sensor.
35	Signal inputs from Autoflame oil pressure sensor.
48	0V supply to an Autoflame oil pressure sensor and/or Autoflame IR scanner.
49	+13.5V supply to an Autoflame oil pressure sensor and/or Autoflame IR scanner.
37	0V supply to an Autoflame temperature or pressure detector, 0-10V external load detector.
38	Signal input from an Autoflame temperature or pressure detector, 0-10V external load detector.
39	12V supply to an Autoflame pressure detector.
40	0V supply to channel 1 and channel 2 servomotors.
41	+12V supply to channel 1 and channel 2 servomotors.
42	Signal from channel 1 servomotor, indicating position.
43	Signal from channel 2 servomotor, indicating position.
44	Signal from channel 3 servomotor, indicating position.
45	Signal from channel 4 servomotor, indicating position.
46	0V Supply to channel 3 and channel 4 servomotors.
47	+12V supply to channel 3 and channel 4 servomotors.
50, 51	Connections to an Autoflame UV scanner.
52	Mains voltage input – external auxiliary delay to purge/ secondary proving set in option/parameter 157.
53	Mains voltage input – burner on/off signal, running interlock circuit.
54	Mains voltage input – air proving switch.
55	Mains voltage input - proving circuits, e.g. gas valve proof of closure.
56	Mains voltage input- lockout reset.
57	Mains voltage output – call for heat.
58	Mains voltage output – burner motor.
59	Mains voltage output – start/pilot valve.
60	Mains voltage output – main fuel valve 1.
61	Mains voltage output – main fuel valve 2.
62	Mains voltage output – vent valve.
63	Mains voltage output – ignition transformer.
64	Fuel 2 Main Valve 1(Dual Fuel Output Mode & Change on the Fly).
66	Mains supply – earth.
67	Main supply – neutral.
68	Mains supply – live/hot.
69	Mains voltage output, power to servomotors and/or servomotor stepdown transformer.

70	Switched neutral – drives channel 1 servomotor clockwise.
71	Switched neutral – drives channel 1 servomotor counterclockwise.
72	Switched neutral – drives channel 2 servomotor clockwise.
73	Switched neutral – drives channel 2 servomotor counterclockwise.
74	Switched neutral – drives channel 3 servomotor clockwise.
75	Switched neutral – drives channel 3 servomotor counterclockwise.
76	Switched neutral – drives channel 4 servomotor clockwise.
77	Switched neutral – drives channel 4 servomotor counterclockwise.
78	Switched neutral – 2-port valve for IBS operation.
79	Switched neutral – alarm output for MM lockout/MM error/EGA error.
80	Start position interlock (selectable via option 154).
81	Purge position interlock/ delay purge time (selectable via option 155).
82	Fuel 2 valves C.P.I/POC (Dual Fuel Output Mode & Change on the Fly).
83	Fuel 2 Main Valve 2 (Dual Fuel Output Mode & Change on the Fly).
84	Fuel 2 Vent Valve (Dual Fuel Output Mode & Change on the Fly).
85	Mains voltage input. For use when using an external flame switch- 0V when at no flame state.
86	Mains voltage input. For use when using an external flame switch- line voltage when at no flame state.
87	Mains voltage input. Select second required setpoint- second set-point facility.
88	Mains voltage input. Lead boiler select (overrides DTI) / Local – remote PID select for external modulation.
89	Mains voltage input – selects fuel 1 curve.
90	Mains voltage input – selects fuel 2 curve.
91	Mains voltage input – selects fuel 3 curve (enables COF when energised with T92 simultaneously).
92	Mains voltage input – selects fuel 4 curve (enables COF when energised with T91 simultaneously).
93	Mains voltage input – warming start or night setback input (selectable via option 79).
94	Mains voltage input – selects hand operation (overrides mode set on MM screen).
95	Mains voltage input – selects low flame hold operation (overrides mode set on MM screen).

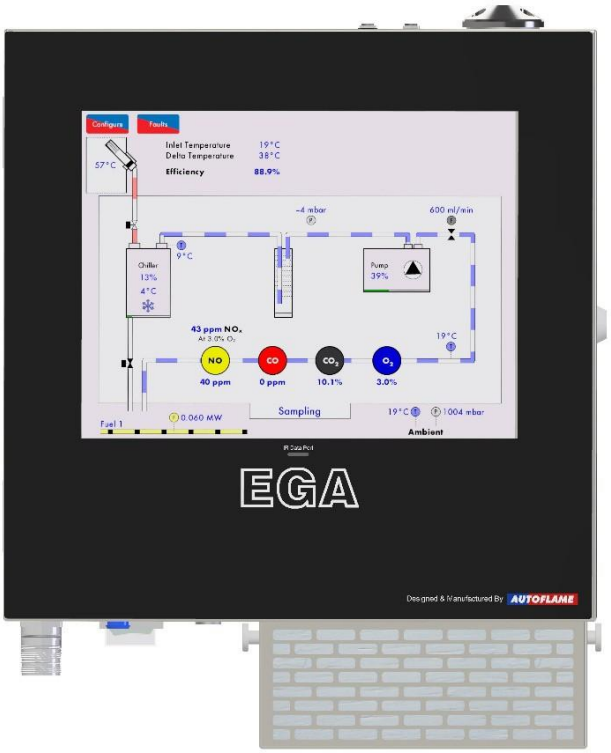
1.3.5 Expansion Board Terminals Description

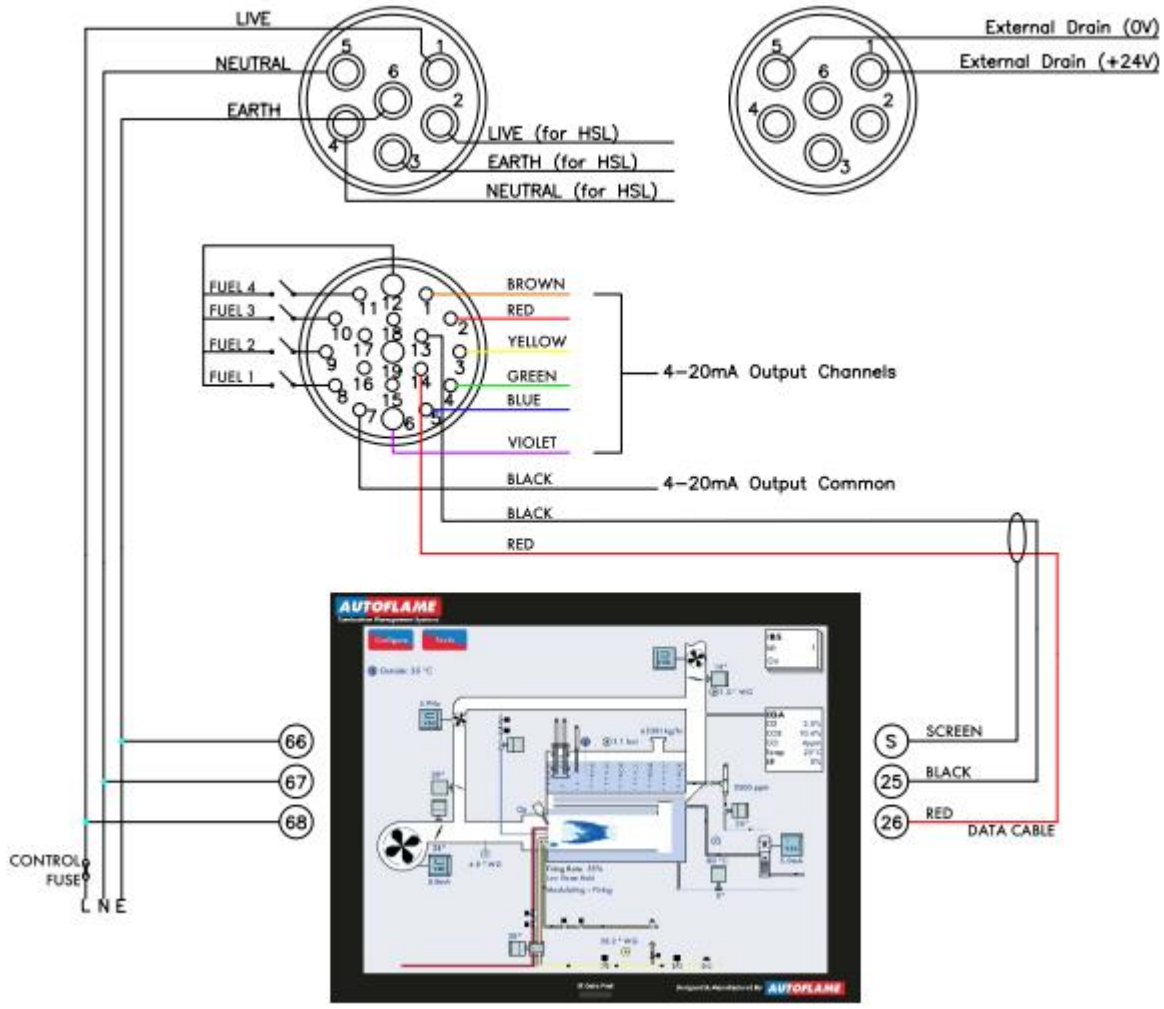
S	All terminals marked S are internally connected. They are provided for connections to the various screened cables.
P-	0V supply to top blowdown and feed water servomotors.
FW	Signal from feed water servomotor, indicating position.
P+	+12V supply to top blowdown and feed water servomotors.
-	Common for terminals T1, T2 and T3.
T1	Signal input from T1 temperature sensor.
T2	Signal input from T2 temperature sensor.
-	Common for terminal T1, T2 and T3.
T3	Signal input from T3 temperature sensor.
TW	Signal from top blowdown servomotor, indicating position.
F-	Common for terminals MF and CF.
MF	Current input, 4-20mA for cold water make up flow meter.
CF	Current input, 4-20mA for condensate return flow meter.
I+	Current output, 4-20mA to feed water VSD.
V+	Voltage output, 0-10V to feed water VSD.
IV-	Common for terminals I+ and V+.
EX-	Common for terminal EX+.
EX+	Current input, 4-20mA for external water level probe or fuel flow feedback.
DT+, DT-	Digital communications from draught control pressure sensor (Fuel 2 Gas Pressure Sensor in Dual Fuel Output Mode).
DP-	0V supply to draught control pressure sensor and draught control servomotor (Fuel 2 Gas Pressure Sensor in Dual Fuel Output Mode).
DP+	+12V supply to draught control pressure sensor and draught control servomotor (Fuel 2 Gas Pressure Sensor in Dual Fuel Output Mode).
DPW	Signal from draught control servomotor, indicating position.
5T+, 5T-	Digital communications from bottom blowdown module and 2nd low probe.
4P-	0V supply to 2nd low resistance probe.
4P+	+12V supply to 2nd low resistance probe.
6T+, 6T-	Communications port connections I/O module RS485.
3P+	+9V supply to TDS probe.

3P-	0V supply to TDS probe.
3T+, 3T-	Digital communication connections from TDS probe.
1P+	+9V supply to capacitance probe 1.
1P-	0V supply to capacitance probe 1.
1T+, 1T-	Digital communications connections from capacitance probe 1.
2P+	+9V supply to capacitance probe 2.
2P-	0V supply to capacitance probe 2.
2T+, 2T-	Digital communications connections from capacitance probe 2.
FO1	First Out annunciation line voltage input 1.
FO2	First Out annunciation line voltage input 2.
FO3	First Out annunciation line voltage input 3.
FO4	First Out annunciation line voltage input 4.
FO5	First Out annunciation line voltage input 5.
FO6	First Out annunciation line voltage input 6.
FO7	First Out annunciation line voltage input 7.
FO8	First Out annunciation line voltage input 8.
FO9	First Out annunciation line voltage input 9.
FO10	First Out annunciation line voltage input 10.
FO11	First Out annunciation line voltage input 11.
FO12	First Out annunciation line voltage input 12.
PF	Power feed 2A output (230V/110V).
FO13	First Out annunciation line voltage input 13.
FO14	First Out annunciation line voltage input 14.
FO15	First Out annunciation line voltage input 15.
HAI	External high water auxiliary input.
1AI	External 1st low water auxiliary input.
2AI	External 2nd low water auxiliary input.
M/R	System alarm mute/reset.
TST	System test alarm inputs/ shunt switch (selectable via expansion option 21).

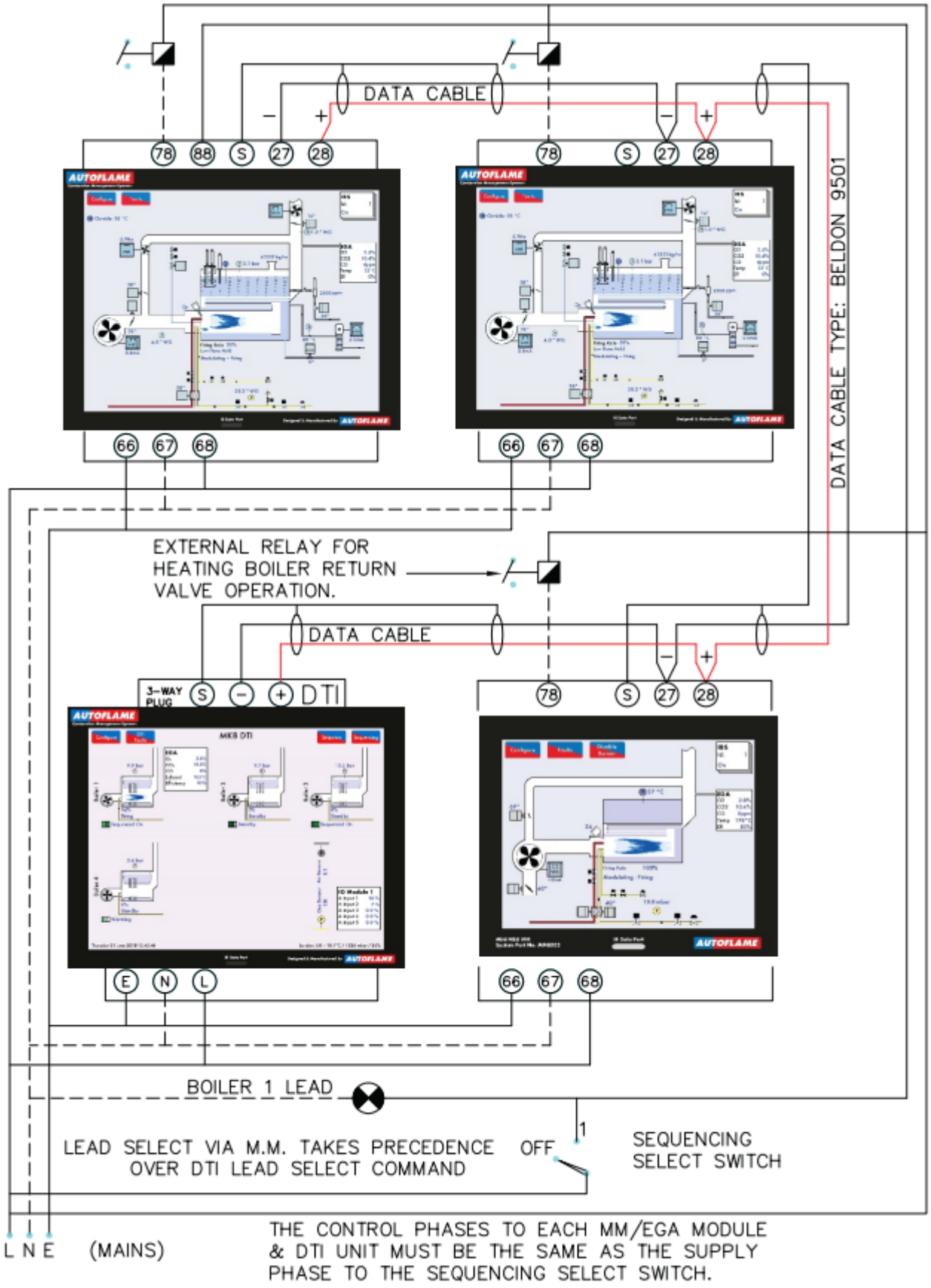
NC	Unused – do not connect.
TB	Switched neutral – top blowdown contactor.
TBI	Switched neutral – drives top blowdown servomotor clockwise.
1LV	Switched neutral – 1st low water visual alarm.
H1A	Switched neutral – 1st low/ high water audible alarm.
2LV	Switched neutral – 2nd low water visual alarm.
2LA	Switched neutral – 2nd low water audible alarm.
HWV	Switched neutral – High water visual alarm.
BB	Switched neutral – Bottom blowdown contactor.
BFW	Switched neutral – Feed water pump contactor.
MVI	Switched neutral – drives feed water servomotor clockwise.
MVD	Switched neutral – drives feed water servomotor counterclockwise.
TBD	Switched neutral – drives top blowdown servomotor counterclockwise.
DCI	Switched neutral – drives draught control servomotor clockwise.
DCD	Switched neutral – drives draught control servomotor counterclockwise.

1.4 Connection Between Mk8 MM and Mk8 EGA EVO

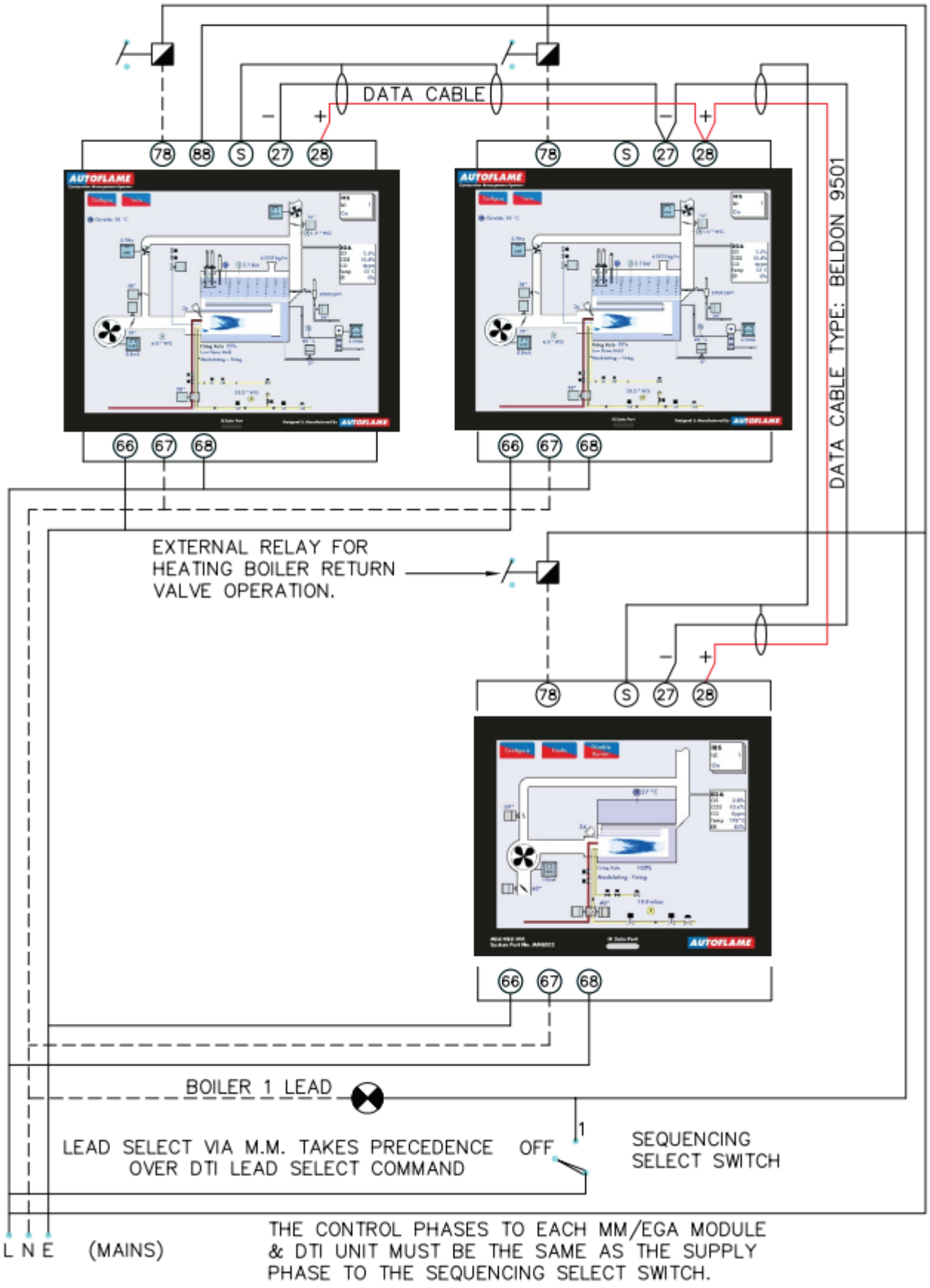




1.5 Connection Between Mk8 MM and Mk8 DTI



1.6 Sequencing Connection Diagram



1.7 Standards

The Mk8 MM has been tested and approved to the following standards:

- BS EN 298: 2012
- BS EN 1643: 2014
- BS EN 1854: 2010
- BS EN 12067-2: 2004
- ISO 23552-1:2007
- UL 372, 5th Edition
- CAN/CSA C22.2 No. 199-M89
- AS 4625–2008
- AS 4630–2005
- FM 7610
- FM 7710

The Mk8 MM has been manufactured in conformance with the applicable design, manufacturing and inspection requirements of EU Regulation (EU) 2016/426 and ISO 9001:2015 quality system.

1.8 Functional Safety

The Mk8 MM has been assessed by Autoflame for Functional Safety using the proven in use method via Route 2H and 2S in accordance with EN61508-2 clause 7.4.4.3 and clause 7.4.10 for operation as a Flame Safeguard device and a Fuel-Air Ratio controller.



The Functional Safety operations assume that the unit is operated in normal operating conditions as defined in section 1.3.

The Mk8MM controller has integrated Flame Safeguard and Fuel-Air Ratio controls. It is intended for use only as described in this manual.

Note: The functional safety assessment does not include the fuel valves. In order to achieve the SIL3 rating defined below, then the SIL rating of the Fuel Valves must meet the hardware architectural constraints for SIL 2 at HFT = 0, SFF > 60% and a common cause factor of less than 10%. The valves should be selected such that considering the valves and the Mk8MM, the combined $PFH_{system} \leq 5\times10^{-7}$.

The Mk8MM is a Type B device with programmable electronics.

1.8.1 Flame Safeguard Device.

The Mk8MM controller contains a built-in **Flame Safeguard** device which monitors the presence/absence of a flame using one or more flame scanners and controls a pair of fuel valves and an ignition transformer. The Flame Safeguard runs according to an embedded state machine which defines the status of all the inputs/outputs and ensures that the valves are shut off in the event of a failure such as a loss of flame.

The **Flame Safeguard** carries out the following tasks:

- Checks the relay outputs prior to combustion.
- Carries out valve proving before and/or after combustion to check the integrity of the gas supply line.
- Follows a flame light off sequence to check the flame is established successfully.
- Monitors the presence/absence of the flame at all times, locking out the system if there is either a simulated flame error when no flame should be present, or a loss of flame error when combustion should be taking place.
- Ensures a safe shutdown of the system in the event of any issues, including loss of power or component failure.
- Continually assesses the integrity of the relays driving the valves to ensure they never remain in a stuck position.

1.8.1.1 Safety Function

The Flame Safeguard safety function is:



When the flame signal does not match the expected state (i.e. simulated flame when combustion is not expected or no-flame signal when combustion should be in progress), the burner is brought to a safe state and the fuel flow is stopped by de-energizing the fuel valves.

1.8.1.2 Constraints

The Mk8MM can operate with single flame scanners or with dual flame scanner connected in parallel in an AND/OR configuration, where:

- AND: Both attached scanners must agree on the status of the flame. Either scanner not seeing the flame will result in a safety lockout.
- OR: Either scanner must see the flame for combustion to continue. This is primarily intended for when different scanners are needed to see the pilot and main flames due to constraints in the burner head design.

If SIL3 operation is required, then two flame scanners operated in AND mode should be used to provide a 1oo2 selection for the flame detection.

The allowed combinations of flame scanners are as shown in the table below:

Table 1 - Flame Scanner Combinations

Type	UV Scanner	Ionization Rod	IR Scanner	Flame Switch*
UV Scanner		-	●	●
Ionization Rod	-		●	●
IR Scanner	●	●		●
Flame Switch*	●	●	●	

* The Flame Switch input is for flame scanners from other manufacturers.

1.8.2 Fuel-Air Ratio Controller

The Fuel-Air Ratio is defined by the movement of up to 4 servomotors controlled directly from the FAR microprocessor. The positions of the servomotors are defined during the commissioning process for the complete combustion curve. The controller then drives the servos up and down the commissioned curve during firing to ensure correct combustion.

The servomotors are driven clockwise or counterclockwise by turning on/off a pair of switched neutral connections to the servo's drive motor. The position of the servomotor, and therefore the damper that it is connected to is determined by feedback from a potentiometer connected directly on the drive shaft.

The feedback follows two paths, one amplified, which must agree on the servo position or else a movement error is generated. The servo's must also get to within a defined error band of their expected angle within a defined time limit or else an error will again be generated.

If an error is generated, the FAR processor instructs the burner control to shut down the system, closing the fuel valves and achieving a safe state. The FAR and BC microprocessors maintain a direct link which must be constantly toggling to confirm that they are both operational. Any failure of the link will also cause a safety lockout of the system.

1.8.2.1 Safety Function

The Fuel-Air Ratio safety function is:



When either the fuel or air servo motors feedback angle does not match the expected angle to which it is being driven, the burner is brought to a safe state and the fuel flow is stopped by de-energizing the fuel valves.

1.8.2.2 Constraints

The Mk8MM can control Autoflame small, large or industrial servos on the 4 servo channels. In addition it can drive a VSD. For the purposes of functional safety, only the 3 servomotor channels are considered.

1.8.3 PFH

A dangerous undetected failure would be where the system fails to respond to either the loss of a flame, or the loss of control on a servo motors by shutting down the fuel valves. The following table defines the average probability of such a failure, and provides the achievable SIL rating:

Table 2 – Mk8MM Controller SIL Ratings

PFH_{Mk8MM}	HFT	SIL Rating
2.83×10^{-8}	1	SIL3

1.8.4 Failure Modes

The Mk8MM is designed to fail safe in the event of any component or site issues, closing off the fuel valves and bringing the burner to a safe state. Issues with loss of flame/simulated flame and servo movement errors will all result in non-volatile lockouts. These must be cleared from the Lockout screen for the Mk8MM to re-try combustion. Lockouts will re-occur if the cause of the fault has not been addressed. Contact your Autoflame trained Service Engineer for resolution of the issue or contact technicalsupport@autoflame.com for further support.

1.8.5 Proof Test



For Functional Safety installations, a Proof Test Interval of 1 year is defined for the Mk8MM. It is required that the proof test is carried out once a year to ensure that the safety functions and diagnostics are operational. This could be done during an annual maintenance service and shall include the following tests (Note only carry out the tests that are relevant to your set-up):

#	Test	Result	Diagnostics tested
1	Remove Flame Scanner 1 from the burner	No Flame Signal Lockout on startup	Count on scanner 1 (1)
2	Remove Flame Scanner 2 from the burner (2)	No Flame Signal Lockout on startup	Count on scanner 2 (1)
3	Disconnect Scanner 1 connection	No Flame Signal Lockout or No Comms lockout for the IR scanner	Count or Comms on scanner 1 (1)
4	Disconnect Scanner 2 connection (2)	No Flame Signal Lockout or No Comms lockout for the IR scanner	Count or Comms on scanner 2 (1)
5	Disconnect UV Self Check Drive (T21/T22) (3)	UV Shutter Fault Lockout	UV Count (self-check)
6	Disconnect Wiper T42 from Servo 1 connection (4)	Servo Movement Error	Servo Movement
7	Disconnect Wiper T43 from Servo 2 connection (4)	Servo Movement Error	Servo Movement
8	Disconnect Wiper T44 from Servo 3 connection (4)	Servo Movement Error	Servo Movement
9	Disconnect Wiper T45 from Servo 4 connection (4)	Servo Movement Error	Servo Movement
10	Disconnect 0V T40 from Servo 1 & 2 connection (4)	Servo Positioning Error	Servo Positioning
11	Disconnect +V T41 from Servo 1 & 2 connection (4)	Servo Positioning Error	Servo Positioning
12	Disconnect 0V T46 from Servo 3 & 4 connection (4)	Servo Positioning Error	Servo Positioning
13	Disconnect +V T47 from Servo 3 & 4 connection (4)	Servo Positioning Error	Servo Positioning
14	With all connections re-made, start the burner normally	Burner starts up and fires	Coil Feedback on all relays. Relay Feedback on all relays
15	Leave Running for at least 1/2 hour. (5) (set low flame hold if required to stop boiler reaching setpoint too soon)	Burner continues to fire normally	All diagnostics checks are completed within this timescale.

(1) whichever type of scanner is fitted.
(2) Omit if only a single scanner is used
(3) Omit if a UV self-check scanner is not used
(4) Check all connected servomotors only.
(5) ½ Hour is the longest diagnostic interval, which is the self-check functions on the UV Self-Check and IR flame scanners

Note: The following **diagnostics** tests are carried out in the normal operation of the system:

- The relay coils driving fuel valves and the safety valves are checked for correct operation continually throughout the operation of the Mk8MM.
- The correct opening and closing of the fuel valves is confirmed every time the system shuts down the burner and restarts.
- The correct operation of the safety relays is verified at the beginning of each start-up process for the burner.
- The correct detection of a flame by a UV bulb scanner is checked at every shut down of the burner, or at every self-check interval if it is a self-check UV scanner (this has a maximum diagnostic test time of 1 hour to generate an error if in fault).
- The data comms of the IR scanner is continually assessed.
- The self-check function of the IR scanner is checked every 30 minutes.
- Servo movement is continually monitored to confirm that the valves or dampers are moving as expected in response to a change in firing rate or request to start-up or shut down the burner.
- The correct operation of the unit is checked against a state machine as it moves through the startup, firing and shutdown procedures.
- The Comms between the BC and FAR microprocessors is continually monitored to ensure both parts of the control system are operating normally.

1.8.6 Maintenance



It is recommended that the Mk8MM is serviced at least once per year. Servicing shall be carried out by an Autoflame trained service engineer who is familiar with the Autoflame controller and systems and has a thorough understanding of burner combustion control.

The servicing should check the Proof Tests as described above and should carry out the following checks:

- Update the software to the latest release if a newer version is available.
- Check the Lockouts, Errors, Alarms and Warnings logs for any issues that have occurred since the last service. If there are persistent themes or regular issues then these should be resolved using the information in the Lockouts and Errors Section 19. Alternatively contact technicalsupport@autoflame.com for help in resolving issues.

1.8.7 Operational Lifetime

The Operational Lifetime of the Mk8MM is defined as 10 years. This is based on experience of the Mk8MM operation in the field and of other Autoflame burner controllers. If a unit is used in a Functional Safety installation, it shall be replaced once the Operational Lifetime has been reached.

2 OPTIONS AND PARAMETERS

The Options, Parameters and Expansion Options must only be changed by factory trained and certified technicians who have a thorough appreciation of the Autoflame combustion systems and the combustion process in general. Any person changing these settings without the correct factory training and understanding of the boiler plant may place themselves and others in a potentially dangerous situation.

2.1 Options

The options, parameters and expansion options and their settings are all viewable while the MM is in run mode. In commissioning mode, all of the options, parameters and expansion options can be adjusted according to the application. Non safety-critical options, parameters and expansion options can be adjusted through Online Changes.



Figure 2.1.i Splash Screen

Power up the unit. If the MM has already been commissioned, press 

when the system starts up. If the system is not already commissioned, the MM will go into commissioning mode automatically.

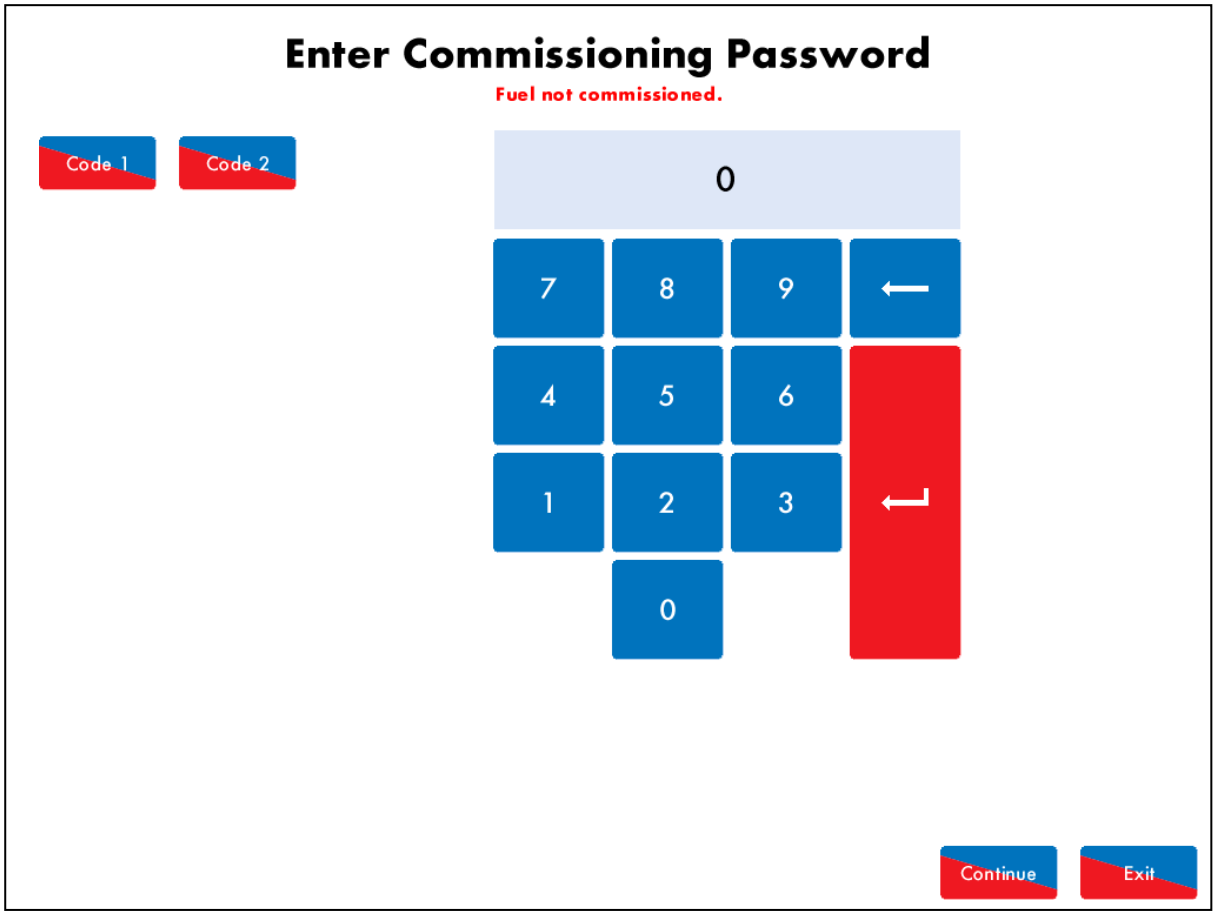


Figure 2.1.ii Enter Commissioning Password

"Enter Commissioning Password" is displayed. Use the keypad to enter the password, then press Continue. Press on Code 1 or Code 2 to change the value of an incorrect entry.

Note: The commissioning password should not be distributed to anyone who is not a factory trained and a certified engineer.

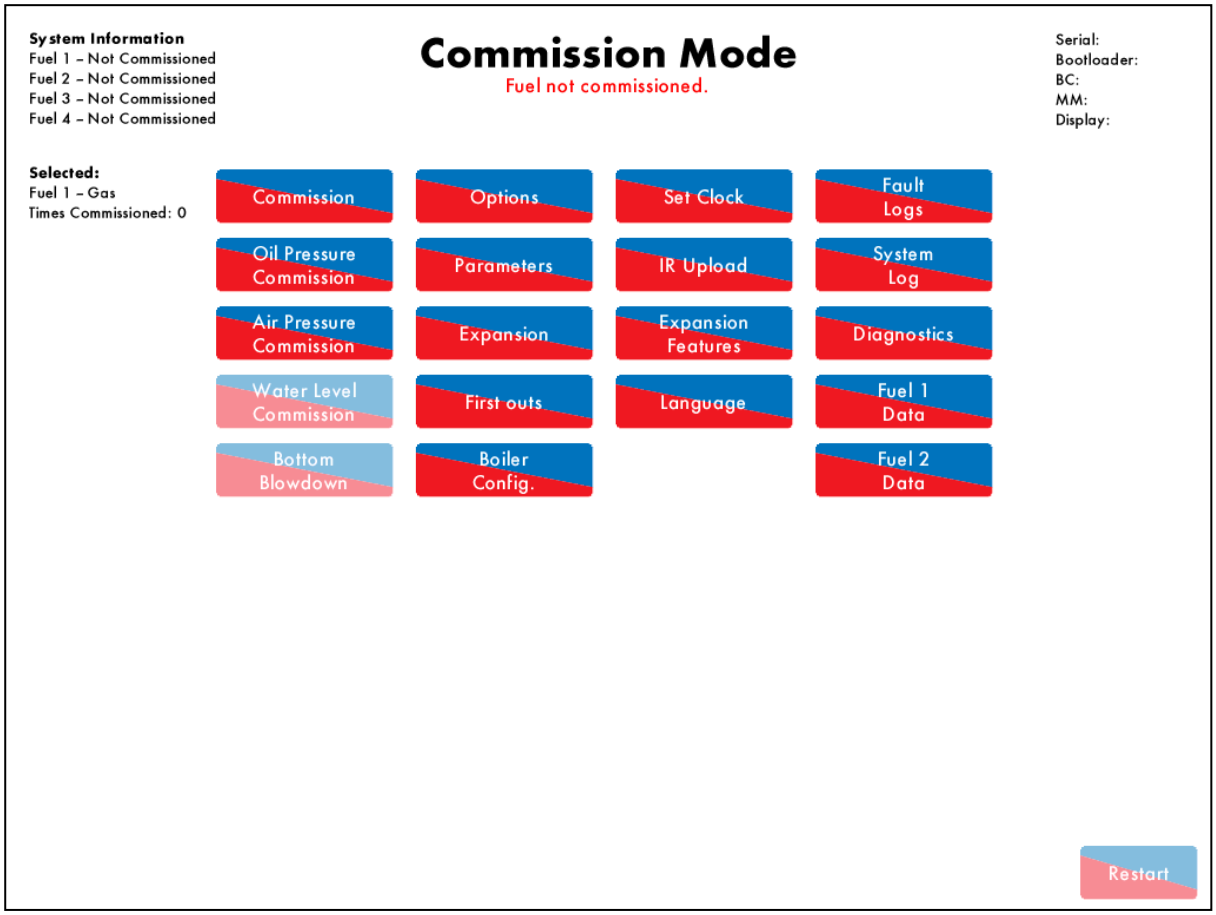


Figure 2.1.iii Commission Mode

The Commission Mode screen gives information on the following:

- Current selected fuel.
- Which fuels have been commissioned.
- Number of times the unit has been commissioned.
- Serial number.
- Bootloader version.
- BC, MM and Display software.

In Commission Mode, the engineer can:

- Commission the burner for selected fuel.
- Commission gas and air pressure sensors.
- Commission water level probes.
- Commission the bottom blowdown module.
- Adjust options, parameters and expansion options.
- Setup and change Boiler Configuration.
- Configure first out settings and labels.
- Set the time and date.
- Upload/download commissioning data.
- Unlock expansion features.
- Set the language.
- View fault logs, system log and diagnostics.
- View fuel commission data.

Note: The Times Commissioned is for the total system and will increment with every fuel commission, single point change and commission data upload.

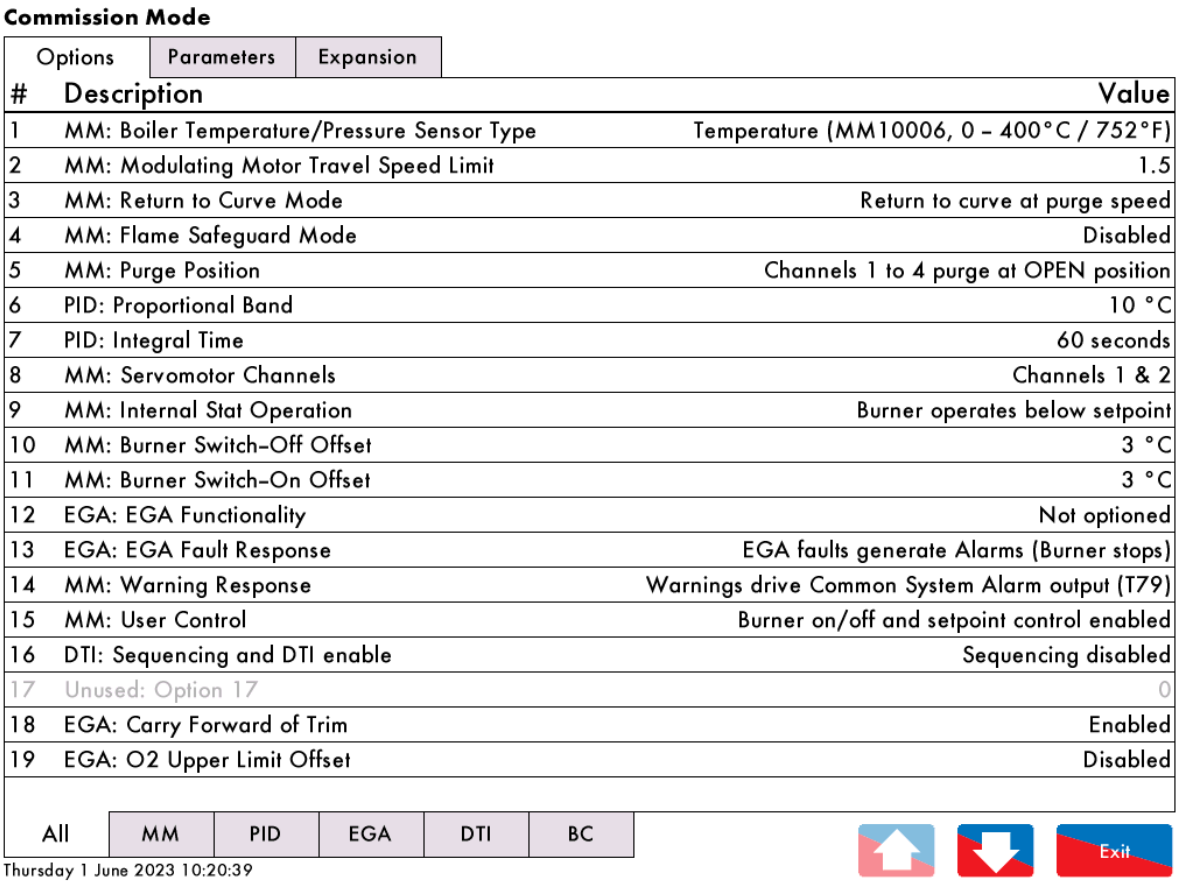


Figure 2.1.iv Options

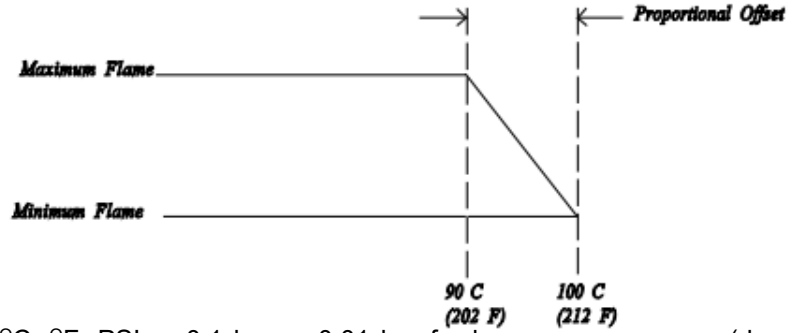
Press 

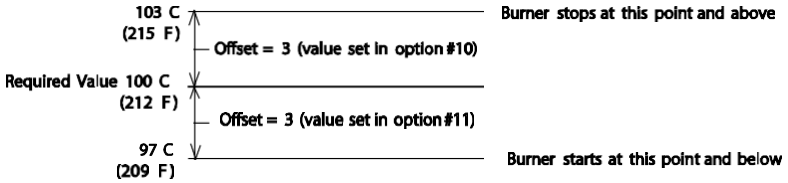
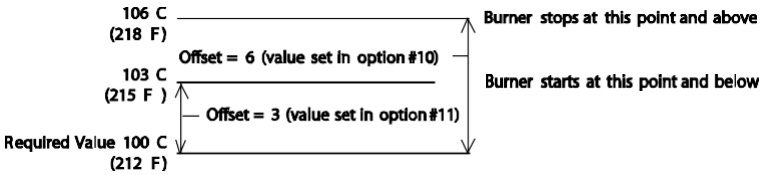
in the Commission Mode screen to access the options. Any number of options/parameters can be changed at one time. By pressing MM, PID, EGA, DTI or BC at the bottom of the screen, the options/parameters can be grouped together by feature.

When the changes have been made to suit the application's needs, press Exit to go back to the Commission Mode screen.

Options/parameters 110 – 160 are the burner control settings and are safety critical; these must be entered with the same setting for both the option and parameter value. If these BC options and parameters do not match, there will be an option/parameter conflict.

To set all the options, parameters and expansion options to the default values and erase the commissioning data, set option/parameter 160 to 5. The MM will then automatically restart and go into Commission mode.

Opt. #	Default	Range	Description
1	0		MM: Boiler Temperature/Pressure Sensor Type
		0	Temperature MM10006
		1	Low pressure MM10010
		2	Medium pressure MM10008
		3	High pressure MM10009
		4	Extra high pressure MM10017
		5	External temperature (voltage input, range set by parameters 52 to 56)
		6	External pressure (voltage input, range set by parameters 52 to 56)
			Note: External load detector wiring low voltage to terminal 37 and high voltage to terminal 38.
2	15		MM: Modulating Motor Travel Speed Limit
			If the modulating speed of the motor is too fast, then decrease the value, and vice versa. At times other than modulation, the motors move at full speed or at the value set in option 75. Movement is limited by the slowest channel i.e. the slowest moving motor.
		6 – 100	0.6 – 10.0
3	0		MM: Return to Curve Mode
			Controls how quickly the MM moves from off-curve positions (Golden Start, FGR) to the firing curve.
		0	Return to curve at purge speed.
		1	Return to curve at modulating speed.
4	0		MM: Flame Safeguard Mode
			When enabled by setting 1, the controller becomes a Flame Safeguard unit. This operates without any control of servo or VSD channels & with a reduced set of screens. (Option/parameter 154) (T80) Start Position Interlock & Purge Position Interlock (option/parameter 155) (T81) Purge Position Interlock must be used. Please check, the Autoflame MK8 Flame Safeguard manual for more information.
		0	Disabled
		1	Enabled
5	1		MM: Purge Position
			This purge position applies to channels 1-4 as selected in options 67-70, however VSD channels will always purge at open position as default. This setting applies for post-purge if set, see option/ parameter 118 and 135.
		0	Channels 1 to 4 purge at HIGH position.
		1	Channels 1 to 4 purge at OPEN position.
6	10		PID: Proportional Band
			The proportional band is an offset below the required setpoint; when the actual temperature/ pressure reaches this band, the burner will begin to modulate as it approaches the required setpoint.
			
		5 - 2000	°C, °F, PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
7	60		PID: Integral Time
			Every 'n' seconds, 10% of the present offset from the required setpoint is added or subtracted when below or above the setpoint, respectively, to the present proportional value. The value of 'n' is the number of seconds set in this option; if set to 0, there will be no integral control.
		0	Disabled
		1 - 250	Seconds

Opt. #	Default	Range	Description
8	0		MM: Servomotor Channels
			Channel 1 is always enabled for fuel; this option sets the channels in use.
		0	Channels 1 & 2
		1	Channels 1, 2 & 3
		2	Channels 1, 2, 3 & 4
			Note: If option 8 is changed after commissioning, then the MM will need to be re-commissioned, unless this option is returned to its previous setting.
9	1		MM: Internal Stat Operation
			The internal stat turns the burner on and off according to the actual value relative to the required setpoint. For setting 0, the internal stat is kept closed all the time, and a working stat must be fitted to the boiler. For setting 1, the internal stat is opened at an offset above the required setpoint, and closed at an offset below the required setpoint. For setting 2,the internal stat is opened at an offset above the required setpoint, and closed an at offset above the required setpoint. The offset values are set in options 10 and 11.
		0	Internal stat always closed
		1	Burner operates below setpoint
		2	Burner operates above setpoint
			E.g. Option 9 = 1, required setpoint = 100^{O}C (212^{O}F)
			
			E.g. option 9 = 2, required setpoint = 100^{O}C (212^{O}F)
			
10	3		MM: Burner Switch-Off Offset
		2 – 1000	^{O}C, ^{O}F, PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
			Note: This option is only relevant if option 9 is set to 1 or 2.
11	3		MM: Burner Switch-On Offset
		0 – 1000	^{O}C, ^{O}F, PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
			Note: This option is only relevant if option 9 is set to 1 or 2.
12	0		EGA: EGA Functionality
			For settings 2 or 3, the EGA will trim on the channel 2 air damper once trim data has been added. If option 12 is set to 0 or 1, then trim can be added at a later date by changing this to 2 or 3 in online changes, then going through single point change to add trim data for each fuel-air position.
		0	Not optioned
		1	Monitoring only
		2	Applies trim
		3	Applies trim, combustion limits tested

Opt. #	Default	Range	Description
13	0		EGA: EGA Fault Response
		0	EGA faults generate Alarms (burner stops)
		1	EGA faults generate Warnings (burners runs)
			Note: EGA alarms will drive the common system alarm output (terminal 79), see option 14 for warning response.
14	1		MM: Warning Response
		0	Warnings do not drive Common System Alarm output (terminal 79)
		1	Warnings drive Common System Alarm output (terminal 79)
15	3		MM: User Control
			This option sets whether the user can turn the burner on and off, or change the required setpoint via the flame screen on the MM
		0	Burner on/off and setpoint control disabled
		1	Burner on/off disabled and setpoint control enabled
		2	Burner on/off enabled and setpoint control disabled
		3	Burner on/off and setpoint control enabled
16	0		DTI: Sequencing and DTI Enable
			A lead boiler can be selected by pressing Lead Boiler in the IBS screen or via the DTI if optioned. Only 1 MM may be selected as lead boiler at a time, or the sequencing will not operate. The Lead Boiler button on the MM and the Lead Boiler Select on terminal 88 (see option 55) both override the DTI Lead Boiler Select.
		0	Sequencing disabled
		1	Sequencing enabled
		2	DTI enabled
		3	Sequencing and DTI
17	-		Unused
18	1		EGA: Carry Forward of Trim
			When the system modulates, the correction that may already exist on the air damper position can be carried forward (only relevant if an EGA is operational on the system). Trim will be reset if the rate of change of the fuel valve angle is greater than that set in parameter 14.
		0	Disabled
		1	Enabled
19	0		EGA: O_2 Upper Limit Offset
			If the current O_2 value is above this offset limit from the commissioned value, an alarm/warning (see option 13) will occur, with option 12 set to 3.
		0	Disabled
		1 – 100	0.1% - 10.0% O_2
20	0		EGA: CO_2 Upper Limit Offset
			If the current CO_2 value is above this offset limit from the commissioned value, an alarm/warning (see option 13) will occur, with option 12 set to 3.
		0	Disabled
		1 – 100	0.1% - 10.0% CO_2
21	0		EGA: CO Upper Limit Offset
			If the current CO value is above this offset limit from the commissioned value, an alarm/warning (see option 13) will occur, with option 12 set to 3.
		0	Disabled
		1 – 200	1 – 200 ppm CO

Opt. #	Default	Range	Description
22	0		EGA: O_2 Lower Limit Offset
			If the current O_2 value is below this offset limit from the commissioned value, an alarm/warning (see option 13) will occur, with option 12 set to 3.
		0	Disabled
		1 – 100	0.1% - 10.0% O_2
23	0		EGA: CO_2 Lower Limit Offset
			If the current CO_2 value is below this offset limit from the commissioned value, an alarm/warning (see option 13) will occur, with option 12 set to 3.
		0	Disabled
		0 – 100	0.1% - 10.0% CO_2
24	-		Unused
25	0		EGA: O_2 Absolute Limit
			If the current O_2 value is below this absolute limit, an alarm/warning (see option 13) will occur, with option 12 set to 3.
		0	Disabled
		1 – 200	0.1% - 20.0% O_2
26	0		EGA: CO_2 Absolute Limit
			If the current CO_2 value is above this absolute limit, an alarm/warning (see option 13) will occur, with option 12 set to 3.
		0	Disabled
		1 – 200	0.1% - 20.0% CO_2
27	0		EGA: CO Absolute Limit
			If the current CO value is above this absolute limit, an alarm/warning (see option 13) will occur, with option 12 set to 3.
		0	Disabled
		1 – 200	1 – 200 ppm CO
28	20		EGA: Trim Threshold
			The trim threshold is an offset from the required setpoint; if the actual value is below this offset, then the EGA will not trim. This option should be set to 0 if trim is to be effective at all times during firing, and/or if external modulation is optioned. No single point changes can be made if the actual value is below this trim threshold.
		0 – 50	^{O}C, ^{O}F, PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
29	0		MM: Golden Start
			Golden start allows an optimum ignition position to be set in the fuel-air curve, which is not necessarily low flame or part of the standard modulating index. Parameter 15 sets how long golden start position is maintained and from which point to start counting down.
		0	Disabled
		1	Enabled. Time counted from point of main flame
		2	Enabled. Time counted from ignition
30	50		DTI: Minimum Remote Setpoint (DTI/ Modbus/External)
			If a required value command is received from the DTI or Modbus that is below this minimum remote setpoint value, then it will be ignored by the MM. The MM will continue to fire to meet the previous required setpoint.
		5 – 9990	^{O}C, ^{O}F, PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)

Opt. #	Default	Range	Description
31	100		DTI: Maximum Remote Setpoint (DTI/ Modbus/External)
		5 – 9990	If a required value command is received from the DTI or Modbus that is above this maximum remote setpoint value, then it will be ignored by the MM. The MM will continue to fire to meet the previous required setpoint. ^{O}C, ^{O}F, PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
32	20		EGA: Trim Delay
		0 – 250	After ignition, the EGA does not Trim for the time delay set in this option(if EGA is set to 2 or 3). This allows for the combustion to stabilise before trimming commences. The delay timer starts at the ignition point. Seconds
33	1		DTI: MM Identification
		1 – 10	Each MM within a sequencing/DTI/Modbus/twin burner loop must be set with an individual ID number. For communications between the MMs, there cannot be more than 1 MM with the same ID number. ID number
34	-		Unused
35	10		DTI: Sequence Scan Time
		1 – 100	This is the time period between sequencing requests from the lead and the lag MMs. On the sequence scan time, the lead MM will demand lag burners to be brought online or offline, depending on load requirements. See parameters 86 and 87 for change down and up thresholds. Accurate fuel flow metering must be entered for sequencing to operate. The MMs must be connected using data cable (Belden 9501) screened at one end. Minutes
36	0		EGA: (Mk7 Only) Sensor Selection
		0 1 2 3	This option selects if the Mk7 EGA is fitted with additional cells. No optional sensor NO_2 optioned SO_2 optioned NO_2 and SO_2 optioned
37	0		PID: Derivative Time
		0 1 – 200	The time taken to add/ remove an additional 10% to the firing rate based on the actual value and the required value. Disabled Seconds
38	2		PID: Derivative Deadband
		0 1 - 15	This deadband is the margin above and below the required setpoint in which no derivative control occurs. Disabled ^{O}C, ^{O}F, PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
39	-		Unused

Opt. #	Default	Range	Description
40	0		DTI: Warming Facility for Low Pressure Steam
			For sequencing applications where non-return valves are not installed, it is not possible to use a setpoint to keep the boilers in a standby condition. A thermostat (aquastat) can be installed into the boiler's shell. Set option 79 to 0 to enable terminal 93 for warming stat. An input on terminal 93 stops/inhibits the burner when the MM is in warming. The boiler will remain in a warming state based on the settings in options 53 and 54.
		0	Steam sequencing with non-return valves
		1	Steam sequencing without non-return valves
41	0		DTI: Warming Mode
			For setting 0, the first lag boiler is kept in a standby state with the second in warming, and the remaining lag boilers off. For setting 1, the first lag boiler is in standby, and the remaining lag boilers are in warming.
		0	One MM in warming state
		1	All unused MMs in warming state
42	20		DTI: Standby Setpoint or Phantom Setpoint Offset
			For sequencing applications where non-return valves are installed, the first lag boiler uses a standby setpoint to keep the boiler in a standby condition. The standby setpoint is set as an absolute value in this option. When the standby setpoint is in effect, the burner is held at low flame hold.
		5 – 9990	^{O}C, ^{O}F, PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
43	0		MM: Multi-Burner Function
			The multi-burner function can be used for up to 10 burners, allowing the firing rates to be synchronised for all the burners in the multi-burner loop. For setting 1, if an error or lockout occurs on a burner, all of the other burners will shut down; setting 1 is suitable for firetube boilers. For setting 2, if an error occurs on a burner, all of the other burners will shut down, however if a lockout occurs, the other burners will continue to fire; setting 2 is suitable for watertube boilers. Fuel flow metering must be commissioned accurately for the multi-burner function to operate. Please refer to section 8 for commissioning of the multi-burner function.
		0	Disabled
		1	Fully linked
		2	Independent on Fault
44	1		MM: Multi-Burner ID
			When using the multi-burner function, the multi-burner IDs must be set on the MMs This option should be set to 1 for the master, and 2 onwards for the slave MMs.
		1 – 10	Multi-Burner ID
45	0		MM: External Modulation
			When enabled, the internal PID control is disabled and the firing rate is set by an external controller applied to the appropriate input terminals 7, 8, 9. This input control signal can be 0-10V (2-10V) or 4-20mA (0-20mA) set through parameter 69, and represent zero/low to high fire by setting parameter 68. A manual reset high limit stat must be fitted. For setting 1, an external working stat is required and option 9 should be set to 0. For setting 2, option 9 should be set to 1 or 2. For setting 3 this permanently limits the firing rate according to the input seen on the aux input channel.
		0	Disabled
		1	Enabled, load sensor not shown
		2	Enabled, load sensor shown
		3	Firing Rate Limiter

Opt. #	Default	Range	Description
46	0		MM: Cold Start Inhibit Time
			If the MM progresses from low fire cold start to firing, once the burner shuts down, a cold start will not occur if the burner starts up again within this cold start inhibit time. This allows the burner to come straight on in normal firing in situations where the demand has increased drastically and the actual value drops fast.
		0	Disabled
		1 – 120	Minutes
47	0		MM: Cold Start Routine
			On burner start-up, if the actual value is at 30% or below of the required setpoint, then the burner will be held at low fire for the number of minutes set in this option. It will then go to mid-fire. If the actual value is below 60% of the required setpoint, then the burner will be held at mid-fire for the set minutes. Once this cold start time has elapsed, or the value goes above 60% of the required setpoint, the burner will go to high fire as per the internal PID. It is not recommended to use cold start routine with external modulation or sequencing.
		0	Disabled
		1 – 2000	Minutes
48	0		MM: Flue Gas Recirculation – Timer
			This is the time that the MM channels (servomotors/ VSDs) are held at the FGR start positions, after which modulation takes place. This timer starts at the end main flame proving. FGR allows approximately 15% of the boiler flue gases via an auxiliary channel (e.g. 3) to be fed back to the burner and mixed with combustion air, to reduce NOx.
		0	Disabled
		1 – 3600	Seconds
49	0		MM: Flue Gas Recirculation – Offset
			This is an offset from the required setpoint. The MM channels (servomotors/VSDs) are held at the FGR start positions until the actual value reaches this offset value below the required setpoint.
		0	Disabled
		1 – 1000	^{O}C, ^{O}F, PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
50	0		MM: Flue Gas Recirculation – Temperature Threshold
			The MM channels (servomotors/VSDs) are held at the FGR start positions until the flue gas temperature has reached 120^{O}C (248^{O}F). This option can only be used if an EGA is optioned and operational.
		0	FGR temperature threshold disabled
		1	FGR temperature threshold enabled
51	2		MM: Multi-Burner Highest Slave ID
			This should be set to the highest slave ID set in option 44 for the MMs in the multi-burner loop.
		2 – 10	Multi-burner slave ID
52	0		MM: Multi-Burner Differential Firing Rate Limit
			If the difference between the firing rates of the Master MM and the slave MMs is equal to or greater that this limit, the Master MM will stop modulating and wait for the slaves to catch up. When the difference reduces to less than or equal to 5%, the Master starts modulating again.
		0	Disabled
		1 – 20	1% - 20%

Opt. #	Default	Range	Description
53	0		DTI: Steam Sequencing Burner Off Time
			When the MM is in warming mode, it will warm to the standby setpoint according to the on and off times set in options 53 and 54.
		0	Disabled
		1 – 200	Minutes
54	5		DTI: Steam Sequencing Burner On Time
			When the MM is in warming mode, it will warm to the standby setpoint according to the on and off times set in options 53 and 54.
		1 – 30	Minutes
55	0		MM: Terminal T88 Function
			This option selects the function of terminal 88, see options 16 and 45. For setting 0, a line voltage input on terminal 88 is used to select the lead boiler in sequencing, and overrides the DTI lead boiler select. For setting 1, a line voltage input on terminal 88 is used to select the external modulation signal and 0V for internal PID. For setting 2, a line voltage input on terminal 88 is used to select firing rate limiter. This permanently limits the firing rate according to the input seen on the aux input channel (parameter 69), at 0V the MM uses its internal firing rate. For setting 3 a line voltage input on terminal 88 is used for external setpoint & 0V for internal setpoint. For setting 4 a line voltage input on terminal 88, uses the fixed firing rate set on option 66, at 0V the MM uses its internal firing rate.
		0	T88 selects Lead Boiler
		1	T88 selects External Modulation
		2	T88 selects Firing Rate Limiter
		3	T88 selects External Setpoint
		4	T88 selects Fixed Firing Rate Limit
56	0		MM: Alarm Output Operation (Terminal #79)
			This is a switched neutral output to select how the alarm function operates.
		0	Relay normally off, on during alarm
		1	Relay normally on, off during alarm
57	0		MM: Fuel Flow Metering
			Fuel flow metering determines the firing rate. If no fuel flow meter is available, a 'dummy curve' should be entered using the burner turndown ratio from the burner rating to determine the low fire point, and the burner rating for the high fire point. If enabled, fuel flow metering is initiated once the burner has been commissioned and is firing. The MM will drive to the low fire point first, and then go up the curve. For setting 2, see options 59 and 60. If using setting 2 for fuel flow feedback, then 4-20mA signal is required on terminals EX- and EX+ on the expansion board (this cannot be enabled with external level sensor nor fully metered combustion control, see expansion option 4). For metric units, fuel flow is commissioned in MW for metric units and MMBTU/hr for imperial units.
		0	Disabled
		1	Enabled
		2	Enabled with 4-20mA feedback
58	-		Unused
59	100		MM: Fuel Flow at Maximum Feedback
			This will set the fuel flow value at 20mA feedback, see option 57.
		1 – 10000	0.01MW – 100.0 MW

Opt. #	Default	Range	Description
60	0		MM: Fuel Flow Feedback Fault Tolerance
			The fuel flow feedback fault tolerance allows an upper limit to be set on the fuel flow when option 57 is set to 2. If the fuel flow exceeds this limit for 5 seconds, then a warning will appear.
		0	Disabled
		1 - 500	0.1% - 50.0% of high-fire fuel flow
61	3725		MM: Fuel 1 Calorific Value
			This is the gross calorific value/higher heating value (HHV) including the latent heat of vaporisation of water. To set either metric or imperial units, see parameter 40. If the units are changed, then this option must be changed accordingly.
		100 – 65000	100 = 1.00MJ/m^3 or 100 Btu/ft^3
62	2068		MM: Fuel 2 Calorific Value
			This is the gross calorific value/higher heating value (HHV) including the latent heat of vaporisation of water. To set either metric or imperial units, see parameter 40. If the units are changed, then this option must be changed accordingly.
		100 – 65000	100 – 1.00 MJ/kg or 100 BTU/lb
63	2068		MM: Fuel 3 Calorific Value
			This is the gross calorific value/higher heating value (HHV) including the latent heat of vaporisation of water. To set either metric or imperial units, see parameter 40. If the units are changed, then this option must be changed accordingly.
		100 – 65000	100 – 1.00 MJ/kg or 100 BTU/lb
64	3725		MM: Fuel 4 Calorific Value
			This is the gross calorific value/higher heating value (HHV) including the latent heat of vaporisation of water. To set either metric or imperial units, see parameter 40. If the units are changed, then this option must be changed accordingly.
		100 – 65000	100 = 1.00MJ/m^3 or 100 Btu/ft^3
65	-		Unused
66	0		MM: Firing Rate Limit
			This is the maximum firing rate that can be obtained by the system, imposed in auto and hand modes. Firing rate limit should not be used with DTI load index control or sequencing.
		0	Disabled
		1 – 100	%
67	1		MM: Channel 1 Purge Position
		0	Channel 1 to purge position
		1	Channel 1 to remain closed for purge
68	0		MM: Channel 2 Purge Position
		0	Channel 2 to purge position
		1	Channel 2 to remain closed for purge
69	0		MM: Channel 3 Purge Position
		0	Channel 3 to purge position
		1	Channel 3 to remain closed for purge
70	0		MM: Channel 4 Purge Position
		0	Channel 4 to purge position
		1	Channel 4 to remain closed for purge

Opt. #	Default	Range	Description
71	0		MM: Continuous Pilot Shut Off Timer
			If continuous pilot is enabled (see option/parameter 111), then after this timer has elapsed when in continuous pilot firing, the burner will go off.
		0	Disabled
		1 - 1440	Minutes
72	0		MM: Continuous Pilot Shut Off Threshold
			If continuous pilot is enabled (see option/parameter 111), then if the actual value is higher than the combined burner switch-off offset (option 10) and this offset above the required setpoint in continuous pilot firing, the burner will go off.
		0	Disabled
		1 – 1000	^{O}C, ^{O}F, PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
73	0		MM: VSD Channel 5 Purge Position
		0	Purge at Maximum Output
		1	Purge at Minimum Output
74	0		MM: VSD Channel 6 Purge Position
		0	Purge at Maximum Output
		1	Purge at Minimum Output
75	100		MM: Purge Motor Travel Speed
			If the speed of the motor is too fast, then decrease the value.
		6 – 100	0.6 – 10.0
76	0		EGA: Trim Channel
			If an EGA is optioned, then trim can be applied to either channel 2 servomotor or channel 5 VSD. For setting 1, options 91 to 98 must be set.
		0	Trim on Channel 2
		1	Trim on Channel 5
77	0		MM: VSD Channel 5 Output at Closed
		0	Maximum Output at Closed
		1	Minimum Output at Closed
78	0		MM: VSD Channel 6 Output at Closed
		0	Maximum Output at Closed
		1	Minimum Output at Closed
79	0		MM: Terminal T93 Function
		0	Warming Stat
		1	Night setback
80	0		MM: Outside Temperature Compensation
		0	Outside Temperature Compensation Disabled
		1	Outside Temperature Enabled using OTC unit
		2	Outside Temperature Enabled using MM sensor
81	90		MM: Setpoint at Minimum Outside Temperature
			This setpoint is limited by the load detector set in option 1.
		20 – 999	^{O}C, ^{O}F, PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
82	30		MM: Minimum Outside Temperature
		0 – 145	Value 30 = -10^{O}C or -10^{O}F (see parameter 40)

Opt. #	Default	Range	Description
83	80		MM: Setpoint at Maximum Outside Temperature
		20 - 999	This setpoint is limited by the load detector set in option 1. ^{O}C, ^{O}F, PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
84	80		MM: Maximum Outside Temperature
		0 - 145	Value 80 = 40^{O}C or 40^{O}F (see parameter 40)
85	0		MM: Night Setback Offset
			This offset value is subtracted from the required setpoint. An input is required on terminal 93, see option 79.
		0	Disabled
		1 – 100	^{O}C, ^{O}F, PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
86	0		MM: Channel 1 Servo Control Method
		0	Autoflame Servo Motor, 0.1 degree control
		1	Autoflame Servo Motor, 0.5 degree control
		2	Industrial Servo Motor, 0.1 degree control
		3	Industrial Servo Motor, 0.5 degree control
		4	IO Unit 4-20mA Servo Motor, 0.5 degree control
		5	IO Unit 4-20mA Servo Motor, 1.0 degree control
87	0		MM: Channel 2 Servo Control Method
		0	Autoflame Servo Motor, 0.1 degree control
		1	Autoflame Servo Motor, 0.5 degree control
		2	Industrial Servo Motor, 0.1 degree control
		3	Industrial Servo Motor, 0.5 degree control
		4	IO Unit 4-20mA Servo Motor, 0.5 degree control
		5	IO Unit 4-20mA Servo Motor, 1.0 degree control
88	0		MM: Channel 3 Servo Control Method
		0	Autoflame Servo Motor, 0.1 degree control
		1	Autoflame Servo Motor, 0.5 degree control
		2	Industrial Servo Motor, 0.1 degree control
		3	Industrial Servo Motor, 0.5 degree control
		4	IO Unit 4-20mA Servo Motor, 0.5 degree control
		5	IO Unit 4-20mA Servo Motor, 1.0 degree control
89	0		MM: Channel 4 Servo Control Method
		0	Autoflame Servo Motor, 0.1 degree control
		1	Autoflame Servo Motor, 0.5 degree control
		2	Industrial Servo Motor, 0.1 degree control
		3	Industrial Servo Motor, 0.5 degree control
		4	IO Unit 4-20mA Servo Motor, 0.5 degree control
		5	IO Unit 4-20mA Servo Motor, 1.0 degree control
90	0		MM: VSD Operation Channel 5
		0	Disabled
		1	Enabled
91	0		MM: Output from MM to VSD Channel 5
		0	Output range 4 to 20mA
		1	Output range 0 to 20mA
		2	Output range 0 to 10V
92	0		MM: Output Units Displayed, VSD Channel 5
		0	Selected output signal
		1	Hertz
93	25		MM: Output Low Speed from MM to VSD Channel 5
		1 – 200	Hertz
94	50		MM: Output High Speed from MM to VSD Channel 5
		1 – 200	Hertz

Opt. #	Default	Range	Description
95	0		MM: Input Signal to MM from VSD Channel 5
		0	Input range 4 to 20mA
		1	Input range 0 to 20mA
		2	Input range 0 to 10V
96	0		MM: Input Units Displayed, VSD Channel 5
		0	Selected input signal
		1	Hertz
97	0		MM: Input Low Speed to MM from VSD Channel 5
		0 – 200	Hertz
98	50		MM: Input High Speed to MM from VSD Channel 5
		0 – 200	Hertz
99	40		MM: VSD Channel 5 Feedback Fault Tolerance
			This is used to check that the feedback varies while modulating. For example, if this option is set to 4%, the tolerance that is allowed while firing is ±4% of the whole VSD range. For commissioning, the difference between the point with the lowest feedback and the point with the highest feedback must be bigger than twice the tolerance, so for the default of 4% tolerance, the difference between the point with the lowest feedback and the point with the highest feedback has to be greater than 8% of the whole VSD range.
		5 – 40	0.5% – 4.0%
100	0		MM: VSD Operation Channel 6
		0	Disabled
		1	Enabled
101	0		MM: Output from MM to VSD Channel 6
		0	Output range 4 to 20mA
		1	Output range 0 to 20mA
		2	Output range 0 to 10V
102	0		MM: Output Units Displayed, VSD Channel 6
		0	Selected output signal
		1	Hertz
103	25		MM: Output Low Speed from MM to VSD Channel 6
		1 – 200	Hertz
104	50		MM: Output High Speed from MM to VSD Channel 6
		1 – 200	Hertz
105	0		MM: Input Signal to MM from VSD Channel 6
		0	Input range 4 to 20mA
		1	Input range 0 to 20mA
		2	Input range 0 to10V
106	0		MM: Input Units Displayed, VSD Channel 6
		0	Selected input signal
		1	Hertz
107	0		MM: Input Low Speed to MM from VSD Channel 6
		0 – 200	Hertz
108	50		MM: Input High Speed to MM from VSD Channel 6
		0 – 200	Hertz

Opt. #	Default	Range	Description
109	40		VSD Channel 6 Feedback Fault Tolerance This is used to check that the feedback varies while modulating. For example, if this option is set to 4%, the tolerance that is allowed while firing is ±4% of the whole VSD range. For commissioning, the difference between the point with the lowest feedback and the point with the highest feedback must be bigger than twice the tolerance, so for the default of 4% tolerance, the difference between the point with the lowest feedback and the point with the highest feedback has to be greater than 8% of the whole VSD range.
		5 – 40	0.5% – 4.0%



For safety reasons, options 110 – 160 must also be entered in as Parameters.

It is the responsibility of the commissioning engineer to ensure that all settings are set in accordance with the appropriate standards, local codes and practices. If options 110 – 160 are not identical with parameters 110 – 160, then the MM will go straight to Commissioning Mode and an option/parameter conflict message will appear.

Opt. #	Default	Range	Description
110	1		BC: UV Flame Scanner Type
			See option/parameter 120 for the UV threshold and 122 for the flame sensor operation. For setting 2, the self-check UV scanner opens and closes a shutter to check that the UV scanner is not giving a false flame signal.
		1 2	Standard scanner Self-check scanner
111	0		BC: Pilot Type
			For interrupted pilot, when lighting off, the pilot valve will close at the point the main flame proving phase begins. For intermittent pilot, when lighting off, the pilot valve will remain open during firing. For continuous pilot, when the burner goes above its off differential of the required setpoint, the burner will continue to fire with the pilot valves energised for the set time period. See options 71 and 72.
		0 1 2 3 4	Interrupted pilot Intermittent pilot No pilot Continuous interrupted pilot Continuous intermittent pilot
			Note: Setting 2 no pilot cannot be used with single valve pilot (option/ parameter 130).
112	40		BC: Pre-Purge Time
			Purging the boiler before burner start-up with air will force any combustion remnants out of the stack. Purge time should be set according to boiler manufacturing guide and local codes and regulations. Time remaining for the pre- purge process to complete is displayed on the main MM screen.
		5 – 240	Seconds
113	3		BC: Pre-Ignition Time
			This is the time period when the ignition transformer is on before the pilot valves opens.
		3 – 5	Seconds
114	3		BC: First Safety Time
			This is the time period when the pilot valve is open, before the flame is checked. The time range of this option depends on whether its gas or oil.
		3 – 10	Seconds
115	3		BC: Pilot Prove Time - Pilot Trial for Ignition (PTFI)
			This is the time period for when the flame is checked after the first safety time, to prove the pilot flame.
		3 – 5	Seconds
116	3		BC: Gas Second Safety Time – Main Trial for Ignition (MTFI)
			This is the time period when the main valves are open and the pilot valve is maintained open, before the flame is checked, for firing on gas. See options/parameters 150 – 153. This does not apply for intermittent pilot, see option/parameter 111. For firing on oil, see option/parameter 123.
		3 – 10	Seconds
117	5		BC: Main Flame Proving Time
			This is the time period after the second safety phase for interrupted pilot or after the pilot proving phase for intermittent pilot, where the flame is checked, before going to normal firing/modulation.
		5 – 20	Seconds

Opt. #	Default	Range	Description
118	0		BC: Post-Purge Time
			If set, a post-purge will occur after a normal burner shutdown. This time set should allow for the servomotors to travel from low fire to purge position. The flame is not checked during post-purge. See option/parameter 135 for NFPA post-purge. Time remaining for the post-purge process to complete is displayed on the main MM screen.
		0 – 100 0 – 100	Seconds (for option/ parameter 135 set to 0 or 2) Minutes (for option/ parameter 135 set to 1 or 3)
119	10		BC: Control Box Recycle Time
			This is the time delay between the burner shutting down, and going through post-purge if optioned, and the burner starting up again.
		3 – 120	Seconds
120	10		BC: UV Threshold
			This is the minimum flame signal strength. A lockout will occur if the UV count drops below this level. The UV counts will try to stabilize at 5 times this level.
		5 – 50	UV counts
121	5		BC: Delay from Start of Pre-Purge until Air Switch Checked
			This time delay where the air switch is not checked is included within the total pre-purge time set in option/parameter 112.
		5 – 10	Seconds
122	0		BC: Flame Sensor Selection
		0 1 2 3 4	UV Flame Switch IR IR and UV IR or UV
123	3		BC: Oil Second Safety Time – Main Trial For Ignition (MTFI)
			This is the time period when the main valves are open and the pilot valve is maintained open, before the flame is checked, for firing on oil. See options/parameters 150 – 153. This does not apply for intermittent pilot, see option/parameter 111. For firing on gas, see option/parameter 116.
		3 – 15	Seconds
124	0		BC: Timeout on Reaching Purge
			If the MM is stuck in Run to Purge or Run to Post-Purge because the servomotors and VSDs are moving to the purge position, then a lockout will occur after this timeout set in this option has elapsed. This does not apply to any requirements on purge timing such as any additional proving inputs.
		0 1 – 3600	Disabled Seconds

Opt. #	Default	Range	Description
125	0		BC: Fuel Pressure Sensor Mode – Fuel 1
			Gas: For setting 1, valve proving and pressure limits are checked by an Autoflame gas sensor. For setting 2, only pressure limits are checked by an Autoflame gas sensor. For setting 3, the system will wait for a mains voltage input on terminal 55 to confirm that the VPS test is completed. If a voltage is not detected on terminal 55 within 10 minutes, a lockout will occur. Please see Autoflame Sensors Guide for options/parameters and wiring guides on VPS and pressure limits setups. Oil: For setting 2, pressure limits are checked by an Autoflame oil sensor.
		0	Not checked
		1	Pressure limits, valve proving
		2	Pressure limits
		3	External VPS
126	0		BC: Fuel Pressure Sensor Mode – Fuel 2
			Gas: For setting 1, valve proving and pressure limits are checked by an Autoflame gas sensor. For setting 2, only pressure limits are checked by an Autoflame gas sensor. For setting 3, the system will wait for a mains voltage input on terminal 55 to confirm that the VPS test is completed. If a voltage is not detected on terminal 55 within 10 minutes, a lockout will occur. Please see Autoflame Sensors Guide for options/parameters and wiring guides on VPS and pressure limits setups. Oil: For setting 2, pressure limits are checked by an Autoflame oil sensor.
		0	Not checked
		1	Pressure limits, valve proving
		2	Pressure limits
		3	External VPS
127	0		BC: Fuel Pressure Sensor Mode – Fuel 3
			Gas: For setting 1, valve proving and pressure limits are checked by an Autoflame gas sensor. For setting 2, only pressure limits are checked by an Autoflame gas sensor. For setting 3, the system will wait for a mains voltage input on terminal 55 to confirm that the VPS test is completed. If a voltage is not detected on terminal 55 within 10 minutes, a lockout will occur. Please see Autoflame Sensors Guide for options/parameters and wiring guides on VPS and pressure limits setups. Oil: For setting 2, pressure limits are checked by an Autoflame oil sensor.
		0	Not checked
		1	Pressure limits, valve proving
		2	Pressure limits
		3	External VPS
128	0		BC: Fuel Pressure Sensor Mode – Fuel 4
			Gas: For setting 1, valve proving and pressure limits are checked by an Autoflame gas sensor. For setting 2, only pressure limits are checked by an Autoflame gas sensor. For setting 3, the system will wait for a mains voltage input on terminal 55 to confirm that the VPS test is completed. If a voltage is not detected on terminal 55 within 10 minutes, a lockout will occur. Please see Autoflame Sensors Guide for options/parameters and wiring guides on VPS and pressure limits setups. Oil: For setting 2, pressure limits are checked by an Autoflame oil sensor.
		0	Not checked
		1	Pressure limits, valve proving
		2	Pressure limits
		3	External VPS

Opt. #	Default	Range	Description
129	0		BC: VPS Operation
		0	VPS operates before start-up
		1	VPS operates after shutdown
		2	VPS operates before and after
130	2		BC: Gas Valve Configuration
		0	No vent valve
		1	Vent normally closed
		2	Vent normally open
		3	No vent valve. Single valve pilot
		4	Vent normally closed. Single valve pilot
		5	Vent normally open. Single valve pilot
131	1		BC: Fuel valve output configuration
			This sets the way multi-fuels are configured on the MM. Setting 0, allows the configuration of 4 fuels and switching between them is possible using changeover relays. Setting 1 allows 2 fuels to be configured with each fuel having its own set of outputs and switching between fuels is possible without changeover relays. Setting 2 is similar to setting 1 but with the possibility of fuel Change on the Fly (COF). See section 4 of this guide for the full details. Fuel curves must be commissioned for each fuel valve output mode. This option must be set before commissioning the MM.
		0	One set of outputs (changeover relays, 4 fuels)
		1	Two sets of outputs (no changeover relays, 2 fuels)
		2	Two sets of outputs, change on the fly (COF)*
			** requires unlock code*
132	20		BC: Gas Valve Proving Time
			This is the time period for when both gas valves are closed to detect a change in air pressure for the 'VPS air proving' phase, or change in gas pressure for 'VPS gas proving' phase.
		10 – 300	Seconds
133	25		BC: Maximum Pressure Change Allowed During VPS
			If MM detects a pressure change greater than this value, a lockout will occur. See parameter 41 for gas pressure display units.
		0 – 13400	0 mbar – 1340 mbar (value 25 = 2.5 mbar) 0" WG – 537.777" WG (value 25 = (1.003 "WG) 0 PSI – 19.435 PSI (value 25 = 0.036 PSI)
134	3		BC: VPS Valve Opening Time
			This is the time period for when a gas valve is opened during each of the VPS phases – 'VPS Venting' for the void venting to the atmosphere and 'VPS Void to Gas' for the void filling with gas.
		3 – 20	Seconds
135	0		BC: Purge Time Units/ NFPA Post-Purge
			See option/parameter 118 for the purge timing. For setting 2, option/parameter 118 must be set to 15 seconds or higher. During the NFPA post-purge, all the servomotors will remain in the position they were in before normal shutdown or lockout. The NFPA post-purge will occur under any normal shutdown or lockout at any point in firing.
		0	Purge time in seconds
		1	Purge time in minutes
		2	NFPA post-purge in seconds
		3	NFPA post-purge in minutes

Opt. #	Default	Range	Description
136	25		BC: Gas Pressure Switch – Offset Lower Limit
		0 – 13400	This is an offset lower limit from the commissioned gas pressure, see parameter 41 for the gas pressure display units. See options/parameters 125, 126, 127 and 128 to enable the pressure limits. When used in FSG mode, Option 136 is used while firing, instead of the commissioned gas pressure. It has to maintain a pressure of at least the Option 136 value. 0 mbar – 1340 mbar (value 25 = 2.5 mbar) 0" WG – 537.777" WG (value 25 = (1.003 "WG) 0 PSI – 19.435 PSI (value 25 = 0.036 PSI)
137	25		BC: Gas Pressure Switch – Offset Upper Limit
		0 – 13400	This is an offset upper limit from the commissioned gas pressure, see parameter 41 for the gas pressure display units. See options/parameters 125, 126, 127 and 128 to enable the pressure limits. 0 mbar – 1340 mbar (value 25 = 2.5 mbar) 0" WG – 537.777" WG (value 25 = (1.003 "WG) 0 PSI – 19.435 PSI (value 25 = 0.036 PSI)
138	25		BC: Gas Static Line Pressure Lower Limit Offset
		0 1 – 50000	For setting 0, if the measure static line pressure during the VPS void to gas phase is below the gas pressure offset lower limit set in option/parameter 136, a lockout will occur. If both options 136 and 138 are set to 0, then a lockout will occur if the measured static line pressure during VPS void to gas phase is below the absolute value in option 133. For setting other than 0, this measured static line pressure is checked against the offset value set in this option. When used in FSG mode, Option 138 controls the gas pressure required during valve proving. Option/ parameter 136 offset lower limit used 0.1 mbar – 5000 mbar (value 25 = 2.5 mbar) 0.040"WG – 2006.630"WG (value 25 = 1.003"WG) 0.001 PSI – 72.519 PSI (value 25 = 0.036 PSI)
139	-		BC: Oil Pressure Switch – Offset Lower Limit
		0 1 – 4000	The MM will check the oil pressure is not below this offset lower limit from the commissioned oil pressure, during firing. Disabled 0.001 Bar – 4.000 Bar (0.015 PSI – 58.015 PSI)
140	0		BC: Oil Pressure Switch – Offset Upper Limit
		0 1 – 4000	The MM will check the oil pressure is not below this offset lower limit from the commissioned oil pressure, during firing. Disabled 0.001 Bar – 4.000 Bar (0.015 PSI – 58.015 PSI)
141	0		BC: Air-Proving Pressure Threshold for Purge
		0 – 1200	This is the minimum air pressure that must be detected by the MM during purge, when using an Autoflame air pressure sensor. If this is set to 0, then MM will look for the minimum air pressure set in option/parameter 149. See parameter 43 for air pressure display units. 0 mbar – 120.0 mbar (0" WG – 48.176" WG)
142	60		BC: UV Shutter Test Interval
		4 – 240	This is the time interval between shutter tests on the self-check UV scanner See options/parameters 110 and 122. Seconds

Opt. #	Default	Range	Description
143	0		BC: No Pre-Purge
			For setting 1, there will only be no pre-purge if the burner has recycled due to meeting operational temperature/pressure, and the system has gone through VPS checks successfully. If the burner has a lockout, or is restarting after a lockout has been cleared, then the MM will force a pre-purge. No pre-purge is only available when the fuel is set to gas.
		0	Enabled
		1	Disabled
144	4		BC: Maximum Allowed UV Self-Check Errors
			The MM will test the flame detection of self-check UV scanner at a time interval, set in option/parameter 142, and will generate a lockout if it has more errors than set in this option. See options/parameters 110 and 122.
		1 – 12	Errors
145			BC: First Out Interlock
			This expansion feature will need to be unlocked to enable first out interlock. For setting 1, all of the first outs will be tied to burner safety stat circuit. They will be automatically set for active low, and then can be selected for non-recycle or recycle. Please see expansion option 110.
		0	Disabled
		1	Enabled
146	-		Unused
147	0		BC: Air Pressure Error Window
			This air pressure error window is only active during modulation; the burner will lockout if the air pressure is outside of this window.
		0 – 300	0 mbar – 30.0 mbar (0” WG – 12.040” WG)
148	0		BC: Air Pressure Sensor Type
			For setting 0, and external air pressure switch must be wired to terminal 54. If a reset of voltage is not detected within 2 minutes on terminal 54 during the ‘Wait for Air Switch’ phase before running to purge, a lockout will occur. For setting 1, the air pressure sensor will look for zero air pressure in the ‘Zero Air Sensor’ phase before running to purge. Setting 2 includes the checks made for settings 0 and 1.
		0	Air switch on T54
		1	Autoflame air pressure sensor
		2	Autoflame air pressure sensor and air switch on T54
149	10		BC: Air-Proving Pressure Threshold
			This is the minimum air pressure that must be detected by the MM during normal firing and during purge when option/parameter 141 is set to 0, when using an Autoflame air pressure sensor. See parameter 43 for air pressure display units.
		7 – 1200	0.7 mbar – 120.0 mbar (0.281” WG – 48.176 “WG)
			Value 10 = 0.401 “WG (1.0 mbar)
150	0		BC: Fuel 1 Type
		0	Gas
		1	Oil
151	1		BC: Fuel 2 Type
		0	Gas
		1	Oil

Opt. #	Default	Range	Description
152	1		BC: Fuel 3 Type
		0	Gas
		1	Oil
153	0		BC: Fuel 4 Type
		0	Gas
		1	Oil
154	0		BC: Terminal T80 Function
			Setting 1 allows an additional safety check on the valves and damper to ensure that they are in the correct position for start/low fire. See Valves and Servomotors manual for information on setup and wiring. When used in flame safeguard mode, this must be set to 1.
		0	Not used
		1	Start Position Interlock
155	0		BC: Terminal T81 Function
			For setting 1, terminal 81 acts as a line voltage input for a mechanical proving switch. The switch must be made when the air channel servo is at the purge position and it must remain made for the whole duration of the purge phase otherwise a lockout is generated. This input must also not be made while not at purge position. For setting 2, terminal 81 acts as purge pressure proving switch input. The switch must be made continuously for the whole duration of the purge time. If it drops out, the purge timer restarts once the signal is made again. It must also not be made before the blower motor starts to confirm the input is working correctly. If this input comes on during the relay tests a lockout is generated. Option 158 adds an optional time limit for the purge pressure proving to be made. When used in flame safeguard mode, this must be set to 1
		0	Not used
		1	Purge position interlock
		2	Purge pressure proving
156	-		Unused
157	0		BC: Delay to Purge (T52) Timeout
			An input on terminal 52 is required to indicate the system is ready to move toward the purge phase. If the MM does not see this input for 1 second within this time set, then a lockout will occur. Setting 0 will disable this timeout, so the MM would sit indefinitely in delay to purge.
		0	Disabled
		1 – 3600	Seconds
158	0		BC: Purge Pressure Proving (T81) Timeout
			If option/parameter 155 is set to 2, then the system will lockout if the purge pressure is not proved within the specified time. Setting to 0 will disable this timeout, so the MM will be in the purge phase indefinitely waiting for the pressure proving signal to be received on terminal 81.
		0	Disabled
		1 – 15000	Seconds
159	-		Unused
160	0		BC: Clear Commissioning Data
		5	Clear all commissioning data, options and parameters
		10	Reset all options to default values
		15	Reset all parameters to default values
		20	Reset all safety options and parameters to default values
		25	Reset all expansion options to default values

2.2 Parameters

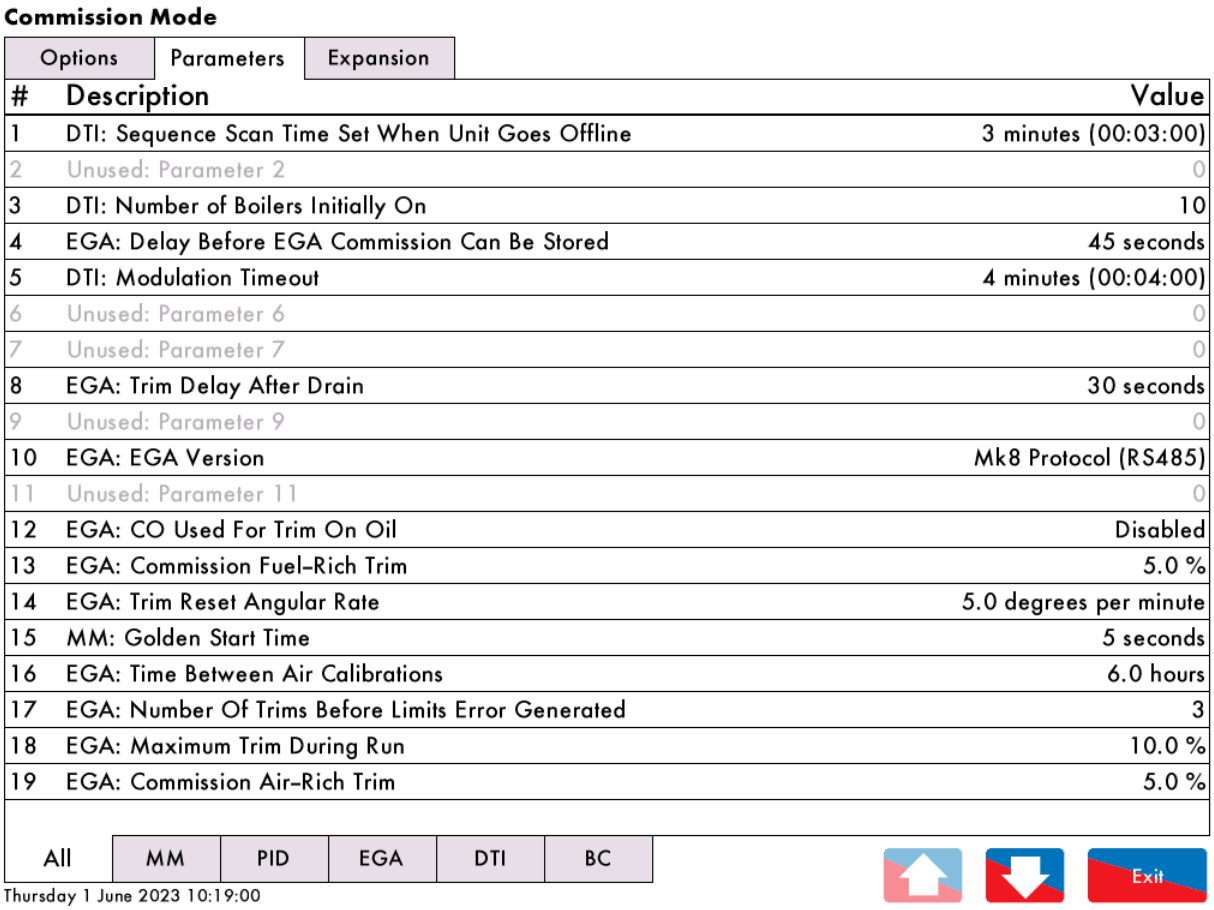


Figure 2.2.i Commission Mode – Parameters

Press 

in the Commission Mode screen to access the Parameters. Any number of options/parameters can be changed at one time. By pressing MM, PID, EGA, DTI or BC at the bottom of the screen, the options/parameters can be grouped together by feature.

When the changes have been made to suit the application's needs, press Exit to go back to the Commission Mode screen.

Options/parameters 110 – 160 are the burner control settings and are safety critical; these must be entered the same for both the option and parameter value. If these BC options and parameters do not match, there will be an option/parameter conflict.

To set all the options, parameters and expansion options to the default values and erase the commissioning data, set option/parameter 160 to 5. The MM will then automatically restart and go into Commission mode.

Par.#	Default	Range	Description
1	3		DTI: Sequence Scan Time Set When Units Goes Offline
		0 – 20	If a sequenced MM drops out of the sequence loop, there is a time delay before the next scan time. Minutes
2	-		Unused
3	10		DTI: Number of Boilers Initially On
		1 – 10	This sets the number of boilers which when powered on after a shutdown, are in the On state in the sequence loop. This should be set to the highest MM ID number (see parameter 57) if the application requires all the MMs to be On in the sequence loop when powered back on.
4	45		EGA: Delay Before EGA Commission Can be Stored
		10 – 120	During commission and single point change, there is a delay before the EGA values are stored. This value should be set in proportion to how long it takes for the gases to reach the EGA Seconds
5	4		DTI: Modulation Timeout
		1 – 50	If a sequenced MM does not start modulating after being asked to by the lead MM, it is ignored in the sequencing loop. Upon the next scan time, if the MM modulates as required, it will be included in the sequencing loop. Minutes
6	-		Unused
7	-		Unused
8	30		EGA: Trim Delay After Drain
		5 – 240	This is the delay after draining the sample, before the trim cycle start. Within this delay, the trim correction on the air damper or VSD is maintained while the EGA drains and the cells are purged with air. Seconds
9	-		Unused
10	2		EGA: EGA Version
		0 1 2	Mk7 - *For use with Mk7 EGA* Mk8 Protocol (Legacy) – *For use with Mk8 EGA* Mk8 Protocol (RS485) – *For use with Mk8 EGA EVO*
11	-		Unused
12	0		EGA: CO Used for Trim on Oil
		0 1	If the fuel has been set as oil (see options/parameters 150 to 153), then the trim function can include CO to calculate the required trim correction. Disabled Enabled
13	50		EGA: Commission Fuel-Rich Trim
		20 – 75	The % of air damper movement when commissioning fuel-rich trim. 2.0% - 7.5%
14	50		EGA: Trim Reset Angular Rate
		0 – 900	This is the change time in the fuel valve angle per minute that will reset the trim correction. 0.0 – 90.0 degrees per minute

Par.#	Default	Range	Description
15	5		MM: Golden Start Time
		2 – 100	This is the time period for how long the servomotors and VSDs are held at the golden start position, see option 29. Seconds
16	12		EGA: Time Between Air Calibrations
		1 – 50	This is the time period between air calibrations if the burner does not go off. 0.5 hours – 25.0 hours
17	3		EGA: Number of Trims Before Limits Errors Generated
		0 – 10	When the combustion limits have been exceeded, the MM will make trim corrections on the air damper. If the number of these trims reaches the value set in this parameter an error will be generated. See options 19, 20, 21, 22, 23, 25, 26, 27 and parameters 94, 96 97 for limits. Number of trims
18	100		EGA: Maximum Trim During Run
		20 – 100	This is the maximum trim % of air damper movement during firing. 2.0% - 10.0%
19	50		EGA: Commission Air-Rich Trim
		20 – 75	This is the % air damper movement when commissioning the air rich trim. 2.0% - 7.5%
20	-		Unused
21	-		Unused
22	-		Unused
23	1		EGA: Add Air When CO Present
		0 1	This sets whether the trim function adds when CO is present. If the O_2 and CO_2 appear air rich but CO appears fuel rich, then the air damper will open further to remove CO. Disabled Enabled
24	120		EGA: (Mk7 Only) Air Calibration Time
		20 – 300	For the Mk8 EGA, this is set as default 6 minutes. Seconds
25	-		Unused
26	8		Trim Samples per Cycle
		1 – 50	A cycle is the period between when does the EGA carries out a drain to get rid of excess moisture in the exhaust gas sample. This parameter sets the number of trim corrections in between drains. Samples Per Cycle
27	-		Unused
28	0		MM: Internal High Limit Setpoint
		0 1 – 9990	Internal High Limit Setpoint is used to define an absolute shutdown setpoint that also operates in commission mode as well as normal running mode. Disabled ^{O}C, ^{O}F, PSI or 0.1 Bar or 0.01 Bar

Par.#	Default	Range	Description
29	1000		MM: Load Sensor Adjustment
		800 – 1200	This adjusts the load sensor (voltage) reading, as a percentage of the reading. Value 1000 = 100.0% of actual reading
30	10		MM: Load Sensor Filter Time
		1 – 40	Seconds
31	0		EGA: (Mk7 Only) Efficiency Calculation Method
			For the Mk8 EGA, efficiency calculation method is set on the EGA itself.
		0	English
		1	European
32	0		MM: User Setpoint Minimum Value
		0 - 9990	This limits the change for the minimum setpoint value in the status screen.
33	0		MM: User Setpoint Maximum Value
		0 - 9990	This limits the change for the maximum setpoint value in the status screen.
34			MM: Vendor Details Line 1
			Enter Vendor Name
35			MM: Vendor Details Line 2
			Enter Address Details (Street)
36			MM: Vendor Details Line 3
			Enter Address Details (Town / City / Zip)
37			MM: Vendor Details Line 4
			Enter Contact Details (Phone / Email Address)
38	***		MM: Commissioning Password Code 1
		0 – 255	Code 1
39	***		MM: Commissioning Password Code 2
		0 – 255	Code 2
40	0		MM: Display Units
		0	Metric units
		1	Imperial units
41	0		MM: Gas Pressure Units
			This will set the units displayed for the Autoflame gas pressure sensor optioned. Note, PSI units are not available for sensor MM80006.
		0	mbar
		1	inWG
		2	PSI
42	0		MM: Oil Pressure Units
			This will set the units displayed for the Autoflame oil pressure sensor optioned.
		0	Bar
		1	PSI
43	-		MM: Air Pressure Sensor Units
			This will set the units displayed for the Autoflame air pressure sensor.
		0	Mbar
		1	inWG

Par.#	Default	Range	Description
47	0		DTI: Standby or Phantom Setpoint Type
			Instead of a fixed setpoint when the MM is in standby mode, it would have its current setpoint offset down by a value. When configured for Phantom Setpoint, the Standby Setpoint Option 42 becomes a Phantom Setpoint Offset.
		0	Use Fixed Standby Setpoint
		1	Use Phantom Setpoint Offset
48	80		PID: Integral Band
			This is the percentage of the proportional band over which the integral control is active.
		0 – 100	0% - 100%
52	0		MM: External Load Detector – Number of Decimal Places
			This affects the external load detector maximum and minimum values set in parameters 53 and 55. See option 1 and parameter 40.
		0	0 decimal place
		1	1 decimal place
		2	2 decimal places
53	20		MM: External Load Detector – Maximum Value
			The scale will depend on how parameter 52 is set. See option 1 and parameter 40.
		0 – 9990	Bar (PSI) or ^{O}C (^{O}F)
			20 = 20 Bar (PSI) or ^{O}C (^{O}F) if parameter 52 is set to 0
			20 = 2.0 Bar (PSI) or ^{O}C (^{O}F) if parameter 52 is set to 1
			20 = 0.2 Bar (PSI) or ^{O}C (^{O}F) if parameter 52 is set to 2
54	0		MM: External Load Detector – Maximum Voltage
		0 – 100	0.0V – 10.0V
55	20		MM: External Load Detector – Minimum Value
			The scale will depend on how parameter 52 is set. See option 1 and parameter 40.
		0 – 9990	Bar (PSI) or ^{O}C (^{O}F)
			20 = 20 Bar (PSI) or ^{O}C (^{O}F) if parameter 52 is set to 0
			20 = 2.0 Bar (PSI) or ^{O}C (^{O}F) if parameter 52 is set to 1
			20 = 0.2 Bar (PSI) or ^{O}C (^{O}F) if parameter 52 is set to 2
56	0		MM: External Load Detector – Minimum Voltage
		0 – 100	0.0V – 10.0V
57	10		DTI: Highest MM ID
			This sets the highest MM ID number for that sequence or DTI loop.
		1 –10	Sequence ID
58	1		EGA: Air Calibration on Startup
			For the Mk8 EGA, the air calibration schedule is set on the EGA itself.
		0	Disabled
		1	Enabled
59	-		Unused
60	60		MM: Logo Display Timer (Standby)
			If a custom logo is stored on the data SD card in the MM, then the custom logo will appear on the screen after this timer in standby mode..
		0	Disabled
		1 – 3600	Seconds

Par.#	Default	Range	Description
61	900		MM: Backlight On Time
			If the screen is not pressed and this timer elapses, the backlight will dim.
		0	Disabled
		1 – 1800	Seconds
62	0		DTI: Hot Water Sequencing
			For setting 0 the boilers, the lag boilers will be off. For setting 1, the lag boiler will operate as steam sequencing, as set in option 41.
		0	Hot water sequencing operates normally
		1	Hot water sequencing operates as steam sequencing
63	0		DTI: Two Port Valve Output Parity
			Sets terminal #78 operation
		0	Valve Normally Open (Closed When Energised)
		1	Valve Normally Closed (Opens When Energised)
64	0		MM: Logo Display Preferences
			If enabled from parameter 60, the custom logo will display for setting 0 & 1, for setting 2 & 3 a black screen will be used as a logo.
		0	Default Behaviour
		1	Logo Displays While Firing
		2	Use Black Screen as Logo
		3	Black Screen as Logo Displays While Firing
68	1		MM: External Modulation Control Range
			The range is set for either low fire to high fire in setting 0, or zero to high fire in setting 1. See options 45 and 55.
		0	Low to high
		1	Zero to high
69	0		MM: Auxiliary Channel Input Range
			This sets the range for external modulation & firing rate limiter input on terminals 7, 8, and 9.
		0	4 to 20mA input
		1	0 to 20mA input
		2	0 to 10V input
70	10		MM: Auxiliary Channel Filter Time
			This sets the time allowed for a reading to be taken on terminals 7, 8 and 9.
		0	Disabled
		1 – 30	Seconds
71	1		MM: Firing Rate Output Control Range
			This sets the range for firing rate output on terminals 16, 17, and 18.
		0	4-20mA, 2-10V, Low to high
		1	4-20mA, 2-10V, Zero to high
		2	0-20mA, 0-10V, Low to high
		3	0-20mA, 0-10V, Zero to high
72	0		MM: External Setpoint Input
			If enabled, terminals 7, 8, and 9 are used for external required setpoint. The range and filtering of the input is set in parameters 69 and 70. The required setpoint range is set in options 30 and 31.
		0	Disabled
		1	Enabled

Par.#	Default	Range	Description
80	0		MM: Distributed Return Temperature Shutdown Delta – T
		0 - 500	A user-defined differential temperature threshold may be configured that causes the burner to stop when breached (i.e. when the difference between inlet & outlet temperatures become too large).
81	0		MM: Distributed Return Temperature Restart Delta - T
		0 - 500	A user-defined differential temperature threshold may be configured that determines when the burner may restart following a shutdown caused by the differential temperature shutdown threshold.
82	0		MM: Distributed Return Temperature Turndown Delta – T
		0 - 500	A differential temperature threshold may be configured that determine the differential temperature at which the maximum firing rate starts to be reduced.
83	-		MM: Display Diagnostic Values
			Enabling this parameter allows the display of more detailed information in the system log.
		0	Disabled
		1	Enabled
84	0		MM: Bluetooth Module
			Enables/disables the on-board Bluetooth module for the purpose of connectivity with the Autoflame Download Manager software. See Autoflame PC Software Guide.
			To enable connectivity via the IR port, this option must be disabled, Bluetooth and IR cannot be used at the same time.
		0	Disabled
		1	Enabled
85	0		MM: Modulation Exerciser Period
			If the modulation exerciser period is enabled, then the MM will repeatedly run between high fire and low fire. This value sets how long the MM will remain at the high fire and low fire positions. This should only be used in test/inspection conditions.
		0	Disabled
		1 – 3600	Seconds
86	85		DTI: IBS Change Down Threshold
			If the combined firing rate of the last 2 MMs in the sequence loop is below this value, then the last lag MM will go from ‘on’ to the next phase(‘standby’, ‘warming’ or ‘off’) depending on how option 41 is set.
		0 – 99	0% - 99%
87	95		DTI: IBS Change Up Threshold
			If the firing rate of the last MM in the sequence loop in the ‘On’ phase is above this value, then the next MM will go to the ‘On’ phase upon the next sequence scan time, to meet the load demand.
		0 – 100	0% - 100%
88	1000		MM: Outside Temperature Sensor Adjustment
			If the outside temperature reading is too high, then decrease this value. If the outside temperature reading is too low, then increase this value.
		500 – 2000	50.0% - 200.0%

Par.#	Default	Range	Description
89			MM: Stat Exerciser Period
			If the stat exerciser period is enabled, then T53 will be turned off for this timer set, and then turned off for this timer set, repeatedly. This should only be used in test/inspection conditions.
		0	Disabled
		1 – 3600	Seconds
90	0		MM: VSD Minimum Feedback Variation Check (Fuel 1)
			Enable/disable VSD feedback variation tests for fuel 1.
		0	Enabled
		1	Disabled
91	0		MM: VSD Minimum Feedback Variation Check (Fuel 2)
			Enable/disable VSD feedback variation tests for fuel 2.
		0	Enabled
		1	Disabled
92	0		MM: VSD Minimum Feedback Variation Check (Fuel 3)
			Enable/disable VSD feedback variation tests for fuel 3.
		0	Enabled
		1	Disabled
93	0		MM: VSD Minimum Feedback Variation Check (Fuel 4)
			Enable/disable VSD feedback variation tests for fuel 4.
		0	Enabled
		1	Disabled
94	0		EGA: NO Upper Limit Offset
			If the current NO value is above this offset limit from the commissioned value, an alarm/warning (see option 13) will occur, for option 12 set to 3.
		0	Disabled
		1 – 200	1 – 200 ppm NO
95	-		Unused
96	0		EGA: Exhaust Temperature Upper Limit Offset
			If the current exhaust temperature value is above this offset limit from the commissioned value, an alarm/warning (see option 13) will occur, for option 12 set to 3. See parameter 40.
		0	Disabled
		1 – 999	1 – 999 deg^{O}C or deg^{O}F
97	0		EGA: Exhaust Temperature Absolute Limit
			If the current exhaust temperature value is above this absolute limit, an alarm/warning (see option 13) will occur, for option 12 set to 3. See parameter 40.
		0	Disabled
		1 – 999	1 – 999 ^{O}C or ^{O}F
98	-		Unused
99	1		MM: Graceful Shutdown
			If enabled, when the fuel is deselected, the fuel valve outputs are de-energised, and then a post-purge occurs before the MM restarts. This must not be used if changeover relays are used on the system. Graceful shutdown cannot be used with assured low fire shut off in parameter 100.
.			Cannot be used with DFOM or COF (option/parameter 131 setting 1 & 2).
		0	Disabled
		1	Enabled

Par.#	Default	Range	Description
100	0		MM: Assured Low Fire Shut Off
			If enabled, when the burner turns off on internal stat, the MM will modulate to low fire, shut down and recycle the system before turning off. Assured low fire shut off cannot be used with graceful shutdown in parameter 99.
		0	Disabled
		1	Enabled
101	0		DTI: Shuffle Sequencing
			This allows the sequence order to be changed remotely through the DTI or Modbus. See option 16 and expansion option 100.
		0	Disabled
		1	Enabled
102	-		Unused
103	0		MM: Air Pressure Warning Lower Offset
		0 – 1000	This is an offset lower limit from the commissioned air pressure. 0 mbar – 100 mbar
104	0		MM: Air Pressure Warning Upper Offset
		0 – 1000	This is an offset upper limit from the commissioned air pressure. 0 mbar – 100 mbar
105	0		MM: Gas Pressure Warning Lower Offset
		0 – 13400	This is an offset lower limit from the commissioned gas pressure, see parameter 41 for the gas pressure display units. These limits are also tested during main flame proving. See options/parameters 125, 126, 127, 128 to enable the pressure limits. A warning will be generated if the measured static line pressure during the VPS void to gas phase is below the absolute value in option 133. 0 mbar (disabled) – 1340 mbar 0 inWG (disabled) – 537.777 inWG 0 PSI (disabled) – 19.435 PSI
106	0		MM: Gas Pressure Warning Upper Offset
		0 – 13400	This is an offset upper limit from the commissioned gas pressure, see parameter 41 for the gas pressure display units. These limits are also tested during main flame proving. See options/parameters 125, 126, 127, 128 to enable the pressure limits. 0 mbar (disabled) – 1340 mbar 0 inWG (disabled) – 537.777 inWG 0 PSI (disabled) – 19.435 PSI
107	***		MM: Online Changes Password Code 1
		0 – 255	Code 1
108	***		MM: Online Changes Password Code 2
		0 – 255	Code 2

Par.#	Default	Range	Description
109	0		MM: Software Voltage Conditioner The MM performs internal tests to ensure that the mains power is safe for the unit to operate (zero crossing and mains input tests). When these tests return a negative result, the MM generates a fault. This parameter governs the way the MM handle these tests results; setting 1 makes the MM more tolerant to the mains power instability while setting 2 disables the errors altogether. ***Note:*** *Setting 2 should only be used temporarily while investigating and correcting the cause of mains power instability. Running the MM continually on unstable power can degrade the MM and cause permanent damage to the unit.*
		0	Standard
		1	Increased
		2	Errors Disabled



Parameters 110 – 160 are a repeat of their corresponding options and will need to have the same value.

It is the responsibility of the commissioning engineer to ensure that all settings are set in accordance with the appropriate standards, local codes and practices. If options 110 – 160 are not identical with the parameters 110 – 160, then the MM will go straight to Commissioning Mode and an option/parameter conflict message will appear.

3 COMMISSIONING PROCEDURE

3.1 Overview



Important Note: Prior to commissioning, the fuel and air servomotors must be calibrated to ensure that the position of the valves and damper correspond to the potentiometer feedback signal as displayed on the MM. When the valve is fully closed, the MM should display zero degrees. If it does not, it is essential to adjust the servomotor potentiometer so that the positions correspond.

The commissioning procedure as described must be strictly adhered to. Anybody commissioning an MM must be trained in operating combustion equipment safely. The Autoflame products must only be installed, set up, commissioned and adjusted by an Autoflame certified technical engineer.

The fundamental idea of the system is to set a fuel valve position and then set a corresponding air damper position. Care must be taken when adjusting the fuel and air positions so as not to create any unstable or hazardous combustion conditions, e.g. moving the fuel valve to the open position without increasing the air damper position. Improper use may result in property damage, serious physical injury or death.

If the MM is commissioned without an EGA then a combustion analyser is required to check the exhaust gases. If the system does have an EGA, then a combustion analyser is not necessary as the EGA performs all normal exhaust gas measurements. When commissioning oil fuel, a smoke detection device is also necessary to check that the smoke generated is within safe limits.

Once a start position has been entered, the high fire position is entered next, then descending fuel/air positions are entered consecutively until finally the low fire position is entered. CH1 and CH2 positions must always be less than the ones previously entered; however CH3 to CH7 can be set lower or higher than the previous position. CH7 is used for the draught servomotor (unlockable expansion feature).

MM Channel	Use (Normal Mode)	Use (DFOM - COF)
Ch1	Fuel valve	Fuel 1 Valve
Ch2	Air damper	Air Damper
Ch3	Auxiliary Servomotor	Fuel 2 Valve
Ch4	Auxiliary Servomotor	Auxiliary Servomotor
Ch5	VSD 1	VSD 1
Ch6	VSD 2	VSD 2
Ch7*	Draught servomotor	Draught servomotor

** unlockable expansion feature*

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

1. Set up Fuel Valves Output Configuration Mode (refer to section 4 of this guide).
2. Check all interconnecting wiring between the MM and external components is correct.
3. Set options, parameters and expansion options required (refer to section 2).
4. Commission bottom blowdown module if optioned.
5. Commission water level probes and external level sensor if optioned.
6. Set up servomotors.
7. Program fuel/air positions.

On a previously commissioned system is it possible to omit steps 1 to 5.

3.2 Installation Checks

3.2.1 Commissioning Checks

When all the installation and burner adjustments are completed, the entire burner control system should be tested in accordance with the manufacturer's instructions. The procedure should verify the correct operation of:

1. Each operating control (temperature, pressure etc.).
2. Each limit switch (temperature, pressure, low water cut-off, etc.).
3. Each interlock switch (airflow switch, high and low fuel pressure or temperature switches, purge and low fire switches, fuel valve proof of closure interlock etc.).
4. Pilot flame failure response and lockout.
5. Main flame failure response and lockout.
6. Tight shut-off for all valves.

3.2.2 Operational Checks

1. Close manual main shut-off valve.
2. Check all limit circuit wiring for proper operation and correct connection.
3. Confirm that the automatic main fuel valves are wired correctly.
4. Power the control and electronically check the proper sequence of operation.
5. After assuring yourself that all the interlocks and valves are properly wired and that the sequence of operation is correct, open the manual main shut-off fuel valve and proceed cautiously through the boiler light off process. Check all safety interlocks for proper shutdown of the boiler.

3.2.3 Installation Precautions

The reliability of the equipment may be impaired if used in environments where strong electromagnetic fields exist e.g. if the equipment is installed in a boiler house where radio systems exist then additional EMC (Electro Magnetic Compatibility) measures may have to be considered. Please contact Autoflame for more information.

3.2.4 Maintenance and Servicing

The Micro-Modulation unit uses solid state technology. It requires no routine maintenance.

The servomotors/gas/oil/FGR valves do require routine maintenance. Any fault associated with these parts is usually diagnosed by the MM. Contact Autoflame for preventative maintenance procedures, please refer to the Valves and Servomotors manual for general checks.

3.3 Servomotors

Autoflame supply three standard sizes of servomotors – small, large and industrial, which can be used for all channels. Autoflame fuel valves require small or large servomotors only. Both small and large servomotors can be configured to drive clockwise or counterclockwise to open a valve or damper. Servomotors can be installed in any orientation; 2 fixed rotation positions if using Autoflame valves. For layout of the small, large and industrial servomotors please refer to the Valves and Servomotors manual.

Viewing the shaft end-on, from the potentiometer end, all servomotors drive in a clockwise direction if power is applied between the LIVE and CW terminals, and counterclockwise if the power is applied between the LIVE and CCW terminal.

The operation of fuel valves and air dampers is often such that they open in a clockwise direction. If the operation needs to be reversed, it is necessary to swap various wiring connections between the MM and the servomotor(s). An example of reversing the operation of a servomotor is shown in Figure 3.3.3.



Note: Servomotors are supplied by the factory set at 0.0° position. Remember that this position may not necessarily automatically position the damper at 0.0° or a closed position. This must be physically checked. Failure to do so can result in serious injury or death.

3.3.1 Adjusting the Servomotor Potentiometer

Before a burner is fired it is essential to set up each Micro-Modulation servomotor. A tamper proof screwdriver is required (please contact Autoflame).

Usually, control valves/air dampers that the servomotors drive, move through up to 90.0° angular degrees. The MM system has the ability to drive valves through 360.0° degrees, but the MM will only display from - 6.0° to 96.0° degrees.



All Channel 1 to 4 and 7 readings displayed on the MM are in angular degrees. It is necessary to adjust the potentiometer in the servomotor assembly so that the MM reads 0.0° when the relevant valve/damper is at its fully closed position. The technician must physically check the mechanical position of the dampers and valves, whilst all servomotors are set to 0.0° before leaving the factory this may have changed during shipping. **DO NOT ASSUME THEY HAVE BEEN PREVIOUSLY SET CORRECTLY.**

Put the MM into the commissioning mode and press CLOSE to position the valve/damper mechanically by using the appropriate up and down buttons (see section 3.4.2).

Remove the servomotor cover.

<u>For air servomotors carry out the following procedure:</u>

Use the channel 2 up/down buttons on the MM to position the air damper to its physically closed position. Loosen the two tamper proof screws just enough to enable the potentiometer to rotate. Rotate the potentiometer clockwise or counterclockwise until the relevant channel reads 0.0. Tighten the two tamper proof screws gently until the potentiometer is secure. Do not over tighten the screws. Check that the display still reads 0.0. If incorrect repeat the adjustment process.

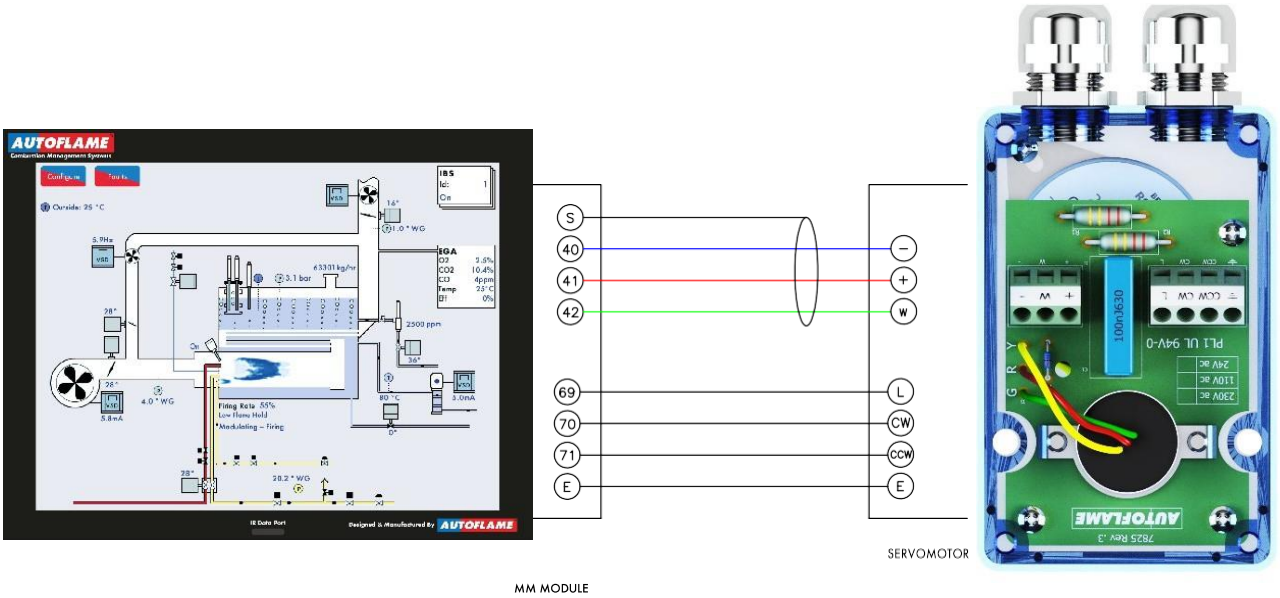
<u>For fuel servomotors carry out the following procedure:</u>

On Autoflame gas, oil and gas/oil piggy-back valves it is necessary to remove the servomotor. Manually position the oil/gas valve slot to its closed position. Observe the position of the drive pin on the servomotor. Use the relevant channel up/down buttons to position the pin so that when the servomotor is reassembled to the valve it is in line with the slot. Reassemble the servomotor to the valve, loosen the two tamper proof screws and proceed to adjust the potentiometer position until 0.0° is displayed. Use the external position indicator to ensure the valve is in the fully closed position.

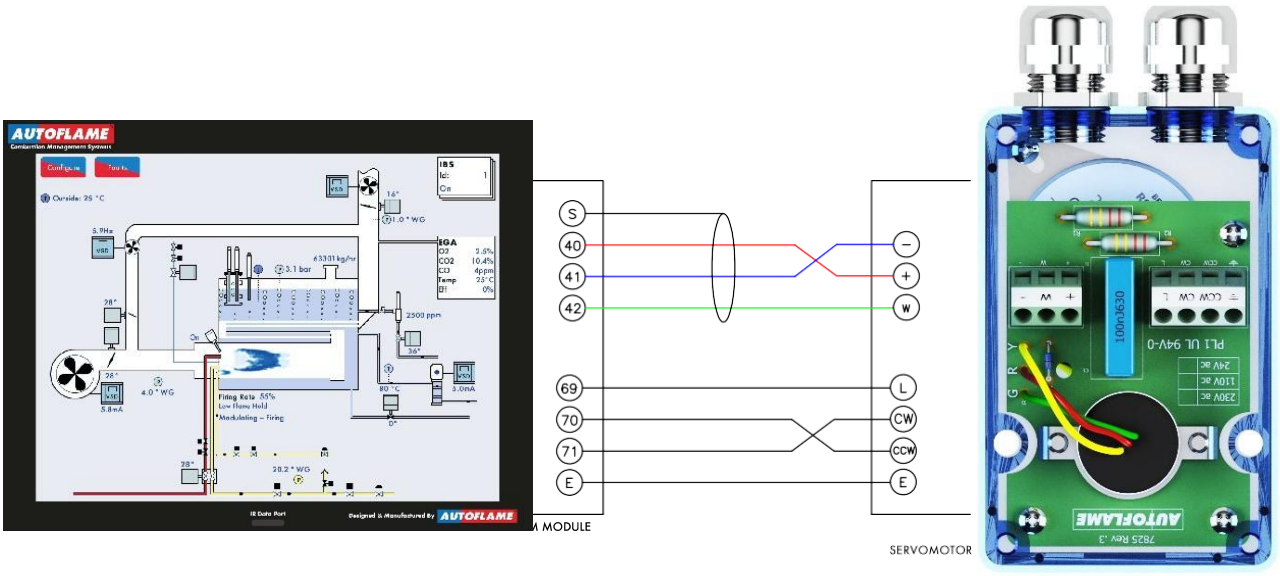
3.3.2 Servomotor Feedback Voltage

In applications where the servomotor is not positioned close to the display then it is possible to measure the feedback voltage from the servomotor in order to ensure that 0.0 degrees is displayed. By testing the DC voltage between the blue and green wires (wiper and 0V) on the servomotor low voltage terminals this will read 0.21V DC when the reading on the display is 0^{O}. The same can be done for when the servomotor is at 96.0^{O} where the voltage will be 3.6V.

3.3.3 Servomotors – Direction Change



SERVOMOTOR CLOCKWISE ROTATION



SERVOMOTOR ANTICLOCKWISE ROTATION

3.3.4 Servomotors with Autoflame Valves

On threaded valves, the pin on the top of the valve is 90 degrees opposite from the position of the butterfly valve.

On flanged valves, the pin on the top of the valve is in line with the position of the butterfly valve.

For both valves the external visual position indicator is in line with the position of the butterfly valve. Regardless of the type of valve being used, the servomotor is dispatched from the factory with the potentiometer in the zero position. The same servomotor will be correct for both types of valve, as the servomotor for the threaded valve is mounted at 90 degrees different from the flanged valve.

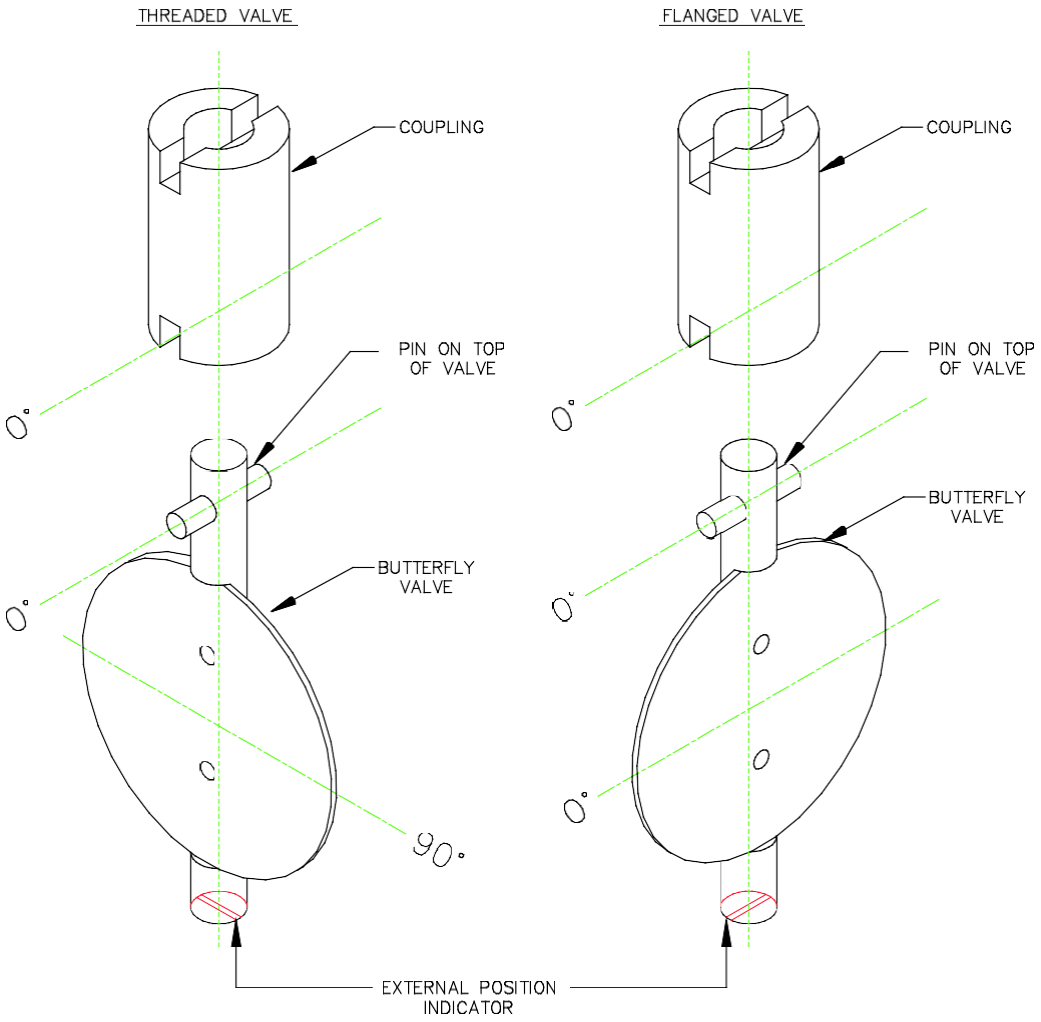


Figure 3.3.4.i Valve Pin Positions

3.4 Commissioning Fuel and Air Positions

The following procedure is for commissioning the EGA with option 12 set to 0 (Not Optioned), or 1 (Monitoring only). Trim can be added later by setting option 12 to 2 (Applies trim) or 3 (Applies trim, combustion limits tested). Please see section 3.7 for adding/adjusting the trim data later during Single Point Change. If the EGA is optioned later in Online Changes, the MM will not require a full re-commission; the trim data can be added in Single Point Change.

For option 12 set to 0 or 1 during commissioning, omit section 3.4.6. For option 12 set to 2 or 3 during commissioning, please include section 3.4.6.

The fuel and air positions need to be programmed for the following points: CLOSED, OPEN, GOLDEN START (if optioned), FGR START (if optioned), LOW FIRE (START), INTER POINTS, and HIGH FIRE.

There must be a minimum of 3 INTER points entered on the fuel-air curve, and a maximum of 18. Points can be added/removed/moved in Single Point Change mode (see section 3.7).

During commissioning the required setpoint is not active; the internal stat remains on at all times regardless of the actual value. Ensure that the high limit stat is set correctly and wired into the recycling interlock (T53), as this will turn the burner off in the event that the safe working maximum temperature or pressure of the boiler is exceeded.

The high limit stat should be set below the rating of the safety valve, please see the manufacturer's guidelines for the safety valve for that boiler.

Note: If a fault occurs, the boiler goes above the high limit stat or power is lost to the MM during commissioning, no data is stored. The points entered are only stored within the MM once the commission has been completed.

3.4.1 Starting Commissioning

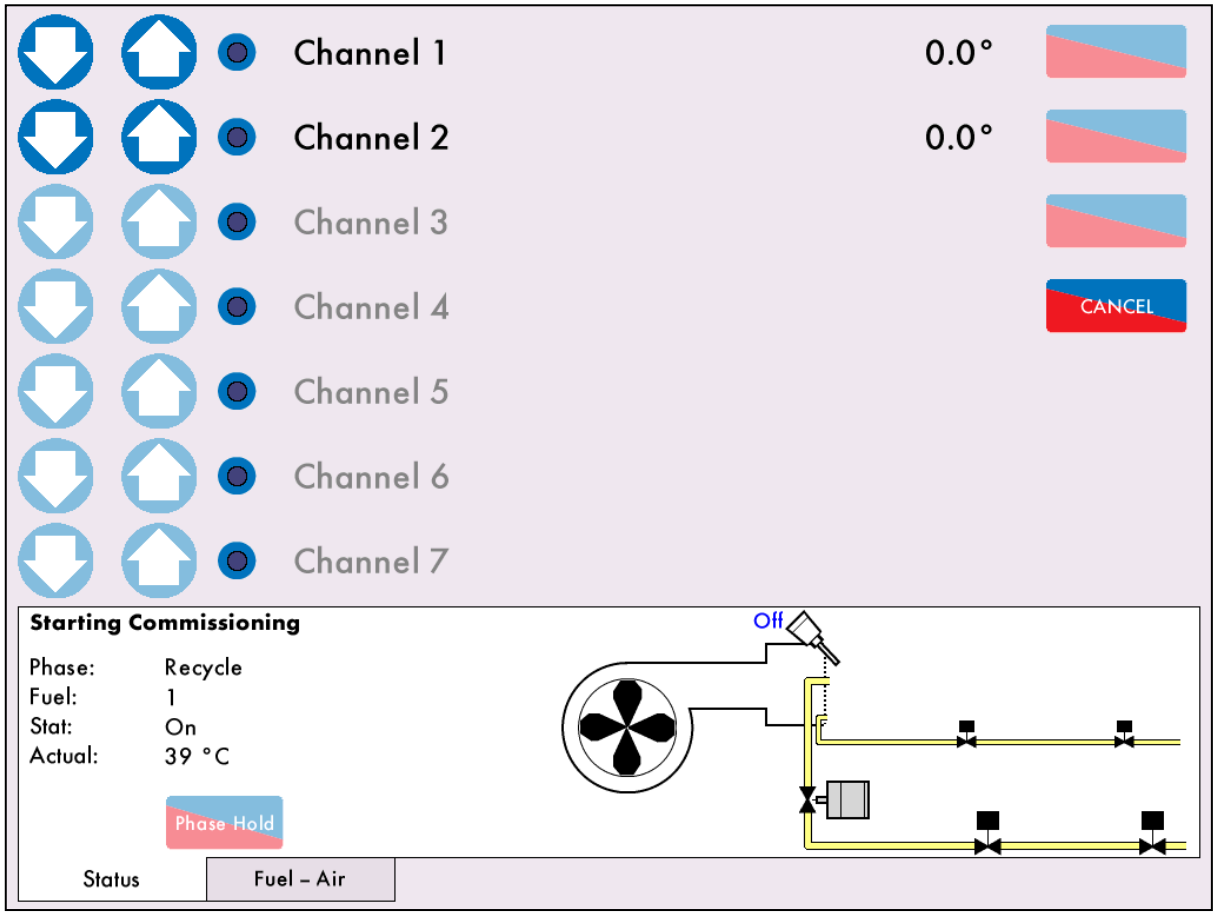


Figure 3.4.1.i Starting Commissioning

Once the options, parameters and expansion options have been set, press Commission on the Commission Mode screen in Figure 2.1.ii. If the MM has already been commissioned, then press Commission on the Home Display.

Figure 3.4.1.i shows the Commissioning screen. In the Commissioning screen, the 7 channel positions will be shown, with the unused channels greyed out.

Once the MM goes through its internal relay checks and VPS (if optioned), the message 'Select Commissioning' will display.

3.4.2 Enter CLOSED Position

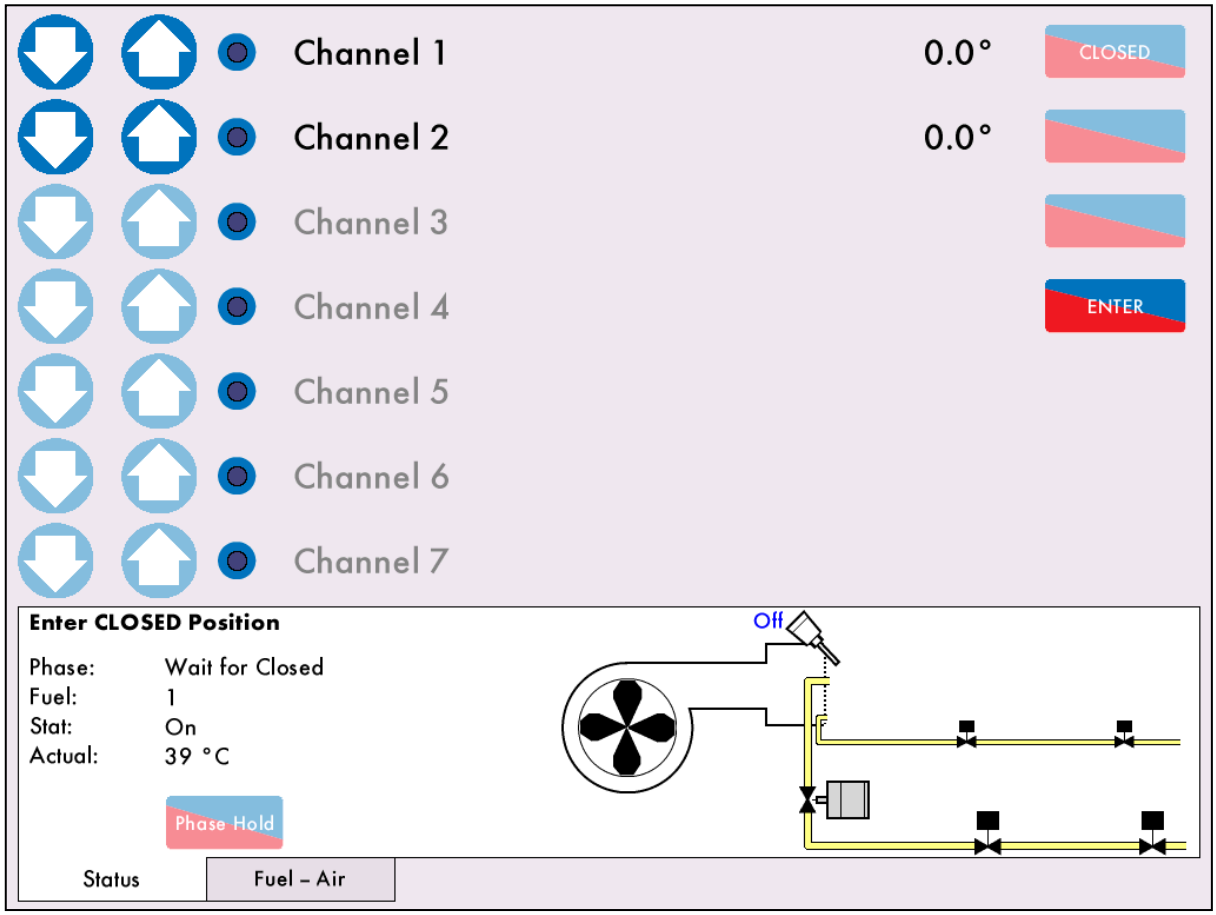


Figure 3.4.2.i Enter CLOSED Position

The MM is now waiting for the CLOSED position to be entered. Press 

to enter this position.

Note: No error checking of the servomotors is enabled at this stage, therefore, do not to drive the servomotors/ dampers beyond any mechanical limitations that may be present on the damper/valve. This may cause damage to the servomotor and/or the damper/valve.

Use the  buttons to set the positions to 0.0^{O}.

Note: Double check the damper/valve is physically at the 0.0 (closed) position. This can be achieved by checking for external indications on the damper assembly or the fuel valve. It is the engineer's responsibility to ensure that the servomotors are correctly calibrated. Incorrect calibration can cause serious injury or death.

Press 

to store the CLOSED position. The burner motor output T58 will energise at this point. A message will then be displayed 'Enter OPEN Position.'

3.4.3 Enter OPEN Position

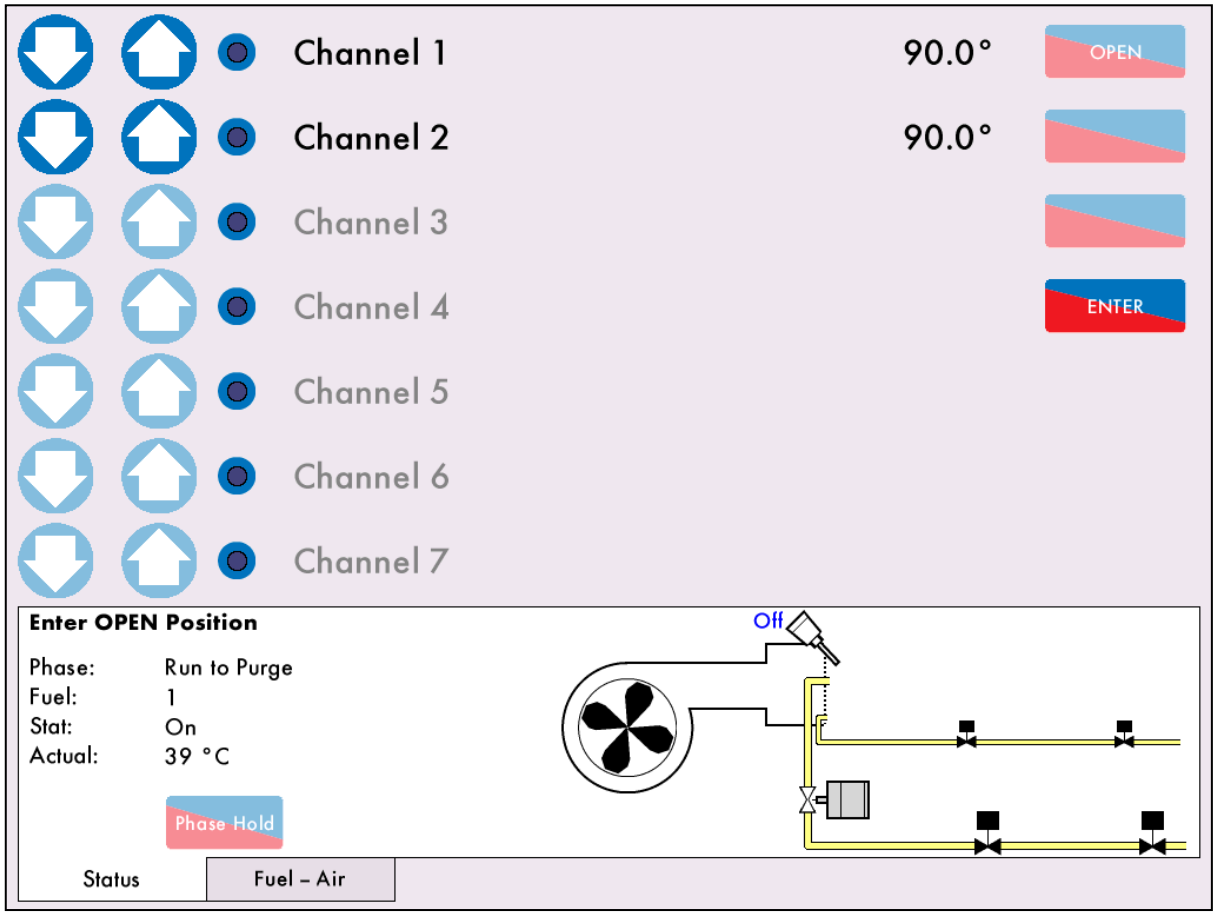
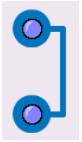


Figure 3.4.3.i Enter OPEN Position

Press  and then drive the fuel and air servomotors to their OPEN position. The button hold facility allows multiple channels to be driven up or down at the same time. Press on the blue circles  next to the channels; once selected they will appear as  to indicate the channels are selected.

Use the  buttons to drive both servomotors to the OPEN position simultaneously. This is normally 90.0 ° for Autoflame gas butterfly valves and burner air dampers, but may be set to less than 90.0 ° if there are mechanical stops/limits on third party valves. Channels 5 and 6 cannot be adjusted at this stage, its calibration is dictated by the drive set-up and relevant options.

Press  to save the OPEN positions.

Pressing on the Fuel-Air tab at any time will give you a graph showing the fuel and air servomotor angles.

3.4.4 Set up START Position

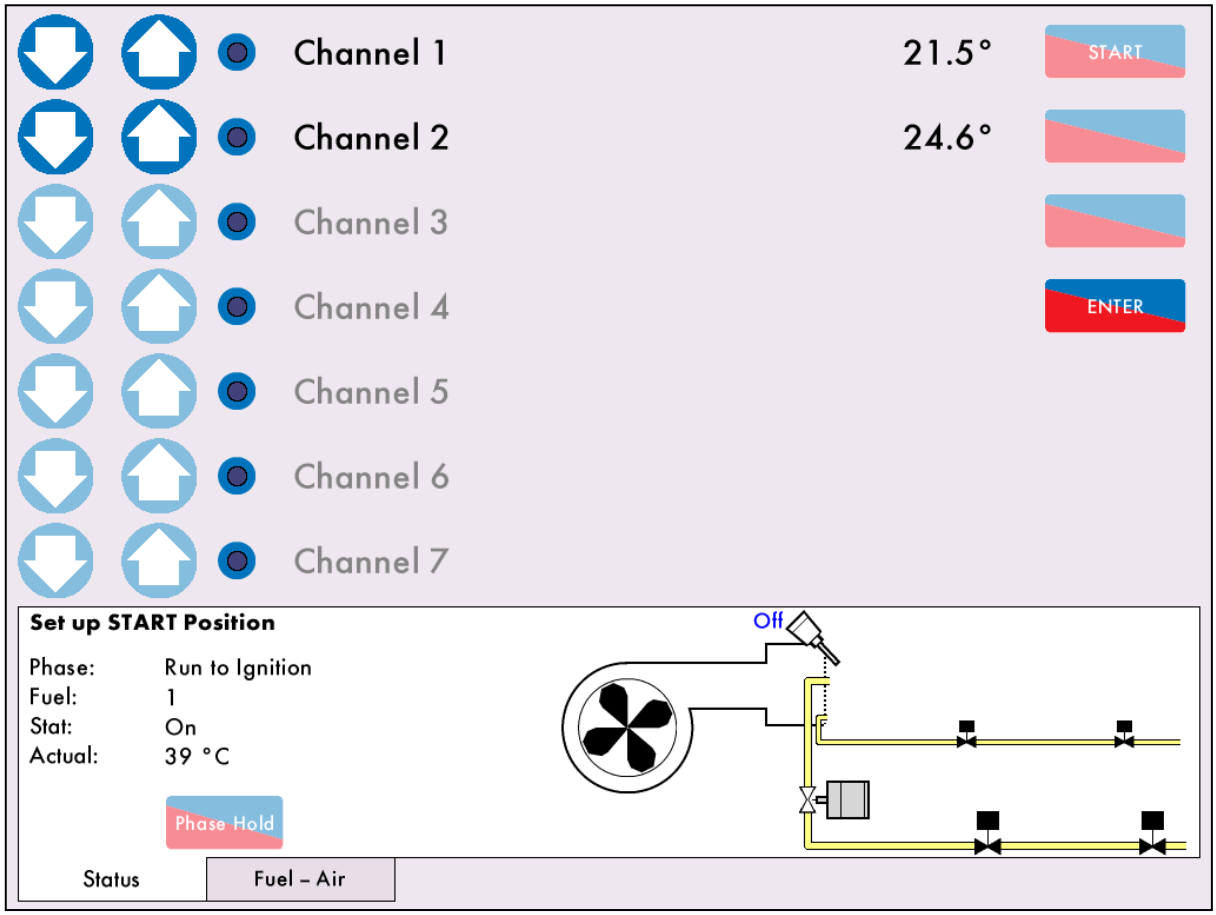


Figure 3.4.4.i Set up START Position

Once the system has purged (see options/ parameters 75 and 112), the message 'Set up START Position' will display on the MM.

Press 

and drive the servomotors to their START position. To enter a fuel START position which is less than 10 degrees below the OPEN position, you must drive the servomotor below this band, and then back open. For example, if the CH1 OPEN position is set at 90.0^{O}, to set a CH1 START position of 83.0^{O}, you must drive the CH1 servomotor to below 80.0^{O} and then to 83.0^{O}.

<u>WARNING:</u> ENTERING THE START POSITION BEFORE REDUCING FUEL INPUT APPROPRIATELY COULD RESULT IN SERIOUS PHYSICAL INJURY OR DEATH.

Press 

to enter the START position, where a light off can take place. These fuel and air positions are not stored permanently as it is just a light-off position to put a flame in the boiler and begin the commissioning process.

3.4.5 Phase Hold

When the system is in commissioning mode only, the Phase Hold feature enables the commissioning engineer to pause the ignition sequence of the burner to make adjustments to the gas regulator if needed.

The phase hold feature can be used in pilot open, pilot proving and main flame proving. If the phase is held in the pilot open stage and the flame goes out, a lockout will occur after 20 seconds. However, if the phase is held in either the pilot proving or main flame proving stages, the MM will lockout immediately if the flame scanner does not detect a flame.

If the flame is present and the 'phase hold' condition is left indefinitely, the 'Freeze Timeout' lockout will occur after 10 minutes. When the system is in a run mode the facility is disabled.

To make adjustments with the gas manually, press 

to keep the system at its current phase position, a little blue dot on this 'button' will appear to indicate that the phase is held. Ensure that the main fuel valve is manually isolated until the pilot flame has been successfully established. Once this has been successfully established, gradually introduce the main fuel supply to the burner while observing the flame stability. Continue to introduce fuel until the manual operated main fuel isolation valve is fully open providing safe and stable combustion that can be maintained. If the combustion is not safe and stable, then adjust the fuel/air ratio accordingly. Once the adjustments have been made, press 

to continue with the commissioning process.

<u>WARNING</u>: IT IS THE RESPONSIBILITY OF THE FACTORY TRAINED TECHNICIAN TO ENSURE THAT USE OF THE PHASE HOLD FACILITY DOES NOT LEAD TO A HAZADOUS SITUATION. FAILURE TO DO SO WILL RESULT IN SERIOUS EQUIPMENT DAMAGE, CRITICAL INJURY OR DEATH.

3.4.6 Add Trim Data During Commissioning

If option 12 is set to 2 or 3 during commissioning, when setting the servomotors for the HIGH, INTER, GOLDEN START, FGR START and START positions, the trim data will also need to be saved for the fuel rich and air rich trim conditions. The message 'Waiting for EGA readings' will display.

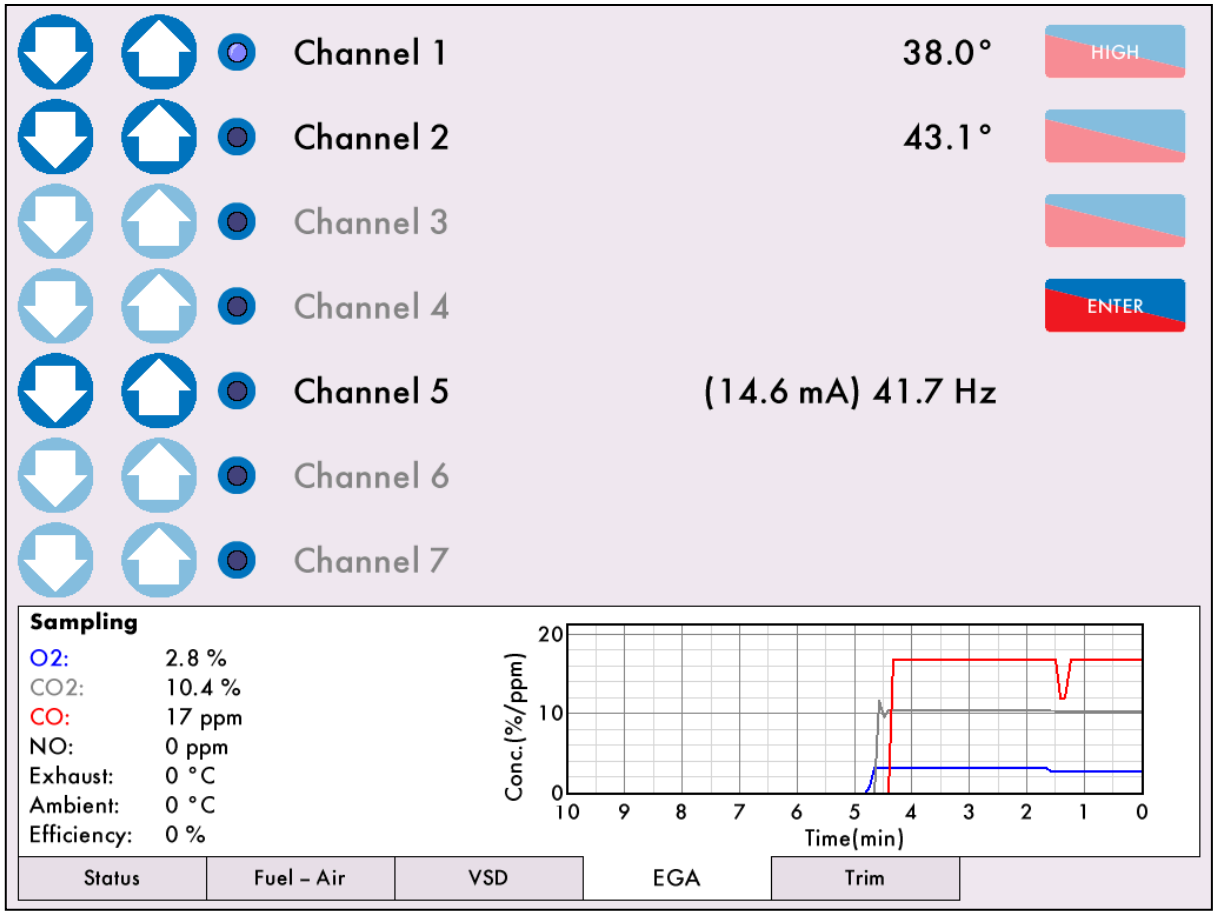


Figure 3.4.6.i Sampling

Press on the EGA tab to display the EGA readings.

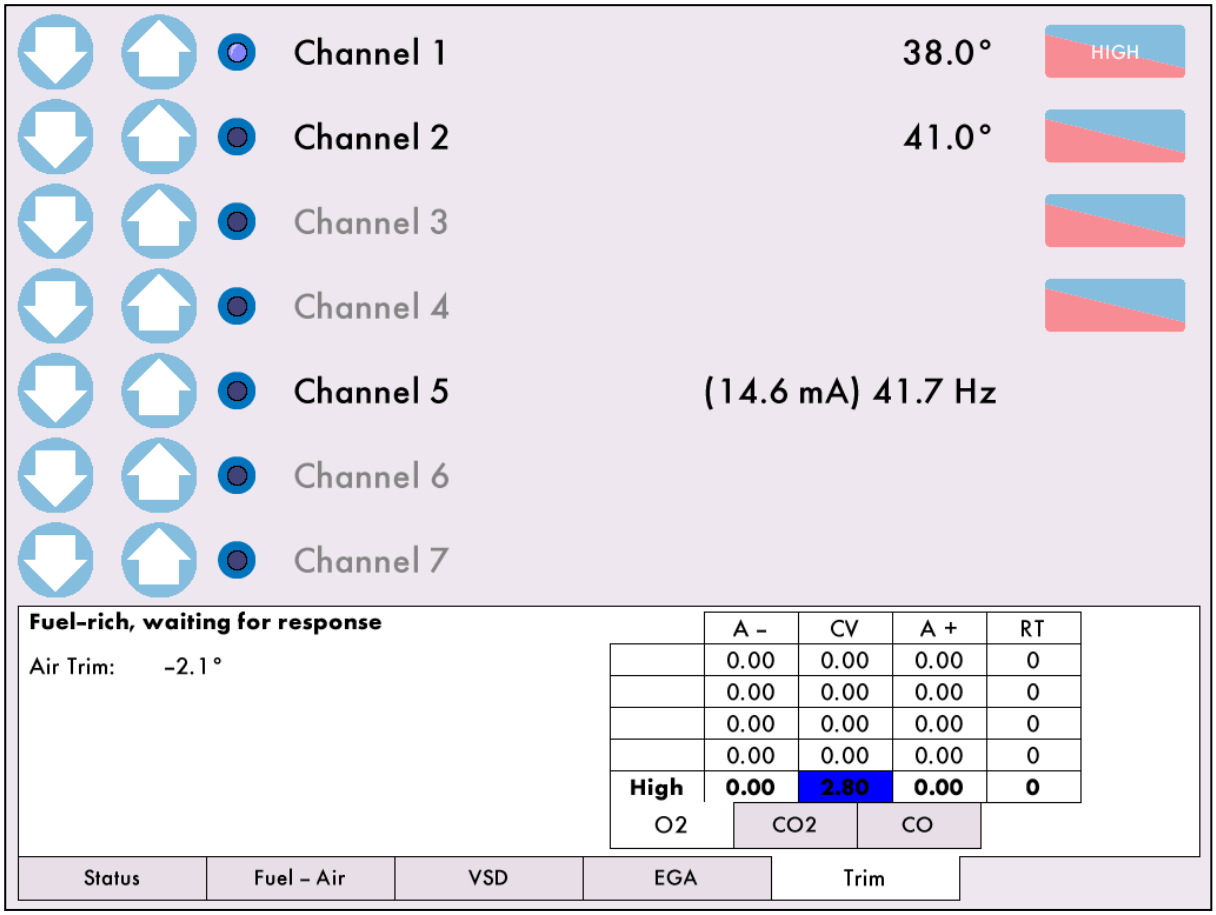


Figure 3.4.6.ii Commissioning with Trim

After you press 

to save those servomotor positions, the EGA will carry out its fuel rich and air rich trim.

Once these trim values have been saved, the system will continue with the commissioning process.

Note: If the MM has not been enabled for trim during commissioning, this can be added later by setting option 12 for trim, and going into Single Point Change to add trim to each point, see section 3.7.

3.4.7 Commissioning VSD

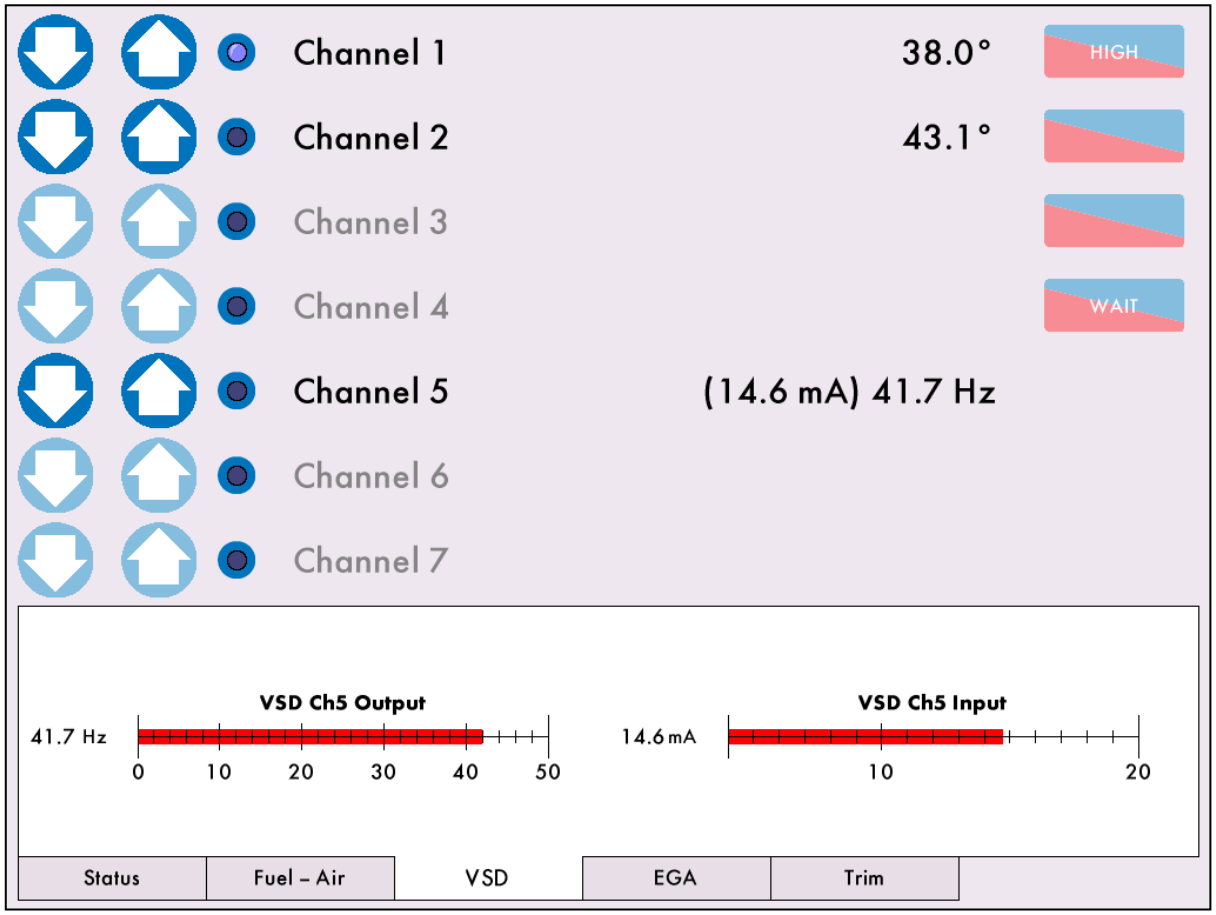


Figure 3.4.7.i Commissioning VSD

Press on the VSD tab to view the VSD output and input signal during commissioning.

If the MM has been enabled with VSD for commissioning and then disabled, or vice versa, a conflict message will appear 'VSD configuration does not match commissioning.'

If there is little movement required with the VSD signal, the feedback fault tolerance should be set accordingly. If the tolerance is not set according to the variation, an error 'VSD feedback change too small' will occur.

Please see options 99 and 109 for the VSD fault tolerance, which ensures that a VSD can be verified to be at the correct speed at low fire and different to that of high fire. This also ensures that the VSD signal is checked for fixed values and cannot be bypassed, preventing an unsafe condition with less air than commissioned. The minimum feedback variation applies to both the upper and lower limits so the total commission must allow for the two combined.

3.4.8 Set GOLDEN START Position

If Golden Start has been enabled in option 29 on a new system which has not been commissioned, the message 'Set Golden Start Position' will display after the START position has been entered.

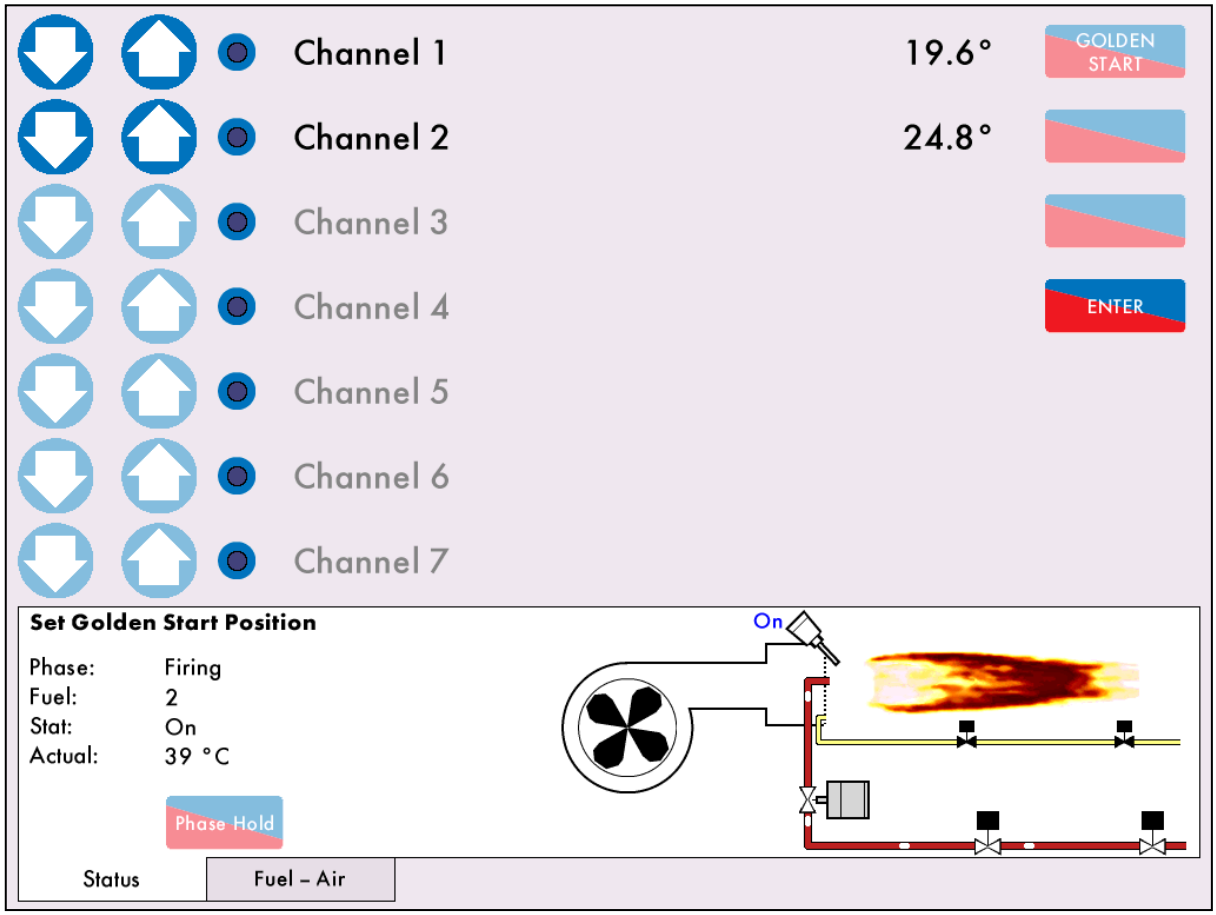


Figure 3.4.8.i Set GOLDEN START Position

Press GOLDEN START to enter the GOLDEN START position. After entering the GOLDEN START position, proceed to the commissioning steps in section 3.4.9 if FGR START has been enabled, or 3.4.10 if no FGR START is enabled.

Enabling Golden Start on a Commissioned System

If the system has already been commissioned without Golden Start enabled, go into Commission mode and set option 29 to enable Golden Start. The forced commission message will appear as 'Golden Start optioned but not commissioned.'

Press Commission on the home screen and once the system goes through its internal relay tests, the message 'Select Commissioning' will appear.

Press CLOSED to go through the commissioning process and enter the CLOSED, OPEN and light-off START positions. After the entering the light-off START position, the message 'Set Golden Start Position' will appear; press GOLDEN START to enter the stored GOLDEN START position and continue with the full commissioning procedure with section 3.4.9 if FGR START has been enabled, or 3.4.10 if no FGR START is enabled.
Alternatively, to just add the Golden Start position and not go through the whole commissioning procedure, press Commission on the home screen, and once the system has gone through its internal relay tests the

message ‘Select Commissioning’ will appear. Press 

and the MM will go through purge. The message ‘Set up START position’ will appear to ignite a flame in the burner, see section 3.4.4. Once the burner is firing, the message ‘Set Golden Start Position’ will appear. Press 

to enter the GOLDEN START position. The message ‘Save Commission’ will appear, press 

to save the GOLDEN START position and then press 

to return to run mode.

Note: If FGR START has also been enabled, this position must be entered after the GOLDEN START position.

The Golden Start position of the fuel and air servomotors is completely independent from the modulating load index and commissioned value data.

The facility is particularly useful on combustion systems with large turndowns and when firing heavy oil, as it enables the burner to start/ignite at a fuel rich position and then, after a stable flame is established, return to the commissioned combustion curve.

The Golden Start position needs to be entered for each required fuel.

The MM holds the Golden Start position for a time set in Parameter 15; this time starts from the point of main flame. After this time, if the Golden Start fuel position is between Low Fire and High Fire, the air damper will open and the fuel valve will stay in the same position, until fuel/air ratio is on the commissioned combustion curve. If the Golden Start fuel position is outside of the main curve, then both the air damper and fuel will go to the Low Fire position. Once on the commission curve, the MM will modulate as per load requirement.

Golden Start can be set in Option 29 to start from first ignition instead of after the main flame stabilisation phase has passed, this is particularly useful for briefly providing additional fuel when starting an oil flame with direct spark (no pilot mode – see option 111)

3.4.9 Set FGR Position

If FGR Start has been enabled in options 48, 49 or 50 on a system which has not been commissioned, the message 'Set FGR Position' will display after entering the light-off START position. If Golden Start has been enabled in option 29, this message will appear after entering the GOLDEN START position.

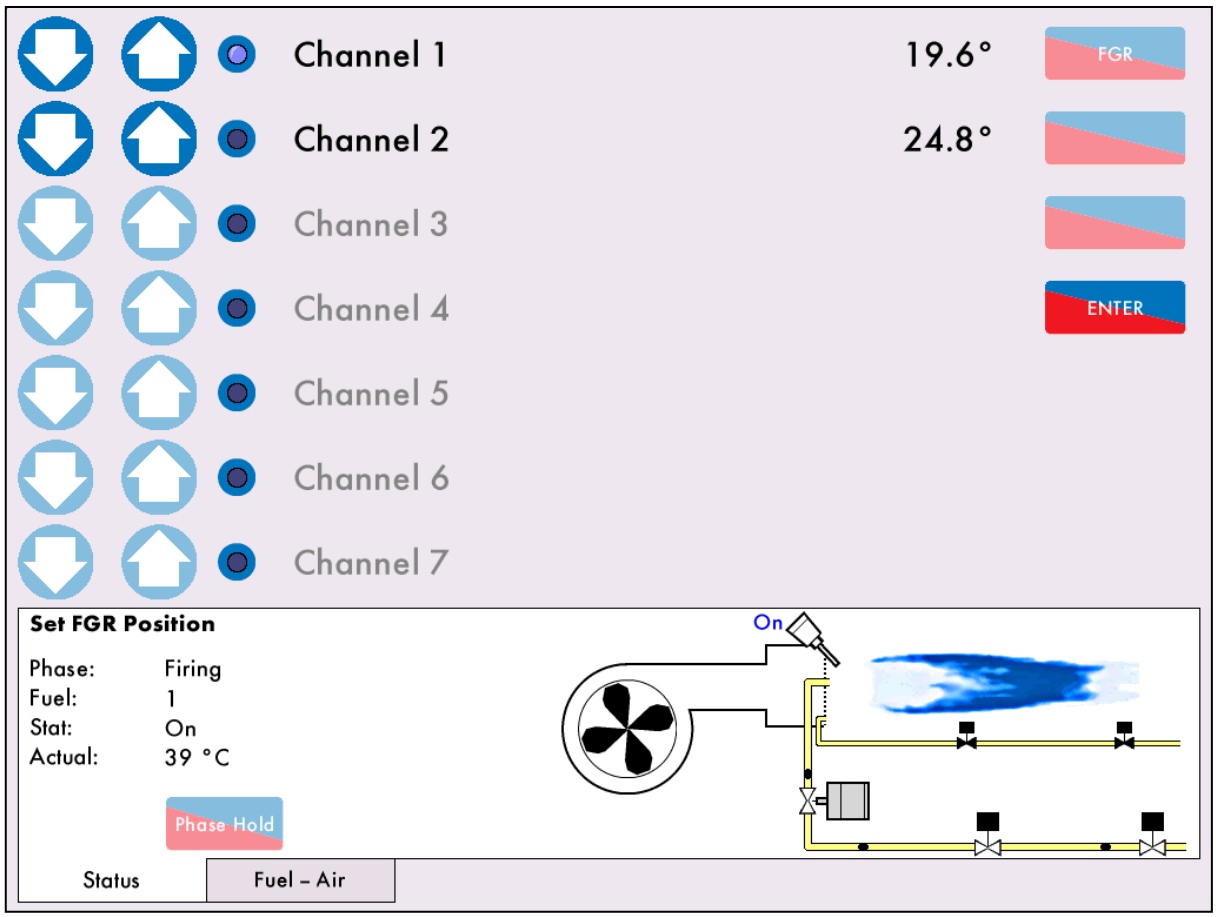


Figure 3.4.9.i Set FGR Position

Press FGR to enter the FGR START position. After entering the FGR START position, proceed to the commissioning steps in section 3.4.10.

Enabling FGR Start on a Commissioned System

If the system has already been commissioned without FGR Start enabled, go into Commission mode and set option 48, 49 or 50 to enable FGR Start. The forced commission message will appear as 'FGR optioned but not commissioned.'

Press Commission on the home screen and once the system goes through its internal relay tests, the message 'Select Commissioning' will appear.

Press CLOSED to go through the commissioning process and enter the CLOSED, OPEN, light-off START and GOLDEN START (if enabled) positions. After the entering the light-off START or GOLDEN START (if enabled) position, the message 'Set FGR Position' will appear; press FGR to enter the stored FGR START position and continue with the full commissioning procedure in section 3.4.10.

Alternatively, to just add the FGR Start position and not go through the whole commissioning procedure, press Commission on the home screen, and once the system has gone through its internal relay tests the

message ‘Select Commissioning’ will appear. Press 

and the MM will go through purge. The message ‘Set up START position’ will appear to ignite a flame in the burner, see section 3.4.4. Once the burner is firing, the message ‘Set FGR Position’ will appear. Press 

to enter the FGR START position. The message ‘Save Commission’ will appear, press 

to save the FGR START position and then press 

to return to run mode.

Note: If both Golden Start and FGR are optioned then the GOLDEN START position is entered before the FGR START position.

Flue Gas Recirculation (FGR) is a method whereby a quantity (approximately 15%) of the boiler flue gases are fed back to the burner and mixed with the combustion air. The virtue of FGR is the reduction of NOx gases. With the FGR facility, servomotor channel 3 can be used to control the amount of flue gas fed back. It is not good practice to feed back the gases when the flue gas is cold, so all the elements (i.e. servomotors and VSD) can be set at ‘FGR’ positions until the gases are hot. During this time the CH3 would normally be set closed. Once the FGR holding conditions are met, modulation takes place in the normal way using the curve entered during commissioning.

FGR can be set as a Timer, Offset or Temperature Threshold (see options 48, 49 and 50).

Note: Golden start takes priority over FGR. Once the golden start timer has finished, the servomotors will go straight to the FGR start position.

3.4.10 Set HIGH Position

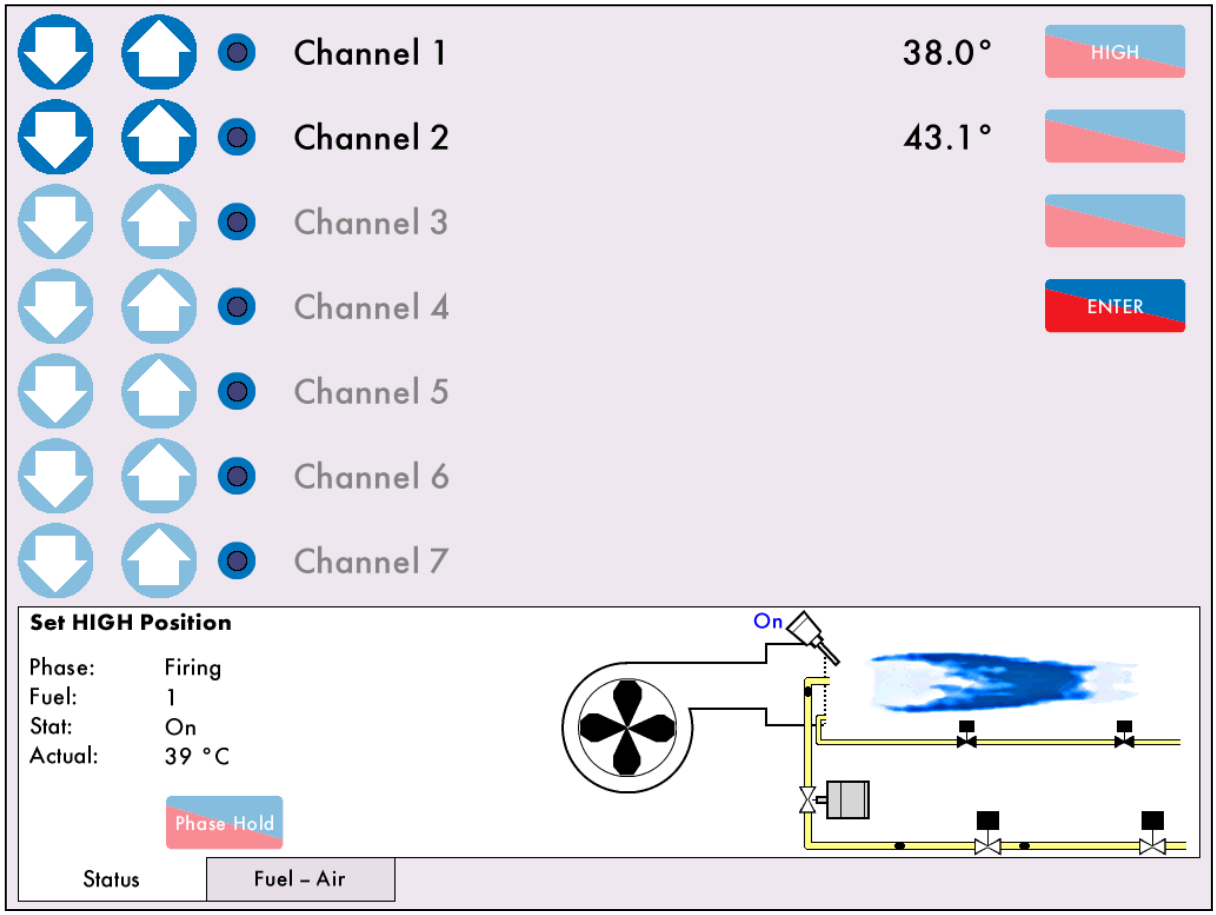


Figure 3.4.10.i Set HIGH Position

Once all the START, GOLDEN START and FGR START positions have been entered, the message 'Set HIGH Position' will appear. Press 

and drive the servomotors (and VSD if optioned) to the HIGH position by opening the air damper and fuel valve some degrees alternatively, so that more fuel is added gradually.

It is not possible to enter the HIGH position higher than the OPEN position. The servomotors must be driven 0.5° up/down from the previous point initially, before entering the next point. Press 

to store this HIGH position.

<u>WARNING</u>: IT IS THE RESPONSIBILITY OF THE COMMISSIONING ENGINEER TO ENSURE THAT THE FLAME IS SAFE AND THERE IS A GOOD COMBUSTION AT ALL TIMES DURING COMMISSIONING.

3.4.11 Set INTER Position

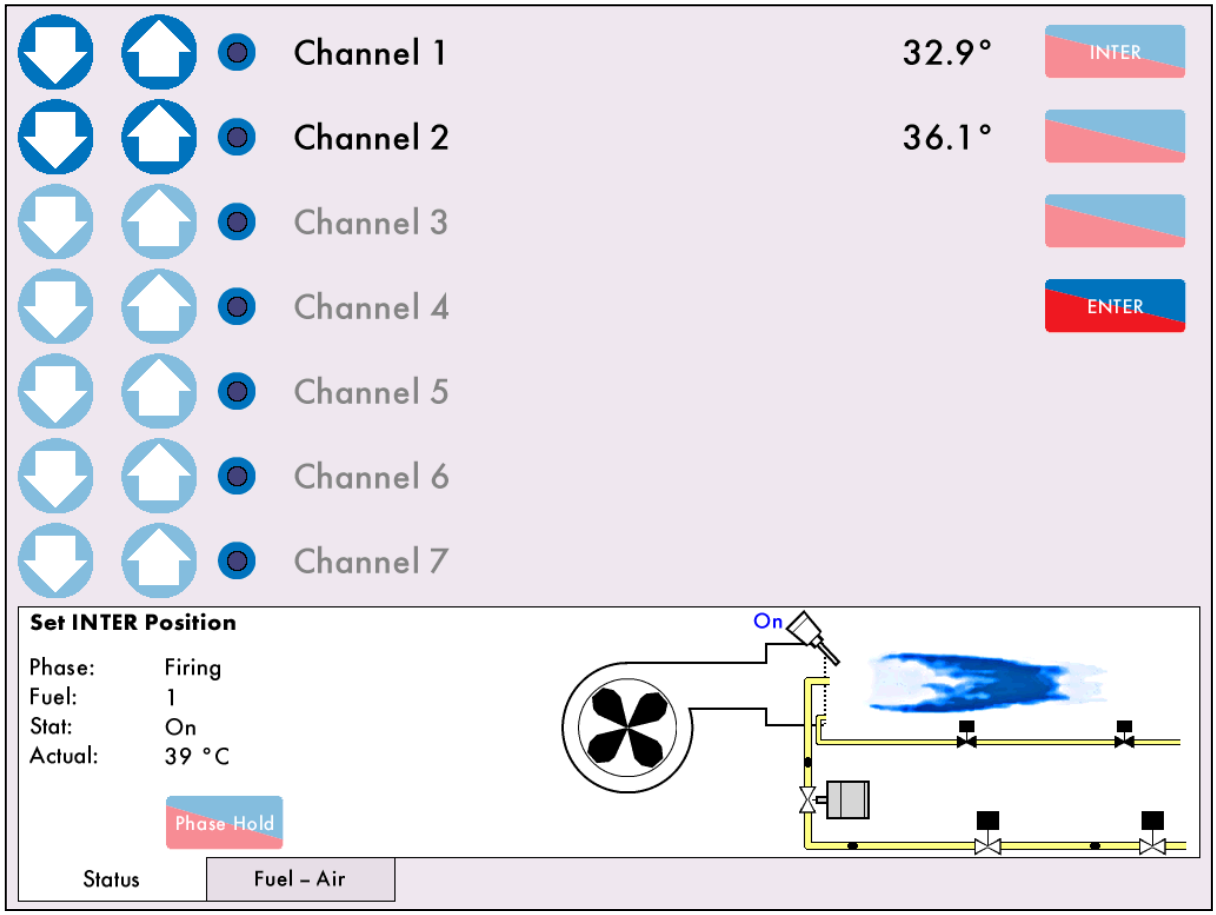


Figure 3.4.11.i Set INTER Position

Once the HIGH position has been entered, the message 'Set INTER Position' will appear. Press INTER to drive the servomotors (and VSD) to the first INTER position. The message 'Move fuel and air positions' will appear at first, as the system must detected a 0.5^{O} movement on CH1 and CH2 before an INTER position can be entered. Press ENTER to store this INTER position.

There must be a minimum of 3 INTER points entered on the fuel-air curve, and a maximum of 18. Points can be added/removed in Single Point Change mode (see section 3.6).

Continue this process until all the required INTER points have been entered.

3.4.12 Set INTER or START Position

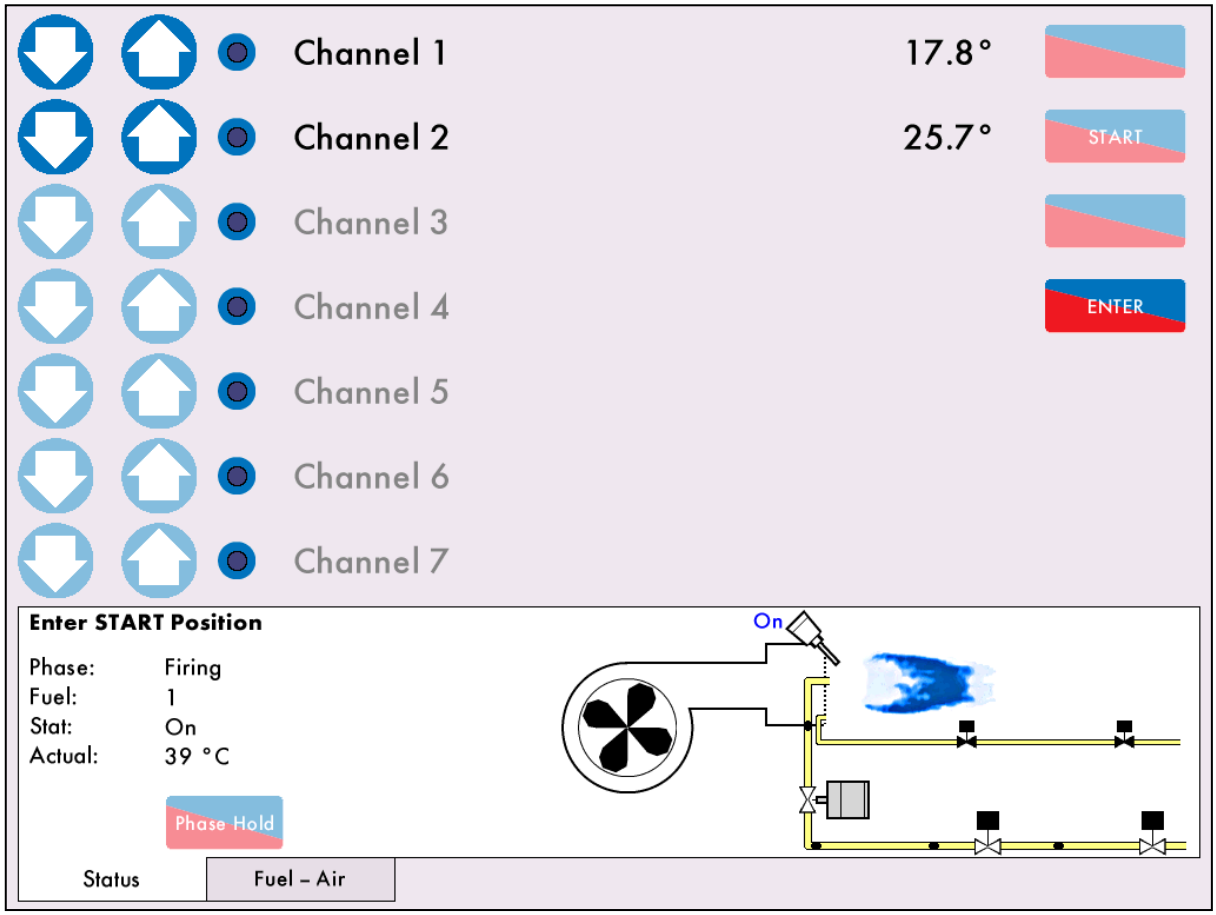


Figure 3.4.12.i Set INTER or START Position

Once the minimum 3 INTER points have been added, you will be prompted to either enter another INTER point or the START/LOW FIRE position.

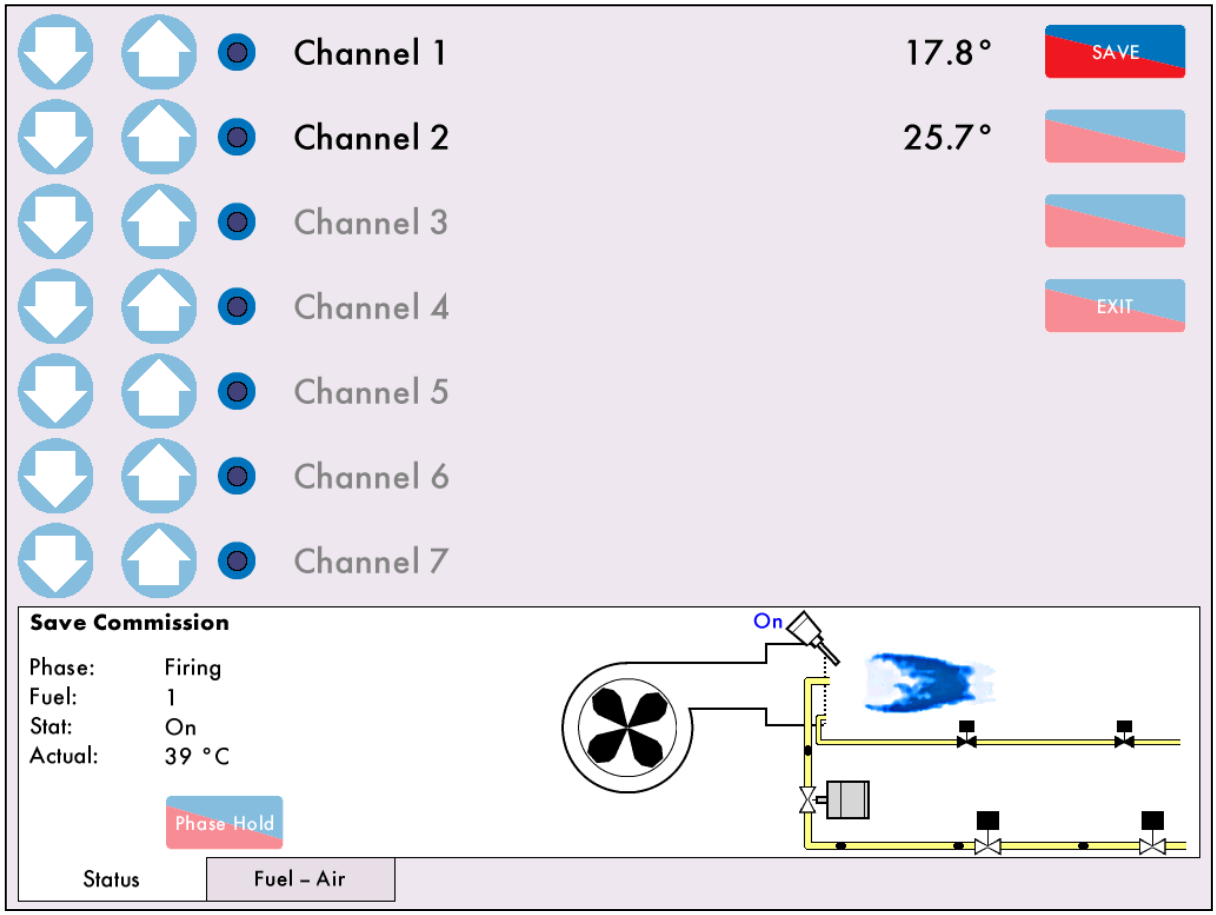
Press 

to drive the servomotors (and VSD) to the START/ LOW FIRE position, and then press 

to store this.

Note: If Golden Start or FGR Start are in use, the Start position is only used for Low Fire.

3.4.13 Save Commission



3.4.13.i Save Commission

Once the START position has been entered, press 

to store this commission curve. The message 'Commission Complete' will appear and press 

to go normal firing mode.

If the burner has been previously commissioned, then the new saved curve will overwrite the previous data for the fuel selected. Failure to save the curve will result in the commissioning data not being stored within the unit and a power loss to the unit will result in a loss of data for the fuel selected.

If during commissioning the burner turns off, due to the 'running interlock' opening or a fault, or if the power has been recycled, no points entered are stored. It is recommended to commission the MM with a quick base curve and then adjust/add/remove the points in the Single Point Change.

Once the burner has been commissioned, the fuel flow metering will need to be entered, please go to section 3.5 Fuel Flow Commissioning. If there is EGA trim data to be added then continue to section 3.7 Single Point Change before section 3.5 Fuel Flow Commissioning.

Note: If commissioning a fuel for the first time the default required setpoint will be 2.0bar/20PSI/20^{O}C/20^{O}F. The burner will shut down at commission completion due to the low default required setpoint. Go to the Status screen to change the required setpoint.

3.5 Fuel Flow Metering

If fuel flow metering has been enabled in option 57, the message 'No Fuel Flow Data' will display on the Home screen once the burner has been commissioned. Fuel flow metering is used to rate the size of the burner and calculate the firing rate.

If fuel flow metering is not commissioned and sequencing is optioned, the MM will assume a default burner rating which is based on the fractional fuel valve angle.

The fuel flow is commissioned from the low fire point up to the high fire point. The low fire point will set the burner rating in MW if metric of MMBtu/hr if imperial.

On the Mk8 MM, fuel flow metering can be taken as the values entered in the fuel flow commissioning screen from the fuel flow meter or through a 4-20mA signal input on terminals EX- and EX+.

3.5.1 Commissioning Fuel Flow Through MM

If a fuel flow meter is not available and only arbitrary values are going to be used, it is important to make sure a good range of values are entered (e.g. 1 to 10) with equal spaces between the values. Not doing this could lead to problems when using IBS and the flame graphic.

When using arbitrary values it is good practice to use the following calculation to determine the heat value for each of the 10 points.

$$Value\ Between\ Points = \frac{Burner\ Rating - \left(\frac{Burner\ Rating}{Turndown}\right)}{9}$$

For example: Burner Rating: 5.4MW; Turndown Ratio: 5:1.

$$\frac{5.4 - \left(\frac{5.4}{5}\right)}{9} = 0.48$$

Giving the range (5.40, 4.92, 4.44, 3.96, 3.48, 3.00, 2.52, 2.04, 1.56, 1.08), with 1.08MW as the low fire point and 5.4MW as the high fire burner rating point derived using an estimated burner turndown value.

Fuel flow metering serves to totalise the amount of fuel being used at each position. If any changes are made to the curve through Single Point Change, then fuel flow will need to be re-commissioned.

Enable Fuel flow commissioning by setting option 57. Fuel flow commissioning is done in Run mode while the burner is firing.

On the Home Screen, press 

to access the System Configuration screen.

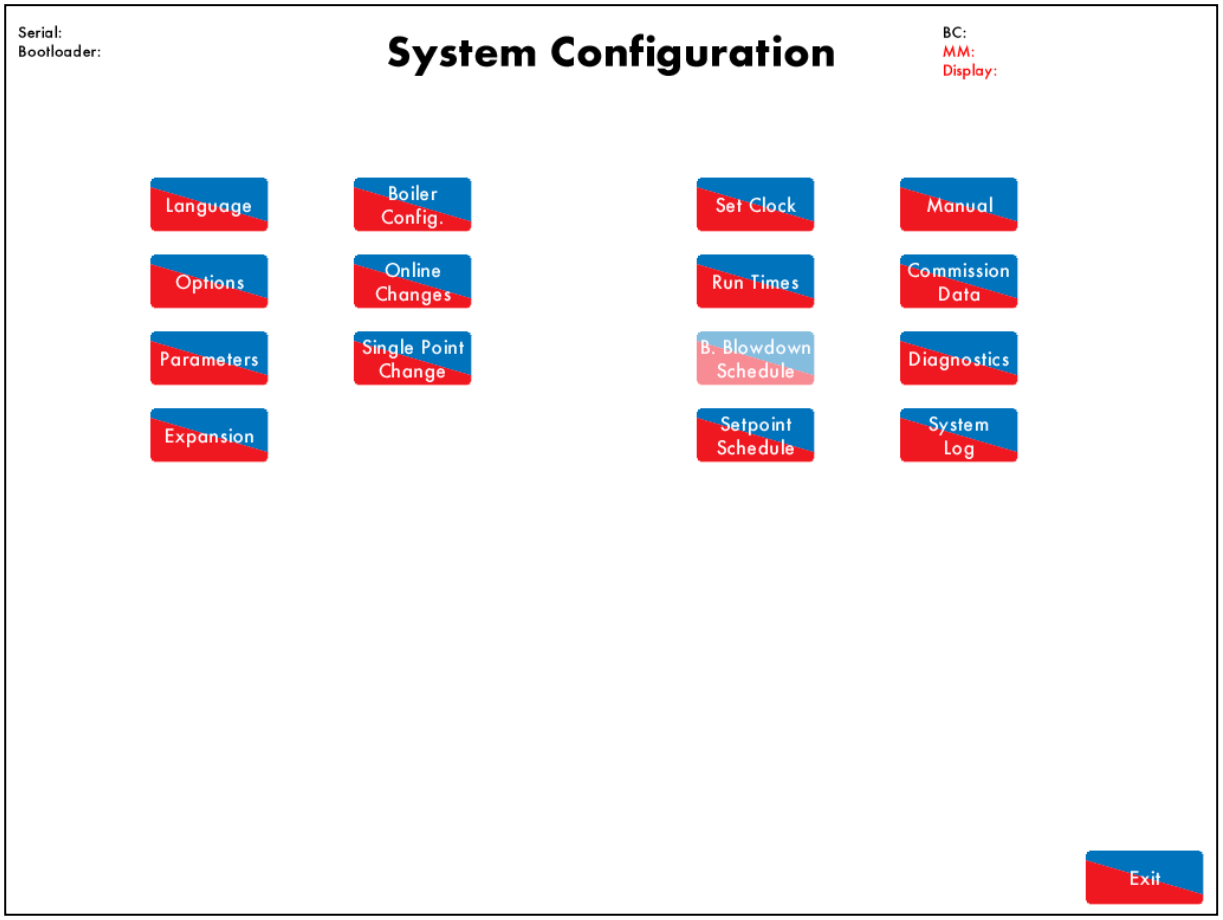


Figure 3.5.1.i System Configuration Screen

On the System Configuration screen press Online Changes. You will be prompted to enter the Online Change password. Press Continue to access the Online Changes screen.

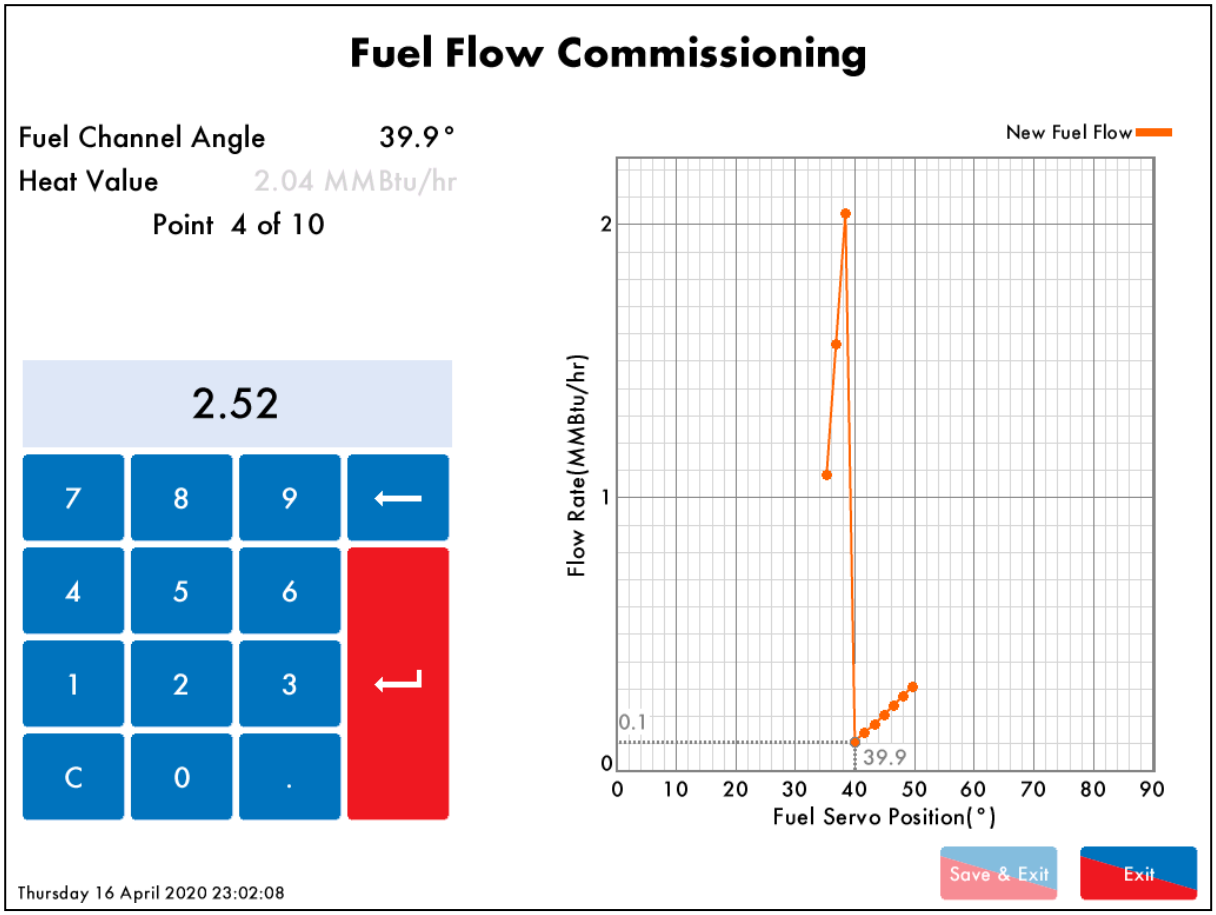


Figure 3.5.iii Fuel Flow Commissioning

Press Fuel-flow Commission to access the fuel flow commissioning screen. There are 10 points which need to be entered across the commission curve from low fire to high fire, with low fire being point 1, and high fire point 10. Type in the heat value or 'dummy value' using the keypad and press the return key to save that point.

Note: The servomotors will drive to the low fire position, and then drive up as the fuel flow commissioning points are entered. Precautions must be taken to ensure that the boiler is warm enough for all 10 points to be entered.

As you enter the heat values for the 10 points, these will become marked on the graph to the right of the screen.

Once the fuel flow commissioning is complete, press Save & Exit to return to modulation in normal firing mode.

If you press Exit at any time during fuel flow commission, this will not store the points.

3.5.2 Commissioning Fuel Flow Through 4-20mA Feedback

If fuel flow metering is enabled through using 4-20mA feedback on terminals EX- and EX+, the heat value will automatically get populated according to the analogue signal at that fuel valve position. After each heat value is displayed, press enter to go to the next fuel flow point.

3.5.3 Calorific Fuel Data

Stats	Kerosene SG	Gas Oil CI/SH	Light fuel Oil SG	Medium fuel Oil SG	Heavy Fuel Oil SG
Relative density 15.6°C (60°F) approx. / = litres x = kg	0.79	0.835	0.93	0.94	0.96
Flash point (closed) min °C (°F)	37.8 (100)	65.6 (150)	65.6 (150)	65.6 (150)	65.6 (150)
Viscosity kinematic (cSt) at					
15.6°C (60°F) approx.	2.0	-	-	-	-
37.8°C (100°F) approx.	-	3.0	-	-	-
82.2°C (180°F) approx.	-	-	12.5	30	70
Equivalent Redwood No.1 Viscosity at 37.8°C (100°F)	-	33 approx	250 max	1000 max	3500 max
Freezing point °C / °F	Below -40	Below -40	Below -40	Below -40	Below -40
Cloud point °C max	-	-2.2	-	-	-
Gross calorific values					
KJ/kg approx.	46,520	45,590	43,496	43,030	42,800
Btu/lb approx.	20,000	19,600	18,700	18,500	18,400
KWh/litre approx.	10.18	10.57	11.28	11.22	11.42
Therms/gallon approx.	1.58	1.64	1.75	1.74	1.77
kW/kg	-	12.66	12.08	-	11.89
Sulphur content % wt.	0.2	0.6	2.3	2.4	2.5
Water content % vol.	Negligible	0.05	0.10	0.20	0.30
Sediment content % wt	-	Negligible	0.20	0.03	0.04
Ash content % wt	-	Negligible	0.02	0.03	0.04
Mean specific heat between0°C - 100°C approx.	0.50	0.49	0.46	0.45	0.45
Volume correction factor per 1°C	0.00083	0.00083	0.0007	0.0007	0.00068
Volume correction factor per 1°F	0.00046	0.00046	0.00039	0.00039	0.00038
Btu/U.S. gallon (US standard)	-	140,000	-	150,000	160,000
Lb/U.S. gallon (US standard)	-	7.01	-	-	7.01
% lighter than water		20%			4%
1 u.s. Gallon of oil / ft of air		1402			

3.5.4 Conversion Factor for Imperial Gas Flow Meters

Required Data: Pressure of gas at meter in “wg
Required gas flow in ft³/min

Calculations: Correction factor = (pressure of gas at meter x 0.00228) + 0.948
Reading on gas meter = required gas flow / correction factor

Example: Pressure of gas at meter = 58” wg
Required gas flow = 95 ft³/min
Conversion factor = (58 x 0.00228) + 0.948 = 1.08
Reading on Meter = 95 / 1.08 = 88 ft³/min

3.5.5 Correction Factor for Burners Significantly Above Sea Level

Note: Above sea level i.e. >200m (1ft = 0.3048m)

Height above sea level in meters, Calculation for correction factor: =

(Pressure of gas at meter x 0.00228) + (0.948 – (height above sea level x 0.0001075))

Example: As above but 250 m above sea level:
Correction factor = (58x0.00228) + (0.948 – (250 x 0.0001075)) = 1.05

3.5.6 Gas Volume Conversion Factors

Assumed gas temperature	10 °C	50 °F
Standard pressure	e 760 mmHg	101.3612 Kpa
Standard temperature	15.56 °C	
Ambient pressure	101.325 Kpa	

Wg "	PSI	mmH2O	mmHg	Kpa	mBar	Conversion factor
1	0.036	25.4	1.867	0.249	2.49	1.0218
2	0.072	50.8	3.734	0.498	4.98	1.0243
3	0.108	76.2	5.601	0.747	7.47	1.0268
4	0.144	101.6	7.468	0.996	9.96	1.0293
5	0.181	127	9.335	1.245	12.451	1.0318
6	0.217	152.4	11.202	1.494	14.941	1.0343
7	0.253	177.8	13.069	1.743	17.431	1.0368
8	0.289	203.2	14.936	1.993	19.921	1.0393
9	0.325	228.6	16.804	2.242	22.411	1.0418
10	0.361	254	18.671	2.491	24.901	1.0443
15	0.542	381	28.006	3.736	37.352	1.0569
20	0.722	508	37.341	4.981	49.802	1.0694
25	0.903	635	46.677	6.227	62.253	1.0819
30	1.083	762	56.012	7.472	74.703	1.0944
35	1.264	889	65.347	8.717	87.154	1.107
40	1.444	1016	74.682	9.963	99.604	1.1195
45	1.625	1143	84.018	11.208	112.055	1.132
50	1.805	1270	93.353	12.453	124.505	1.1445
55	1.986	1397	102.688	13.699	136.956	1.1571
60	2.166	1524	112.024	14.944	149.406	1.1696
65	2.347	1651	121.359	16.189	161.857	1.1821
70	2.527	1778	130.694	17.435	174.307	1.1947
75	2.708	1905	140.03	18.68	186.758	1.2072
80	2.889	2032	149.365	19.925	199.208	1.2197
85	3.069	2159	158.7	21.171	211.659	1.2322
90	3.25	2286	168.035	22.416	224.109	1.2448
95	3.43	2413	177.371	23.661	236.56	1.2573
100	3.611	2540	186.706	24.907	249.01	1.2698
110	3.972	2794	205.377	27.397	273.911	1.2949
120	4.333	3048	224.047	29.888	298.812	1.3199
130	4.694	3302	242.718	32.379	323.713	1.345
140	5.055	3556	261.388	34.869	348.614	1.37
150	5.416	3810	280.059	37.36	373.515	1.3951
160	5.777	4064	298.73	39.851	398.416	1.4201
170	6.138	4318	317.4	42.341	423.317	1.4452
180	6.499	4572	336.071	44.832	448.218	1.4703
190	6.86	4826	354.741	47.323	473.119	1.4953
200	7.221	5080	373.412	49.813	498.02	1.5204

How to use this information:

1. Measure Volumetric flow of gas for 1min in ft3 (i.e. ft3/min). Note 1m3 = 35.31ft3.
2. Multiply this volume flow by 60 to give volumetric flow per hour (i.e. ft3/hr).
3. Measure the pressure of the gas supply.
4. Use the table above to obtain a conversion factor.
5. Multiply the volume flow per hour by the conversion factor to obtain a volume at reference conditions.
6. For natural gas, the calorific value is typically 1000 Btu/ft3. To obtain the firing rate of the boiler at standard reference conditions multiply the volume at reference conditions by 1000.

Represented as an equation:
Firing rate = (Measured Volumetric flow per minute x 60 x Conversion factor x 1000) Btu/hr.

3.6 Gas/Air Pressure Commission

To commission the gas pressure sensor, go to Commission Mode and press Gas Pressure Commission. The MM will then run through the points to store the gas pressure values.

If the VPS is optioned on, the unit will run through this valve proving process. The MM will go from Low Fire to High Fire and store the gas pressure values along the curve. Once these values are stored, the upper and lower offset limits will be adjusted to the new commissioned gas pressure values.

If the burner turns off during the gas/air pressure commission, the gas/air pressure commission process will be restarted. This ensures that the MM does not run with an incomplete set of gas/air pressure readings.

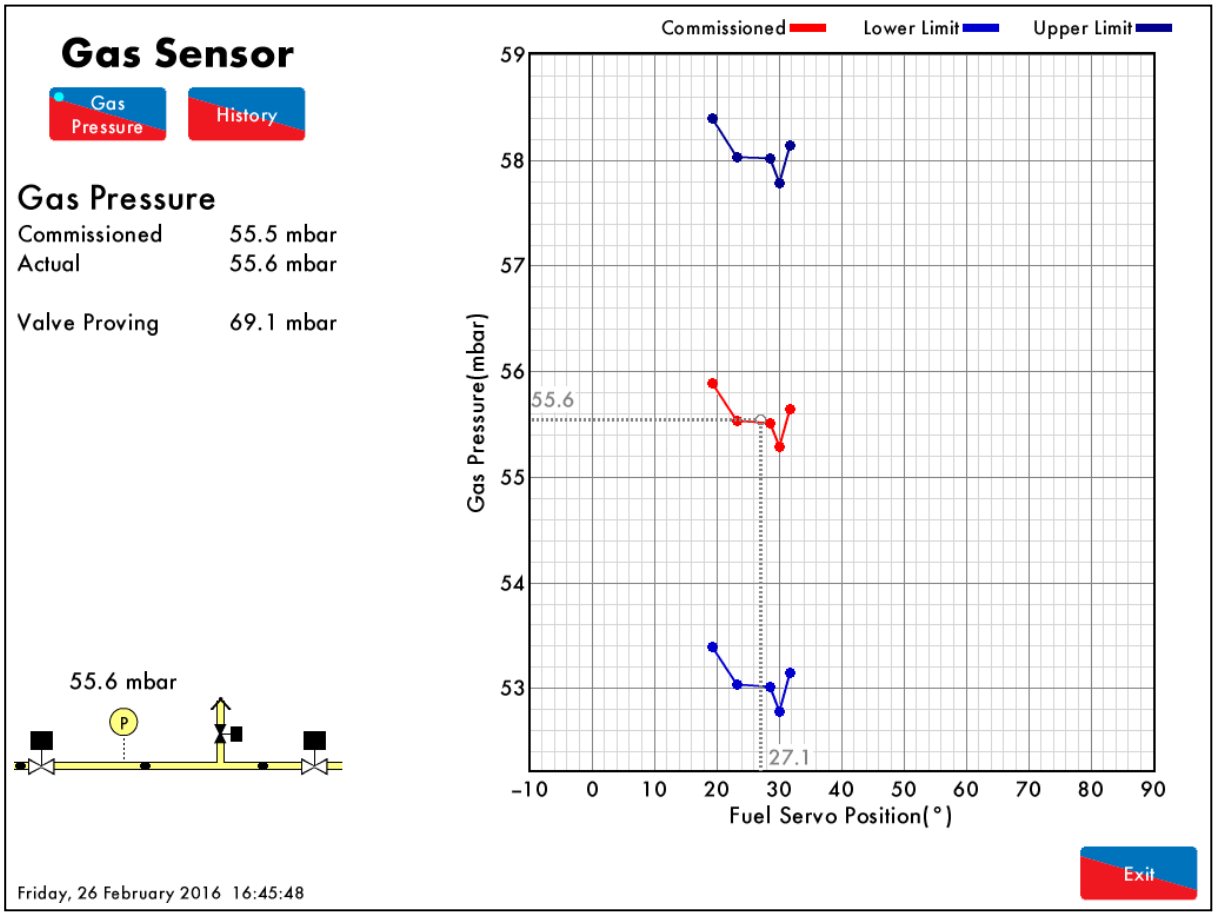


Figure 3.6.i Gas Sensor

To commission the air pressure sensor, in Commission Mode screen press Air Pressure Commission. The air pressure sensor commission procedure is the same as the gas pressure sensor commission procedure. The same procedure also applies for commissioning the oil pressure sensor.

Note: If the gas or air pressure sensor is replaced with the same sensor type (same pressure range) then the sensor will not need to be recommissioned.

Note: For applications where VPS is required after burner shutdown only, the option/parameter 129 should be set to 0 when doing the first gas sensor commission on the system to store the valve proving gas pressure. During normal running, option/parameter 129 can be set to 1.

3.7 Single Point Change

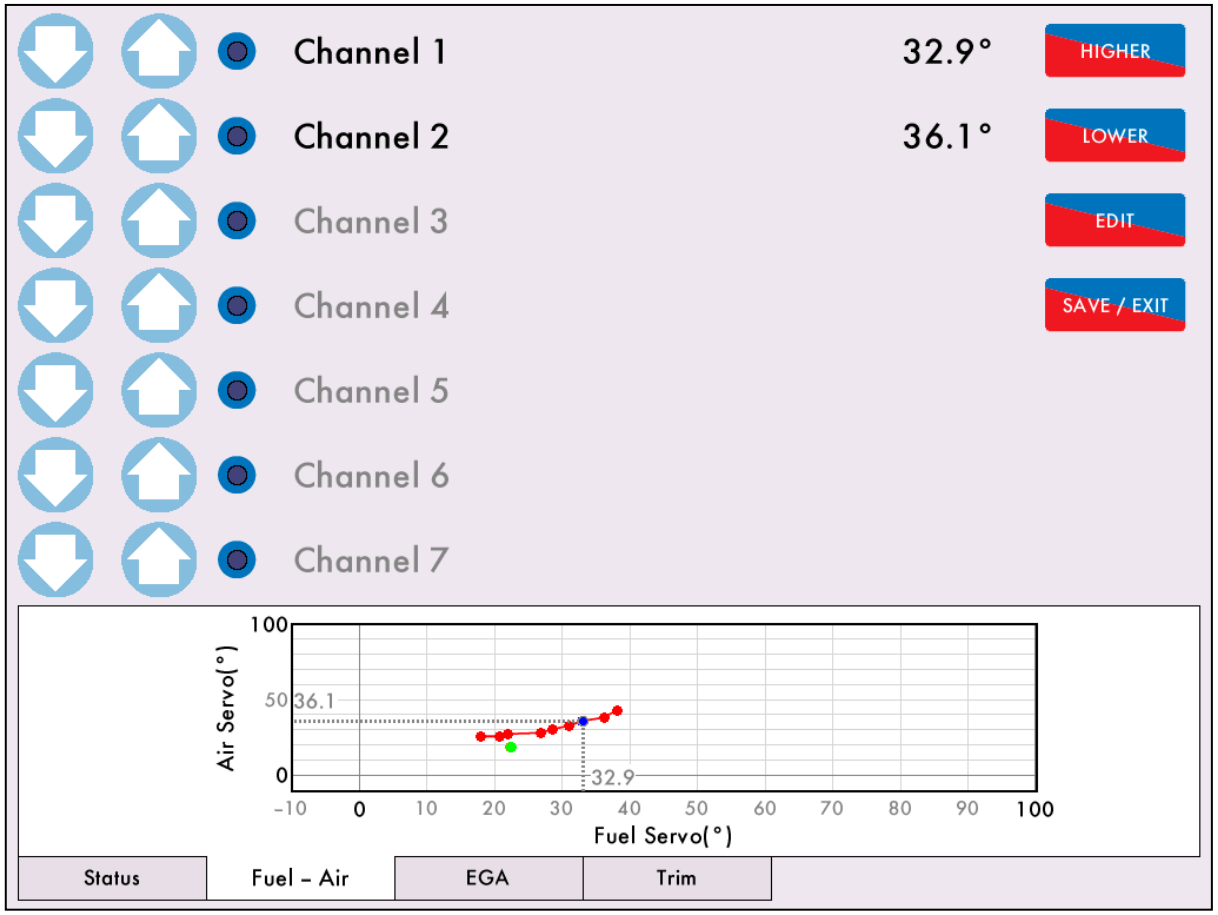


Figure 3.7.i Single Point Change

Single Point Change can only be accessed when the burner is firing and in Run mode. Press Single Point Change in the system configuration screen and enter the password to access Single Point Change mode.

Select the point to be edited or added trim to by pressing HIGHER or LOWER to go up and down the fuel curve, then press EDIT.

The Status screen will display the message ‘Select change to make’.

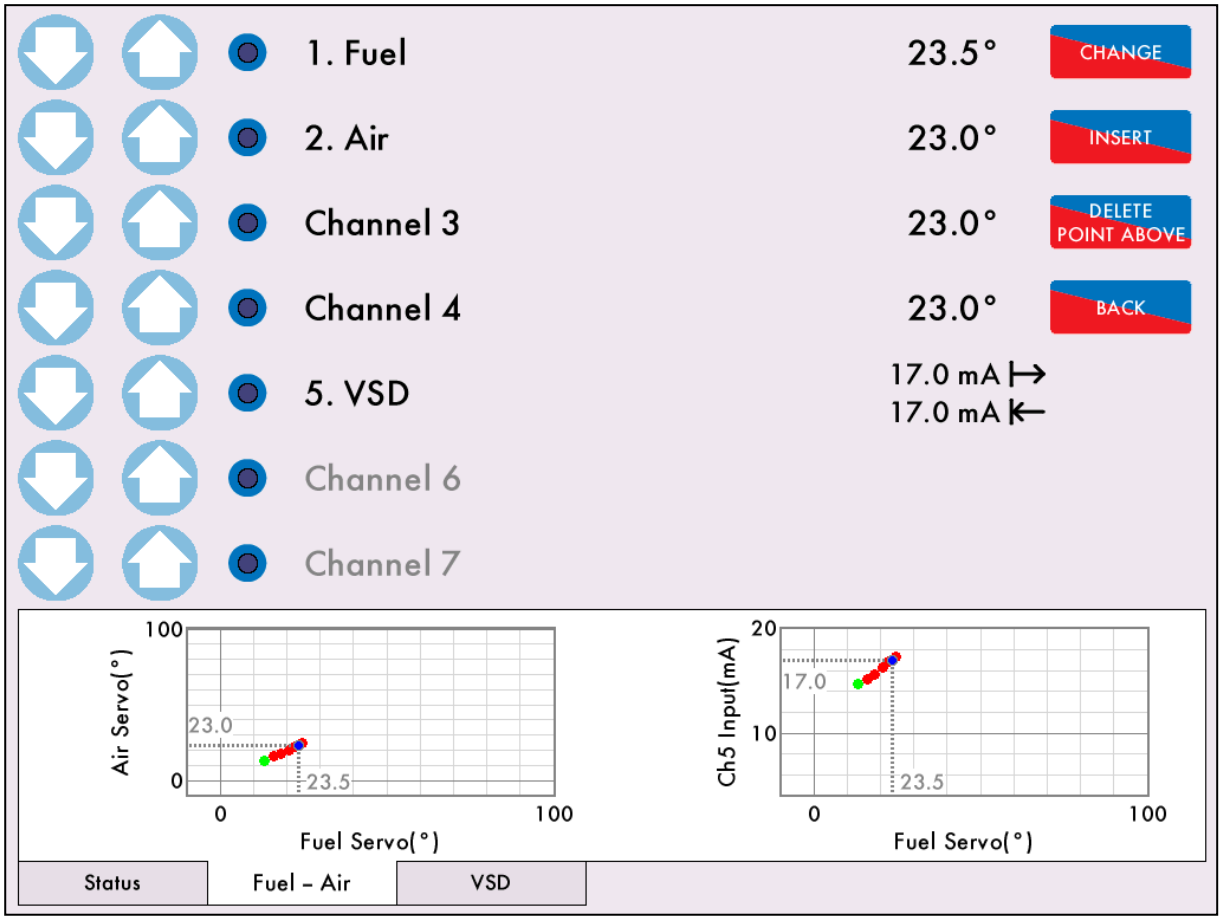


Figure 3.7.ii Changes

To edit a previously entered point press CHANGE and make adjustments to the positions as needed (see Figure 3.7.i).

To enter a new point press INSERT.

To delete a point on the curve, move to a point below that one to be deleted and press DELETE POINT ABOVE.

Press CONFIRM to confirm the change.

Note: It is not possible to delete LOW or HIGH FIRE positions or have less than 3 INTER points.

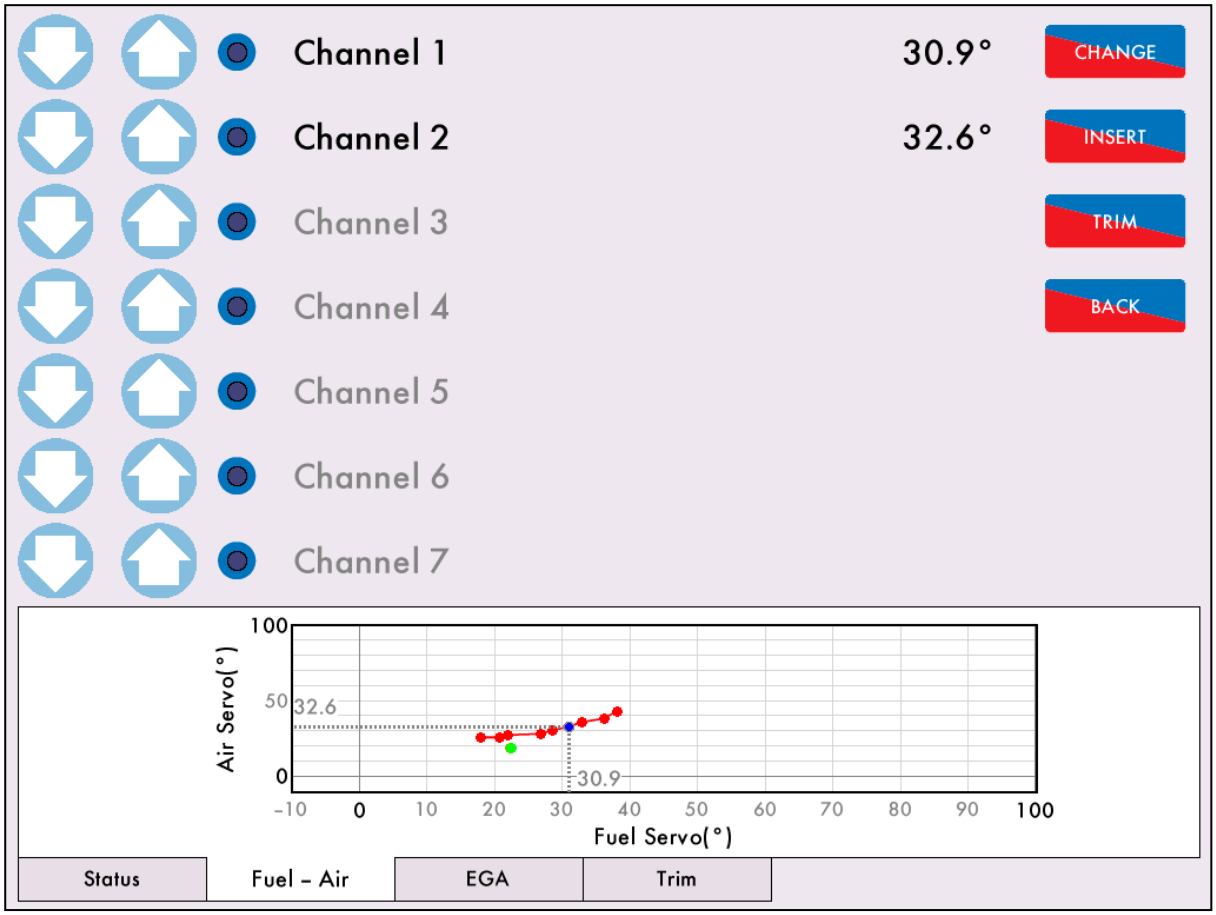


Figure 3.7.iii Changing a point in single point change

Press MOVE to edit the fuel, air and/or VSD commissioned value of that point. Once the changes have been made, press ENTER to save this position. If a point is overwritten, the trim data is cleared and the trim data will need to be added.

Press DELETE to remove the point; there must be a minimum of 3 INTER points.

To add trim data to a point press 

, see section 3.4.6.

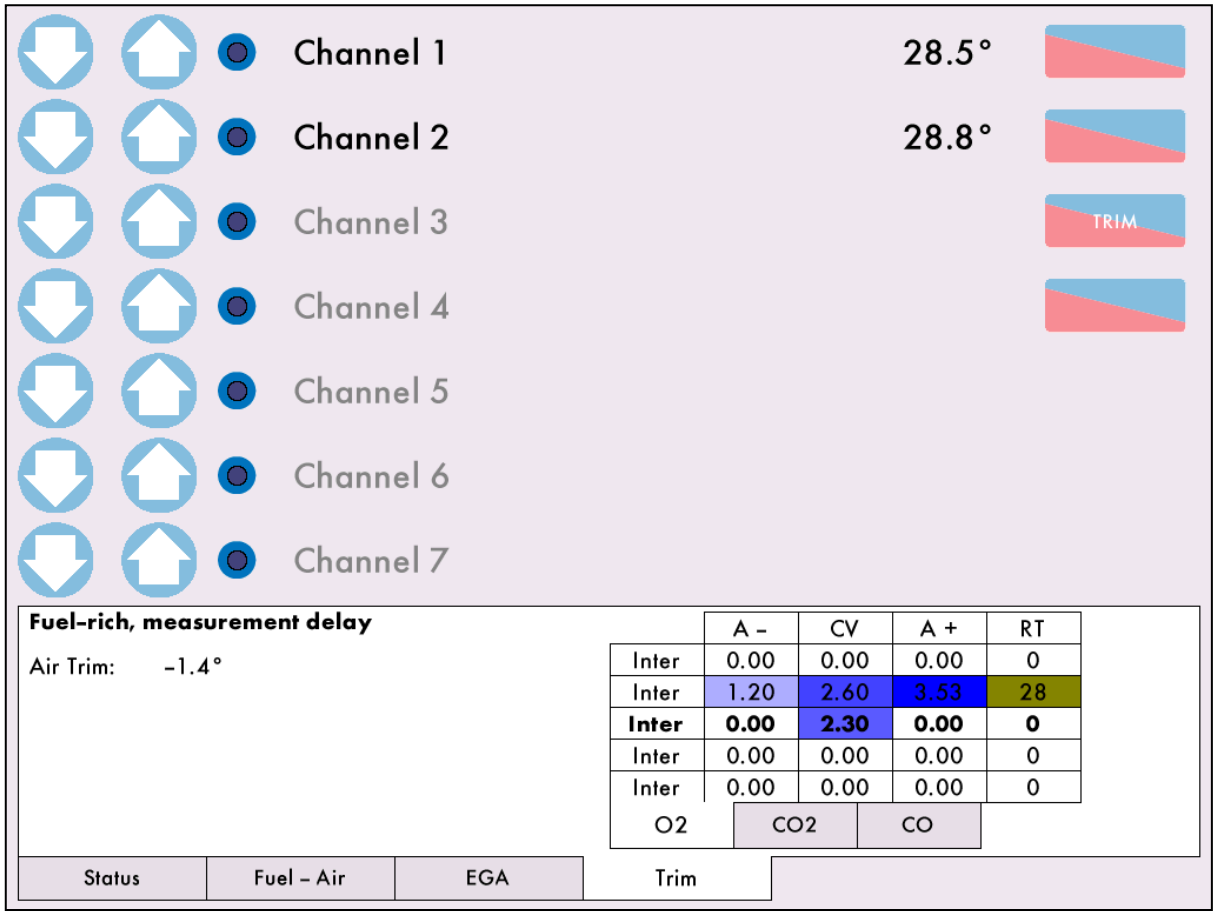


Figure 3.7.iv Single Point Change – Trim

The MM will store the trim values for this position.

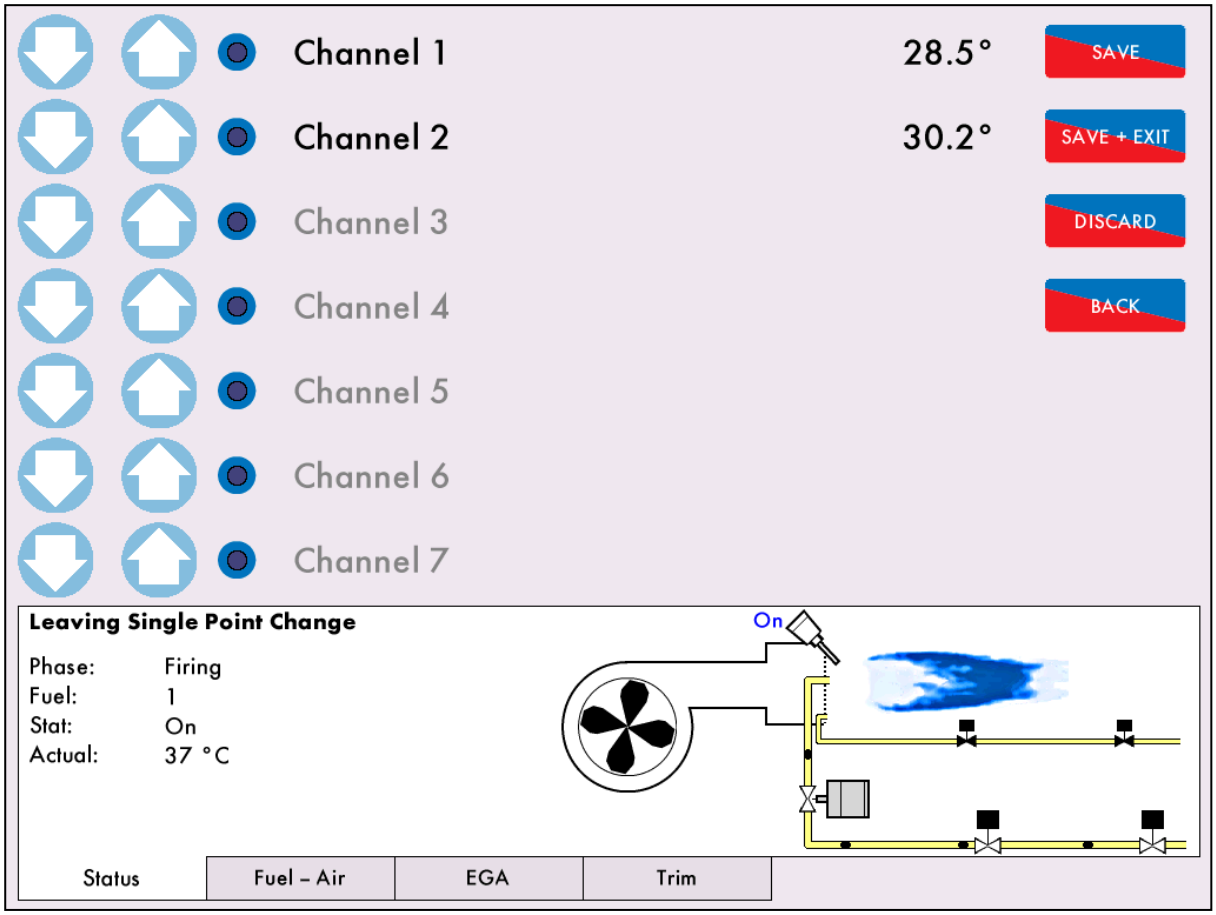


Figure 3.7.v Exit Single Point Change

Press 

to store the changes made. Press 

to store these changes and leave Single Point Change mode.

The fuel flow commissioning must be entered (again) if the following changes are made in single point change

- HIGH or START position is changed.
- EGA trim data has been added.
- Points have been added.

Please see section 3.5 Fuel Flow Commissioning.

3.8 Online Changes

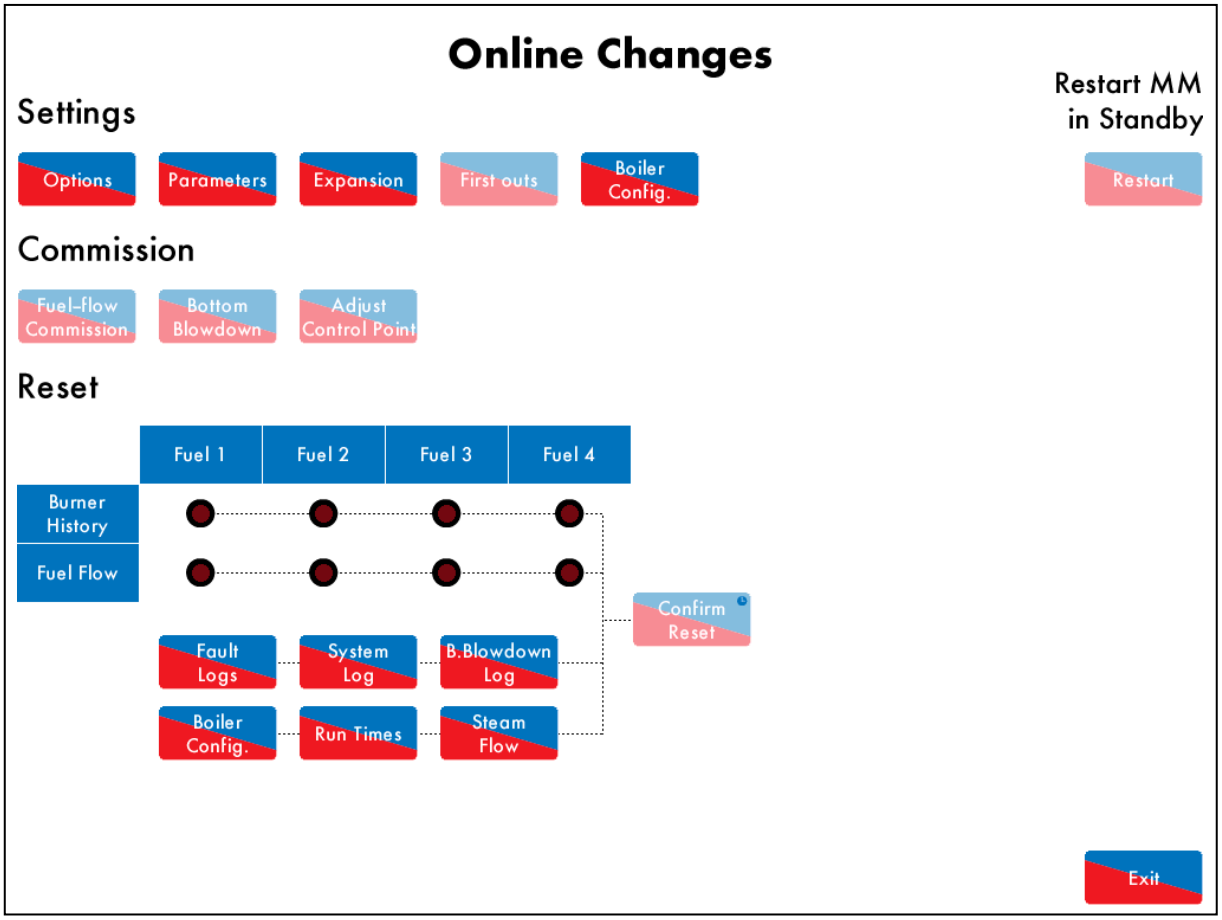


Figure 3.8.i Online Changes Screen

The Online Changes is accessed by pressing 

on the system configuration screen, and then entering the password. The Online Changes feature allows the following:

- Change non-safety critical options, parameters and expansion options.
- Configure settings and labels for first outs.
- Fuel flow commissioning.
- Set bottom blowdown servomotor positions.
- Adjust water level control point.
- Reset burner history.
- Reset fuel flow data.
- Reset fault logs.
- Reset system log.
- Reset bottom blowdown log.
- Reset boiler configuration.
- Reset run times.
- Reset steam flow metering.
- Restart MM if the burner is in standby.

3.9 Setpoint Schedule

3.9.1 Setpoint Schedule Overview

Some application require variable heat output level during different hours of the day or different days of the week or both, for example different production levels or building heating requirements, the user might want to have the setpoint to vary during the day or during the days of the week or both.

Setpoint Schedule allows the user to configure the setpoint to vary during the day or the week or both. It can be setup on the MM screen in Online Changes mode once the MM has been commissioned

Setpoint Schedule is an MM Expansion Feature that requires the purchase of an unlock code (part # MK8011), this must be uploaded to the MM via Autoflame Download Manager software, please see Autoflame Software Guide for more details.

3.9.2 Configuring Setpoint Schedule

From the main MM screen, press Configure then Setpoint Schedule, enter the Online Changes password to access the Setpoint Schedule setup screen.

Press the Disable button on the top right corner of the screen, this will turn to Enabled allowing the user to make changes to the schedule.

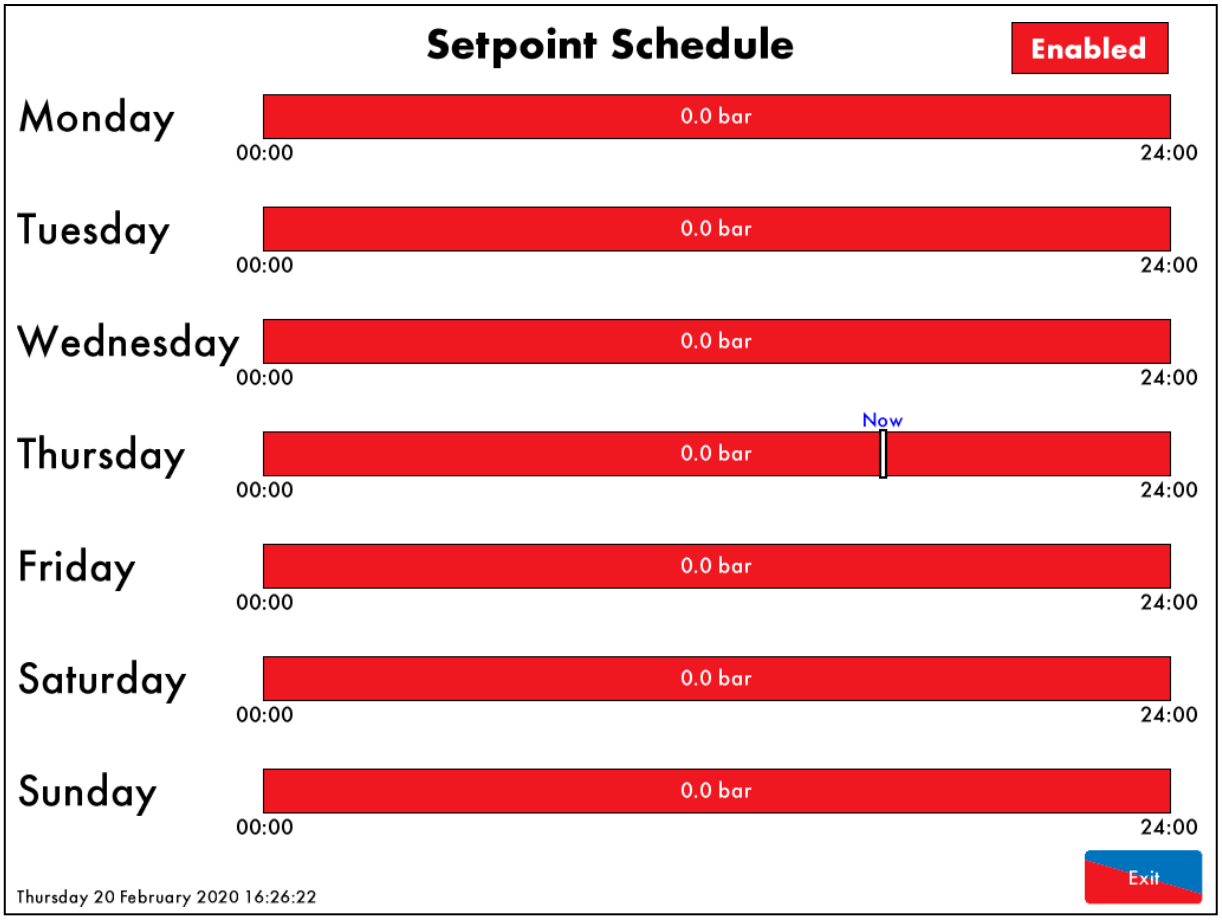


Figure 3.9.2.i: Setpoint Schedule screen

Select the day on which you want to make changes, use the black dot  in a drag-and-release motion to set the time periods that you want to define a different setpoint for.

By taping on the block dot, it will be activated and appear with green frame  indicating that the setpoint after it can be changed using the setpoint up and down value arrows

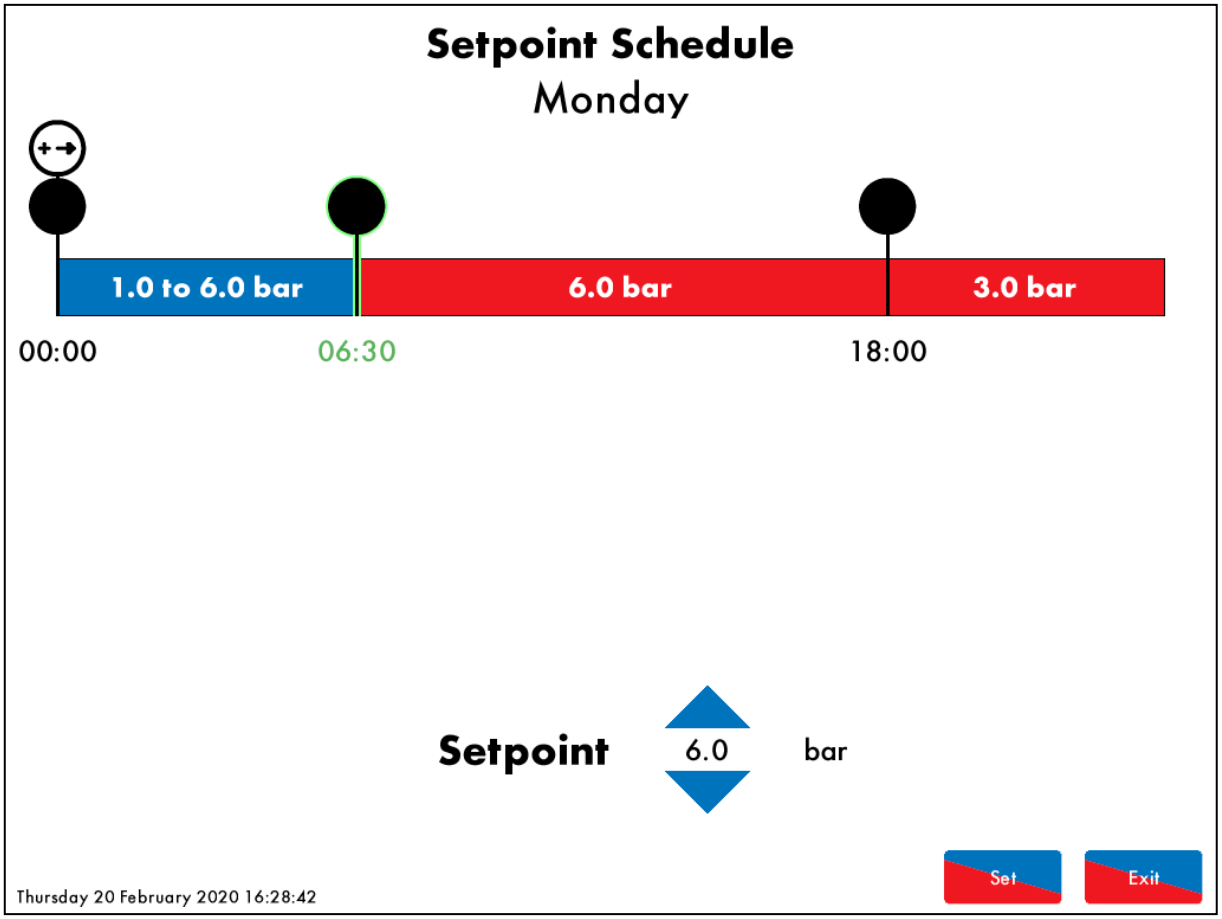


Figure 3.9.2.ii: Setting different setpoints throughout the day

To set a variable or gradual setpoint for a specific period of time, tap on the red bar, its colour will change to blue, specify the start and end setpoints using the up and down arrows.

After setting the setpoint, click  to store the settings or click  to exit without saving the changes.

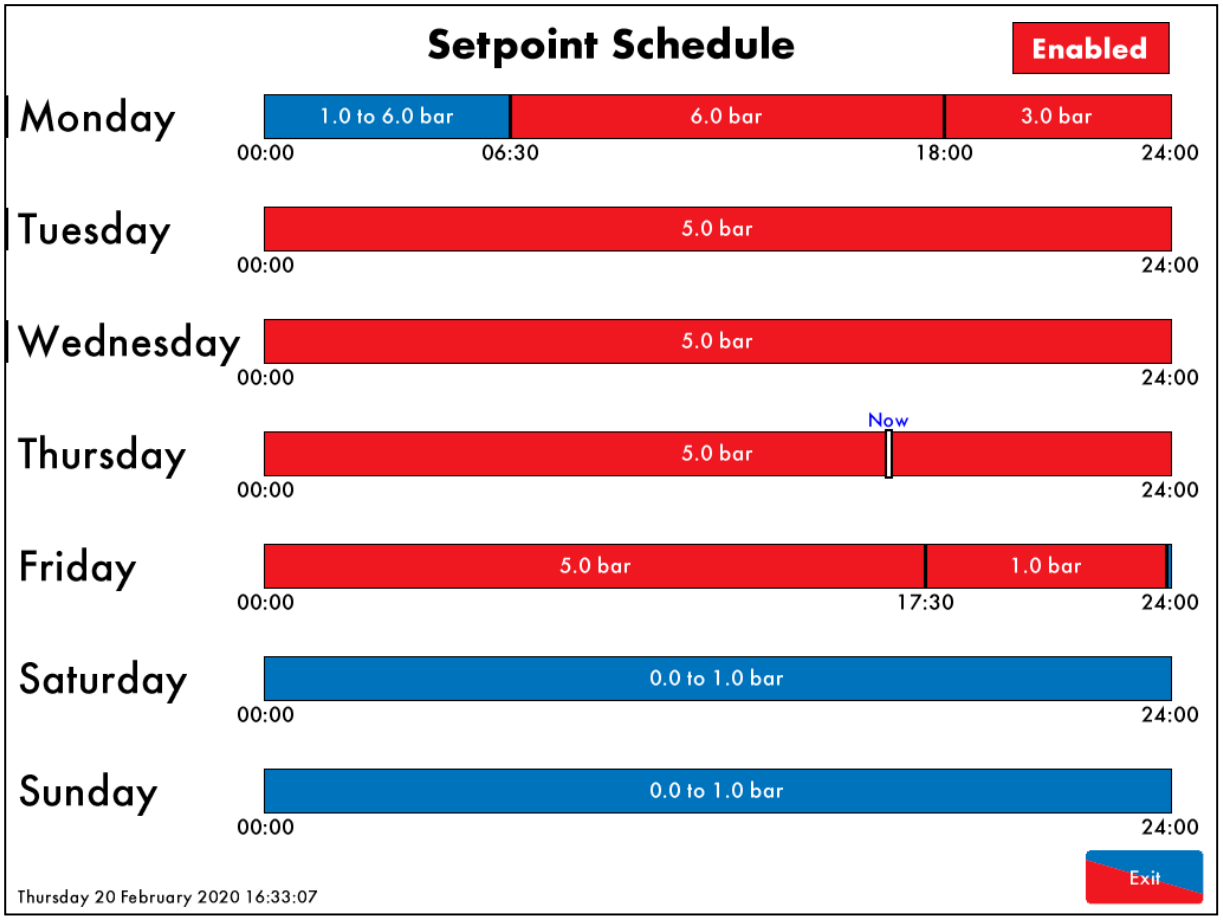


Figure 3.9.2. iii: Different setpoints configured throughout the week using Setpoint Schedule

3.10 Setpoint Programs

3.10.1 Setpoint Programs Overview

Setpoint programs gives the user more flexibility in terms of timing such as, Setpoints can be fixed or ramp between two values over any period of time. You can also disable the burner for a timed period. Setpoint Programs can be setup from the system configuration menu. Up to 8 different programs can be configured, with their being a limit of 16 events per program.

Setpoint Programs is an MM Expansion Feature that requires the purchase of an unlock code (part # MK8012), this must be uploaded to the MM via Autoflame Download Manager software, please see Autoflame Software Guide for more details.

3.10.2 Configuring Setpoint Programs

From the main MM screen, press 

then 

, enter the Online Changes password to access the Setpoint Programs setup screen.

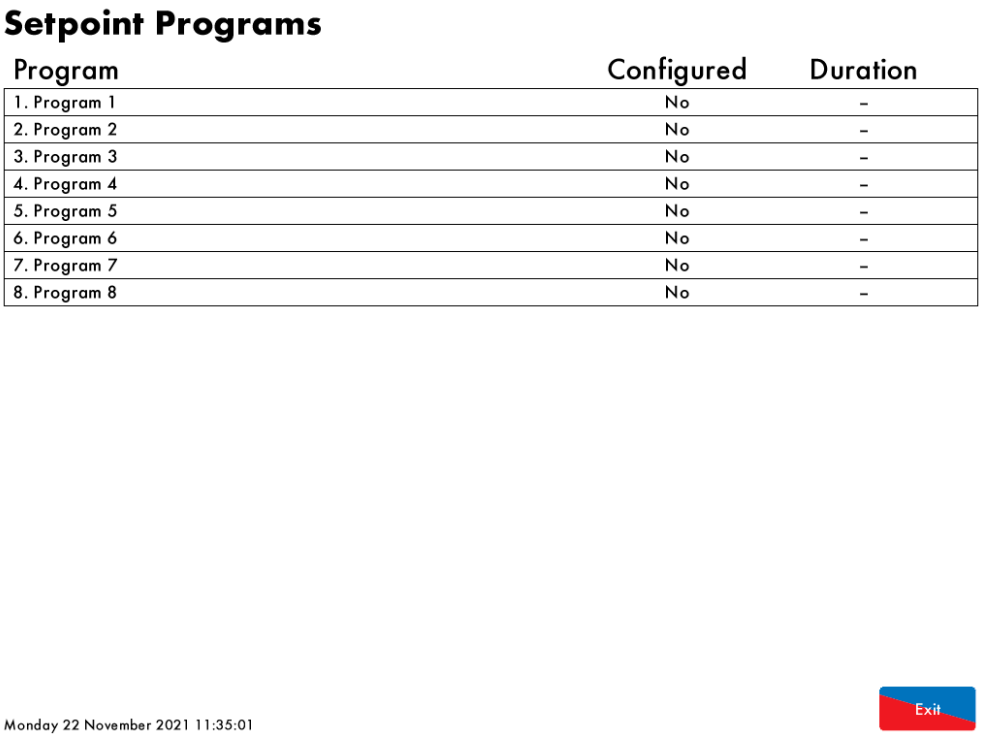


Figure 3.10.2. i: Setpoint Program screen

Once you select a program to configure, you'll enter into the edit program screen as shown on Figure 3.10.2. ii.

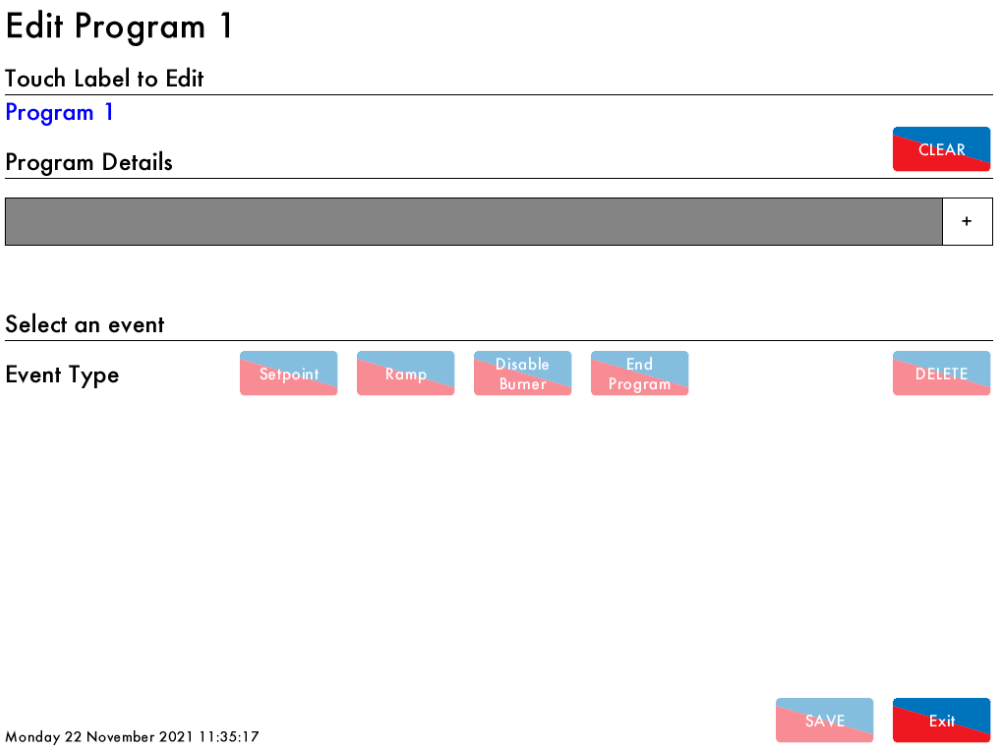


Figure 3.10.2. ii: Creating a setpoint program

To create a program, start by pressing the + button, this allows the user to create an event by setting the setpoint, ramp the temperature or pressure & disable the burner. The programs have an optional "end" command which will return to other setpoint methods (internal/DTI/etc) after the program time has elapsed or can stay in the program at the final setpoint value indefinitely.

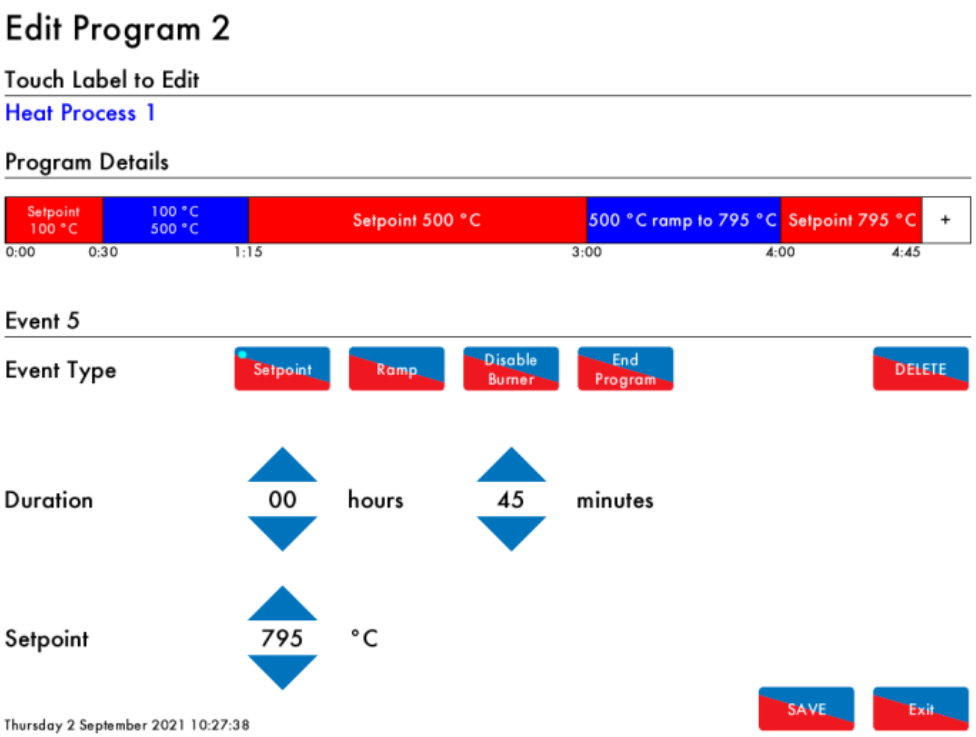


Figure 3.10.2. iii: Example of creating a program showing event types, duration of the program.

Once a program is running the operator can:

- Pause the program (holding the current setpoint)
- Stop the program
- Adjust the current program time, skipping ahead or going back to some other part of the program. For instance, a boiler gradual warm-up program could be started at the current boiler temperature.

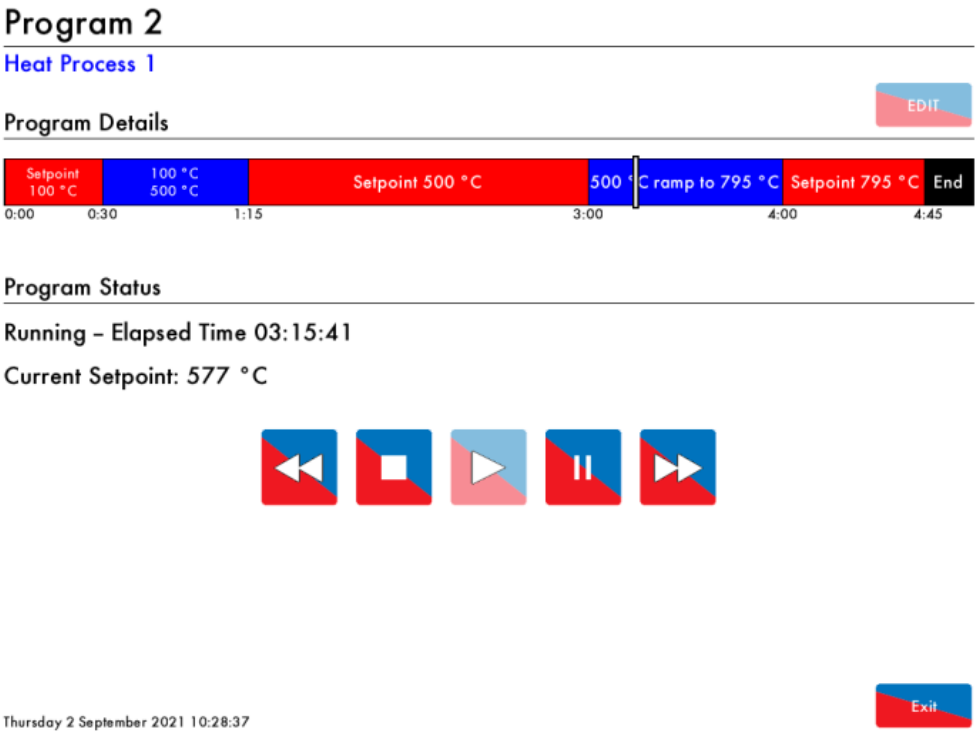


Figure 3.10.2. iv: Setpoint program currently running.

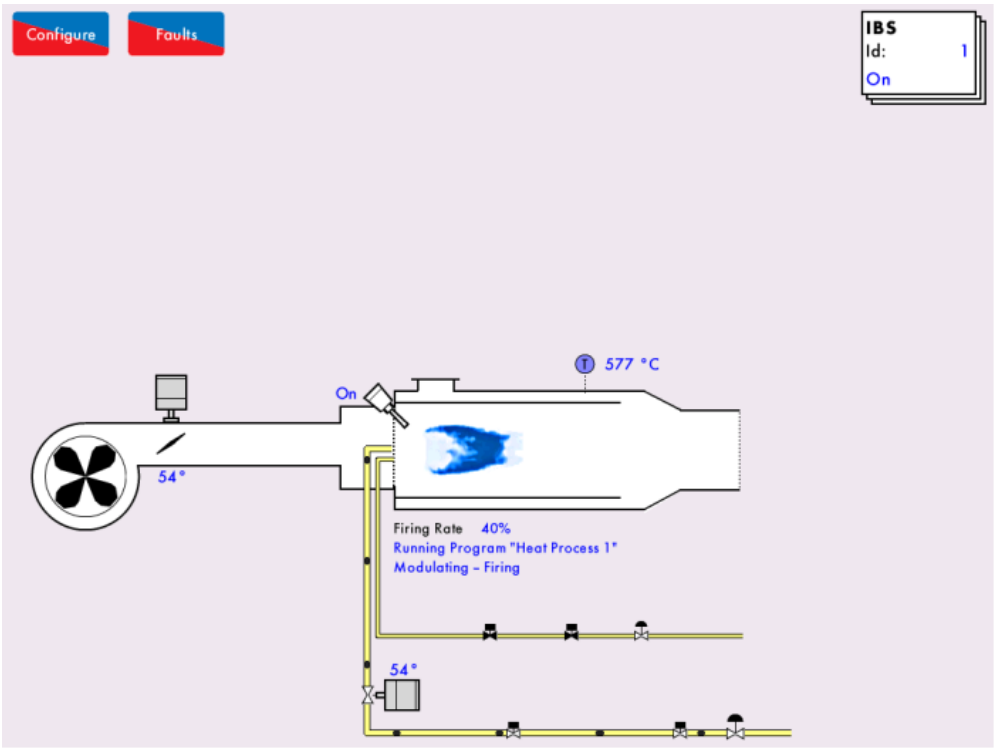


Figure 3.10.2. v: Setpoint program running.

Programs can be edited (behind the online-changes password) so long as one isn't running.

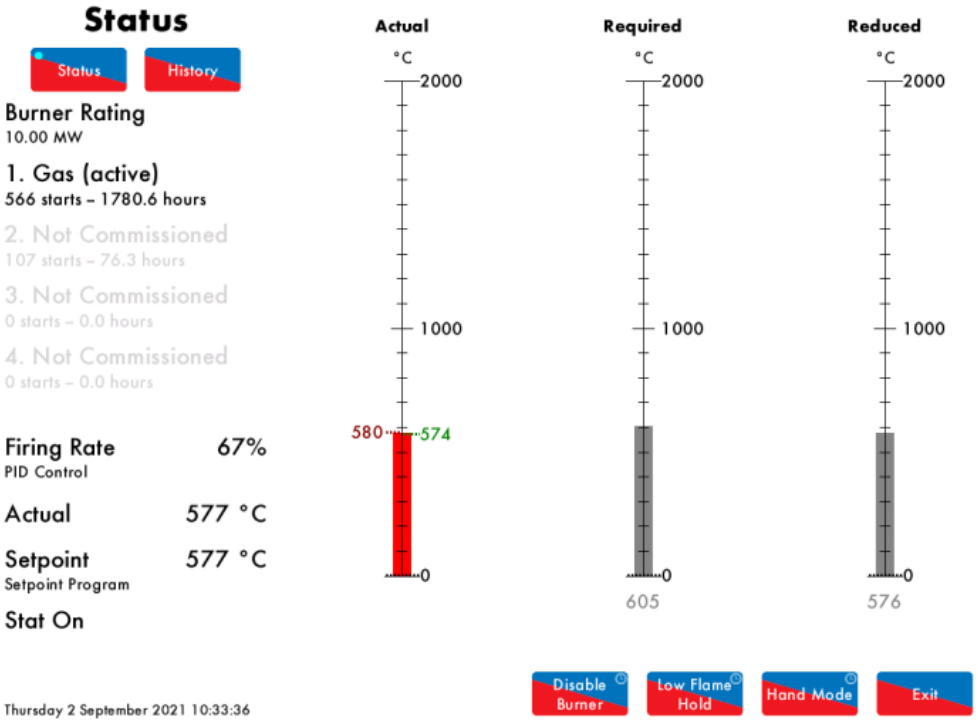


Figure 3.10.2. v: Status screen indicating that the Setpoint program running.

4 FUEL OUTPUT MODES & CHANGEOVER OPTIONS

4.1 Overview

The Mk8 MM has the capability of controlling multi-fuel applications in various ways; it offers the possibility of commissioning up to 4 different fuels as well as offering 3 different ways of switching between fuels.

The MM's default Single Fuel Output Mode allows the commissioning of up to 4 different fuel curves using the same set of fuel outputs and changing between fuels is possible using changeover relays. The Dual Fuel Output Mode allows the configuration and commissioning of 2 different fuels using individual set of outputs for each fuel on the MM and therefore no changeover relays are required when switching between fuels.

The fuel Change on the Fly feature (COF) offers the possibility of switching between fuels configured in Dual Fuel Output Mode without the need to turn off the burner, thus eliminating downtimes when switching between fuels, reducing heat loss from the pre and post-purge processes as well as reducing thermal stress on the boiler. COF also opens the possibility of setting up automatic fuel switchover (for example when the main fuel is running low).

The system and burner suitability must be considered before setting up the fuel output mode or configuring a system for COF.

PLEASE NOTE: External VPS can't be used with dual fuel output / COF mode.

4.2 Fuel Output Modes on the Mk8 MM

Option / Parameter 131 (Fuel Valve Output Configuration) allows multi-fuels to be configured in 2 different ways on the Mk8 MM:

1) Single Fuel Output Mode (SFOM) – One Set of Fuel Outputs
This is the standard (default) mode, it allows the configuration and commissioning of up to 4 different fuels using single set of outputs on the MM, switching between fuels is possible through the use of changeover relays.

2.a) Dual Fuel Output Mode (DFOM) – Two Sets of Fuel Outputs
Available as standard, it allows 2 fuels to be configured and commissioned using 2 separate sets of fuel outputs on the MM (2 main valves and one vent valve) and inputs (Proof of closure/ CPI). No changeover relays are required to change between fuels in DFOM.

2.b) Dual Fuel Output Mode with Change on the Fly (DFOM-COF)
This mode operates in the same way as Dual Fuel Output Mode but also allows switching between fuels while the burner is firing.

When COF is enabled and fuel select is triggered while the burner is firing, the burner simply modulates to low fire. The air damper angle is increased to allow extra air for both fuels to fire at the same time, and the second fuel is introduced so both fuels fire simultaneously for a short period of time. The first fuel is then turned off and the burner modulates up to the required firing rate without turning off the burner. The MM still runs through all the standard safety checks.

The Changeover on the Fly is an unlockable feature that requires the purchase of unlock code (COF) before it can be optioned, this can be uploaded to the MM via IR Lead using Autoflame Download Manager software (version 8.13 and above). COF is available only on Revision 4 of the Mk8 MM, for more information please contact Autoflame.

Option 131 Setting	Fuel valve output configuration
0	One set of outputs (changeover relays, 4 fuels)
1	Two sets of outputs (no changeover relays, 2 fuels) - Default
2	Two sets of outputs, change on the fly (COF)*

The fuel curves must be commissioned according to the optioned fuel output mode, so if Single Fuel Output Mode is optioned, the fuels must be commissioned in Single Fuel Output Mode. Changing the fuel valve Output Mode requires recommissioning of any fuel used in that mode.

4.3 Single Fuel Output Mode (SFOM)

Single Fuel Output Mode (SFOM) is the standard (default) mode of operation for the Mk8 MM, it can be selected by setting Option/ Parameter 131 to 0. In this mode it is possible to configure and commission 4 fuels utilising the main set of fuel outputs on the MM and using changeover relays.

4.3.1 Fuel Configuration and Wiring in SFOM

In Single Fuel Output Mode, up to 4 fuels are wired to the MM's main fuel output terminals using changeover relays:

- All configured fuels are controlled by the same fuel channel.
- Combustion air is controlled by a defined air damper channel and/or VSD channel.
- All fuels use the same Proof of Closure / CPI input.

Terminal	Description	Function
T60	Main Fuel Valve 1	Mains voltage output for valve 1 - fuel 1
T61	Main Fuel Valve 2	Mains voltage output for valve 2 - fuel 1
T55	Main Fuel Valves CPI/POC	Proving Circuit – Fuel 1 Proof of Closure
T62	Main Fuel Vent Valve	Mains voltage output – vent valve
T31,32,33 & 34	Main Fuel Gas Pressure Sensor	In case of gaseous fuel
T35, 48 & 49	Main Fuel Oil Pressure Sensor	In case of liquid fuel

4.3.2 Pressure Sensors in SFOM

The same fuel pressure sensor is used for all fuels configured in SFOM for valve proving and/or limits testing, and it can be switched over from one fuel to another using a changeover relay. Only the fuel that is firing is checked; the inactive fuels are not checked.

4.3.3 Commissioning in SFOM

When using SFOM any fuels used have to be commissioned in Single Fuel Output Mode, therefore fuels commissioned in DFOM will require recommissioning.

The fuels can use the same servo channels, also it is possible to use the same servo motor to control multi- fuels using the 'piggyback' valve arrangement.

4.3.4 Fuel Changeover Process in SFOM

Fuel changeover is possible in SFOM using changeover relays, when the fuel select input is changed on the MM, this will trigger an MM shutdown and restart on the newly selected fuel. The MM will go through the standard optioned safety checks during the process.

In SFOM, it is possible to switch between fuels at any MM phase (firing, standby, etc.).

4.4 Dual Fuel Output Mode (DFOM)

Dual Fuel Output Mode (DFOM) can be selected by setting Option / Parameter 131 to 1. The main MM screen displays the fuel trains for fuel 1 and 2 based on the optioned fuel types (Option 150/151), with fuel 1 displayed on the right side of the screen and fuel 2 on the left, it is also possible to display 2 gas fuels or 2 oil fuels at the same time. In this mode the boiler configuration setting for fuel trains displayed (Option 15) has no effect.

4.4.1 Fuel Configuration and Wiring in DFOM

In Dual Fuel Output Mode both fuels are wired directly to the MM using 2 independent sets of outputs without the use of relays:

- Fuel 1 is controlled by Channel 1.
- Fuel 2 is controlled by Channel 3.
- Air is controlled by Channel 2 (and a VSD channel if using a VSD).

“Proof of Closure” (CPI) inputs are required for both fuels and must remain active for the non-firing fuel while firing on the other fuel.

Terminal	Description	Function
T60	Main Fuel Valve 1	Mains voltage output for valve 1 - fuel 1
T61	Main Fuel Valve 2	Mains voltage output for valve 2 - fuel 1
T55	Main Fuel Valves CPI/POC	Proving Circuit – Fuel 1 Proof of Closure
T62	Main Fuel Vent Valve	Mains voltage output – vent valve
T31,32,33 & 34	Main Fuel Gas Pressure Sensor	In case of gaseous fuel
T35, 48 & 49	Main Fuel Oil Pressure Sensor	In case of liquid fuel
T64	2nd fuel Valve 1	Mains voltage output for valve 1- fuel 2
T83	2nd Fuel Valve 2	Mains voltage output for valve 2 - fuel 2
T82	2nd Fuel Valves CPI/POC	Proving Circuit – Fuel 2 Proof of Closure
T84	2nd Fuel Vent Valve	Mains voltage output – vent valve
DT+, DT-, DP-& DP+	2nd Fuel Gas Pressure Sensor	In case of gaseous fuel

4.4.2 Pressure Sensors in DFOM

If 2 gas fuels are going to be configured in DFOM, 2 separate gas pressure sensors may be used for both fuels simultaneously for the purpose of limits testing as well as valve proving, depending on Options 125 & 126 setting.

The main gas pressure sensor which can be wired to terminals 31-34 on the main MM board is used for Fuel 1, an additional gas pressure sensor can be used for fuel 2 if required; this can be wired to terminals (DT+, DT-, DP-, DP+) on the MM Expansion Board.

Valve proving may be used with or without a vent valve (Option 130 setting 2 or 3).

If 2 liquid fuels are configured in DFOM, it is not possible to use pressure sensors for both fuels at the same time.

4.4.3 Commissioning in DFOM

When using Dual Fuel Output Mode, any fuels used must be commissioned in Dual Fuel Output Mode, therefore fuels commissioned in SFOM will require recommissioning.

Fuel 1 uses channel 1 for fuel and channel 2 for air. Channel 3 is not available when running fuel 1 since it is permanently assigned to fuel 2. When commissioning fuel 1 the closed position for servo channel 3 should be set, but it will not be possible to move servo channel 3 after this.

Fuel 2 uses channel 3 for fuel and channel 2 for air. Channel 1 is not available when running fuel 2 since it is permanently assigned to fuel 1. When commissioning fuel 2 the closed position for servo channel 1 should be set, it will not be possible to move servo channel 1 after this.

IMPORTANT: If a VSD is used to control the air fan in addition to the air damper servo, it is very important to have similar VSD signal output on both fuels commissioned in Dual Fuel Output Mode.

4.4.4 Fuel Changeover Process in Dual Fuel Output Mode

On a system configured in Dual Fuel Output Mode, when fuel select is triggered on the MM, fuel changeover will only take place if the MM is in one of the following modes:

- In normal “Run” mode the fuel can be changed while the burner is in the Recycle or Standby states.
- In “Commission Mode” the fuel can be changed while in the commission menu screen (but not in the commissioning screen).
- In “Run” mode if the fuel input is changed while firing, it will cause a burner shutdown, allowing the fuel to be changed when Recycle/Standby state is reached.

The selected fuel must be commissioned in Dual Fuel Output Mode, if the newly selected fuel is not commissioned then a warning will appear indicating that the selected fuel cannot be run and the MM will continue in its current mode running on the same fuel (if the burner is firing then it will continue to fire on the current/original fuel). This warning will clear automatically when the fuel selection is returned to the current fuel.

If the burner is firing and the newly selected fuel has a gas pressure sensor optioned then a fuel pressure test will take place. The supply-side fuel valve for the newly selected fuel is briefly opened and the fuel pressure is measured. If the fuel pressure is within the optioned limits of the commissioned pressure for the new fuel, then the fuel changeover process may continue, otherwise the MM will continue to fire on the current fuel. This does not happen if an oil fuel is selected.

Failure of a gas pressure limits test at this point will trigger a warning indicating that low gas pressure prevented a fuel changeover. This warning will clear automatically when the fuel selection is returned to the current fuel. Selecting the new fuel again will perform another gas pressure test.

If the burner is firing and a burner shutdown is triggered, the shutdown will follow any optioned procedures such as low-fire shutdown, post-purge, valve proving, etc. If the current fuel is reselected while the burner is still firing the fuel change shutdown can be cancelled.

Once the MM reaches the Recycle/Standby state, the fuel changeover takes place and the burner will restart on the newly selected fuel.

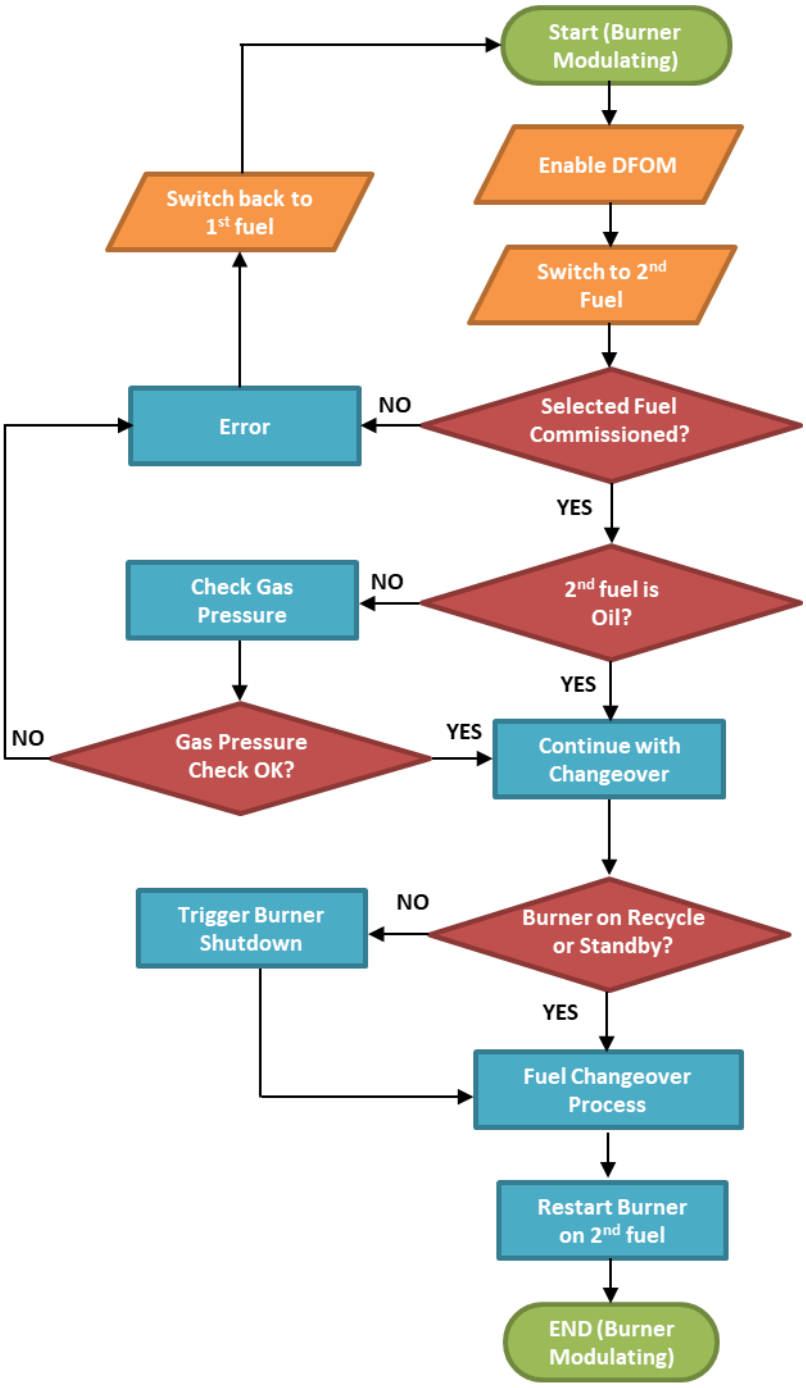


Figure 4.4.4: Fuel Changeover Process in Dual Fuel Output Mode

4.5 Fuel Change on the Fly (COF)

4.5.1 Overview

Fuel Change on the Fly (COF) can be optioned by setting option/parameter 131 to 2. In this mode, the fuel setup is the same as in Dual Fuel Output Mode, the fuel changeover process however, is completely different.

Fuel Change on the Fly is activated by applying live voltage input to terminals 91 and 92 simultaneously.When these inputs are active, a message “COF Enabled” is displayed on the MM’s main boiler screen.

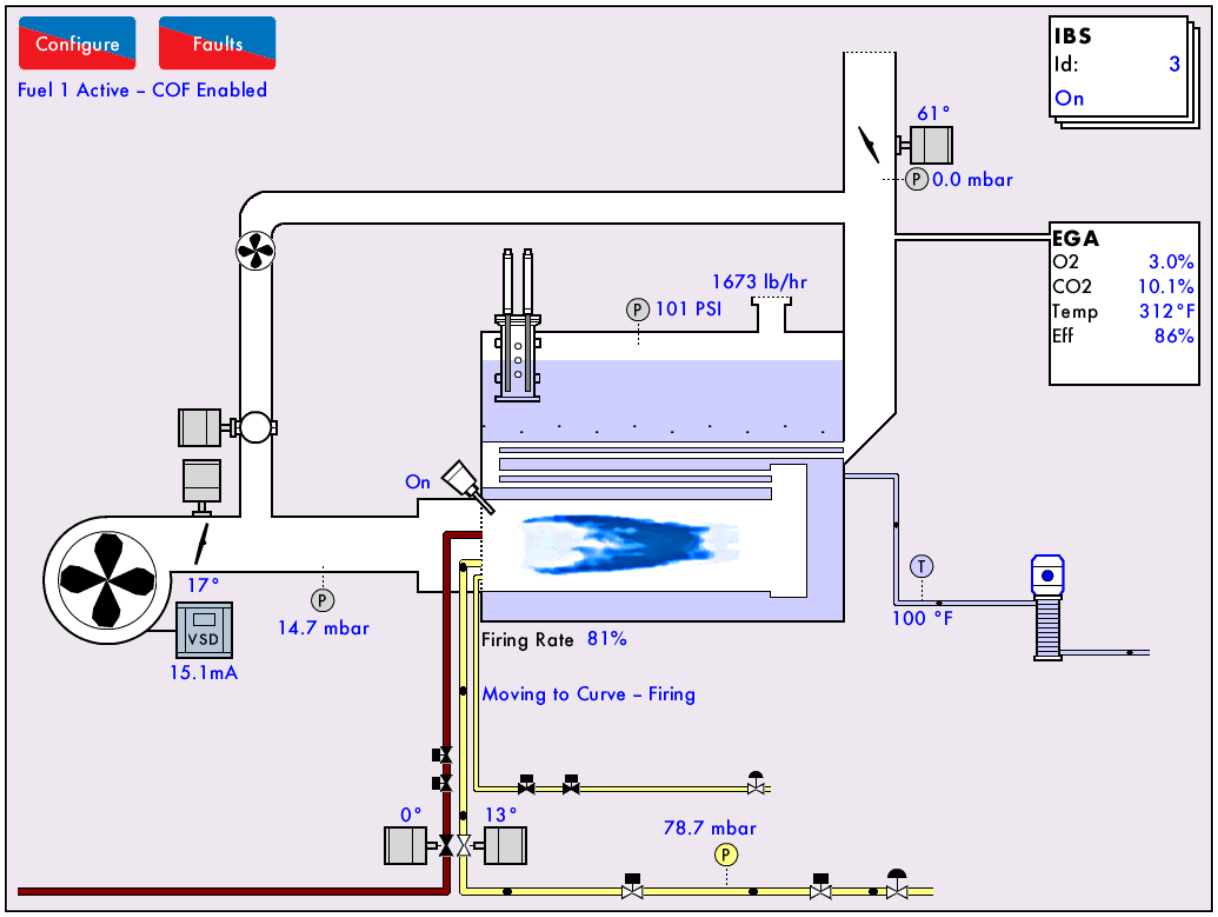


Figure 4.5.1: The main MM screen with “COF Enabled” before fuel changeover

If the COF input is not active (no live voltage on terminals 91 & 92) when the selected fuel is changed then the MM will operate as already described for Dual Fuel Output Mode, shutting down the burner for a fuel change.

If COF is not enabled, the MM will change fuel in the same way as in Dual Fuel Output Mode, shutting down the burner and restarting on the newly selected fuel.

4.5.2 Checks before COF can take place

Fuel Change on the Fly can be triggered by introducing live voltage to T91 & T92 simultaneously, the changeover can only happen if the burner is in firing mode. The MM will undergo the following checks before going ahead with a COF fuel change:

MM Phase: Modulating – Firing
For a Fuel Change on the Fly to take place, the MM will first check whether the newly selected fuel is commissioned, if the selected fuel is not commissioned then a warning will be displayed indicating that the selected fuel cannot be run. This warning will clear automatically when the fuel selection is returned to the current fuel. If the burner is firing, then it will continue to fire on the current fuel.

MM Phase: Modulating - Gas Pressure Test
If the burner is firing and the newly selected fuel has pressure sensor optioned (depending on option 125- 126 setting), a fuel pressure test will take place, during which the supply-side fuel valve (Valve 1) for the new fuel is briefly opened and the fuel pressure is measured. If the fuel pressure is within the optioned limits (in options 136 & 137) of the commissioned pressure then the fuel changeover process may continue, however if the pressure for the selected fuel is not within these limits the MM will continue to fire on the current fuel. Failure of a gas pressure test at this point causes a warning to be generated, indicating that gas pressure prevented a fuel changeover. This warning will clear automatically when the fuel selection is returned to the current fuel. Selecting the new fuel again will perform another gas pressure test. This test does not take place if an oil fuel is selected.

4.5.3 COF Changeover Position

This is a position at which both fuels fire simultaneously as part of the fuel Change on the Fly process.

MM Phase: Modulating to COF
The current fuel modulates down its commissioned curve to its low fire point (or its FGR point if optioned)

MM Phase: Fuel Changeover – Firing
From this point the MM moves to the **COF Changeover Position** which is generated by a combination of the two commissioned fuel curves as follows:

- Servo 1 (Fuel 1) COF changeover position is the commissioned angle for the low fire point (or the FGR point for fuel 1 if optioned).
- Servo 3 (Fuel 2) COF changeover position is the commissioned angle for the low fire point (or the FGR point for fuel 2 if optioned).
- Servo 2 (Air Angle) COF changeover position is an increased air angle calculated to provide enough air for safe combustion of the both fuels to fire simultaneously and to make sure that the combustion is Air-Rich during the changeover process.
- Other channels, if optioned (i.e. servo 4, draught servo, and VSDs) take the larger value or more open angle of the two fuels at the changeover point (FGR or low fire).

IMPORTANT: If a VSD is used to control the air fan in addition to the air damper servo, it is very important to have similar VSD signal output on both fuels when commissioning the fuels in Dual FuelOutput Mode, this is to ensure that sufficient amount of air is present for both fuels to fire at the COF Changeover Position.

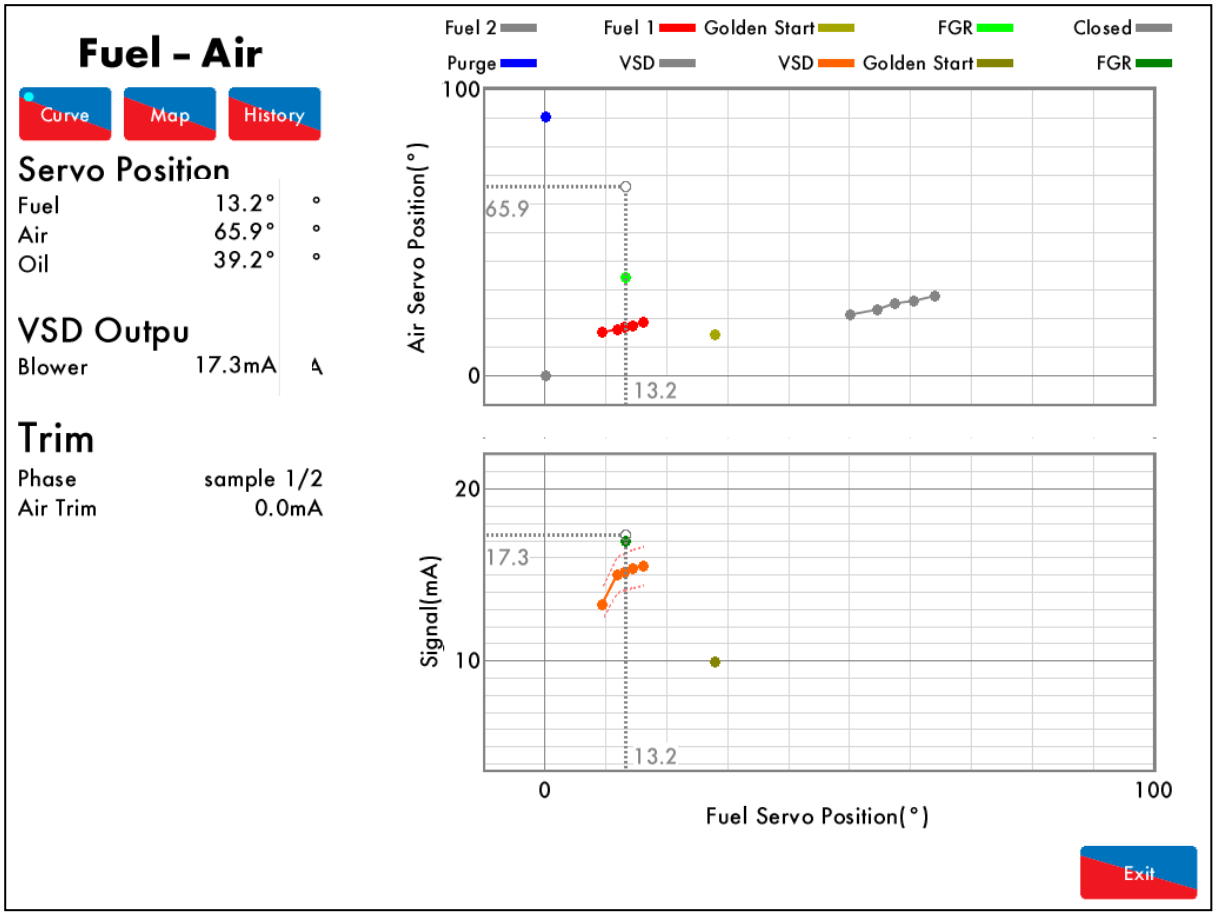


Figure 4.5.3 COF Changeover Position

4.5.4 COF Fuel Changeover

Once the COF Changeover Position has been reached, the fuel changeover process takes place, the process takes the following steps:

- **MM Phase: Fuel Changeover – COF Pre-Ignition**

A pre-ignition phase turns on the ignition and pilot outputs (if interrupted pilot is selected in option 111); these outputs remain on during the changeover process while both fuels are firing simultaneously.

- **MM Phase: Fuel Changeover – COF 1st Safety**

The new fuel main valves are opened starting its main flame. The two fuels fire together for the main flame proving time (Option 117).

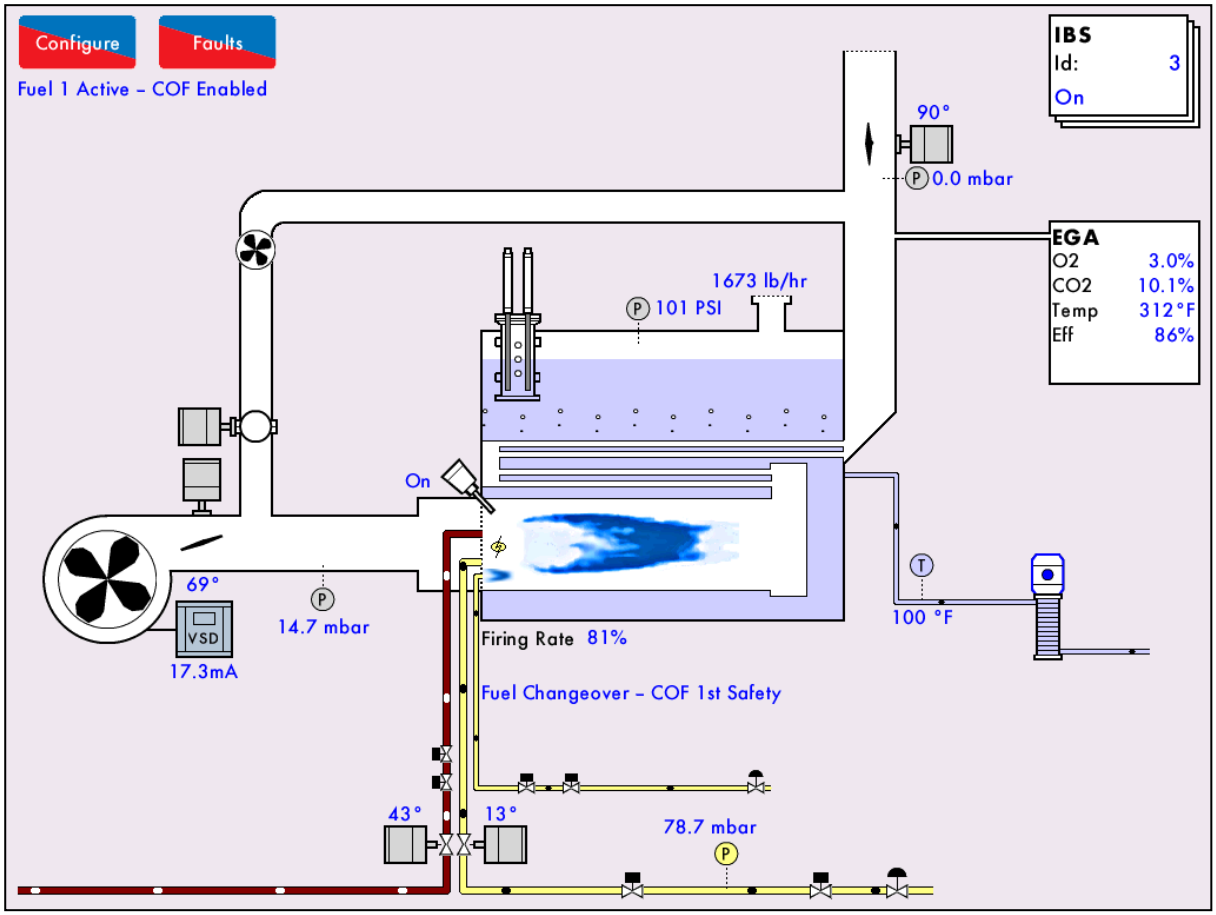


Figure 4.5.4: COF 1st safety phase where both fuels fire simultaneously

- **MM Phase: Fuel Changeover - COF 2nd safety**

The original fuel main valves are turned off and the new fuel servo/VSD channels move onto the commissioned curve of the new fuel while maintaining the same fuel channel angle. The main flame on the new fuel is monitored for five seconds in the COF 2nd safety phase.

- **MM Phase: Moving to Curve – COF Main Proving**

The pilot (if interrupted pilot is selected in option 111) and ignition outputs are turned off.

- **MM Phase: Moving to Curve – Firing**

The new fuel starts to modulate up its commissioned curve.

4.5.5 Checks after COF Fuel Changeover

After a fuel changeover, if valve proving is optioned on the previous fuel which is now no longer firing, valve proving takes place for that fuel while the current fuel continues to fire. This verifies that no leaks are present on the non-running fuel valves. Failure of valve proving will cause a lockout that stops the burner.

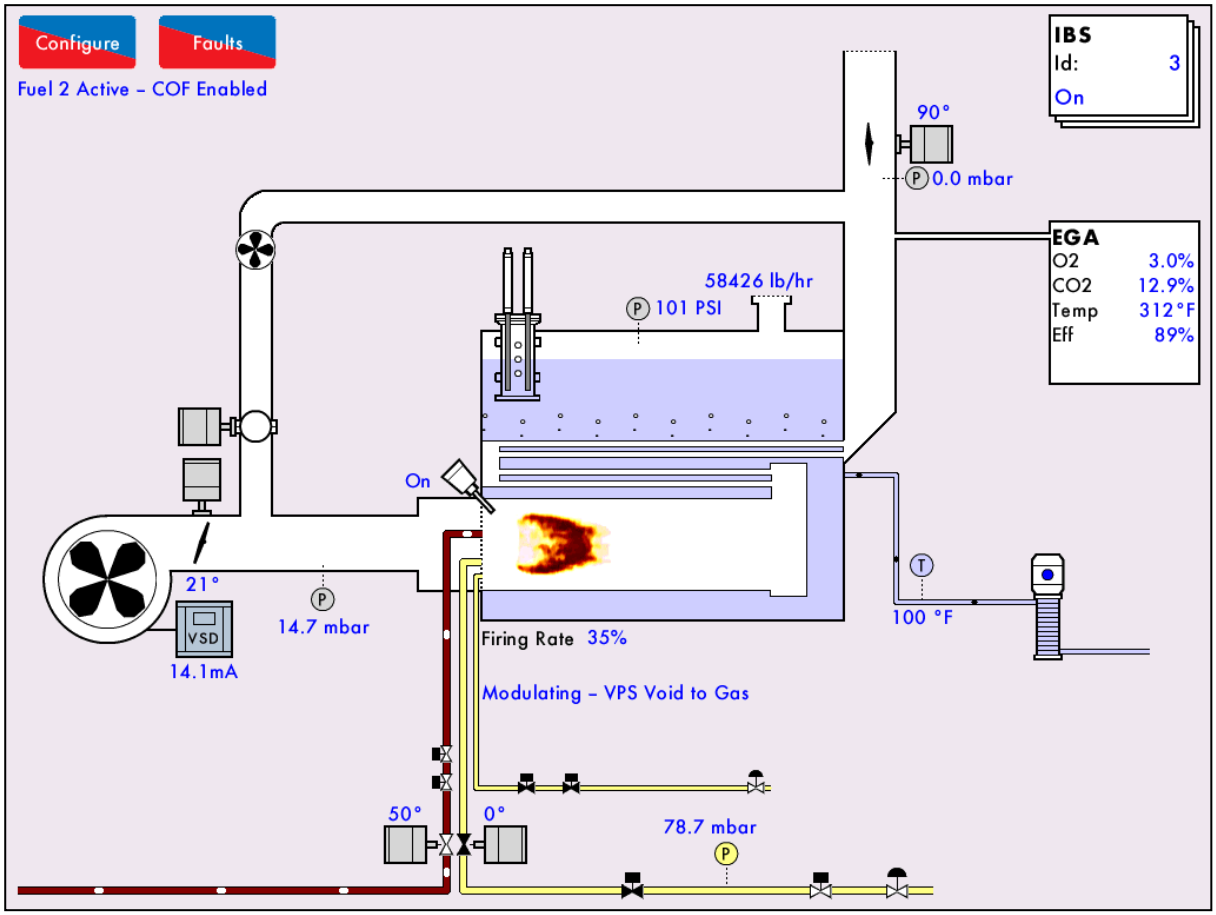


Figure 4.5.5: After COF changeover, valve proving takes place for the fuel that is not firing

4.5.6 Continuous Pilot with COF

Continuous Pilot mode (option 111) allows the MM to shutdown the main flame and run on only a pilot flame when the main stat turns off (when the boiler reaches its setpoint) but T53 remains engaged. When operating in COF mode with the COF input active, it is possible to change fuel while the burner is in this Continuous Pilot Standby state.

When fuel selection is changed, the MM moves to the restart position of the selected fuel, inhibiting the burner from starting until the new position is reached.

Please refer to section 5 for full details about Continuous Pilot.

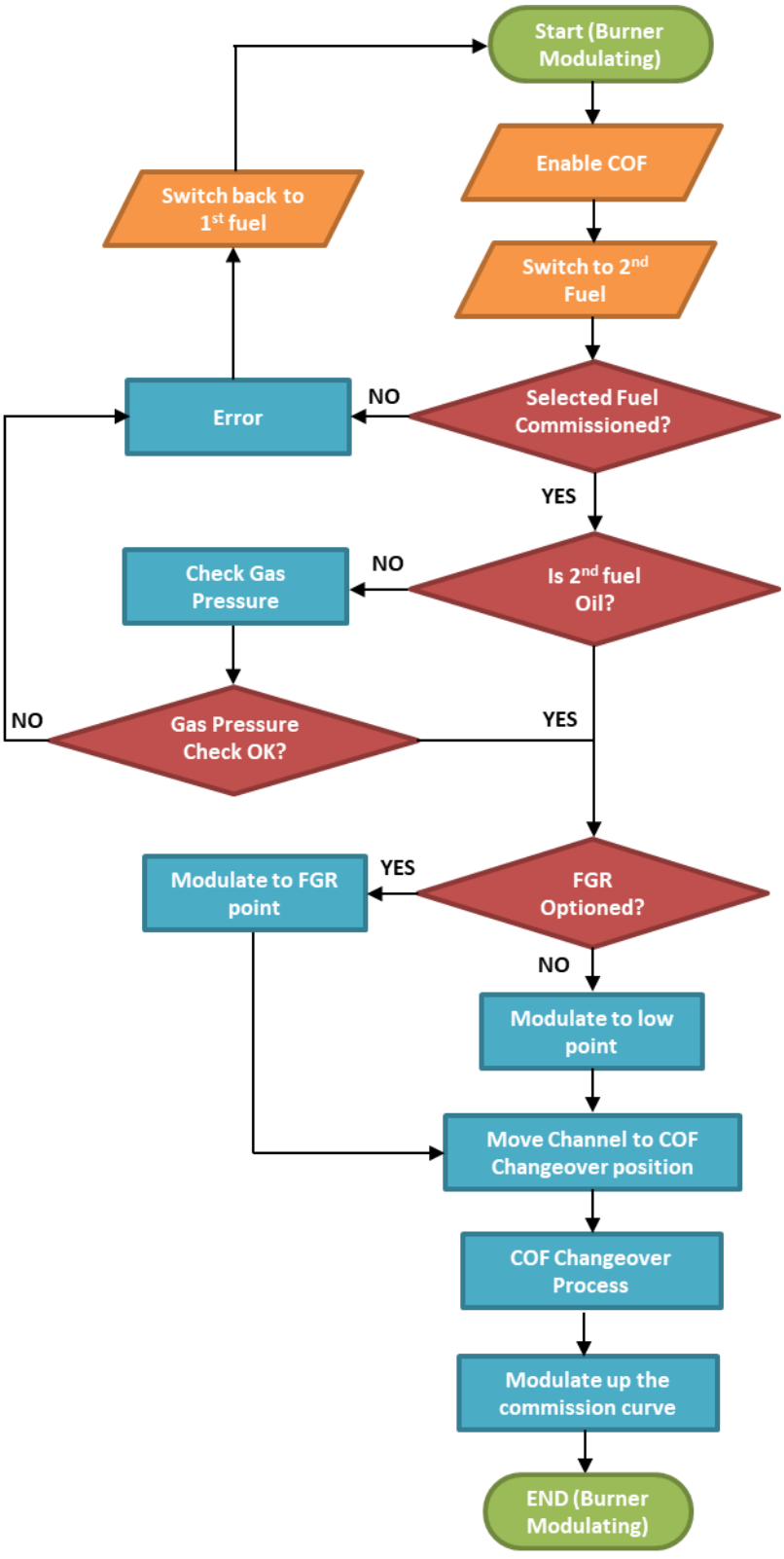


Figure 4.5.6: Fuel Changeover on the Fly Process

4.6 Gas Pressure Sensors and Valve Proving in DFOM with COF

There are some key differences in the operation of gas pressure sensors and valve proving between Single Fuel Output Mode and Dual Fuel Output Mode.

Before and/or after firing the burner (according to Option 129) valve proving takes place simultaneously for any fuel for which it is optioned. Failure of the valve proving process on either fuel will cause a lockout that stops the burner. This does not happen in Single Fuel Output Mode.

The tests performed during valve proving are different in Dual Fuel Output Mode:

- If a fuel is about to be fired (at burner start-up or before a COF changeover to that fuel) the static line pressure is tested against the optioned pressure limits defend in options 136, 137 and 138. This is the same as in single fuel output (standard) mode.

- If the fuel is not about to be fired, the static line pressure is tested (at burner start-up for the 2nd fuel or after a COF changeover for example) against a lower threshold, defined by Option 133 (Maximum pressure change allowed during valve proving). This tests that the pressure is high enough for valve proving to be valid (a drop in pressure can be detected that would cause the test to fail) but it does not require that the fuel has enough pressure to fire. This is to accommodate fuels that may not always be available such as waste biogas collected and burned periodically. It means that low pressure on a fuel that isn't about to fire will not prevent the burner from firing on the current fuel, provided that the pressure on the 2nd fuel is high enough to prove that the valve are not leaking.

If the fuel selection is changed while the burner is firing, and the newly selected fuel has a gas pressure sensor optioned then a fuel pressure test will take place. The supply-side fuel valve for the new fuel is briefly opened and the fuel pressure is measured. If the fuel pressure is within the optioned limits of the commissioned pressure (set in options 136 & 137) the fuel changeover may continue – otherwise the MM will continue to fire on the current fuel. It should be noted that low pressure at this point will not generate a lockout as valve proving is not being performed.

After a Fuel Change on the Fly, if valve proving is optioned for the fuel that has just been turned off then valve proving will take place on that fuel while the burner continues to fire. The pressure must be high enough for valve proving to be valid or a lockout will be generated, but the pressure does not need to be as high as the commissioned limits.

When valve proving is performed on the inactive fuel while the active fuel is firing the gas pressure sensor will be re-zeroed for 3 gas valve configurations. The gas sensor will not be re-zeroed with 2-valve configuration (Option 13 setting 0 or 3).

Fuel pressure limits continue to be tested for the currently firing fuel as normal, including when other operations such as valve proving are taking place on the other fuel.

4.7 Limitations of DFOM and COF

The following functions cannot be used if the MM is configured for Dual Fuel Output Mode or COF:

- Fully Metered Combustion.
- Single Valve Pilot (Option 130 settings 3, 4 &5).
- No Pilot Mode (Direct Spark, option 111 setting 2) on Gas fuels only.
- Multi-burner mode will operate with Dual Fuel Output Mode but is not possible with COF.
- Although it is possible to configure 2 liquid fuels, it is not possible to have pressure sensors for both fuels at the same time.
- Piggyback valve arrangement, separate servomotor is required for each fuel.
- Dual Fuel Output Mode and COF features will not be displayed on the Mk7 DTI, only Mk8 DTI is able to display these features.

5 PID CONTROL

The standard control algorithm used by the Mk8 MM to control the fuel/air ratio is PID control; Proportional-Integral-Derivative control. The control algorithm compares the actual measured temperature or pressure and compares it to the user specified setpoint temperature or pressure. Depending on the measured and setpoint values, the MM's PID control will then either modulate the burner up or down. The rate of change or speed of the burner modulation in relation to changes in measured temperature or pressure is dependent on the settings of the PID control. The PID control action is the sum of the "Proportional" + "Integral" + "Derivative" actions of the PID control. Each contributes to how the 3 term PID control modulates the burner and each operates as outlined below.

Most applications can be controlled adequately using just the Proportional and Integral settings - a PI control setup.

5.1 Proportional Band

The Proportional term is specified in option 6 by defining the "Proportional band" (P-Band). The P-Band is simply an offset from the setpoint pressure or temperature. Outside and below the P-Band, the MM's PID control will modulate the burner at maximum flame, upon reaching the P-Band, it will then modulate the burner linearly down (see option 6).

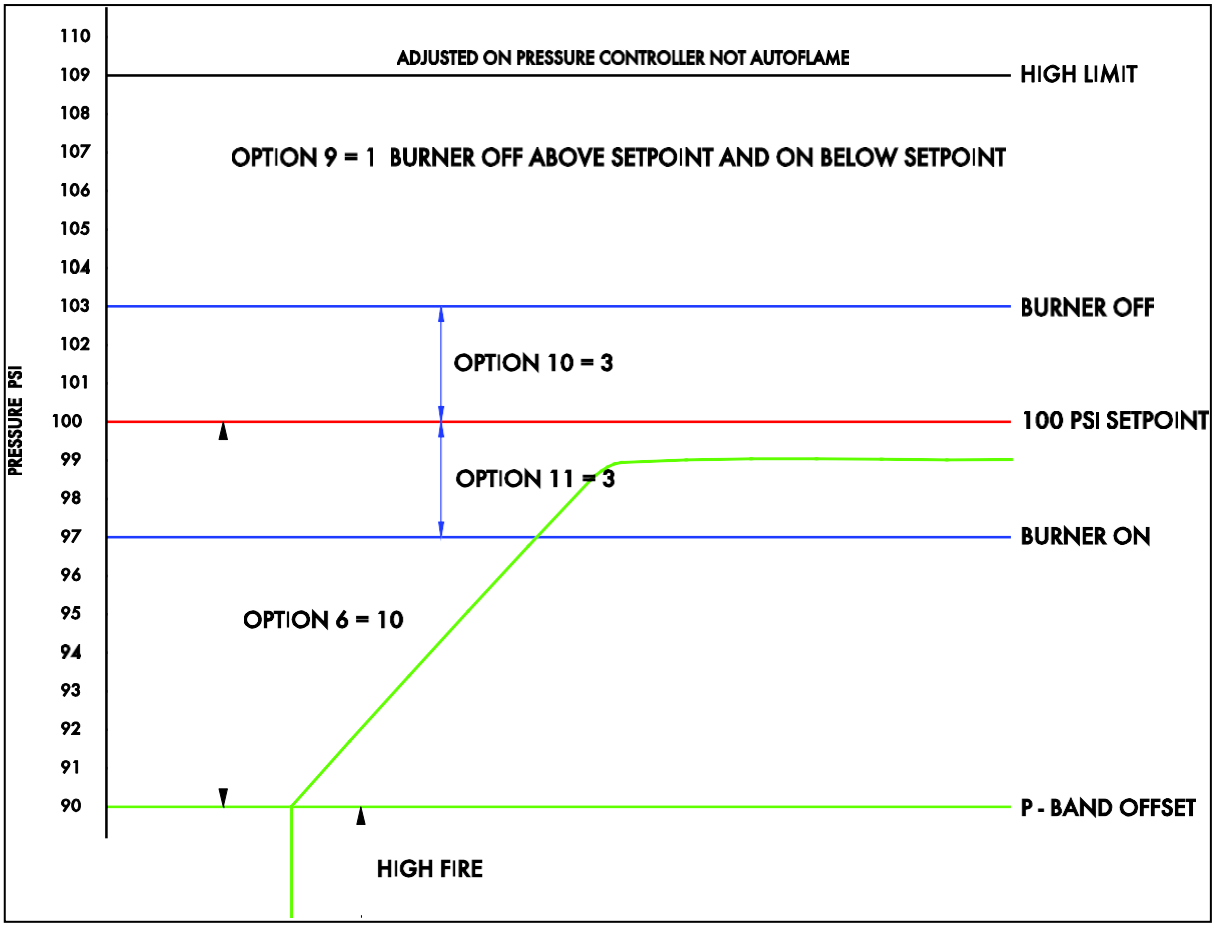


Figure 5.1.i Proportional Band

5.2 Integral Control

The Integral term is specified in option 7, where the “Integral time”, also known as “Reset time”, is set. Within a threshold of the P-Band, the integral term has the effect of increasing or decreasing the burner firing rate by a specific amount every “n” seconds. The amount the firing rate is adjusted by is specified in parameter 48, the default is 80% of the difference between the measured and setpoint temperature or pressure values, and the time period this amount is added, every “n” seconds, “n” is specified in option 7, the default is 60s.

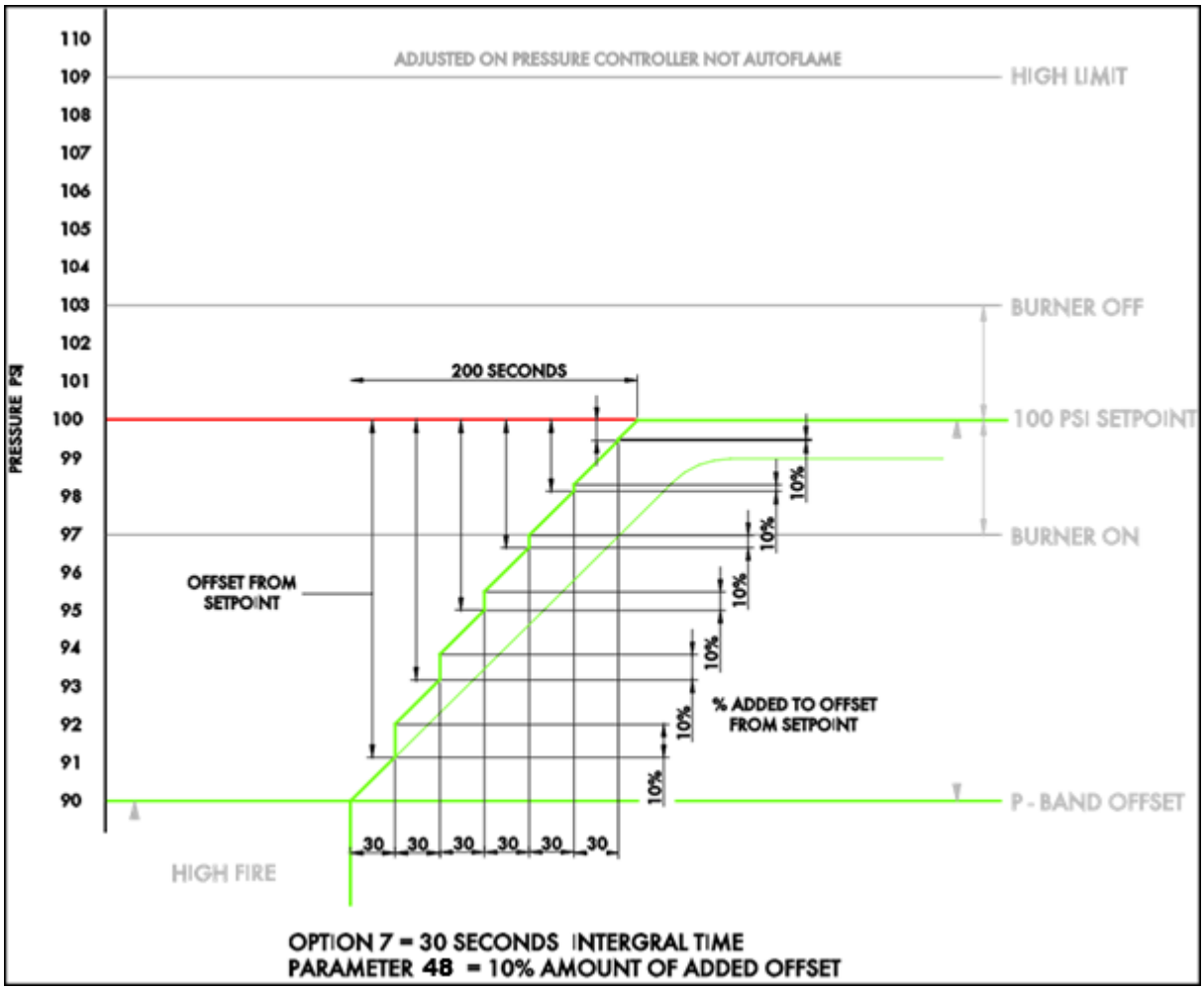


Figure 5.2.i Integral Control

(Parameter 48 = 0.8, Integral operation band of P-Band)

5.3 Derivative Control

The Derivative term of the control system analyses the rate of change in the difference between the measured and set point temperature or pressure. Derivative specific options are set in option 37, 38 and 39. The time interval over which the compared and measured temperature or pressure values are taken is set in option 37, the derivative dead-band or margin above and below the required set point in which no derivative action occurs is set in option 38, and the response sensitivity as a percentage of firing rate increase or decrease is defined in option 39.

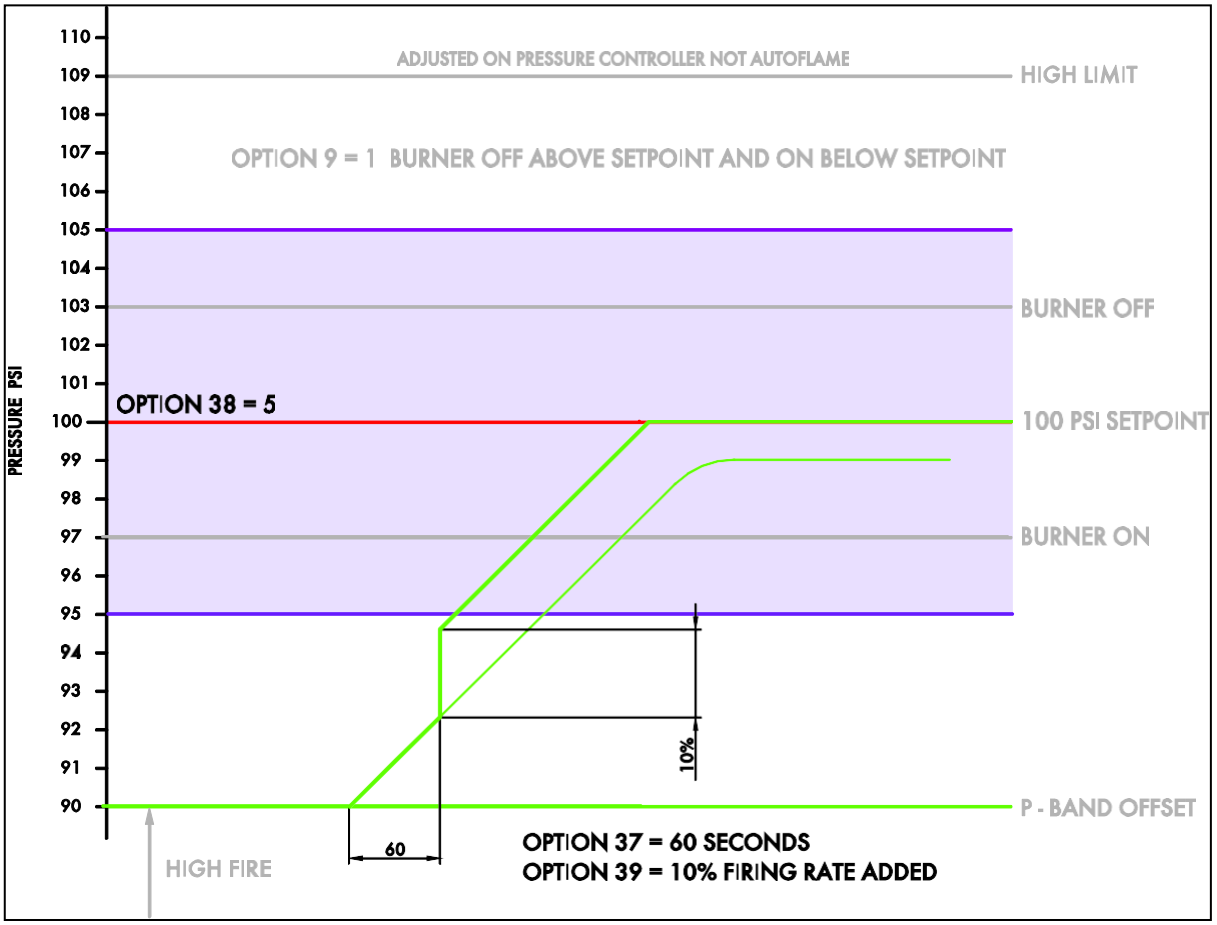


Figure 5.3.i Derivative Control

NOTE: The derivative action occurs at all points outside of the deadband. This includes within the proportional band.

6 MM FEATURES

6.1 Firing Rate Control

6.1.1 Hand Operation

Hand operation enables the firing rate positions to be set to a specific position, in the range of low to high fire, when the burner is firing. Fuel flow metering must be entered. IBS sequencing will not operate correctlyif the MM is in hand mode. Hand mode can only be activated when the burner is firing.

The Mk8 MM will go into hand mode when a voltage is detected on Terminal 94 or when the hand mode button 

is pressed in the Status screen. Arrows will then appear on the screen which can be used to increase and decrease the firing rate. Once the hand mode is deactivated, the MM will go to auto mode and fire according to normal modulation.

If Hand and Low Flame Hold are selected at the same time via Terminals 94 and 95, then Low Flame Hold takes priority.

6.1.2 Low Flame Hold

Low flame hold is the state when the MM's firing rate goes to its low fire position, while the burner is firing. Fuel flow metering must be entered. Sequencing will not operate correctly if the MM is in low flame hold.

Low Flame Hold can be selected on the Mk8 MM by introducing live input on terminal 95 or by pressing the Low Flame Hold soft button 

from the MM status screen. The low fire position will be maintained until the input on terminal 95 is removed or the button is pressed again. When switching from low flame hold to auto the MM will return to normal modulation.

6.1.3 Auto Operation

The MM 'Auto' operation enables the burner modulation to maintain the setpoint; the firing rate will modulate according to how far away the actual temperature or pressure is away from the required setpoint. The firing rate is determined from the fuel flow metering entered via option 57 - the more accurate the fuel flow metering, the more accurate the firing rate.

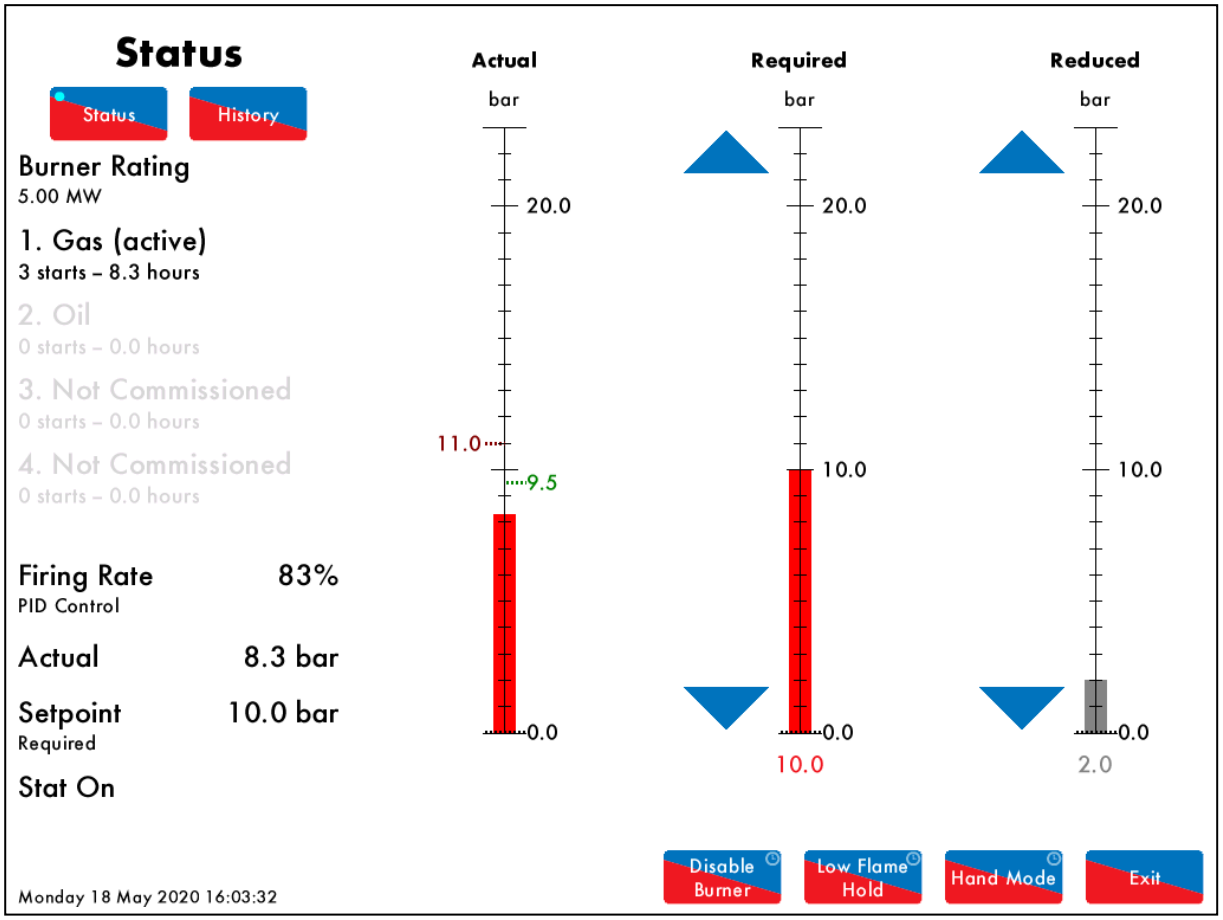


Figure 6.1: Mk8 MM status screen

6.2 Using 4-20mA Servomotors

6.2.1 Overview

A third party 4-20mA servomotor can be used with the Mk8 MM in conjunction with an Autoflame universal Mk8 IO Module (part #DTI80022). The IO module acts as an interface between the MM and the 4-20mA servomotors. This feature is used in sites where the fuel and/or air going into the burner cannot be controlled by mains voltage or where pneumatic control already exists. The MM will send a 4-20mA signal out from the IO module for the position of the servomotor for it to move according to the commissioned fuel-air curve and receives a 4-20mA signal back to the IO to indicate where the external 4-20mA servomotor position is currently.

The Mk8 MM channels which can be controlled using an external 4-20mA servomotor include channels 1, 2, 3, 4 and 7. Any or all of the 5 servomotor channels available on the Mk8 MM can be independently configured to use an external 4-20mA servomotor or an Autoflame servomotor.

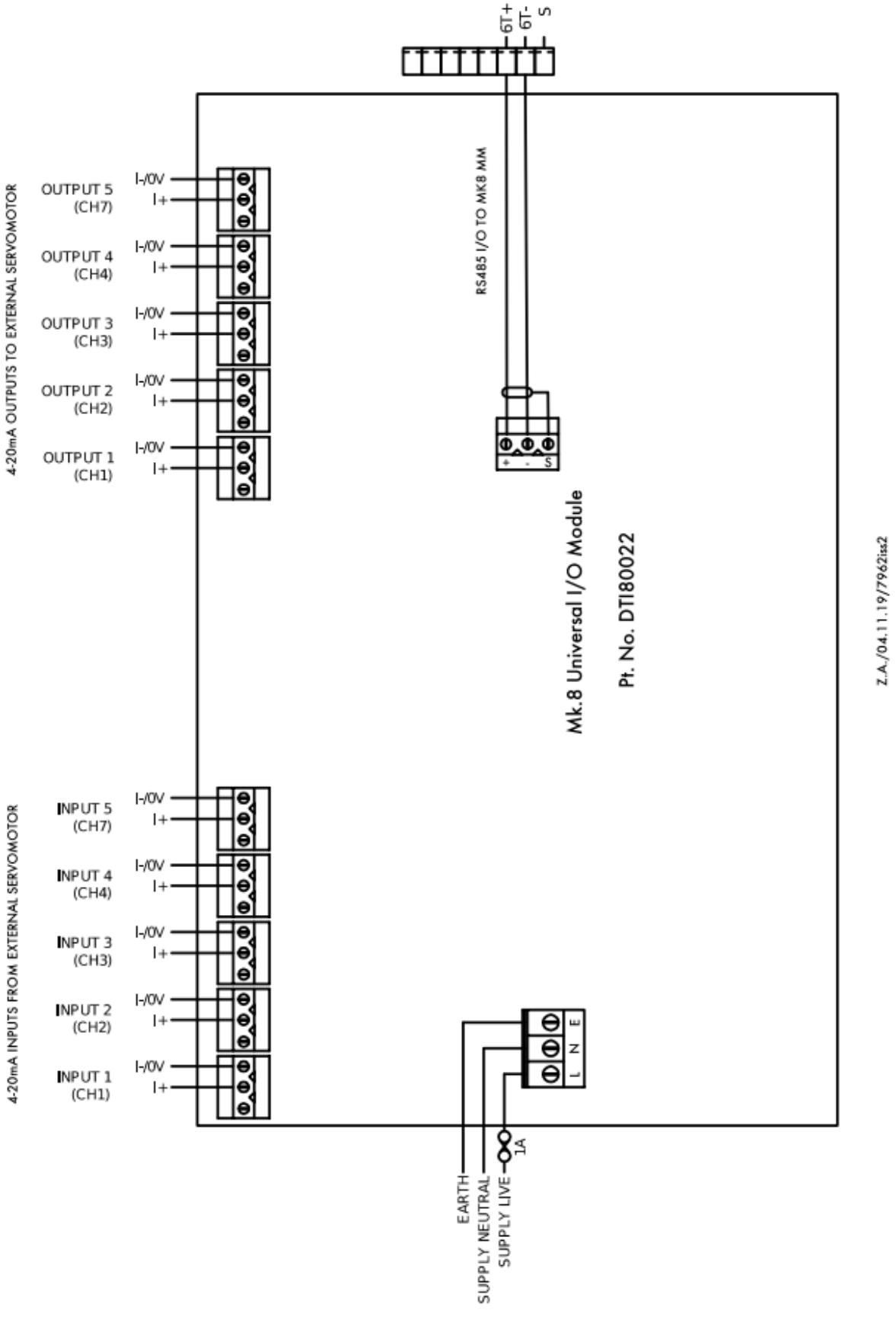
Servomotor channel	IO Module Analogue Input/ Output
1	1
2	2
3	3
4	4
7	5

6.2.2 External 4-20mA Servomotor Requirements

For the MM to control the servomotor channels via external 4-20mA servomotors, the following requirements must be met:

1. The external 4-20mA servomotor must be capable of being controlled to an angular accuracy no higher than 0.5°.
2. There must be both a 4-20mA input and 4-20mA positional feedback from the external 4-20mA servomotor.
3. The feedback signal from the external 4-20mA servomotor must correlate directly to the input signal. For example, if 8mA is outputted from the MM, then the servomotor should move to the position that gives 8mA feedback to the MM.
4. The range of the external 4-20mA servomotor is 4mA for the closed position at 0.0° up to 20mA for the open position at 90.0° position, with a linear scaling. For example, 12mA will correspond to a position of 45.0°.
5. Neither the input or output signal from the external 4-20mA servomotor follows loop control; this means that if the MM sends a signal of 10mA to the servomotor via the IO module, and the servomotor does not have angular position to return a 10mA signal back to the MM, then a fault condition will occur.

6.2.3 Wiring


6T+
6T-
S
RS485 I/O TO MK8 MM
4-20mA OUTPUTS TO EXTERNAL SERVOMOTOR
OUTPUT 5 (CH7)
OUTPUT 4 (CH4)
OUTPUT 3 (CH3)
OUTPUT 2 (CH2)
OUTPUT 1 (CH1)
I-/0V
I+
Mk.8 Universal I/O Module
Pt. No. DTI80022
Z.A./04.11.19/7962iss2
4-20mA INPUTS FROM EXTERNAL SERVOMOTOR
INPUT 5 (CH7)
INPUT 4 (CH4)
INPUT 3 (CH3)
INPUT 2 (CH2)
INPUT 1 (CH1)
L
N
E
1A
EARTH
SUPPLY NEUTRAL
SUPPLY LIVE

6.2.4 Settings

It is possible to use a combination of external 4-20mA servomotors and Autoflame servomotor, for example, channel 1 can be set as an Autoflame servomotor and channel 2 can be set as an external 4-20mA servomotor. The degree of accuracy when using an external 4-20mA servomotor via a Universal IO module is 0.5°, in comparison to the accuracy level of 0.1° which is possible on the Autoflame servomotor. The control method for each servomotor can be set by the following options:

Option	Mk8 MM
86	Channel 1 Servo Control Method
87	Channel 2 Servo Control Method
88	Channel 3 Servo Control Method
89	Channel 4 Servo Control Method
Expansion Option	Mk8 MM
81	Draught Servo Control Method

The IO module must be configured for ID 1. Please refer to the Autoflame PC Software Guide for more information. The MM will automatically configure all other settings in the IO module unit required for operation Please note that mixed IO software version 3.01 or above is required.

6.2.5 Commissioning

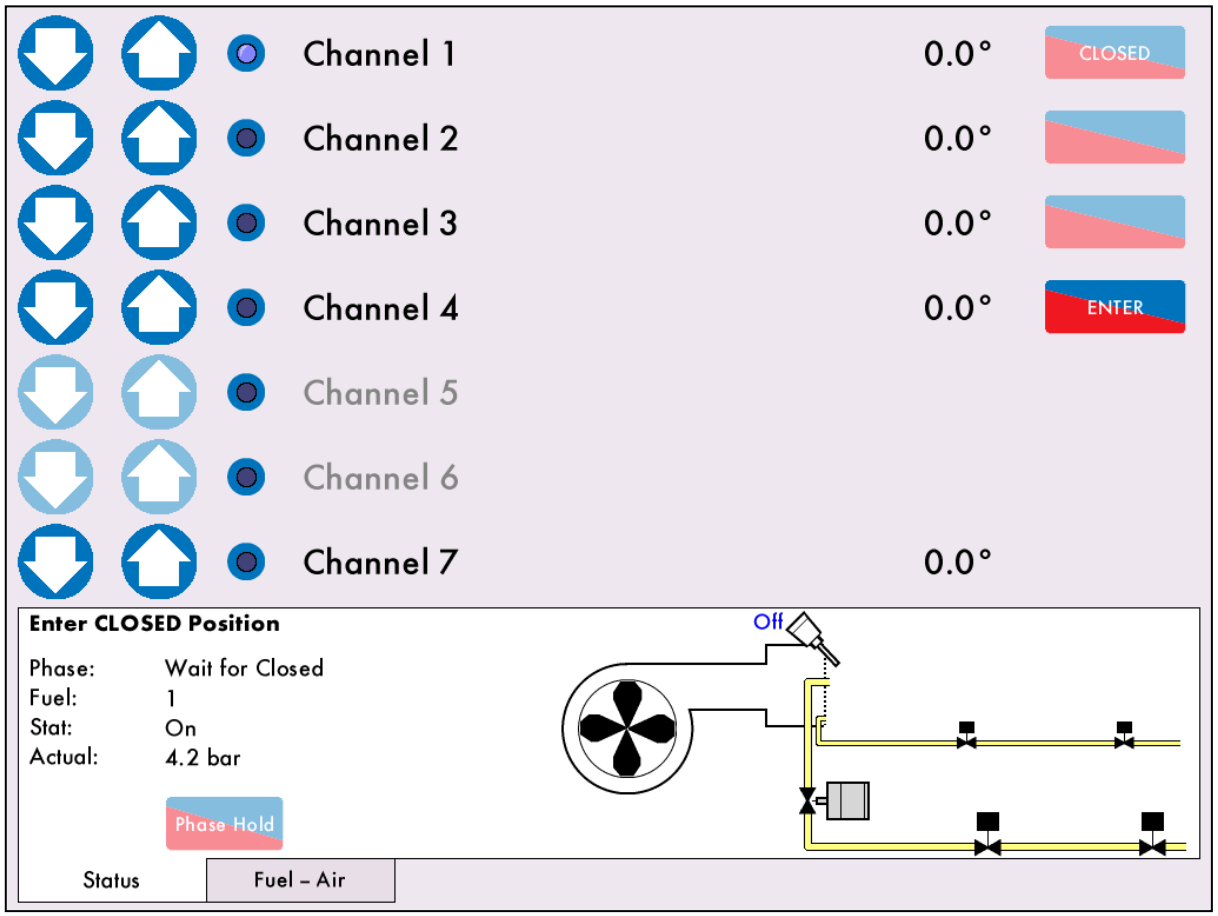


Figure 6.2.5: Commissioning External 4-20mA Servomotor

The commission procedure for the Mk8 MM with external 4-20mA servomotors follows the normal commissioning procedure, with the positions displayed in angular degrees. In run mode, the servomotor screens show the same information as that displayed for Autoflame servomotors.

6.3 Flame Detection Using Flame Switch

The Mk8 MM can utilise an external flame switch for the purpose of flame detection. To configure operation with a flame switch, option/parameter 122 can be set to 1.

The operation of Terminals 85 and 86 will be as follows:

- When the flame switch indicates no flame, the voltage on Terminal 85 must be 0Vac, and the voltage on Terminal 86 must be mains voltage (110/230Vac).
- When the flame switch indicates the presence of a flame, the voltage on Terminal 85 must be mains voltage (110/230Vac), and the voltage on Terminal 86 must be 0Vac.

Terminal 85 is the functional input for detecting the flame.

Terminal 86 is solely for the purpose of checking that Terminal 85 is operating correctly.

Terminal 86 must be seen to be the inverse of Terminal 85, i.e. if Terminal 85 is at 0Vac, Terminal 86 must be at mains voltage and if Terminal 85 is at mains voltage, Terminal 86 must be at 0Vac.

If Terminal 86 does not follow the inverse of Terminal 85 ‘Terminal 86 inverse’ error will be triggered.

Important notes:

- Within the Mk8 MM there is a latency of 250 milliseconds on the monitoring of Terminal 85. To ensure a 1 second overall flame failure response time, it is essential that the response time of the flame switch is set to no more than 750 milliseconds.
- Flame switches often provide a volt free changeover contact to indicate the flame status. Alternatively, they may provide a pair of `inverse’ outputs. If the flame switch only provides a single output terminal, a relay will have to be installed between the flame switch and the MM to provide a set of volt free changeover contacts.

6.4 Continuous Pilot

The Mk8 MM has a continuous pilot (pilot relight – return to pilot) feature. If continuous pilot is enabled, when the burner goes above its setpoint off position, the burner will continue to fire with only the pilot valves energised.

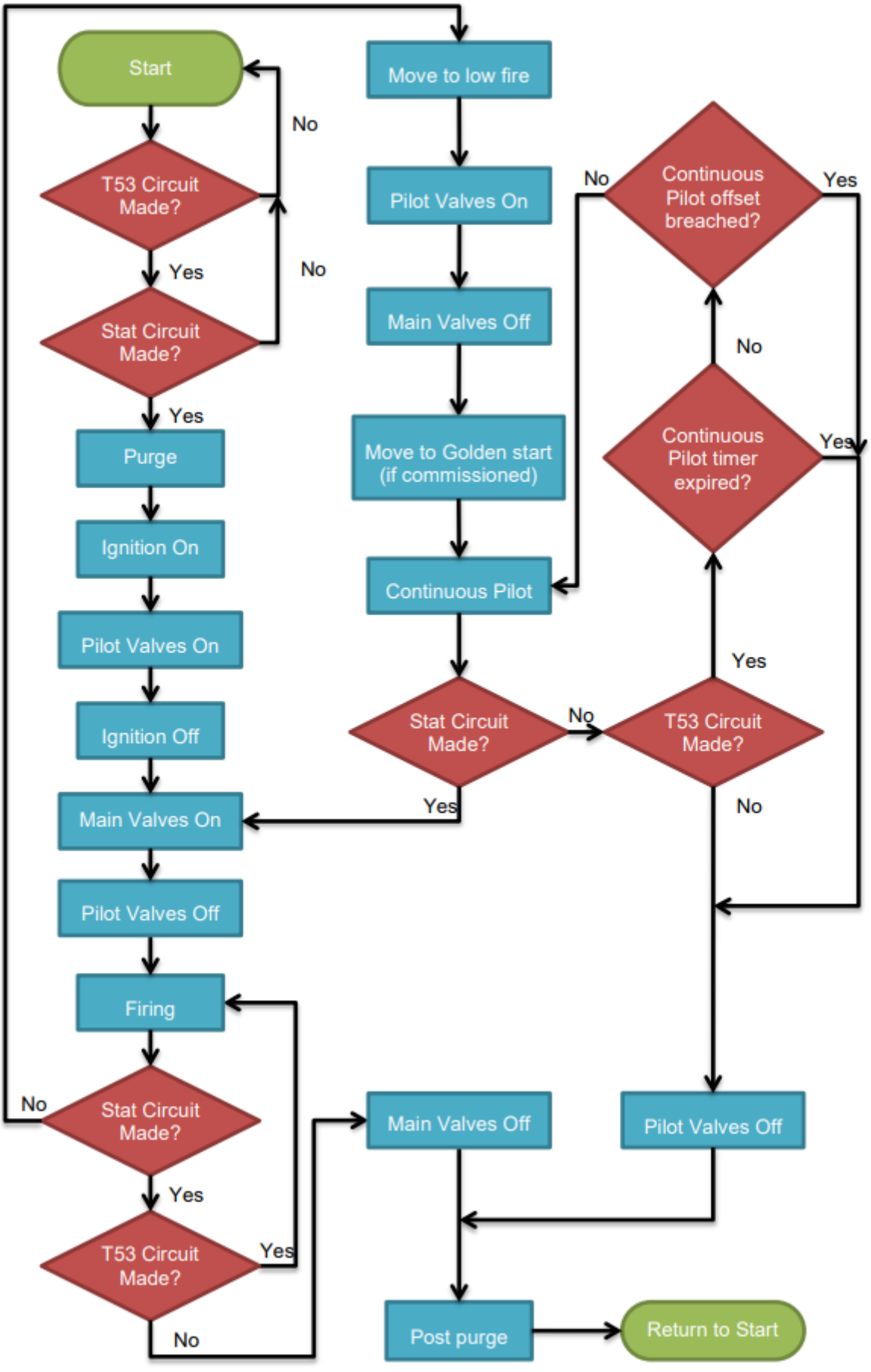
To enable continuous pilot, set option/ parameter 111 to either 3 or 4 interrupted continuous pilot or intermittent continuous pilot. If the burner goes off on high temperature/ pressure, then the pilot will continue to fire for a time period, set in option 71. After the time set in option 71, if the main flame is not re-established through load demand, the system will shut down and recycle. Option 72 sets the offset above the required setpoint where during the time period, if the actual temperature/ pressure goes above this value, the pilot will turn off as well.

In the situation when the burner switches back to pilot flame, the burner will open the pilot valves and after the second safety time (option/parameter 116), the burner will close its main valves. During the hot standby position, the gas pressure is checked by the gas sensor, it is important that the main valves and pilot valves are connected with a small measuring pipeline. When burner is ready to go back to main flame the main fuel valves will open and after the second safety time the pilot valves will be closed, and the normal operation will start again.

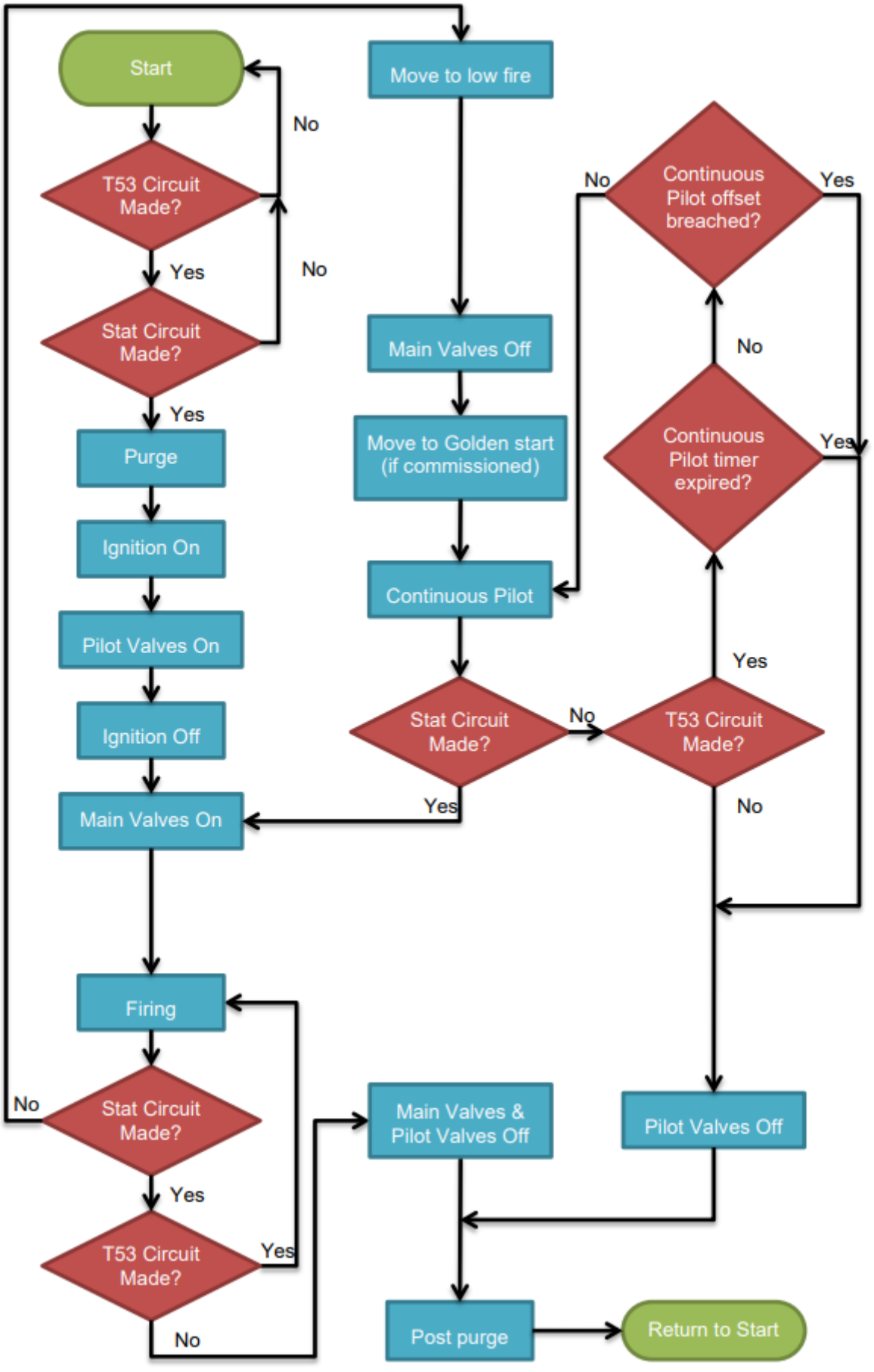
When default settings are used, the quickest the MM can go from pilot to high fire once the stat comes on is approximately 30 seconds. At the slowest motor travel speed and the maximum timings, it would take approximately 1minute and 30 seconds to go from pilot to high fire.

It is recommended that assured low fire shutoff (parameter 100) is used with continuous pilot.

6.4.1 Continuous Pilot with Interrupted Pilot Sequence



6.4.2 Continuous Pilot with Intermittent Pilot Sequence



6.5 Load Sensor Value Calibration

To calibrate the actual value, Parameter 29 allows you to adjust the actual value for the temperature/ pressure sensor reading between a range of 80.0% and 120.0%.

The load sensor can be calibrated via Commissioning Mode or through Online Changes.

Note: The percentage change may not be linear to the current temperature/ pressure, i.e. 80% of 100°C may not show 80°C.

For example, if the actual temperature was showing as 91°C on the MM, but the true temperature was 79°C, change the value in parameter 29 until the correct temperature adjustment has been made. Figure 3.9.1.i shows the load sensor adjusted by 96.0% to display 79°C.

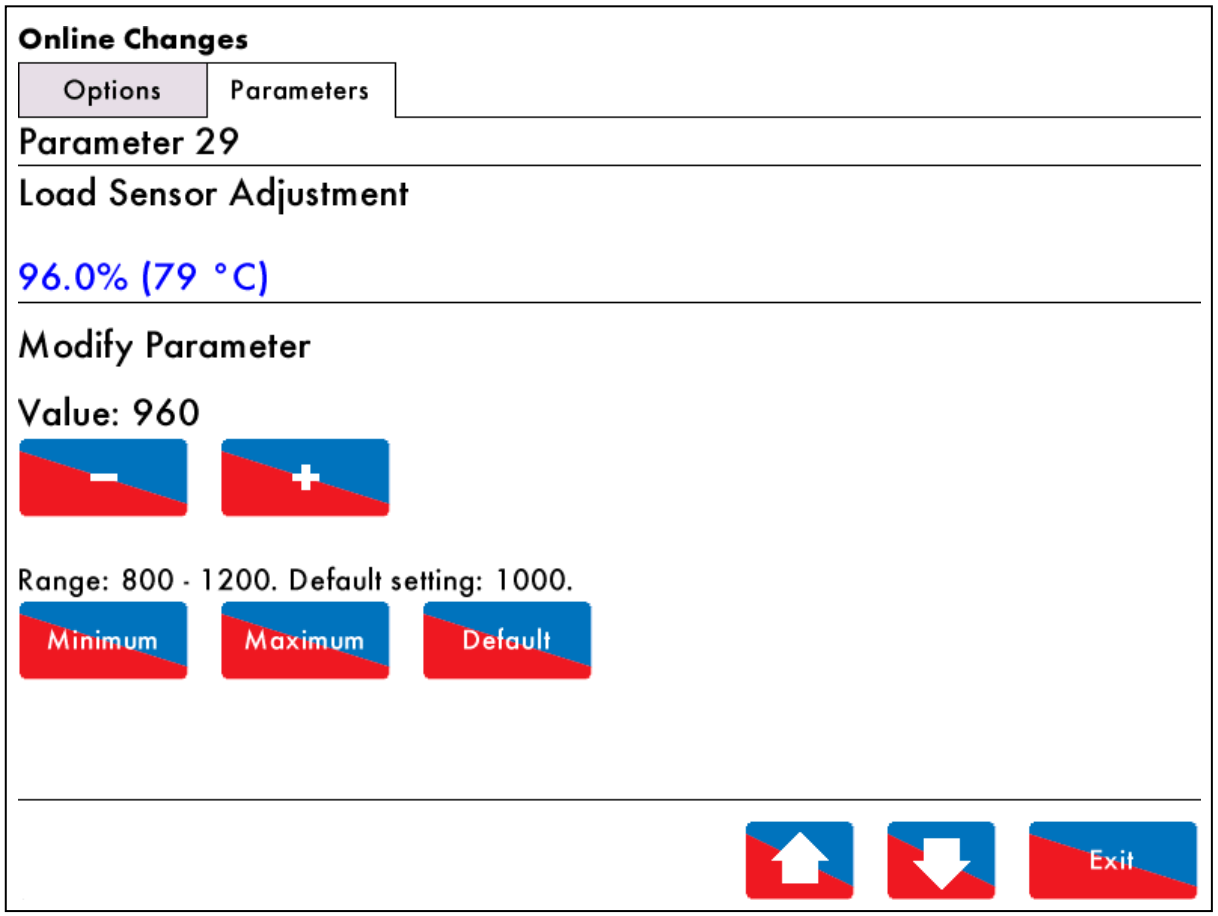


Figure 6.5: Load Sensor Adjusted

6.6 External Modulation

When using External Modulation, the internal PID control is disabled and the firing rate is set by an input control signal on terminals 7, 8 and 9 as appropriate for 0 – 10V or 0/4 – 20mA. Set parameter 68 for the external modulation control range, and parameter 69 for the input range.

There are two options to enable the use of External Modulation:

- Option 45: Setting this option to either 1 or 2 enables the constant use of the external input signal for the modulation control.
- Option 55: Setting this option to 1 enables the possibility for the user to choose between internal PID control and External Modulation according to the signal provided on terminal 88. Providing a line voltage input on terminal 88 selects External Modulation and 0V selects Internal PID.

Note: External Modulation cannot be used if External Setpoint is enabled, as the Auxiliary Analogue Input can only be used for a single functionality.

6.7 External Setpoint

The Auxiliary Analogue Input channel can be used to receive an external setpoint input. This feature can be enabled in parameter 72 and an input control signal needs to be provided on terminals 7, 8 and 9 as appropriate for 0-10V or 0/4-20mA. The input signal range and filtering time are set in parameters 69 and 70 respectively. The minimum and maximum external setpoint input values are set in options 30 and 31 respectively.
When External Setpoint is enabled, the MM uses the signal provided into the auxiliary analogue input to determine the required setpoint value.

There are two options to enable the use of External Setpoint:

- Parameter 72: Setting this to 1 enables the constant use of the external input signal for the setpoint control.
- Option 55: Setting this option to 3 enables the possibility for the user to choose between internal setpoint control and External Setpoint according to the signal provided on terminal 88. Providing a line voltage input on terminal 88 selects External Setpoint and 0V selects Internal Setpoint.

When External Setpoint is enabled, Second Setpoint input may be used to select the reduced setpoint.

Note: External Setpoint cannot be used if External Modulation is enabled, as the Auxiliary Analogue Input can only be used for a single functionality.

6.8 Second Setpoint Select

Terminal 87 allows selecting between the main setpoint and a secondary setpoint. When terminal 87 is at 0V the MM uses the internal ‘Required’ setpoint value. When a line voltage input is provided on terminal 87, the MM uses the internal ‘Reduced’ setpoint value. A second setpoint input (T87) may be used to select the reduced setpoint.

6.9 Start Position Interlock and Purge Position Interlock

Options/parameters 154 and 155 have been added to set the function of terminals 80 and 81, respectively. Terminal 80 can be used for start position interlock and Terminal 81 can be used for either purge position interlock or purge pressure proving. Proving valves (end switch) provides a secondary confirmation that a valve has reached a predefined position.

To install the End Limit Switches,

1. Mount the servomotor onto the valve and ensure the potentiometer reads the correct position on the MM for the “CLOSED” and “OPEN” valve positions.
2. Mount the End Switch Proving Unit (E.S.P.U.). The servomotor may have to be moved to a suitable position in order to allow the E.S.P.U. to be attached to the valve.
3. Undo the End Limit Switch holding screws.
4. Adjust the position of CAM corresponding to switches 1 (S1) and 2 (S2) by loosening the CAM screws and move to the required position.
5. Wire the ESPU according to the Valve Proving the End Limit Switch will be required to provide. See the End Limit Switch wiring diagram in Figure 4.5.i

Note: The use of these switches is determined by the necessary application approvals. These are not required to meet UL, FM or CE.

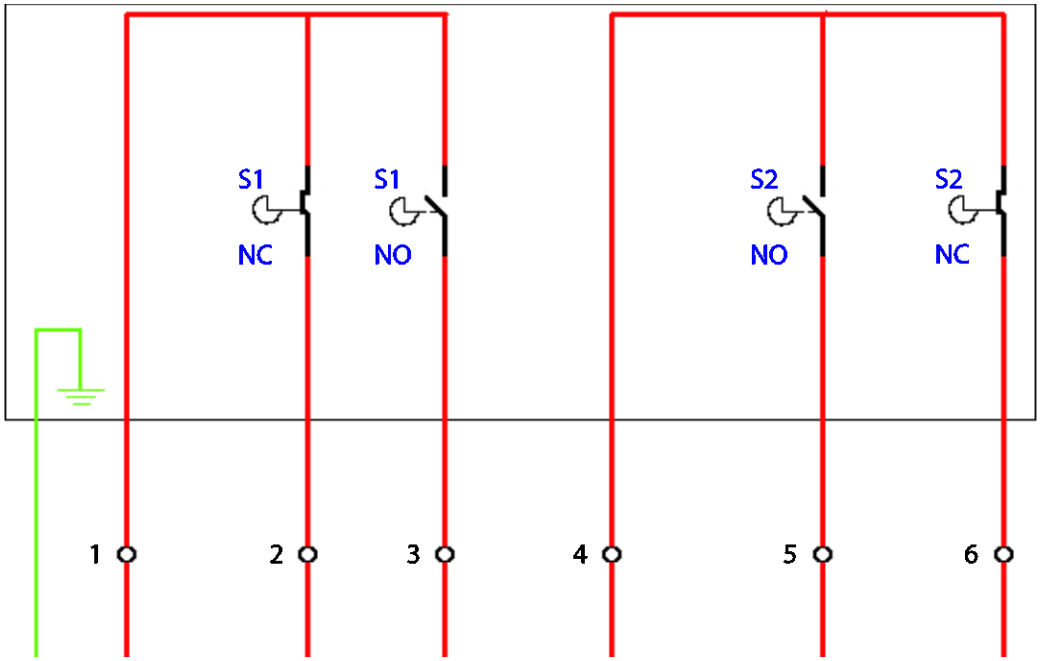


Figure 6.9: End Switch Wiring Schematic

End Limit Switches are mounted on the end of bespoke valves (please contact Autoflame regarding bespoke valve manufacture) which are attached to the air and fuel valve and commissioned depending on the use of the End Limit Switches. An End Limit Switch comprises of two switches, as shown in Figure 4.5.i. Each comprises of an Earth and 6 connections to be wired as appropriate. The switches S1 and S2 are setup as per on site specification. These are then wired into either or both terminals 80, the start position interlock, and terminal 81 purge position interlock.

If option/ parameter 154 is set to 1, then the MM waits at RUN TO IGNITION until this interlock is made on terminal 80. If option/ parameter 155 is set to 1 then MM waits at RUN TO PURGE until this interlock is made on terminal 81.

6.10 Purge Pressure Proving/ Purge Hold

Setting option/ parameter 155 to 2 makes terminal 81 a purge pressure proving input. In this case a pressure switch to provide the purge pressure proving signal needs to be installed and the feedback connected to terminal 81. The switch must be made continuously for the whole duration of the purge time. If the signal is lost the purge time stops and it restart when the switch is made again. If the switch is made before the blower motor starts a lockout is generated.
Option/ parameter 158 allows to set a timeout for the purge pressure proving. If the system does not see a signal on terminals 81 within the time set in option parameter 158 a lockout is generated. Setting option/parameter 158 to 0 disables the timeout functionality and the MM will stay in the purge phase indefinitely.

To allow for a quick cool down of the boiler a manual switch can be added to the panel. This switch can then be used to break the feedback from the pressure switch to the MM causing the MM to stay purging for the desired time period.

Caution: When it is desired to end the continuous purge, it is necessary to disable the burner prior to turning the manual switch back to the normal position. Otherwise the burner will start up.

6.11 No Pre-Purge

It is possible to minimise the burner start-up time by bypassing the pre-purge. The major advantage of this control means that the overall boiler efficiency is increased by minimising the heat loss to the stack during a purge cycle. This means the burner starts-up quicker, therefore reaching setpoint in a reduced time. According to the EN676 European regulation, the burner is allowed to restart without a pre-purge if the burner has recycled due to operational temperature/pressure. When the burner is stopped by a lockout then this procedure is not allowed, and the burner will have to start-up as normal with a pre-purge. In order for no pre-purge to be active, valve proving must take place and finish successfully. If this valve proving operation is successful, then the burner may start-up without a pre-purge.

In order to initiate the no pre-purge feature, option/ parameter 143 must be set to a value of 1. During the first start-up the burner will start with a pre-purge initiated. Once the complete commissioning curve has been entered and the burner has started successfully, the burner will then start-up every time with no pre-purge. If the burner goes above its setpoint and turns off on high temperature/ pressure, then the next time the burner starts-up, it will go through the VPS operation and then light off without a pre-purge, i.e. the burner has shut down in a controlled manner and the gas valves have been checked for integrity.

According to the EN676 regulation, the burner is only allowed to work in this manner if VPS operation has been set to operate before the burner starts up: option/parameter 129 must be set to 0.

The start sequence without pre-purge is as follows:

1. Firstly, the system goes through its internal tests and relay checks.
2. Call for heat on Terminal 57 activates and the system will go through the VPS operation.
3. If this operation is successful, then the MM will drive the channels to the light off or start position.
4. Once all channels reach the start position then the burner will light off.

burner shuts down in an abrupt manner, e.g. loss of power to the unit, then the next time the burner starts-up a complete purge will be initiated.

If no pre-purge is enabled in option/parameter 143, and one or more of the following conditions occur, the next time the burner starts up, a complete pre-purge will be initiated:

- Burner lockout
- Loss of power to the MM
- VPS checks have failed
- MM has been in standby for 24 hours or more

Note: Pre-purge is only available on fuels which are optioned as gaseous.

7 INTELLIGENT BOILER SEQUENCING

The objective of Intelligent Boiler Sequencing (IBS) is to ensure that the minimum number of boiler/ burner units are in operation at any one time to satisfy the heat or steam requirement imposed upon the boiler plant, in the case of multi-boiler installations.

The benefits from using IBS include an increased savings in electrical costs, a reduction in thermal stress on the lag boilers, and an increase in overall plant efficiency. It is possible on the MMs to select steam sequencing, low pressure steam sequencing or hot water sequencing.

There are variations of the IBS software that can be selected via the options/parameters procedure: hot water boilers, and steam boilers.

A maximum of ten MM, EGA, universal I/O modules may be interconnected by a two wire screened data cable. Any MM interconnected may be selected as the lead boiler for the sequencing. The lead boiler is identified by:

1. Connecting a mains voltage onto Terminal 88 (only on the Mk8 MM)
2. Selecting Lead boiler in the IBS screen
3. Instructing the modules via the DTI module (Data Transfer Interface) or by PC CEMS Audit/DTI Manager software.

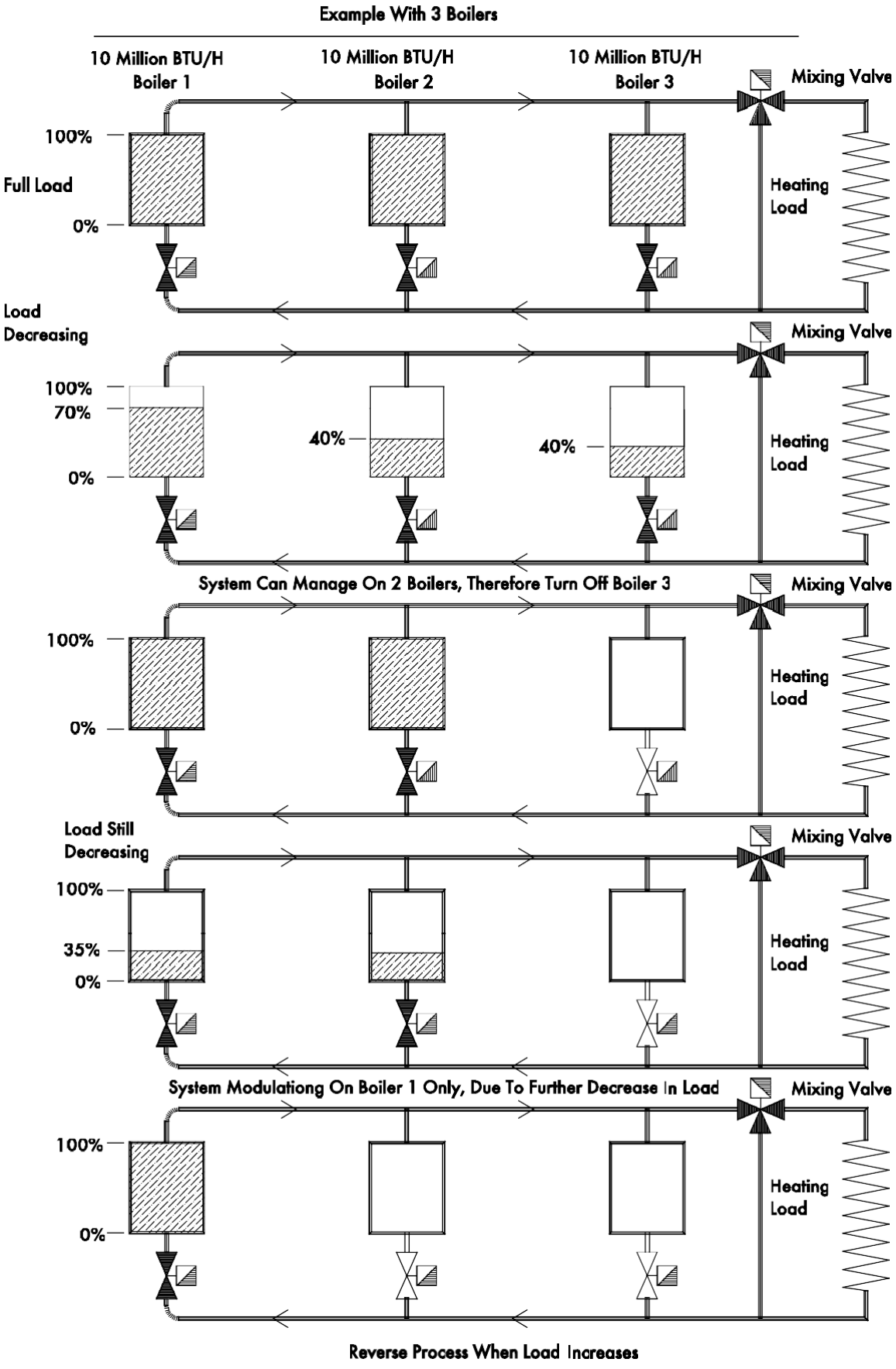
The sequence order of the MMs in the loop can be changed by changing their ID numbers or by changing the order on the DTI if shuffle sequencing is enabled through parameter 101.

Sequencing can be used with external load detector and multi-burner operation, but it cannot be used with external modulation.

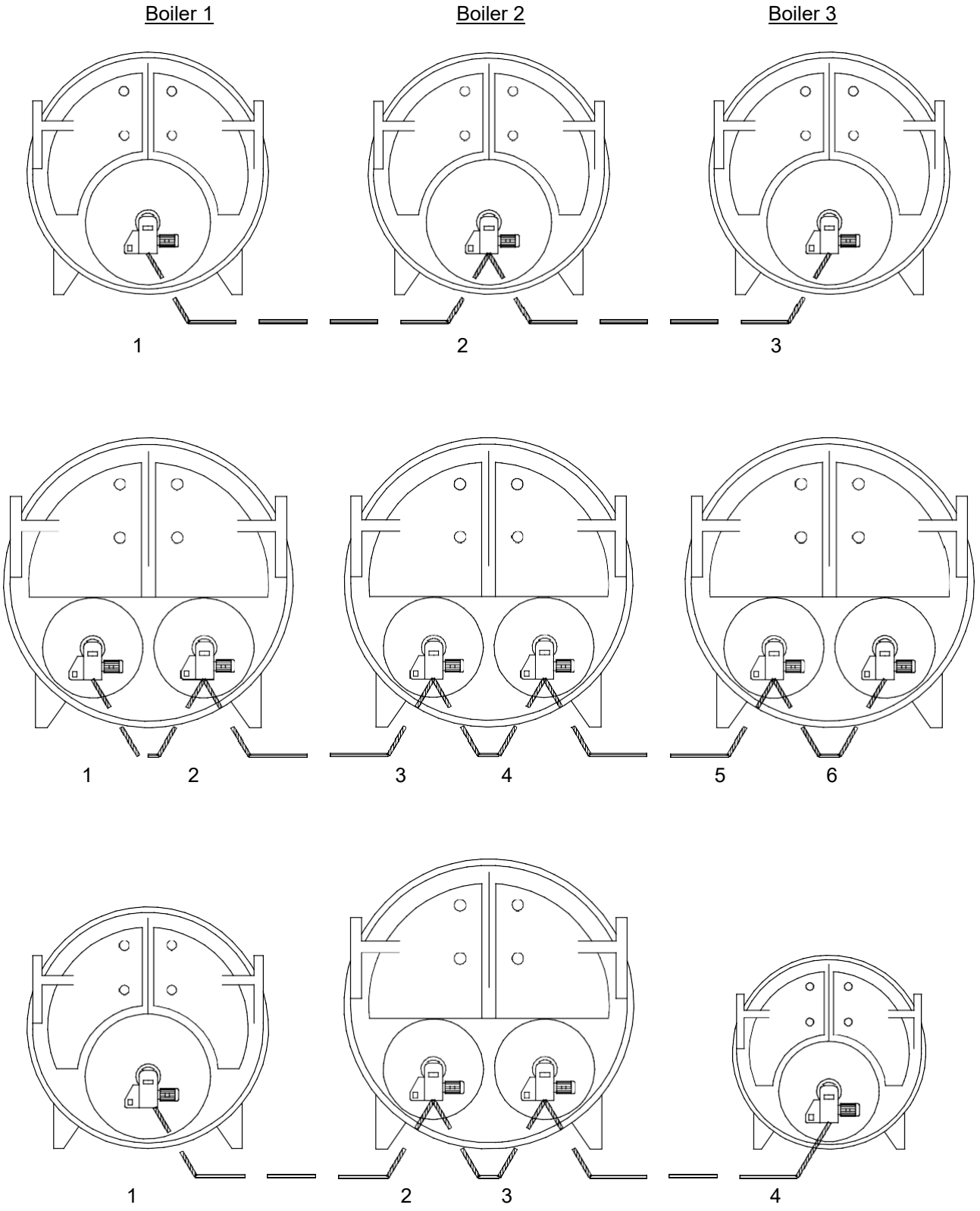
7.1 Sequencing Schematics

Please see sections 1.5 and 1.6 for the sequencing wiring diagrams.

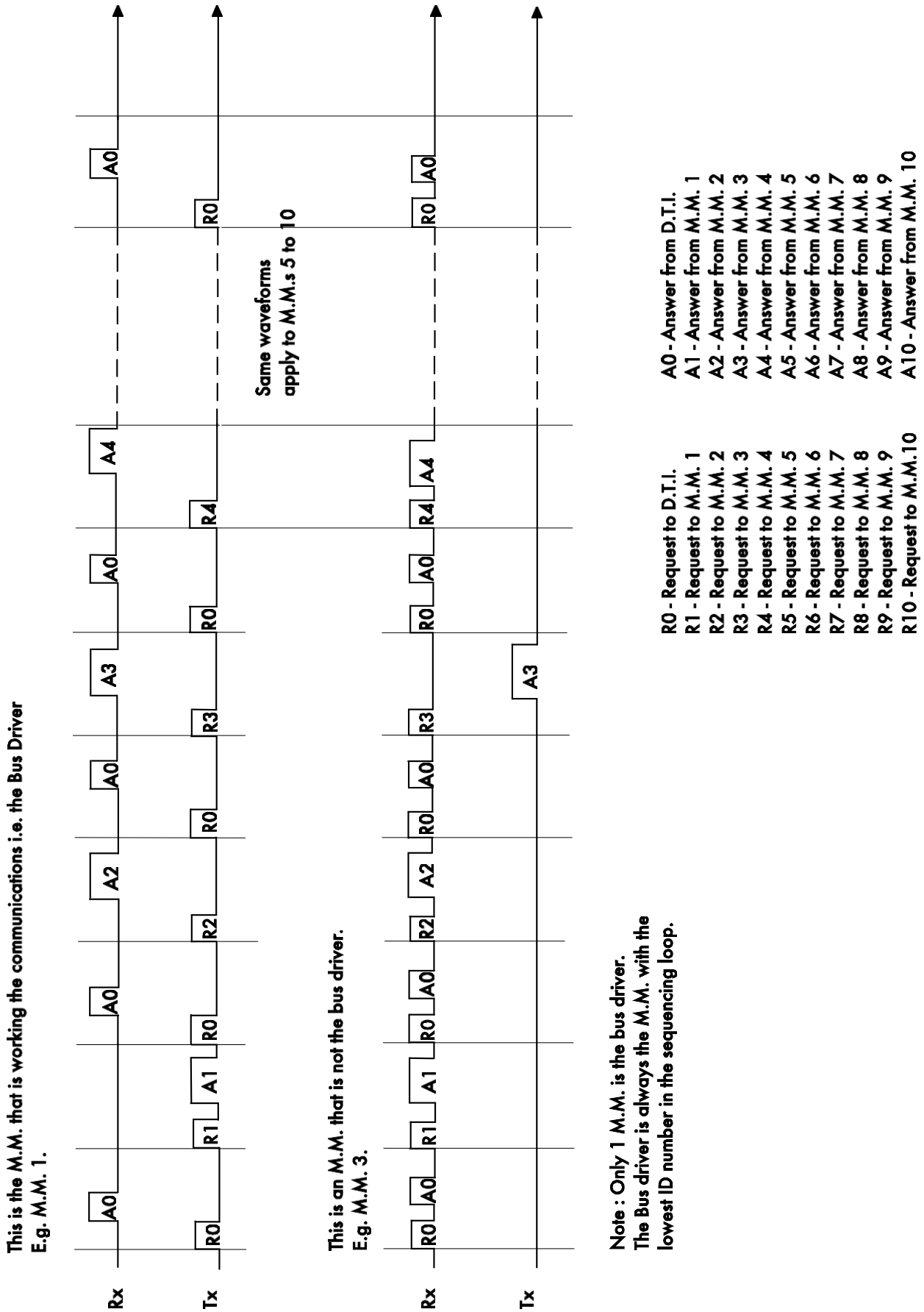
7.1.1 Hot Water Example



7.1.2 Single/ Multi-Burner Examples



7.1.3 IBS Communications



7.2 Sequencing Options and Parameters

The following tables show the options, parameters and expansion options relevant to IBS.

Option	Description
16	Sequencing and DTI enable
33	MM identification
35	Sequence scan time
40	Warming facility for low pressure steam
41	Warming mode
42	Standby setpoint
53	Steam sequencing burner off time
54	Steam sequencing burner on time
57	Fuel flow metering
Parameter	**Description**
1	Sequence scan time set when unit goes offline
3	Number of boilers initially on
5	Modulation timeout
57	Highest MM ID
62	Hot water sequencing
86	IBS change down threshold
87	IBS change up threshold
101	Shuffle sequencing
Expansion Option	**Description**
100	Sequencing/DTI or Modbus function

7.3 Hot Water Sequencing

7.3.1 Implementing Hot Water Sequencing

For hot water sequencing, a temperature detector must be fitted to all the MMs (only Master MMs in Multi- Burner operation if option 14 is set to 1 – Mk8 MM only) and option 1 must be set to 0 or 5.

As sequencing is based on firing rate, the MMs must have fuel flow metering entered, see option 57. The burner rating is set as point 1 low fire in fuel flow commissioning. See section 3.5 for more information on fuel flow commissioning.

The MMs can be configured for sequencing either in Commissioning Mode, or Online Changes; this allows the commissioning engineer to implement/adjust sequencing later after the burners have been commissioned.

Each MM in the sequencing loop must be set with an individual ID number through option 33; no two MMs can have the same ID number in sequencing, Multi-Burner operation, and when connected to a DTI/Modbus interface. The highest MM ID number should be set for that sequencing loop in parameter 57, so the system only looks for communications with these MMs. The maximum number of MMs that can be in a sequence loop is 10. If there is a DTI in the sequence loop, to control the sequence loop via the DTI, parameter 101 must be set to 1.

To enable sequencing, option 16 must be set to 1, or 3 for sequencing with DTI. If option 16 is set to 3, then the DTI/Modbus interface is capable of some remote control. The individual and global required setpoint, lead boiler select, sequence order, enable/disable and firing rate can be set remotely. If an MM's firing rate is set by the DTI/Modbus interface, then that MM will not follow the sequencing loop.

For hot water sequencing, option 53 must be set to 0 to disable the standby warming which is used in steam sequencing. Options 40 and 41 must be set to 0 on all the MMs in the sequencing loop. If warming is required for lag hot water boilers, then hot water sequencing can function like steam sequencing by setting parameter 62.

In a sequence loop, there is one lead burner, and the rest are lag MMs. The lead burner identifies its own firing rate by looking at its fuel flow metering data, proportional to the system's load requirements. Having established the percentage firing rate and maximum heating capacity, the MM will calculate the amount of heat being contributed to the system by this burner.

The sequence scan time, see option 35, sets after how often the firing rates of all the MMs in the loop are assessed. The scan time has a critical effect on the responsiveness of the sequencing system. Too long a scan can result in the boilers not coming online quick enough to meet the load demand; too short a scan time (shorter than the burner start-up time) can cause another boiler to be brought online before the previous lag boiler has started firing. The scan time should normally be set as a minimum, to the start-up time for the burner.

The lead burner looks at its firing rate and sends a command to the lag MMs to either contribute to load because it cannot reach the setpoint, or to stop contributing to the load because the system has met the load demand. Only one lead burner can be selected at one time - if more than 1 is selected as lead burner, then the MMs will ignore the sequencing loop commands and return to independent firing. Parameter 2 sets how often the 'bus driver' MM requests and transmit information to the other MM The 'bus driver' is always the MM with the lowest ID number.

The MMs will start, continue or stop contributing to the load based on the change up and down thresholds, see parameters 86 and 87. The next lag MM will be brought online if the lead burner cannot cope with the load demand, and its firing rate is above the change up threshold. Alternatively, the MM will go into standby, warming or offline if the last two lag MMs have a total combined firing rate less than the change down threshold, because the system can cope with the load demand.

For example, if the change up threshold in parameter 87 is set at 90%, then if the last firing MM in the sequence is above 90% firing rate, then at the next scan time, the next lag MM will be brought online.

If at the next scan time, the firing rates of the last two online lag MM are 30% and 40% respectively, and the change down threshold in parameter 86 is set at 80%, then the last lag MM will go into standby, warming or off depending on how the sequencing mode is set.

If a lag burner fails to start when requested, the scan time will be decreased by the offset set in parameter 1, until it is automatically ignored from the sequencing communication loop. If a lag burner fails to modulate after being requested to contribute to the load requirement, then that MM will be ignored from the sequencing communication loop after a time delay set in parameter 5.

After a power recycle, the number of MMs which are initially set on when the MMs start up again, is set in parameter 3.

7.3.2 Two Port Valve Operation

In hot water sequencing, when there is no demand for all of the lag boilers to be on, the system will close the two port valves on the lag boilers that do not need to be on. This will stop the hot water circulating in the system from passing through the boiler and the heat being wasted. It is possible to use Terminal 78 which is a switched neutral to control the two port valve. This works by switching to neutral once the burner has stopped firing but if the temperature of the boiler ever gets above the required set point then Terminal 78 will switch back even if the boiler is not firing.

- When the two port valve is closed on an OFF lag boiler, if at any time, the residual heat in that boiler is above the required setpoint, the valve is opened immediately and the heat is let through the system. The two port valve then stays open.
- When the lead boiler recognises that it needs a lag boiler to come online after the sequence scan time, the lag boiler will then run its relay tests. This will open the two port valve immediately and it will then stay open.

For the two port valve to close, the lag boiler must be in standby mode, and the actual setpoint must be on or below the required setpoint; it must be in this condition for at least one minute.

Terminal 78 on the MM is a switched neutral connection for controlling a two port valve that would normally be installed in the boilers return pipe connection to the common return header. This facility ensures that boilers that are switched ‘offline’ do not contribute return temperature water to the flow header thereby diluting the flow temperature to the building.

7.4 Steam Sequencing

7.4.1 Warming Steam Boilers

The difference between steam pressure sequencing is the warming periods; the IBS settings explained in section 7.3.1 are the same (see section 7.4.2 for options 40, 41 and 53). By keeping the lag boilers at low fire when they are in standby/ warming, when they are requested by the lead MM to come online and contribute to the load, they will not be started from cold.

A steam boiler is at risk of thermal shock if not warmed before running at high fire. If the lag boiler is required to contribute to the steam load, then the boiler must be warm in order to contribute quickly in a safemanner. If the boiler is started from cold and allowed to fire at a high firing rate straight away, then this may cause damage to the boiler. The tubes will increase in temperature and if the boiler started from a cold position, then this will cause thermal shock to the boiler.

Additionally, not warming a steam boiler can result in a slow response to meet the system's steam demand. For process applications and critical sites such as hospitals, it is imperative that the steam is met efficiently and quickly. If one of the boilers fails or locks out, then it is very important that the next boiler in the sequencing loop gets up to pressure as quickly as possible. Therefore, if this starts up from a cold status then this will take a long time to get up to pressure safely. By warming this lag boiler this means that the boiler will maintain a pressure, offset from the required setpoint in order to ensure that when required this gets up to pressure quickly.

7.4.2 Implementing Steam Sequencing

When the IBS software control package is applied to steam boilers, its operation is similar to hot water sequencing but with additional features and enhancements as explained below. In the case of heating boilers only two states in the control form exist, either on or off. When steam boiler variations of IBS are optioned, there are three states which are controlled sequentially.

Just like in hot water sequencing, steam sequencing is used to ensure that only the minimum boilers required are contributing to meet the required setpoint, reducing fuel consumption.

The steam sequencing operation has 4 sequencing states:

- On – the burner fires and modulates freely to meet the required setpoint. The burner will start and stop according to the above and below offset differentials (see options 9, 10 and 11).
- Standby – the burner remains at the low fire position to meet the standby setpoint (set as an absolute value in option 42). The burner will start and stop according to the above and below offset differentials (see options 9, 10 and 11).
- Warming – the burner remains at the low fire position to meet the standby setpoint (see option 42) and runs according to a timer of X minutes firing (see option 54) and Y minutes not firing (see option 53). If option 53 is set to 0, then the burner will continually fire at the low fire position to meet the standby setpoint in the warming state.
  The burner can also be controlled by a (warming) thermostat fitted in the boiler shell, wired to terminal 93 (see option 79).
- Off – the burner does not fire.

As well the options/parameters given in section 7.3.1, the following also need to be set for steam sequencing:

- Option 41 – Sets whether all the lag boiler states, either the first lag is kept in standby state with the second lag in warming and the remaining lag MMs off, or all the lag boilers after the first lag boiler are kept in warming state and there are no boilers offline.
- Option 42 – Sets the standby setpoint for sequencing where non-return valves are installed; the first lag boiler will aim to maintain this standby setpoint when in the warming/standby phase. This is set as absolute value.
- Options 53 – Sets the steam sequencing burner off time. This is the time in minutes for how long the boiler will be off for during Warming mode.
- Option 54 – Sets the steam sequencing burner on time. This is the time in minutes for how long the boiler will be in low flame hold for the boiler to heat up to its standby setpoint, when in Warming mode. Option 42 sets the standby setpoint.

7.4.3 Low Pressure Steam Sequencing

For steam boiler plants where check (non-return) valves are not installed, or the required setpoint is less than 2 Bar (20 PSI), it is not possible to use a standby setpoint. Each pressure sensor would read the same pressure value, regardless of individual boiler temperature/ pressure. A thermostat (Aquastat) can be installed into the boiler shell, and option 40 must be set to low pressure steam sequencing.

For the Mk8 MM, with option 79 set to 0, (terminal 93 used for warming stat.), an input on terminal 93 stops/inhibits the burner when the MM is in warming. Removal of this voltage allows the burner to run. The boiler will remain in a warming state based on the settings in options 53 and 54

7.5 Troubleshooting – Sequencing

The IBS software can be used for up to 10 MM modules. It can be burners with water level control and EGAs.

Troubleshooting

If the IBS software is not turning the lag boilers on and off as needed to meet load demand, this indicatesthat there an issue with the sequencing communications.

Fuel flow metering must be set correctly on all the MMs as this is used to determine the firing rate and burner rating which the IBS software looks at to decide whether to bring on or turn off lag boilers.

The MMs must be connected via a Belden 9501 daisy chain configuration, with the data cable screened atone end.

During firing, an MM will be removed from the sequence loop should any of the following occur:

- Communications to the MM has timed out
- The MM has been disabled remotely via the DTI or a BMS with option 16 set to 3
- Option 16 on the MM is not set to 1 or 3
- The MM is in an error, burner lockout or expansion alarm state
- The MM has not started modulating within the required time
- The DTI is manually controlling the firing rate
- Modulation exerciser is being used
- Option 47 has been set for cold-start routine
- The MM is in Hand or Low Flame Hold mode
- The MM has been optioned for Modbus

Testing Communications with an LED

When having communications problems between Autoflame MMs, a simple test with a standard 5V LED can confirm if they are due to hardware or wiring problems.

Take a standard 5V LED and wire it into terminals 27 and 28 of the MM ensuring correct polarity (black connected to the negative leg of the LED). If the MM is communicating, the LED will flash intermittently. If the LED does not flash, check the polarity is correct on the LED. If the LED still does not flash, please contact Autoflame Sales Department. Do this for all the MMs in the sequence.



8 MULTI-BURNER OPERATION

8.1 Multi-Burner Overview

Some special applications such as dual furnace fire tube boilers, multi-burner water tube boilers and other application may require Multi-Burner operation. This feature can be used where two or more independent burners require controlling simultaneously.

In multi-burner operation setup, all components must be kept separate and independent for each burner, so each burner should have its own independent components, this includes:

- Air damper.
- Air fan / blower and its motor.
- Induced draught fan / blower and its motor.
- Draught control damper / valve and its control servomotor.
- Draught pressure sensor.
- Air pressure sensor or switch.
- Gas pressure sensor or switch.
- Forced FGR fan / blower.
- FGR valve and its control servomotor.

In multi-burner operation a leading MM is set as the main controller; this is called the Master MM, any other MM units in the setup are secondary and called Slave MMs. In a multi-burner setup only one Master MM can be setup and as many as 9 Slave MMs can be used to control up to 10 burners in total.

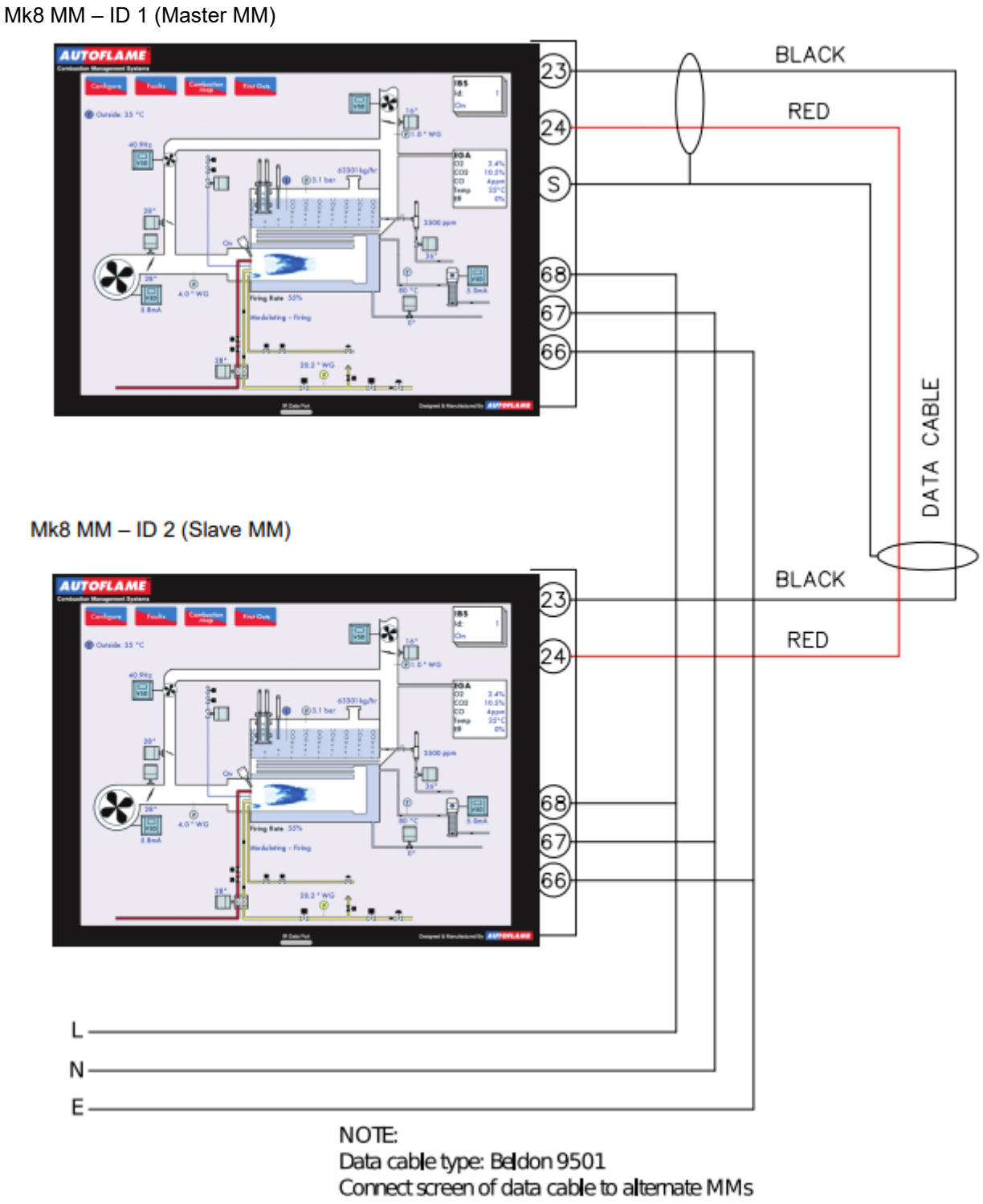
Note:

- All MMs in a multi-burner operation must have identical version of the software (MM, BC & DI).
- Fuel Change on the Fly (COF) feature cannot be used with Multi-Burner operation.

8.2 Configuring Multi-Burner Operation

8.2.1 Wiring

Terminals 23 and 24 on the Mk8 MM are used for Multi-Burner communications, a screen must be connected at one end. The connection must be made as per the diagram below:



8.2.2 Options and Parameters

The following table shows the Mk8 MM options relevant to implement Multi-Burner operation.

Option	Description
43	Multi-Burner Function
44	Multi-Burner ID
51	Multi-Burner Highest Slave ID

8.2.3 Commissioning in Multi-Burner Operation

In Multi-Burner operation, the MMs can be commissioned simultaneously or individually.
To commission all MMs simultaneously, option 43 should be set to 1 or 2.
To commission the MMs individually, option 43 should be set to 0, then changed to 1 or 2 after the commissioning is done.

Before commissioning, set the ID number for each MM in option 44. The Master MM must have ID number 1 and the Slave MM must have ID number of 2 or greater.

The multi-burner ID is independent of sequence ID number, which should also be set as required in option 33. Option 51 must be set to the highest multi-burner ID in the multi-burner configuration as set in option 44.

It is the commissioning engineer's responsibility to ensure that no adverse effects are caused as a result of using this feature, particularly, stress to a boiler not designed to have only one burner firing. It is strongly recommended to have all burners commissioned simultaneously.

After setting the relevant options, the MM can be commissioned as detailed in section 3. After commissioning all the MMs, if commissioned individually, option 43 will need to be set to 1 or 2 as appropriate.

8.2.4 Fuel Flow Metering in Multi-Burner Operation

To enter fuel flow commissioning, all MMs should be in firing mode, all burners will follow the firing rate of the unit being metered. Each MM must have its fuel flow metering done individually one at a time. Please refer to section 3.5 for information on how to set-up fuel flow metering.

8.2.5 Single Point Change in Multi-Burner Operation

For Single Point Change, all burners will follow the firing rate of the MM unit being subject to the Single Point Change. It is not possible to perform single point change on more than one unit at a time.
After performing single point change to the commissioning curve, the fuel flow metering needs to be re-done on all MMs in the Multi-Burner setup.

8.3 Multi-Burner Operation Options

Multi-Burner function can be configured in 2 different ways as set in option 43; fully linked or independent on fault.

8.3.1 Fully Linked Operation

This operation mode is most common in multi-burner fire-tube boiler applications. Fully linked operation can be selected by setting option 43 to 1, in this case all MMs will fire simultaneously, the Slave MM(s) will always take the firing rate from the Master MM, including when the master has been put in low flame hold or hand mode. All MMs will start-up together and phases are checked for multi-burner sync – position to purge, position to start, ignition and modulation.

All burners will always fire simultaneously; the internal stat of all MMs will open if any one of the MMs is shut down by an external stat.

If a lockout or error occurs on one of the MMs, then all burners will turn off, until the lockout/error has been reset, all MMs will proceed to start-up and fire simultaneously

A load detector does not need to be wired to the slave MMs, only the master MM. The load detector input on the slave MMs can be left open circuit.

For hand and low flame hold modes, the inputs must be wired to terminals 94 and 95 respectively on the Master MM, no inputs are required on the Slave MMs for Hand Mode or Low Flame-Hold modes.

For sequencing with multi-burner, the Master MMs can be connected via terminals 27 and 28 in a daisy-chain configuration. Option 16 should be set to 1 or 3 on all master MMs. If all the MMs are connected to a DTI, then they should all be connected via terminals 27 and 28 in a daisy chain configuration, including the slave MMs, Option 16 should be set to 0 on all slave MMs. This would allow the DTI to gather information from all the MMs in the loop. The lead boiler switch should only be wired to terminal 88 on the Master MMs.

If there is a loss of communications between the MMs, all of them will open their internal stat and a ‘multi-burner communications fault’ alarm will occur. They will all shut down and only start once all are communicating via the multi-burner link.

8.3.2 Independent on Fault

This operation mode is most suitable for water-tube boilers with multi-burners and can be selected by setting option 43 to 2; all MMs can fire simultaneously and independently.

The Slave MMs will always take their firing rate from the Master MM, including when the Master MM has been put in low flame hold or hand mode, apart from when the master is not firing or is in a lockout state. If the Master MM is powered off, has an error or multi-burner communications loss, all burners will shut down.

If a Slave MM is powered off, has an error, lockout or multi-burner communications loss, then the other MMs will continue to fire independently. When the Master MM is powered back on, the error is reset or the multi- burner communications is recovered, all burners will then start-up in sync and resume firing in multi-burner operation. When a Slave MM is powered up, the error, lockout or multi-burner communications recovered, it will restart and resume multi-burner operation.

When Multi-Burner operation setup is set as Independent on Fault, a load detector must be wired to the Master MM as well as all Slave MMs.

For hand and low flame hold modes, inputs can be wired to terminals 94 and 95 on all MMs. When the Master MM is put into low flame hold or hand mode, all Slave MMs will follow the Master MM. If a Slave MM is put into hand or low flame hold mode, the burner will continue to follow the Master MM.

When multi-burner MMs are setup as independent, each individual MM will go into hand or low flame hold if the input is active on its terminals 94 and 95, respectively.

8.4 Multi-Burner with Water Level Control

Water Level Control must be enabled on the Master MM only and disabled on all Slave MMs.

All MMs can fire simultaneously or independently as per section 8.2 with water level safety provided by the Master MM. If the Master MM is powered off, has a communication loss or an error or expansion alarm, then the Slave MMs will all shut down, until the Master MM is powered on, communication is restored, or the error or expansion alarm has been reset.

If the Master MM has a normal lockout or is not running due to internal or external stat, when option 43 is set to 1, then the Slave MMs will continue to fire independently. Unless the Master MM is powered off, has a communications loss, develops an error or an expansion alarm.

In order to meet BS EN 12953, the minimum requirements for safe water level control are to have an independent high integrity self-monitoring low water cut off, in addition to the water level control. When using the Autoflame water level control, an auxiliary 2nd low probe must be fitted to meet these requirements in the EU.

8.5 Multi-Burner with EGA

8.5.1 Multi-Burner with Single EGA

The multi-burner function can be used in conjunction with an Exhaust Gas Analyser (EGA) to monitor and trim emissions. When using the multi-burner function, it is possible to use only one EGA if the boiler has a common stack and the burners are firing into the same combustion chamber. The following modules are required:

- 2 or more Mk8 MMs for multi-burner application
- 1 x Mk8 EGA and sampling probe to measure the exhaust gases from the common stack

The EGA sampling probe is mounted in the stack, and the EGA communicates with the Master MM through the data link on terminals 25 and 26. The EGA data is then transferred over to the Slave MMs via the multi-burner data link on terminals 23 and 24. In addition to the multi-burner options the following EGA options will need to be set on the master only:

- Option 12 – EGA Operation
- Option 33 – MM Identification (Master MM ID must match EGA ID)

All burners need to be either fully commissioned simultaneously, with the points in the combustion curve entered at the same point and at similar angular degrees to ensure that all burners are firing with good emissions throughout the firing range. Alternatively, the systems can be commissioned independently with option 12 set to 1 (EGA for monitoring only) and then set to 2 or 3 afterwards with trim values entered in single point change on the master MM only. Once trim is commissioned on the Master MM, all burners will modulate as normal and follow the trim as set in the Master MM.

Safety limits of combustion on EGA can also be used with multi-burner operation, allowing the user to set absolute or offset limits of O_2, CO, CO_2, NO and exhaust temperature, on the Master MM only. Any combustion limits alarms will operate as set in EGA option 13 on the Master MM. Please refer to the EGA Setup Guide for more information on setting up combustion limits.

In critical situations where one of the MMs is in fault condition, single burner firing can be used. However, it is recommended that the EGA is optioned to monitor only (Mk8 MM option 12 set to 1) or completely disabled to ensure reliability. Provided no changes are made to the combustion either through re-commissioning, or single point change, the EGA can be re-optioned when required.

8.5.2 Multi-Burner with individual EGAs

If the Master and Slave MMs fire into individual combustion chambers, individual EGAs can be used for each MM, by mounting the sampling probes in the individual flue or in the first pass, before the flues join to meet a common stack.

The EGA sampling probe is mounted in the stacks, and the EGA communicates with each MM individually through a direct data link on terminals 25 and 26, these cannot be wired in parallel or series. In addition to the multi-burner options, the following EGA options need to be set on each MM:

- Option 12 – EGA Operation
- Option 33 – MM Identification (MM ID must match EGA ID)

All MMs need to be fully commissioned simultaneously, with the points in the combustion curve entered at the same point and at similar angular degrees to ensure that all burners are firing with good emissions throughout the firing range. Alternatively, the MMs can be commissioned independently with option 12 set to 1 (EGA monitoring only) and then set to 2 or 3 afterwards with trim values entered in single point change one system at a time. Once all systems are commissioned, all MMs will modulate as normal and trim to their own trim curve.

Combustion Safety Limits on the EGAs can also be used with multi-burner operation, allowing the user to set absolute or offset limits of O_2, CO, CO_2, NO and exhaust temperature. Any combustion limits alarms will operate as set in EGA option 13, the effect on other multi-burner systems is dependent on option 43 setting. Please refer to the EGA Setup Guide for more information on setting up combustion limits.

8.6 Multi-Burner External Modulation

Multi-Burner can be used with both permanent external modulation and switched external modulation. Only the Master MM needs to be wired for external modulation. Please see section 6.6 for more details about external modulation.

8.6.1 Permanent External Modulation

With option 45 set to 1 or 2 and option 55 set to 0 for permanent external modulation the following occurs when there is an error/lockout:

Option 43 = 1
If either the Master or Slave MM has a lockout, then both MMs will go into standby. Once the fault condition has been cleared, both MMs will start up in sync.

Option 43 =2
If the Master MM has a lockout, then the Slave MM will continue to fire at low flame hold. Once the lockout is reset, the Master MM will go through its start-up sequence and the MMs will sync once it has reached firing; they will continue to fire as per the external modulation signal.

If the Slave MM has an error/lockout, then the Master MM will continue to fire on its own, following the external modulation to reach the setpoint.

8.6.2 Switched External Modulation

With option 45 set to 0, and option 55 set to 1 for switched external modulation, a line voltage on terminal 88 switches the MM from internal PID to external modulation. Switched modulation cannot be used with sequencing.

The following occurs when there is a lockout:

Option 43 = 1
When the terminal 88 input is switched on, all MMs change to external modulation. If either the Master or a Slave MM has a lockout with either external modulation switched on or off, all MMs will go into standby. Once the fault has cleared, they will start up and fire in sync.

Option 43 = 2
With the switched external modulation input turned off on terminal 88, so that all MMs are using the internal PID, if the Master or a Slave has a lockout, then the other will continue to fire following the internal PID.Once the fault has cleared, they will fire simultaneously with internal PID.

If the MMs are switched on for external modulation and the Master MM has a lockout, then the slave MM will go to internal PID and continue to fire. Once the lockout has been reset, the Master MM will go through the start-up sequence and synchronise with the Slave MM once it has reached firing status, they will continue to fire following the external modulation.

If the MMs are switched on for external modulation and a Slave MM has a lockout, the Master MM will continue to fire with external modulation. Once the fault has been reset, they will sync when the Slave MM reaches firing status and continue with external modulation.

9 EXPANSION FEATURES

The Mk8 MM Expansion Features allow additional boiler operations to be controlled using the Mk8 MM. Most operations related to the boiler can be controlled using the Mk8 MM Expansion Features.

The following expansion features are available on the Mk8 MM:

Expansion Feature	Part Number
Autoflame Water Level	MK8001
Analogue Water Level (requires Autoflame Water Level)	MK8002
Top Blowdown	MK8003
Bottom Blowdown	MK8004
Draught Control	MK8005
Direct Modbus	MK8006
First Out Annunciation	MK8007
Fully Metered Combustion System	MK8008
Heat Flow (Steam Flow + Hot Water Flow)	MK8009
Fuel Change On the Fly (COF)	MK8010
Setpoint Schedule	MK8011
Setpoint Programs	MK8012
Flame Safeguard Unlock*	MK8013

Expansion Features can be unlocked by uploading an unlock code to the Mk8 MM via Autoflame Download Manager software. The unlock code is unique for each Expansion Feature and for each MM serial number, the unlock code is issued for the MM based on the serial number of that MM and will not work on any other MM.

Multiple Expansion Features can be unlocked at the same time by uploading multiple codes to the MM at the same time. Please see Autoflame PC Software Guide for more details on unlocking Expansion Features.

In commissioning mode, Expansion Features can be enabled, disabled or configured according to the system's requirements. Press 

in the Commission Mode screen to access all the MM Expansion Options.

Non safety-critical Expansion Options can be setup or changed through Online Changes which requires entering the Online Changes passcode. From the home MM screen, press 

then 

, enter the Online Changes passcode and press 

to configure the Expansion Options.

The Expansion Options can be viewed in read-only while the MM is in run mode. From the home MM screen, press 

and then 

to view the Expansion Options.

By pressing WLC, TBD, BBD, DC, Modbus FO, Flow, FM, Temp at the bottom of the screen, the options can be grouped together by the Expansion Feature.

When changes have been made to suit the application's needs, press 

to go back to the Commission Mode screen.

Please check the specific expansion feature's section for the relevant expansion options.
To set all the options, parameters and expansion options to the default values and erase the commissioning data set option/ parameter 160 to 5. The MM will automatically restart.

***Please note:** The Flame Safeguard Unlock code (MK8013), is used if the MK8 MM is locked as a Flame Safeguard Unit (MM80001/FSG). The MK8 MM must have the software (DI 8.16, FAR 8.21) & above, to use Flame Safeguard mode. For more information on Flame Safeguard mode, please see the Autoflame Mk8 Flame Safeguard manual.

9.1 Unlocking Expansion Features via Mk8 MM

To unlock the Expansion features on a MK8 MM, you will need to go into commission mode as shown in Figure 2.1.iii, and then press the Expansion Features button.

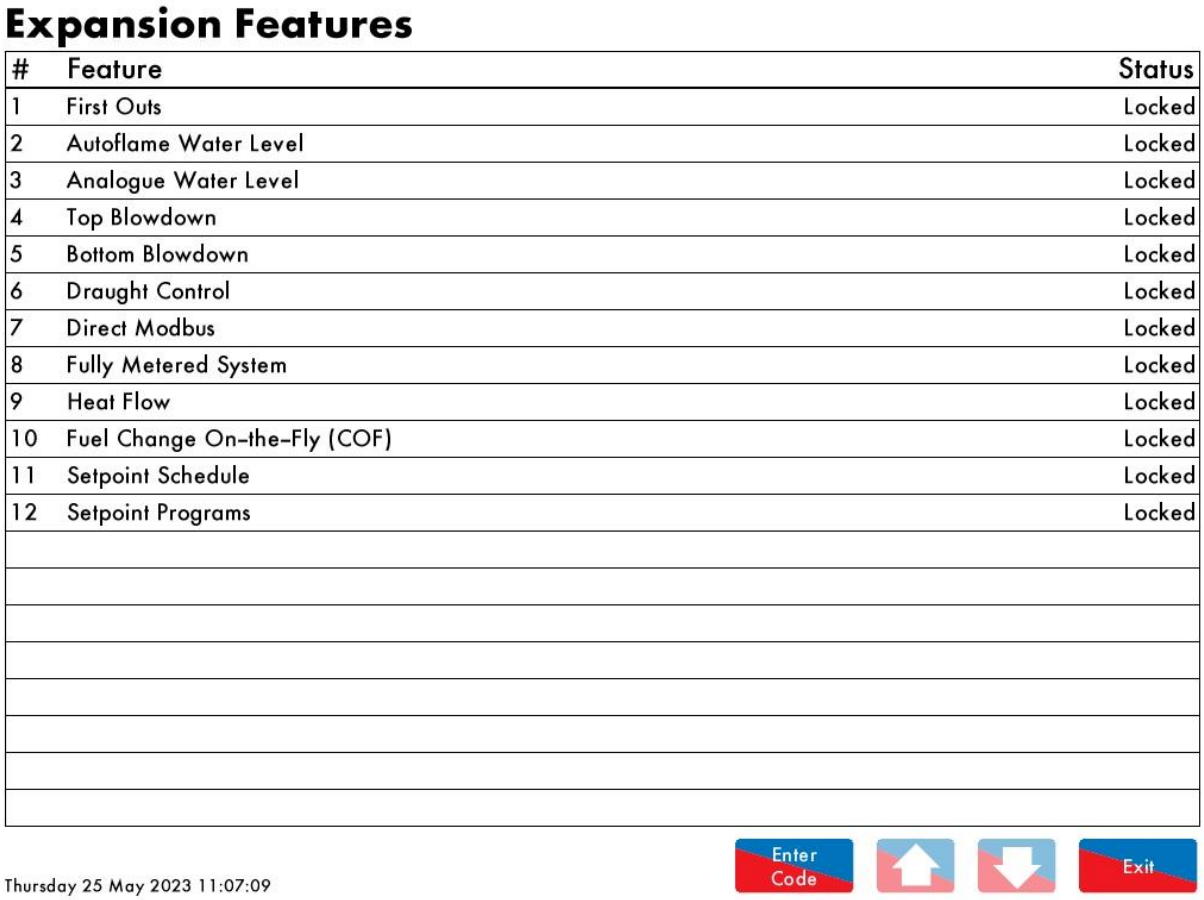


Figure 9.1.i After pressing the Expansion features button, you can upload the unlock code via Download Manager

Once the Expansion Features button has been pressed, you have the option of using Download Manager and an IR Lead (MM80010) to upload the unlock code. Please see the Autoflame PC software guide for more details.

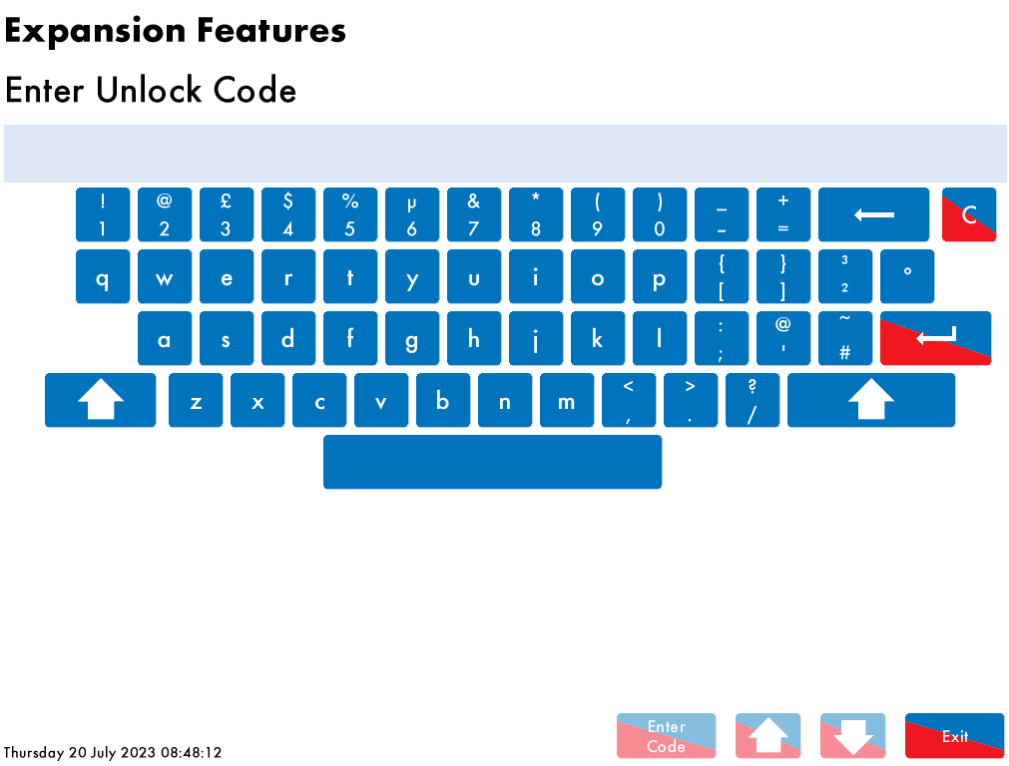


Figure 9.1.ii Expansion Features unlock code keypad

Alternatively, by pressing the 

button as shown in figure 9.1.i, you can type in the Unlock code on the keypad, if you don't have access to the Download Manager software.

Once the code has been typed in, press the  button as shown in Figure 9.1.ii, to have the code unlocked.

Please note: The MK8 MM must have the following software (DI 8.11, FAR 8.15) & above, to enter the unlock code via the MM keypad.

10 WATER LEVEL CONTROL

10.1 Overview

10.1.1 Safety

The purpose of a steam boiler is to generate steam in a safe and efficient manner. The heat produced from the fuel combustion is transferred to the water in the boiler. The water evaporates to steam under pressure. The boiler manufacturer will have designed the boiler so that the steam is drawn out from the header at a safe rate.

As the steam is released, water must be fed into the boiler at the same time to ensure that the water level does not reach a critical low. If the burner continues to fire with not enough water in the steam boiler, serious damage can occur and there is a high risk of an explosion due to the boiler's metal overheating. Hence, the water level in a steam boiler must be continuously monitored and controlled so that when firing there is always sufficient amount of water in the boiler.

Depending on where the steam boiler is operating, there are local codes and regulations regarding the safe operation of the steam boiler, all these codes and regulations must be adhered to.

10.1.2 Autoflame Water Level Control

Autoflame Water Level control in the Mk8 MM focuses on safety and accuracy in controlling the water level in a steam boiler. The intelligent water level control includes high water alarms, 1st low and 2nd low alarms. Alarm level reporting deals with the ability to determine whether the current water level in the boiler is above or below a pre-determined level. These levels vary with each installation and must therefore be programmed on site by a qualified commissioning engineer.

The feedwater flow is managed by 3-element control, in response to the water level measured by the level sensing devices' readings, boiler pressure and the burner's firing rate. The flow is controlled by a fully modulating feedwater/VSD or by using an on/off signal from a feedwater pump. The feedwater going into the boiler can be controlled in the following ways by setting expansion option 2:

- Pump on/off only.
- Pump on/off and servomotor control.
- Pump on/off and VSD control.
- Pump on/off, servomotor and VSD control.

The Autoflame 3-element level control has been granted a worldwide patent; being the only system that can combine firing rate, steam pressure and water level within one controller for the purpose of improving feedwater control. Safety, accuracy and integrity are guaranteed.

The levels which are commissioned when using capacitance probes and/or external level sensing 4-20mA device include high, control point, 1st low, 2nd low and end of probe.

The level of the water in the boiler should be maintained appropriate to the amount of steam being generated. Should the water level drop below this ideal level by an excessive amount, it is necessary to stop the burner firing. If there is insufficient water in the boiler, damage may occur to its structure, and in extreme cases, cause an explosion. The water level control herein is designed to maintain a satisfactory level of water in the boiler, whilst controlling and reporting low water level conditions.

Traditional feed water control manages water level in the boiler, steam flow and feed water flow separately, whereas the Autoflame feed water control coordinates the water level, firing rate and steam pressure simultaneously.

10.1.3 Water Treatment

Water is a solvent, and its natural form will contain impurities that can have an unwanted effect on the boiler operation by either corroding the metal heat transfer surfaces, or by lowering the rate of heat transfer from the surfaces to the water. The impurities which are found in water include:

Symbol	Name	Effect
$CaCO_3$	Calcium carbonate	Soft scale
$Ca(HCO_3)_2$	Calcium bicarbonate	Soft scale + CO_2
$CaSO_4$	Calcium sulphate	Hard scale
$CaCl_2$	Calcium chloride	Corrosion
$MgCO_3$	Magnesium carbonate	Soft scale
$MgSO_4$	Magnesium sulphate	Corrosion
$Mg(HCO_3)_2$	Magnesium bicarbonate	Scale, corrosion
NaCl	Sodium chloride	Electrolysis
Na_2CO_3	Sodium carbonate	Alkalinity
$NaHCO_3$	Sodium bicarbonate	Priming, foaming
NaOH	Sodium hydroxide	Alkalinity, embrittlement
Na_2SO_4	Sodium sulphate	Alkalinity
SiO_2	Silicon dioxide	Hard scale

The water treatment regime in any boiler installation has an effect on the life of the boiler. It is important to install any level controls in accordance with the local and national authorities' boiler inspection bodies, approval authorities and boiler manufacturer's guidelines. As well as this, it is vitally important to select a suitable water level treatment regime to ensure correct and safe operation of the Autoflame system. Water treatment companies should be able to assist with the selection and implementation of a suitable water treatment regime.

It is important to remember that the guidelines set are limits that should not be exceeded at any time. If these guidelines and limits are not maintained, then this can cause adverse effects on equipment installed as well reducing the longevity of the boiler and increasing ongoing maintenance requirements.

Total dissolved solids (TDS) are impurities which have not been boiled off with the steam. If the TDS becomes more and more concentrated in the water, bubbles and foaming will occur at the water surface. If these solids then leave with the steam from the boiler, they can contaminate the steam plant equipment, such as heat exchangers, steam traps and control valves. The boiler manufacturer will specify the required TDS level in the water for that boiler. The Mk8 MM has an expansion feature which allows the system to control the TDS level in the boiler via top blowdown control, please see section 4 for top blowdown control.

Suspended solids will exist in the water and if the boiler water is disturbed, they will remain in this state, however when the water is still, these solids will descend to the bottom. Over time, these solids will build up and reduce the heat transfer and may result in the boiler running less efficient. To reduce this sludge which will build up at the bottom of the boiler, the Mk8 MM has a bottom blowdown control expansion feature. Please see section 12 for bottom blowdown control.



Note: It is the responsibility of the boiler operator to ensure that the water used in the boiler has beentreated and maintained according to the boiler manufacturer's specifications.

10.2 Water Level Control Expansion Options

The table below shows the Expansion Options used for configuring Autoflame Water Level Control as well as Analogue Water Level Control.

#	Default	Range	Description
1	0		WLC: Water Level Control Function
			For setting 1, there must be a minimum of two-level sensing elements or a conflict will appear. The capacitance probes with/without external level sensor will be commissioned at end of probe, second low, first low, control point and high water.
		0	Water level control disabled
		1	Water level control enabled
2	0		WLC: Feedwater Control Element
			The feedwater control element will act according to the levels set relative to the control point, through expansion options 10, 11 and 12. Setting 0 Feedwater is controlled using pump on/off only. Setting 1-7 Feedwater is controlled via PID loop, see expansion options 13, 14, 15, and 16. Pump output terminal: BFW. Servomotor terminals: P-, FW, P+, MVI, MVD.VSD terminals: I+, V+ and IV-.
		0	Pump on/off only
		1	Pump on/off and Servo Control
		2	Pump on/off and VSD Control (0-10V / 0-20mA)
		3	Pump on/off and VSD Control (4-20mA / 2-10V)
		4	Pump on/off and Servo Control (0-10V / 0-20mA)
		5	Pump on/off and Servo Control (4-20mA / 2-10V)
		6	Pump on/off, Servo Control, VSD Output (0-10V / 0-20mA)
		7	Pump on/off, Servo Control, VSD Output (4-20mA / 2-10V)
3	0		WLC: Capacitance Probes
			If water level control is enabled, the MM will require a minimum of 2 level sensing elements. For the possible water level sensing device combinations, please see section 10.4.
		0	Capacitance probes disabled
		1	One capacitance probe
		2	Two capacitance probes
4	0		WLC: External Level Sensor
			The external level sensor is wired to terminals EX- and EX+ and will give a 4-20mA signal. The readings can be scaled in expansion options 30 and 31. If an external level sensor is used, then a 4-20mA signal for fuel flow feedback cannot be enabled (option 57) and fully metered combustion control cannot be enabled (expansion option 140). For the possible water level sensing device combinations, please see section 10.4.
		0	External Level Sensor Disabled
		1	External Level Sensor Enabled
5	0		WLC: Auxiliary Alarm Inputs
			For setting 1, the auxiliary alarm mains inputs terminals HAI, 1AI and 2AI are used in addition to the capacitance probes with/without external level sensor readings. For the possible water level sensing device combinations, please see section 10.4.
		0	Auxiliary alarm inputs disabled
		1	Auxiliary alarm inputs enabled

#	Default	Range	Description
6	0		WLC: Second Low Probe
			For setting 0, it is recommended that an auxiliary second low mains input is wired to terminals 2AI. For setting 1, the Autoflame conductive second low probe is wired to terminals 4P-, 4P+, 6T- and 6T-. Please see local codes/ regulations for second low probe and auxiliary second low alarm setup. For the possible water level sensing device combinations, please see section 10.4.
		0	Second low probe disabled
		1	Second low probe enabled
7	0		WLC: Pre-High Alarm Percentage
			The pre-high alarm level is at percentage between the control point and high water, with the control point being referring to 0% and the high water referring to 100%. For setting 0 there is no pre-high alarm and for settings higher than 1, the MM will generate an alarm if the water level reaches this % value between the commissioned control point and high water. For example, if this is set to 45%, then a pre-high alarm will occur if the water level rises to 45% between the control point and high water level.
		0	Disabled
		1 – 99	1% - 99%
8	0		WLC: Pre-First-Low Alarm Percentage
			The pre-first-low alarm level is at percentage between the control point and first low, with the control point being referring to 0% and the first low referring to 100%. For setting 0 there is no pre-first-low alarm and for settings higher than 1, the MM will generate an alarm if the water level reaches this % value between the commissioned control point and first low. For example, if this is set to 45%, then a pre-first-low alarm will occur if the water level drops to 45% between the control point and first low level.
		0	Disabled
		1 – 99	1% - 99%
9	0		WLC: Burner Operation at High Water
			For setting 0, the burner will continue to fire at high water. For setting 1 the burner will stop firing at high water. Expansion option 10 sets whether the pump turns off above the control point or high water.
		0	Burner runs at high water
		1	Burner stops at high water
10	0		WLC: Pump Turn Off Point
			The water level at which the pump turns off is set as a percentage above the control point for setting 0, or above the high water for setting 1, see expansion option 11.
		0	Pump turns off above control point
		1	Pump turns off above high water
11	30		WLC: Pump Turn Off Percentage
			When the water level reaches this percentage of the control point or high water, depending on how expansion option 10 is set, the pump will turn off. If expansion option 10 is set to 0, then this percentage will be between the control point and high water. If expansion option 10 is set to 1, then this percentage is above high water, and should not be set more than a safe top of the probe level.
		0 – 100	0% - 100%

#	Default	Range	Description
12	10		WLC: Pump Turn On Percentage
		0 – 100	When the water level drops to the control point, the pump will turn on at this percentage in between the control point and high water. 0% - 100%
13	100		WLC: Feedwater Control Proportional Band
		0 1 – 500	This proportional band is defined as a fraction of the distance from the control point to first low. The default setting of 100% means that the proportional output reaches maximum (fully open feedwater valve or maximum VSD output) when the water level drops to first low. At halfway between control point and first low the feedwater valve would be 50% open (or the VSD output will be 50%). Reducing the proportional band to 50% would mean that the proportional output reaches maximum (fully open feedwater valve or maximum VSD output) when the water level drops to 50% of the way between control point and first low. Increasing the proportional band to 500% would mean that the water level would have to drop to 5 times the distance from control point to first low. By the time the level drops to first low the feedwater valve will only be 20% open (or the VSD output will be 20% of its maximum output) Disabled 1% - 500%
14	20		WLC: Feedwater Control Integral Time
		0 1 – 1000	The integral element in the feedwater control will make corrections to the feedwater via the servomotor or VSD, depending on expansion option 2. For a slower response, increase the integral time. For a quicker response in critical steam applications to avoid the water level reaching first low, decrease the integral time. However, if overshoot occurs and the water level rises to above the control point and this is not desired, then the derivative element will need to be enabled, see expansion option 15. Disabled Seconds
15	0		WLC: Feedwater Control Derivative Time
		0 1 – 1000	The derivative element in the feedwater control is suitable for applications requiring a quick response but the water level should not rise too high above the control point. For example, if the burner is set to stop firing at high water in expansion option 9 and high water is commissioned not too far above from control point, then overshoot is undesirable in a critical steam application, as the burner would stop firing. Disabled Seconds
16	900		WLC: Feedwater Servo Open Angle
		100 – 900	The feedwater servomotor closed position is set by zeroing the potentiometer in commissioning mode. As default the servomotor is set as fully open, however this setting can be decreased to shorten the operational movement range of the servomotor. 10.0^{O} – 90.0^{O}

#	Default	Range	Description
17	0		WLC: Pump Bypass Operation
			The pump bypass (terminal TB) will turn on at the switch point set as a % of the open range of the valve, and will turn off at an offset from the switch point, set as the bypass hysteresis, see expansion options 18 and 19. However if the pump is turned off, then the pump bypass will also be turned off. For setting 1, the pump bypass hysteresis is below the switch point, so the pump bypass will turn off at an offset below the switch point. For setting 2, the pump bypass hysteresis is above the switch point, so the pump bypass will turn off at an offset above the switch point.
		0	Pump bypass disabled
		1	Pump bypass on above switch point
		2	Pump bypass on below switch point
18	20		WLC: Pump Bypass Switch Point
			The bump bypass switch point is set as a percentage of the valve open range set in expansion option 16.
		5 – 95	5% - 95%
19	5		WLC: Pump Bypass Hysteresis
			The pump bypass hysteresis is set at percentage from the pump bypass switch point set in expansion option 18, and this will below the switch point for expansion option set to 1 (pump bypass on above switch point) and above the switch point for expansion option set to 2 (pump bypass on below switch point).
		0	Disabled
		1 – 50	1% - 50%
20	0		WLC: Burner Operation on Feedwater Control Fault
			For setting 0, the burner will continue to fire if there is a feedwater fault. If the burner continues to fire and the water level drops below the control point to first low, an alarm will occur and the burner will stop firing. If a feedwater servomotor fault occurs, the feedwater pump will continue to operate. For setting 1 the burner will stop firing if there is a feedwater fault.
		0	Burner runs on feedwater control fault
		1	Burner stops on feedwater control fault
21	1		WLC: Test Input Operates Shunt Switch
			The test input terminal TST can be set for checking the auxiliary alarm outputs or shunt switch. For setting 0, hold the test input continuously to cycle through alarm outputs every two seconds. For setting 1, hold the test input for three seconds to trigger the shunt switch operation, and to cancel the shunt switch operation, hold the test input for a further three seconds. See expansion options 22 and 23 for the shunt switch timings.
		0	Test input operates alarm outputs test
		1	Test input operates shunt switch
22	300		WLC: Shunt Switch – Time to 1st Low
			When the shunt switch test is activated in expansion option 21, there is time delay for the water to reach the first low level, allowing the operator to decrease the water level. This test checks the first low alarm while the burner continues to operate. If water does not drop to the first low level in this time period, then MM will revert back to normal run mode and cancel the shunt switch test.
		30 – 600	Seconds

#	Default	Range	Description
23	300		WLC: Shunt Switch – Time to 2nd Low
		30 – 600	After the shunt switch has been tested for first low, there is further time delay for the water to reach the second low level, allowing the operator to further decrease the water level. This test checks the second low alarm while the burner continues to operate. If water does not drop to the second low level in this time period, the burner will turn off. Seconds
24	5		WLC: Sudden Pressure Drop Trigger Rate
		1 – 100	If the pressure drops by this value set over 3 seconds to a pressure below the reset offset from the required pressure setpoint set in expansion option 26, then a sudden pressure drop condition is detected and the control point will increase by a percentage set in expansion option 25. PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
25	25		WLC: Sudden Pressure Drop Control Point Increase
		0 1 – 75	If a sudden pressure drop is detected, the water level control point will increase to the percentage of the control point set. Once the steam pressure increases to the reset offset value from the required pressure setpoint, the control point will return to the commissioned value. See expansion options 24 and 26. Disabled 1% - 75%
26	10		WLC: Sudden Pressure Drop Reset Offset
		0 1 – 100	If the pressure drops by the value set in expansion option 24 over 3 seconds to a pressure below this reset offset from the required pressure setpoint, then a sudden pressure drop condition is detected and the control point will increase by a percentage set in expansion option 25. Disabled PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
27	30		WLC: Probe Mismatch Threshold
		5 – 500	The probe mismatch threshold is a percentage of the first low. If the probes and/or external level sensors read a difference in the level greater than this value set for 30 seconds, then a probe mismatch alarm will occur. 5% - 500%
28	3		WLC: Capacitance Probe Still Water Threshold
		0 1 – 100	This threshold set is the distance between the high peak and low peak of the water wave signature. If the capacitance probes detect a reading between the high peak and low peak which is less than this value for 30 seconds while the burner is firing, a capacitance probe still water alarm will occur. Disabled 1 – 100mm or 0.0 – 3.9” (see parameter 40)
29	10		WLC: Capacitance Probe Filter Time
		1 – 30	The filter time is the rolling time period, over which the capacitance probes take the water level reading. When a moving water level is detected this time period reduces in proportion linearly to the movement. Seconds

#	Default	Range	Description
30	0		WLC: External Level Sensor Scaling
			If an external level sensor is set in expansion option 4, then the 4-20mA signal will need be scaled for the length of the sensor.
		0	Disabled
		1 – 20000	0.01 – 200.00mm/mA or 0.01 – 200.00”/mA (see parameter 40)
31	10		WLC: External Level Sensor Filter Time
			The filter time is the rolling time period over which the external level sensor takes the water level reading. When a moving water level is detected this time period reduces in proportion linearly to the movement.
		1 – 30	Seconds
32	3		WLC: Wave Signature Average Level
			The wave signature average level is set as percentage of the wave signature height of the water level.
		0 – 10	0 – 100% (value 3 = 30%)
33	0		WLC: Feedwater Control Dead Band
			The Feedwater Control Dead Band is defined as a fraction of the distance from the Control Level to First Low and operates this far above and below the control point. When this option is activated, water level control (servo position or VSD output) will not be updated while the water level is within this dead band, allowing small variation in the water level to be ignored.
		0	Disabled
		1 – 50	Dead Band %
34	0		WLC: External Level Sensor No Correction Pressure
			This option allows the readings from an external water level sensor (4-20mA) to be compensated according to the current boiler pressure. Correction is applied linearly between the boiler pressures specified in Exp Options 34 and 35.
			The No Correction Pressure is the pressure above which compensation starts to be applied to the water level signal.
		0 – 1000	0.0 – 100.0 bar
35	0		WLC: External Level Sensor Maximum Correction Pressure
			This option allows the readings from an external water level sensor (4-20mA) to be compensated according to the current boiler pressure. Correction is applied linearly between the boiler pressures specified in Exp Options 34 and 35.
			The External Level Sensor Maximum Correction Pressure is the pressure at which maximum compensation is applied to the water level signal.
		0 – 1000	0.0 – 100.0 bar
36	0		WLC: External Level Sensor Maximum Correction
			The maximum compensation (in mm) that is applied to the external water level signal (at the pressure set in Exp Option 35)
		0 – 2000	0 – 2000 mm
37			WLC: Audible Alarm Timeout Period
			Sets the time counter for water level alarm or warning.
		0 - 3600	Seconds
38	0		WLC: First Low Alarm Type
			First low alarm can be configured to give a recycling or non-recycling fault.
		0	First Low Generates Recycling Alarm
		1	First Low Generates Non-Recycling Alarm

#	Default	Range	Description
39	0		WLC: Pre-First Low - Visual Alarm Output Mode
			The Pre-First Low Visual Alarm Output can be configured for pulsed or continuous output. This is to allow this output, to drive a secondary Feedwater Pump at an adjustable level between Control Point and First Low.
		0	First Low Pre-Alarm Output is Pulsed
		1	First Low Pre-Alarm Output is Continuous

10.3 Water Valves

10.3.1 Specifications

Water valves are universal for feed water, TDS, and bottom blowdown function. The table below lists the feedwater valves and the required servomotor size for each valve.

Valve Type	Size	Part No.	Servomotor Required		
			Large	UNIC05	UNIC10
Threaded BSP/ NPT	15mm (½")	WLCVO15	•		
	20mm (¾")	WLCVO20	•		
Flanged PN40	25mm (1")	WLCVO25/FL		•	
	40mm (1 ½")	WLCVO40/FL			•
	50mm (2")	WLCVO50/FL			•
Flanged ANSI 300lb	25mm (1")	WLCVO25/FLU		•	
	40mm (1 ½")	WLCVO40/FLU			•
	50mm (2")	WLCVO50/FLU			•

Maximum operating pressure: 29 Bar (425 PSI)
Maximum operating temperature: 235°C (455°F)

Note: Autoflame water level probes are rated at maximum 27 Bar (392 PSI) and 230°C (446°F).





Note: Please check Autoflame Valves and Servomotors Guide for water level valves dimensions, specifications, drawings and information on service and maintenance.

10.3.2 Feed Water Valve Sizing

Feed water valves are available as threaded or flanged. Use the water velocity, pressure drop across the valve, water flow rate and steam flow rate to find the correct valve size.

Autoflame Part No. WLCV015 - ½" feed water valve water flow calculations @20°C								
Water Velocity		Pressure Drop Across Valve		Water Flow Rate			Steam Flow Rate	
Ft/sec	M/sec	ΔP PSI	ΔP Bar	G/hr (imp)	G/M (imp)	G/M (US)	lbs/hr	Kg/hr
6	1.82	1	0.07	160	2.6	3.2	1600	727
9	2.74	2	0.14	235	3.9	4.7	2350	1068
15	4.57	5	0.34	380	6.3	7.6	3800	1727
21	6.40	10	0.68	560	9.3	11.2	5600	2545
26	7.90	15	1.03	700	11.6	14	7000	3182
32	9.73	20	1.38	820	13.6	16.4	8200	3727

Autoflame Part No. WLCV020 - ¾" feed water valve water flow calculations @20°C								
Water Velocity		Pressure Drop Across Valve		Water Flow Rate			Steam Flow Rate	
Ft/sec	M/sec	ΔP PSI	ΔP Bar	G/hr (imp)	GPM (imp)	US GPM	lbs/hr	Kg/hr
8	2.43	1	0.07	460	7.7	9.2	4600	2090
12	3.65	2	0.14	665	11	13.3	6650	3022
19	5.79	5	0.34	1100	18.3	22	11000	5000
28	8.53	10	0.68	1630	27.1	32.63	16300	7409
34	10.34	15	1.03	2000	33.3	40	20000	9090
40	12.16	20	1.38	2400	40	48	24000	10909

Autoflame Part No. WLCV025 - 1" feed water valve water flow calculations @20°C								
Water Velocity		Pressure Drop Across Valve		Water Flow Rate			Steam Flow Rate	
Ft/sec	M/sec	ΔP PSI	ΔP Bar	G/hr (imp)	GPM (imp)	US GPM	lbs/hr	Kg/hr
13	3.96	1	0.07	1560	26	31.2	15600	7091
21	6.4	2	0.14	2300	38.3	46	23003	10456
32	9.75	5	0.34	3800	63.3	76	38005	17275
46	14.02	10	0.68	5600	93.9	112	56007	25458
60	18.24	15	1.03	7000	116.6	140	70008	31822
70	21.28	20	1.38	8200	136.6	164	82011	37278

Autoflame Part No. WLCV040 – 1 ½" feed water valve water flow calculations @20°C								
Water Velocity		Pressure Drop Across Valve		Water Flow Rate			Steam Flow Rate	
Ft/sec	M/sec	ΔP PSI	ΔP Bar	G/hr (imp)	GPM (imp)	US GPM	lbs/hr	Kg/hr
17	5.17	1	0.07	4700	78.3	94	47005	21366
25	7.60	2	0.14	6700	11.6	134	67007	30458
39	11.86	5	0.34	11200	186.6	224	112015	50916
60	18.24	10	0.68	16500	275	330	165022	75010
75	22.80	15	1.03	20000	333.3	400	200028	90922
90	27.36	20	1.38	24000	400	480	240033	109126

Autoflame Part No. WLCV050 - 2" feed water valve water flow calculations @20°C								
Water Velocity		Pressure Drop Across Valve		Water Flow Rate			Steam Flow Rate	
Ft/sec	M/sec	ΔP PSI	ΔP Bar	G/hr (imp)	GPM (imp)	US GPM	lbs/hr	Kg/hr
21	6.38	1	0.07	10000	166.6	200	100014	45461
31	9.42	2	0.14	15000	250	300	150020	68191
46	13.99	5	0.34	24000	400	480	240033	109106
72	21.89	10	0.68	36000	600	720	360049	163659
85	25.84	15	1.03	44000	733	880	440061	200028
110	33.44	20	1.38	51000	850	1021	510072	231851

10.3.3 Feed Water Control

The boiler feed water can be controlled using:

- Pump on/off only
- Pump on/off and servomotor control
- Pump on/off and VSD control
- Pump on/off, servomotor control and VSD output

The table below shows the terminals on the MM allocated for the feed water control parts.

Terminal	Description
P-	0V supply to top blowdown and feed water servomotors
P+	+12V supply to top blowdown and feed water servomotors
TW	Signal from feed water servomotor, indicating position
MVI	Drive output to Open feedwater valve
MVD	Drive output to Close feedwater valve
I+	Current output, 0-20mA or 4-20mA to feed water VSD or servomotor
V+	Voltage output, 0-10V or 2-10V to feed water VSD or servomotor
IV	Common terminals for I+ and V+
BFW	Feed water pump contactor

The table below shows the expansion options relating to feed water control.

Expansion Option	Description
2	Feed water control element
10	Pump turn off point
11	Pump turn off percentage
12	Pump turn on percentage
13	Feed water control proportional band
14	Feed water control integral time
15	Feed water control derivative time
16	Feed water servo open angle
20	Burner operation on feed water control fault

The feed water pump can be set so that it turns off and on at percentages above and below the control point/high water, via the feed water pump contactor on terminal BFW.

If the feed water control is set with servomotor or VSD, then the 3-term PID control will operate. The proportional band set in expansion option 13 is the percentage between the control point and 1st low level where corrections are made to the servomotor/VSD to maintain the control point - outside of the p-band, the servomotor/VSD will remain fully open. The integral time set in expansion option 14 will set how fast the system responds to feed water changes - for a slower response increase the integral time, and decrease it for a faster response. The derivative time set in expansion option 15 is used when a quick response is required but where overshoot is undesired; the water level should not rise too high above the control point, so the derivative element will need to be enabled.

The feed water servomotor closed position is set by zeroing the potentiometer in Commissioning mode, however the open position is set in expansion option 16.

10.4 Ways of Level Sensing

10.4.1 Overview

Water level control requires a minimum of two water level sensing devices, one of which must be an analogue device (capacitance probe or external level sensing device).

The MM will show the capacitance probe reading(s), the external level sensor reading, and a combined reading of the optioned analogue sensing devices, as well as the 2nd low probe and auxiliary alarm inputs status.

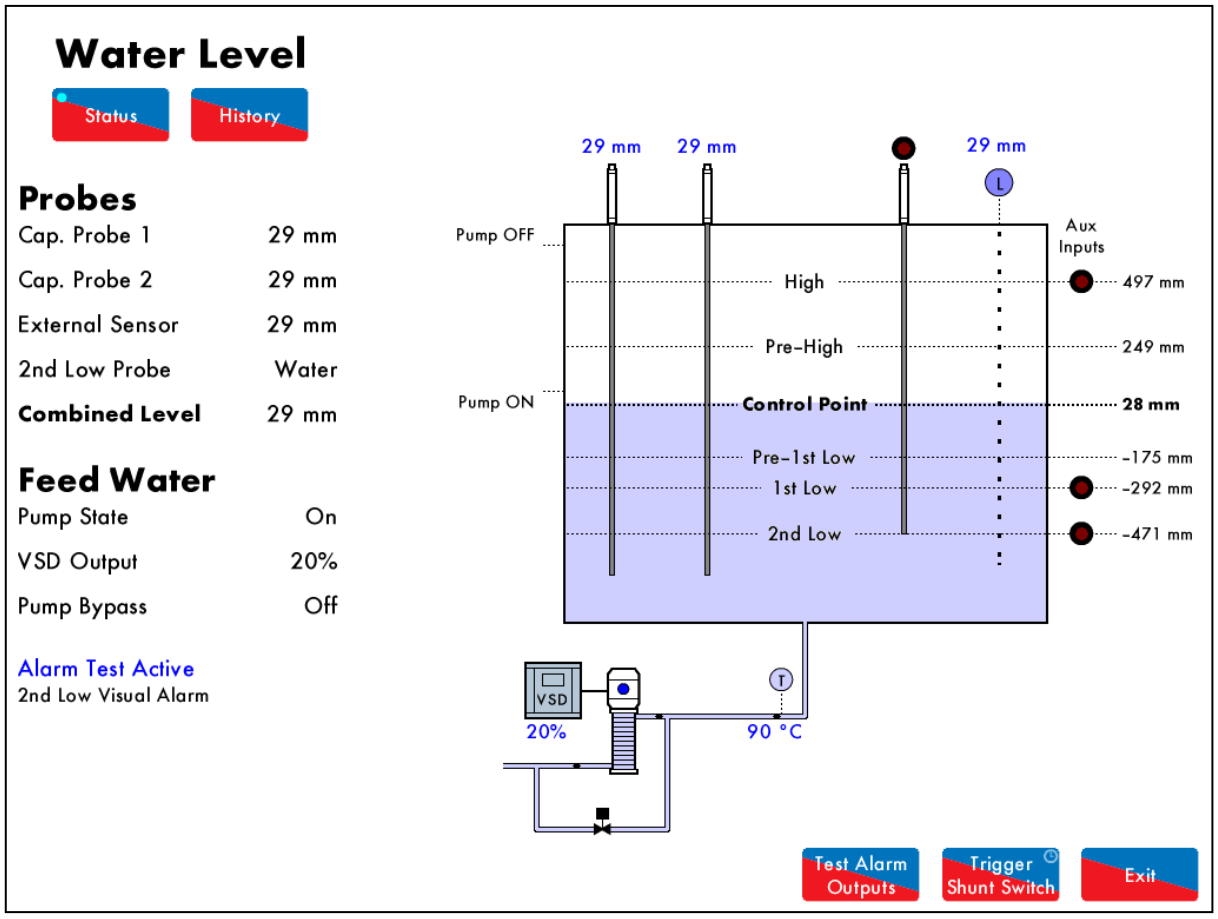


Figure 10.4.1.i Water Level Status – Combined Level Sensing

10.4.2 Configuration

The following tables show the expansion options which need to be set on the Mk8 MM for the different ways of water level detection.

Expansion Option	Description	Setting
1. One capacitance probe, external level sensor		
1	Water level control function	1
3	Capacitance probes	1
4	External level sensor	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

2. One capacitance probe, external level sensor, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	1
4	External level sensor	1
5	Auxiliary alarm inputs	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

3. One capacitance probe, external level sensor, 2nd low probe		
1	Water level control function	1
3	Capacitance probes	1
4	External level sensor	1
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

4. One capacitance probe, external level sensor, 2nd low probe, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	1
4	External level sensor	1
5	Auxiliary alarm inputs	1
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

5. One capacitance probe, 2nd low probe		
1	Water level control function	1
3	Capacitance probes	1
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

6. One capacitance probe, 2nd low probe, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	1
5	Auxiliary alarm inputs	1
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

7. One capacitance probe, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	1
5	Auxiliary alarm inputs	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

8. Two capacitance probes		
1	Water level control function	1
3	Capacitance probes	2
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

9. Two capacitance probes, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	2
5	Auxiliary alarm inputs	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

10. Two capacitance probes, 2nd low probe		
1	Water level control function	1
3	Capacitance probes	2
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

11. Two capacitance probes, 2nd low probe, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	2
5	Auxiliary alarm inputs	1
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

12. Two capacitance probes, external level sensor		
1	Water level control function	1
3	Capacitance probes	2
4	External level sensor	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

13. Two capacitance probes, external level sensor, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	2
4	External level sensor	1
5	Auxiliary alarm inputs	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

14. Two capacitance probes, external level sensor, 2nd low probe		
1	Water level control function	1
3	Capacitance probes	2
4	External level sensor	1
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

15. Two capacitance probes, external level sensor, 2nd low probe, auxiliary alarm inputs		
1	Water level control function	1
3	Capacitance probes	2
4	External level sensor	1
5	Auxiliary alarm inputs	1
6	Second low probe	1
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required
30	External level sensor scaling	As required
31	External level sensor filter time	As required

16. External level sensor, auxiliary alarm inputs		
1	Water level control function	1
4	External level sensor	1
5	Auxiliary alarm inputs	1
30	External level sensor scaling	As required
31	External level sensor filter time	As required

17. Auxiliary alarm inputs, 2nd low probe		
1	Water level control function	1
5	Auxiliary alarm inputs	1
6	Second low probe	1

18. External level sensor, 2nd low probe		
1	Water level control function	1
4	External level sensor	1
30	External level sensor scaling	As required
31	External level sensor filter time	As required

10.5 Capacitance Probes

10.5.1 Overview

The Autoflame capacitance probes can be used in conjunction with the Mk8 MM to detect the water level in the boiler. The system safety is guaranteed as the level measurement is managed by two identical capacitance probes both of which measure and control to the level switching points entered at the time of commissioning.

The capacitance probes are designed to work with steam boilers where the chemical treatment is maintained to the limits stated within these standards and guidelines. When the chemical treatment is maintained to levels under the maximum limits as stated in the standard's tables, the water level probes will work as expected.

When using two capacitance probes, the water level is read to a resolution of less than 1mm in still water. This resolution is maintained during normal operation by Autoflame's patented "wave signature and turbulence management" software. The patented movement detection of water feature ensures that no static value can be accepted, i.e. the probes are in turbulent water. The swell management feature prevents intermittent shutdowns from the 1st low being switching due to increases in steam requirements. The Mk8 MM knows the firing rate and boiler pressure and accommodates for this transient condition by increasing the 'control point' level.

The capacitance probes are high integrity self-checked and continuously monitored by the Autoflame MM control system.



Figure 10.5.1.i Capacitance Probe

Movement Detection of Water

When the burner is running it is expected that a wave turbulence signature in excess of 20Hz / 1mm will always be present (due to vibration of thermal energy). Both probes are checked for this value. This feature ensures that either probe cannot read a still water condition when the burner is running. This safety check ensures no static or stuck value can be accepted, thereby checking that the probes are in water.

Swell Management

When there is a sudden drop in boiler pressure an increase in water level will be observed. This is due to the expansion of the steam bubbles in the water causing the water level to increase. It follows that the waterfeed would then turn off or go to a low flow condition. The Autoflame system identifies this ambiguous condition by monitoring the sudden increase in burner firing rate to meet the load demand and increases the "required water level" by up to 50% of the distance between the normal "required level" and the "high water level". When normal conditions are reinstated and the boiler firing rate stabilises, the "required level" returns to the normal setting. This stops spurious shutdowns due to 1st low being switched during these transient conditions. The Autoflame system knows what the firing rate and boiler pressure is at any one time and uses this information to identify the above condition. This feature is one of the main elements in the patent claim.

10.5.2 Operation

Capacitance is a measurement of how much a body can store electrical charge. The capacitance is measured between the surface area of the probe and the surface area of the boiler shell. As the water level changes the surface area of the boiler shell covered will change, so a change in the capacitance will be detected. The measured capacitance will increase as the water level in the boiler rises, as the surface area covered with water will be bigger with more water in the boiler.

The capacitance readings are constantly checked between both probes, the commissioned value and an internal hardware reference capacitor (to account for long term drift and temperature variations). Both probes control typically: “high level”; “required level”; “first low” and “second low”. The actual water level readings taken from both probes are constantly compared and checked against each other, as well the commissioned water levels. When controlling the required level this data stream is combined with a PI algorithm which controls either the two-port feed water control valve or the variable speed drive to the feed water pump. Each probe is self-checked for electrical and mechanical integrity by hardware references and self-checking software routines. Each probe and its control electronics are compensated for ambient temperature variations and component drift, guaranteeing absolute safety of operation.

By our method the probes control the required level by learning the wave signature and managing the turbulence within the boiler shell. This “wave signature management” accounts for the changes in burner firing rate and any variance in pressure in the boiler shell. Incorporated within the system hardware are all necessary electronic switching functions to control audible alarms, mute/reset and indication lights required to meet standard North American and European codes. Safety, accuracy and integrity are guaranteed.

The Mk8 MM calculates a single average water level figure based on the max and min reading. Expansion Option 32 controls whether the average is weighted towards the minimum value, the maximum value, or in-between.

When Expansion Option 32 is 0% the MM takes the minimum signal level. When Expansion Option 32 is 100% the MM takes the maximum signal level. If it’s 50% then the average level used will be halfway between maximum and minimum values. Since the probe readings are in Hz, the higher the reading the lower the water level. This means that setting Exp Option 32 to 0% would just take the maximum levels seen as the average level, or setting it to 100% would take the minimum levels seen.

10.5.3 Specification

Part No.	Length (Metric)	Length (Imperial)
WLCP500	500mm	20”
WLCP750	750mm	30”
WLCP1000	1000mm	40”
WLCP1250	1250mm	50”
WLCP1500	1500mm	60”

Custom length capacitance probes available upon request.

Specifications	Metric	Imperial
Supplied flying lead	2m	6ft
Probe connection– quick connect	½” NPT Tapered Tread	
Ingress Protection	IP 68	NEMA 6P
Temperature rating of housing	0 - 70°C	32 - 158°F
Nominal Size of Line	15mm	½”
Maximum Allowable Pressure	27 Bar	392 PSI
Maximum Allowable Temperature	230°C	446°F
Test Pressure	40 Bar	580 PSI
Material	Stainless Steel	
Coating	PTFE coated	



Note: The probes must not be cut. If the probes are cut this will act as a short between the positive and negative plates of the capacitor and will stop the probes from working.

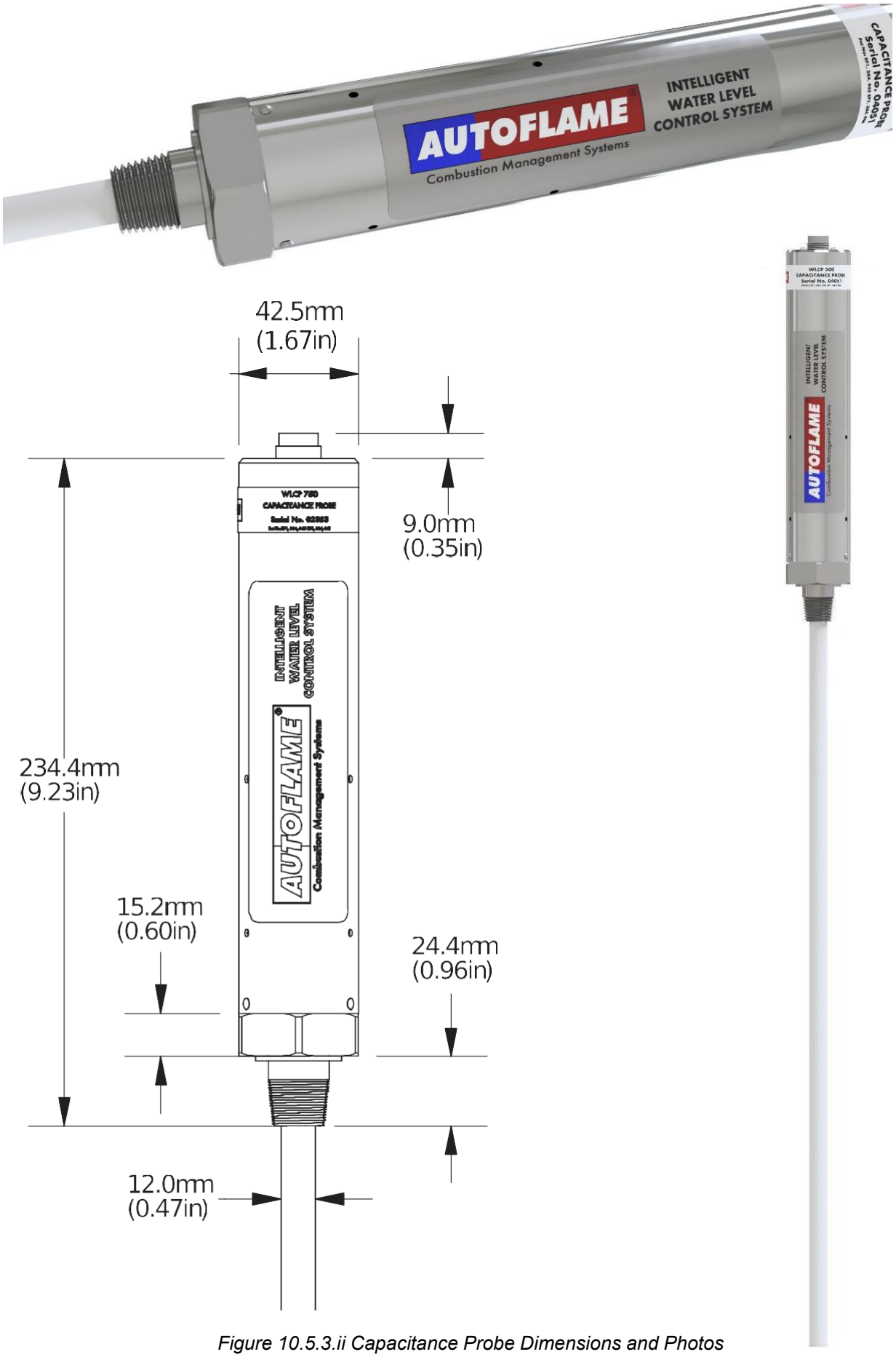


Figure 10.5.3.ii Capacitance Probe Dimensions and Photos

10.5.4 Installation Safety Guidelines



The notes and mechanical executions implicit in the following diagrams for capacitance probe installation are to be used for guidance purposes only. Local state and national codes must be adhered to in all cases. It is important to use only qualified and experience installation personnel who have been factory trained.

Under all boiler operation codes that Autoflame is aware of, it is not permitted to install only two capacitance probes without an additional water level detection device. When the capacitance probes are installed on a boiler application in this way, the boiler must be protected using a separate auxiliary low water cut-off device.

For fire tube steam boilers, a sight gauge glass must be installed to visually indicate the level of the water in the boiler. The water in the sight gauge glass is considerably colder than the water in the boiler and does not contain bubbles or current effects.

Installation diagrams:

10.5.4.A Capacitance Probe – Externally Mounted Pots
10.5.4.B Capacitance Probe – Internally Mounted Pots
10.5.4.C Capacitance Probe – Installation for a Water Tube Boiler
10.5.4.D External Probe – Recommended Chamber Dimensions

Figure 10.5.4.A: Capacitance Probe – Externally Mounted Pots

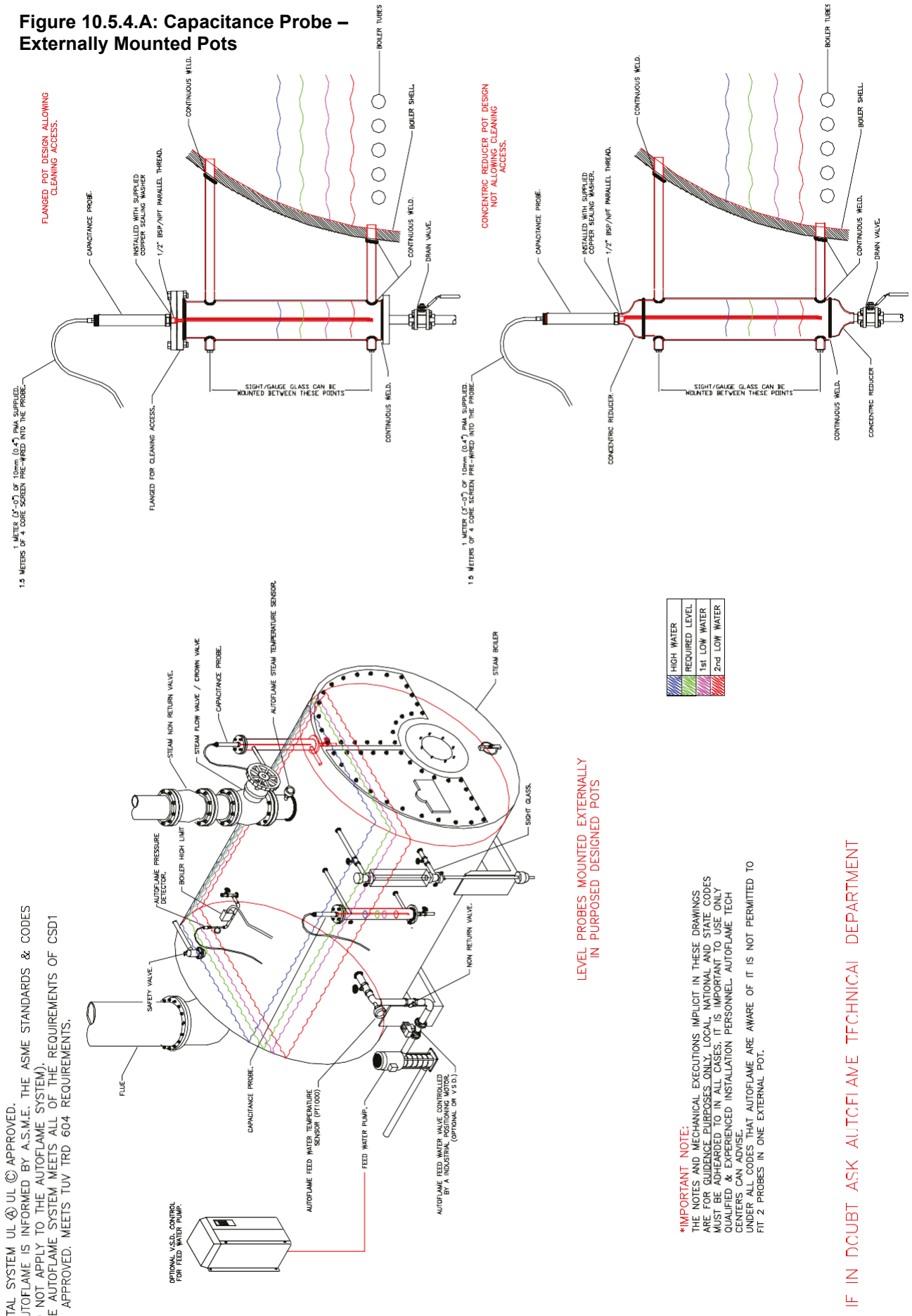


Figure 10.5.4.B: Capacitance Probe – Internally Mounted Pots

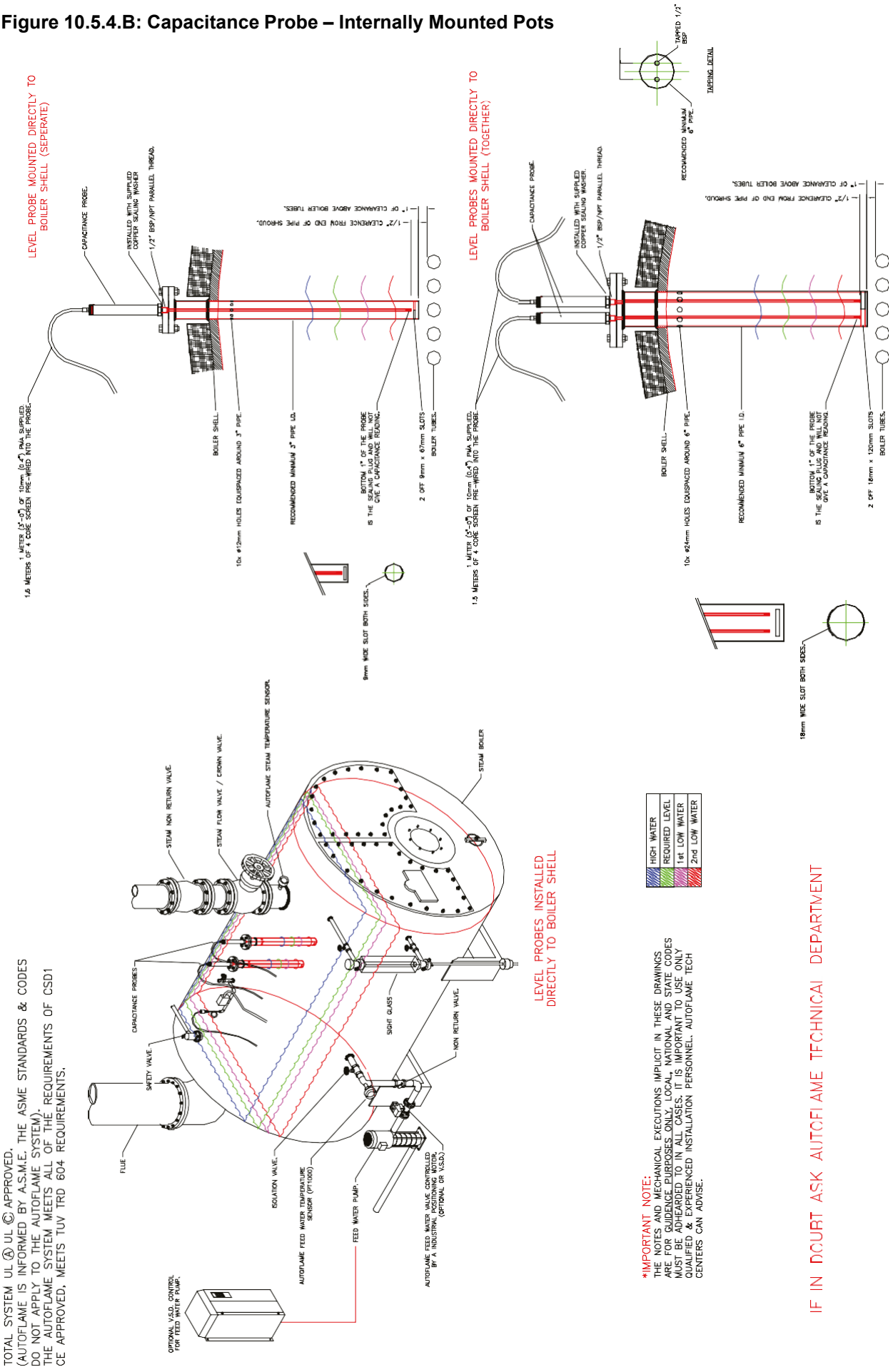


Figure 10.5.4.C: Capacitance Probe – Installation for a Water Tube Boiler

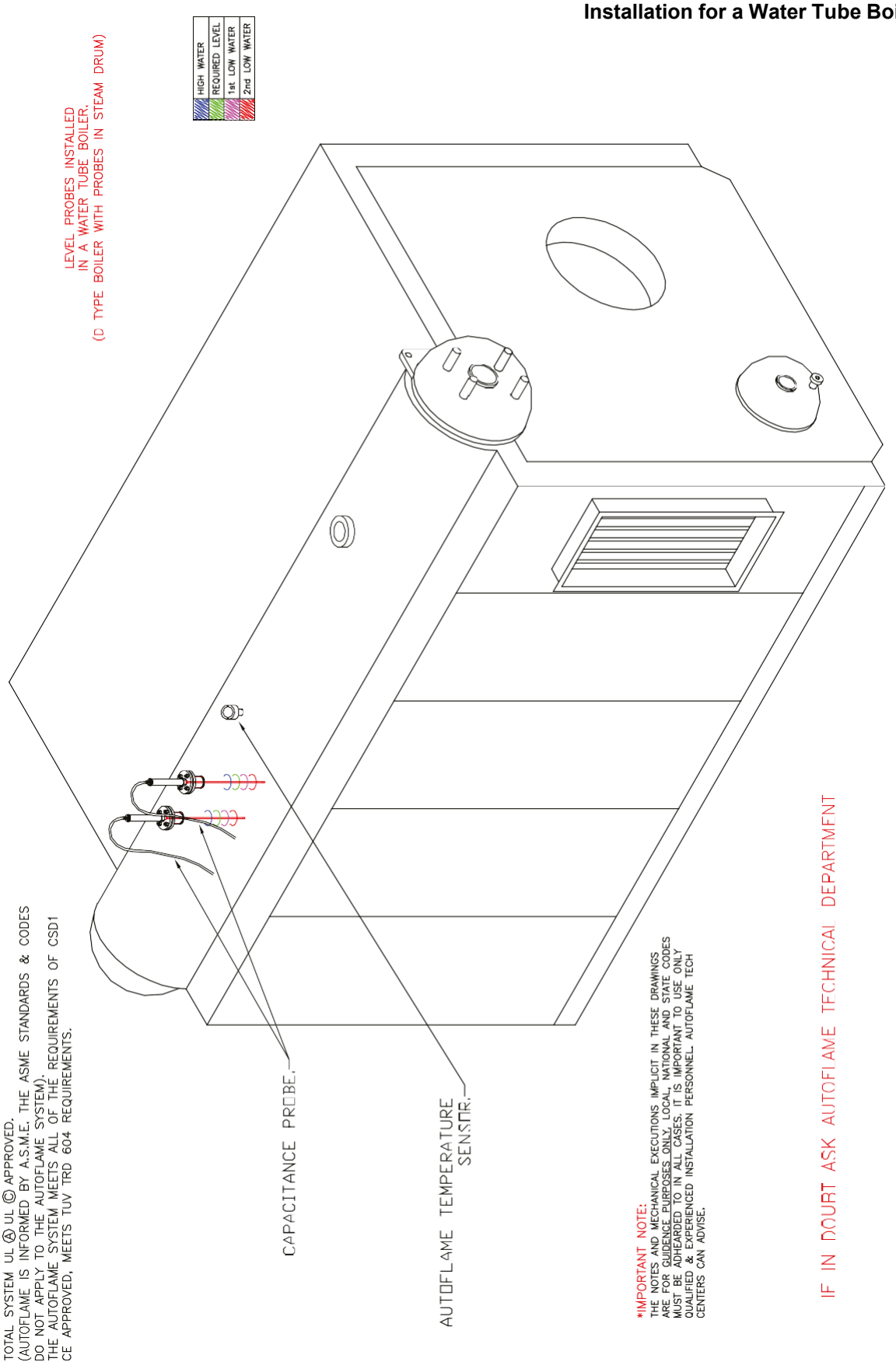
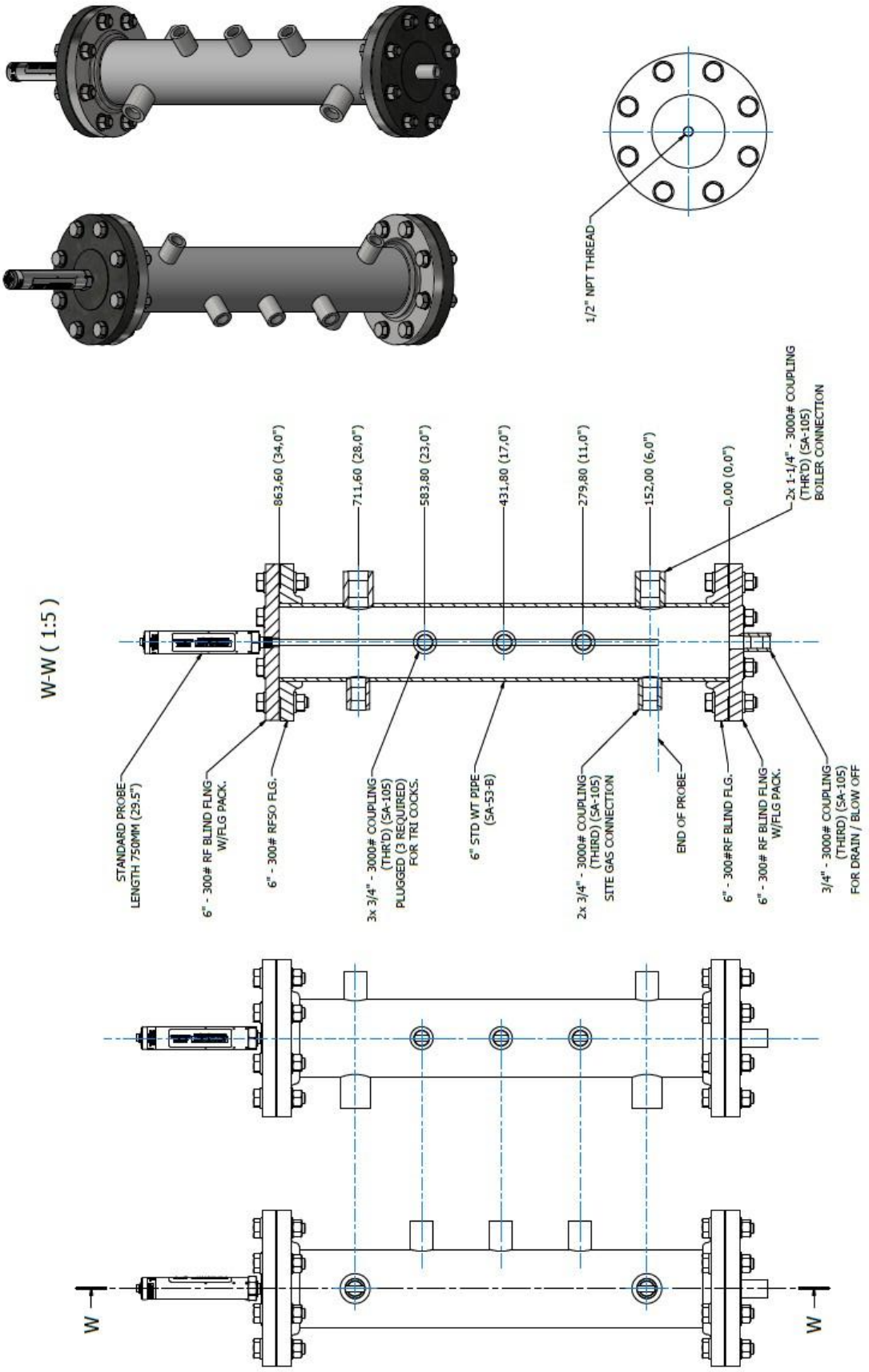


Figure 10.5.4.D: External Probe Chamber – Recommended Dimensions



10.5.5 Configuration

The table below shows the terminals allocated on the MM for the capacitance probes.

Terminal	Description
1P+	+9V supply to capacitance probe 1
1P-	0V supply to capacitance probe 1
1T+	Digital communications connections from capacitance probe 1
1T-	Digital communications connections from capacitance probe 1
2P+	+9V supply to capacitance probe 2
2P-	0V supply to capacitance probe 2
2T+	Digital communications connections from capacitance probe 2
2T-	Digital communications connections from capacitance probe 2

When wiring the capacitance probes, the screen is connected through the casing of the lead and through the probe; therefore, the flying lead should be connected to the MM without a screen. The screen should be carried through until the connection to the MM; the screen should not be connected to the S terminal.

The table below shows the expansion options to be set when using capacitance probes with the MM for water level detection.

Expansion Option	Description	Setting
1	Water level control function	1
3	Capacitance probes	1 or 2
27	Probe mismatch threshold	As required
28	Capacitance probe still water threshold	As required
29	Capacitance probe filter time	As required

10.5.6 Capacitance Probes Maintenance

When carrying out a boiler service, the capacitance probes must be cleaned and checked for correct and safe operation. Use a nonabrasive cleaning method and a PTFE surface cleaning detergent to clean the probe. Care must be taken to ensure that the PTFE coating on the surface of the probes is not damaged. After cleaning the probes, the water levels commissioned for those probes must be checked.

If the probes are mounted directly into the boiler shell it is important to lag the flanges in order to avoid overheating of the electronics. It is recommended that the probes are not installed too close to the steam take-off and safety valve connection, but also not too close to the boiler end plates. If possible, they should be installed near the sight gauge glass.

10.6 2nd Low Probe

10.6.1 Overview

The 2nd low probe is a conductivity probe, and its purpose is to act as an additional 2nd low water cut-off when the water falls too low in the boiler. The conductive technology with safe electronic control has been granted a worldwide patent for its continuous electrical and mechanical self-checking software. The 2nd low probe is a high-integrity safety device with self-checking functionality.

If the water level in the boiler falls below the end of the probe, then a 2nd low water level alarm will occur. The water level may be low due to insufficient water in the feed water tank, feed water pump failure, feed water line isolated and/or the level controls have failed. If there is not enough water in the boiler, the heated tubes will be left exposed and unable to cool down as there is no longer water to transfer the heat to. If the burner were to continue firing, the temperature of the tubes would be rapidly increase, reducing the metal strength, and could cause a collapse or explosion. On the MM system a 2nd low water level alarm will immediately shut down the burner.

10.6.2 Operation

The water level detection probes use capacitance technology, whereas the 2nd low safety probe uses conductive technology. Following basic electric circuit theory, when the probe is in the water in the boiler and an electrical voltage is applied, the current will flow; when water level drops below the probe, no current will flow. This is the basic principle of the 2nd low safety probe: If the water levels drop below the cut-length of the probe, then a 2nd low water alarm will occur on the MM or for standalone mode, the volt-free connection will open to indicate this alarm. When used with an MM, the 2nd low water alarm requires a manual reset.

10.6.3 Specifications

Specifications	Metric	Imperial
Part number	SLP70001	
Compatible with	Mk8 MM and Mk7 MM	
Standalone usage	Yes	
Internal relay	Self-checking	
Technology	Conductivity	
Material	Stainless Steel	
Coating	PTFE coated	
Integration with external safety devices and circuits	Volt free contacts	
Thread type	NPT	
Standard probe length*	750mm	30”
Supplied flying lead	2m	6ft
Probe connection– quick connect	½” NPT Tapered Tread	
Ingress Protection	IP 68	NEMA 6P
Temperature rating of housing	0 - 70°C	32 - 158°F
Nominal Size of Line	15mm	½”
Maximum Allowable Pressure	27 Bar	392 PSI
Maximum Allowable Temperature	230°C	446°F
Test Pressure	40 Bar	580 PSI

*The 2nd low probe can be cut to length to suit application

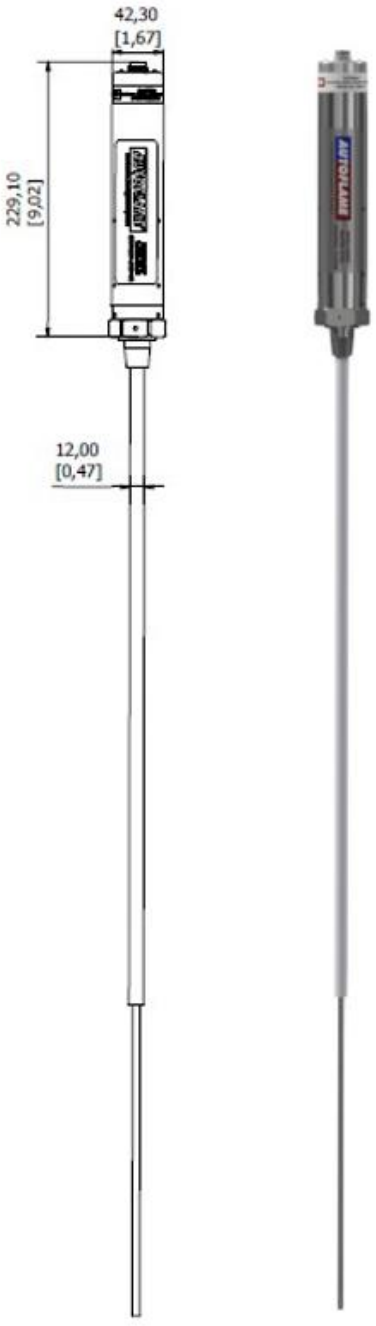
2nd Low Probe Flying Lead

The 2nd low probe is supplied with a 2m (6ft) flying lead, which has quick-connect multi-pin end. The cable shield is connected to the probe body.

Description	Wire	MM Terminal
Optional ground connection (not used)	Black	
0V Power (DC or AC)	Blue	4P-
12V Power (DC or AC)	Red	4P+
RS485 Comms -	Yellow	5T-
RS485 Comms +	Green	5T+
Volt-free connection 1 (250mA max)	Brown	
Volt-free connection 2 (250mA max)	Purple	

If using the 2nd low probe for standalone operation, then the volt-free connections must be used - the volt-free connection will be closed when water is detected and there is no system fault.

Dimensions



10.6.4 Installation and Safety Guidelines

The 2nd low probe's length must be equivalent to the 2nd low water level in the boiler as recommended by the boiler's manufacturer - this length should match the commissioned 2nd low level of the capacitance probes or external level sensing device.

The 2nd low probe can be cut to the required length using pression cutting equipment. If this is not available, please order the exact probe length from Autoflame.

The 2nd low probe should not be installed in the same pot as the capacitance water level probes. Any blockages in the line will affect the levels; therefore the 2nd low probe should be fitted in a pot with a separate line to the water level probes line. If the water level probes are installed in a pot externally mounted to the boiler as shown in section 10.5.4.A, the 2nd low probe can either be fitted in a separate pot, or internally mounted pot directly into the boiler. If the water level probes are installed in internally mounted pots as shown in section 10.5.4.B, the 2nd low probe can also be installed in an internally mounted pot directly into the boiler.

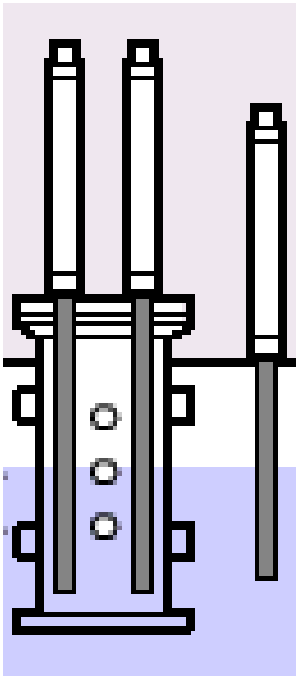


Figure 10.6.4.i Capacitance Probes and 2nd Low Probe displayed on the main Mk8 MM screen

10.6.5 Configuration

The table below shows the Mk8 MM terminals allocated for the 2nd low safety probe.

Terminal	Description
5T+	Digital communication connections from 2nd low resistance probe
5T-	Digital communication connections from 2nd low resistance probe
4P+	+12V supply to 2nd low resistance probe
4P-	0V supply to 2nd low resistance probe

The screen is connected through the casing of the flying lead supplied with the 2nd low safety probe. When connecting the flying lead to the MM, do not wire the screen at the MM.

The table below shows the expansion options to be set when using the 2nd low probe with the MM.

Expansion Option	Description	Setting
1	Water level control function	1
6	Second Low Probe	1

Note: 2nd low probe can only be used in conjunction with an analogue sensing device such as two capacitance probes or one capacitance and an external level sensor at minimum; please see section 10.4 Ways of Level Sensing for more information.

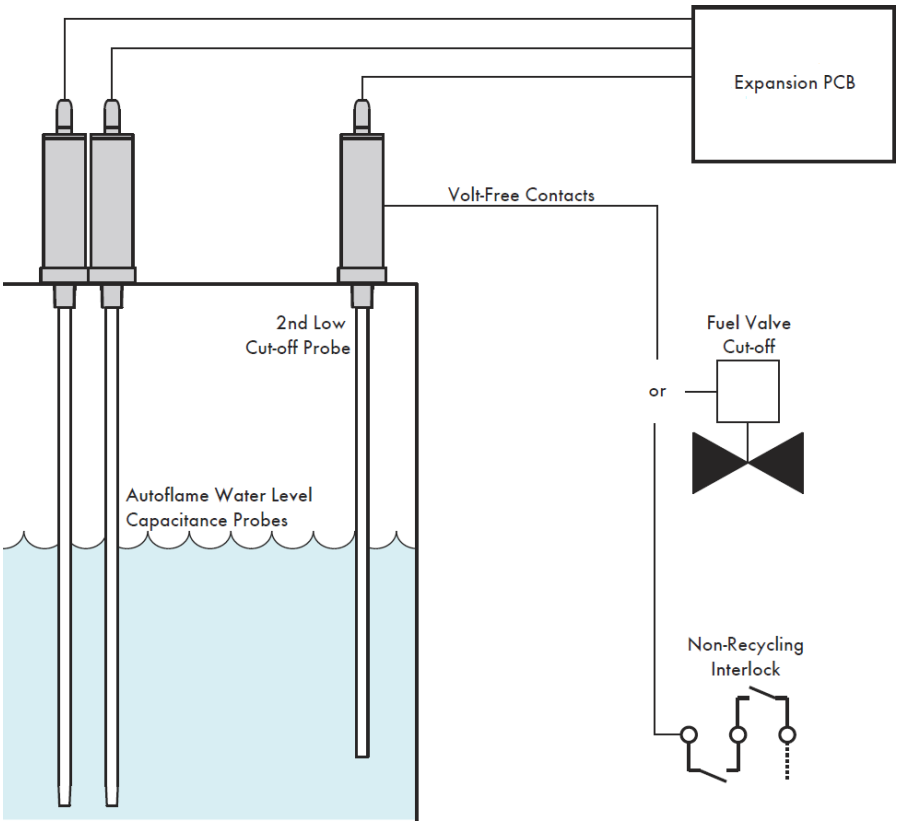


Figure 10.6.5.i 2nd Low Probe Installation Example

To install the 2nd low probe, no commissioning is required; just simply option the probe in expansion option 6. The bottom of the 2nd low probe should be at the capacitance probes/external level sensor commissioned 2nd low level or higher.

10.7 Analogue Water Level

An external level sensor (4-20mA input) can be used for water level detection on the Mk8 MM. This sensor will give an analogue signal to the MM to indicate level across a 4-20mA input range. The water levels commissioned for the external level sensor are the same for the capacitance probes which are HIGH, CONTROL POINT, 1st LOW, 2nd LOW and END OF PROBE.

The table below shows the terminals allocated on the MM for an external level sensor.

Terminal	Description
EX-	Common for terminal EX+
EX+	Current input, 4-20mA for external water level probe (or fuel flow feedback)

The table below shows the expansion options to be set to for using external level sensor on the MM.

Expansion Option	Description	Setting
1	Water level control function	1
4	External level sensor	1
30	External level sensor scaling	As required
31	External level sensor filter time	As required

Note: An additional water level safety device such as 2nd low probe or an auxiliary alarm input is required as minimum with the analogue water level detection device

Note: The external level sensor cannot be used with 4-20mA input for the fuel flow feedback, see option 57.

Note: When commissioning the water level using an External level sensor, the maximum value at high water is 20mA, and at low water is 4mA. If required the other way round, a signal invertor can be used.

10.8 Auxiliary Alarm Inputs

For additional safety, it is possible to retain the site's existing float type level controls by using auxiliary alarm inputs. The schematic below shows an example of how to wire such alarm inputs.

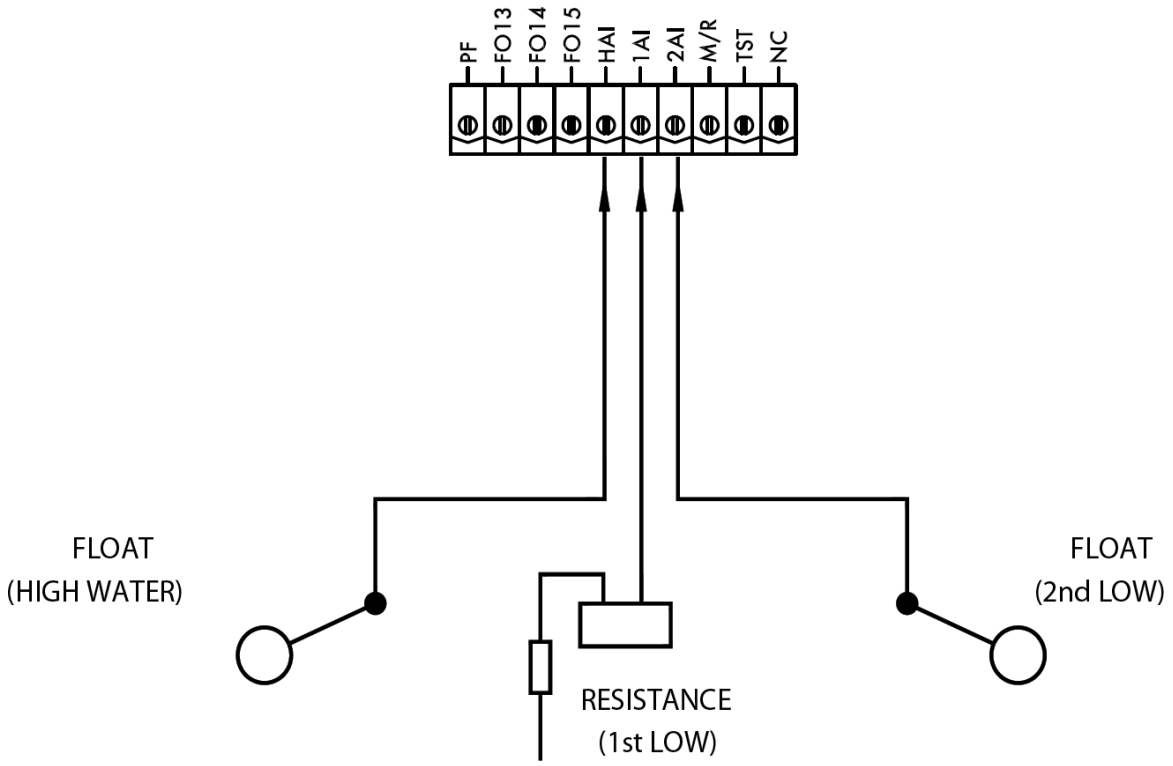


Figure 10.7.i Wiring Auxiliary Alarm Inputs

Note: If any of the three alarms are not being used when an auxiliary alarm inputs have been enabled, a line voltage input should be connected to the corresponding terminals to stop a fault occurring.

The table below shows the expansion options to be set on the MM for the auxiliary alarm inputs.

Expansion Option	Description	Setting
1	Water level control function	1
5	Auxiliary alarm inputs	1

Note: Auxiliary alarm inputs can only be used in conjunction with an analogue sensing device such as two capacitance probes or one capacitance and an external level sensor at minimum. Please see section 10.4 Ways of Level Sensing for more information.

10.9 Commissioning Procedure

10.9.1 Commissioning Checks

When commissioning a burner with Autoflame water level control, the water level probes and external water level sensor must be commissioned initially before the combustion curve is put in. Once the burner is commissioned with the Mk8 MM, the water level probes will need to be recommissioned once the boiler is upto pressure, and water in the boiler is hot enough.

When all the installation and burner adjustments are completed, the entire burner control system should be tested in accordance with the manufacturer's instructions. The procedure should verify the correct operation of:

1. Each operating control (temperature, pressure etc.).
2. Each limit switch (temperature, pressure, low water cut-off, etc.).
3. Each interlock switch (airflow switch, high and low fuel pressure or temperature switches, purge and low fire switches, fuel valve proof of closure interlock etc.).
4. Pilot flame failure response and lockout.
5. Main flame failure response and lockout.
6. Tight shut-off for all valves.

Please refer to section 10.5.4 for the Installation and Safety Guidelines.

10.9.2 Levels

End of Probe: The end of probe level is used to identify the point below which the probe cannot obtain a valid water level - it has no operational use.

High: A high water level, although not dangerous, it is undesirable as water particles may infiltrate the steam header. If the boiler water level goes above this point the burner may or may not continue to run depending on the system configuration. If a high water level condition is detected, a high water audible and visual indicators are triggered to notify the user. The audible indicator may be muted by means of the mute/reset push button. The burner can be set to continue or stop firing at high water in expansion option 9.

Control Point: This is the ideal water level that the feed water control will try to maintain.

1st Low: A 1st low water level is a point below the control point at which the burner will turn off. If the water level falls below this point, a 1st low audible and visual indicators are activated. The audible indicator may be muted by means of the mute/reset push button. If the water level is restored above this point the burner will start automatically and all indicators will also be reset.

2nd Low: A 2nd low water level is a point below 1st low at which the burner will remain off. If the water level falls below this point, a 2nd low audible and visual indicators are triggered. The audible indicator may be muted by means of the mute/reset push button. Even if the water level is restored above this point the burner will remain off. Operator intervention is required to manually reset the system and can only be performed once the level is above the 2nd low point. The 2nd low reset condition is non-volatile - if the system is powered down the reset condition will remain when power is reapplied. In this scenario the operator reset will still be necessary.

10.9.3 Setting End of Probe Level

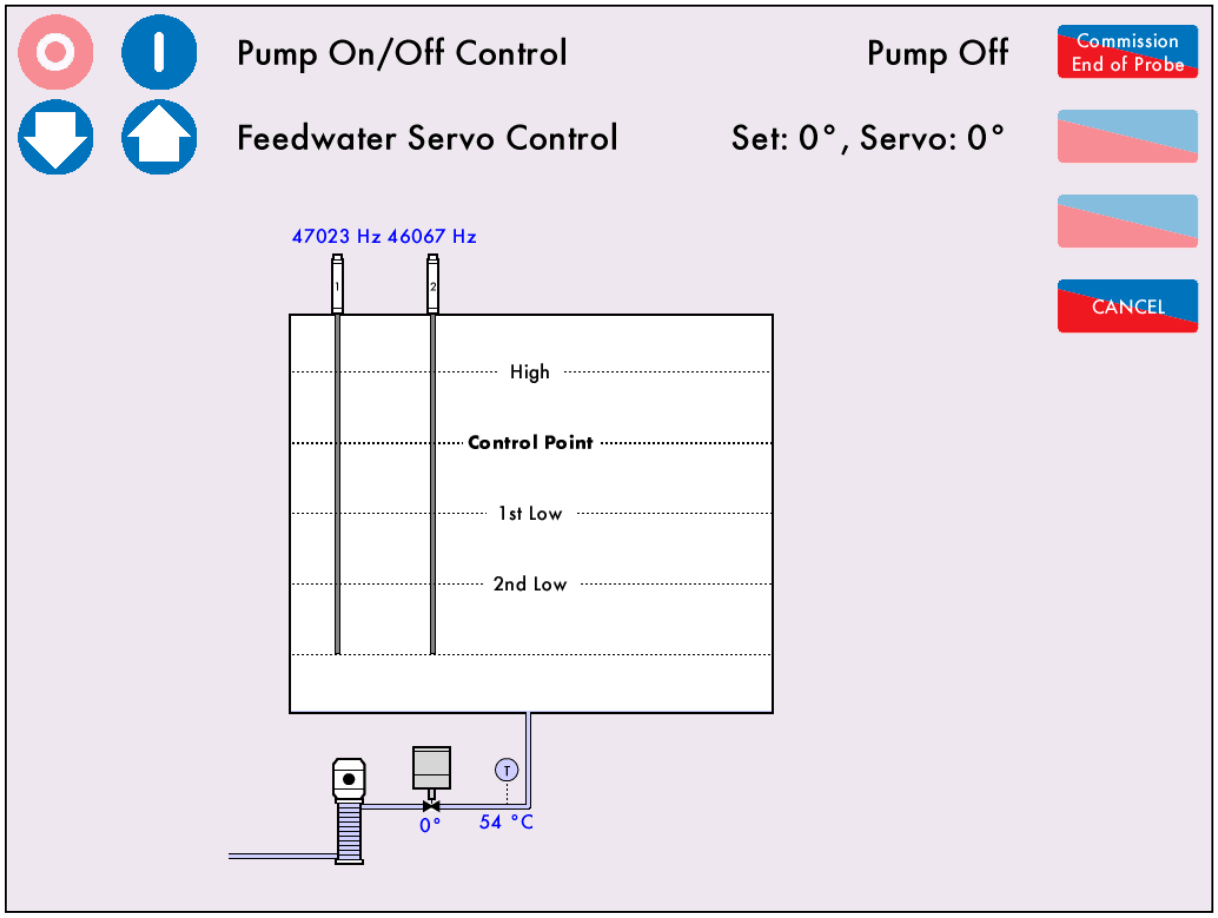


Figure 10.9.3.i Commission End of Probe Level

Power on the MM and in Commission mode, press 

to begin the water level commission process.

When commissioning the capacitance probes, the readings will display in Hz. The external level sensor will display in mA.

Press 

to begin commissioning. The first position to be entered is the end of probe level. This is the very minimum level of water in the boiler, and this is displayed as the lowest water visible in the sight gauge glass. Increase the water level until the it reaches the end of the capacitance probe/ external level sensor. Press  to turn the pump on. Press  to open the servomotor/ increase or decrease the VSD output if enabled in expansion option 2. Press  to turn the pump off. As the water level exceeds the end of the probe, the displayed probe values will begin to change.

To leave the water level commissioning process, press 

.

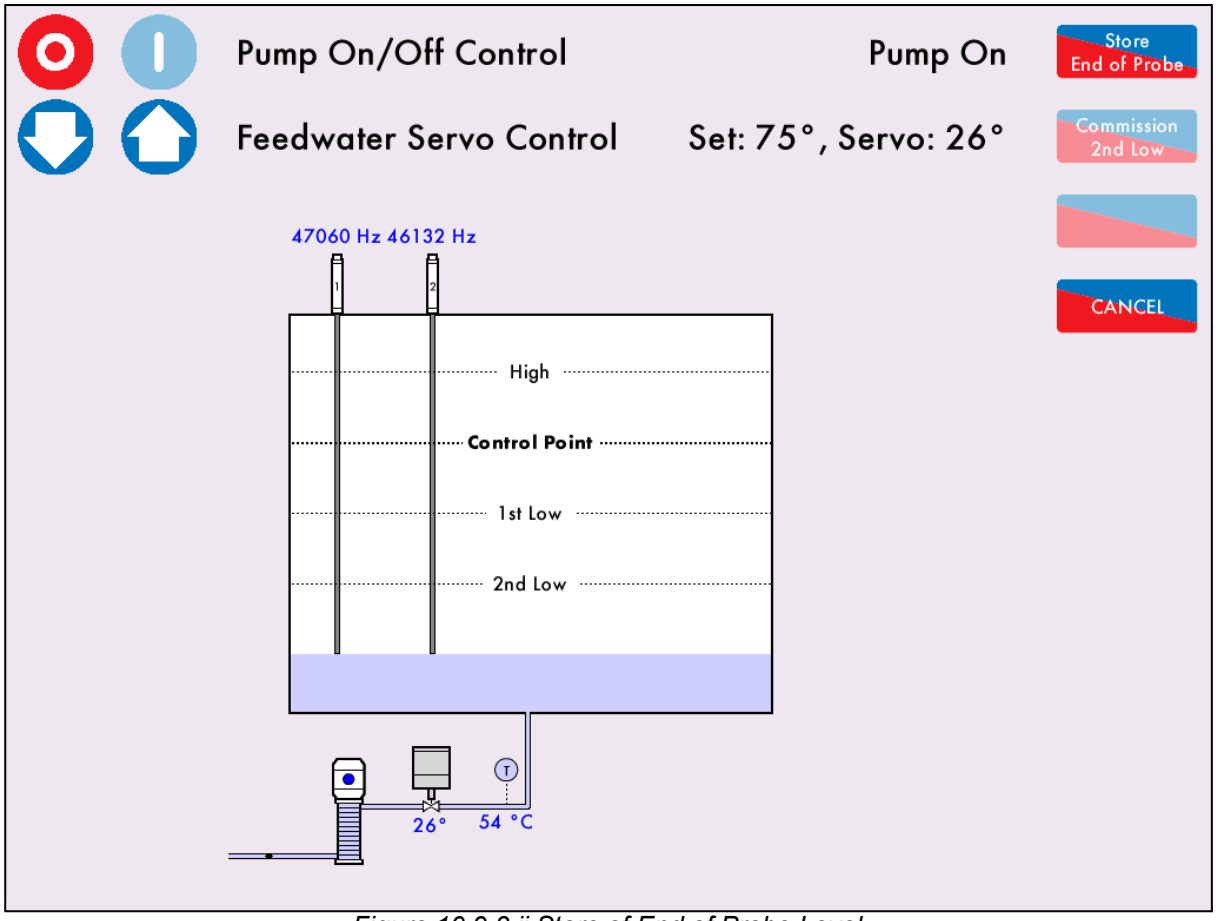


Figure 10.9.3.ii Store of End of Probe Level

Once the desired end of probe level is reached, close the feedwater valve and turn the pump off.

Allow some time for the readings to settle and then press Store End of Probe to store these readings.

Once the level has been entered, it is possible to update the commissioned readings by adjusting the water level and pressing Update End of Probe.

10.9.4 Setting 2nd Low Level

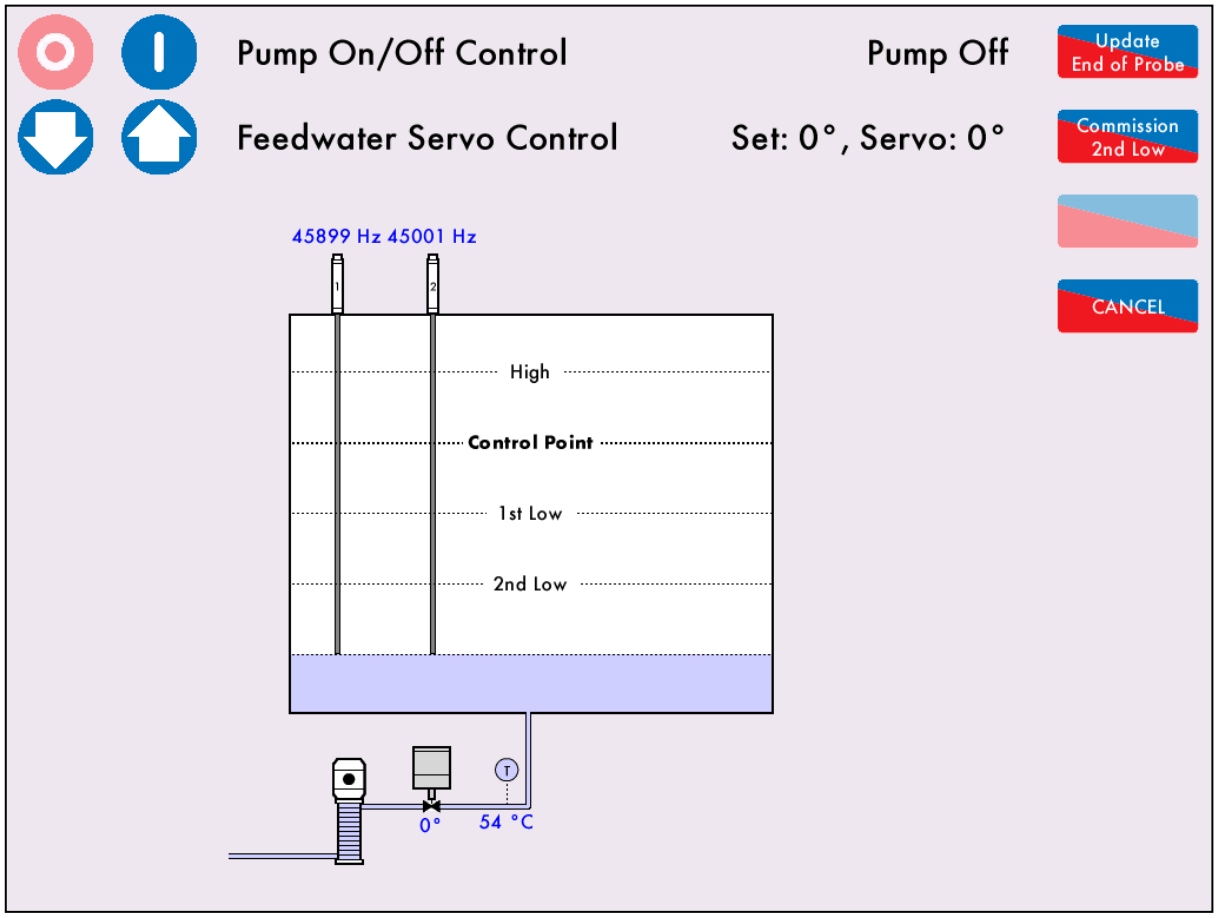


Figure 10.9.4.i Commission 2nd Low Level

After storing or updating the end of probe level, press Commission 2nd Low to increase the water level to the 2nd low level. It is recommended that there is a 25mm (1") gap between the commissioned levels, which is approximately 500Hz.

Once the water has risen to the required 2nd low level, turn the pump off and close the valve. Let the readings settle and press Store 2nd Low.

If required, the 2nd low level can be updated by adjusting the water level and pressing Update 2nd Low once the position has been stored.

10.9.5 Setting 1st Low Level

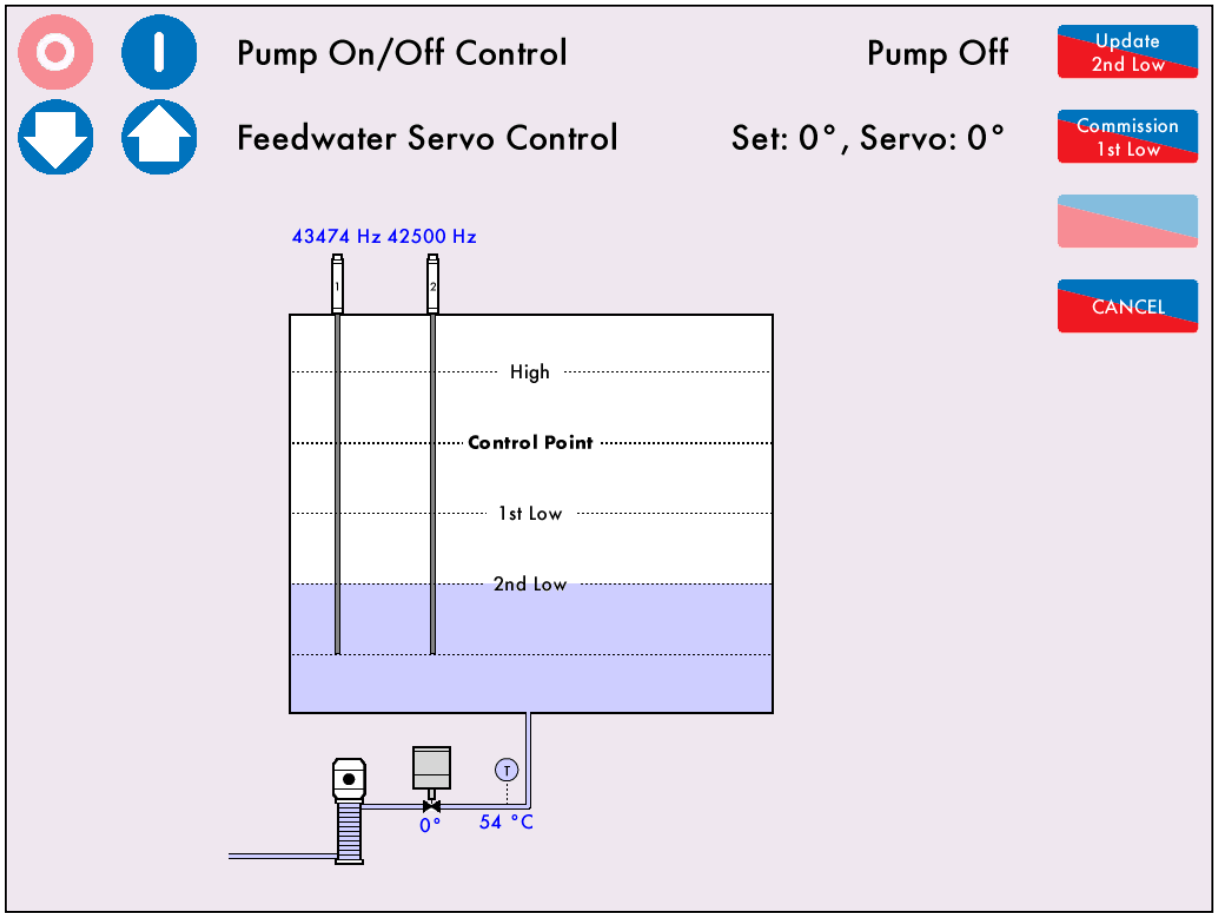


Figure 10.9.5.i Commission 1st Low Level

After storing or updating the 2nd low level, press Commission 1st Low to increase the water level to the 1st low level. Once the water has risen to the required 1st low level, turn the pump off and close the valve. Let the readings settle and press Store 1st Low.

If required, the 1st low level can be updated by adjusting the water level and pressing Update 1st Low once the position has been stored.

10.9.6 Setting Control Point Level

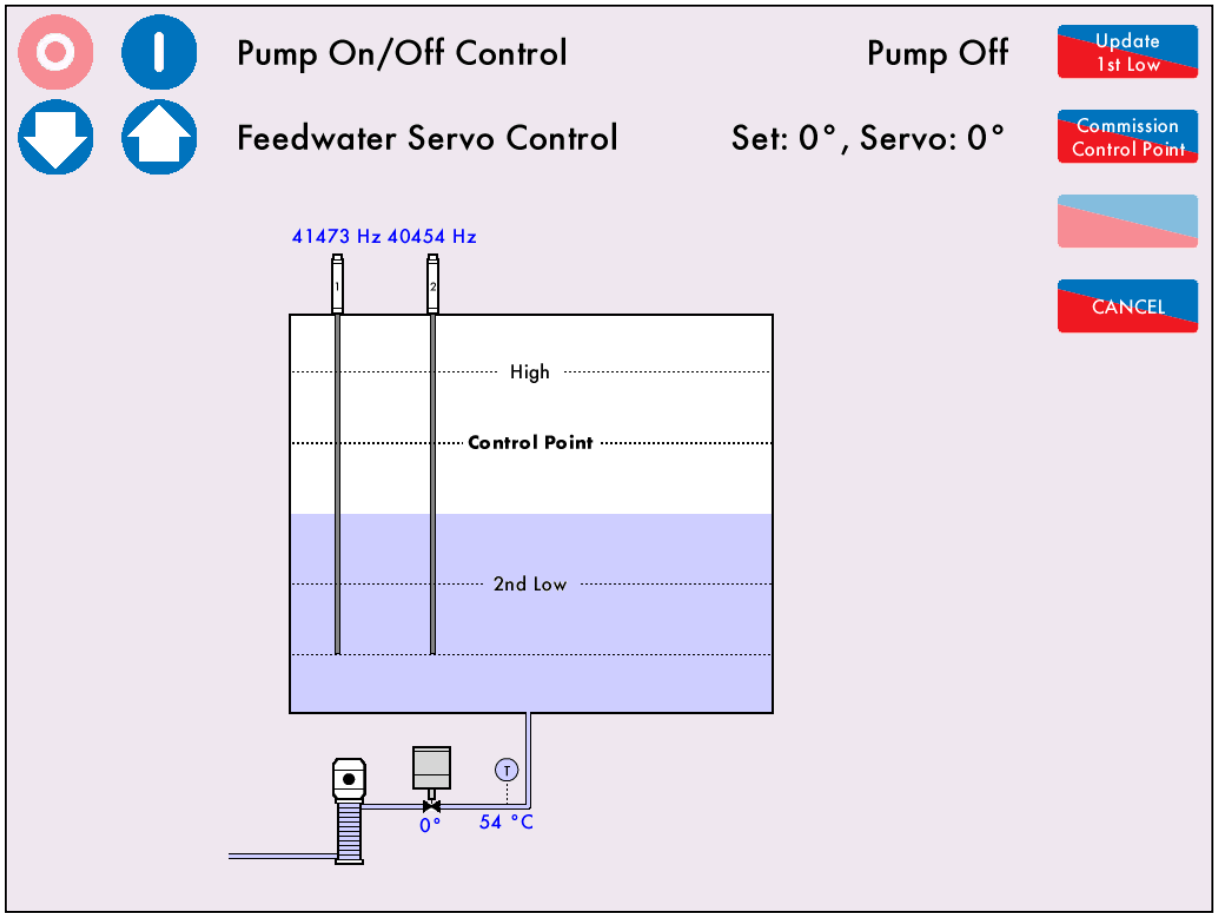


Figure 10.9.6.i Commission Control Point Level

After storing or updating the 1st low level, press Commission Control Point to increase the water level to the 1st low level. Once the water has risen to the required control point level, turn the pump off and close the valve. Let the readings settle and press Store Control Point.

If required, the control point level can be updated by then adjusting the water level and pressing Update Control Point once the position has been stored.

10.9.7 Setting HIGH Level

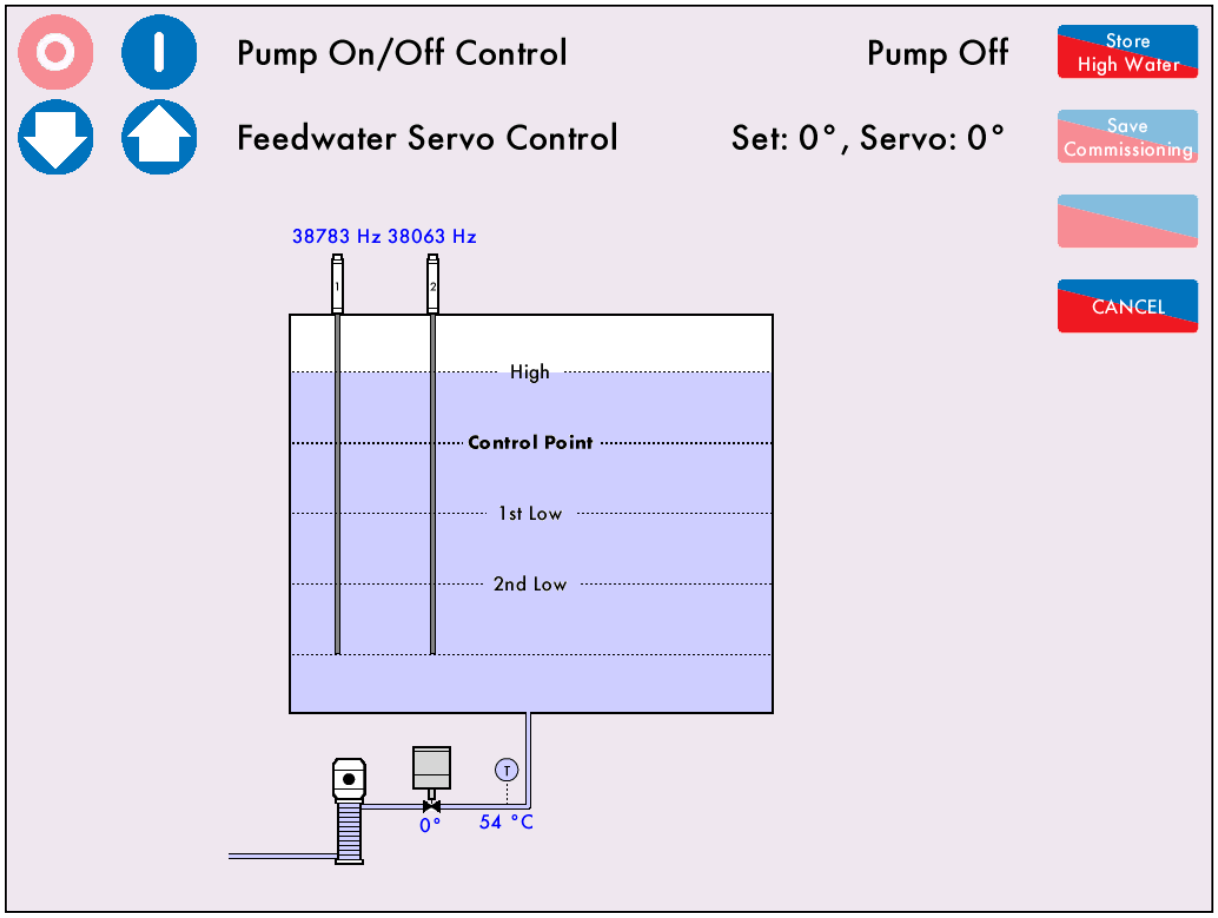


Figure 10.9.7.i Store High Water Level

After storing or updating the control point level, press 

to increase the water level to the high water level.

Once the water has risen to the required high water level, turn the pump off and close the valve. Let the readings settle and press 

.

If required, the high water level can be updated by adjusting the water level and pressing 

once the position has been stored.

10.9.8 Save Commissioning

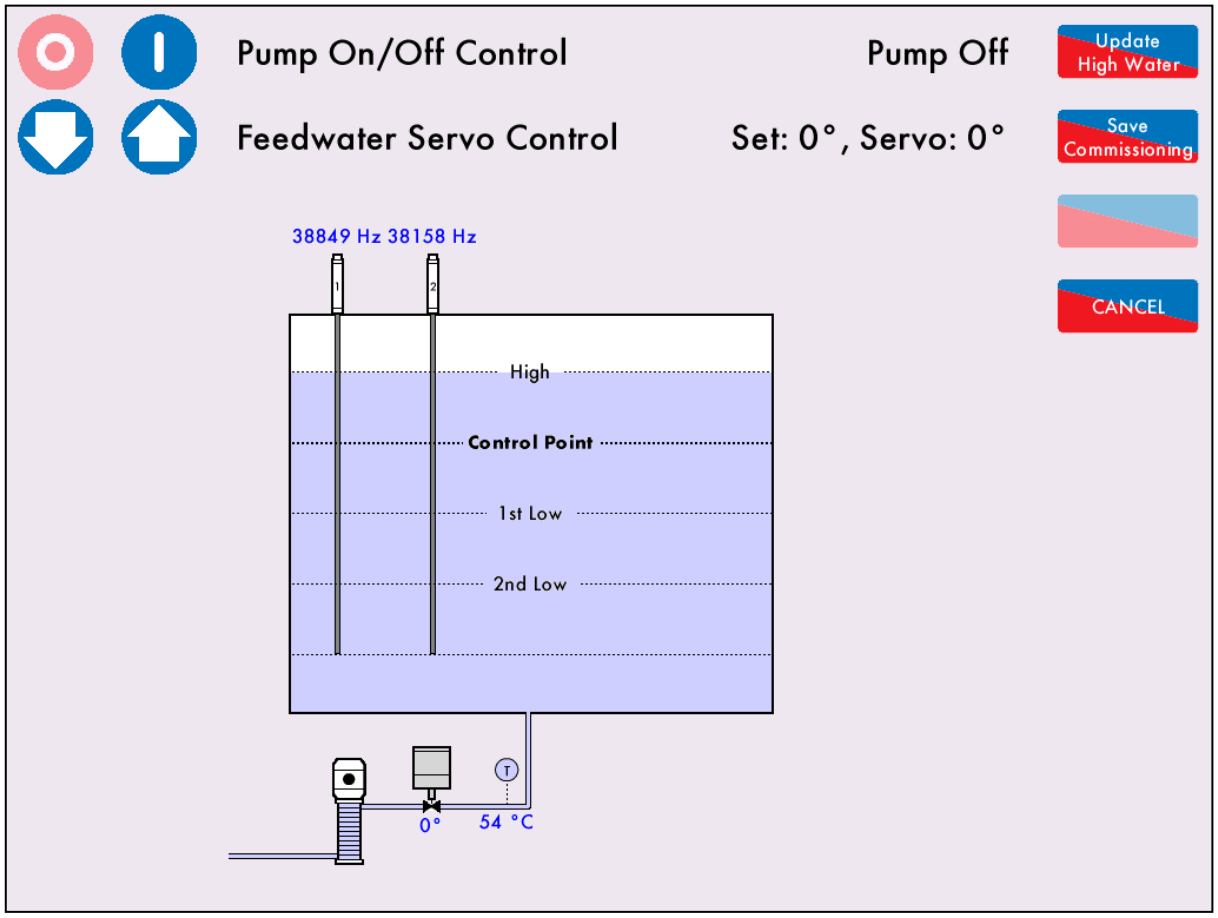


Figure 10.9.8.i Save Commissioning

After storing or updating the high water level, press 

to save the commissioned water level readings.

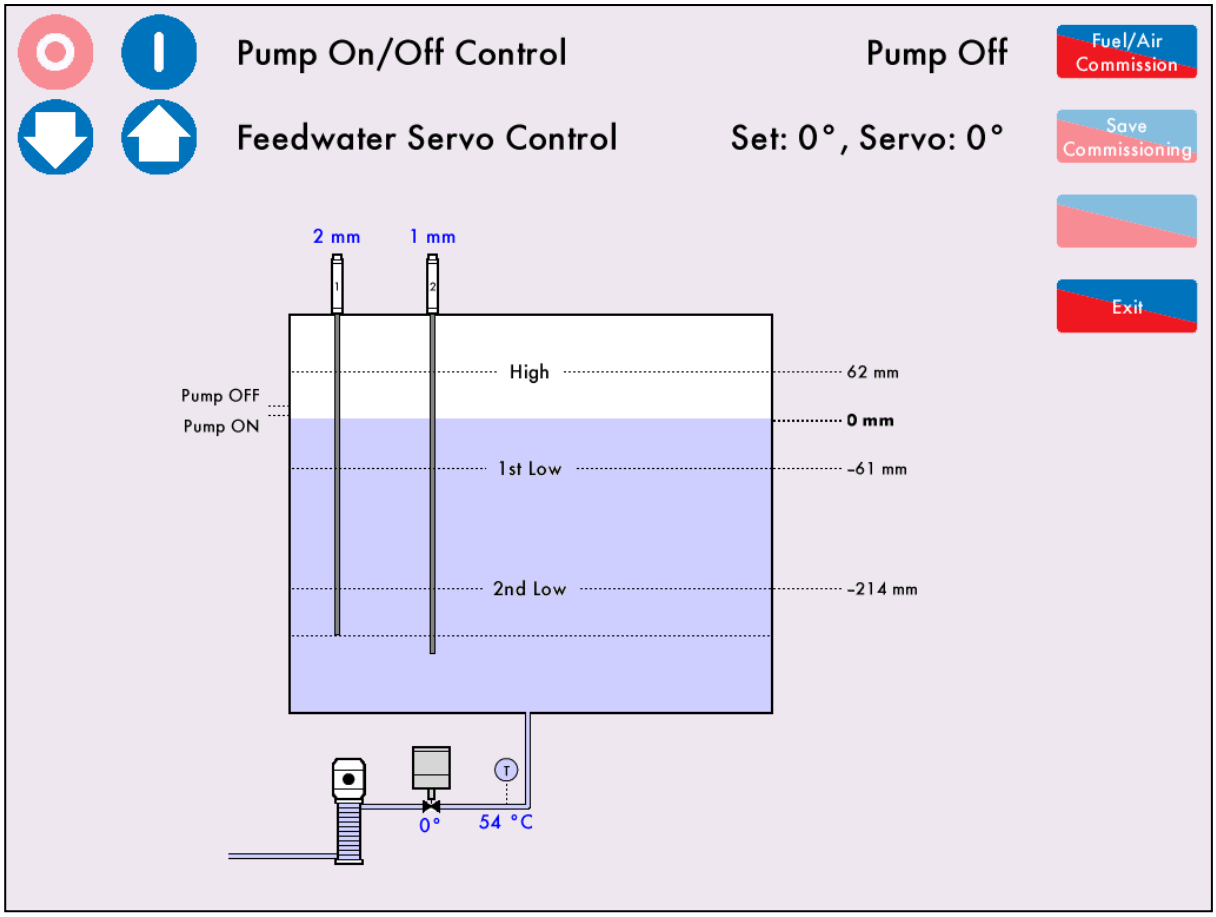


Figure 10.9.8.ii Fuel/Air Commission

Once the water level has been commissioned, adjust the water level to reach the control point, and either press Fuel/Air Commission to commission the burner after the operational checks of the water level operation in section 10.9.9 has been carried out, or press Exit to return to Commissioning Mode.

10.9.9 Operational Checks

Once the capacitance probes/external level sensor have been commissioned, the water level operation must be checked for safety and alarms. The burner can then be commissioned and the water level probes re-commissioned when there is heat in the boiler.

- Water level operation must be checked after commissioning or after modification of any setups. These operational checks are for boilers without a shunt switch, see section 10.10.3 for shunt switch.
- Set the system to RUN mode and allow the burner to fire. With the boiler supplying steam at a steady rate check that the water level is maintained at the control point for modulating control. For on/off control, check that the boiler feed water pump turns on and off appropriately at the commissioned points. Ensure that all audible and visual alarm indicators are inactive.
- Reduce the level of the water (by blowdown or other suitable means), check that a 1st low alarm occurs, and the burner stops firing when the water level is just below the commissioned 1st low level.
- Ensure that the 1st low audible and visual indicators are active. If fitted, press the external mute/reset button and check that the audible alarm is muted.
- Reduce the level of the water further and check that the 2nd low alarm is displayed when the water level is just below the commissioned 2nd low level; the burner should remain off.
- Ensure that the 2nd low audible and visual indicators are active. If fitted, press the external mute/reset button and check that the audible alarm is muted.
- All 1st Low/2nd low alarm conditions must be cleared before proceeding to test the high water. To test high water, it is necessary to increase the water level to just above that of the commissioned high water position. If there is no means to manually increase the level of the water, it is possible to select Water Level Commission mode and increase the level of the water manually. The MM can then be restarted by de-selecting and re-selecting the fuel. The unit will restart in RUN mode and should report a high water alarm. Check the burner operation runs or stops according to expansion option 9.
- Ensure that the high water audible and visual indicators are active. If fitted, press the external mute/reset button to check that the audible alarm is muted.
- Check the operation of the TB output terminal if using a contactor with solenoid valve.
- Once the water level control has passed these operational checks, the burner can now be commissioned with a fuel to air curve, after which the probes are re-commissioned at boiler pressure.



Note: All local & national codes for safe operation of boiler plant must be adhered to. If in any doubt contact your local specialist authority.

10.9.10 Adjust Control Point

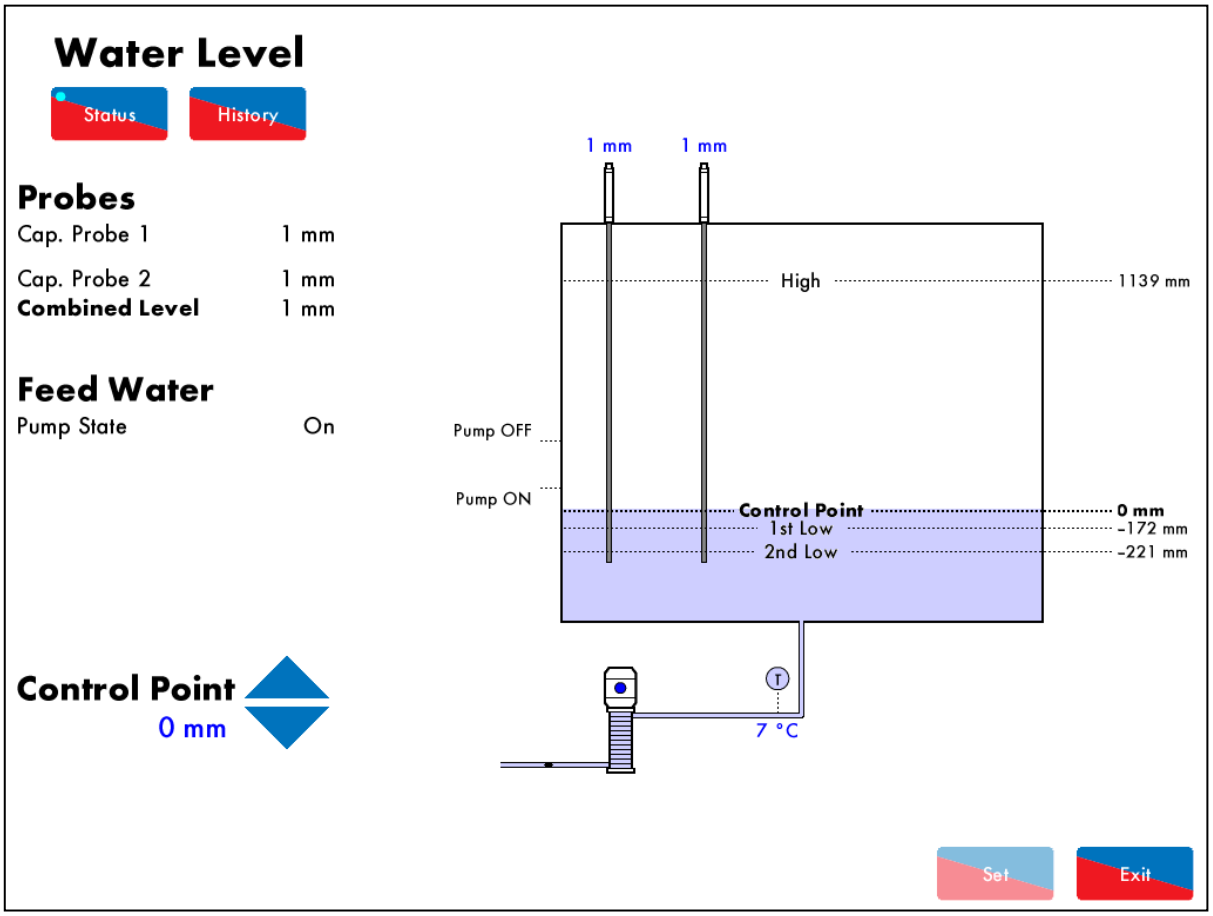


Figure 10.9.10.i Adjust Control Point

The control point set during water level commissioning can be adjusted through Online Changes. Press Adjust Control Point in Online Changes and go to the Water Level Status and change the control point as required. This cannot be set higher than the high water level or lower than 1st low level. The pump on/off percentages and pre-level alarms will change with the new control point.

Once the control point has been adjusted, press Set to save, and then press Exit to leave the Water Level Status screen.

10.10 Water Level Control Functions

This section describes the additional functions used to accurately control the water level.

10.10.1 Pre-Alarms

In addition to the water level alarms for high water, 1st low and 2nd low, pre-alarms can also be set which include pre-high and pre-1st low.

The table below shows the expansion options for pre-alarms.

Expansion Option	Description
7	Pre-high alarm percentage
8	Pre-first-low alarm percentage

The pre-high level is set as a percentage between the control point and high water level, with the control point representing 0% and the high water level representing 100%. If the water exceeds this pre-high level, a warning will be triggered and the burner will continue to fire.

The pre-1st low level is set as a percentage between the control point and 1st low level, with the control point representing 0% and the 1st low level representing 100%. If the water falls below this pre-1st low level, a warning will be triggered and the burner will continue to fire.

10.10.2 Pump Bypass

The pump bypass operation prevents the pump pushing water against a closed feed water valve. The MM terminal used is TB - pump bypass contactor.

The table below shows the expansion options for pump bypass.

Expansion Option	Description
17	Pump bypass operation
18	Pump bypass switch point
19	Pump bypass hysteresis

The pump can be bypassed at a percentage set in expansion option 18, above or below the switch point. The switch point is set as percentage of the feed water valve open position set in expansion option 16.

For pump bypass on above switch point, the pump bypass will turn on at a percentage above the valve open range set as a switch point, and it will turn off at a percentage below the switch point set as the hysteresis from the switch point.

For pump bypass on below switch point, the pump bypass will turn on at a percentage below the valve open range set as a switch point, and it will turn off at percentage above the switch point, set as the hysteresis from the switch point.

10.10.3 Test Outputs and Shunt Switch

The test input terminal TST can be used to check the auxiliary alarm outputs or the shunt switch operation when the burner is firing. The table below shows the expansion options for the test input.

Expansion Option	Description
21	Function of test input
22	Shunt switch – time to 1st low
23	Shunt switch – time to 2nd low

When the test input is set for auxiliary alarm outputs checks, hold the test input continuously to cycle through the alarm outputs every two seconds.

For shunt switch test, there is time delay for the burner to reach 1st low set in expansion option 22, allowing the operator to decrease the water level to check the 1st low alarm. If the water does not drop to 1st low within this time, the shunt switch test will be cancelled, and the MM will revert to normal operation. There is additional delay set in expansion option 23 to allow the operator to decrease the water to 2nd low to check the 2nd low alarm. If the water level does not drop in this time, the MM will leave shunt switch mode and the burner will turn off.

A timer is displayed on the screen when doing these tests as shown below. After reaching 2nd low, if the water level does not rise to control point within 10 minutes, alarms will be triggered.

The alarm outputs and shunt switch can also be checked via the Water Level Status screen on the MM.

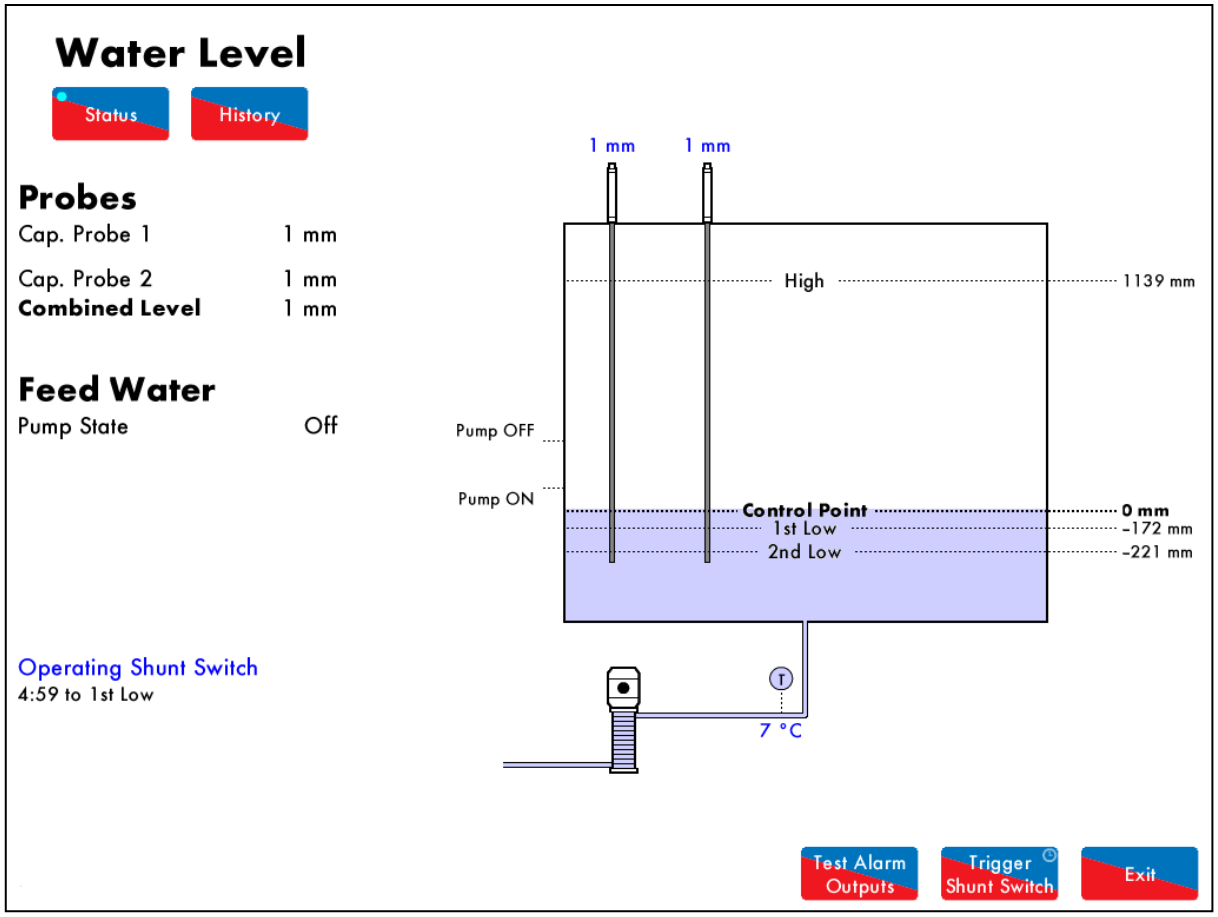


Figure 10.10.3.i Trigger Shunt Switch

Press Test Alarm Outputs to cycle the alarm outputs every 2 seconds. Press Trigger Shunt Switch to check the water level alarms as described above.

10.10.4 Sudden Pressure Drop

Swell management uses the firing rate and boiler pressure to prevent intermitted shutdowns due to 1st low level alarm being activated during transitory conditions.

Please see section 10.5.1 for more information on swell management.

The table below shows the expansion options for sudden pressure drop.

Expansion Option	Description
24	Sudden pressure drop trigger rate
25	Sudden pressure drop control point increase
26	Sudden pressure drop reset offset

When there is a sudden steam demand, steam is drawn from the header rapidly. The boiler steam pressure will decrease quickly, so the MM will increase its firing rate to meet the load demand.

A sudden pressure drop condition will be true when the pressure drops by the value set in expansion option 24 over a time of 3 seconds to a pressure below the reset offset from the require pressure set in expansion option 26. When a sudden pressure drop is detected, the control point is increase by the percentage set in expansion option 25.

Without the sudden pressure drop function, the system will trigger a 1st low water level alarm as the feed water pump/servomotor would not react quick enough to maintain the water level in the boiler.

10.11 Faults

The table below show the faults which are directly related to the water level control function.

Fault	Type	Message	Description
100	Alarm	Cap Probe 1 Communications Fault	No comms with capacitance probe 1
• Check wiring and screen on terminals 1P+, 1P-, 1T+ and 1T-			
101	Alarm	Cap Probe 2 Communications Fault	No comms with capacitance probe 2
• Check wiring and screen on terminals 2P+, 2P-, 2T+ and 2T-			
102	Alarm	Cap Probe 1 Short Circuit	Hz reading is below 10kHz
• Check water level Hz reading • Check wiring on terminals 1P+, 1P-, 1T+ and 1T-			
103	Alarm	Cap Probe 2 Short Circuit	Hz reading is below 10kHz
• Check water level Hz reading • Check wiring on terminals 2P+, 2P-, 2T+ and 2T-			
104	Alarm	Cap Probe 1 Temp Compensation Error	Temperature corrected probe reference is not as expected
• Re-commission capacitance probes at temperature			
105	Alarm	Cap Probe 2 Temp Compensation Error	Temperature corrected probe reference is not as expected
• Re-commission capacitance probes at temperature			
106	Alarm	Cap Probe 1 Still Water Detected	Wave signature high to low peak distanceis less than still water threshold
• Check still water threshold in expansion option 28 • Check capacitance probe 1 reading history			
107	Alarm	Cap Probe 2 Still Water Detected	Wave signature high to low peak distanceis less than still water threshold
• Check still water threshold in expansion option 28 • Check capacitance probe 2 reading history			
108	Alarm	Cap Probe 1 Serial Number Mismatch	Probe serial number detected is not the commissioned probe serial number
• If changing capacitance probe 1, re-commission is required			
109	Alarm	Cap Probe 2 Serial Number Mismatch	Probe serial number detected is not the commissioned probe serial number
• If changing capacitance probe 2, re-commission is required			
110	Alarm	Cap Probe 1 Detected But Not Optioned	Probe connected but not optioned
• Check expansion options 1 and 3 • Check wiring on terminals 1P+, 1P-, 1T+ and 1T-			
111	Alarm	Cap Probe 2 Detected But Not Optioned	Probe connected but not optioned
• Check expansion options 1 and 3 • Check wiring on terminals 2P+, 2P-, 2T+ and 2T-			
112	Alarm	External Level Sensor Input Low	3mA or lower received from 4-20mA external level sensor
• Check feedback from external level sensor • Check wiring on terminals EX- and EX+			
113	Alarm	Probe Reading Mismatch	Difference between probes/sensor readings is below mismatch threshold
• Check expansion option 27 • Check capacitance probes and sensor readings			
114	Alarm	Probe Serial Numbers are the Same	One capacitance probe detected on both capacitance probe terminals
• If using two capacitance probes, then two individual probes must be connected • Check wiring on terminals 1P+, 1P-, 1T+, 1T-, 2P+, 2P-, 2T+ and 2T-			

Fault	Type	Message	Description
120	Alarm	Aux WL Inputs Mismatch	High water and 1st or 2nd low auxiliary level inputs detected simultaneously
• Check wiring on terminals HAI, 1AI and 2AI			
121	Alarm	Water Levels Diverse	Probes/ sensor detects 1st or 2nd low and high water simultaneously
• Check water level readings for probes and sensor if optioned • Re-commission probes/sensor			
122	Alarm	Permanent Alarm Reset Input	Input held on alarm reset terminal for more than 10 seconds
• Check input on terminal M/R			
123	Alarm	Second Low Probe Communications Fault	No comms with second low probe
• Check wiring and screen on terminals 5T+, 5T-, 4P- and 4P+			
124	Alarm	Second Low Probe Hardware Fault	Internal check failed
• Contact Autoflame approved local tech centre			
125	Alarm	Permanent Test Input	Input held on test terminal for more than 60 seconds
• Check input on terminal TST			
126	Alarm	Second Low Probe Detected but Not Optioned	Second low probe connected but not optioned
• Check expansion option 6 • Check wiring on terminals 5T+, 5T-, 4P- and 4P+			
127	Alarm	Aux WL Inputs Detect but Not Optioned	Mains detected on auxiliary WL inputs but not optioned
• Check expansion option 5 • Check wiring on terminals HAI, 1AI and 2AI			
130	Alarm/Warning - exp. option 20	Feed Water Servo Position Error	Servomotor is outside of the commissioned range
• Check wiring on terminals P-, FW and P+ • Check signal cable form the MM to the servomotor is screened at one end • Check that the servomotor is zeroed correctly			
131	Alarm/Warning - exp. option 20	Feed Water Servo Movement Error	Servomotor moves when not expected and vice versa
• Check wiring and voltages on terminals MVI and MVD • Check servomotor drives in correct direction • Check feed water valve is not stuck			
150	Alarm/Warning -exp. option 9	High Water	Probes/sensor detect water level above commissioned high water
• Check water level reading			
151	Warning	Pre-High Water	Probes/sensor detect water level above set pre-high water
• Check water level reading • Check expansion option 7			
152	Warning	Pre-1st Low	Probes/sensor detect water level below set pre-1st low
• Check water level reading • Check expansion option 8			
153	Alarm	1st Low	Probes/sensor detect water level below commissioned 1st low
• Check water level reading • 1st low alarm will automatically clear if water level increases above 1st low			

Fault	Type	Message	Description
154	Alarm	2nd Low	Probes/sensor detect water level below 2nd low
• Check water level reading • 2nd low alarm requires manual reset			
155	Warning	Shunt Switch Time Expired	Once shunt switch time expires, systemgoes to normally running
• If water drops after shunt switch time expires, system will generate 1st or 2nd low as relevant			

11 TOP BLOWDOWN

11.1 Overview

11.1.1 Importance of Maintaining TDS

To manage a steam boiler for optimum efficiency and reliability, an important requirement is to ensure that the Total Dissolved Solids (TDS) in the water are measured and controlled to the right level for that boiler. It is generally accepted that for water tube boilers the level of TDS measured should not exceed 1,500 PPM by volume and for fire tube boilers the TDS should not be higher than 2,500 PPM by volume. The figures stated are not definitive and in all applications the recommendations of the boiler manufacturer or water treatment chemist should be implemented.

It has been established that the conductivity of water is proportional to the measured TDS as long as the temperature remains constant. Any variations in temperature will affect the measured conductivity by nominally 2% per 1°C. It follows that the temperature of the water must be measured, and the conductivity reading must be adjusted before a TDS reading can be extrapolated from this line of data. The Autoflame system incorporates a temperature measurement sensor in the steam drum to establish the steam temperature, this steam data is used to constantly correct the conductivity value.

A second variable that effects the conductivity measurement is polarization of the water sample; this occurs when electrical energy from the probe builds up a relatively tiny offset above or below the earth (0 Volt value). This polarization value is typically noticeable when a continuous frequency is being emitted from the probe as part of the conductivity measurement method.

The Autoflame system deals with the potential problem of polarization in the following manner: The probe measures any build-up of voltage potential above or below earth or 0V in the water sample. The measured polarization voltage data is used to modify the conductivity calculation. The Autoflame system emits electrical energy at a rate of 10 x 300 microsecond pulses every second. This translates into a method where we are emitting electrical energy for 0.6% of the sample time. All other manufacturers who use the frequency method are emitting electrical energy for 100% of the sample time. It follows that the polarization problem in these cases would be 167 times greater.

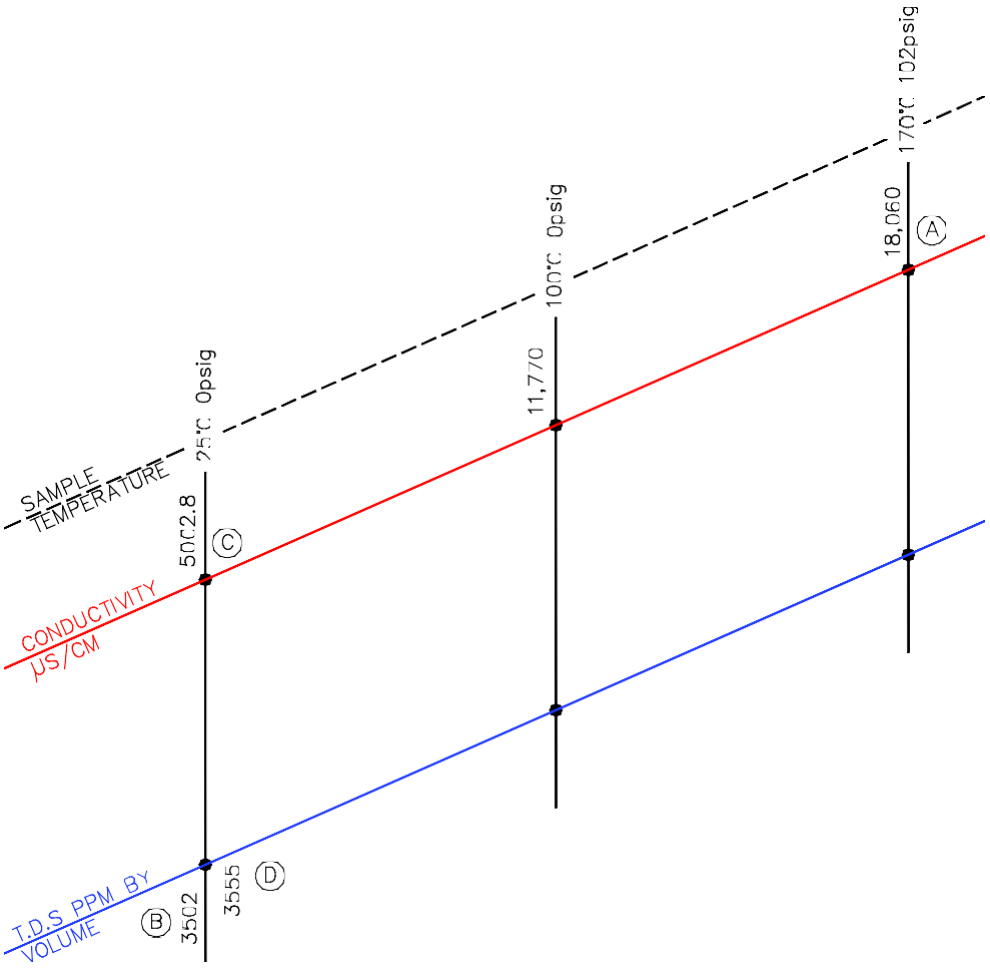
A third problem that affects the accuracy of the TDS measurement is the build-up of scale on the probe electrode. By design the water sampling container has been arranged so that the turbulence created during the blow down sequence will ensure that the probe remains effectively free of scale or deposited solids that could be held in suspension. The probe is self-cleaning.

The sampling container has a known orifice size. From this it is possible to calculate the percentage losses due to surface blowdown. This is possible because the following parameters are known which include hole size, temperature, pressure, pressure drop across the solenoid and the time that the solenoid is open for.

It can be seen from the above that the Autoflame TDS system deals succinctly with three of the main problem areas that are encountered when designing an accurate TDS control solution.

11.1.2 TDS, Conductivity and Temperature

A = These values measured by probe & sensors at steady state operating conditions.
B = This value is the conductivity value multiplied by 0.7 (TDS in PPM).
C = This conductivity value is temperature corrected to 25°C / 77°F.
D = This is measured TDS value entered into the system to affect a user “calibration”.



I. Conductivity measurement corrected at 2% per 1°C.
II. At 25°C TDS in ppm is calculated by multiplying the conductivity value by 0.7 factor.
III. Both above multipliers are user variable to accommodate specific site conditions.

At the time of manufacture, every TDS probe has a “Calibration Correction Coefficient” or CCC embedded into its internal memory. The TDS probe is immersed in a water sample with a known TDS (3500ppm for example) at 25°C (77°F) which would give a reading of 5000 micro-siemens. If the reading from the probe does not agree with this general CCC value, a correction multiplier or divider is entered into this specific probe’s memory. This is its own dedicated CCC value.

11.2 Top Blowdown Expansion Options

The table below shows the expansion options which need to be set for Top Blowdown Control.

#	Default	Range	Description
40	0		TBD: Top Blowdown Function
			To enable top blowdown, the top blowdown expansion feature must be unlocked. The TDS value in the water, measured by the TDS probe on terminals 3P+, 3P-, 3T+ and 3T-, is maintained by a PID loop, see expansion options 52, 53 and 54. For setting 1, the terminal TB output will open and close an external solenoid valve. For setting 2, the top blowdown valve is open and closed via a top blowdown servomotor on terminals P-, FW, P+, TBI and TBD. For setting 3, continuous top blowdown management is enabled for the top blowdown. For setting 4, the TDS probe is used for water hardness monitoring only.
		0	Top blowdown disabled
		1	Top blowdown using solenoid
		2	Top blowdown using servo (2-state)
		3	Top blowdown using servo (continuous)
		4	Water Hardness Monitoring
41	0		TBD: TDS Units
			The TDS units can be displayed in ppm or µS/cm.
		0	Concentration in ppm
		1	Conductivity in µS/cm
42	2500		TBD: TDS Target
			This is the set TDS target value which the TDS control will try to maintain by open and closing the solenoid or top blowdown valve, see expansion option 40. The target TDS value should be set according to the boiler manufacturer's guidelines.
		50 – 9999	ppm or µS/cm (see expansion option 41)
43	180		TBD: TDS Temperature Compensation
			The steam temperature is calculated from the steam pressure sensor reading. The TDS value read will be corrected by the % per ^{O}C set, for the difference between the steam temperature and 25 degrees ^{O}C, so the TDS measured value displayed is shown corrected to 25 degrees ^{O}C. This temperature compensation coefficient will depend on the contaminants in the water and should be set accurately for the contaminants that make up the TDS in the water.
		20 – 1000	0.20 – 10.00% per ^{O}C
44	65		TDS PPM Conversion
			The ppm to µS/cm conversion coefficient will depend on the contaminants in the water and should be set accurately for the contaminants that make up the TDS in the water.
		20 – 100	0.20 – 1.00ppm / (µS/cm)
45	1000		TBD: TDS Adjustment
			This value will automatically display the adjustment factor when the TDS probe is recalibrated during running.
		10 – 999	0.010 – 9.999

#	Default	Range	Description
46	0		TBD: TDS Warning Level
			The TDS warning level is an absolute limit; if the average TDS reading taken from the measurement time is higher than this TDS limit, a warning will be generated. This limit should not be set lower than the target TDS value set in expansion option 42.
		0	Disabled
		1 – 5000	ppm or µS/cm (see expansion option 41)
47	10		TBD: Pressure Threshold
			This pressure threshold is an offset below the required pressure setpoint. If the actual pressure is below this offset pressure, then TDS control will not operate.
		0	Disabled
		1 – 100	PSI or 0.1 bar or 0.01 bar for low pressure sensor (depends on load detector set in option 1 and metric/imperial units set in parameter 40)
48	25		TBD: Sample Time
			The first stage of the TDS control cycle is the sample time, where the solenoid valve or top blowdown servomotor is fully opened to take a sample.
		2 – 60	Seconds
49	25		TBD: Settle Time
			The second stage of the TDS control cycle is the settle time. Following taking a sample time in expansion option 48, the solenoid valve or top blowdown servomotor goes fully closed to allow the sample to stabilise for this settle time.
		2 – 60	Seconds
50	10		TBD: Measurement Time
			The third stage of the TDS control cycle is the measurement time. Following the settle time in expansion option 49, TDS probe will a measure the TDS in the sample every second set in the measurement time. The average across these measurements is taken as the TDS reading for that cycle. A longer measurement time will allow an average to be taken over more TDS probe measurements, and so the TDS readings will be smooth.
		2 – 30	Seconds
51	600		TBD: Blowdown Time
			The final stage of the TDS control cycle is the blowdown time. Following the measurement time in expansion option 50, if the measured reading is less than 100ppm below the target value, the solenoid valve or top blowdown servomotor will remain closed for the duration of the blowdown time. If the measure reading is higher than the target TDS value, the PID control will operate.
		10 – 1200	Seconds

#	Default	Range	Description
52	1800		TBD: Proportional Band
		10 – 10000	The proportional band is set as an offset of above the set TDS target value, within the proportional band, the PID control will make corrections during the blowdown time to maintain the TDS target value. If using a solenoid valve or servomotor (2-state) TDS control, then the P elementwill determine how long the valve is fully open for before it goes to fully closed, during the blowdown time. If using servomotor continuous TDS control, then the P element will determine what angle the valve is opened to during the blowdown time. If the measured is above this proportional band, then the solenoid valve or top blowdown servomotor will remain fully open. ppm or µS/cm (see expansion option 41)
53	600		TBD: Integral Time
		0 1 – 1000	For a slower response, increase the integral time. For a quicker response with fast changing TDS values, decrease the integral time. Disabled Seconds
54	5		TBD: Derivative Time
		0 1 – 1000	For water level with a quickly changing TDS value in the water, aderivative time can be added to prevent overshoot. Disabled Seconds
55	900		TBD: Servo Open Angle
		100 – 900	The TDS servomotor closed position is set by zeroing the potentiometer in commissioning mode. As default the servomotor is set as fully open, however this setting can be decreased to shorten the operational movement range of the servomotor. 10.0˚ – 90.0˚
56	0		TBD: TDS Alarm Level
		0 1 – 5000	Disabled ppm
57	0		TBD: No Blowdown Idle Time
		0 1 – 720	If enabled, it allows a long delay between blowdowns to be configured. This idle time kicks in when a sample is taken and the result is below the target value (no blowdown required). If/when a blowdown is required, the TDS still operates according to the Exp Option 51 Blowdown Time. Disabled Minutes

11.3 TDS Valves

The valves used for Bottom Blowdown, Feed Water and TDS are universal. See the table below for the valve sizes and servomotor required for each valve.

Valve Type	Size	Part #	Servomotor Size
Threaded BSP/ NPT	15mm (½")	WLCVO15	Large 25Nm
	20mm (¾")	WLCVO20	Large 25Nm

Please check the Autoflame Valve & Autoflame Servomotor guides for the full details, including dimensions, drawings and information for servicing and maintenance.



Figure 11.3.1.i TDS Valve installation example

The table below shows the available TDS probe and valve assembly part numbers.

Type	Part Number	Parts Supplied
TDS management, on/off control 230V	TDS70001	TDS probe, 230V solenoid valve,
TDS management, on/off control 110V	TDS70001/110	TDS probe, 110V solenoid valve,
TDS management, modulating 230V, ½"	TDS70001/M15	TDS probe, ½" valve, 230V large servomotor
TDS management, modulating 230V, ¾"	TDS70001/M20	TDS probe, ¾" valve, 230V large servomotor
TDS management, modulating 110V, ½"	TDS70001/M15/A	TDS probe, ½" valve, 110V large servomotor
TDS management, modulating 110V, ¾"	TDS70001/M20/A	TDS probe, ¾" valve, 110V large servomotor
TDS management, modulating 24V, ½"	TDS70001/M15/D	TDS probe, ½" valve, 24V large servomotor
TDS management, modulating 24V, ¾"	TDS70001/M20/D	TDS probe, ¾" valve, 24V large servomotor
TDS solenoid valve 230V	TDS70002	230V solenoid valve
TDS solenoid valve 110V	TDS70002/110	110V solenoid valve
TDS probe	TDS70003	TDS probe

11.4 TDS Probe

11.4.1 Specification



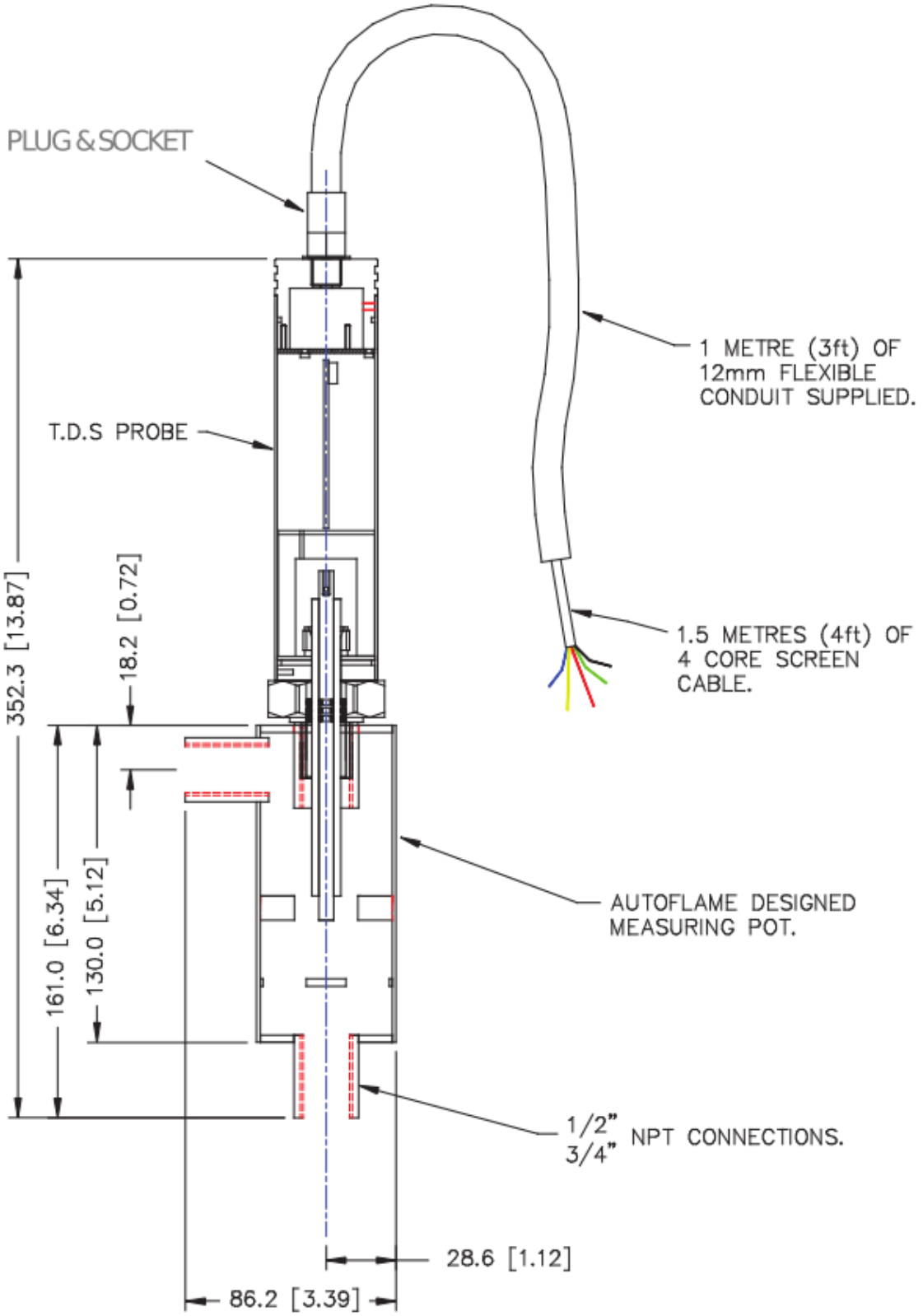
Figure 11.4.1.i TDS Probe

The TDS probe part number: TDS70003

- Timed pulsed top blowdown or continuous top blowdown operation selectable on the Mk8 MM.
- Self-cleaning design. Turbulence created during the blowdown sequence ensures that the probe remains effectively free of scale or deposited solids that could be held in suspension.
- Stainless steel housing.
- PTFE coated.

Specifications	Metric	Imperial
Supplied flying lead length	2m	6ft
Probe connection (quick connect)	½" BSP Parallel Thread	
External temperature rating	0 - 70°C	32 - 158°F
Ingress Protection	IP68	NEMA 6P
Nominal Size of Line	15mm	½"
Maximum Allowable Pressure (with modulating valve)	27 Bar	392 PSI
Maximum Allowable Pressure (with solenoid valve)	10 Bar	145 PSI
Maximum Allowable Temperature	230°C	446°F
Test Pressure	40 Bar	580 PSI

11.4.2 Dimensions



11.4.3 Installation

The diagrams below show the installation methods for the TDS probe incorporating Autoflame's sampling system, (all dotted components are to be supplied by the customer).

Note: There must be a minimum of 3ft (0.9m) straight pipe installed from the valve, of the same diameter as the actual valve.

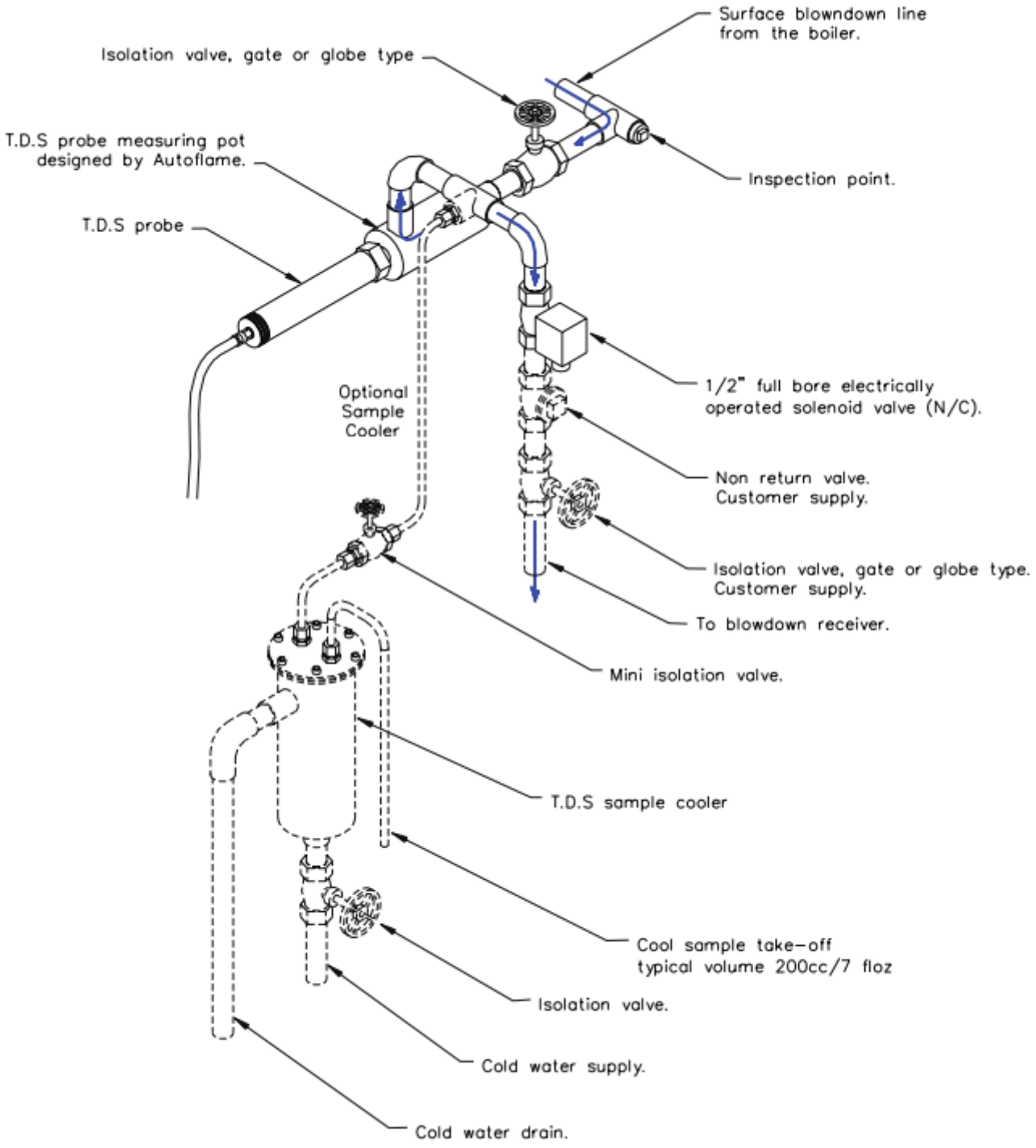


Figure 11.4.3.i TDS Probe Horizontal Installation

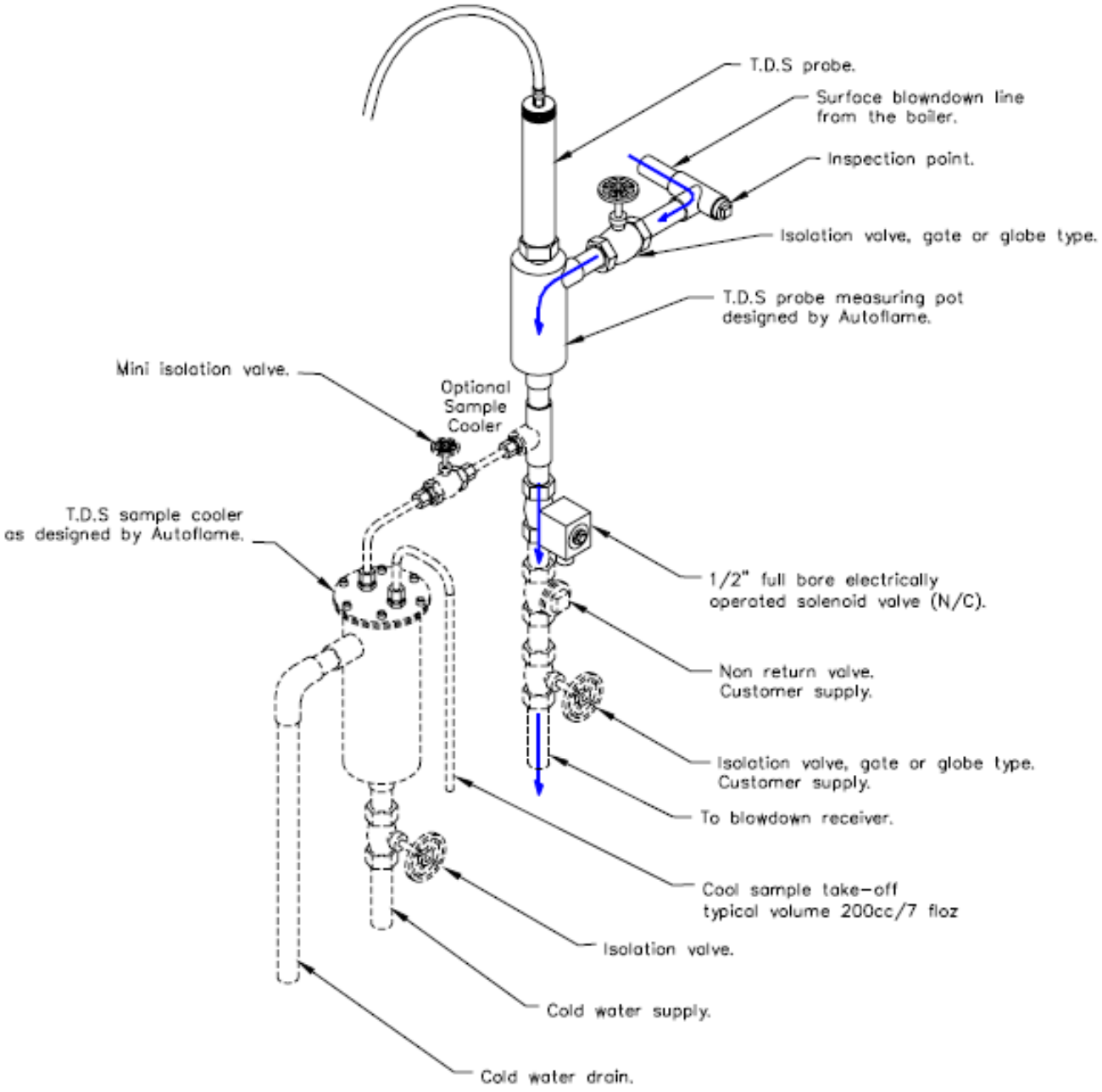


Figure 11.4.3 ii TDS Probe Vertical Installation

11.5 Configuration

11.5.1 Wiring

The table below indicates the terminals on the Mk8 MM allocated for Top Blowdown control.

Terminal	Description
P-	0V supply to top blowdown and feed water servomotors
TW	Signal from top blowdown servomotor, indicating position
P+	+12V supply to top blowdown servomotors
3P+	+9V supply to TDS probe
3P-	0V supply to TDS probe
3T+	Digital communications connection from TDS probe
3T-	Digital communications connection from TDS probe
TB	Switched neutral – top blowdown contactor
TBI	Switched neutral – drives top blowdown servomotor clockwise
TBD	Switched neutral – drives top blowdown servomotor counterclockwise

11.5.2 Top Blowdown PID Controller

Top Blowdown control only makes corrections to the open time of the valve (solenoid valve, 2-state servomotor or modulating servomotor) during blowdown time when the TDS level is within the P band (Proportional Band set in expansion option 52).

If the current TDS level is above the P band level, the valve (solenoid valve or 2-state servomotor or modulating servomotor) will remain fully open.

In systems with fast changing TDS level and to increase the TDS control responsiveness, the I term (Integral time set in expansion option 53) can be decreased.

To prevent overshoot, a D term (Derivative time set in expansion option 54) can be set according to the system requirements.

11.6 Ways of Controlling TDS Level

11.6.1 Continuous TDS Control

1. The first stage of the TDS control cycle is the sample time where the valve is fully opened to take a fresh sample for a time period set in expansion option 48.

2. After a fresh sample has been taken and the sample time elapsed, the second stage is the settle time. In the settle time, the valve fully closes to let the sample settle, for a time period set in expansion option 49.

3. Once the settle time is over, the valve will remain closed for another time period called measurement time, set in expansion option 50. The TDS probe will measure this sample and this is the reading in the TDS control.

4. If the measured value is less than the target value set in expansion option 42 minus 100ppm, the valve will not blowdown, and remain fully closed for the blowdown. For example, if the target TDS value was set as 2200pppm, the measured value was 2099ppm or less the valve would not blowdown. At the end of the blowdown time, the cycle will repeat and the TDS control will progress to the sample time.

5. If after the settle time the measured value is above the TDS target value minus 100ppm, the valve will drive open to a position determined by the PI loop to blowdown the valve and try to maintain the TDS target value. For example, if the target value was set to 2200ppm, the measured value would need to be 2100ppm or more for the valve to blowdown. At the end of the blowdown time set in expansion option 51, the valve will go to fully open for the sample time, to repeat the TDS control loop.

11.6.2 Solenoid and Servomotor 2-State TDS Control

1. The first stage of the TDS control cycle is the sample time where the valve is fully opened to take a fresh sample for a time period set in expansion option 48.

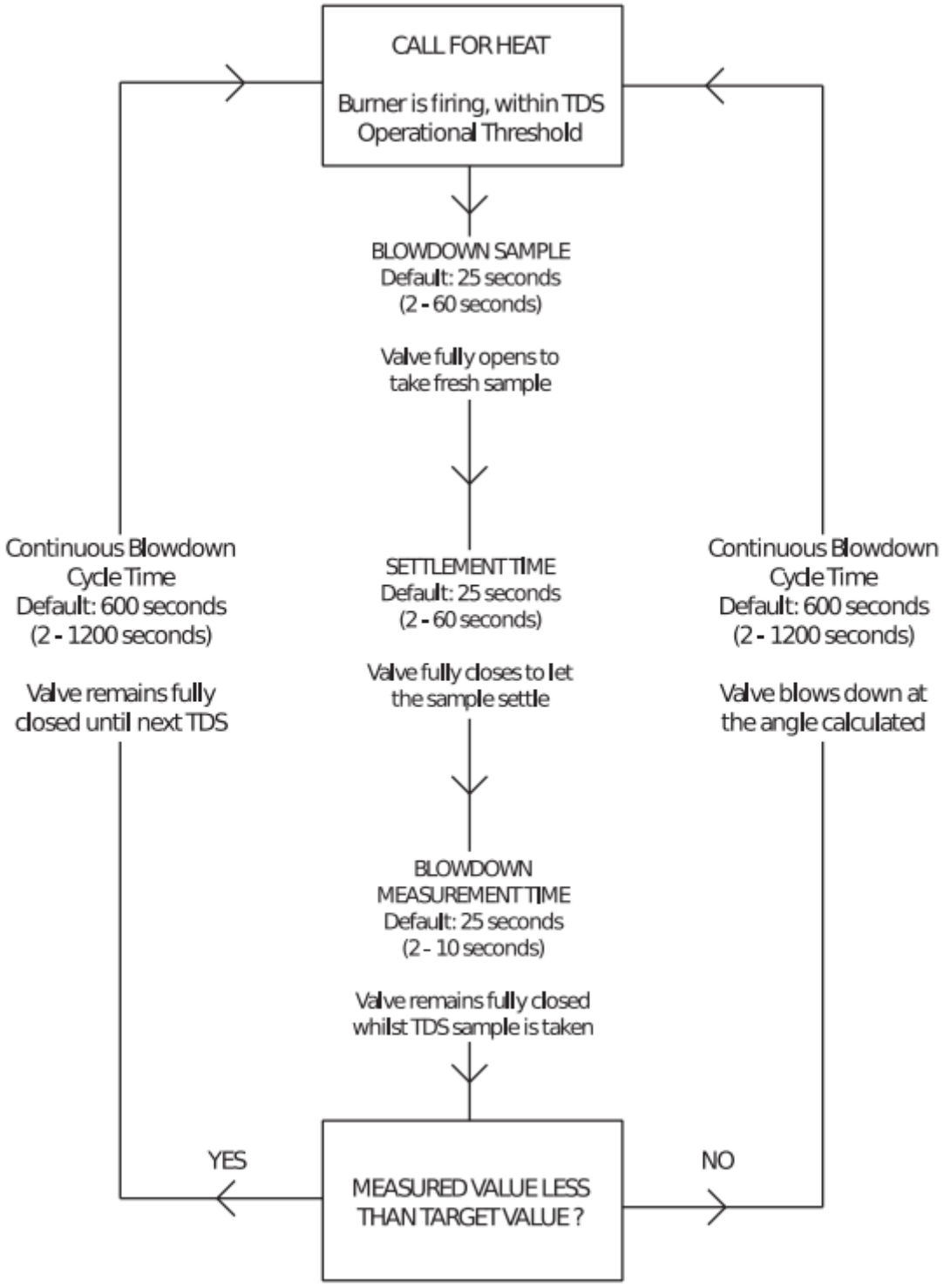
2. After a fresh sample has been taken and the sample time elapsed, the second stage is the settle time. In the settle time, the valve fully closes to let the sample settle, for a time period set in expansion option 49.

3. Once the settle time is over, the valve will remain closed for another time period called measurement time, set in expansion option 50. The TDS probe will measure this sample and this is the reading in the TDS control.

4. If the measured value is less than the target value set in expansion option 42 minus 100ppm, the valve will not blowdown, and remain fully closed for the blowdown. For example, if the target TDS value was set as 2200pppm, the measured value was 2099ppm or less the valve would not blowdown. At the end of the blowdown time, the cycle will repeat and the TDS control will progress to the sample time.

5. If after the settle time the measured value is above the TDS target value minus 100ppm, the valve will remain fully open for part of the blowdown time; this fully open interval is determined by the P element, and then the valve will go to fully closed for the remainder of the blowdown time. For example, if the target value was set to 2200ppm, the measured value would need to be 2100ppm or more for the valve to blowdown. At the end of the blowdown time, the valve will go to fully open for the sample time, to repeat the TDS control loop.

11.6.3 TDS Timing Diagram



For continuous TDS control the valve blows down at an angle calculated by the PI loop. For solenoid or servomotor 2-state TDS control the P band determines how long the valve remains open before closing during the blowdown time.

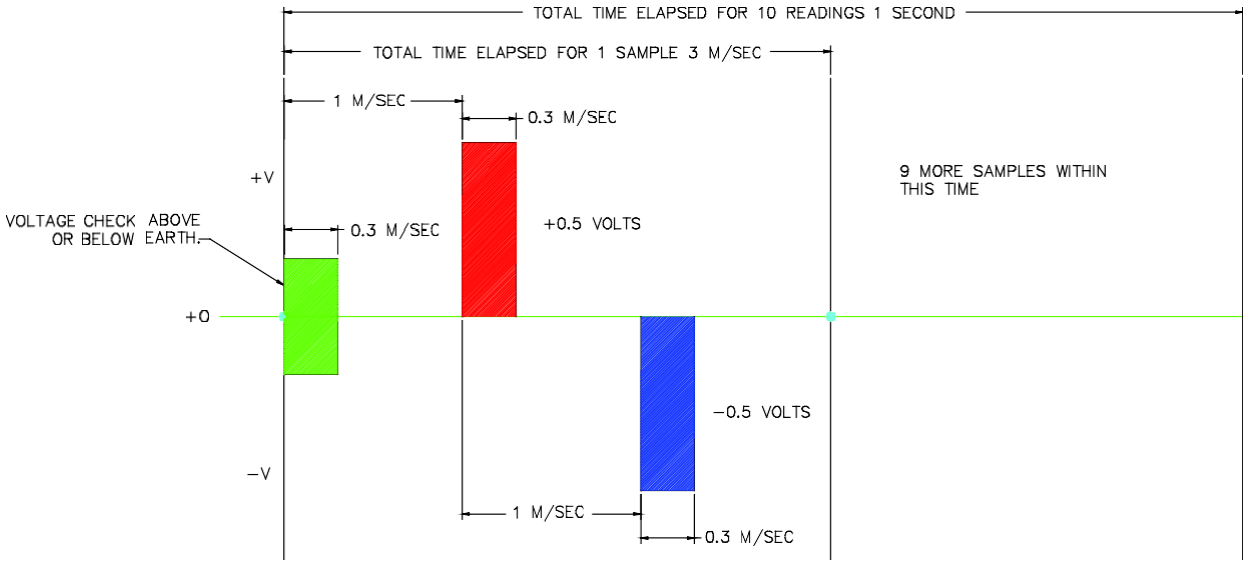
11.6.4 Sample Routine

The time for one complete measurement cycle is 3 milliseconds. It can be seen that 10 measurement cycles are made within one second. These measurements are averaged over one second. Conductivity is calculated by dividing measured milliamps by 0.5 volts which gives a value in micro-siemens.

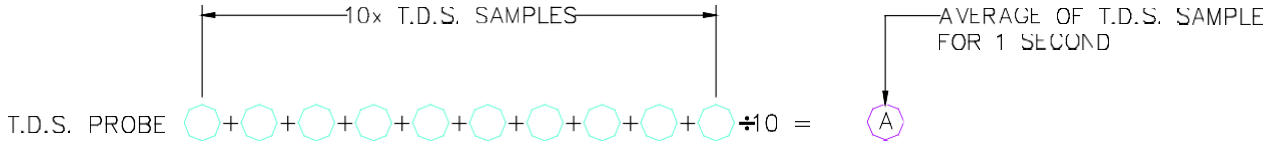
At the start of each measurement cycle the sample is checked for polarization. This background voltage effect is taken into the conductivity calculations.

Temperature and pressure are measured by the Autoflame system and this information is used to continually modify the calculated conductivity/TDS value from its calibrated point. Nominally for every 1°C increase or decrease, 2% is added or subtracted from the conductivity value. The exact figure is calculated by the system.

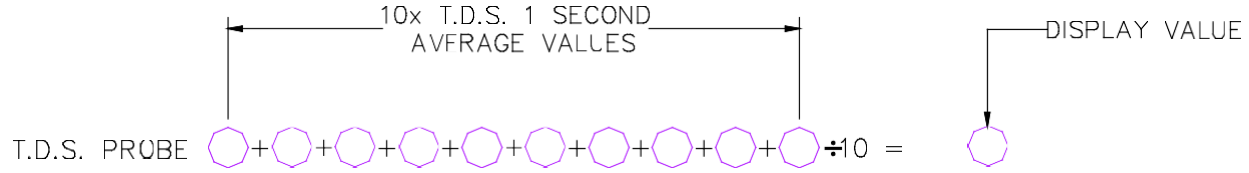
The system relates conductivity in micro siemens to TDS in ppm by a 0.7 multiplier. Within the control software there is an adjustment of ± 7% for this multiplier which is user variable.



The TDS system logs each of the samples within the 1 second time period. It takes all 10 sample values, adds them together then divides them by 10 to obtain the average TDS value for the one second period.



Once the TDS software has calculated the average TDS value for the 10 samples within one second, it will then extract these averages and add the last 10 together and divide them by 10 to give the actual TDS reading. This value will be displayed on the M.M.

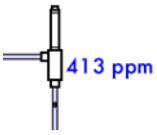


When a new average of the 1 second samples is obtained, the software will utilise the last 9 averages, it will then add the new average to them and divide it by 10 to obtain the new TDS value.

11.7 Water Hardness Monitoring

Feed Water Hardness can be continually monitored using Water Hardness Monitoring feature, to enable this feature, Expansion Option 40 must be set to 4 – Water Hardness Monitoring. When this option is selected, the TDS probe will continually measure the feedwater hardness and will output live readings on the home MM screen.

A TDS probe pot is required to be used with a TDS probe - this is mounted directly into the feedwater flow to allow the TDS probe to measure the hardness level in the feed water.



To enter the Water Hardness information screen, press on the TDS probe on the home MM screen, this displays information about the current water hardness reading as well as a graph which records the water hardness history for the past 24 hours.

A water hardness warning level can be set in Expansion Option 46 so that an MM alarm will be triggered if this threshold is reached. An alarm level can also be set in Expansion Option 56 - this information will also be displayed in the water hardness screen.

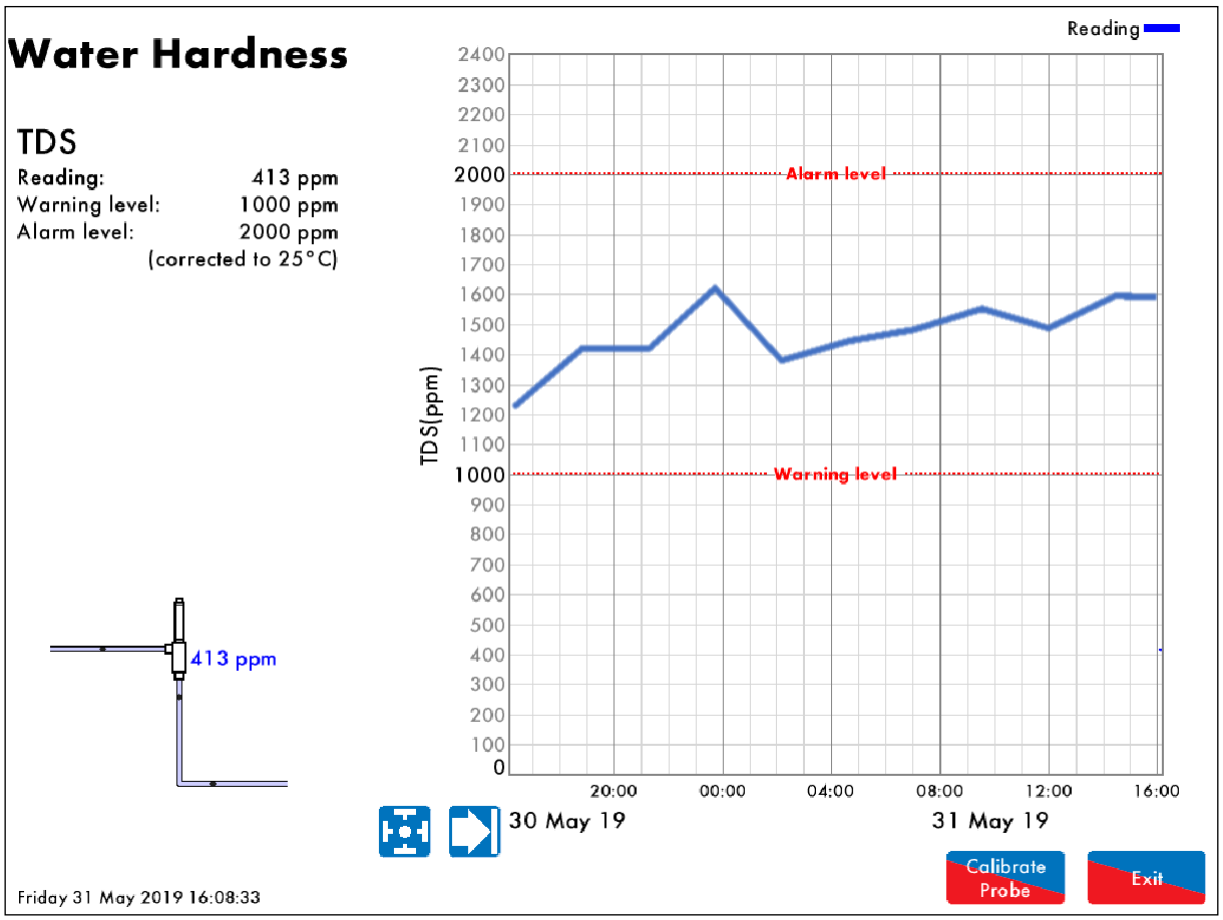
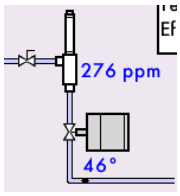


Figure 11.7 – Water Hardness Monitoring Screen

11.8 Calibrating the TDS Probe

Press on the TDS probe / servomotor 

on the MM Home screen to access the Top Blowdown Control screen. The TDS value is shown corrected to 25°C. The TDS temperature compensation is set in expansion option 43.

The TDS target value is set in expansion option 42.

Top blowdown control does not function when the pressure is below the offset pressure from the required setpoint which is set in expansion option 47.

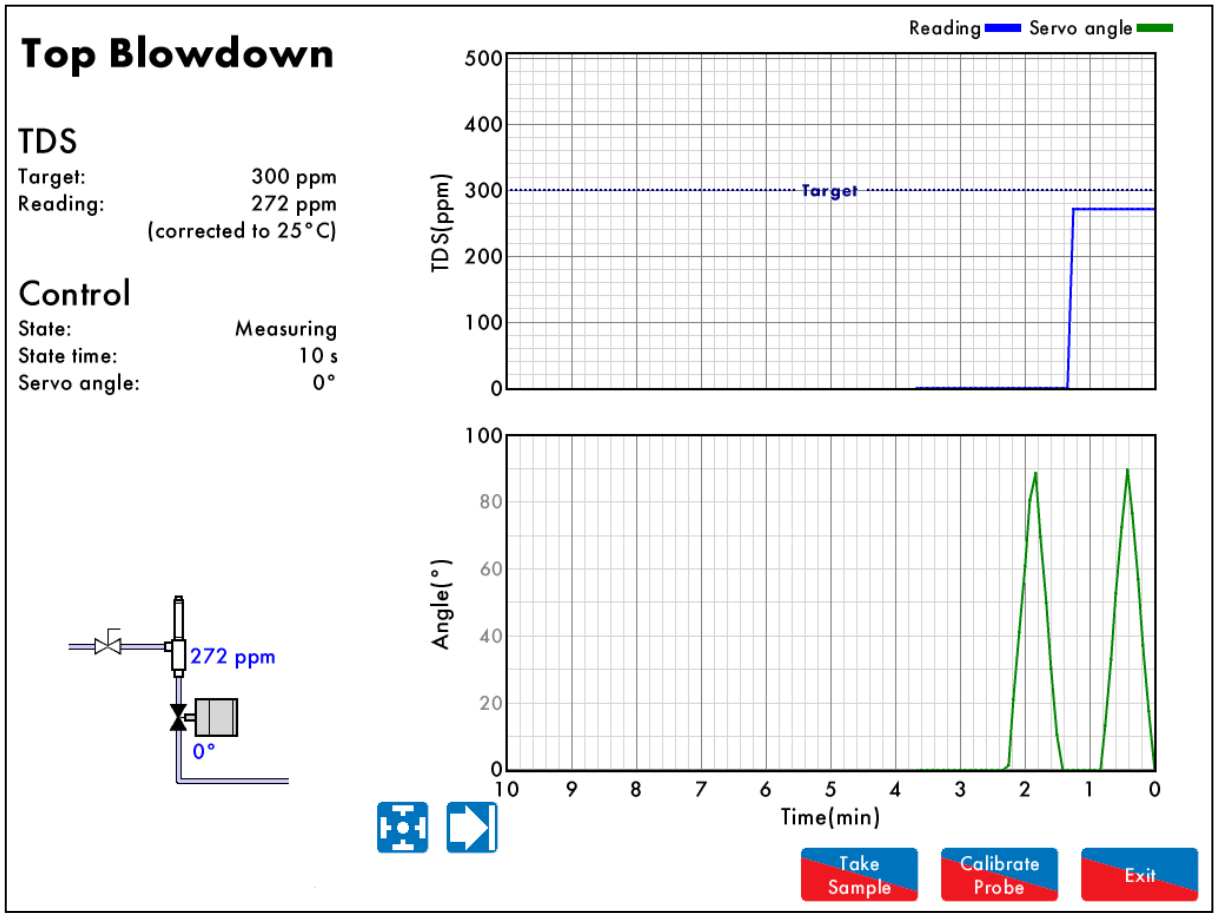


Figure 11.8A - Top Blowdown Screen

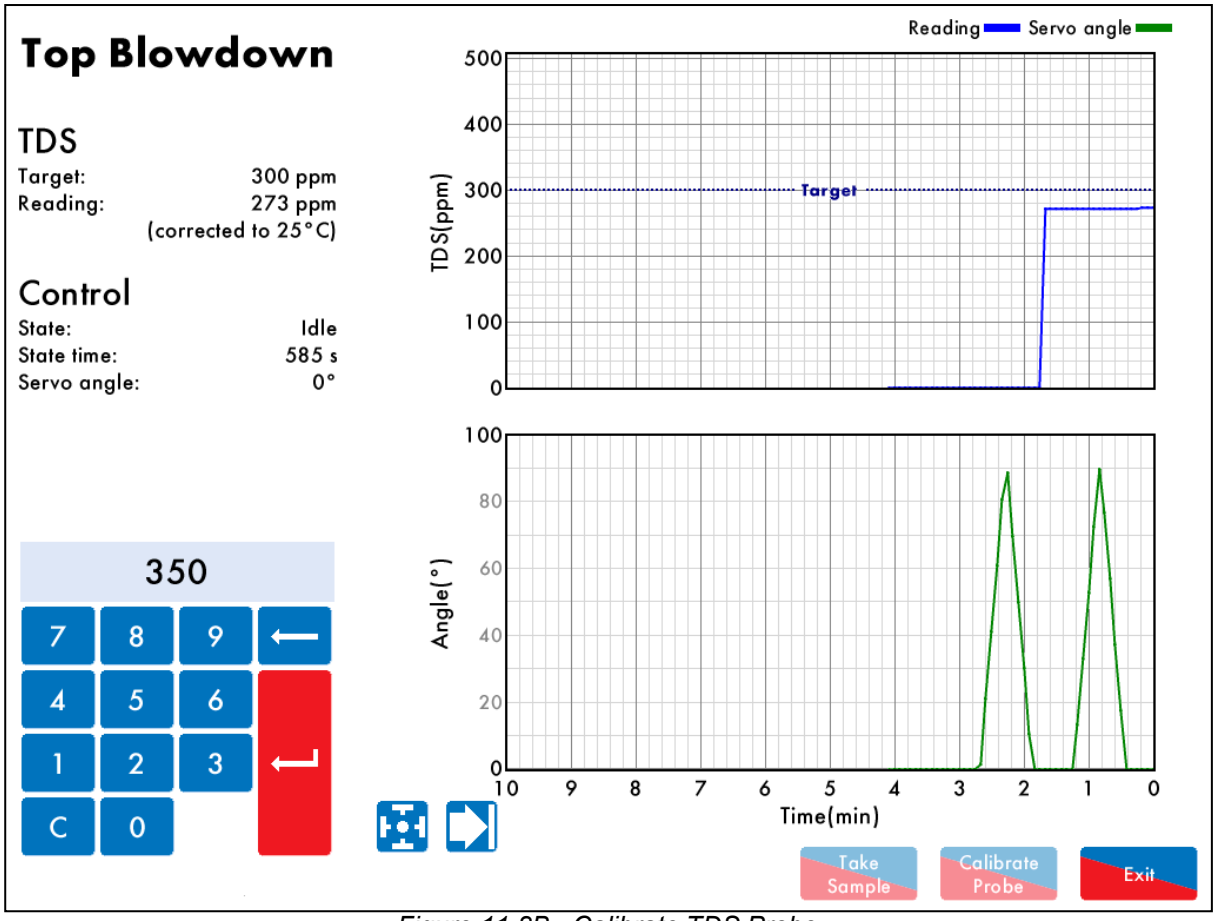


Figure 11.8B - Calibrate TDS Probe

After taking and analysing a manual sample of the TDS, in order to calibrate the TDS probe, press Calibrate Probe, enter the value using the on-screen keypad and press ↵ to enter the TDS value. This value must be within 10% - 990% of the probe reading to avoid incorrect calibration. If there is an air lock, the TDS probe will not be calibrated as the reading will be 0ppm.To check the manual sample value against the now calibrated probe value, press Take Sample to sample the TDS using the probe.

Note: Top blowdown control does not operate when the TDS probe is being calibrated, when a fresh sample is taken or when the burner is not firing.

11.9 Faults

The table below show the faults which are directly related to the top blowdown function.

Fault	Type	Message	Description
200	Warning	Top Blowdown Sensor Communications Fault	No comms with the top blowdown sensor
• Check wiring and screen on terminals 3P+, 3P-, 3T+ and 3T-			
201	Warning	Top Blowdown Servo Position Error	Servomotor is outside of the commissioned range
• Check wiring on terminals P-, TW, P+ and TBI, TBD • Check signal cable form the MM to the servomotor is screened at one end • Check that the servomotor is zeroed correctly			
202	Warning	Top Blowdown Servo Movement Error	Servomotor moves when not expected and vice versa
• Check wiring on terminals TBI and TBD • Check servomotor drives in correct direction • Check top blowdown valve is not stuck			
250	Warning	Top Blowdown Reading High	TDS value detected too high
• Check expansion option 46 and TDS value			

12 BOTTOM BLOWDOWN

12.1 Overview

The purpose of bottom blowdown is to remove solids which build up in the bottom of a steam boiler. In the Autoflame system, there are options to either manage the blowdowns through automatic timings, or to manually trigger them. The programmable electronic automatic blowdown ensures repeatable blowdown timings without the need of a compressed air supply. A pulsed bottom blowdown is used to disturb settled solids at the bottom of the boiler, making the evacuation effect more efficient. The timings and intervals of the bottom blowdowns are user configurable.

The Bottom Blowdown function on the Mk8 MM can be configured in two ways:

- Bottom blowdown using solenoid.
- Bottom blowdown using Autoflame controller.

The benefits of the Autoflame Bottom Blowdown system include:

- Options for solenoid blowdown of fully modulating blowdown.
- Full stainless-steel valve construction.
- 24V DC Autoflame industrial type servomotors for control and repeatability.
- Electronic proof of open/close end switches.
- Lithium-Ion battery technology ensures guaranteed closure on power failure.
- Total electronic operation – no compressed air supply required.
- Timed blowdown with manual/automatic operation.
- Bottom blowdown sequence logging.
- Up to 10 timed blowdowns over a 24-hour period are possible.
- Repeatable up to 10 times from 1 to 60 seconds for each blowdown cycle.
- ‘Parked’ position to reduce valve opening time.
- Quick servomotor disconnect facility for manual actuation.
- Rotary operation ensures watertight shutoff.
- Sealing design concept ensures no leaks.

12.2 Bottom Blowdown Expansion Options

The table below shows the Expansion Options used for configuring Autoflame Bottom Blowdown.

#	Default	Range	Description
60	0		BBD: Bottom Blowdown Function
			To enable bottom blowdown, the bottom blowdown expansion feature must be unlocked. The bottom blowdown function can be set for up to 10 timed blowdowns over 24 hours. For setting 1, the timed blowdown output terminal BB is used with an external solenoid valve. For setting 2, the bottom blowdown control module is used on terminals 5T+ and 5T-, which is connected to the bottom blowdown servomotor.
		0	Bottom blowdown disabled
		1	Bottom blowdown using solenoid
		2	Bottom blowdown using Autoflame controller
61	0		BBD: Bottom Blowdown Triggering
			For setting 0, when the MM does not need a manual trigger for a blowdown to start when the configured blowdown timing is reached. For setting 1, a manual trigger is required to start the blowdown when the configured blowdown timing is reached.
		0	Automatic triggering
		1	Manual triggering
62	0		BBD: Bottom Blowdown Reduction
			If bottom blowdown reduction is enabled, then the timing of the blowdown will reduce in proportion to the steam production. If there is no steam production and the configured blowdown timing is reached, then the minimum time for that blowdown can be set in expansion option 63.
		0	Bottom blowdown reduction disabled
		1	Bottom blowdown reduction enabled
63	0		BBD: Minimum Blowdown Duration
			This is the minimum duration for which blowdown will occur if bottom blowdown reduction is enabled in expansion option 62. For setting 0, if there is no steam production, no blowdown will occur, however if a time is set, then the minimum blowdown duration will be used when there is no steam production.
		0	Disabled
		1 – 60	Seconds
64	0		BBD: Boiler Steam Production Rating
			If bottom blowdown reduction is enabled in expansion option 62, then the maximum steam production rating for that boiler should be set. The bottom blowdown time is reduced according to the current steam production and maximum steam production ratio. This will mean that the blowdown occurs for a shorter time when there is low steam production.
		0 – 5000	0 – 500000 kg/hour or 0 – 1102310l lb/hr (see parameter 40)
65	0		BBD: Minimum Blowdown Always Enforced
			Turning on this bottom blowdown option will ensure that the minimum blowdown time specified in expansion option 63 will take place even if Bottom blowdown reduction is active and no steam has been generated since the last blowdown. If expansion option 63 is disabled, with the Minimum Blowdown Enforced, then no blowdown will occur.
		0	Minimum Blowdown Not Enforced
		1	Minimum Blowdown Enforced

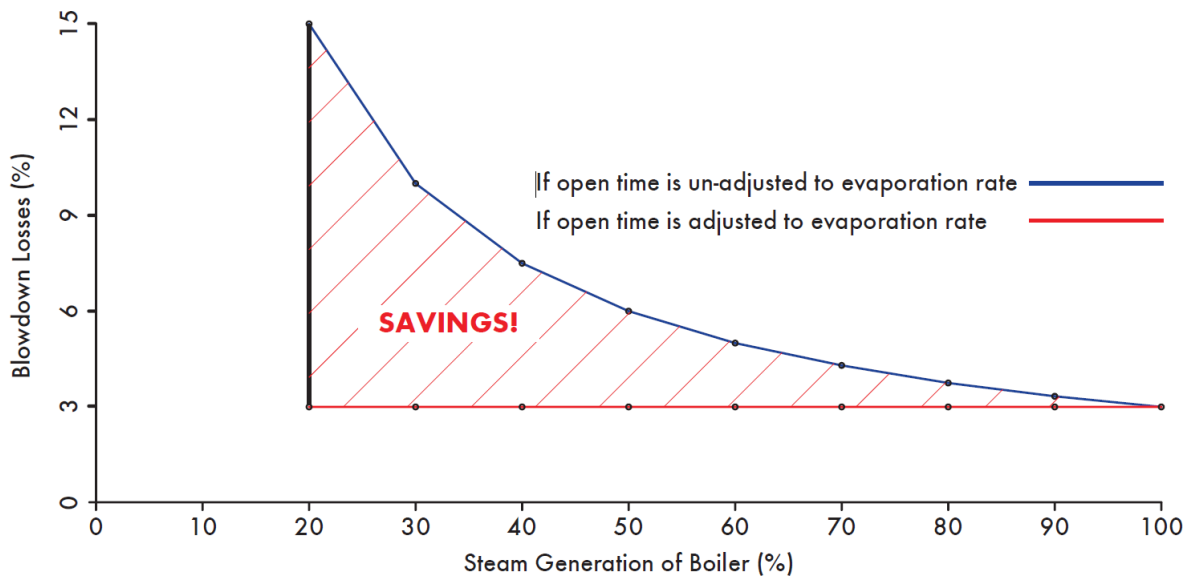
12.3 Bottom Blowdown Reduction

12.3.1 Blowdown Energy Savings

With a typical loss in steam generation of 3% from the conventional bottom blowdown management,Autoflame have developed a Bottom Blowdown Time Reduction feature to minimise these losses which occur when keeping the boiler heat transfer surfaces clean.

It follows that blowdown time can be reduced as a function of the rate of steam generation. Silt and sludge formation within the boiler is always in ratio to work done or steam generation. Therefore, the reduction in the blowdown valve open time can be made, as long as the reduced open time is in ratio to the evaporation rate or steam generation rate.

- Blowdown savings in the region of 1-2% are possible on total fuel usage (dependant on boiler load).
- Blowdown timing automatically reduced in ratio to steam generation.
- Blowdown timings set by users.
- Operators may only trigger pre-set timings, eliminates excessive blowdown by operator.
- Ensures minimal blowdown to satisfy removal of solids, silt and sludge.



For time reduced bottom blowdown, steam flow metering and fuel flow metering is required. Steam flow metering can be set through expansion option 120, please see section 16 for more information. Fuel flow metering can be set through option 57.

12.3.2 Calculation for Bottom Blowdown Reduction

For timed reduced bottom blowdown with Mk8 MM, the maximum steam production, used to base how the bottom blowdown time is scaled down to, is set through expansion option 64. The blowdown time is reduced according to the ratio of the actual steam production to the maximum steam production for that period. If the blowdown is calculated above the stored blowdown time set by the user in the bottom blowdown screen, then the extra time will get carried over to the next timed blowdown. This extra time will remain carried over to the following blowdowns until the steam production has lowered and the blowdown is therefore lowered.

There can be up to 10 blowdowns over a 24-hour period, with each blowdown:

Blowdown Time	BD_1	BD_2	BD_3	BD_4	BD_5	BD_6	BD_7	BD_8	BD_9	BD_{10}
Time between Blowdowns	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}

The configured blowdown time for that period x which has been set by the user is:

$$BD_x = Blowdown\ time\ (sec)$$

The time between the blowdowns which is sent by the user is:

$$Tx = Time\ between\ Blowdowns\ (hours)$$

Therefore over a 24 hour period:

$$T_1 + T_2 + T_3 + T_4 + T_5 + T_6 + T_7 + T_8 + T_9 + T_{10} = 24\ hours$$

The blowdown time for that 24-hour period is then:

$$BD_1 + BD_2 + BD_3 + BD_4 + BD_5 + BD_6 + BD_7 + BD_8 + BD_9 + BD_{10} = BD_T$$

The maximum blowdown period can be calculated as:

$$BD_{max}(seconds) = \left(\frac{BD_T}{24}\right) x\ T_x$$

The maximum steam flow which is set in expansion option 64 is:

$$SF_{max}$$

The average steam flow for that period which is given from steam flow metering is:

$$SF_x$$

The calculated steam flow ratio for that period is then:

$$SF_{CX} = \frac{SF_X}{SF_{MAX}}$$

The adjusted blowdown time according to steam production is then:

$$BD_A = \frac{SF_{CX} \times T_X \times BD_T}{24}$$

If the adjusted blowdown time is calculated higher than the maximum blowdown time, the time is carried over to the next scheduled blowdown operation:

$$BD_A > BD_{max}\ Extra\ time\ is\ carried\ over\ to\ next\ blowdown\ operation$$

If the calculated adjusted blowdown time is lower than the minimum blowdown time set in expansion option 63, and expansion option 62 is set for minimum blowdown enforced, then:

$$BD_A < BD_{min}\ Minimum\ blowdown\ time\ is\ enforced$$

Example

The maximum steam flow rate, which is set through expansion option 64 as 20,000lb/hour.

Blowdown Time	BD_1	BD_2	BD_3	BD_4
Time between Blowdowns	T_1	T_2	T_3	T_4

In this example the 4 blowdowns are configured with the total blowdown timings (Repeats x Duration) as:

BD_1 = 10s at T_1 00:00
BD_2 = 10s at T_2 06:00
BD_3 = 10s at T_3 14:00
BD_4 = 10s at T_4 18:00

For period 2, if the average steam flow rate for that period from the Mk8 MM steam flow metering is 12,000lb/ hour, then the calculated steam flow ratio is then:

$$SF_{C2} = \frac{SF_2}{SF_{max}} = \frac{12{,}000lb\ /hr}{20{,}000lb\ /hr}$$

$SF_{C2} = 0.6$

The total configured blowdown time over the 24 hours is:

$$BD_T = BD_1 + BD_2 + BD_3 + BD_4 = 10s + 10s + 10s + 10s$$

$$BD_T = 40s$$

The maximum blowdown time for period 2 is:

$$T_x = T_2 - T_1 = 06{:}00 - 00{:}00 = 6\ hours$$

Therefore, the adjusted blowdown time is:

$$BD_A = \frac{SF_{cx} \times T_x \times BD_T}{24hours} = \frac{0.6 \times 6hours \times 40secs}{24hours}$$

$$BD_A = 6s$$

The Maximum blowdown time for period 2 is 13s. Therefore, a full 6s blowdown will be carried out.

The maximum blowdown time for period 3 at full steam rate of 20,000lb/hr is:

$$T_x = T_2 - T_1 = 014{:}00 - 06{:}00 = 8\ hours$$

Therefore, the adjusted blowdown time is:

$$BD_A = \frac{SF_{cx} \times T_x \times BD_T}{24hours} = \frac{1 \times 8hours \times 40secs}{24hours}$$

$$BD_A = 13.3s$$

The Maximum blowdown time for period 3 is 10s. Therefore 3.3s is carried over to period 4.

Time Reduced Bottom Blowdown for Standalone Operation

When using the time reduced bottom blowdown in standalone operation, the maximum steam flow rate and the average steam flow rate are taken from the 4-20mA input to the Bottom Blowdown Module. Please see Autoflame Modules Guide for more information.

12.4 Installation Guidance

The Bottom Blowdown valve must be sized appropriately for the size of the boiler and blowdown rate required, which will be affected by the boiler pressure, size of blowdown line and blowdown line length from the boiler to the bottom blowdown vessel. The blowdown rate that is required for that boiler will vary according to the operating conditions, contaminants in the feed water and boiler design.

In multi-boiler systems where a bottom blowdown valve is fitted to each boiler, enabling Autoflame sequencing in option 16 will ensure that only boiler in that loop blows down at a given time. If a blowdown time is set the same on all the MMs in a sequencing loop, the MM with the lowest ID complete its blowdown first, followed by the rest of the MMs, sequentially. If Autoflame sequencing is not used for multi-boiler system requiring bottom blowdown in the UK, then valves must be interlocked; this ensures that only one boiler can be blown down at a time. Please see local code and regulation on bottom blowdown in multi-boiler systems.

The Autoflame Bottom Blowdown Module (part number BBC70004) has a built-in, rechargeable Lithium-Ion battery, so should a power failure to the module occurs, a Bottom Blowdown fault or MM error will be triggered, and the servomotor will drive the blowdown valve to the closed position using battery power. The servomotor is powered by 24VDC from the bottom blowdown module.



Note: The bottom blowdown valve must be installed along the blowdown pipeline according to local code and regulations. It is the responsibility of the factory trained technician or engineer to configure the bottom blowdown timings according to the specifications given by the boiler manufacturer.

12.4.1 Bottom Blowdown Valve

The valves used for Bottom Blowdown, Feed Water and TDS are universal. See the table below for the valve sizes and servomotor required for the blowdown valves. The servomotors are 24VDC version.

Valve Type	Size	Part No.	Servomotor Size	
			UNIC05	UNIC 10
Flanged PN40	25mm (1”)	WLCVO25/FL	•	
	40mm (1 ½”)	WLCVO40/FL		•
	50mm (2”)	WLCVO50/FL		•
Flanged ANSI300lb	25mm (1”)	WLCVO25/FLU	•	
	40mm (1 ½”)	WLCVO40/FLU		•
	50mm (2”)	WLCVO50/FLU		•

Maximum operating pressure: 29 Bar (425 PSI)
Maximum operating temperature: 235°C (455°F)

Please check the Autoflame Valves & Servomotors guide for the full details on the bottom blowdown valve and servomotors including dimensions, drawings and information on service and maintenance.



12.4.2 Bottom Blowdown Using Solenoid Valve

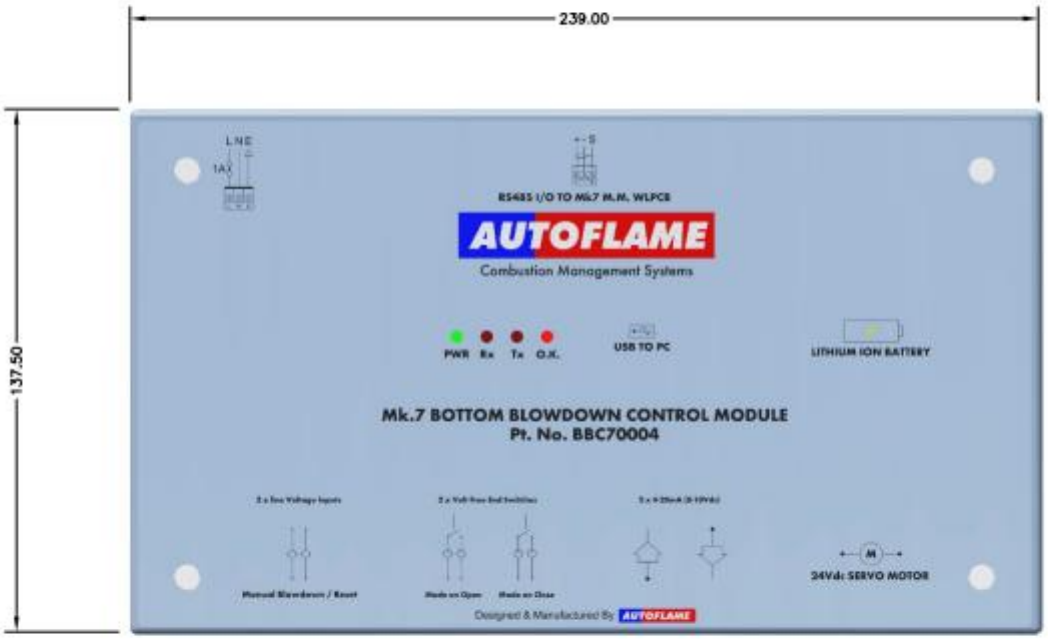
Terminal BB (switched neutral) on the Mk8 MM expansion board can be used to energise a bottom blowdown solenoid valve through a contactor.

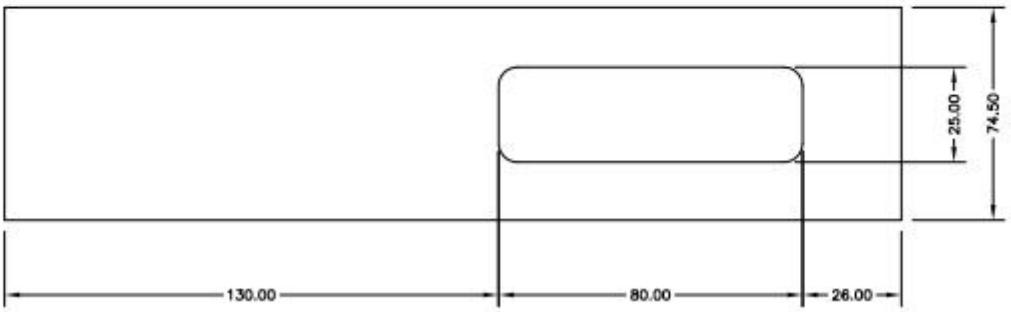
12.4.3 Bottom Blowdown Module

If the bottom blowdown module is used with the MM, please follow the commissioning and blowdown timing configuration steps in section 12.5. If the bottom blowdown module is used as a standalone unit, please refer to the Modules Guide for instructions on using the Bottom Blowdown Board Configurator software.

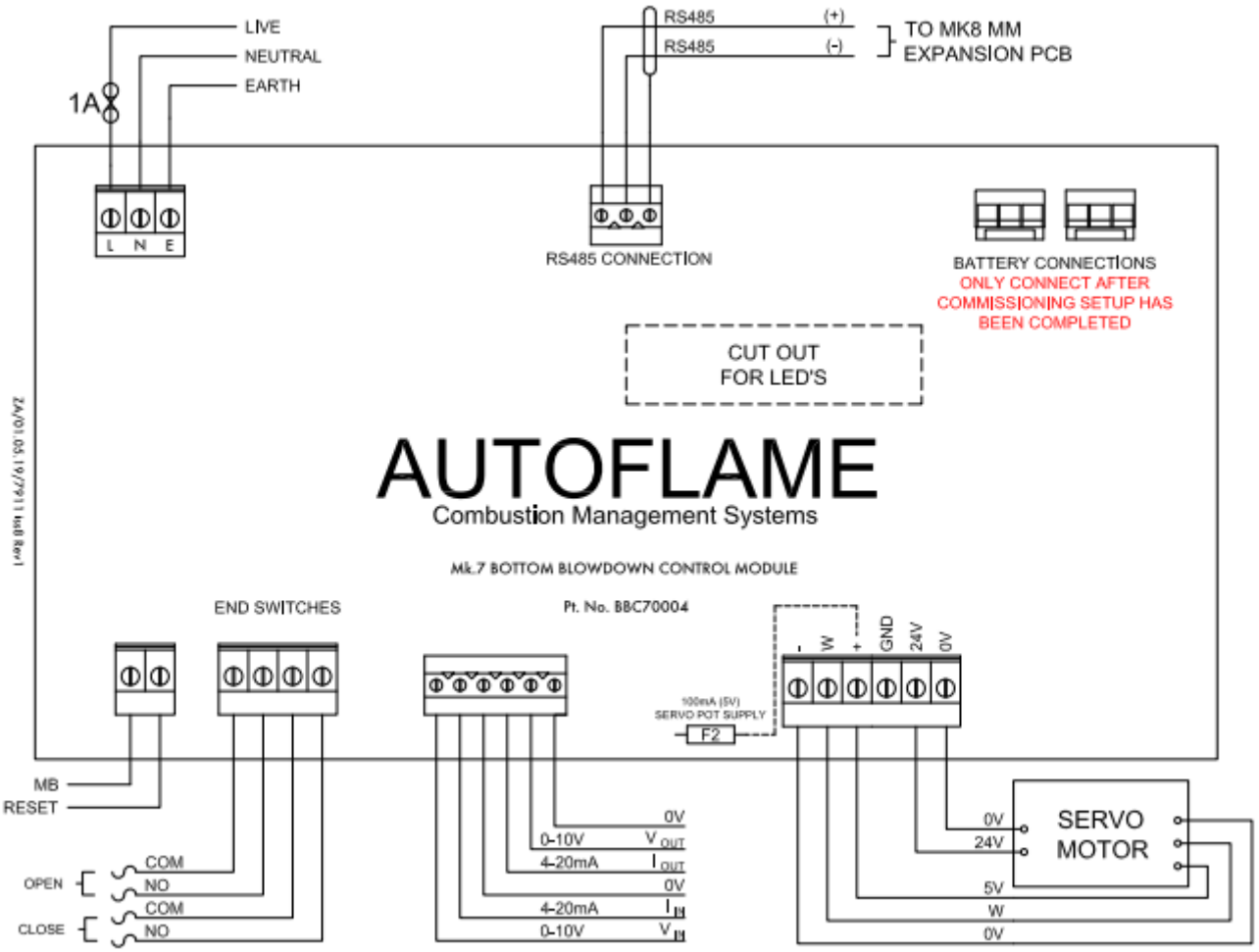
Dimensions







Bottom Blowdown Module Wiring



Terminal	Description
L	Live
N	Neutral
E	Earth
RS485 +	Connection MM terminal 5T+
RS485 -	Connection MM terminal 5T-
S	Screen at module
MB	Manual Blowdown
RESET	Reset bottom blowdown module error
OPEN COM/NO	Volt-free connection for open position
CLOSE COM/NO	Volt-free connection for closed position
V_{IN}	Voltage 0-10V input for steam production rating (standalone use)
I_{IN}	Current 4-20mA input for steam production rating (standalone use)
0V	Common for terminals V_{IN} or I_{IN}
V_{OUT}	Voltage 0-10V output for bottom blowdown valve position
0V	Common for terminals V_{OUT} or I_{OUT}
-	0V supply to servomotor from MM
W	Signal from servomotor indicating position
+	+5V supply to servomotor from MM
GND	Ground/Earth
24	+24V supply to servomotor from battery
0	+0V supply to servomotor from battery

12.5 Set-up

For a new installation, after checking the wiring, performing safety installation checks, and settings the options, parameters and expansion options, the servomotor closed position can be set in password protected Commissioning Mode or Online Changes for an already commissioned system.

When the bottom blowdown module is used as standalone, it must be configured using the bottom blowdown configurator PC software. Please see the Autoflame Modules Guide for more information.

The battery connectors on the bottom blowdown module must remain disconnected during the commissioning of bottom blowdown, these can be reconnected after the commissioning process is completed.



Please note: The fault reset switch should not be used in MM mode, this is for use in standalone mode only.

12.5.1 Bottom Blowdown Settings

The bottom blowdown function can be set using an external solenoid valve or the bottom blowdown module, see expansion option 60.

When a bottom blowdown time is due, the blowdown can be set to occur automatically, or by a pressing the manual trigger on the bottom blowdown screen, see expansion 61.

Bottom blowdown reduction allows the timing of the blowdown to be adjusted according to the steam production, see expansion option 62.

If there is no steam production when a blowdown time is due, the MM/module will ignore the blowdown or blow down the valve for a minimum duration, see expansion option 63.

If using bottom blowdown reduction, the boiler steam production rating must be set and the fuel flow metering must be set and commissioned, see expansion option 64 and option 57.

The industrial UNIC servomotors which are used with the water valve for bottom blowdown are factory set with the closed position at 0.0° and open position at 90.0°.

However please do physically check the servo position manually and also check the potentiometer reading on the servo, this should read 0V at closed position. Please refer to section 3.3 for servomotor checks and adjustments.

The default parked position is set the same as the closed position 0.0°, however this can be adjusted using the Bottom Blowdown Board Configurator software; refer to the Autoflame Modules Guide. The parked position is a near closed position. During a bottom blowdown event, the servomotor will move to the parked position rather than the closed position during the valve closed interval. This allows a not fully closed position to be set for the parked position, reducing the time take for the servomotor to drive to 90.0^{O} for the valve open interval.

The table below shows a summary of the bottom blowdown expansion options.

Expansion Option	Description
60	Bottom blowdown function
61	Bottom blowdown triggering
62	Bottom blowdown reduction
63	Minimum blowdown duration
64	Boiler steam production rating
65	Minimum blowdown always enforced

12.5.2 Setting Servomotor

Please check the servo position manually, and then check the potentiometer reading on the servomotor. This should read 0º at closed position. Please refer to section 3.3 for servomotor checks and adjustments.

When the bottom blowdown module is first enabled, the red and green LEDs will flash on the modulate indicating a fault; there is fault because the module has not seen the servomotor go to the closed position yet. The warning 'Bottom Blowdown Servo Not Commissioned' will appear. The servomotor closed position can be set in password protected Commissioning mode or Online Changes.

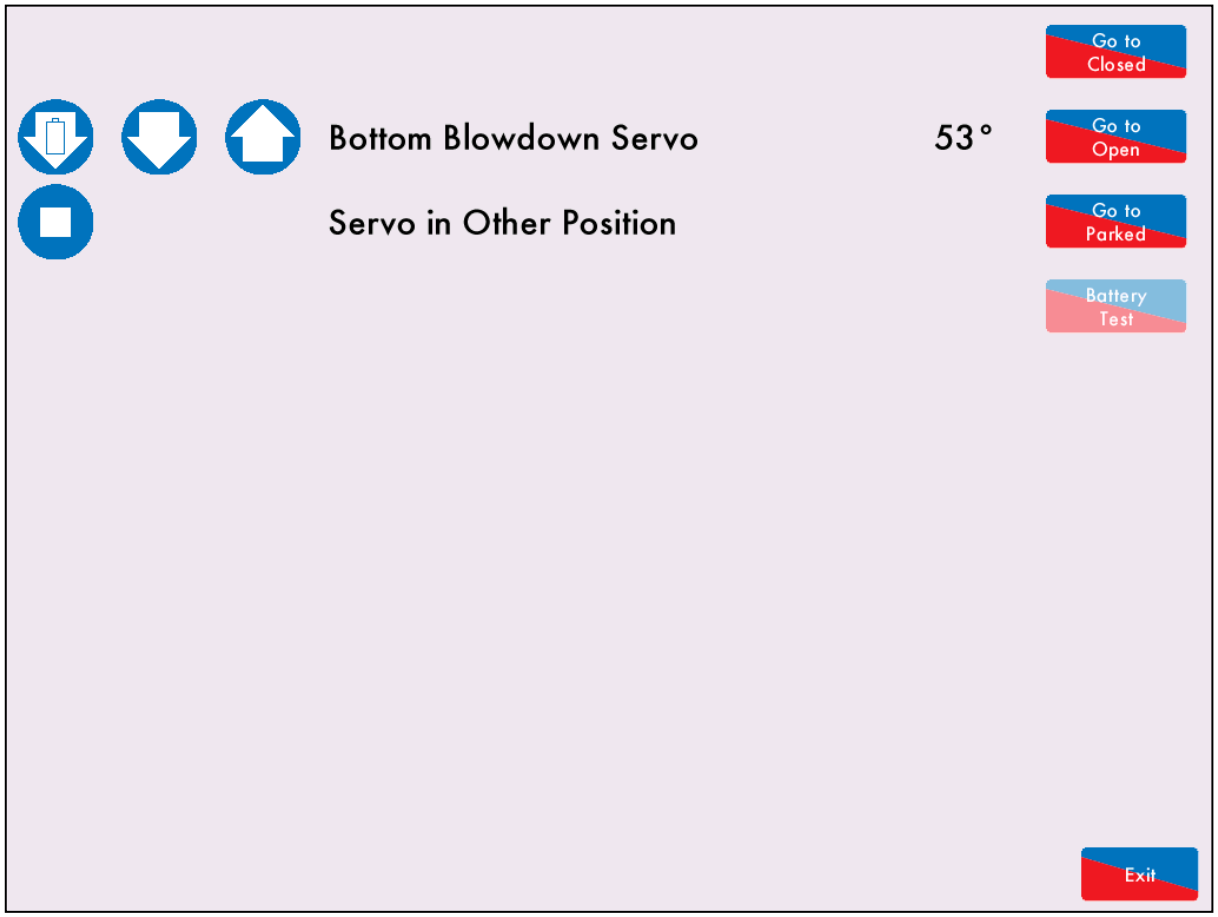


Figure 12.5.2.i Servo in Other Position

Press Bottom Blowdown in the Commission Mode screen or press Bottom Blowdown in Online Changes and enter the password.

The screen will show the current Bottom Blowdown servomotor angle. If the servomotor is not at the closed position, the message 'Servo in Other Position' will appear.

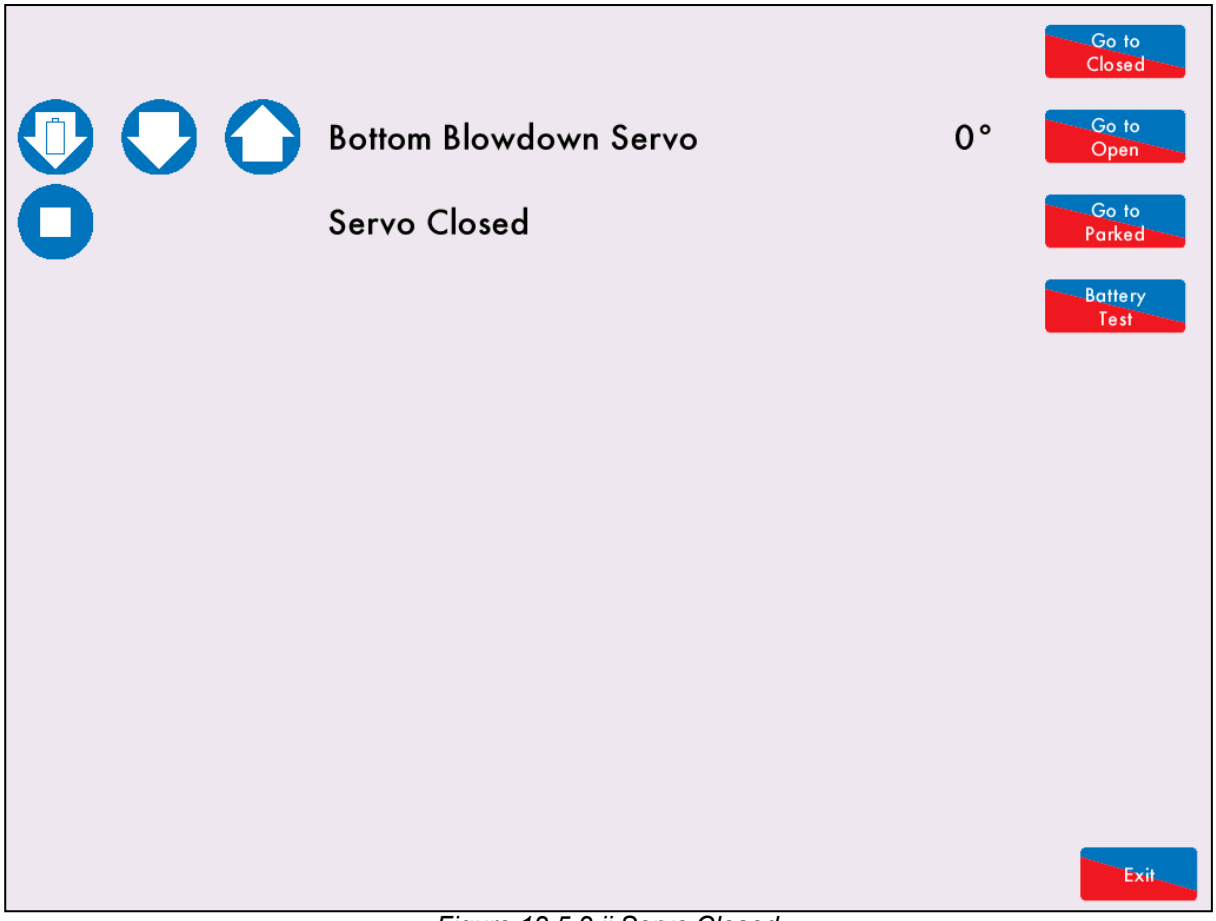


Figure 12.5.2.ii Servo Closed

When first enabled, the Bottom Blowdown Module must detect the servomotor at the closed position to clear the 'Servo in Other Position' warning.

Press 

to drive the servomotor to the closed 0.0° position. Pressing  will drive the servomotor into the closed or open direction. Pressing  will stop the servomotor driving.

When the servomotor is moving, the message 'Servo Closing' will appear, and when it has reached the closed position, the message will change to 'Servo Closed.' The positioning potentiometer on the blowdown servomotors does not need to be zeroed.

Press  to drive the servomotor towards the closed position using the battery power within the Bottom Blowdown Module.

When charged, the Bottom Blowdown Module battery should measure 13VDC+, if this falls below 12.4VDC, there will be not enough power in the battery to drive the valve to the closed position should a power failure occur, in this case a Bottom Blowdown Controller Main Power Fault will be triggered.

To test the battery operation, drive the servomotor to the closed position, then press 

. The servomotor will drive the valve to the parked position using mains power, and then it drives it to the closed position using the battery power to test the battery. If the battery cannot drive the valve to the closed position, a Bottom Blowdown Servo Battery Drive Fault will be triggered.

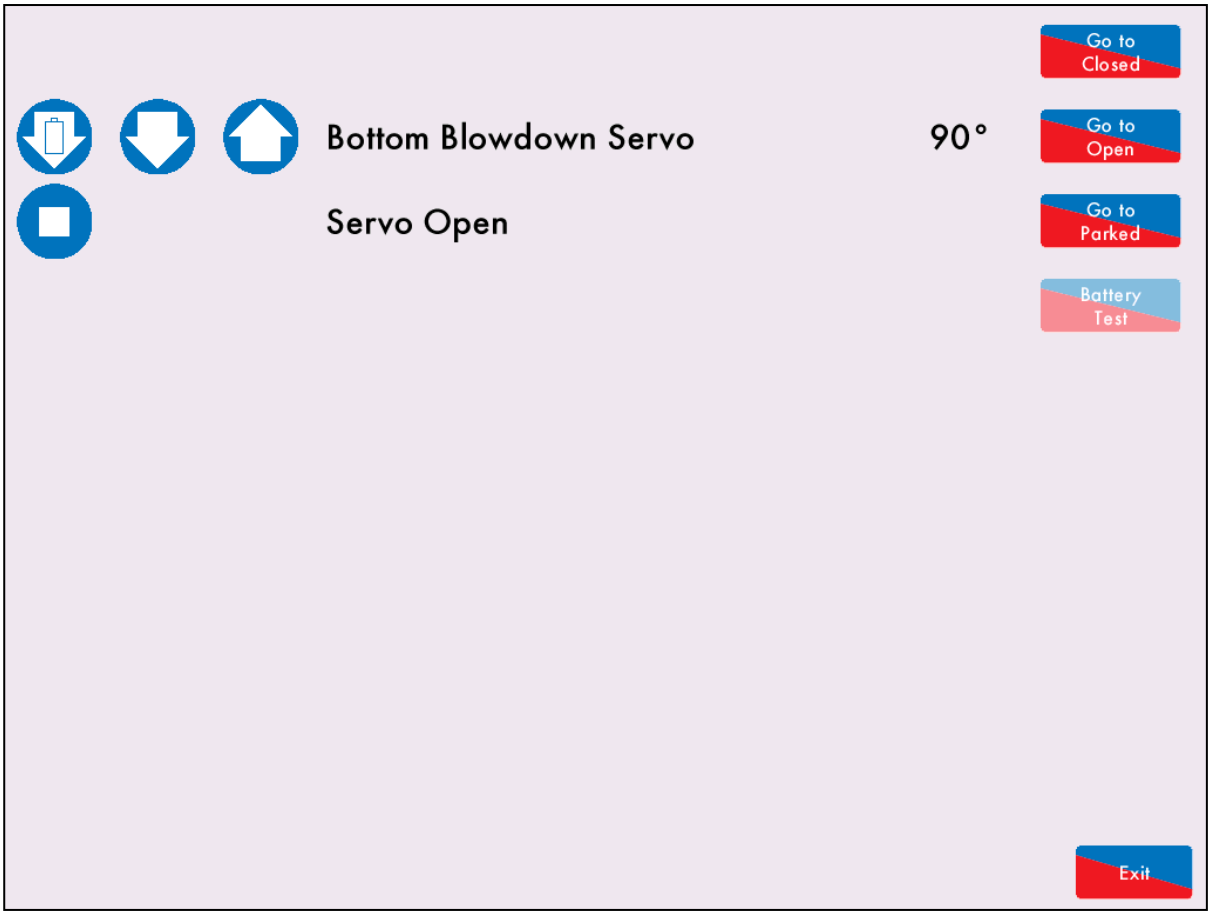


Figure 12.5.2.iii Servo Open

Press  to drive the servomotor to the open 90.0° position.

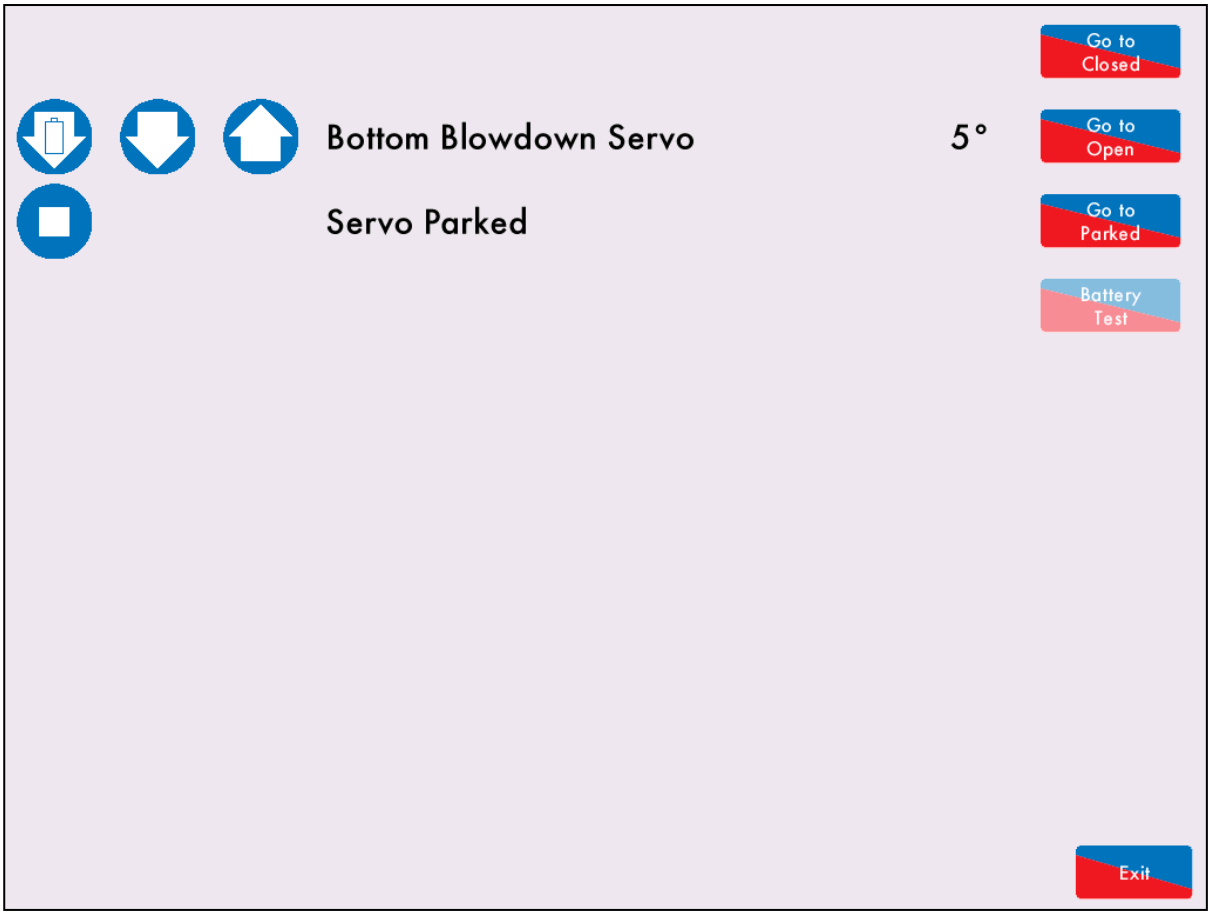


Figure 12.5.2.iv Servo Parked

Press 

to drive the servomotor to the parked position. The parked position is set using the Bottom Blowdown Board Configurator software, please see the Autoflame PC Software Guide for more information.

Now the Bottom Blowdown servomotor has been set for the closed and open position. Press 

to leave the configuration screen.

The battery connectors on the bottom blowdown module can be reconnected after the commissioning process is completed.

12.6 Bottom Blowdown Configuration

12.6.1 Bottom Blowdown Schedule

If a Bottom Blowdown Module is used, on Mk8 MM go to 

and press 

and enter the password to access the Bottom Blowdown Schedule screen.



Figure 12.6.i Bottom Blowdown Configuration Screen – None Set

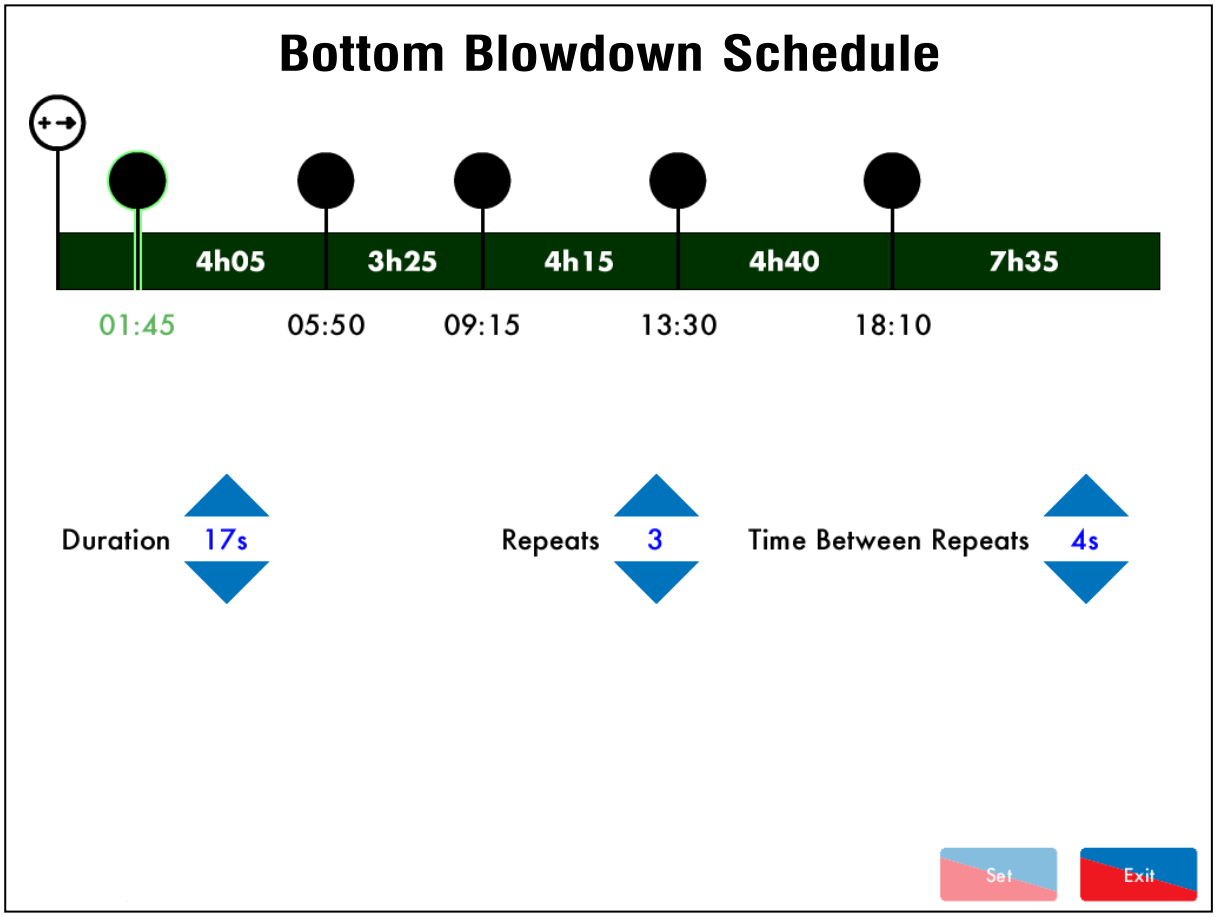


Figure 12.6.ii Bottom Blowdown Configuration

To add a blowdown time, press and drag the pointer to the left or right to adjust this time. Use the buttons to increase or decrease the blowdown duration, number of blowdown repeats or the time between blowdown repeats.

The bottom blowdowns can be schedule at 5-minute intervals within the following range:

Configuration	Range
Duration of blowdown	1 – 60s
Number of blowdown repeats	1 – 10
Time between blowdown repeats	1 – 60s
Number of scheduled blowdowns	1 – 10 over 24-hour period

To remove a blowdown time, press on and drag it up, and then press to remove this blowdown time from the schedule.

Once the blowdown times have been set, press Set to save the blowdown times, and then press Exit to leave the bottom blowdown configuration screen.

12.6.2 Bottom Blowdown Log

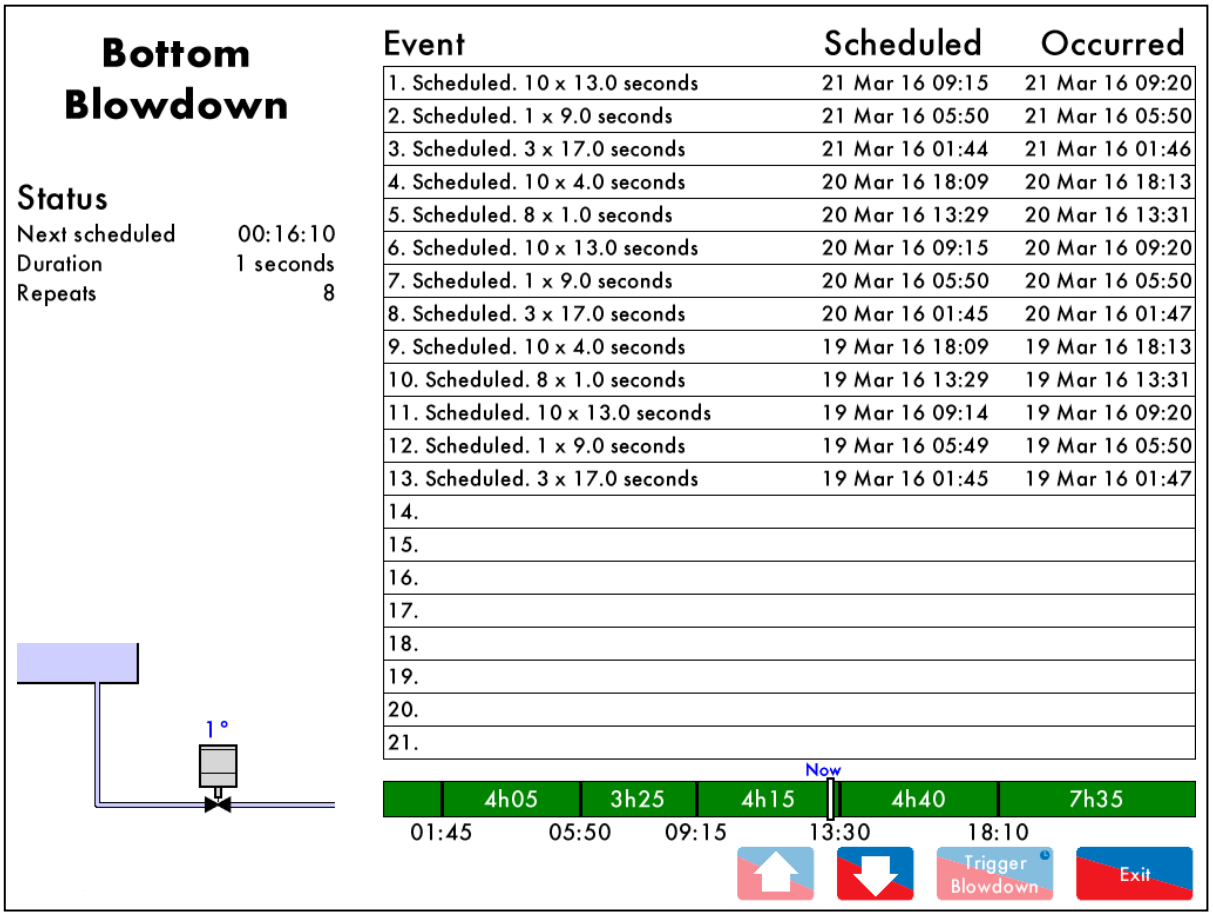


Figure 12.6.1 Bottom Blowdown Log

On the home MM screen, press on the bottom blowdown valve  to access the bottom blowdown log screen. The bottom blowdown log stores the last 128 blowdowns, with the following information:

- Type of blowdown: scheduled, manual.
- Date and time of scheduled blowdown.
- Date and time the blowdown occurred.
- Number of repeats and the duration of blowdown.

The bottom blowdown status shows a timer for when the next blowdown is due. If expansion option 61 is set for manual triggering, then when the next blowdown is due, the 

button must be pressed for the valve to blowdown. The status will then show ‘waiting trigger’ until this is pressed, or a line voltage input is detected on terminal MB on the bottom blowdown module. If the blowdown is not triggered, the log will show the scheduled blowdown as ‘missed’

If the bottom blowdown reduction has been enabled in expansion option 62, then the calculated reduced time will be displayed on the log.

The bottom blowdown log can be cleared in Online Changes.

12.7 Faults

The table below show the faults which are directly related to the Bottom Blowdown function.

Fault	Type	Message	Description
300	Warning	Bottom Blowdown Controller Comms	No comms with bottom blowdown controller
• Check bottom blowdown controller is powered on and enabled • Check wiring and screen on terminals 5T+ and 5T-			
301	Warning	Bottom Blowdown Controller Software Fault	Internal check failed
• Contact Autoflame approved local tech centre			
302	Warning	Bottom Blowdown Servo Closing Fault	No movement detected when bottom blowdown valve goes to close
• Check wiring on terminals 5T+ and 5T- • Check bottom blowdown valve is not stuck			
303	Warning	Bottom Blowdown Servo Opening Fault	No movement detected when bottom blowdown valve goes to open
• Check wiring on terminals 5T+ and 5T- • Check bottom blowdown valve is not stuck			
304	Warning	Bottom Blowdown Servo Battery Drive Fault	Battery has failed on bottom blowdown controller
• Contact Autoflame approved local tech centre			
305	Warning	Bottom Blowdown Controller MainPower Fault	Main power has failed on bottom blowdown controller
• Contact Autoflame approved local tech centre			
350	Warning	Bottom Blowdown Servo Not Commissioned	Bottom blowdown controller has not been requested to drive servomotor to closed since it was powered on
• Commission bottom blowdown servomotor			

13 DRAUGHT CONTROL

13.1 Overview of Draught Control

Draught control is used to manage the excess draught from stacks, in both fire-tube and water-tubeapplications, so heat transfer from the hot gases to the boiler tubes can be optimised. Both heat transfer rate and combustion rate depend on the motion of the flue gases; any changes in boiler pressure can affect the amount of combustion air entering the burner, possibly resulting in unburnt fuel. An excess of unburnt fuel can lead to unsteady combustion with dangerous consequences. A tall stack is susceptible to a changing pressure which is caused by stack temperature and wind velocity. The main benefits of maintain stack pressure through draught control include:

- Improves heat transfer.
- Improves combustion efficiency.
- Reduces room heat loss.
- Improves flame stability while reducing chance of pilot light failure.
- Improves flame retention.
- Reduce soot accumulation.

The Autoflame draught control stores the pressure conditions at the commissioning stage and modulates with the firing curve to maintain this, irrespective of changing firing rate and stack conditions. Normally there is a vertical main stack which has a horizontal cross connection from the boiler flue gas outlet; this is then connected into the main stack.

The boiler only works at optimum efficiency when all the conditions that affect its operation are held at good, commissioned values. Therefore, under the new arrangement, a butterfly valve driven by a positioning motor, is placed in the horizontal back flue typically two or three metres from the boiler. A differential pressure sensor is then inserted into the flue that is between the boiler outlet and the butterfly valve. As stack energy alters, the suction or pressure would vary at this point. It can be seen that by measuring the pressure of the draught at the position of the damper could be adjusted to bring the pressure or suction back to its commissioned value, the complete system would then be operating at optimum efficiency again.

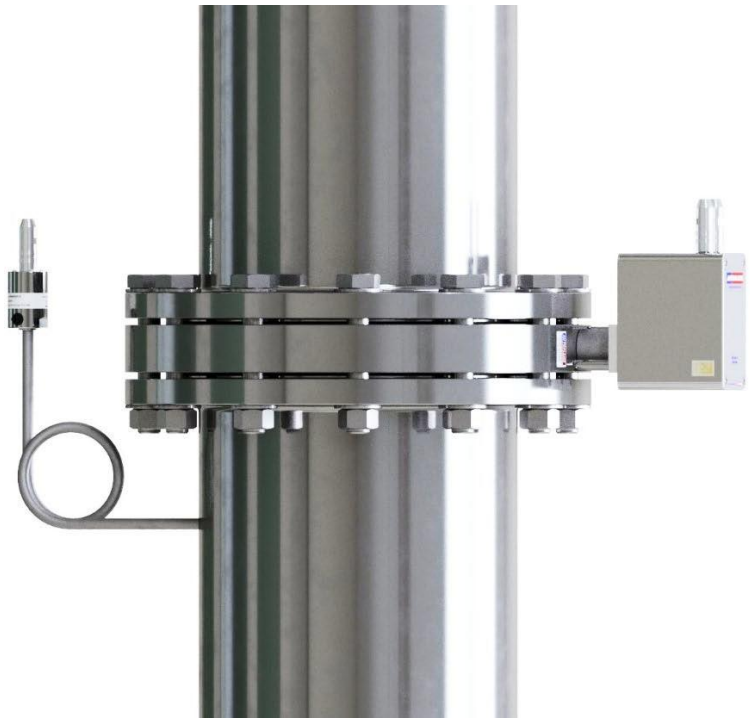


Figure 13.1.i Stack with Draught Control



Figure 13.1.ii Autoflame Draught Control

After commissioning is completed, every fuel and air position will have a stack damper position together with a stored draft pressure. The stack pressure is controlled by air pressure sensor, stack damper and PI loop. When the system is in run mode the stack damper will be positioned according to the stored commissioning pressure. If the stack pressure reading measured by the differential air pressure sensor reads a different condition to the stored value, then the stack damper butterfly valve will be adjusted to ensure that the stack pressure is brought back to its commissioned value.

13.1.1 Parts Required for Draught Control

Depending on the setup, Draught Control may require the following parts:

- Air Pressure Sensor – please see Autoflame Sensors Guide.
  A siphon loop must be fitted on the flue for air sensor.
- Positioning Servomotor, this may also require a mounting kit if used with a third-party damper – See section 13.4 for Draught control wiring setup. For more details, please see Autoflame Valves and Servomotors Guide.
- Draught Damper – Available upon request with the servo mounting fitted as standard, please contact Autoflame for sizes and availability.

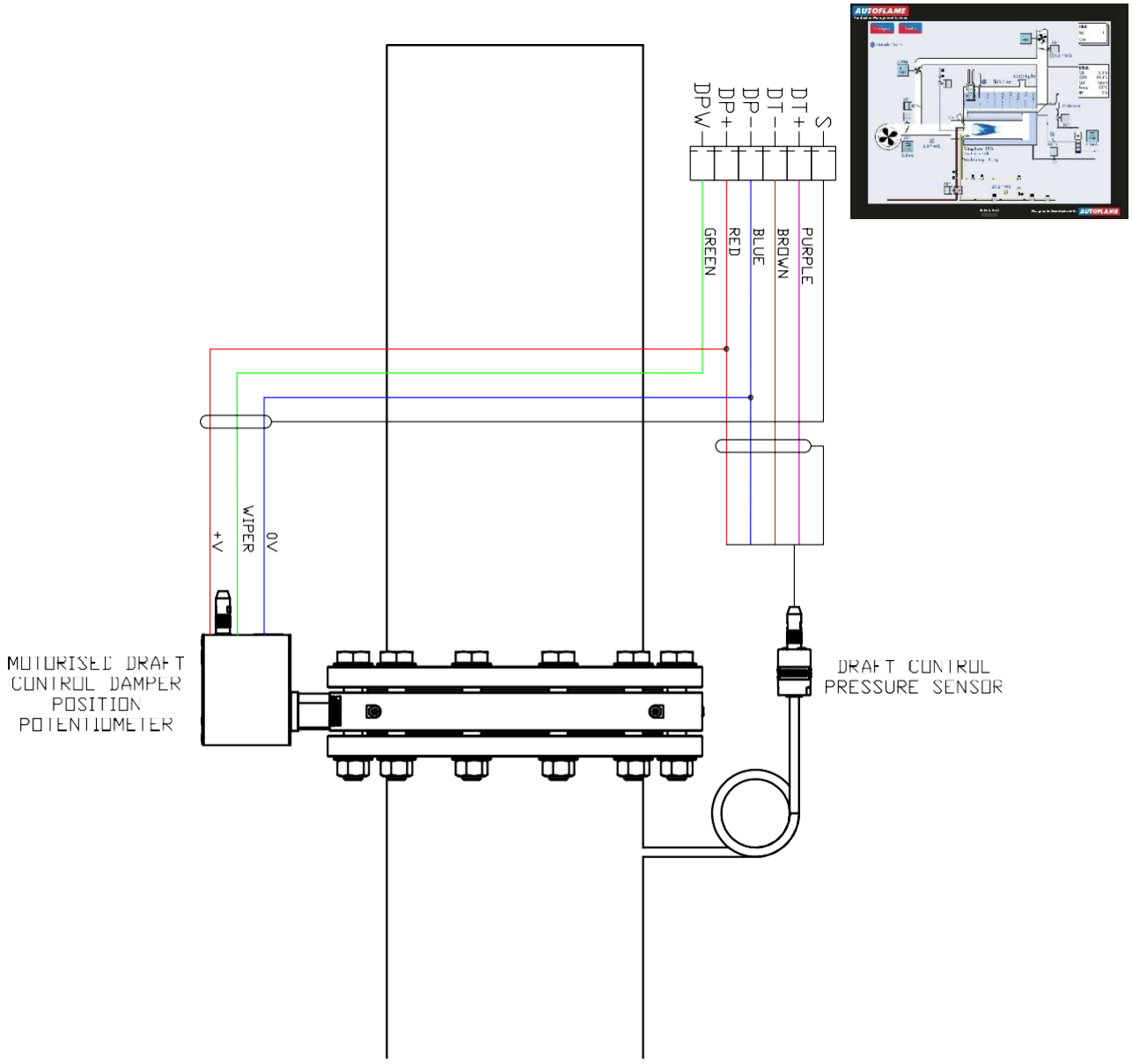


Figure 13.1.1 Draught Control installation and wiring schematic

13.2 Draught Control Expansion Options

The table below shows the Expansion Options used for Draught Control configuration.

#	Default	Range	Description
80	0		DC: Draught Control Servo Channel
			To use a draught servomotor on channel 7 with or without the draught control function, the draught control expansion feature must be unlocked. The servomotor is wired to terminals DP-, DP+, DPW, DCI and DCD. For setting 0 the draught servomotor is optioned off. For setting 1, the draught servomotor can be set for draught control or just servomotor operation in expansion option 82.
		0	Draught servo disabled
		1	Draught servo enabled
81	0		DC: Draught Servo Control Method
		0	Autoflame servomotor, 0.1 degree control
		1	Autoflame servomotor, 0.5 degree control
		2	Industrial servomotor, 0.1 degree control
		3	Industrial servomotor, 0.5 degree control
		4	IO Unit 4-20mA servomotor, 0.5 degree control
		5	IO Unit 4-20mA servomotor, 1.0 degree control
82	0		DC: Draught Control Function
			For setting, if the draught servomotor channel is enabled in expansion option 80, but the draught control is disabled, the servomotor will open and close according to its commissioned curve, without any corrections to maintain stack pressure. For setting 1, the MM will make corrections to the stack damper as the measured stack pressures varies from the commissioned stack pressure. The draught air pressure sensor is wired to terminals DT+, DT-, DP- and DP+.
		0	Draught control disabled
		1	Draught control enabled
83	15		DC: Draught Servo Minimum Angle
			A minimum angle for the draught servomotor when the draught control is enabled in expansion option 82, at all other times other than the closed position. During commissioning, the servomotor position cannot be set lower than this minimum angle value, except for the closed position.
		0 – 90	0^{O} – 90^{O}
84	1		DC: Maximum Compensation
			The maximum compensation angle is the percentage of the commissioned draught servomotor angle. This is the maximum correction on the stack damper either forwards or backwards, during draught control.
		0	10%
		1	15%
		2	20%
85	5		DC: Delay Before Compensation
			This time delay is used for two stages in the burner cycle; once main flame has been established, the draught control operation will only begin after this time delay. During firing, correction on the stack damper will only be made if the servomotor is outside of the angle variation tolerance for that commissioned point, for this time period, see expansion option 86.
		1 – 30	Seconds

#	Default	Range	Description
86	10		DC: Commissioned Angle Variation Tolerance
		0 – 60	During firing, if the draught servomotor angle is outside of the commissioned variation tolerance for the time period set in expansion option 85, corrections will be made on the stack damper. 0^O – 60^O
87	0		DC: Pressure Tolerance Before Fault
		0 1 – 500	This is the maximum variation from the commissioned draught air pressure. If the pressure is at this maximum variation or higher for 2 minutes (see expansion 93), then an alarm/warning is generated, see expansion option 88. Disabled 0.1 – 50.0 mbar or 0.1 – 50.0” WG (see parameter 43)
88	0		DC: Action on Pressure Sensor Fault
		0 1	For setting 0, an alarm will occur and the burner will stop firing. For setting 1, a warning will occur and the burner will continue firing, with the draught servomotor will move to the commissioned angle throughout the firing curve, without any draught control compensation. Draught pressure sensor fault generates alarm Draught pressure sensor fault generates warning
89	15		DC: Pressure Sensor Filter Time
		1 – 60	This is the time period over which the draught air pressure sensor readings are filtered over time. If there is excess fluctuation in the pressure readings, increase the filter time. To improve the system’s response to changes in pressure, decrease the filter time. Seconds
90	200		DC: Proportional Band
		1 – 10000	The proportional band is an offset from the commissioned draught air pressure, where the PI control will make corrections to maintain the commissioned air pressure. 2.00 – 100.00 mbar or 2.00 – 100.00” WG (see parameter 43)
91	5		DC: Integral Time
		1 – 1000	For a slower response to the changes in draught air pressure, increase the integral time. For a quicker response, decrease the integral time. Seconds
92	0		DC: Action on Draught Pressure out of Range
		0 1	Allows the draught pressure outside of tolerance fault (Expansion 87) to generate an alarm or warning. Draught Pressure out of range generates Warning Draught Pressure out of range generates Alarm
93	120		DC: Draught Pressure out of Range Response Time
		0 - 300	Configure the time it takes when draught pressure tolerance fault (Expansion 87). Seconds
94	0		DC: Draught Pressure out of Range Fault Reset Type
		0 1	For setting 0, the draught pressure tolerance fault (Expansion 92) is set as recycling, For setting 1, the fault is set as non-recycling Generates Recycling Fault Generates Non-Recycling Fault

13.3 Draught Control Operation

13.3.1 Operation Overview

The draught servomotor can be set on the Mk8 MM for servomotor movement only or draught control with a pressure sensor to maintain the stack pressure.

The draught control trim functionality follows the same ideology to the EGA, where corrections are made to air damper to compensate for the changes in exhaust gas values from their commissioned values, caused by fluctuations in ambient conditions. For Autoflame draught control, corrections are made to the stack damper to compensate for changes in wind and ambient conditions which cause the stack pressure to differ from the commissioned stack pressure along the fuel curve.

Once the burner starts up and the main flame stabilised, there is a time delay where no draught control operation occurs, set in expansion option 85. After this time delay elapses, as the air going into the burner is increased from low fire to high fire, the boiler pressure may change, and the draught servomotor will move to follow these changes as commissioned. If the atmospheric or stack pressures have changed from their commissioned values along the curve, the air damper will either move in the open, or close direction to adjust the air pressure in the stack back to its set value.

The smallest angle that the draught damper can drive to while running is defined by expansion option 83; when the burner turns off, the draught damper will go to commissioned closed position to maintain heat within the boiler.

If draught control is optioned off after being commissioned, then the draught servomotor will continue to move to its commissioned angular position as the burner fires.

13.3.2 Deactivation Window

There is a deactivation window, outside of which no trim occurs, and the air damper remains at the previously trimmed position until back within the window and trim is required. This deactivation window is defined by expansion options 85 - delay before compensation and 86 – commissioned angle variation tolerance. If the draught servomotor has moved more than the set angular degrees “x”, within the time period set “y”, then no trim functionality will operate, if trim has been performed prior to this deactivation then the trim is carried forward.

For example, when the burner is first switched on, if the burner comes out of warming in lead-lag control or is switched from low flame hold to auto mode, there is a high load demand. In these situations the firing rate may ramp up quickly to meet load demand, at this point if the draught servomotor is required to move greater than the commissioned angle variation tolerance and quicker than the delay before compensation then no trim functionality will occur and any trim % will be carried forward.

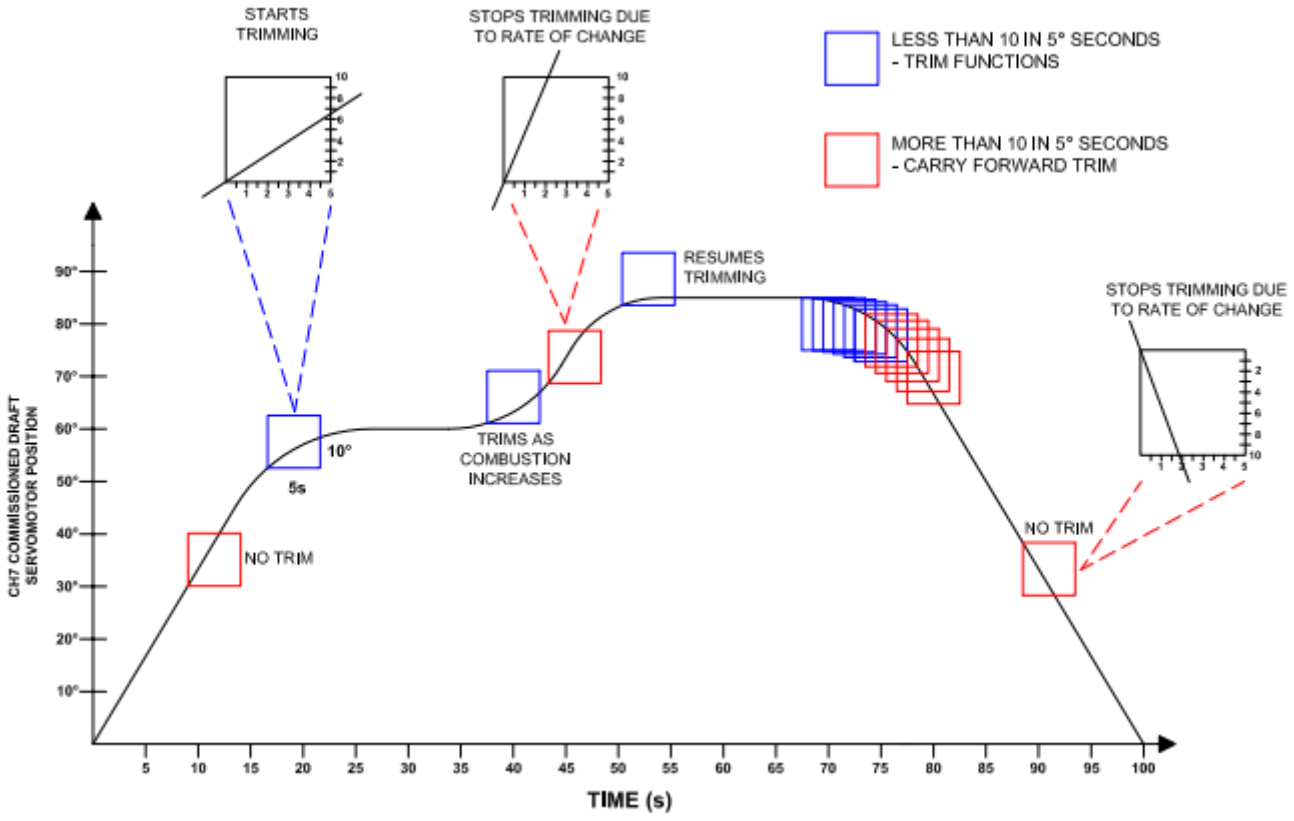


Figure 13.3.2.i Deactivation Window

13.3.3 Draught Control Trim

If within the trim window, the trim functionality is controlled by the maximum forward or backward trim set in expansion option 84 maximum compensation, and also by the PI settings in expansion options 90 proportional band and 91 integral time. The maximum compensation set in expansion option 84 is the maximum percentage of the commissioned draught servomotor angle to which the stack damper will trim negative or positive.

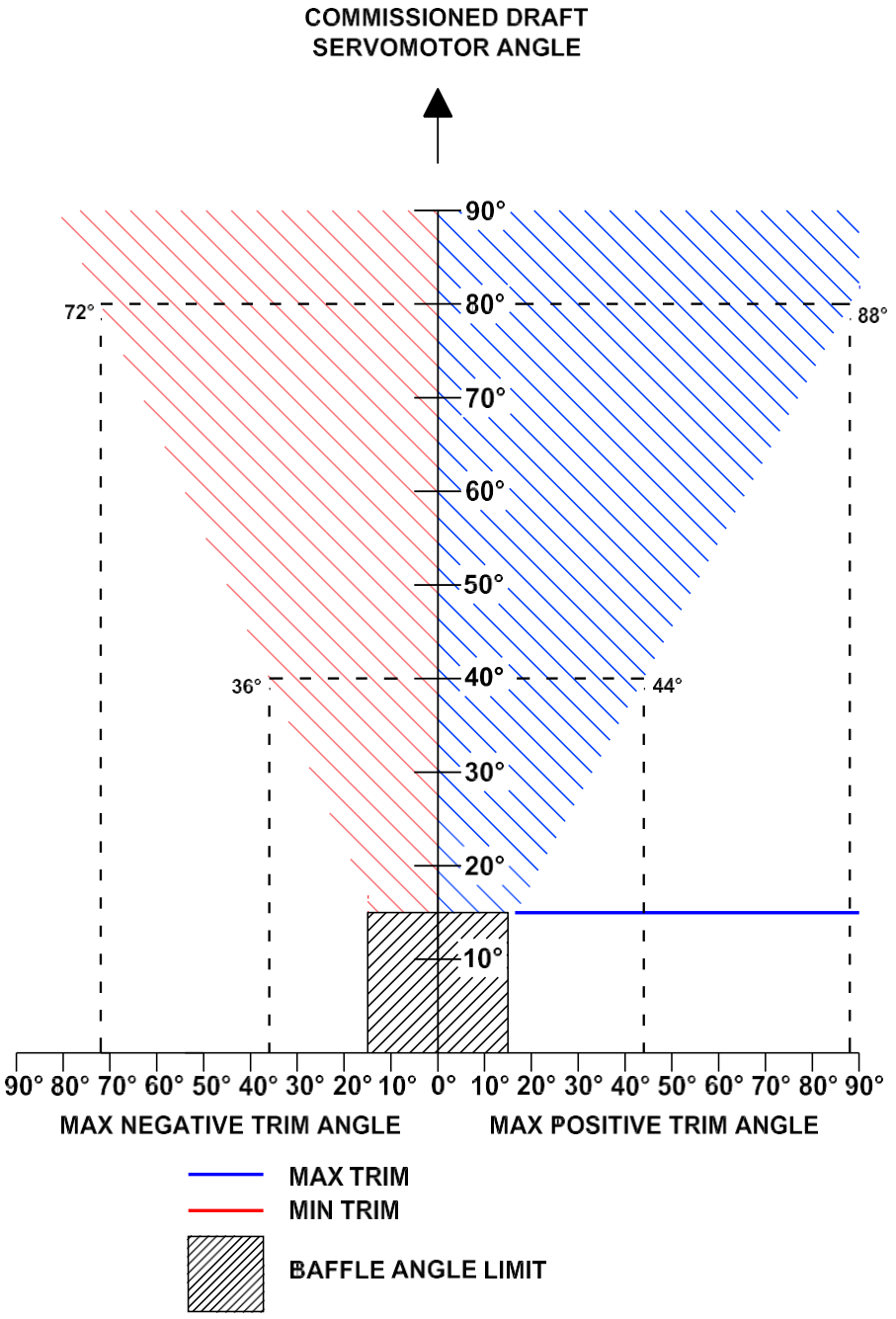


Figure 13.3.3.i Draught Control Trim

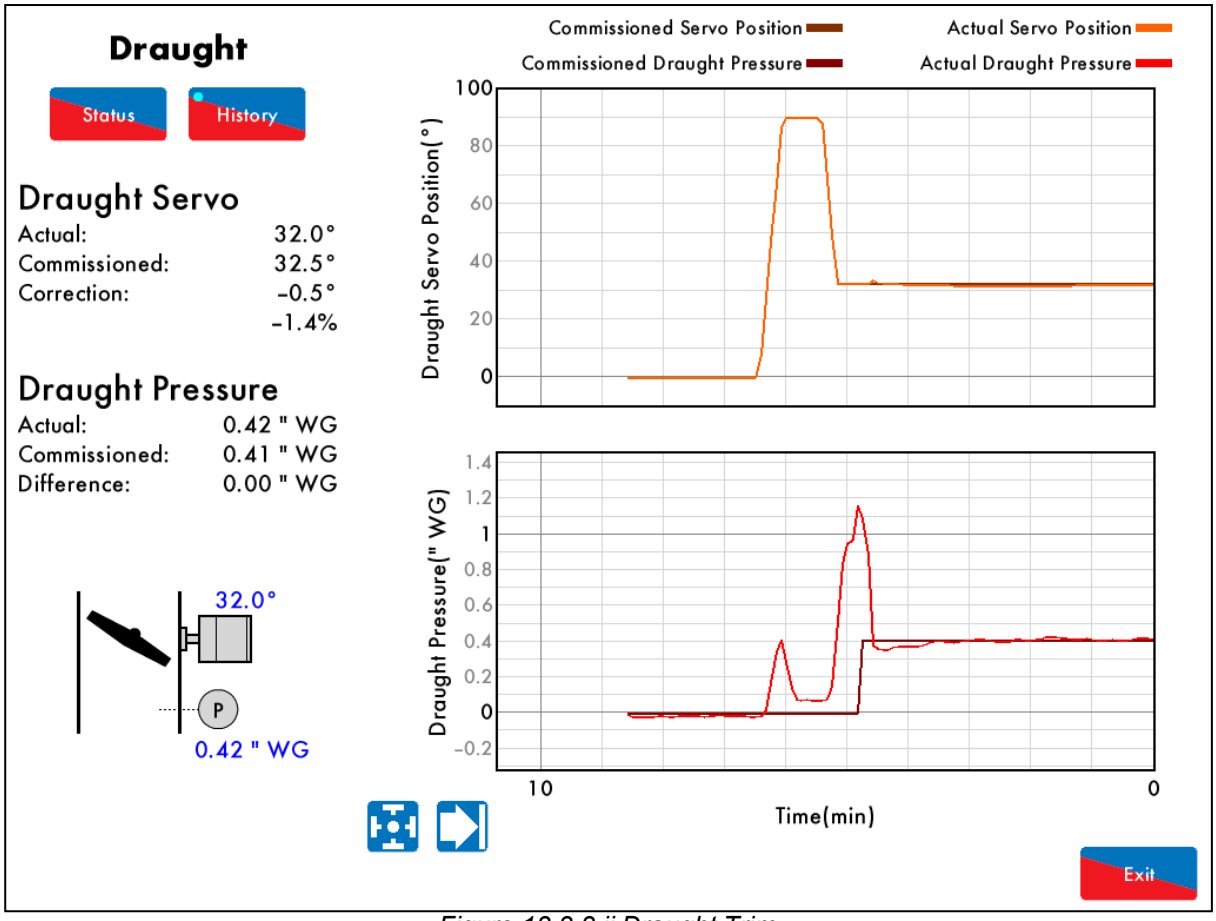


Figure 13.3.3.ii Draught Trim

Figure 13.3.3.ii shows the draught trim operation to maintain the commissioned draught pressure.

13.4 Draught Control Set-Up

13.4.1 Configuration

The draught control servomotor positions, and the stack pressure, when using draught control, are enabled and set during the burner commissioning procedure.

Due to softened error checking, it is recommended to use an industrial UNIC servomotor for the draught channel; however, a small/large servomotor can be used for smaller applications. The servomotor will need to be sized according to the torque requirements of the stack damper. If draught control is enabled in expansion 82, then a Mk8 air pressure sensor is also required, part number MM80005.

For information on installing the draught servomotor and air pressure sensor, please see section 13.1. For dimensions and technical specification for the draught servomotor, please refer to Autoflame Valves and Servomotors manual.

The table below shows the MM terminals for the draught servomotor and Mk8 air pressure sensor.

Terminal	Description
DT+	Digital communication connections from draught control pressure sensor
DT-	Digital communication connections from draught control pressure sensor
DP-	0V supply to draught control pressure sensor and draught control servomotor
DP+	+12V supply to draught control pressure sensor and draught control servomotor
DPW	Signal from draught control servomotor, indicating position
DCI	Switched neutral – drives draught servomotor clockwise
DCD	Switched neutral – drives draught servomotor counter clockwise
PF	Power feed 2A output (230V/110V)

When wiring the air pressure sensor, the screen is connected through the casing of the lead and through the sensor; therefore, the flying lead should be connected to the MM without a screen. The screen should be carried through until the connection to the MM; the screen should not be connected to the S terminal.

The table below shows the expansions options to be set when using draught control.

Expansion Option	Description
80	Draught control servo channel
81	Draught servo control method
82	Draught control function
83	Draught servo minimum angle
84	Maximum compensation
85	Delay before compensation
86	Commissioned angle variation tolerance
87	Pressure tolerance before fault
88	Action on pressure sensor fault
89	Pressure sensor filter time
90	Proportional band
91	Integral time
92	Action on Draught Pressure out of range
93	Draught Pressure out of range response time
94	Draught Pressure out of range fault reset type

13.4.2 Ways of Using Draught Servomotor

The draught servomotor can be used for draught control trim with an air pressure sensor, or as a draught servomotor which drives to commissioned positions along the firing curve.

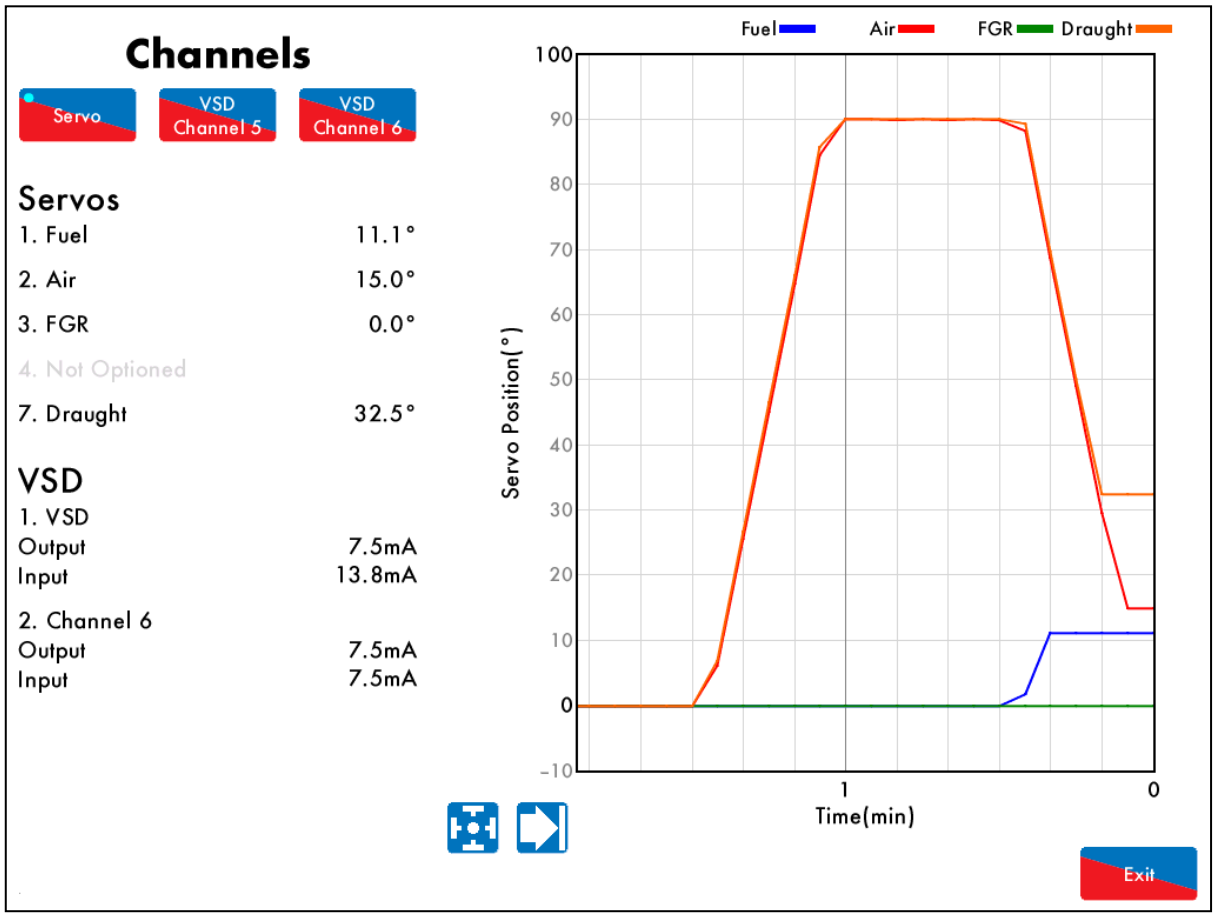


Figure 13.4.2.i Draught Servomotor

Figure 13.4.2.i shows the draught servomotor enabled without draught control trim.

13.5 Commissioning Draught Control

13.5.1 Commissioning Checks

Important Note: Prior to commissioning, the fuel and air servomotors must be calibrated to ensure that the position of the valves and damper correspond to the potentiometer feedback signal as displayed on the MM. When the valve is fully closed, the MM should display zero degrees. If it does not, please adjust the servomotor potentiometer.

If the MM is commissioned without an EGA then a combustion analyser is required to check the exhaust gases. If the system does have an EGA, then a combustion analyser is not necessary as the EGA performs all normal exhaust gas measurements. When burning oil, a smoke detection device is also necessary to check that the smoke generated is within safe limits.

To implement commissioning efficiently, 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; the commissioning data entered so far is not lost, provided power is not lost to the MM. When the burner is called back on, the system starts automatically, and commissioning can proceed from where it was left.

Once a start position has been entered, the high fire position is entered next, then descending fuel/air positions are entered consecutively until finally the low fire position is entered. CH1 and CH2 positions must always be less than the ones previously entered; however, CH3 to CH7 can be set lower or higher than the previous position. CH7 is used for the draught servomotor (unlockable expansion feature).

CH1 Fuel valve
CH2 Air damper
CH3 Auxiliary Servomotor
CH4 Auxiliary Servomotor
CH5 VSD 1
CH6 VSD 2
CH7 Draught servomotor (unlockable expansion feature)

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 is correct.
2. Set options, parameters and expansion options required.
3. Commission bottom blowdown module if optioned.
4. Commission water level probes and external level sensor if optioned.
5. Set up servomotors.
6. Program fuel/air positions.

On a previously commissioned system is it possible to omit steps 1 to 5.

13.5.2 Commissioning Screen

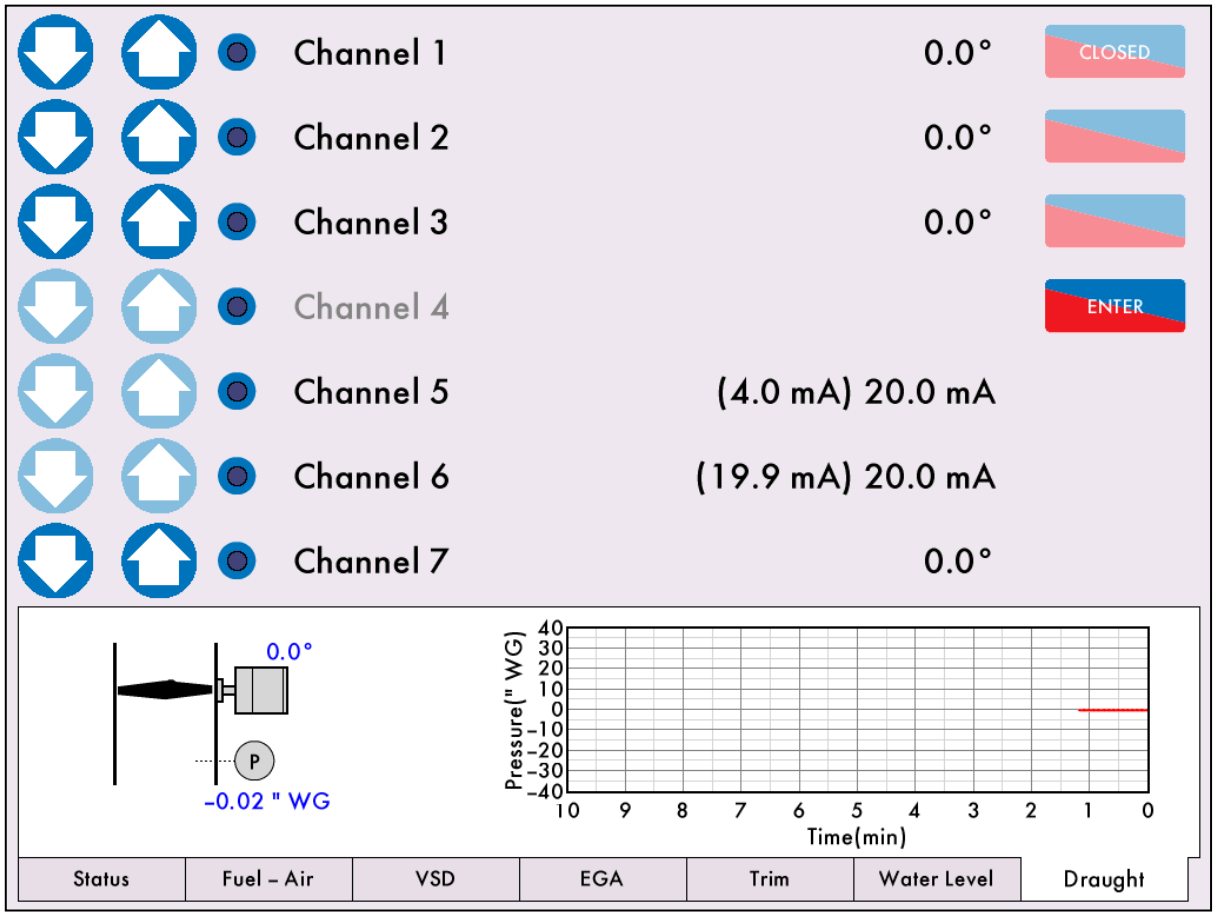


Figure 13.5.2.i Commissioning Draught Servomotor

To commission the draught servomotor, go to the commissioning screen by pressing 

in the Commission mode screen.

In addition to the CH7, a draught pressure tab is available on the MM screen whilst commissioning if draught control is enabled rather than draught servomotor. Use CH7 to change the draught damper angle to maintainthe boiler's ideal stack pressure throughout the commissioning curve.

Note: If on the day of commission, there are extreme conditions such as heavy wind, the stored angles for the draught damper along the commissioned curve may not be relevant for a day with average wind speed over the stack.

Go through the burner commissioning process as described in section 3.4 and entered the draught servomotor positions as required. The draught servomotor cannot be set at a position lower than the minimum angle set in expansion option 83, all positions except for the closed which can be set lower.

13.6 Faults

The table below show the faults which are directly related to the draught control function.

Fault		Message	Description
400	Alarm/Warning - option 88	Draught Pressure Sensor Timeout	No comms within 2 seconds fromdraught pressure sensor
• Check wiring and screen on terminals DT+, DT-, DP- and DP+			
410	Alarm/Warning - option 88	Draught Pressure Outside Tolerance	Pressure is outside of set tolerance
• Check expansion option 87			

14 DIRECT MODBUS

14.1 Overview

The Mk8 MM can be accessed remotely in one of the following two ways:

- Direct Modbus access from the Mk8 MM.
- Through a Mk8 DTI connected to the Mk8 MM.

If Direct Modbus is used on the Mk8 MM (for example connecting the MM directly to a Building Management System - BMS), then neither Autoflame Intelligent Boiler Sequencing (IBS) nor the DTI can be used on that MM. A Mk8 DTI is required if IBS and Modbus are required at the same time.

There are a limited number of Modbus addresses available on the Mk8 MM which can be accessed directly without using a DTI.

14.2 Direct Modbus Expansion Options

The table below shows the Expansion Options used for configuring Direct Modbus.

#	Default	Range	Description
100	0		Modbus: Sequencing/DTI or Modbus Function
			If Direct Modbus is enabled, then option 16 must be set to 0, as Intelligent Boiler Sequencing cannot be used with direct Modbus.
		0	MM/DTI Sequencing
		1	Modbus
101	0		Modbus: Modbus Baud Rate
			The Baud Rate on the MM should be set the same as the Baud Rate used on the external Modbus communication program.
		0	9600 Baud
		1	19200 Baud
102	0		Modbus: Modbus Parity Setting
			The parity on the MM should be set the same as the baud rate used on the external Modbus communication program.
		0	No parity
		1	Odd parity
		2	Even parity
103	1		Modbus: Modbus Stop Bits Setting
			The stop bits on the MM should be set the same as the baud rate used on the external Modbus communication program.
		1	1 Stop Bit
		2	2 Stop Bits
104	1		Modbus: Modbus Device ID
			This ID is used to recognise the device on the external Modbus communication program.
		1 – 247	ID number
105	0		Modbus: Modbus Data Format
			The binary format on the MM should be set the same as the baud rate used on the external Modbus communication program.
		0	Binary format
		1	ASCII format
106	0		MM: MM Status Modbus Address 30102 Function
			Setting 0 means Modbus shows 1 for Firing or 0 for not Firing. Setting 1 means Modbus shows a value describing the current MM state. For more details for setting 1, see section 14.4.1.
		0	Modbus address 30102 shows Firing Status
		1	Modbus address 30102 shows MM State

14.3 Setup and Configuration

Up to 10 MMs can be linked together and connected to any Management System that supports Modbus protocol via terminals 27 and 28. Each Mk8 MM needs to be set with an individual Modbus Device ID in expansion option 104.

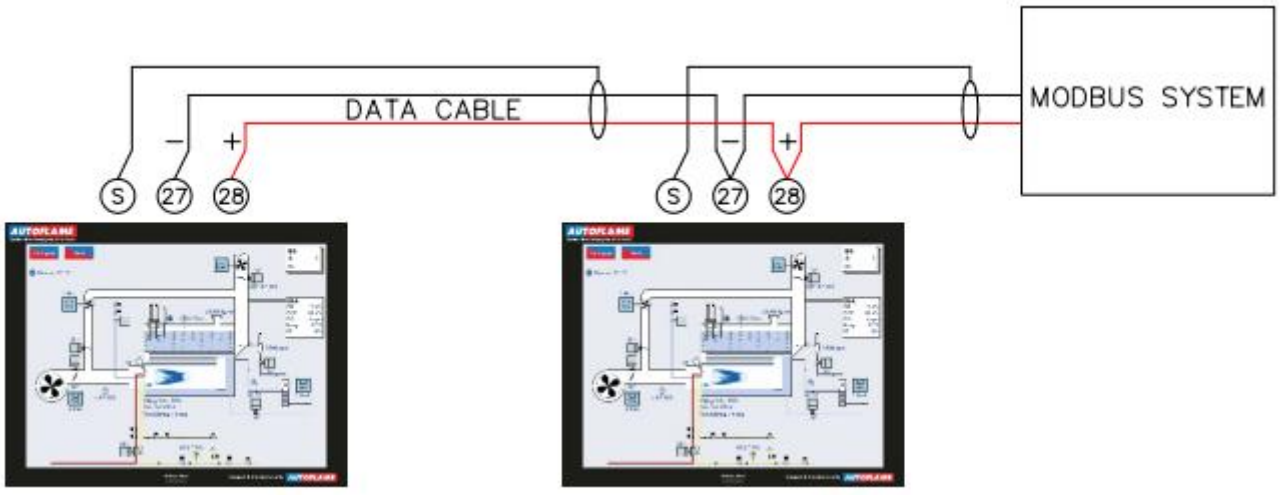
The following expansion options need to be set on the Mk8 MM to configure Direct Modbus.

Expansion Option	Description
100	Sequencing/DTI or Modbus function
101	Modbus baud rate
102	Modbus parity setting
103	Modbus stop bits setting
104	Modbus device ID
105	Binary format

The MM communicates using an RS485 data link from terminals 27 (-ve) and 28 (+ve), the connection must be screened from the MM side only. Belden 9501 data cable is recommended for the communication.

The following terminals are used for Direct Modbus.

Terminal	Description
27	RS485 -
28	RS485 +
S	Screen



The maximum block of addresses the MM can read and write to is 127, as per Modbus having a built-in limit of 255 byte packets.

If the MM does not receive any Modbus commands for 60 seconds, the Modbus goes ‘offline.’ You can keep the Modbus ‘online’ with a simple instruction, such as polling or setting a single value to that individual MM. If the Modbus is ‘offline’ then remote setpoint and firing rate set via Modbus will be disabled. The only exception is the enable/disable burner which changes the enable/disable button on the MM on the home screen, as this change will last until the Modbus state is changed again or the enable/disable button is pressed again.

If the MM is powered off or the communications is lost, the Modbus address values from the unit will not be true.

Please check the Modbus settings on your Modbus device before configuring it with the Mk8 MM.

14.3.1 Modbus to BACnet/Ethernet IP/Metasys N2 via RS485 with AFPROTOAIR

The Mk8 MM can also communicate from Modbus to BACnet/IP, BACnet MSTP, Ethernet/IP or Metasys N2 with our Protonode convertor (part # AFPROTOAIR) via RS485.

The AFPROTOAIR is pre-loaded with tested Profiles/Configurations for the supported MK8 devices (Mk8 DTI, MK8 MM, Mini Mk8, Mk8 EGA EVO). You would need to select the Mk8 MM profile, whilst setting up the Protonode convertor via the web configurator.

You can also connect multiple Mini Mk8, Mk8 MM or MK8 EGA EVO by daisy-chain via RS485 onto the Protonode, as long as the Modbus device ID (Option 104 for Mini MK8) (Expansion 104 for MK8 MM) (Setting 57 on Mk8 EGA EVO) are different from each unit & their respective profiles are selected. For more information, please see Technical Bulletin # 287 & the AFPROTOAIR manual.



14.4 Modbus Addresses

There are 4 types of Modbus addresses:

0x Read/Write Digital outputs – off/on commands

1x Read Digital inputs – off/on signals/indications

These are binary values and have a 0/1 value indicating an off/on or no/yes value.

3x Read Analogue inputs – variable data in

4x Read/Write Analogue outputs – variable adjustments

These are multiple integer values and can have a value of 0 to 65534 and do not contain decimal points i.e. channel 1 position Modbus value is 900 which is equivalent to 90.0°.

Address Type: RWD = Read / Write Digital
RD = Read Digital
RWA = Read / Write Analogue
RA = Read Analogue

#	Type	Description	Details
00001	RWD	Enable/Disable MM	0 = Burner is enabled 1 = Burner is disabled Value changes state of enable/disable button on MM home screen; changes are kept if MM loses comms with Modbus device sending commands
10001	RD	Heartbeat	0 = No Comms 1 = Comms Output toggles every 500ms to show the unit it is functioning
10194	RD	Running Interlock Status	0 = Running interlock (T53) is off 1 = Running interlock (T53) is on
10217	RD	EGA Trim Optioned	0 = Trim not optioned 1 = Trim optioned Returns value 0 when option 12 is set for monitoring only.
10218	RD	EGA is Trimming	0 = EGA not trimming 1 = EGA is trimming Returns value 0 is actual temperature/pressure is below trim threshold
10219	RD	EGA Cooler Ready	0 = Cooler is not ready 1 = Cooler is ready Returns value 0 if EGA is in error state
10220	RD	EGA Ambient Temp OK	0 = Temperature not OK 1 = Temperature OK
10221	RD	EGA NO_2 On	0 = NO_2 cell not optioned 1 = NO_2 cell optioned See option 36, valid for Mk7 EGA only
10222	RD	EGA SO_2 On	0 = SO_2 cell not optioned 1 = SO_2 cell optioned See option 36, valid for Mk7 EGA only
10224	RD	EGA OK to Sample	0 = EGA is not sampling 1 = EGA is sampling
10233	RD	Hand Mode	0 = MM not in hand mode 1 = MM in hand mode
10234	RD	Low Flame Hold	0 = MM not in low flame hold 1 = MM in low flame hold
10242	RD	Disabled Status	0 = Burner enabled 1 = Burner disabled Returns state of enable/disable button on MM home screen and same value as address 00001

#	Type	Description	Details
12001	RD	Water Level Optioned	0 = Water level not optioned 1 = Water level optioned
12002	RD	Units Imperial or Metric	0 = Imperial 1 = Metric
12003	RD	Feedwater Pump State	0 = Pump off 1 = Pump on
12004	RD	TDS Units	0 = ppm 1 = µS/cm
12005	RD	Water Level Ready	0 = No, water level is not optioned or a water level fault is active 1 = Yes, requires water level to be optioned and no waterlevel faults
12006	RD	TDS Optioned	0 = TDS not optioned 1 = TDS optioned
12007	RD	First Out 1 State	0 = First Out 1 not active 1 = First Out 1 active (does not mean first out has been cleared)
12008	RD	First Out 2 State	0 = First Out 2 not active 1 = First Out 2 active (does not mean first out has been cleared)
12009	RD	First Out 3 State	0 = First Out 3 not active 1 = First Out 3 active (does not mean first out has been cleared)
12010	RD	First Out 4 State	0 = First Out 4 not active 1 = First Out 4 active (does not mean first out has been cleared)
12011	RD	First Out 5 State	0 = First Out 5 not active 1 = First Out 5 active (does not mean first out has been cleared)
12012	RD	First Out 6 State	0 = First Out 6 not active 1 = First Out 6 active (does not mean first out has been cleared)
12013	RD	First Out 7 State	0 = First Out 7 not active 1 = First Out 7 active (does not mean first out has been cleared)
12014	RD	First Out 8 State	0 = First Out 8 not active 1 = First Out 8 active (does not mean first out has been cleared)
12015	RD	First Out 9 State	0 = First Out 9 not active 1 = First Out 9 active (does not mean first out has been cleared)
12016	RD	First Out 10 State	0 = First Out 10 not active 1 = First Out 10 active (does not mean first out has been cleared)
12017	RD	First Out 11 State	0 = First Out 11 not active 1 = First Out 11 active (does not mean first out has been cleared)
12018	RD	First Out 12 State	0 = First Out 12 not active 1 = First Out 12 active (does not mean first out has been cleared)
12019	RD	First Out 13 State	0 = First Out 13 not active 1 = First Out 13 active (does not mean first out has been cleared)
12020	RD	First Out 14 State	0 = First Out 14 not active 1 = First Out 14 active (does not mean first out has been cleared)
12021	RD	First Out 15 State	0 = First Out 15 not active 1 = First Out 15 active (does not mean first out has been cleared)

#	Type	Description	Details
12022	RD	First Out 1 Not Reset	0 = No First Out 1 Errors, 1= First Out 1 needs to be Reset
12023	RD	First Out 2 Not Reset	0 = No First Out 2 Errors, 1= First Out 2 needs to be Reset
12024	RD	First Out 3 Not Reset	0 = No First Out 3 Errors, 1= First Out 3 needs to be Reset
12025	RD	First Out 4 Not Reset	0 = No First Out 4 Errors, 1= First Out 4 needs to be Reset
12026	RD	First Out 5 Not Reset	0 = No First Out 5 Errors, 1= First Out 5 needs to be Reset
12027	RD	First Out 6 Not Reset	0 = No First Out 6 Errors, 1= First Out 6 needs to be Reset
12028	RD	First Out 7 Not Reset	0 = No First Out 7 Errors, 1= First Out 7 needs to be Reset
12029	RD	First Out 8 Not Reset	0 = No First Out 8 Errors, 1= First Out 8 needs to be Reset
12030	RD	First Out 9 Not Reset	0 = No First Out 9 Errors, 1= First Out 9 needs to be Reset
12031	RD	First Out 10 Not Reset	0 = No First Out 10 Errors, 1= First Out 10 needs to be Reset
12032	RD	First Out 11 Not Reset	0 = No First Out 11 Errors, 1= First Out 11 needs to be Reset
12033	RD	First Out 12 Not Reset	0 = No First Out 12 Errors, 1= First Out 12 needs to be Reset
12034	RD	First Out 13 Not Reset	0 = No First Out 13 Errors, 1= First Out 13 needs to be Reset
12035	RD	First Out 14 Not Reset	0 = No First Out 14 Errors, 1= First Out 14 needs to be Reset
12036	RD	First Out 15 Not Reset	0 = No First Out 15 Errors, 1= First Out 15 needs to be Reset

#	Type	Description	Details
30101	RA	Load Index	Firing rate %
30102	RA	Firing Status	0 = Non-modulating 1 = Modulating Returns value 0 single point change, fuel flow metering and commissioning *For Setting 1 see section 14.4.1
30104	RA	Burner Rating	MW x 10 Metric units determined from fuel flow metering
30105	RA	Actual Value	Imperial: temperature °F, pressure PSI, low pressure PSI x 10
30106	RA	Required Value	Metric: temperature °C, pressure Bar x 10, low pressure Bar x 100 Imperial: temperature °F, pressure PSI, low pressure PSI x 10
30107	RA	Selected Fuel	0 = Fuel 1 1 = Fuel 2 2 = Fuel 3 3 = Fuel 4
30109	RA	Channel 1 Position	Degrees x 10 Range is -6.0° to 96.0°
30110	RA	Channel 2 Position	Degrees x 10 Range is -6.0° to 96.0°
30111	RA	Channel 3 Position	Degrees x 10 Range is -6.0° to 96.0°
30112	RA	Channel 4 Position	Degrees x 10 Range is -6.0° to 96.0°
30113	RA	MM Error Number	0 = System does not have an error N = error number, check error codes
30114	RA	Multi-Burner ID	MM ID number set in option 44
30115	RA	EGA Current O_2 Value	% x 10
30116	RA	EGA Current CO_2 Value	% x 10
30117	RA	EGA Current CO Value	ppm x 10
30118	RA	EGA Current Exhaust Gas Temperature	Metric: temperature x 10 °C Imperial: temperature x 10 °F
30119	RA	EGA Current Efficiency Value	% x 10
30120	RA	EGA Current NO Value	ppm x 10
30121	RA	EGA Current SO_2 Value	ppm x 10
30122	RA	EGA Commissioned O_2 Value	% x 10
30123	RA	EGA Commissioned CO_2 Value	% x 10
30124	RA	EGA Commissioned CO Value	ppm x 10
30125	RA	EGA Commissioned Exhaust Gas Temperature	Metric: temperature x 10 °C Imperial: temperature x 10 °F
30126	RA	EGA Commissioned Efficiency Value	% x 10
30127	RA	EGA Commissioned NO Value	ppm x 10
30128	RA	EGA Commissioned SO_2 Value	ppm x 10
30129	RA	EGA Error Code	0 = EGA does not have a fault, N = EGA error
30130	RA	Minimum Remote Setpoint	Metric: temperature °C, pressure Bar x 10, low pressure mbar x 100 Imperial: temperature °F, pressure PSI, low pressure PSI x 10
30131	RA	Maximum Remote Setpoint	Metric: temperature °C, pressure Bar x 10, low pressure mbar x 100 Imperial: temperature °F, pressure PSI, low pressure PSI x 10

#	Type	Description	Details
30132	RA	Current Flow Thousands	Metric kW Imperial MMBTU/hr x 1000 Remainder after whole number of MW or MMBTU/hr x 1000 taken away. E.g. 1.5MW gives 500 value and 15.1MMBTU/hr gives 100 value
30133	RA	Current Flow Millions	Metric MW Imperial MMBTU/hr Whole number of MW or MMBTU/hr. E.g. 1.5MW gives 1 value and 15.1MMBTU/hr gives 15 value
30134	RA	Fuel 1 Flow Total Thousands	Metric kW/hr Imperial MMBTU/hr Remainder after whole number of MW/hr or MMBTU x 1000 taken away, x 1000. E.g. 1.5MW/hr gives 500 value and 15.1MMBTU gives 100 value
30135	RA	Fuel 1 Flow Total Millions	Metric MW/h Imperial MMBTU Whole number of MW/hr or MMBTU. E.g. 1.5MW/hr gives 1 value and 15.1MMBTU gives 15 value
30136	RA	Fuel 1 Flow Total Billions	Metric GW/hr Imperial MMBTU / 1000 Whole number of GW/hr or MMMBTU E.g. 1.5MW/hr gives 0 value and 15.1MMBTU gives 0 value
30137	RA	Fuel 2 Flow Total Thousands	Metric kW/hr Imperial MMBTU/hr Remainder after whole number of MW/hr or MMBTU x 1000 taken away, x 1000. E.g. 1.5MW/hr gives 500 value and 15.1MMBTU gives 100 value
30138	RA	Fuel 2 Flow Total Millions	Metric MW/h Imperial MMBTU Whole number of MW/hr or MMBTU. E.g. 1.5MW/hr gives 1 value and 15.1MMBTU gives 15 value
30139	RA	Fuel 2 Flow Total Billions	Metric GW/hr Imperial MMBTU / 1000 Whole number of GW/hr or MMMBTU E.g. 1.5MW/hr gives 0 value and 15.1MMBTU gives 0 value
30140	RA	Fuel 3 Flow Total Thousands	Metric kW/hr Imperial MMBTU/hr Remainder after whole number of MW/hr or MMBTU x 1000 taken away, x 1000. E.g. 1.5MW/hr gives 500 value and 15.1MMBTU gives 100 value
30141	RA	Fuel 3 Flow Total Millions	Metric MW/h Imperial MMBTU Whole number of MW/hr or MMBTU. E.g. 1.5MW/hr gives 1 value and 15.1MMBTU gives 15 value
30142	RA	Fuel 3 Flow Total Billions	Metric GW/hr Imperial MMBTU / 1000 Whole number of GW/hr or MMMBTU E.g. 1.5MW/hr gives 0 value and 15.1MMBTU gives 0 value
30143	RA	EGA Current Ambient Temperature	Metric: temperature x 10 °C Imperial: temperature x 10 °F
30144	RA	EGA Current Delta Temperature	Metric: temperature x 10 °C Imperial: temperature x 10 °F
30145	RA	EGA Commissioned Ambient Temperature	Metric: temperature x 10 °C Imperial: temperature x 10 °F
30146	RA	EGA Commissioned Delta Temperature	Metric: temperature x 10 °C Imperial: temperature x 10 °F
30147	RA	UV Counts	Returns value displayed on MM
30148	RA	IR Counts	Returns value displayed on MM

#	Type	Description	Details
30149	RA	Flame Switch Status	0 = Off 1 = On
30150	RA	EGA Current NO_2 Value	ppm x 10
30151	RA	EGA Commissioned NO_2 Value	ppm x 10
30801	RA	Fuel 4 Flow Total Thousands	Metric kW/hr Imperial MMBTU/hr Remainder after whole number of MW/hr or MMBTU x 1000 taken away, x 1000. E.g. 1.5MW/hr gives 500 value and 15.1MMBTU gives 100 value
30802	RA	Fuel 4 Flow Total Millions	Metric MW/h Imperial MMBTU Whole number of MW/hr or MMBTU. E.g. 1.5MW/hr gives 1 value and 15.1MMBTU gives 15 value
30803	RA	Fuel 4 Flow Total Billions	Metric GW/hr Imperial MMBTU / 1000 Whole number of GW/hr or MMMBTU E.g. 1.5MW/hr gives 0 value and 15.1MMBTU gives 0 value
30804	RA	VSD 1 Output	mA x 10 or V x 10
30805	RA	VSD 1 Input	mA x 10 or V x 10
30806	RA	VSD 2 Output	mA x 10 or V x 10
30807	RA	VSD 2 Input	mA x 10 or V x 10
30808	RA	Channel 7 Position	Degrees x 10 Range is -6.0° to 96.0°
30830	RA	Lockout Number	0 = System is not in lockout N = lockout number
30831	RA	Fuel 1 Type	0 = Gas 1 = Oil Option / Parameter 150 value
30832	RA	Fuel 2 Type	0 = Gas 1 = Oil Option / Parameter 151 value
30833	RA	Fuel 3 Type	0 = Gas 1 = Oil Option / Parameter 152 value
30834	RA	Fuel 4 Type	0 = Gas 1 = Oil Option / Parameter 153 value
30839	RA	Fuel 1 Hours Run	Completed hours
30840	RA	Fuel 2 Hours Run	Completed hours
30841	RA	Fuel 3 Hours Run	Completed hours
30842	RA	Fuel 4 Hours Run	Completed hours
30843	RA	Fuel 1 Start-ups	Number of start-ups on Fuel 1
30844	RA	Fuel 2 Start-ups	Number of start-ups on Fuel 2
30845	RA	Fuel 3 Start-ups	Number of start-ups on Fuel 3
30846	RA	Fuel 4 Start-ups	Number of start-ups on Fuel 4
30847	RA	Current Air Pressure	mbar x 10 “wg x 10 Parameter 43 value
30849	RA	Current Gas Pressure	mbar x 10 “wg x 10 PSI x 100 Parameter 41 value
32001	RA	Capacitance Probe 1 Signal	Hz reading
32002	RA	Capacitance Probe 1 Reading on MM	Metric: mm Imperial: inches x 10

#	Type	Description	Details
32005	RA	Capacitance Probe 2 Signal	Hz reading
32006	RA	Capacitance Probe 2 Reading on MM	Metric: mm Imperial: inches x 10
32009	RA	Alarm Status	0 = No alarm 1 = Alarm
32010	RA	Warning Status	0 = No warning 1 = Warning
32012	RA	Alarm Code	0 = System is not in alarm N = Alarm number
32013	RA	Warning Status	0 = System is not in warning N = Warning number
32014	RA	Steam Temperature	°C
32015	RA	Feed Water Temperature	°C
32016	RA	Steam Flow Rate	lbs per hour
32017	RA	Heat to Steam Output	BTU per lb
32018	RA	Feed Water Control Element	%
32020	RA	Sudden Pressure Drop	0 = Sudden pressure drop not detected 1 = Sudden pressure drop detected
32021	RA	Boiler Efficiency	% Returns value 0 if no heat flow function is enabled
32022	RA	Economiser Efficiency	% Returns value 0 if no heat flow function is enabled
32023	RA	Totalised Steam low word (lbs)	Total steam output = steam low word + (65536 x steam high word)
32024	RA	Totalised Steam high word (lbs)	Total steam output = steam low word + (65536 x steam high word)
32025	RA	Steam Temperature (°F)	°F
32026	RA	Feed Water Temperature (°F)	°F
32027	RA	Steam Flow Rate	Kg per hour
32028	RA	Heat to Steam Output (KJ/kg)	KJ per kg
32029	RA	Totalised Steam low word (kg)	Total steam output = steam low word + (65536 x steam high word)
32030	RA	Totalised steam kg high word (kg)	Total steam output = steam low word + (65536 x steam high word)
32037	RA	Cold Start Status	0 = System not in cold start mode 1 = System in cold start mode
32040	RA	TDS Target Value	Target value in ppm or µS/cm
32041	RA	TDS Measured Value	Measured value in ppm or µS/cm
32045	RA	Current Draught Servo Angle	Metric: mbar x 10 Imperial: “wg x 10
32046	RA	Current Draught Pressure	Metric: mbar x 10 Imperial: “wg x 10
32047	RA	Commissioned Draught Pressure	Metric: mbar x 10 Imperial: “wg x 10
32048	RA	Time to Next Bottom Blowdown	Returns value = (hours x 100) + minutes e.g. 215 is 2 hours 15 minutes
32049	RA	Current Heat Flow	Metric: MW x 10 Imperial: MMBTU/hour x 10
32050	RA	Current Water Flow	Metric: Litres per second x 1000 Imperial: US gallons per minute x 1000
32051	RA	External Level Sensor Reading Depth	Metric: mm Imperial: inches x 10
32052	RA	Second Low Probe Input	0 = No water is detected 1 = Water is detected

#	Type	Description	Details
32053	RA	Auxiliary High Water Input	0 = Input not active 1 = input active
32054	RA	Auxiliary 1st Low Input	0 = Input not active 1 = input active
32055	RA	Auxiliary 2nd Low Input	0 = Input not active 1 = input active
32056	RA	Combined Water level Reading Depth	Metric: mm Imperial: inches x 10
32057	RA	Current steam flow, high word Lb/hr	Lbs per hour This is an extension of the existing address 32016. If the value gets too large to fit in a 16 bit Modbus register this address holds any value greater than 65535, in the same way that the existing registers with high word/low word work. Value =(65536 * high word) + low word
32058	RA	Current steam flow, high word Kg/hr	Kgs per hour This is an extension of the existing address 32027. If the value gets too large to fit in a 16 bit Modbus register this address holds any value greater than 65535, in the same way that the existing registers with high word/low word work. Value =(65536 * high word) + low word
32060	RA	Makeup water temperature	°C
32061	RA	Condensate temperature	°C
32062	RA	Water in temperature	°C
32063	RA	Economiser input temperature	°C
32064	RA	Economiser output temperature	°C
32065	RA	Make up temperature	°F
32066	RA	Condensate temperature	°F
32067	RA	Water in temperature	°F
32068	RA	Economiser input temperature	°F
32069	RA	Economiser output temperature	°F
33001	RA	Fully Metered Excess Air Reading Valid	0 = Invalid reading 1 = Valid reading
33002	RA	Fully Metered Current Excess Air %	Excess air % x 1000
33003	RA	Fully Metered Commissioned Excess Air %	Excess air % x 1000
33010	RA	Fully Metered Current Fuel Mass Flow Thousands	Metric: kgs x 1000 Imperial: lbs x 1000
33011	RA	Fully Metered Current Fuel Mass Flow Singles	Metric: 0 to 999 kgs Imperial: 0 to 999 lbs
33012	RA	Fully Metered Commissioned Fuel Mass Flow Thousands	Metric: kgs x 1000 Imperial: lbs x 1000
33013	RA	Fully Metered Commissioned Fuel Mass Flow Singles	Metric: 0 to 999 kgs Imperial: 0 to 999 lbs
33014	RA	Fully Metered Current Fuel Volume Flow Thousands	m^3 per hour
33015	RA	Fully Metered Current Fuel Volume Flow Singles	m^3 per hour
33016	RA	Fully Metered Fuel Flow Meter Current (4-20mA) Signal	mA x 10
33017	RA	Fully Metered Fuel Temperature	Metric: °C x10 Imperial: °F x 10

#	Type	Description	Details
33018	RA	Fully Metered Fuel Pressure	Metric: mbar x 10 (Using Oil: Bar x 10) Imperial: “WG x 10 or PSI x 100 (Using Oil: PSI x 1)
33019	RA	Fully Metered Fuel Channel Correction Fraction	Applied correction x 1000
33020	RA	Fully Metered Current Air Mass Flow Thousands	Metric: kgs x 1000 Imperial: lbs x 1000
33021	RA	Fully Metered Current Air Mass Flow Singles	Metric: 0 to 999 kgs Imperial: 0 to 999 lbs
33022	RA	Fully Metered Commissioned Air Mass Flow Thousands	Metric: kgs x 1000 Imperial: lbs x 1000
33023	RA	Fully Metered Commissioned Air Mass Flow Singles	Metric: 0 to 999 kgs Imperial: 0 to 999 lbs
33024	RA	Fully Metered Current Air Volume Flow Thousands	m^3 per hour
33025	RA	Fully Metered Current Air Volume Flow Singles	m^3 per hour
33026	RA	Fully Metered Air Flow Meter Current (4-20mA) Signal	mA x 10
33027	RA	Fully Metered Air Temperature	Metric: °C x10 Imperial: °F x 10
33028	RA	Fully Metered Air Pressure	Metric: mbar x 10 Imperial: “WG x 10
33029	RA	Fully Metered Air Channel Correction Fraction	Applied correction x 1000
33030	RA	Fully Metered Atmospheric Air Pressure	Metric: mbar x 10 Imperial: “WG x 10
40001	RWA	Remote Required Setpoint	Metric: temperature °C, pressure Bar x 10, low pressure Bar x 100 Imperial: temperature °F, pressure PSI, low pressure PSI x 10 After 1 minute of no Modbus communications to the unit, the MM will ignore this required value and use the required setpoint set on the MM’s status screen.
40121	RWA	Remote Firing Rate	Percentage (%) 40131 must be set to 1 to change the firing rate remotely
40131	RWA	Remote Firing Rate Enable	0 = Remote firing rate disabled 1 = remote firing rate enabled

14.4.1 Modbus address for MM Status (30102)

MM Expansion option 106 sets how Modbus address for MM status (30102) operates. When Expansion Option 106 is set to 1. “Modbus address 30102 shows MM State”. The following values are shown on the table below.

Code	Explanation
1	Recycle
2	Standby
3	Starting
4	Wait Secondary Proving
5	Wait CPI
6	Wait Air Switch
7	Zero Air Sensor
8	Valve Proving
9	Run to Pre-Purge
10	Pre-Purge
11	Run to Start
12	Pre-Ignition
13	Pilot Proving
14	Main Flame Proving
15	Golden Start
16	FGR
17	Firing
18	Moving to low fire to shut down
19	Moving to low fire for COF Changeover
20	COF Changeover
21	Firing on Continuous Pilot Only
22	Run to Post-Purge
23	Post-Purge
24	Post-Firing Valve Proving
255	Fault

15 FIRST OUTS

15.1 Overview of First Outs

When the control circuit has a long series chain of various thermostats and switching elements, it can be difficult to identify which element has opened the control circuit. With First Outs expansion feature it is possible to monitor up to 15 different inputs in a series control circuit on the Mk8 MM. Each input responds to a signal voltage of between 110V to 230Vac.

The First Outs can be configured for active input state low or high. When the active input state is set to low, the first out is triggered when the input is low, and when it is set for high, it will be triggered when the input is high. The table below shows the functions that can be set for the first outs.

The First Out logs can be displayed by pressing 

in the Home screen, which gives information on the First Out number, trigger time and the time it was reset.

15.2 First Outs Expansion Options

The table below shows the Expansion Options used for configuring First Outs.

#	Default	Range	Description
110	0		FO: First Outs Function
			If first outs are enabled, they can be configured and labelled in Commission mode and Online Changes. To tie the first outs interlock to the MM's safety stat, see option / parameter 145.
		0	Disabled
		1	Enabled

15.3 First Outs Configuration

15.3.1 Enabling First Outs

To enable first outs, the following expansion must be set.

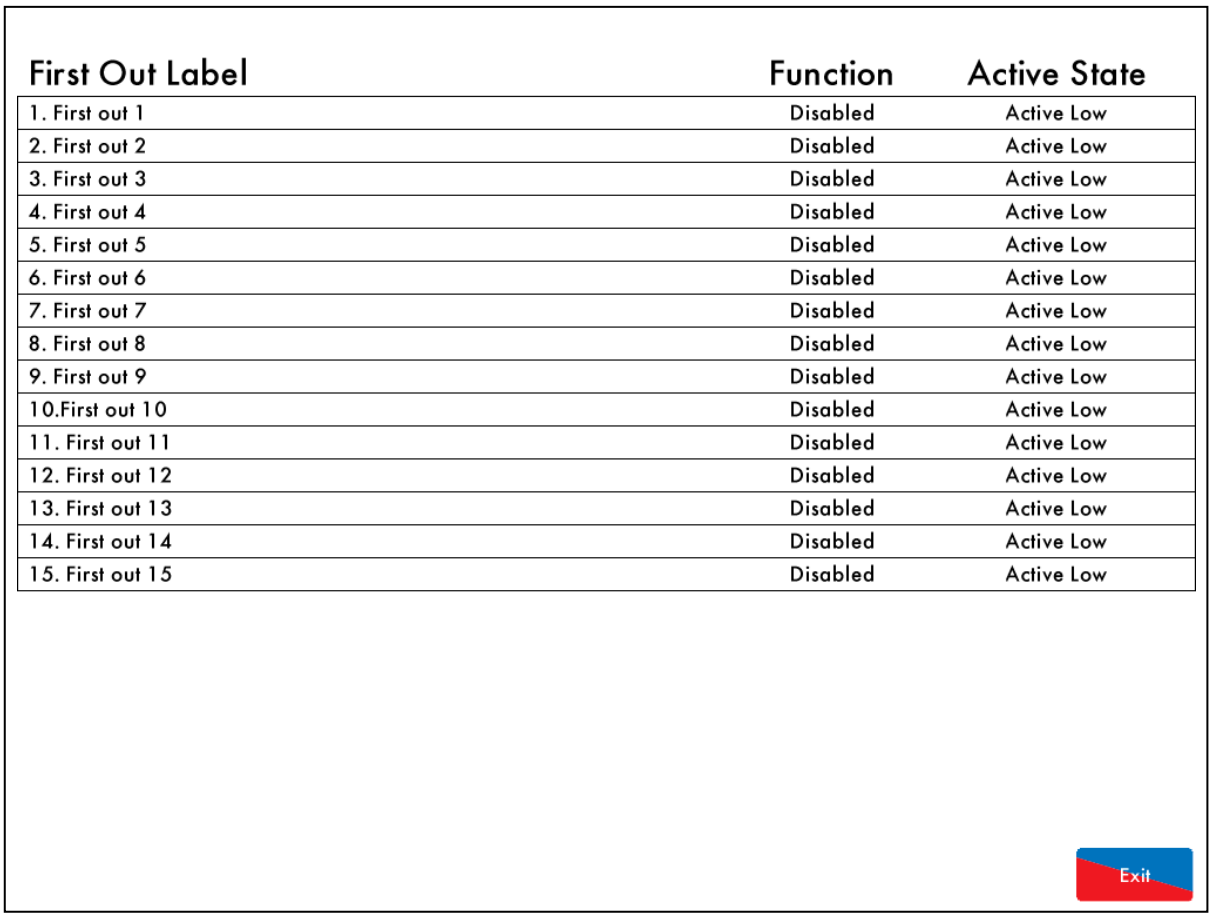
Expansion Option	Description	Setting
110	First Outs function	1

15.3.2 Accessing First Outs

First outs can be configured either in Commission mode or Online Changes. Press 

in Commission mode or press 

in Online Changes to access the First outs screens.



First Out Label	Function	Active State
1. First out 1	Disabled	Active Low
2. First out 2	Disabled	Active Low
3. First out 3	Disabled	Active Low
4. First out 4	Disabled	Active Low
5. First out 5	Disabled	Active Low
6. First out 6	Disabled	Active Low
7. First out 7	Disabled	Active Low
8. First out 8	Disabled	Active Low
9. First out 9	Disabled	Active Low
10.First out 10	Disabled	Active Low
11. First out 11	Disabled	Active Low
12. First out 12	Disabled	Active Low
13. First out 13	Disabled	Active Low
14. First out 14	Disabled	Active Low
15. First out 15	Disabled	Active Low

Figure 15.3.2 First Outs main screen

15.3.3 First Out Function

In the First Outs screen, press on the First Out number to be configured and select the function of first out when upon the active state set for high or low.

Function When Active	Description
Disabled	Does not function.
Monitor	Burner continues firing, but the events will be logged.
Non-recycle	Burner stops firing and the first out must be reset for the burner to restart.
Recycle	Burner stops firing and restarts automatically when the input state changes.
Stop EGA Sampling	Burner continues firing, but the EGA stops sampling.
Stops EGA Trimming	Burner continues firing, but the EGA trim stops operating.
External Stat	Used if external stat is optioned.

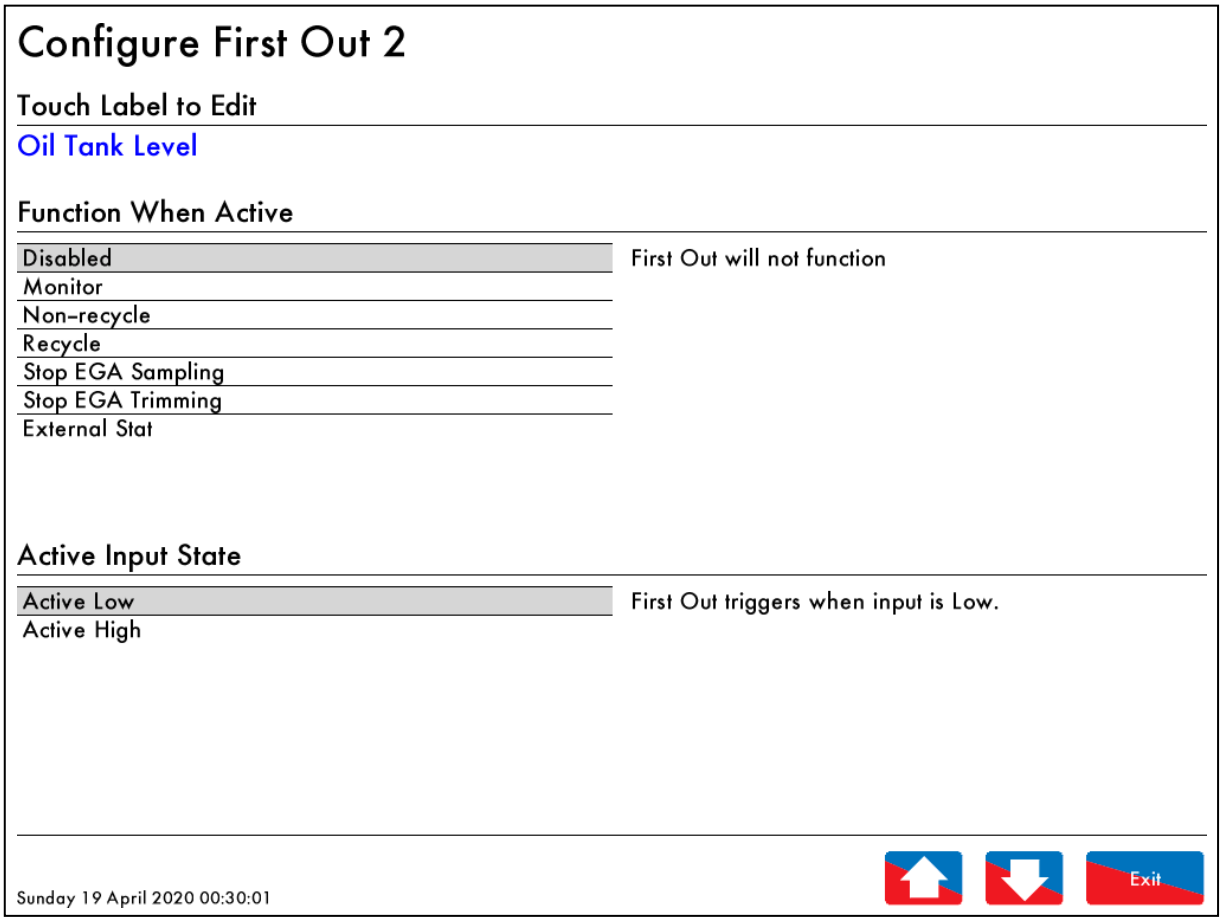


Figure 15.3.3 Configuring a First Out

15.3.4 Edit First Out Label

On the Configure First Out screen, press the First Out label highlighted in blue under Touch Label to Edit, use the on-screen keyboard to edit the name as required, once finished press  to save the change.

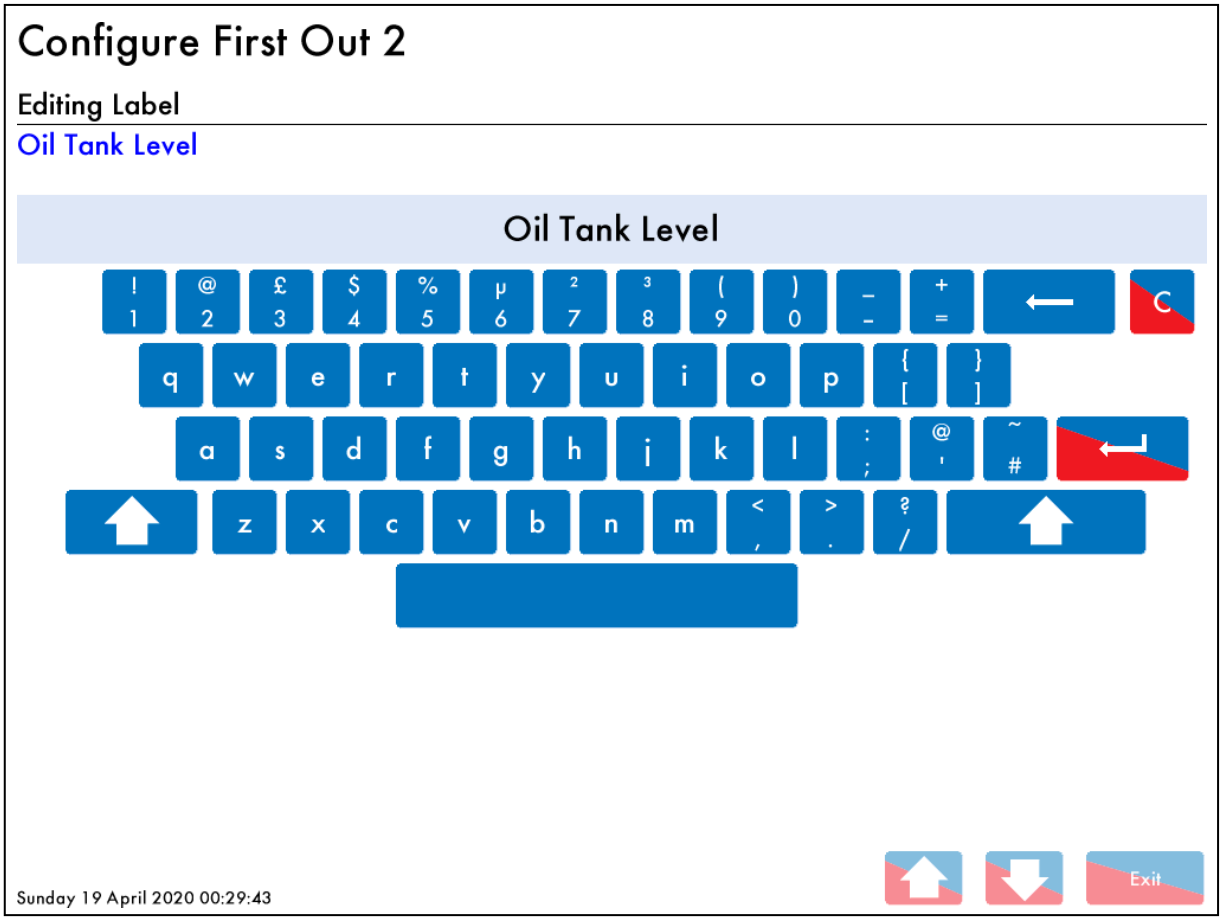


Figure 15.3.4 Editing First Out Label

15.3.5 First Outs Interlock

The First Outs can be directly and automatically connected to the stat circuit on the Mk8 MM without the need to physically connect the First Outs to terminal 53 on the MM.

The table below shows the settings which must be set for First Out Interlock.

Option/Parameter	Description	Setting
145	First Out Interlock	1

For Option 145 setting 1 (Enabled), once a First outs has been detected a lockout will occur.

Any unused inputs need to be tied to mains level, as you can't disable these inputs, like you can with the First Outs on their own.

First Out Interlock only allows the First Outs to be configured as:

- Non-recycle or recycle
- Active low

The First Out Interlock function is UL approved.

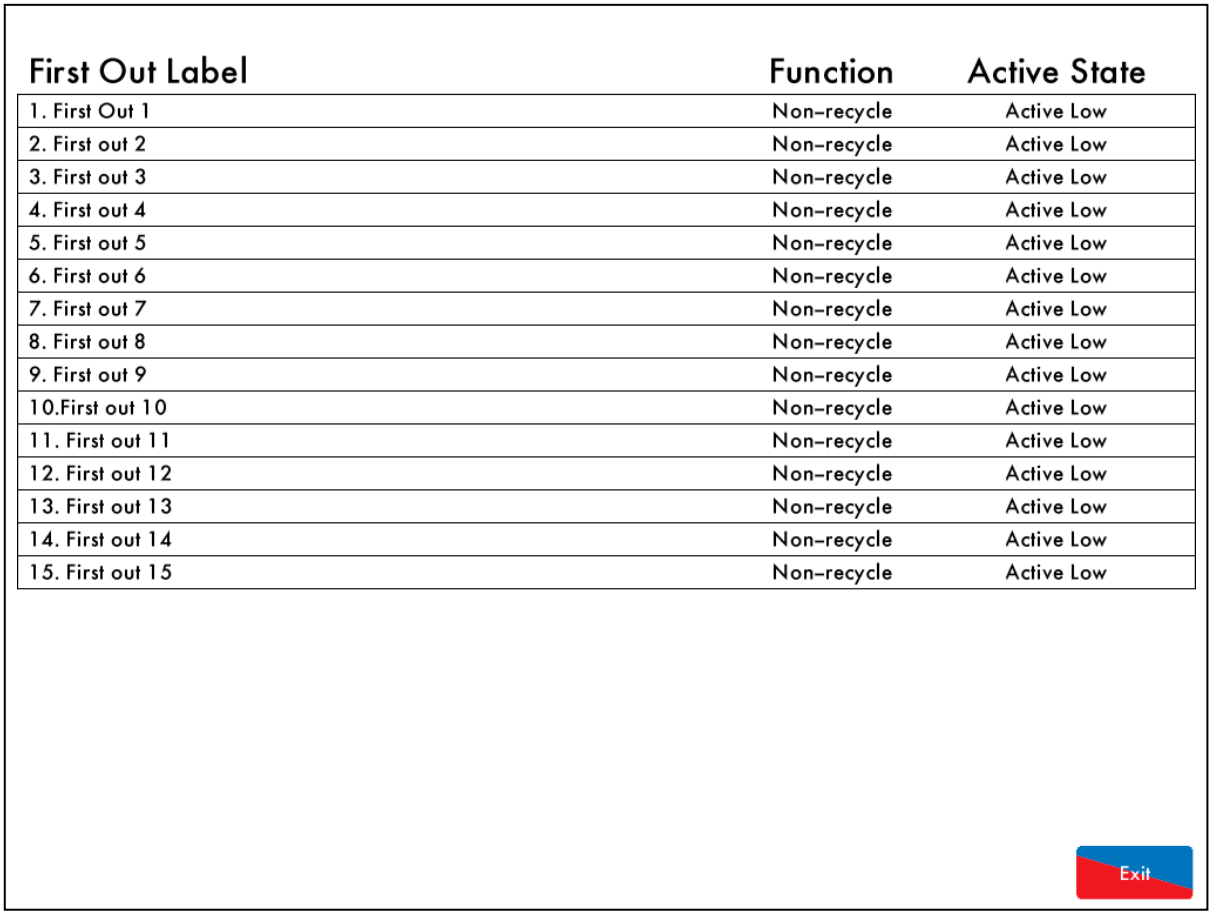


Figure 15.3.5 i First Out Interlock Enabled

The schematic below shows an example of wiring First Outs on a Mk8 MM.

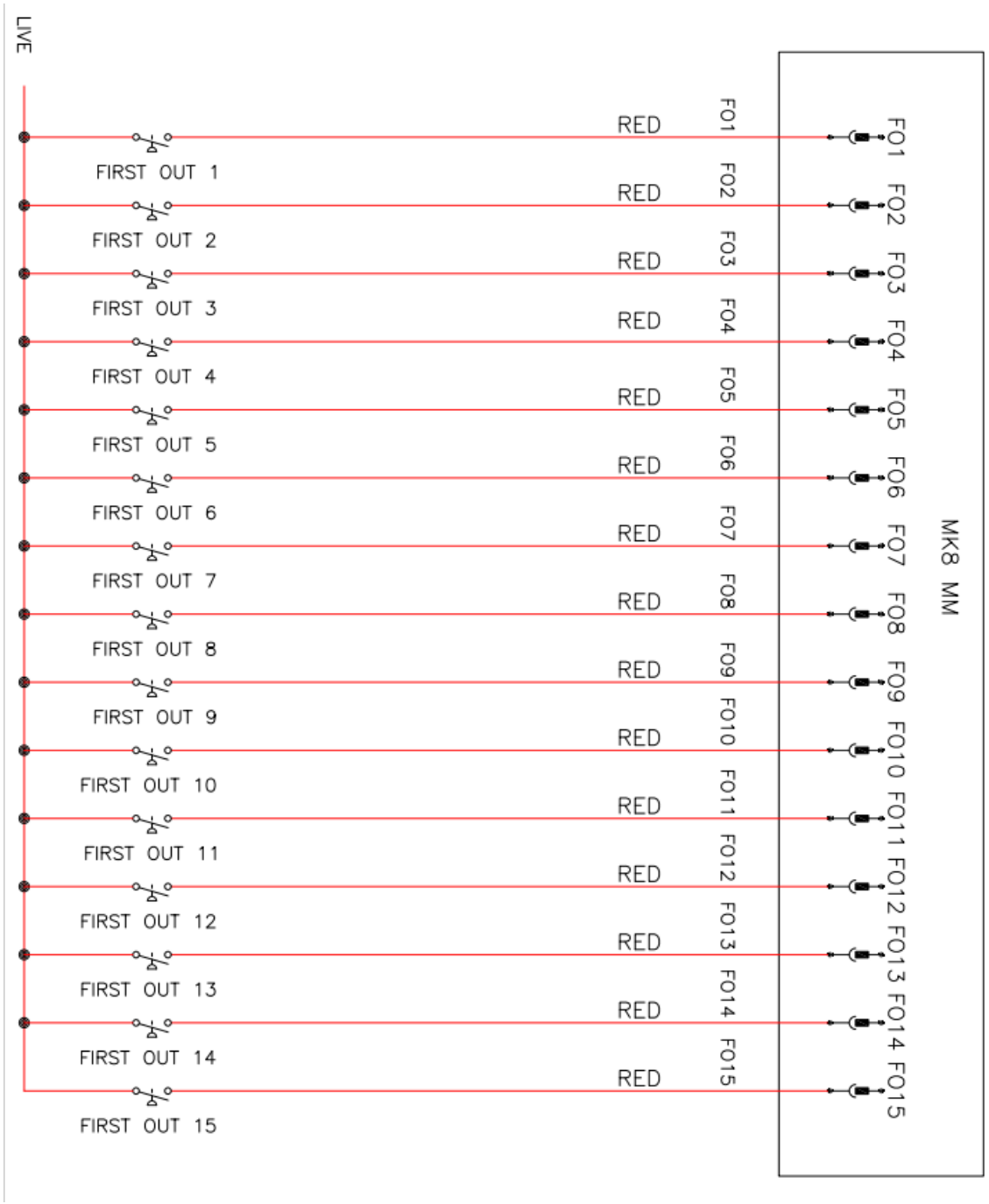


Figure 15.3.5 ii First Outs Wiring Diagram

16 HEAT FLOW

16.1 Overview

The purpose of Heat Flow Metering is to measure the amount of steam or hot water being produced and to check the amount of heat this is delivering. The majority of steam plants require Heat Flow Metering to check how much steam is being generated and used and at what cost, so the overall plant efficiency can be determined.

Steam or hot water flow meters are very expensive to procure and complex to install, however, Autoflame Mk8 MM offers a simple, accurate and cost-effective steam/hot water flow metering solution integrated into the MM.

Autoflame has been granted a worldwide patent on the Heat Flow Metering function on the Mk8 MM.

Note: Fuel flow metering is required for steam/hot water flow metering.

16.2 Expansion Options

The table below shows the Expansion Options used for configuring Heat Flow Metering.

#	Default	Range	Description
120	0		Flow: Heat Flow Function
			Used to enable and define the Heat Flow function as well as enabling a spare temperature sensor
		0	Disabled
		1	Steam Flow with Default Values
		2	Steam Flow
		3	Steam Flow with Economiser
		4	Steam Flow with Deaerator
		6	Steam Flow with Deaerator and Feed Sensor
		7	Hot Water Flow with Default Values
		8	Hot Water Flow
		9	Hot Water flow with Economiser
		10	Steam Flow from Feed Water Meter
		11	Steam Flow from Feed Water Meter and Feed Sensor
		12	Spare Temperature Sensor Only
121	100		Flow: Boiler Standing Losses
			The boiler standing losses are known as the heat lost from the boiler surfaces and pipework through radiation, and is set as a percentage of the maximum continuous rating of the boiler.
		0 – 200	0.00 – 2.00%
122	100		Flow: Blow Down Losses
			This is the typical losses resulting from top blowdown and bottom blowdown operations.
		0 – 100	0.00 – 10.0%
123	0		Flow: Blow Down Loss Calculation Method
			For setting 0, a fixed blow down loss is used in the steam or hot water flow metering, set in expansion option 122. For setting 1, the blow down loss will change according to the current firing rate in the metering calculation.
		0	Fixed loss
		1	Loss proportional to firing rate
124	100		Flow: Make Up Flowmeter Range
			The make-up water flowmeter range is only relevant if the steam flow metering function has been set with deaerator in expansion option 120.
		0 – 9999	0.0 – 999.9 litres/s or gallon/s (see parameter 40)
125	100		Flow: Condensate Flowmeter Range
			The condensate flowmeter range is only relevant if the steam flow metering function has been set with deaerator in expansion option 120.
		0 – 9999	0.0 – 999.9 litres/s or gallon/s (see parameter 40)
126	80		Flow: Default Feedwater Temperature
			If the heat flow function is set for steam or hot water flow metering using default values, then this default feedwater temperature is used for the steam or hot water flow metering calculations.
		0 – 300	^{O}C or ^{O}F (see parameter 40)

#	Default	Range	Description
127	10		Flow: Steam Flow Start Pressure Offset
			The steam flow start pressure is an offset of the required pressure. Steam flow metering will begin when the actual pressure is within this offset from the required pressure, as the system would be generating useful steam.
		0	Disabled
		1 – 100	0.1 – 10.0 bar or 1 – 100 PSI (see parameter 40)
128	10		Flow: Steam Flow Stop Pressure Offset
			The steam flow stop pressure is an offset below the required pressure. if the actual steam pressure below this value, then steam flow metering will stop.
		0	Disabled
		1 – 100	0.1 – 10.0 bar or 1 – 100 PSI (see parameter 40)
129	0		Flow: Heat Flow Data Source
			For setting 0, the T1, T2 and T3 temperature sensor are wired to the MM, and the heat flow function is set via expansion option 120.
			For setting 1-10, the same temperature information is fed back to the MM via
			connections to the IO module. The ID number of the IO module must be set in this option. The MM takes the temperature sensors readings from the IO.
		0	Sensors connected to MM
		1 – 10	Sensors connected to IO Unit 1 – 10
130	0		Temp: Spare Temperature Sensor Function
		0	Disabled
		1	Coil Temperature
		2	Exhaust Gas Temperature
		3	Cold Start Temperature
		4	Superheater Mixing Valve
131	0		Temp: Spare Temperature Shutdown Threshold
			When this threshold is reached, the burner will shutdown and an alarm is triggered. The temperature has to drop below the threshold to allow the user to reset this alarm.
		0	Disabled
		1 – 2000	Degree °C

16.3 Wiring

The table below shows the terminals used for the steam flow metering.

MM Terminal	Description
-	Common for terminals T1, T2 and T3
T1	Signal input from T1 temperature sensor
T2	Signal input from T2 temperature sensor
T3	Signal input from T3 temperature sensor
F-	Common for terminals MF and CF
MF	Current input, 4-20mA for cold water make up flow meter
CF	Current input, 4-20mA for condensate return flow meter

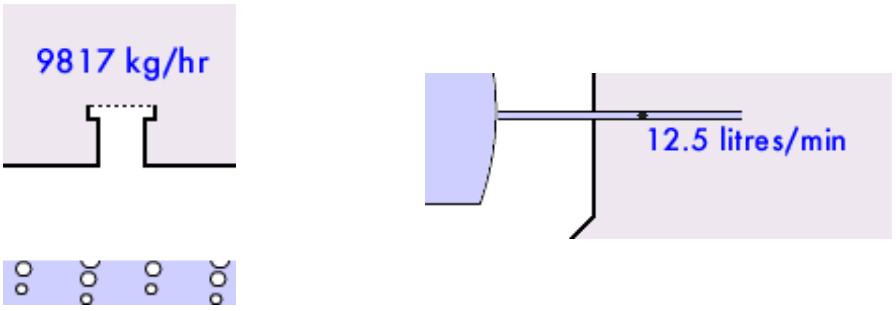
Boiler Load Detectors – Temperature:



Probe Length	Temp. Range	Part No.
100mm	0 to 400°C	MM10006/100
150mm		MM10006/150
200mm		MM10006/200
250mm		MM10006/250
400mm		MM10006/400
4”	0 to 752°F	MM10006/100U
6”		MM10006/150U
8”		MM10006/200U
10”		MM10006/250U
12”		MM10006/400U

16.4 Heat Flow Function

Heat Flow Function set in Expansion Option 120 can be configured and used in different ways.



1. Steam Flow with default values

The steam flow is a calculated value based on:

- The commissioned Fuel Flow Metering on the MM, enabled in option 57.
- The standing losses are set as a fixed percentage in Expansion Option 121
- The total blowdown losses are set as a fixed percentage in Expansion Option 122
- The stack losses are set as a default fixed percentage value in the MM. If an EGA is enabled then the stack losses are taken from the EGA rather than using a default value for the calculation.

Temperature sensors terminals configuration:

T1	Not Used
T2	Not Used
T3	Spare Input (Temperature Expansion Feature)

2. Steam Flow

A temperature sensor is used to measure the feed water temperature and the value is taken into the calculation for greater accuracy.

Temperature sensors terminals configuration:

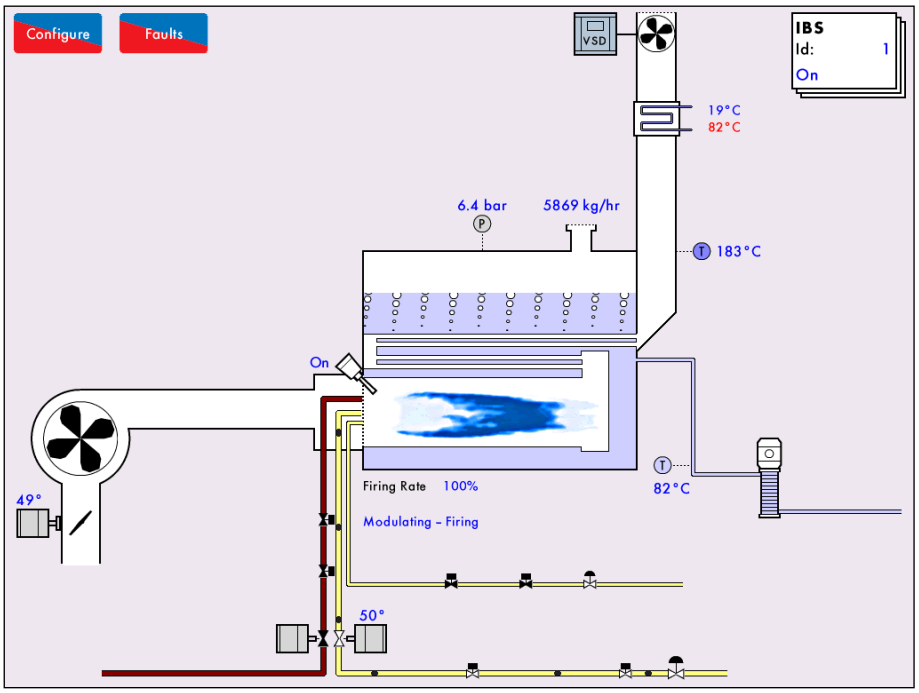
T1	Input Temperature (Feed Water)
T2	Not Used
T3	Spare Input (Temperature Expansion Feature)

3. Steam Flow with Economiser

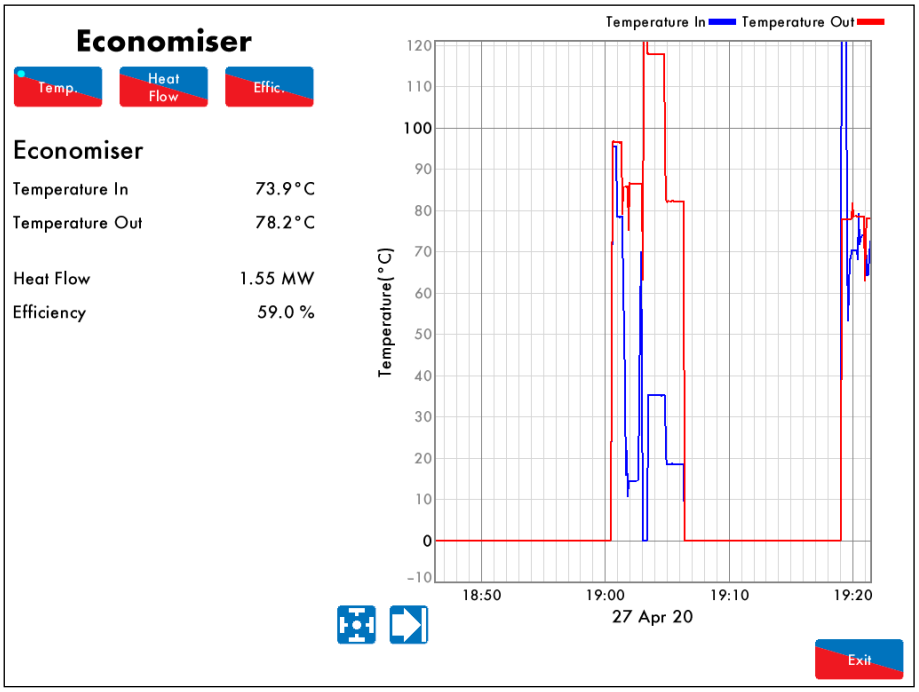
To be used in boilers with an economiser. The temperature of the water going in and out of the economiser is measured.

Temperature sensors terminals configuration:

T1	Input Temperature (Economiser Output)
T2	Feedwater Temperature (Economiser Input)
T3	Spare Input (Temperature Expansion Feature)



The Economiser screen can be accessed by pressing  from the main MM screen.



4. Steam flow with Deaerator

Can be used for systems with deaerators. The temperature of the make up water and the condensate temperature is measured and used in the heat flow calculation.

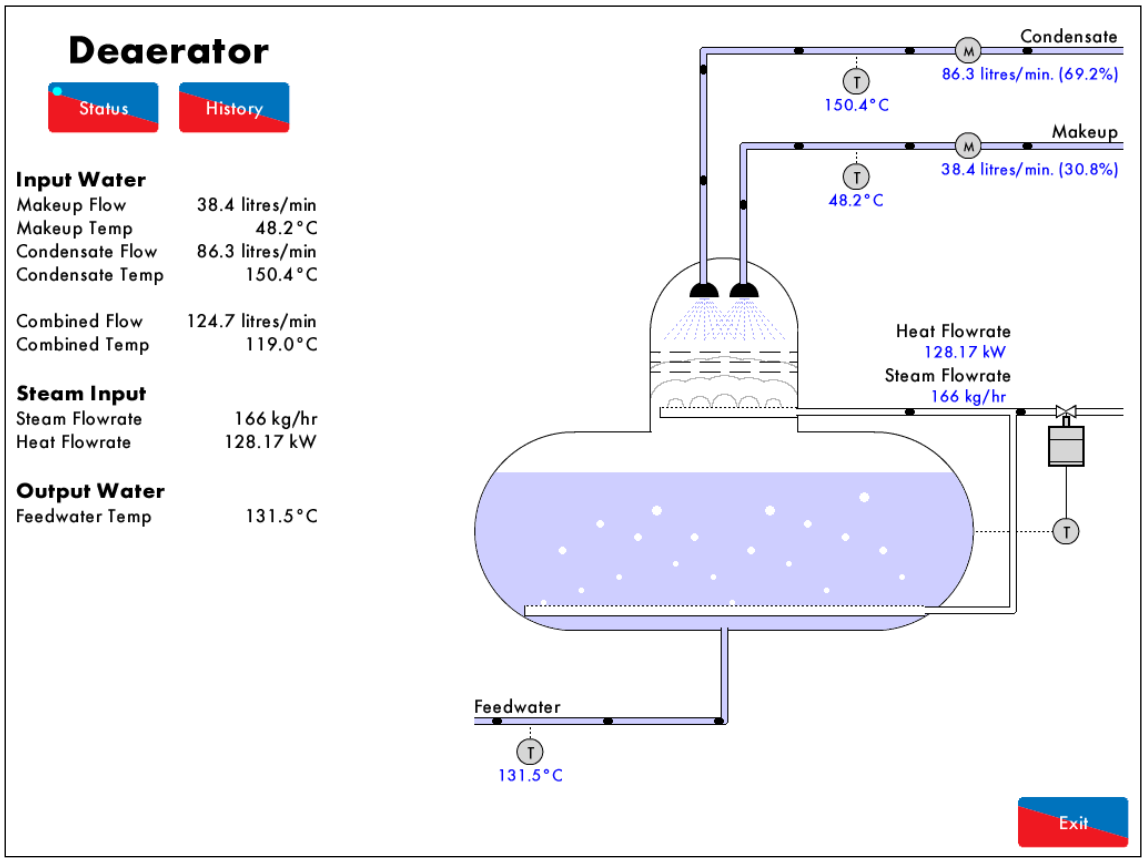
Temperature sensors terminals configuration:

T1	Make Up Temperature
T2	Spare Input (Temperature Expansion Feature)
T3	Condensate Temperature

5. Steam flow with Deaerator and Feed Sensor

This function is used for systems with a deaerator. The flowrate of the make-up water, feedwater and condensate has to be measured using a flow meter.

The MM Deaerator screen displays the live values as well as a history graph for the deaerator data.



Temperature sensors and flowmeters terminals configuration:

T1	Make Up Temperature
T2	Feed Water Temperature
T3	Condensate Temperature
MF	Current input, 4-20mA for cold water make up flow meter
CF	Current input, 4-20mA for condensate return flow meter

7. Hot Water Flow with Default Values

The hot water flow is a calculated value based on:

- The commissioned Fuel Flow Metering on the MM, enabled in option 57.
- The standing losses are set as a fixed percentage in Expansion Option 121
- The total blowdown losses are set as a fixed percentage in Expansion Option 122
- The stack losses are set as a default fixed percentage value in the MM. If an EGA is enabled then the stack losses are taken from the EGA rather than using a default value for the calculation.

No additional temperature sensor required.

T1	Not Used
T2	Not Used
T3	Spare Input (Temperature Expansion Feature)

8. Hot Water Flow

A temperature sensor is used to measure the feed water temperature and the value is taken into the calculation for greater accuracy.

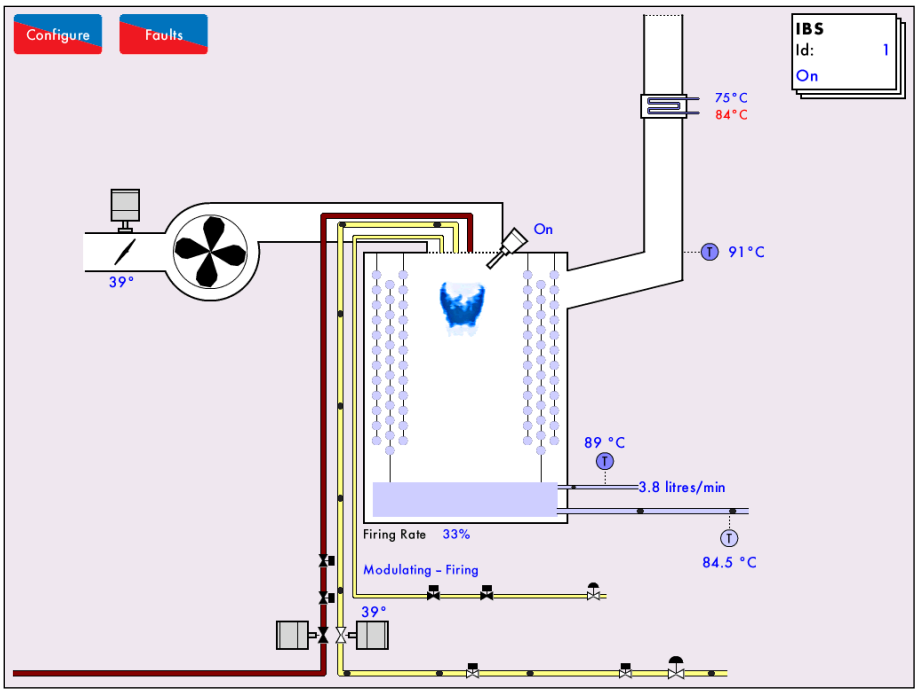
Temperature sensors terminals configuration:

T1	Input Temperature (Feed Water)
T2	Not Used
T3	Not Used

9. Hot Water Flow with Economiser

Temperature sensors terminals configuration:

T1	Input Temperature (Economiser Output)
T2	Feed Water Temperature (Economiser Input)
T3	Not Used



Hot Water Flow with Economiser on a vertical condenser hot water boiler

10. Steam Flow from Feed Water Meter

Temperature sensors and flowmeters terminals configuration:

T1	Not Used
T2	Not Used
T3	Spare Input (Temperature Expansion Feature)
MF	Current input, 4-20mA for cold water make up flow meter

11. Steam Flow from Feed Water Meter and Feed Sensor

Temperature sensors and flowmeters terminals configuration:

T1	Input Temperature (Feed Water)
T2	Not Used
T3	Spare Input (Temperature Expansion Feature)
MF	Current input, 4-20mA for cold water make up flow meter

12. Spare Temperature Sensor Only

Temperature sensors terminals configuration:

T1	Not Used
T2	Not Used
T3	Spare Input (Temperature Expansion Feature)

16.5 Steam Flow Metering

16.5.1 Steam Flow Calculation

By the addition of one temperature detector it is possible to extrapolate steam flow from a boiler both as an instantaneous value and a totalised amount over time. A full Steam Flow Metering package is available with just the addition of one temperature sensor to the system, avoiding the cost of an expensive steam flow meter and orifice plate that is typically accurate at the higher firing rates only.

Example 1: Steam Flow with Default Values

The fuel flow metering has been set in option 57 and commissioned for gas. The standing losses are set default as 1% in expansion option 121. The total blowdown losses are set default as 1% in expansion option 122. The stack losses are set as default in the MM as 15% for oil and 19% for gaseous fuels.

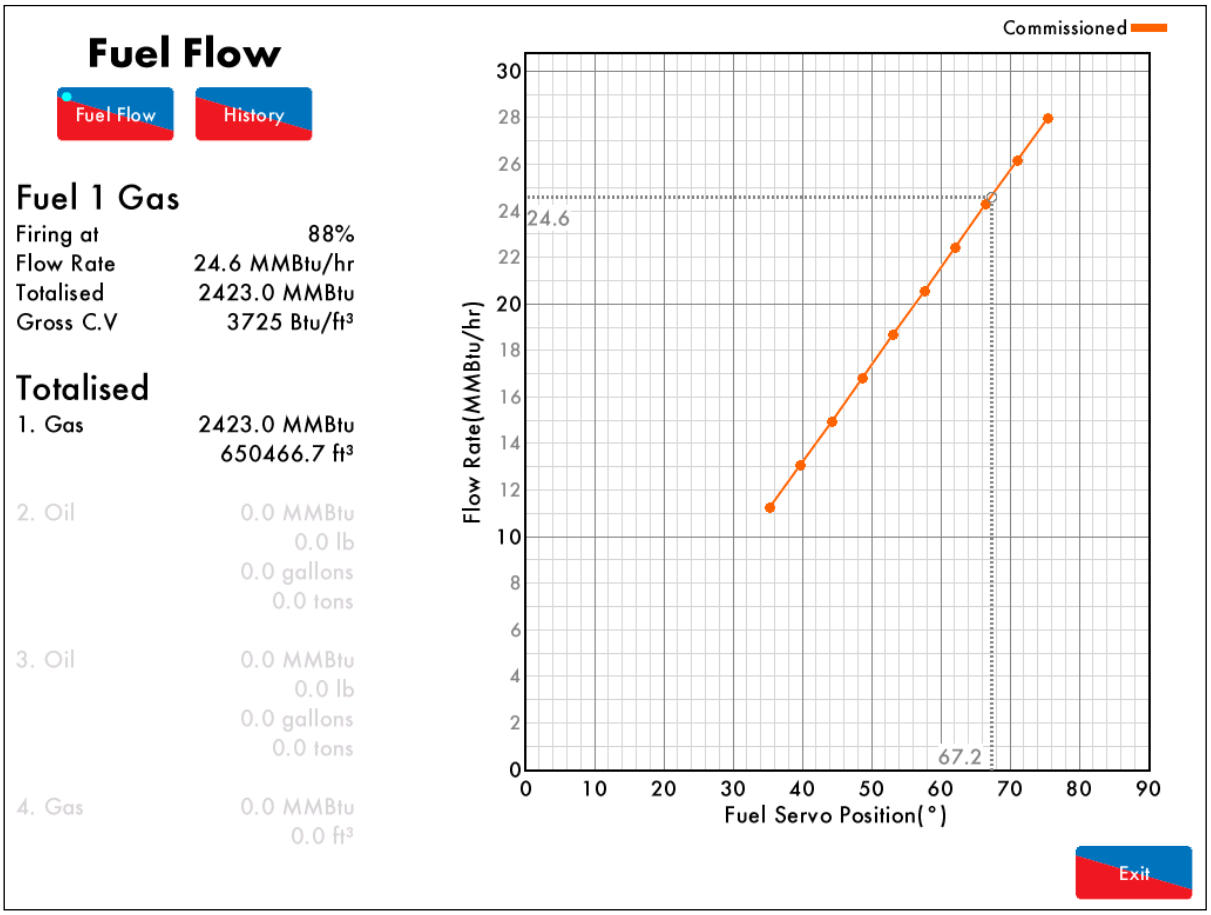


Figure 16.5.1.i Fuel Flow

From fuel flow metering, in the screen above the burner is currently firing at 88% with a flow rate of 24.6MMBtu/hr. The net calorific value of the fuel into the wet side of the boiler can be determined by taking away the losses from the flow rate:

Standing losses = 1% x Heat Input
Standing losses = 1% x 24,600,000 Btu/hr

Therefore standing losses currently stand at 246,000 Btu/hr.

Stack losses = 19% x Heat Input
Stack losses = 19% x 24,600,000 Btu/hr

Therefore stack losses are currently 4,674,000 Btu/hr.

Note: If an EGA is optioned, then the stack losses are taken from the EGA data rather than default system values, this provides greater accuracy.

Combined blowdown losses = 1% x Heat input
Combined blowdown losses = 1% x 24,600,000 Btu/hr

Therefore, combined blowdown losses are currently 246,000 Btu/hr.

Net Calorific Value of Fuel (Wet)
= Heat Input – Standing losses – Stack losses – Combined blowdown losses

Net Calorific Value of Fuel (Wet)
= 24,600,000 Btu/hr – 246,000 Btu/hr – 4,674,000 Btu/hr – 246,000 Btu/hr

Therefore, the net calorific value of the fuel (wet) is 19,434,000 Btu/hr.

The boiler efficiency is determined by:

$$Boiler\ efficiency = \frac{Net\ calorific\ value\ of\ fuel\ (wet)}{Heat\ input}$$

$$Boiler\ efficiency = \frac{19{,}434{,}000\ Btu/hr}{24{,}600{,}000\ Btu/hr}$$

Therefore the current boiler efficiency is 79.0%, which is seen on the Steam Flow Status screen.

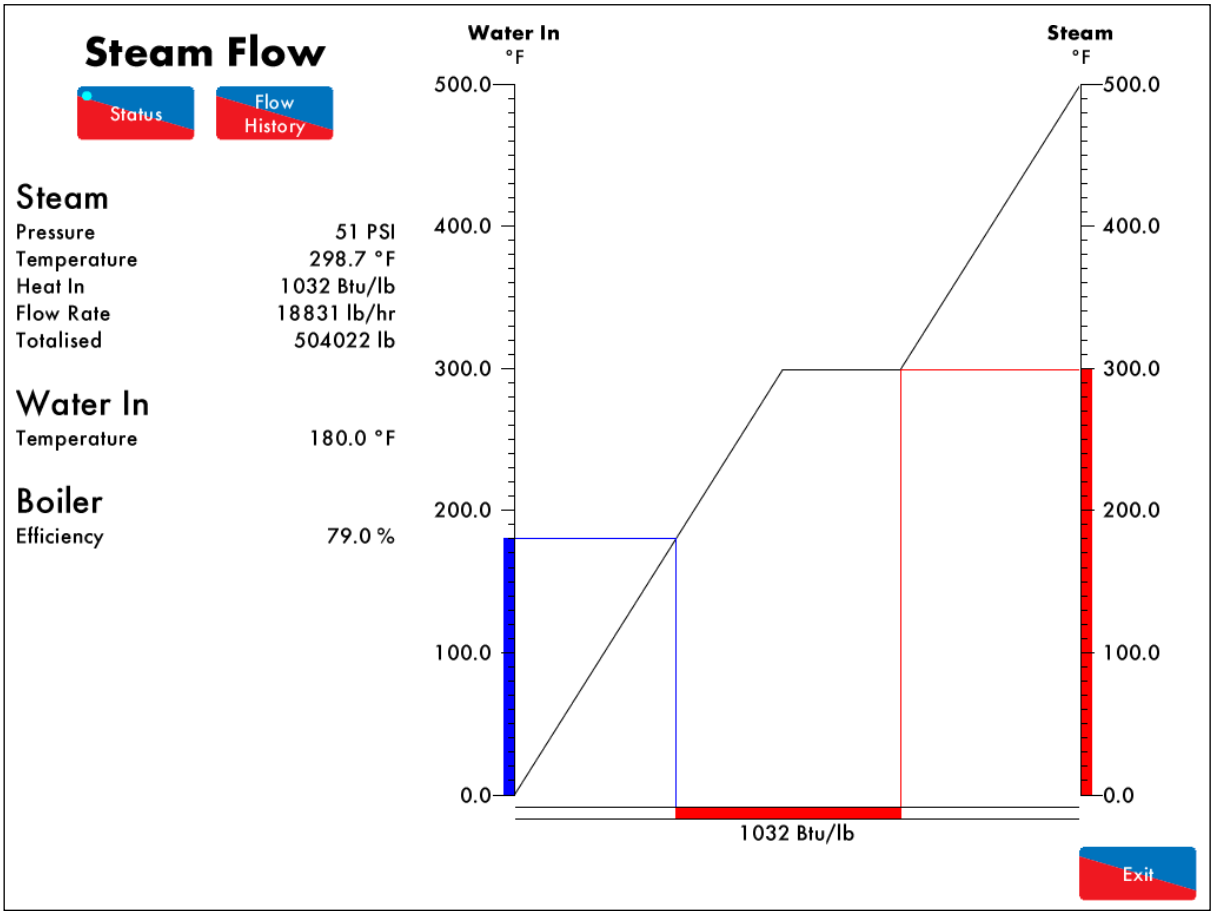


Figure 16.5.1.ii Steam Flow Status

The Steam Flow status screen shows that the feed water temperature is currently at 180.0°F, with steam at a pressure of 51 PSI and 298.7˚F.

Note: Feed water temperature sensors can be used for greater accuracy.

The amount of heat needed to change the feed water to steam is found by the amount of heat needed to raise 1 lb of feed water at 180.0°F to steam at 51 PSI and 298.7 ˚F. The standard steam tables are built in within the steam flow metering on the MM, and this is then calculated as 1032 Btu/lb. This figure is the latent heat of liquid into steam (gas) plus the sensible heat components.

The steam flow rate is shown in lb/hr is determined by:

$$Steam\ flow\ rate = \frac{Net\ calorific\ value\ of\ fuel\ (wet)}{Heat\ required\ to\ raise\ current\ feed\ water\ to\ steam}$$

$$Steam\ flow\ rate = \frac{19{,}434{,}000\ Btu/hr}{1032\ Btu/lb}$$

Therefore, the current steam flow rate is calculated to be 18,831 Btu/lb.

Example 2: Steam with Deaerator

A common practice in steam generation is the use of a “deaerator” to remove the oxygen from the feed water and hence reduce the incidence of oxygen corrosion in the boiler and steam & condensate pipework.

The principle of a deaerator is to mix the make-up water with the condensate return and live steam direct from the boiler in a tank. Flash steam may also be directed back to the tank. The effect is to mechanically “scrub” the oxygen from the feed water and also to preheat it before it is pumped into the boiler.

In the system as set out above, it is no longer valid to measure the temperature of the feed water just before it enters the boiler as the inlet temperature for the “steam meter” calculation. This water has already been preheated by steam from the boiler and therefore this additional energy should not be taken into the software calculation.

The solution is to treat the boiler and deaerator as one system. The energy into the system is supplied by the burner and the inlet temperature is the “weighted average” of the condensate return temperature and makeup water temperature. The outlet steam temperature is measured by a temperature sensor in exactly the same way as in a system without a deaerator.

First the percentage “Make up“ in the “Feed water” must be calculated.

$$\%\mathrm{Mu} = \frac{100 \text{ x } \mathrm{V2}}{(\mathrm{V2} + \mathrm{V1})}$$

Where: %Mu = % Cold make up water
V1 = Volume flow rate of condensate return water
V2 = Volume flow rate of cold make up water

Assuming a steam boiler with a volume of condensate return of 40 GPM and make up water of 8 GPM;

$$\text{Make up } \% = \frac{100 \text{ x } 8}{(8 + 40)} = 16.7\%$$

In order to calculate the second part to establish the “Weighted Average Temperature”, the following equation is used.

$$\mathrm{Tave} = \mathrm{T3} - \frac{(\%\mathrm{Mu} \text{ x } (\mathrm{T1A} - \mathrm{T1}))}{100}$$

Where: T_{ave} = Weighted Average temperature
T3 = Temperature of condensate
T1 = Temperature of make-up water
%Mu = Percentage of make-up water

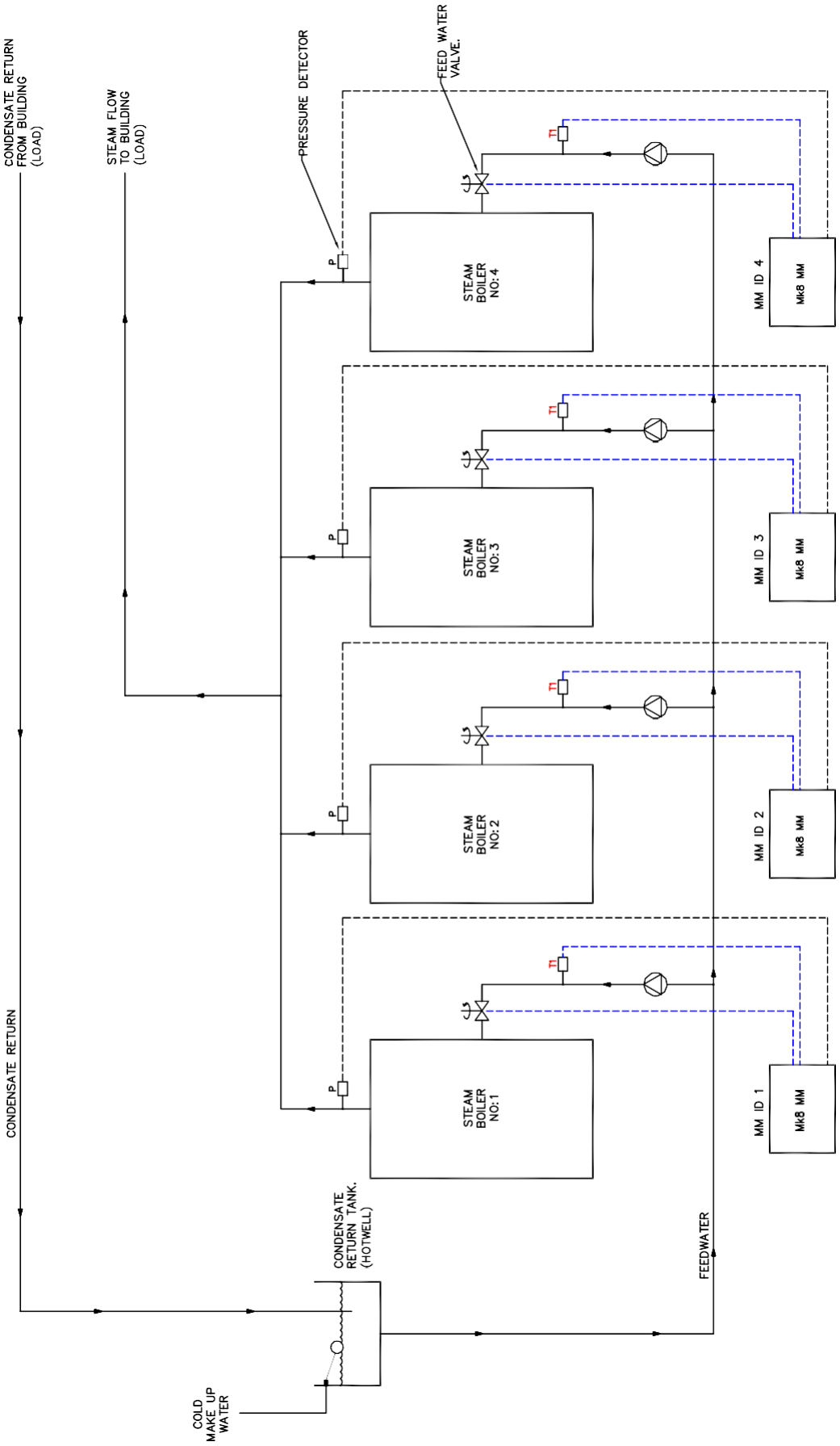
Steam boiler with condensate return temperature of 176°F and a make-up water temperature of 41°F. From the above example the make-up percentage is 16.7%

$$\text{Weighted Average} = 176 - \frac{(16.7 \text{ x } (176 - 41))}{100} = 153.4°\mathrm{F}$$

To implement the above control, the above calculations have been imbedded in the MM to obtain the “Weighted Average Temperature” (T_{ave}).

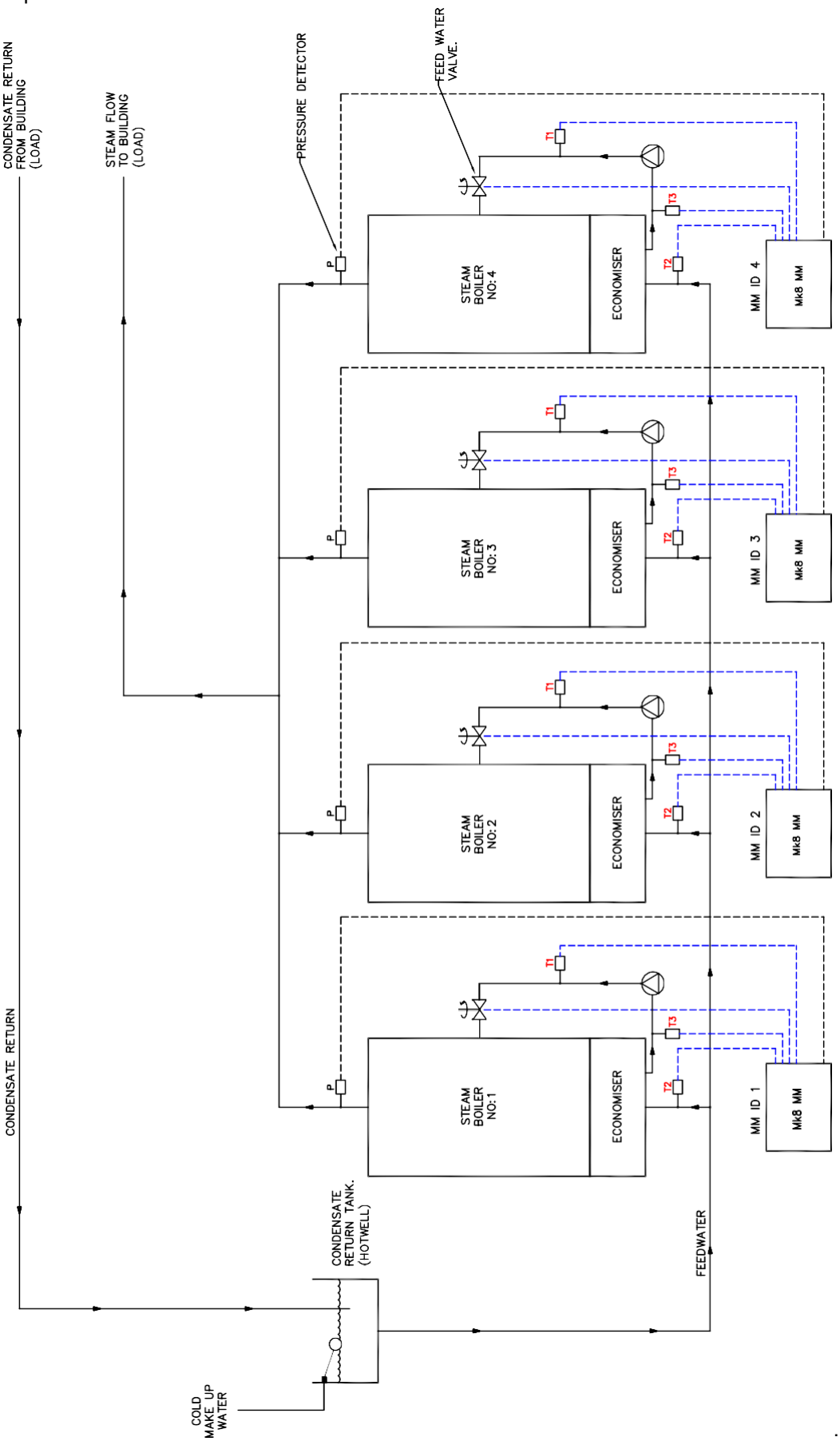
16.5.2 Steam Flow

Expansion option 120 set to 2



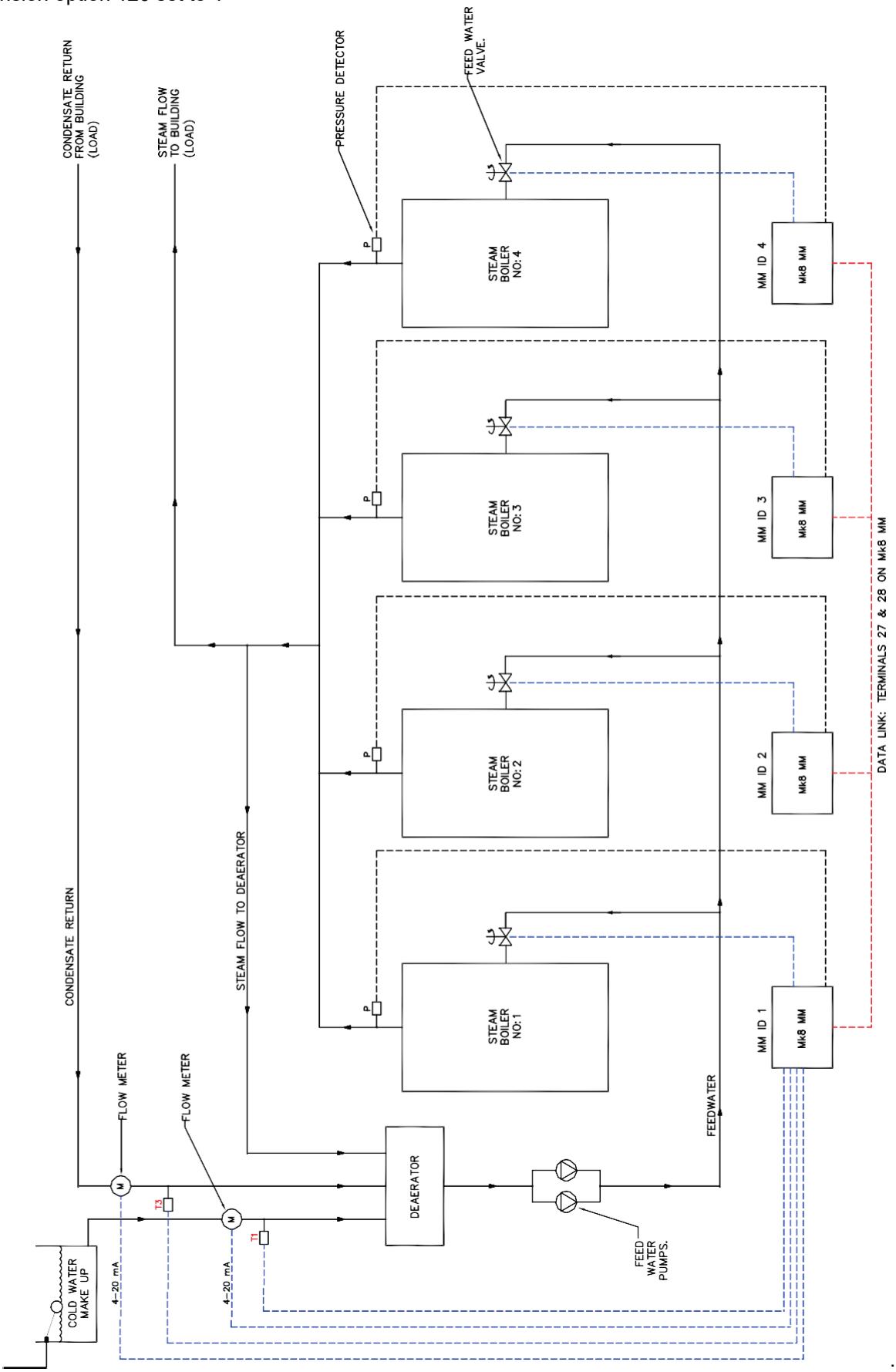
16.5.3 Steam Flow with Economiser

Expansion option 120 set to 3



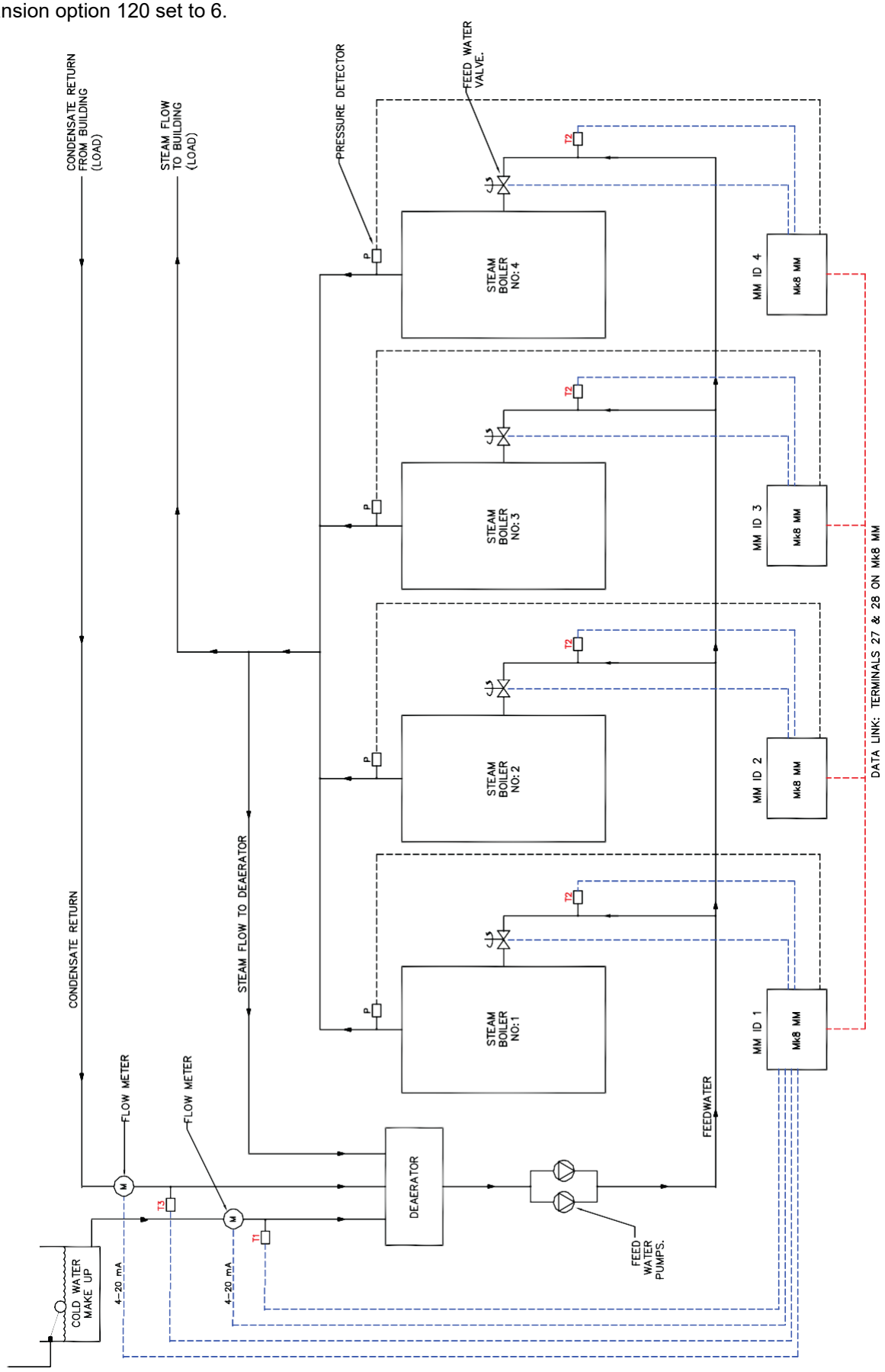
16.5.4 Steam Flow with Deaerator

Expansion option 120 set to 4



16.5.5 Steam Flow with Deaerator and Feed Sensor

Expansion option 120 set to 6.



16.6 Hot Water Flow Metering

Heat Flow Metering is the measurement of the amount of heat being transferred to the water by a hot water boiler. If the stack losses and the standing losses of the boiler at any moment are known then the remaining energy is transferred to the water.

From the Exhaust Gas Analyser (EGA):

$$\text{stack losses} = 100 - \text{combustion efficiency}$$

Radiation losses are specific to the boiler; 1% radiation losses are typical for a packaged boiler operating at Maximum Continuous Rating (MCR). The loss is constant regardless of boiler output.

At 50% firing rate the radiation loss is equal to 2% of the energy input.

The total heat input at any given time is given by the Heat Flow Metering so the instantaneous heat input to the water can be calculated, and by integrating these values we can get a totalised value for hot water flow.

16.6.1 Hot Water Flow Calculation

$$Efficiency\ \% = 100\% - \left(Stack\ loss + \frac{Radiation\ Losses\ \times 100}{Firing\ Rate}\right)$$

$$\text{Useful Heat into Water} = \text{Total Heat}\ \times \frac{\text{Efficiency}}{100}$$

$$\text{Volume Flow in lbs/hr} = \frac{\text{Useful heat MBTU/Hr}}{\text{SP Ht BTU/lb/°F}\ \times\ (\text{Flow Temp} - \text{Return Temp})}$$

$$\text{Volume Flow in cu ft Hr} = \frac{\text{Volume Flow in lbs/hr}}{\text{Density of Water at Return Temperature}}$$

$$\text{Since 1 cu ft Hr} = 0.124676\ \text{US GPM}$$

$$\text{Volume Flow in US G. P. M.} = \text{Volume Flow in cu ft Hr} \times 0.124676$$

Calculation Example

A boiler firing at 75% firing rate has a heat input of 20,472,840 BTU/Hr (6MW). The temperature of the flow (MM temperature detector) is 185°F and the temperature of the return water (T1 temperature sensor) is 167°F. The combustion efficiency is 82% (given by the Mk8 MM). Radiation losses stand at 1% at Maximum Continuous Rating.

Description	Imperial units	Metric units
Firing rate	75%	75%
Input	20.47 MMBTU/HR	6MW
Return Temperature	167°F	75°C
Flow Temperature	185°F	85°C
Sp Hot water	1.0 BTU/lb/°F	4.18KJ/KG/°C
Density Water	60.68lb/cuft @176°F	972 kg M³ @80°C
Combustion Efficiency	82%	82%

$$Efficiency\ \% = 100\% - \left(18\% + \frac{1\% \times 100}{75\%}\right)$$
$$= 80.67\%$$

$$\text{Useful Heat into Water} = \text{Total Heat} \times \frac{\text{Efficiency}}{100} = 20{,}472{,}840 \times \frac{80.67}{100}$$

$$= 16{,}514{,}440\ \text{BTU/hr}$$

$$\text{Volume Flow in lbs/hr} = \frac{16{,}515{,}440}{1 \times (185 - 167)}$$

$$= 917{,}524.4\ \text{lbs/hr}$$

$$\text{Volume Flow in cu ft Hr} = \frac{\text{Volume Flow in lbs/hr}}{\text{Density of Water at Return Temperature}}$$

$$= \frac{917{,}524.4}{60.68} = 15{,}120.7\ \text{cu ft Hr}$$

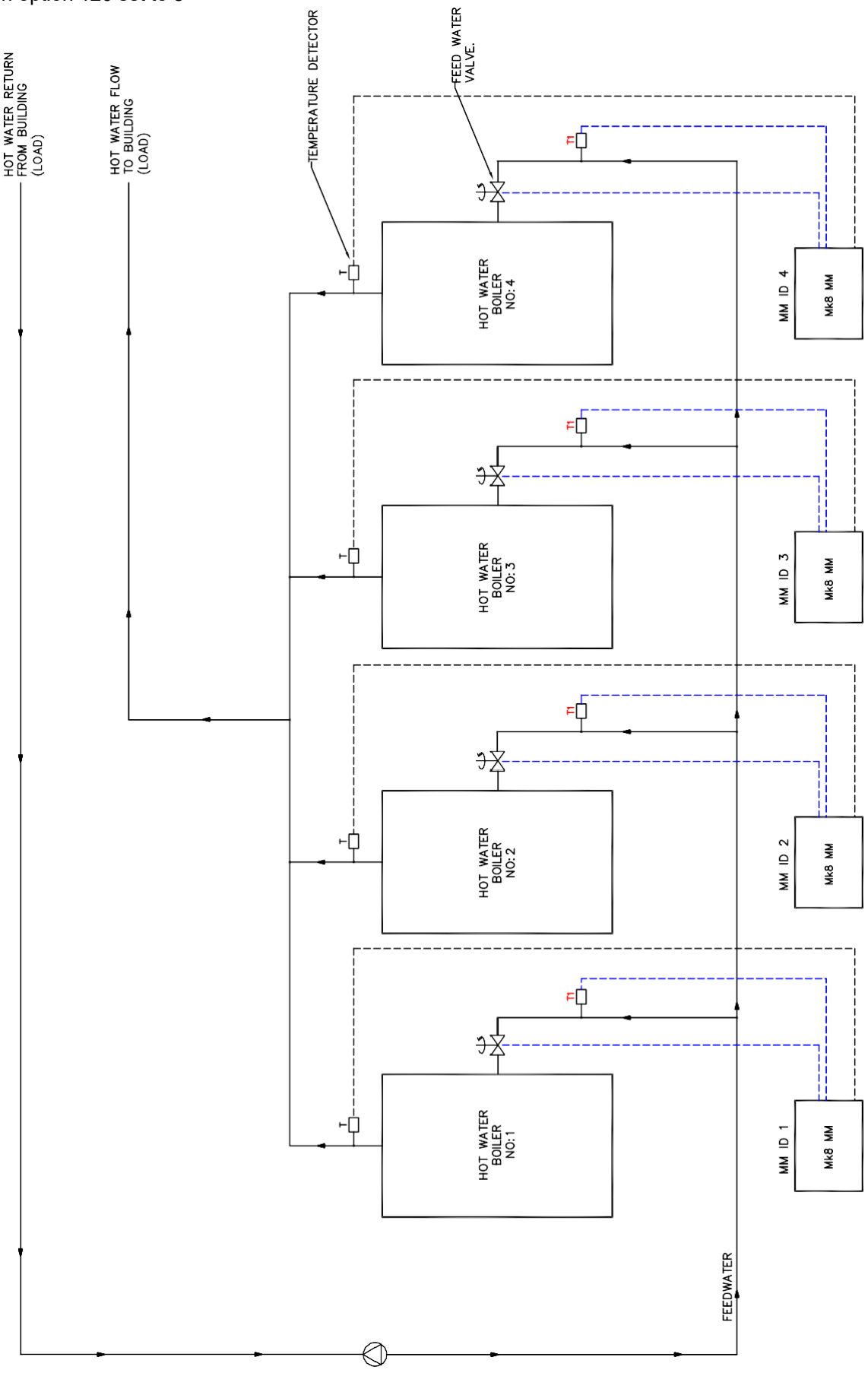
$$\text{Volume Flow} = 15{,}120.7\ \text{cu ft Hr} \times 0.124676 = 1{,}885.2\ \text{US GPM}$$

From the above we can see that by enabling Heat Flow Metering expansion function and adding a return temperature detector to the Mk8 MM, the following information can be obtained:

- Heat input into the water
- Water volume flow

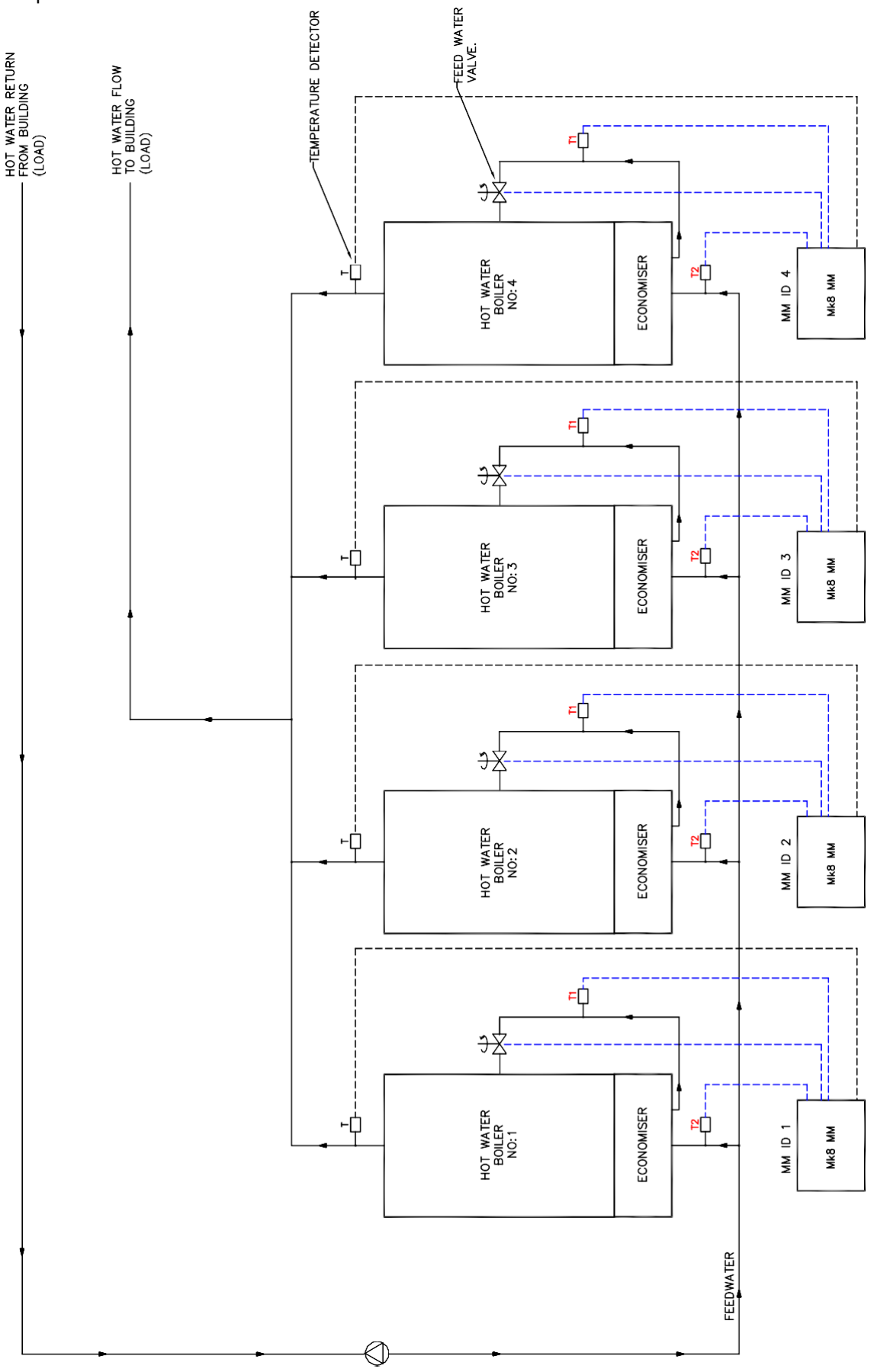
16.6.2 Hot Water Flow

Expansion option 120 set to 8



16.6.3 Hot Water Flow with Economiser

Expansion option 120 set to 9



16.7 Spare Temperature Sensor

The Spare Temperature Sensor feature may be used when the selected heat flow mode leaves one or more temperature sensor inputs unused. It allows an additional temperature sensor to be used to monitor the exhaust temperature or the coil/tube temperature of the boiler. Alternatively it may be used to control an enhanced version of the Cold Start feature in which temperature thresholds can be configured to keep the boiler at minimum and half firing rates until the threshold temperatures are met.

Additionally, the spare temperature sensor can be used for a Superheater Mixing valve. This controls the CH7 servo PID (Exp Option 115-119) where utilising the spare temperature sensor, when it reaches its target temperature (Exp 116) CH7 servo will open or close depending on Exp 117. Please note, that the draught servo (Exp 80) must be disabled to use the Superheater function. Draught Control commissioned servo & Superheater CH7 PID can't both be used at the same time.

To use the Spare Temperature Sensor feature, the Heat Flow Metering expansion feature must be unlocked.

16.7.1 Configuration Options

The table below shows the expansion features relevant to the spare temperature sensor feature.

#	Default	Range	Description
115	0		Temp: Servo Ch7 PID – Source Temperature
			Selects which temperature sensor input to use, or select Disabled to disable the feature.
		0	Disabled
		1	Temperature input T1
		2	Temperature input T2
		3	Temperature input T3
116	0		Temp: Servo Ch7 PID – Target Temperature
			Sets a target temperature that the PID attempts to maintain by moving the draught servo.
		0	Disabled
		1 – 2000	Degree °C/F (see parameter 40)
117	0		Temp: Servo Ch7 PID – Response Direction
			Selects whether the draught servo opens or closes to reduce or increase the controlled temperature.
		0	Servo opens when above target to reduce temperature
		1	Servo closes when above target to reduce temperature
		2	Servo opens when below target to increase temperature
		3	Servo closes when below target to increase temperature
118	200		Temp: Servo Ch7 PID – Proportional Band
			Selects a temperature variation from the setpoint that generates the maximum proportional response.
		1 – 10000	Degree °C/F (see parameter 40)
119	10		Temp: Servo Ch7 PID – Integral Time
			Controls the response speed of the integral part of the PID control.
		1 – 1000	Seconds
130	0		Temp: Spare Temperature Sensor Function
		0	Disabled
		1	Coil Temperature
		2	Exhaust Gas Temperature
		3	Cold Start Temperature
		4	Superheater Mixing Valve

#	Default	Range	Description
131	0		Temp: Spare Temperature Shutdown Threshold
			When this threshold is reached, the burner will shutdown and an alarm is triggered. The temperature has to drop below the threshold to allow the user to reset this alarm.
		0	Disabled
		1 - 2000	Degree °C/F (see parameter 40)
132	0		Temp: Cold Start Low Threshold
			When this threshold is reached, the MM lets the firing rate go up to Mid fire, whilst still in Cold Start Mode.
		0	Disabled
		1 – 2000	Degree °C/F (see parameter 40)
133	0		Temp: Cold Start High Threshold
			When this threshold is reached, the MM leaves Cold Start Mode and can freely modulate to any firing rate.
		0	Disabled
		1 – 2000	Degree °C/F (see parameter 40)
134	0		Temp: High Temperature Shutdown Stops Feedwater Pump
			When optioned, high temperature shutdown via the spare temperature sensor input will stop the feedwater pump.
		0	Disabled
		1	Enabled

16.7.2 Spare Temperature Sensor Terminal

The use of the spare temperature sensor is governed by expansion option 120.

Heat flow function – Expansion Option 120

If steam flow metering is not used then expansion option 120 can be set to 12 – spare temperature sensor only. If a spare temperature sensor is required with steam flow metering, please see the table below for the possibility and the sensor number used for this function.

#	Setting	Spare Temperature Sensor Used
1	Steam Flow with default values	T3
2	Steam Flow	T3
3	Steam Flow with Economiser	T3
4	Steam flow with Deaerator	T2
6	Steam flow with Deaerator and Feed Sensor	N/A
7	Hot Water Flow with Default Values	N/A
8	Hot Water Flow	N/A
9	Hot Water Flow with Economiser	N/A
10	Steam Flow from Feed Water Meter	T3
11	Steam Flow from Feed Water Meter and Feed Sensor	T3
12	Spare Temperature Sensor Only	T3

A standard Autoflame temperature sensor can be used as a spare sensor, please refer to the Autoflame Sensors Manual.

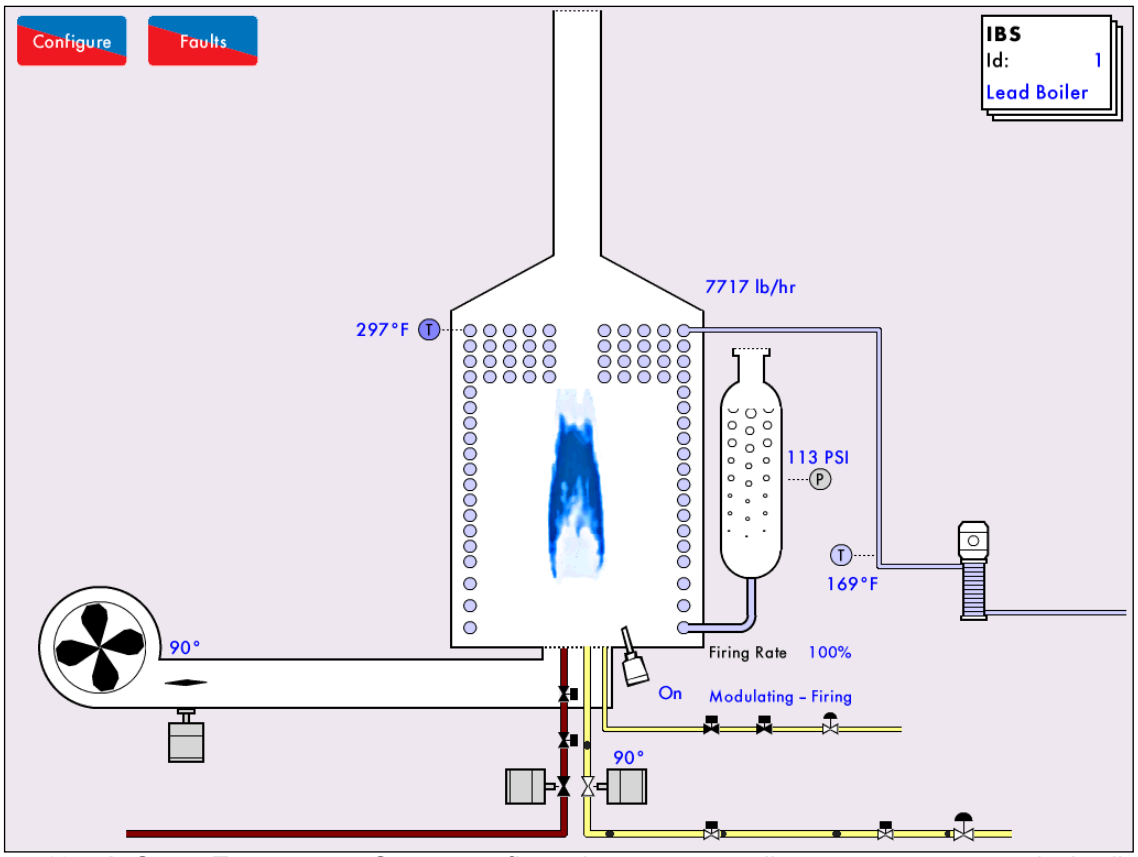


Figure 16.7.A: Spare Temperature Sensor configured to measure coil temperature on a vertical coil-tube steam generator

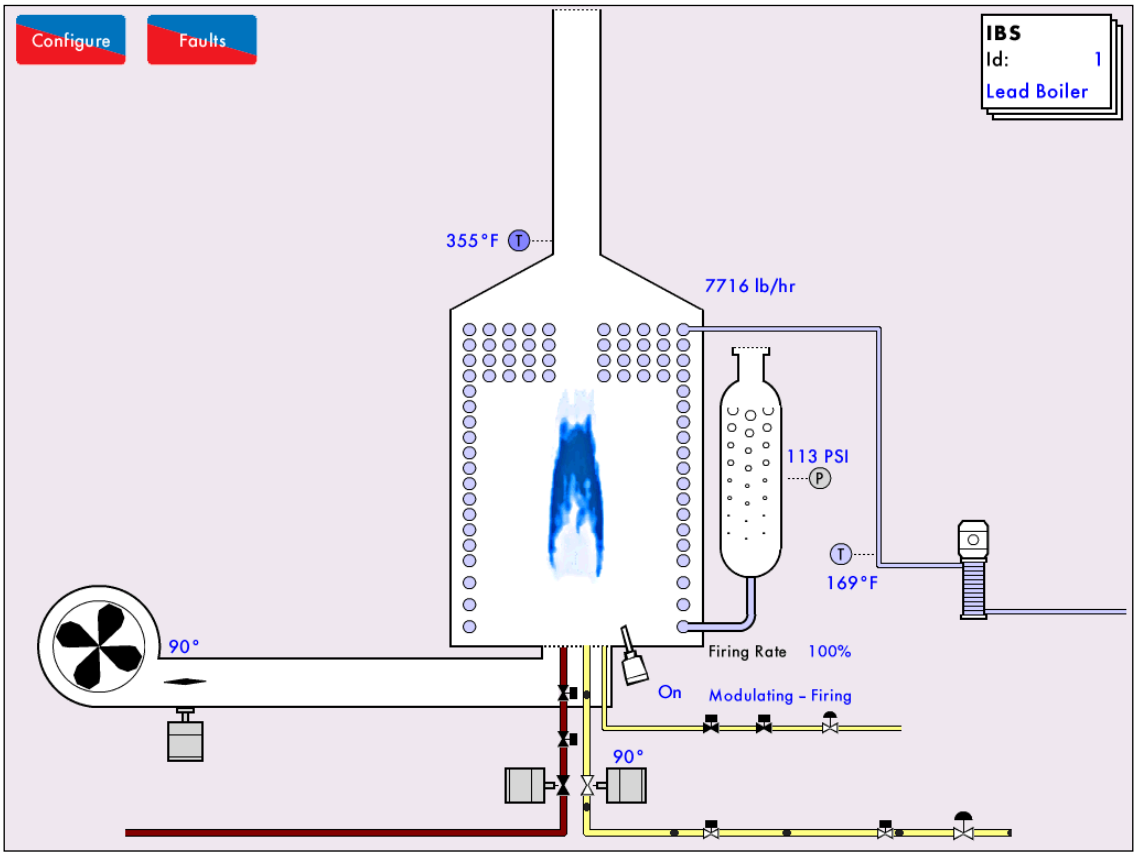


Figure 16.7.B: Spare Temperature Sensor configured to measure exhaust (stack) temperature on a vertical coil-tube steam generator

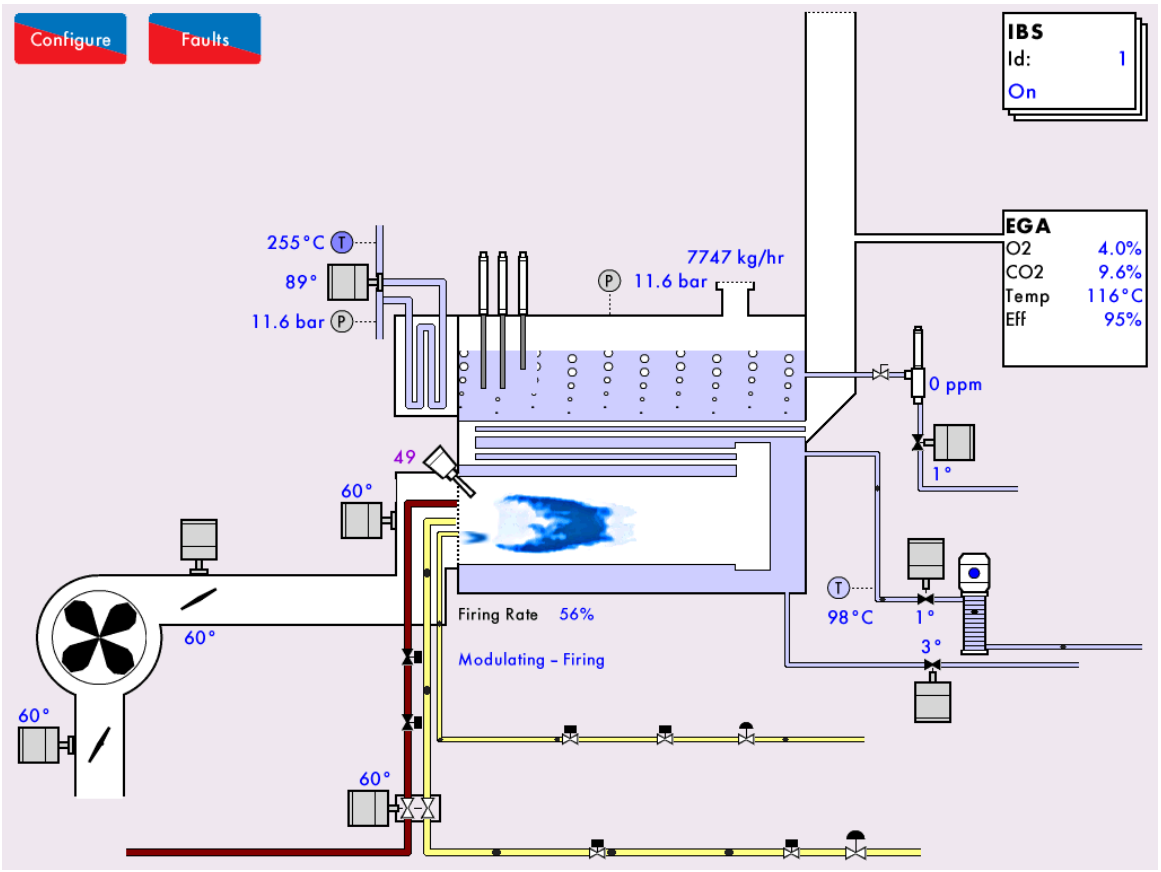


Figure 16.7.C: Spare Temperature Sensor configured for a Superheater Mixing Valve on a three pass fire tube boiler using Steam flow.

16.7.3 Exhaust Temperature Shutdown Threshold

Expansion option 131 allows a spare temperature shutdown threshold to be set. The burner will shutdown and an alarm will be triggered when this threshold temperature is reached. This alarm can only be reset when the spare temperature sensor reading drops below this threshold.

16.8 Faults

The table below show the faults which are directly related to the heat flow function.

Fault	Type	Message	Description
440	Warning	Temperature Sensor T1 Fault	Fault or no comms with T1 sensor
• Check wiring and screen on terminals –and T1			
441	Warning	Temperature Sensor T2 Fault	Fault or no comms with T2 sensor
• Check wiring and screen on terminals – and T2			
442	Warning	Temperature Sensor T3 Fault	Fault or no comms with T3 sensor
• Check wiring and screen on terminals – and T3			
443	Warning	Make Up Flow Meter Fault	Fault or no comms with make up flow meter
• Check wiring and screen on terminals F- and MF			
444	Warning	Condensate Flow Meter Fault	Fault or no comms with condensate flow meter
• Check wiring and screen on terminals F- and CF			
650	Alarm	Coil Temperature Shutdown Threshold	Expansion option 131 threshold has been exceeded
• Check boiler's coil temperature • Check expansion option 131.			
651	Alarm	Exhaust Temperature Shutdown Threshold	Expansion option 131 threshold has been exceeded
• Check the exhaust gas temperature • Check expansion option 131.			

17 FULLY METERED COMBUSTION CONTROL

17.1 Overview

17.1.1 Introduction

The fuel-air mixture determines the combustion performance; poor mixing of the fuel and air reduces the burner's combustion performance, and in turn, decrease the combustion efficiency. High fuel-rich combustion results in incomplete combustion, leaving unburnt fuel in the combustion gas. Unburnt fuel causes soot build-up and releases harmful CO emissions to the atmosphere. Incomplete combustion wastes fuel so additional fuel is required to meet the load demand, causing higher fuel cost.

On the contrast, high amount of excess air in the combustion process wastes the heat generated by the combustion process to heat the excess air and also accelerates the combustion gas travel through the boiler. This in turns require more fuel to meet the demand and wastes fuel and increase costs. The fully metered system is used in applications where it is not possible to measure the exhaust gases in the stack, or if the firing rate is critical to system and controlled remotely.

17.1.2 Importance of Excess Air

In ideal stoichiometric combustion, all the fuel is mixed with the exact amount of air for it to be converted fully to CO_2, H_2O (N_2), releasing heat from the reaction. In the practical world where ideal and laboratory conditions do not always exist, it is necessary to add more air than that required in stoichiometric combustion to ensure complete combustion. The equivalence ratio of the combustion is:

$$Equivalence\ ratio = \frac{stoichiometric\ air\ to\ fuel\ ratio}{current\ air\ to\ fuel\ ratio}$$

$$Equivalence\ ratio\ \emptyset = \frac{\left(m_a/m_f\right)_{stoichiometric}}{\left(m_a/m_f\right)_{current}}$$

Or alternatively, if the volume is known:

$$Equivalence\ ratio\ \emptyset = \frac{\left(n_a/n\right)_{stioichiometric}}{\left(n_a/n_f\right)_{current}}$$

Where n is the number of moles of gas, proportional to the corrected volume.

The excess air is the extra amount of air supplied over the amount of air required for complete combustion, and can be determined from the equivalence ratio:

$$Excess\ air = \frac{1 - Equivalence\ ratio}{Equivalence\ ratio}$$

$$Excess\ air\ \varepsilon = \frac{1 - \emptyset}{\emptyset} \times 100\%$$

This can be converted to the wet exhaust gas O_2 by:

$$O_2 = \frac{21\%}{1 + \left(\frac{1}{\varepsilon}\right)}$$

Higher excess air levels will give higher O_2 values in the exhaust gases. The optimum excess air will depend on the fuel type, the combustion chamber design and the burner turndown. High performance burners will operate at 3% O_2 (dry) when firing on natural gas, which is equivalent to 15% excess air going into the burner, whilst producing 0ppm of CO. The stoichiometric data in the lookup tables of the software gives the excess air based on the fuel and air flow rates, and the calorific value of the fuel.

17.2 Fully Metered Control Expansion Options

The table below shows the Expansion Options used for configuring Fully Metered Control.

#	Default	Range	Description
138	0		FM: Fuel Flow Meter Offset
		0	Disabled
		1 – 2000	-100.0 to +100.0 m^3/hr
139	0		FM: Air Flow Meter Offset
		0	Disabled
		0 – 2000	-100.0 to +100.0 m^3/hr
140	0		FM: Fully Metered Function
			The fully metered function maintains the commissioned heat input and fuel-air ratio based on 4-20mA signals from the fuel and air mass or volume flow meters. External water level sensor and 4-20mA fuel flow feedback must be disabled.
		0	Disabled
		1	Enabled
141	0		FM: Fuel Flow Meter Type
			The fuel-air ratio is derived from the mass flow rates of the fuel and air going into the burner. The fuel flow meter is wired to terminals EX+ and EX-, and the 4-20mA signal is scaled by setting expansion option 142. For setting 0, a volume flow meter is used and a displayed mass flow rate is calculated using either internal constants or via measured temperature/pressures. For setting 1, a mass flow meter is used to the display the mass flow rate, when using a fuel mass flow meter, expansion options 145 and 147 must be set to 0. Setting 2 is the same as setting 0 but for a volume meter with square root extraction included.
		0	Volume flow meter
		1	Mass flow meter
		2	Volume flow meter (with square root extraction)
142	0		FM: Fuel Flow Meter Scaling
			The fuel flow meter is scaled by setting the flow rate at 20mA feedback from the flow meter.
		0 – 65535	0 – 65535 m^3/hr (ft^3/hr)
143	-		FM: Air Flow Meter Type
			The air flow meter is wired to terminals MF and F-, and the 4-20mA signal is scaled in expansion option 144. For setting 0, a volume flow meter is used and a displayed mass flow rate is calculated using either internal constants or via measured temperature/pressures. For setting 1, a mass flow meter is used to the display the mass flow rate, when using a fuel mass flow meter, expansion options 146 and 148 must be set to 0. Setting 2 is the same as setting 0 but for a volume meter with square root extraction included.
		0	Volume flow meter
		1	Mass flow meter
		2	Volume flow meter (with square root extraction)
144	0		FM: Air Flow Meter Scaling
			The air flow meter is scaled by setting the flow rate at 20mA feedback from the flow meter.
		0 – 65535	0 – 65535 $m^£$/hr (0ft^3/hr)

#	Default	Range	Description
145	0		FM: Fuel Temperature Sensor Enable
			The fuel temperature sensor is wired to terminal T3. This cannot be used with the mass flow meters for fully metered, or at the same time as steam/hot water flow metering, see expansion options 141 and 120.
		0	Disabled
		1	Enabled
146	0		FM: Air Temperature Sensor Enable
			The air temperature sensor is wired to terminal T2. This cannot be used with the mass flow meters for fully metered, or at the same time as steam/hot water flow metering, see expansion options 141 and 120.
		0	Disabled
		1	Enabled
147	0		FM: Fuel Pressure Sensor Enable
			The fuel pressure sensor is wired to terminals 31, 32, 33 and 34. This cannot be used with the mass flow meters for fully metered. The pressure sensor can still be used for flame safeguard checking such as high/low pressure limits and VPS.
		0	Disabled
		1	Enabled
148	0		FM: Air Pressure Sensor Enable
			The air pressure sensor is wired to terminals 31, 32, 33 and 34. This cannot be used with the mass flow meters for fully metered. The pressure sensor can still be used for flame safeguard checking such as high/low pressure limits and VPS.
		0	Disabled
		1	Enabled
149	100		FM: Maximum Fuel Channel Compensation (Firing Rate)
			This is the maximum percentage of the fuel servomotor angle which the MM will move towards the closed and open position to maintain the commissioned firing rate (heat input). The fuel servomotor angle will never exceed commissioned high fire position or go below the commissioned low fire position.
		0 – 100	0.0% - 10.0%
150	100		FM: Maximum Air Channel Compensation (Fuel/Air Ratio)
			This is the maximum percentage of the air servomotor angle which the MM will move towards the closed and open position to maintain the commissioned fuel-air ratio. The air servomotor's movement ranges from the commissioned closed position to the commissioned open to close positions.
		0 – 100	0.0% - 10.0%
151	0		FM: Action on Air Adjustment Failure
			If after the air servomotor has made adjustments to compensate for the changes in the flow rate, and the fuel-air ratio cannot still be met, an alarm or warning will occur. For setting 0, the MM generates an alarm and will lockout the burner upon on an air adjustment failure. For setting 1, the MM generates a warning. For setting 2, the MM generates a warning and disables the air adjustment and the air servomotor returns to the original commissioned curve.
		0	Generate alarm
		1	Generate warning
		2	Generate warning, disable air adjustment

#	Default	Range	Description
152	0		FM: Action on Flow Meter Failure
			If one of the flow meters loses communications with the MM or has a fault, the MM can either generate alarm and lockout the burner, or generate the warning and revert to the commissioned curve with no fuel and air servomotor trim adjustments.
		0	Generate alarm
		1	Generate warning
153	1013		FM: Default absolute ambient air pressure
			The default ambient air pressure must be set when using volume flow meters, to derive the mass flow rate used to calculate the fuel-air ratio.
		1013	1013 mbar (406.5" WG)
		850 – 1100	mbar (341.1 – 441.5"WG)
154	656		FM: Fuel 1 Density
			The fuel density must be set when using volume flow meters, to derive the mass flow rate used to calculate fuel-air ratio. This is at 1013mbar, 15^{0}C (14.69 PSI, 59^{O}F)
		656	0.656 kg/m^3 at 1013mbar, 15^{0}C (0.041 lb/ft^3)
		1 – 10000	0.001 – 10.0 kg/m^3 (0.00006 lb/ft^3 – 0.625 lb/ft^3)
155	656		FM: Fuel 2 Density
			The fuel density must be set when using volume flow meters, to derive the mass flow rate used to calculate fuel-air ratio. This is at 1013mbar, 15^{0}C (14.69 PSI, 59^{O}F)
		656	0.656 kg/m^3 at 1013mbar, 15^{0}C (0.041 lb/ft^3)
		1 – 10000	0.001 – 10.0 kg/m^3 (0.00006 lb/ft^3 – 0.625 lb/ft^3)
156	656		FM: Fuel 3 Density
			The fuel density must be set when using volume flow meters, to derive the mass flow rate used to calculate fuel-air ratio. This is at 1013mbar, 15^{0}C (14.69 PSI, 59^{O}F)
		656	0.656 kg/m^3 at 1013mbar, 15^{0}C (0.041 lb/ft^3)
		1 – 10000	0.001 – 10.0 kg/m^3 (0.00006 lb/ft^3 – 0.625 lb/ft^3)
157	656		FM: Fuel 4 Density
			The fuel density must be set when using volume flow meters, to derive the mass flow rate used to calculate fuel-air ratio. This is at 1013mbar, 15^{0}C (14.69 PSI, 59^{O}F)
		656	0.656 kg/m^3 at 1013mbar, 15^{0}C (0.041 lb/ft^3)
		1 – 10000	0.001 – 10.0 kg/m^3 (0.00006 lb/ft^3 – 0.625 lb/ft^3)
158	0		FM: Action on Fuel Adjustment Failure
			If after the fuel servomotor has made adjustments to compensate for the changes in the flow rate, and the fuel-air ratio cannot still be met, an alarm or warning will occur. For setting 0, the MM generates an alarm and will lockout the burner upon on a fuel adjustment failure. For setting 1, the MM generates a warning. For setting 2, the MM generates a warning and disables the fuel adjustment and the fuel servomotor returns to the original commissioned curve.
		0	Generate Alarm
		1	Generate Warning
		2	Generate Warning, Disable Fuel Adjustment

#	Default	Range	Description
159	0		FM: Flow Meter Filter Length
			This is the time period over which the Flow Meter readings are filtered over time. If there is excess fluctuation in the flow readings, increase the filter time. To improve the system's response to changes in flow, decrease the filter time.
		0	1s
		1 – 60	1s to 60s

17.3 Fully Metered Combustion Control Operation

17.3.1 Philosophy

The fully metered system will add a layer on top of the standard commission map, with the aim of maintaining the fuel-air ratio for each firing rate. The system can either directly measure mass flow or use corrected volume flows to maintain this ratio.

The Mk8 MM continuously measures the fuel and air flows to compensate for any variations from stored values, in an effort to maintain the commissioned burner efficiency. To compensate for changes, the MM will trim the air damper position to try to maintain the commissioned excess air. In addition, the MM will move the fuel valve, to try to achieve the firing rate required to maintain the commissioned heat input.

The fully metered combustion control works with the commissioned fuel valve and air damper positions, storing the mass or volume flow of the fuel and air at each point. The flow data is recorded using two 4-20mA inputs, which can be the data from a mass flow meter or calculated from volume flow meter. When using a volume flow meter, the fuel density is used to calculate and display a mass flow using either default values or temperature and Autoflame pressure sensors.

If variations occur from the commissioned fuel or air flow, the MM will trim servomotors up to an option limited percentage of their commissioned positions at that time. Unlike other systems, the Autoflame fully metered operation is based on the commissioned fuel-air curve, so combustion deviations are compensated for faster than those systems without a base firing curve. Should any faults occur with the meters, the control can be optioned to revert to the default fuel-air curve to allow the burner to continue to run.

As the fuel valve moves to reach the commissioning firing rate, based on the measured mass flow rate, the air damper will also adjust to achieve the commissioned excess air, due to the proportional change required in air flow.

17.3.2 Firing Rate

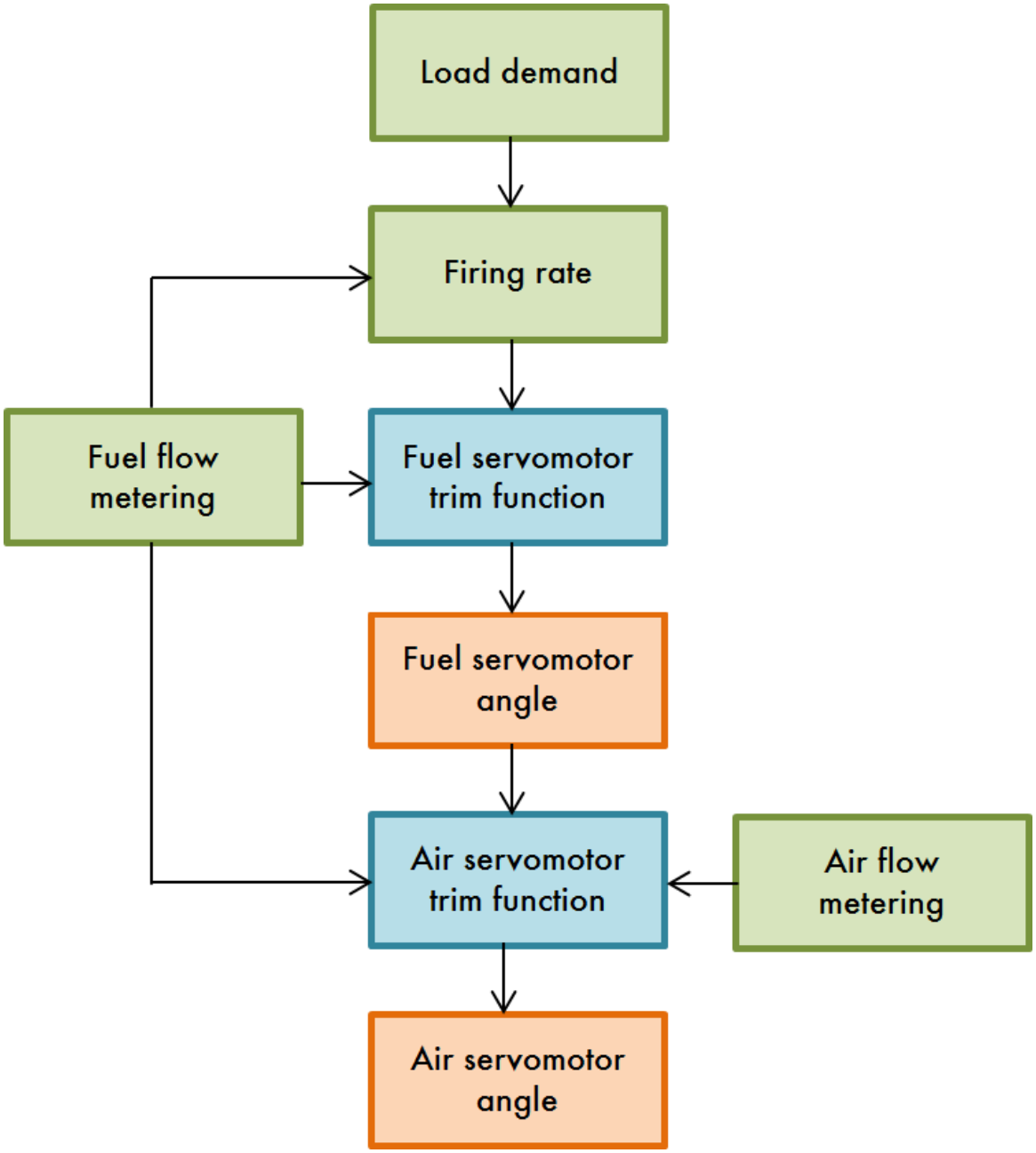
When measuring the mass flow, the control process will aim to maintain the same fuel-air ratio as the commissioned fuel flow and air flow ratio. The burner's firing rate can be controlled by the Autoflame internal PID, external modulation, hand mode, DTI firing rate or Modbus firing rate. Without fully metered combustion control, the MM would map the fuel valve angle through the fuel flow curve, whereas with this control, the fully metered system firing rate is proportional to the mass flow. The firing rate is then determined by:

$$Firing\ rate = \frac{Current\ mass\ fuel\ flow\ rate}{Maximum\ mass\ fuel\ flow\ rate} \times 100\%$$

The maximum mass fuel flow rate is the fuel flow rate recorded at the high fire position during commissioning. From this, once the burner commission is complete, the fuel flow curve is mapped out automatically based on the formula above. This means that if the flow meters fail, the MM can revert back to the default behaviour and use the pre-stored fuel flow curve. Also, if after commission the high fire position was moved in single point change, the MM will update the fuel flow curve automatically.

17.3.3 Control Process

The air servomotor will trim to maintain the commissioned fuel-air ratio. The fuel servomotor will trim to maintain the commissioned firing rate. Both of these control function operate independently if fully metered combustion control is enabled.



17.3.4 Mass Flow Meters

When using mass flow meters, the fuel and air rates displayed on the MM, are based on the 4- 20mA input signals from the mass flow meters. The control process will aim to maintain the same fuel-air ratio as those set during the commissioning process.

If the fully metered system is set with a fuel mass flow meter, then the fuel temperature and pressure sensors are not required for the fully metered control; however, the pressure sensor can still be used for VPS and high/low pressure limits. If an air mass flow meter is used, then again, the air temperature and pressure sensors are not required; however, the air pressure sensor can still be used for air pressure checking during burner start-up e.g. purge air pressure proving.

The calorific value of the fuel is used to calculate the excess air, so this must be entered accurately.

17.3.5 Volume Flow Meters

When using volume flow meters for the fuel and mass flow rate information, corrections need to be applied to derive the mass flow rate. The MM calculates the mass flows using the fuel density and calorific value; these must be set accurately for the fuel being metered. If a differential pressure sensor is being used the system can be optioned to perform square root extraction on the input, thus saving an external converter.

Based on the ideal gas flow, assuming that the humidity and the specific gas constant do not vary, the mass flow rate is related to the volume flow rate by the following equation:

$$Mass\ flow\ rate\ \propto \frac{Pressure}{Temperature} \times Volume\ flow\ rate$$

$$\dot{m} \propto \frac{P}{T}$$

This formula is used internally in the MM to calculate a mass flow rate. This is calculated individually for both gas and air in the MM using the following assumptions:

Variable	Action
Ambient air pressure	Average ambient pressure, set in expansion option 153
Differential air pressure	Air pressure correction not used (assumed 20mbar)
Air temperature	Air temperature correction not used (assumed 20^{O}C)
Gas pressure	Gas pressure correction not used (assumed 100mbar)
Gas temperature	Gas temperature correction not used (assumed 5^{O}C)

If additional Autoflame temperature and pressure sensors are used on either or both the gas and air, then the calculated mass flow rate displayed will be more accurate. In the event of a sensor failure, the temperature/pressure value of the failed sensor that was stored at commissioning of value is used to calculate the displayed mass flow rate allowing the system to continue to run. If the gas and air pressure sensors are used also used for the VPS, gas pressure limits or air sensors limits, then the burner will lockout in the event of a sensor failure.

17.4 Set-Up

17.4.1 Configuration

At minimum the MM will require 4-20mA signals from the air and gas flow meters. If using mass flow meters, then temperature and pressure sensors for the fuel and air must be disabled for fully metered (they can still be used for flame safeguard). Volume flow metering requires the fuel air and temperature and pressure values to derive the mass flow rates. When using volume flow metering, enabling temperature and pressure sensors will make the displayed mass flow calculation more accurate. Temperature and pressure sensors should be installed near the volume flow meters.

The table below shows the MM terminals used for fully metered combustion control.

Terminal	Description	Function
T2	T2 temperature sensor	Fuel temperature
-	Common	Common for T2
T3	T3 temperature sensor	Air temperature
-	Common	Common for T3
F-	Common	Common for MF
MF	Make-up flow meter 4-20mA	Air flow rate
EX-	Common	Common for EX+
EX+	4-20mA	Gas flow rate
31	Digital input signal (brown)	Gas/ air pressure sensors
32	Digital input reference (purple)	
33	DC neutral (blue)	
34	DC power (red)	

When wiring the gas and air pressure sensors, the screen is connected through the casing of the lead and through the sensor; therefore the flying lead should be connected to the MM without a screen. The screen should be carried through until the connection to the MM; the screen should not be connected to the S terminal.

The table below shows the options/expansions options to be set for fully metered combustion control.

Option	Description	Setting
57	Fuel flow metering	1
61	Fuel 1 calorific value	Must be set accurately
62	Fuel 2 calorific value	Must be set accurately
63	Fuel 3 calorific value	Must be set accurately
64	Fuel 4 calorific value	Must be set accurately
Expansion Option	**Description**	**Setting**
140	Fully metered function	1
141	Fuel flow meter type	As required
142	Fuel flow meter scaling	As required
143	Air flow meter type	As required
144	Air flow meter scaling	As required
145	Fuel temperature sensor enable	Optional
146	Air temperature sensor enable	Optional
147	Fuel pressure sensor enable	Optional
148	Air pressure sensor enable	Optional
149	Maximum fuel channel compensation	As required
150	Maximum air channel compensation	As required
151	Action on air adjustment failure	As required
152	Action on flow meter failure	As required
153	Default ambient air pressure	As required
154	Fuel 1 density	Required for volume flow meter
155	Fuel 2 density	Required for volume flow meter
156	Fuel 3 density	Required for volume flow meter
157	Fuel 4 density	Required for volume flow meter

The current firing rate can be fed back to an external system via a 4-20mA output signal on terminals 16, 17 and 18.

17.4.2 Limitations

When using a volume flow meter, the mass flow rate is calculated using the volume flow rate and either default pressure and temperature values, or the measured pressure and temperature values.

The MM's fully metered combustion control is capable of controlling the most common hydrocarbon fuels including methane, ethanol, ethane, butane, pentane, acetylene and 1-proponal.

For FGR, oxy fuels, hydrogen and special fuels, please contact Autoflame prior to use.

The fully metered combustion control will not work on oil combustion curves.

If fully metered combustion control is used, then neither an external 4-20mA sensor for auxiliary water level control nor external fuel flow metering using 4-20mA input can be used. When using the fully metered system, the fuel flow metering is automatically calculated from the flow rate.

If an EGA is optioned, a conflict will occur if 3-parameter trim is activated.

The gas/air pressure sensor recommission feature is not available when using volume flow meters, if these pressure sensors need to be recommissioned; a full recommission of the burner is required. This is due to the pressures needing to be stored at the same time as the required volume flow.

Economiser or deaerator options for steam/heat flow metering cannot be used if the temperature sensors or make-up flow meter inputs are being used for volume flow metering. The IO module can be used instead for deaerator.

During running the system can adjust the channel 2 air servomotor from the commissioned closed and open positions to bring the combustion to the commissioned fuel-air ratio, as the fuel servomotor moves. However,the rest of the channels can only be moved from the low fire and high position, and not outside of this range. This means that if the fuel servomotor is at the commissioned high fire position, it cannot move further. The firing rate is limited to less than 100% and if it is critical to the system operation, then the actual firing rate should be monitored.

The calorific value must be entered corrected to the 1013mbar and 15^{O}C, see options 61 to 64.

17.4.3 Commissioning

Important Note:

Prior to commissioning, the fuel and air servomotors must be calibrated to ensure that the position of the valves and damper correspond to the potentiometer feedback signal as displayed on the MM. When the valve is fully closed, the MM should display zero degrees. If it does not, please adjust the servomotor potentiometer.

The commissioning procedure as described must be strictly adhered to. Anybody commissioning an MM must be trained in operating combustion equipment safely. The Autoflame products must only be installed, set up, commissioned and adjusted by an Autoflame certified technical engineer.

The fundamental idea of the system is to set a fuel valve position and then set a corresponding air damper position. Care must be taken when adjusting the fuel and air positions so as not to create any unstable or hazardous combustion conditions, e.g. moving the fuel valve to the open position without increasing the air damper position. Improper use may result in property damage, serious physical injury or death.

The equivalence ratio and excess air provided on the MM are calculated displays based on setup and inputs from external sources. The exhaust gases should be monitored using a combustion analyser at all times during commissioning and for any changes to the combustion curve.

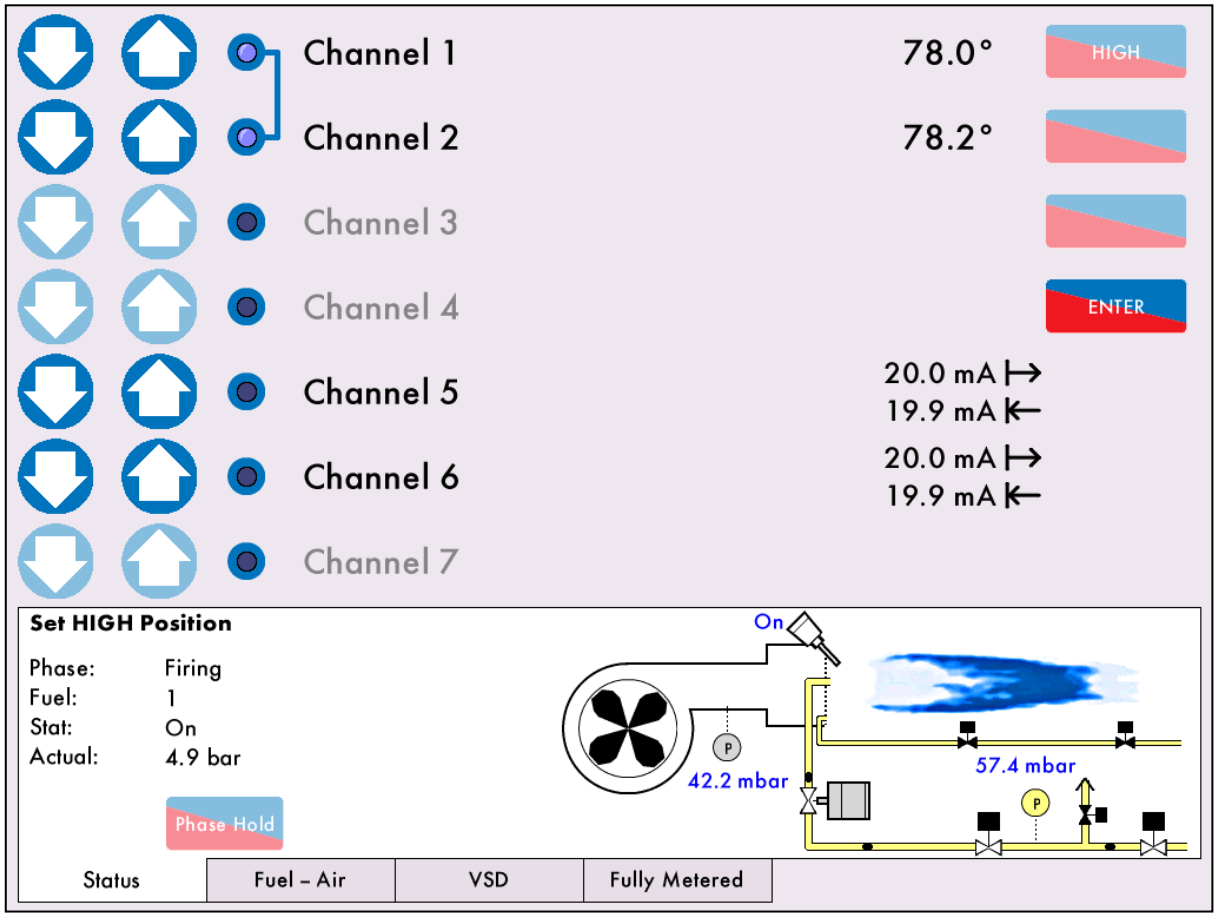


Figure 17.4.3.i Set HIGH Position

For the installation and pre-commissioning checks, please refer to sections 3.2 and 3.3.

The same commissioning procedure for the fully metered combustion control system as the standard system's servomotors and VSDs. The difference is that the commissioning engineer can see on the screen the excess air going into the combustion process and can set the servomotors and VSDs accordingly.

The screen above shows the HIGH position for the servomotors and VSDs being set.

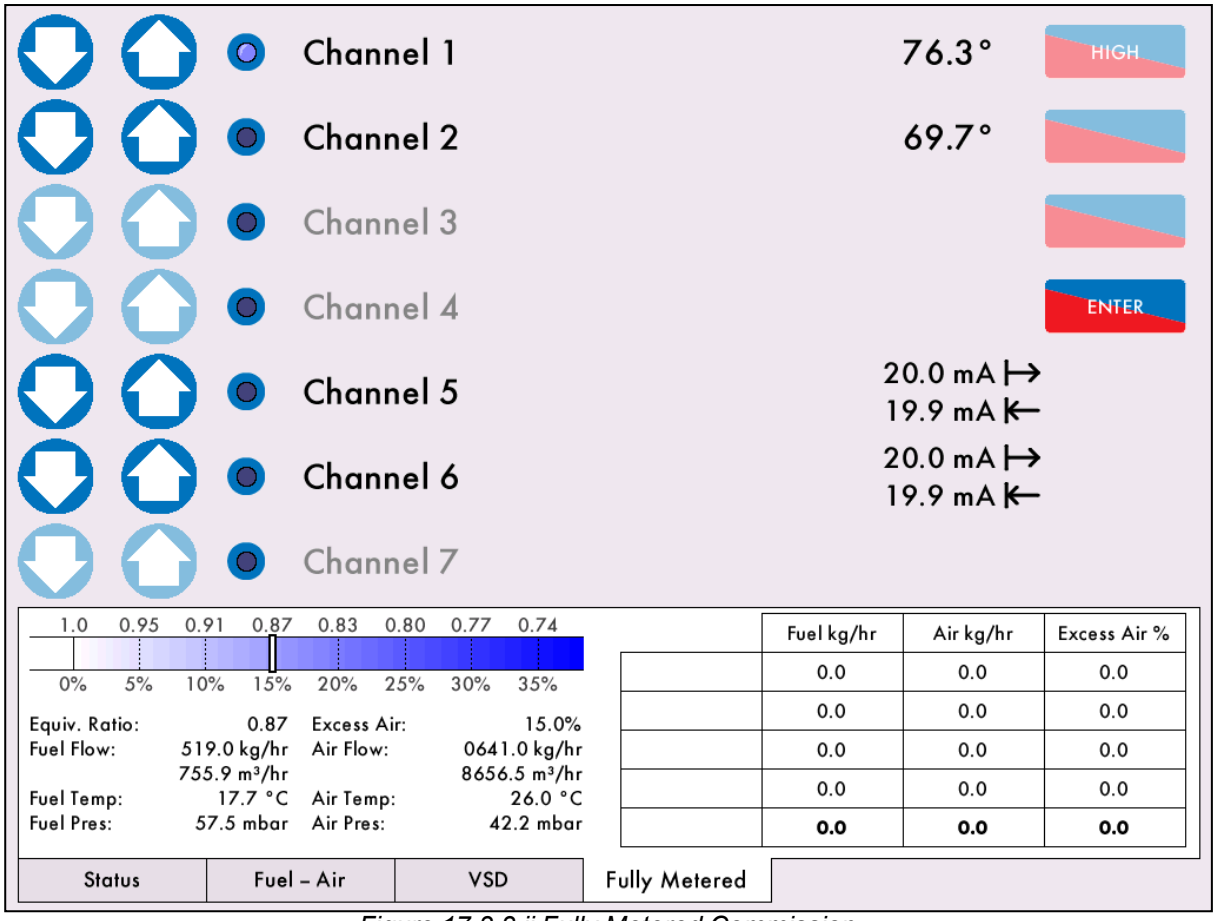


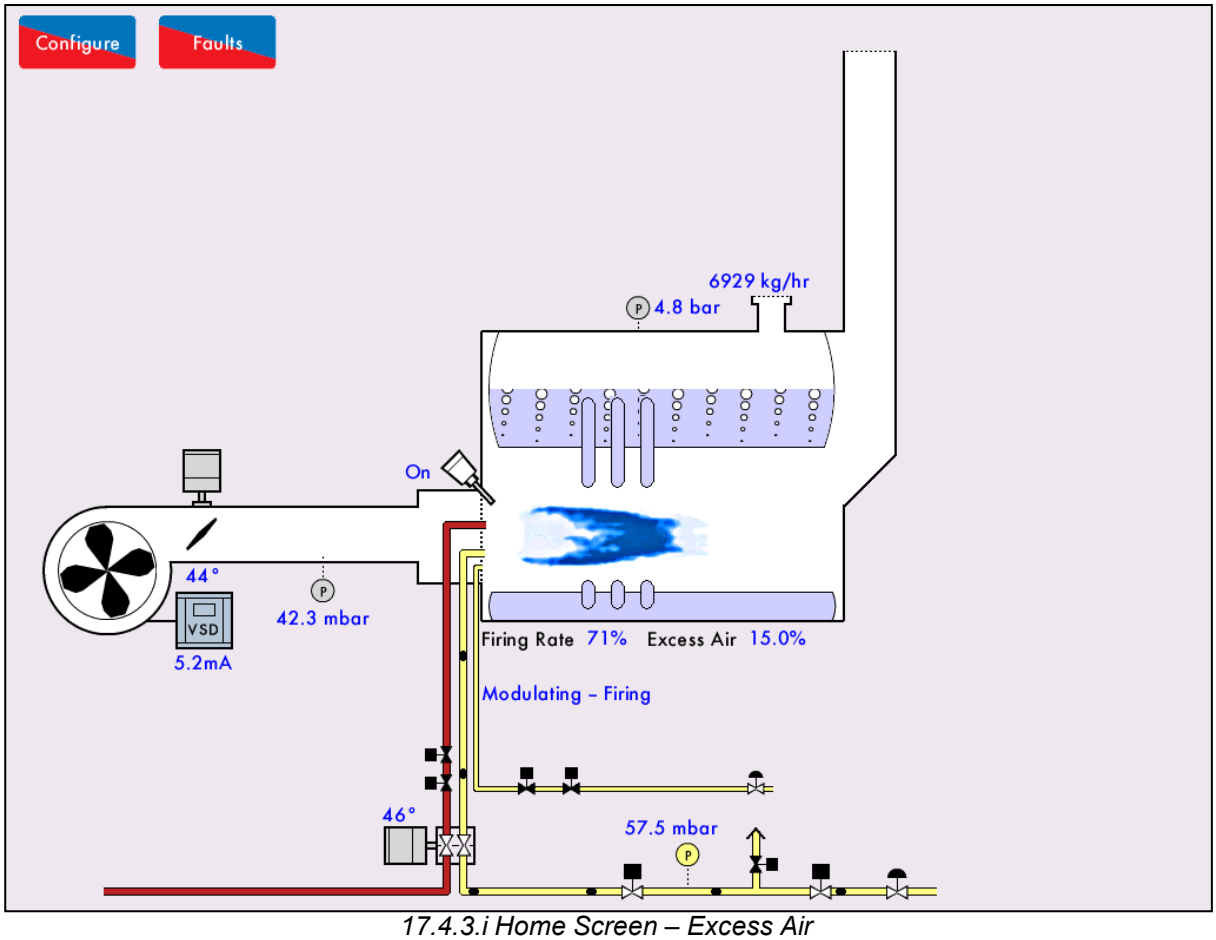
Figure 17.3.3.ii Fully Metered Commission

Pressing on the fully metered tab in the commission screen can show the following, based on how the system has been set:

- Equivalence ratio ϕ.
- Fuel flow rate (mass, volume).
- Fuel temperature.
- Fuel pressure.
- Excess air ε.
- Air flow rate (mass, volume).
- Air temperature.
- Air pressure.

The table will populate mass flow rates of the fuel and air, and the excess air, for each commissioned point.

The commissioned points can be changed/added/removed in single point change as normal, please see section 3.7 for more information. Note, if the sensors or the flow meters have a fault, then single point change feature is disabled.



17.4.3.i Home Screen – Excess Air

The home screen will display the current excess air going into the combustion process.

Pressing on the servomotors will show the fuel-air screens with the following information available:

- Current fuel and air mass flow rates
- Current fuel and air volume flow rates
- Current fuel and air temperatures
- Current fuel and air pressures
- Current fuel and air correction % to maintain the fuel-air ratio at that firing rate
- Current equivalence ratio
- Current excess air
- Commissioned excess air

17.5 Faults

The table below show the faults which are directly related to the fully metered combustion control function.

Fault	Type	Message	Description
550	Alarm/Warning – exp. option 152	Fuel Flow Meter Fault	Less than 3mA signal received from fuel flow meter
• Check wiring and screen on terminal MF and F- • Warning if expansion option 152 is set to 1 and MM will use the commissioned value without any fuel or air servomotor adjustment			
551	Alarm/Warning – exp. option 152	Air Flow Meter Fault	Less than 3mA signal received from air flow meter
• Check wiring and screen on terminal EX+ and EX- • Warning if expansion option 152 is set to 1 and MM will use the commissioned value without any fuel or air servomotor adjustment)			
552	Warning	Fuel Temperature Sensor Fault (T2)	Fault or no comms with T2 sensor
• Warning – MM will use commissioned temperature • Check wiring and screen on terminals – and T2			
553	Warning	Air Temp Sensor Fault (T3)	Fault or no comms with T3 sensor
• Warning – MM will use commissioned temperature • Check wiring and screen on terminals – and T3			
554	Warning	Fuel Pressure Sensor Fault	Fault or no comms with fuel pressure sensor
• Check wiring and screen on terminals 31 – 34 • If warning generate, MM will use commissioned value • Lockout if option/parameters 125/126/127/128 is set for VPS high/low pressure limits in flame safeguard			
555	Warning/Lockout – option 148	Air Pressure Sensor Fault	Fault or no comms with air pressure sensor
• Check wiring and screen on terminals 31 – 34 • Lockout if option 148 is set for air pressure sensor in flame safeguard			
560	Alarm/Warning – exp. option 151	Fully Metered Air Adjustment Failure	Air adjustment has reached limit and fuel-air ratio still not met
• Check for changes affecting combustion including fuel/air pressure, temperature etc. • Warning if expansion option 151 is set to 1 • Warning and air adjustment is disabled if expansion option 151 is set to 2			

18 OPERATION

18.1 Home Screen

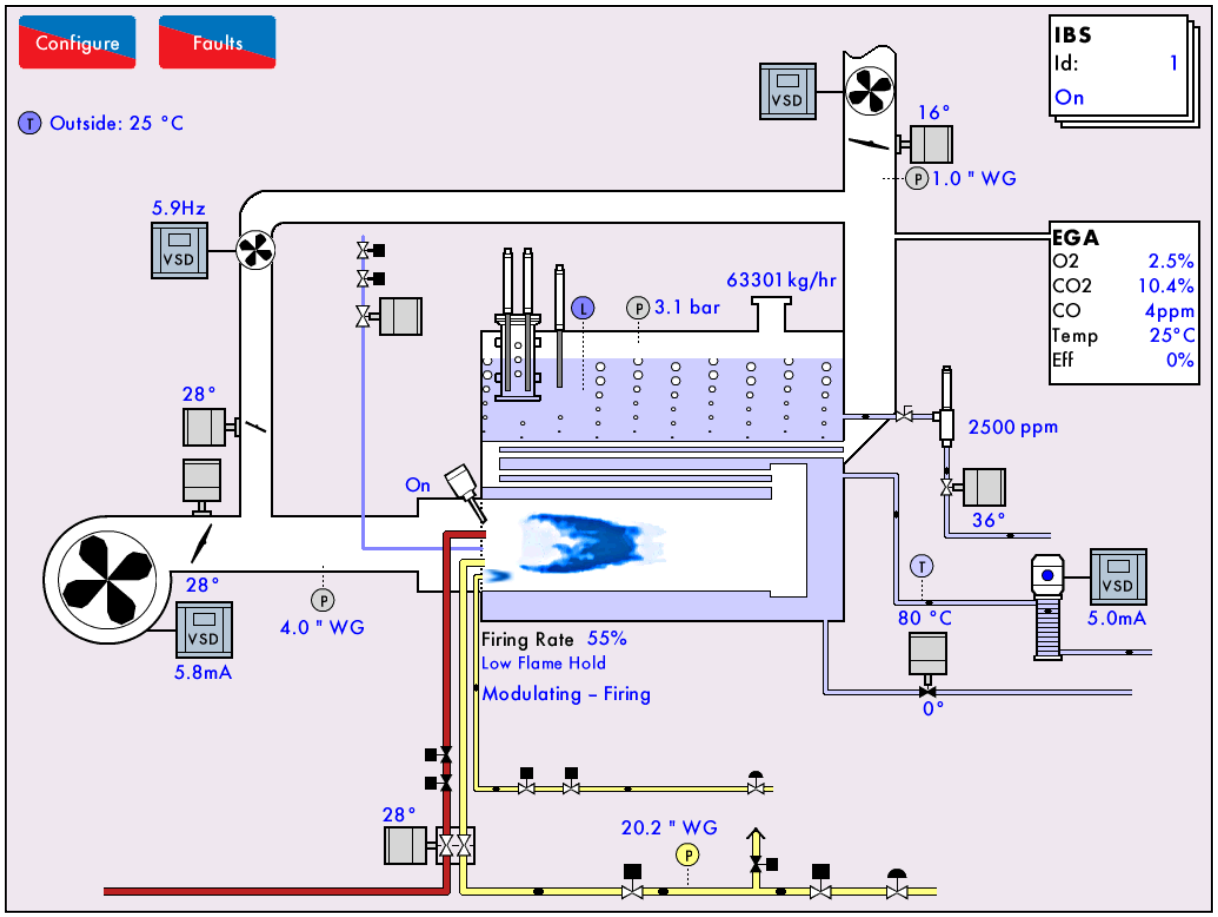
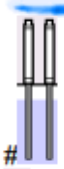
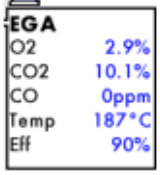
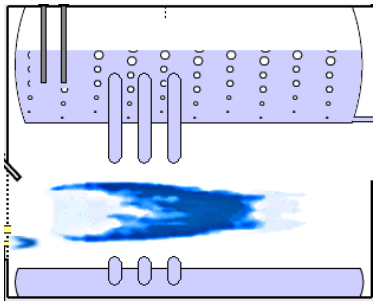


Figure 18.1.i Home Screen

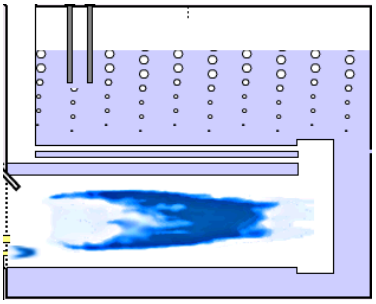
The home screen shown in Figure 18.1.i displays the current boiler setup. It provides operation information for each component of the burner/boiler in real time. Pressing on components will display further information e.g. pressing on the servomotor image will show the servomotor position history. This boiler room setup can be configured to display what is actually on site, please see section 18.19.5 Boiler Room Configuration.

18.1.1 Home Screen Components

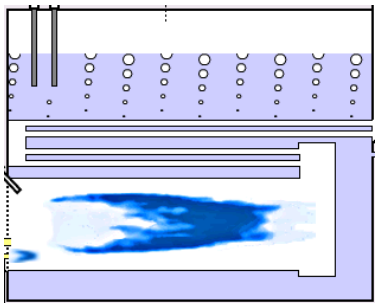
	Servomotor		Variable speed drive
	Flame scanner		Oil pressure sensor
	Air pressure sensor/ boiler steam pressure detector		Gas pressure sensor
	Boiler temperature detector/ outside temperature sensor		Feed water temperature sensor
	Main fuel valve open		Main fuel valve closed
	Pilot gas valve open		Pilot gas valve closed
	Control fuel valve open		Control fuel valve closed
	Main gas regulator		Pilot gas regulator
	Gas flowing		No gas flowing
	Oil flowing		No oil flowing
	Combustion air fan		Induced draught fan
	Gas flame		Oil flame
	Capacitance probes		2nd Low conductivity probe
	External level sensor for water level		Steam header
	TDS probe		Feed water pump
	IBS Information		EGA Information



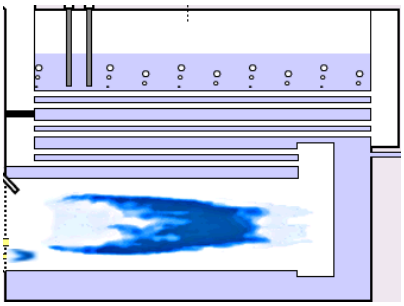
Water tube



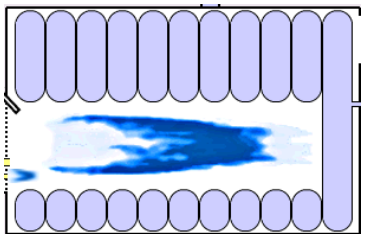
Two Pass Fire Tube



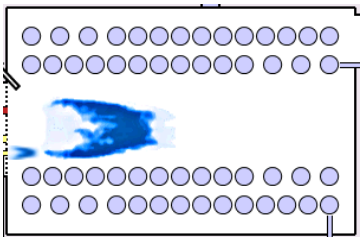
Three Pass Fire Tube



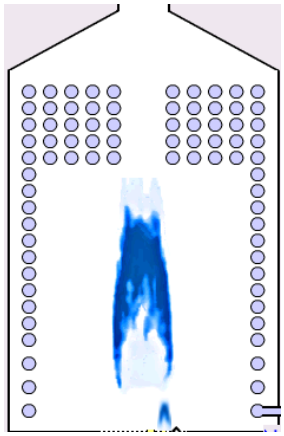
Four Pass Fire Tube



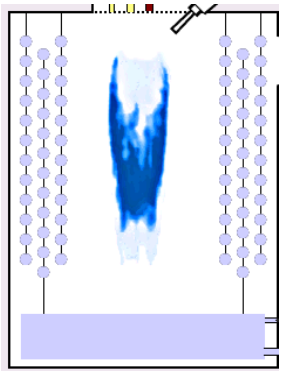
Cast Sectional Tube



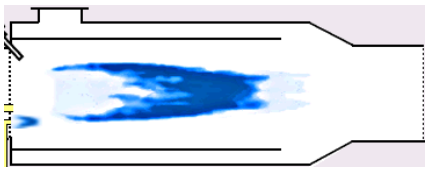
Horizontal Coil Tube



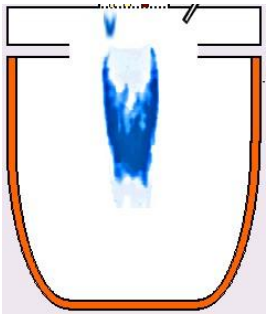
Vertical Coil Tube



Vertical Condenser



Kiln



Crucible

18.1.2 Faults



Figure 18.1.2.i Lockouts

Press 

in the Home screen to view the faults, which are categorised into lockouts, errors, alarms, warning and first out alarms, and are access by pressing on the corresponding tabs.

Fault	Type	Shuts Down Burner	Reset By
Lockout	Burner control fault	Yes	Reset button or input on T56
Error	Internal or hardware fault	Yes	Power cycle
Alarm	Critical system fault	Yes	Reset button or input
Warning	Non-critical fault	No	Reset button
First out	Configurable fault	Optional	Reset button/ auto

18.2 Status Screen

18.2.1 Status

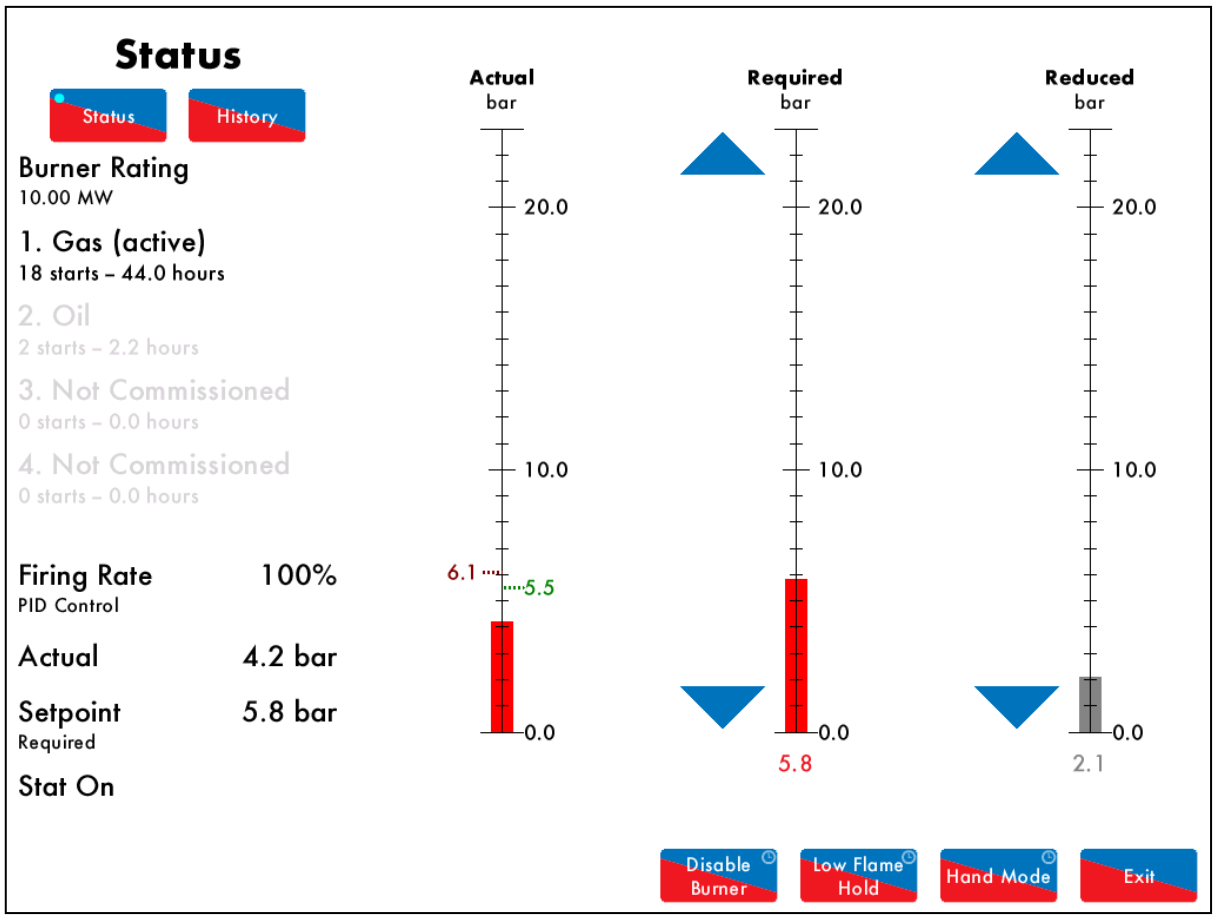


Figure 18.2.1.i Status

Press on the boiler load detector or the boiler image in the Home screen (Figure 18.1.i) to display the Status screen, which gives the following information:

- Burner rating
- Current fuel selected and type
- Burner starts and run hours
- Current firing rate
- Control method – internal PID control, external modulation or DTI/remote firing rate
- Actual temperature/pressure reading from load detector
- Current setpoint – required, reduced, DTI or external
- Stat status – running interlock T53/ internal stat
- Burner switch on/off offset
- Reduced setpoint
- Indication if MM is firing to meet required or reduced setpoint (red = active, grey = inactive)
- Arrows for adjusting setpoint

Press the  arrows to change the required or reduced setpoints. If these arrows are not displayed, then either the user setpoint change has been disabled (option 15), the DTI is controlling the setpoint (option 16), external setpoint is enabled (parameter 72), or OTC is enabled (option 80).
Note: Use parameters 29 and 30 to adjust the load detector reading if required.

18.2.2 Status – History

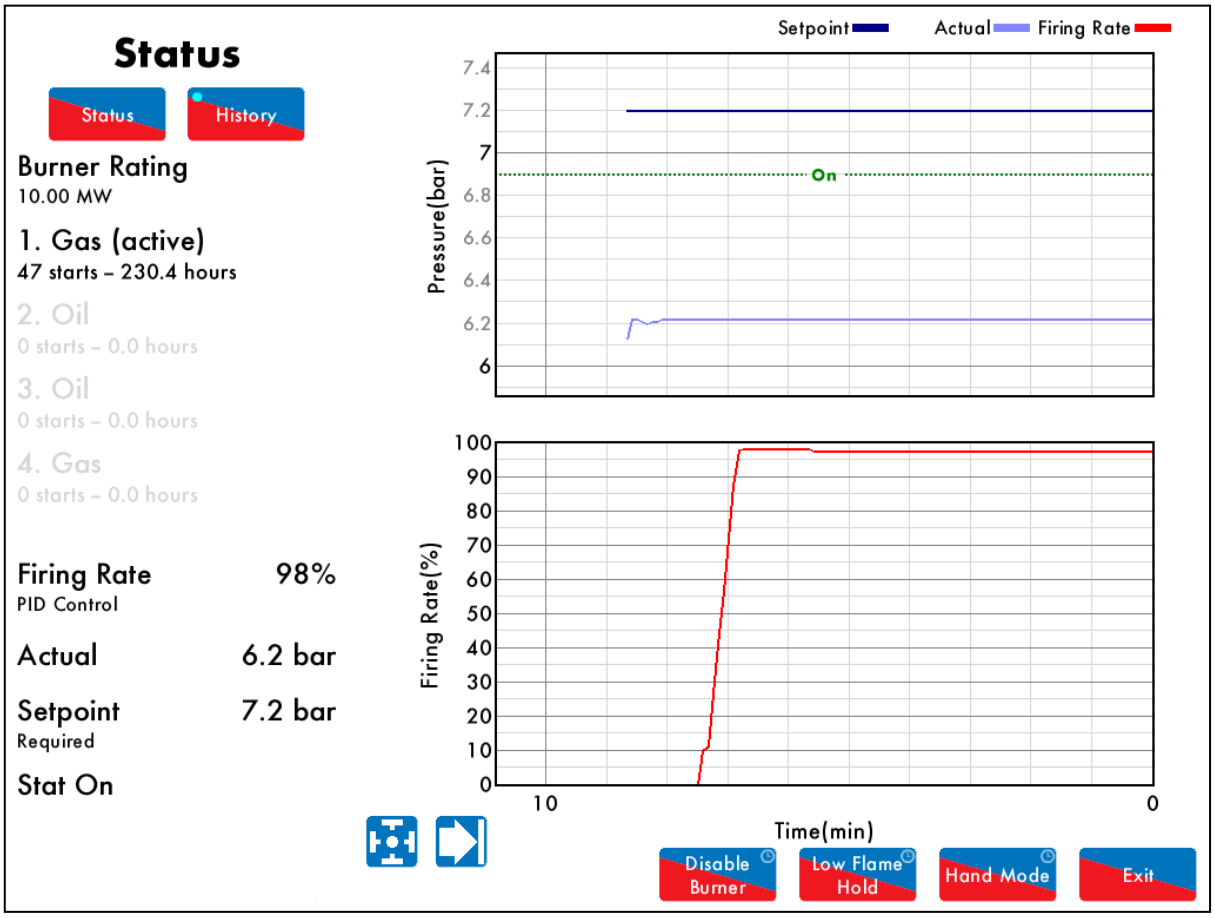


Figure 18.2.2.i Status – History

Press 

in the Status screen in Figure 18.2.1.i to show the Status History. The setpoint, actual temperature/pressure and firing rate are displayed graphically.

This data is logged for 24 hours on the MM. Use the  buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

18.2.3 Status – Burner Enable/Disable

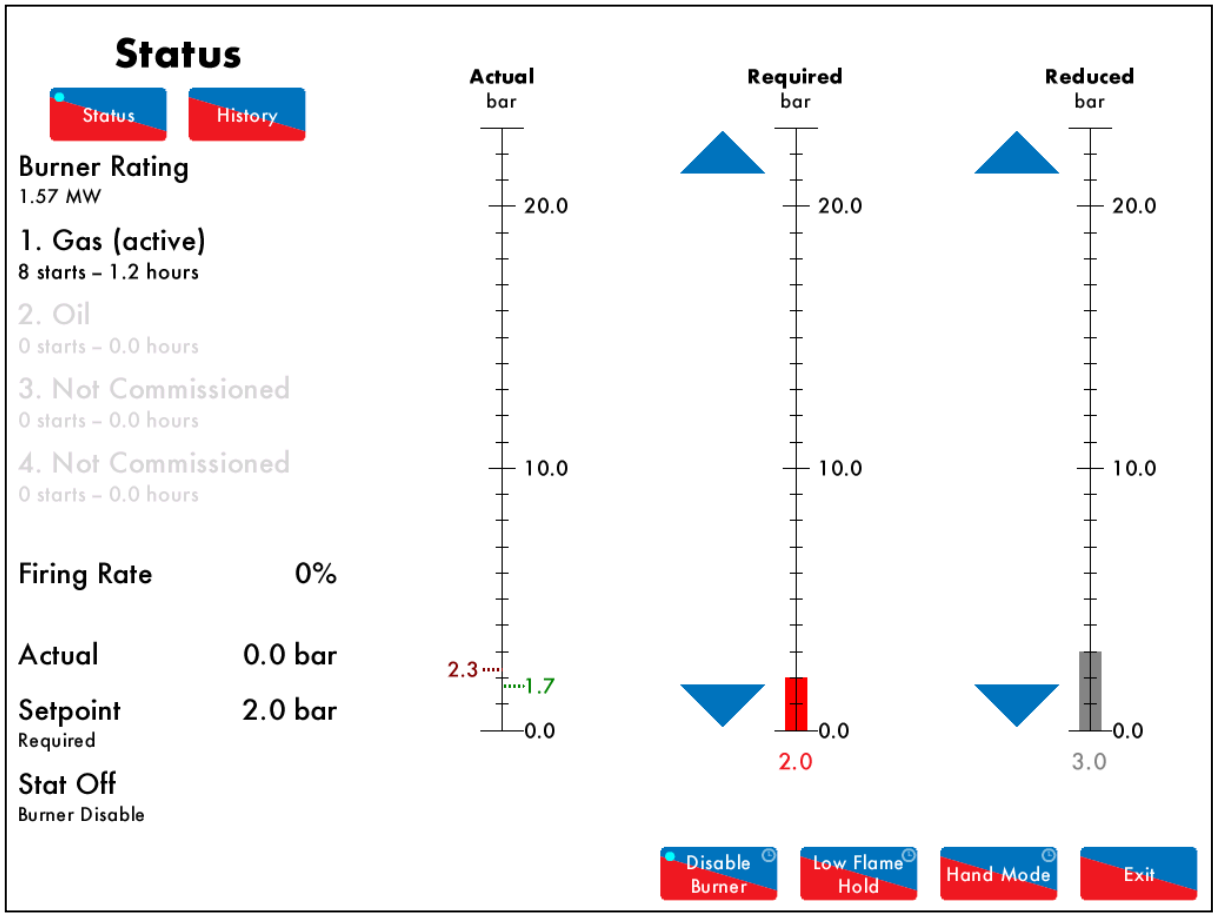


Figure 18.2.3.i Status – Burner Enable/Disable

Press and hold 

for 3 seconds in the Status screen in Figure 18.2.1.i to disable the burner. Press and hold this same button to enable the burner.

18.2.4 Status – Low Flame Hold

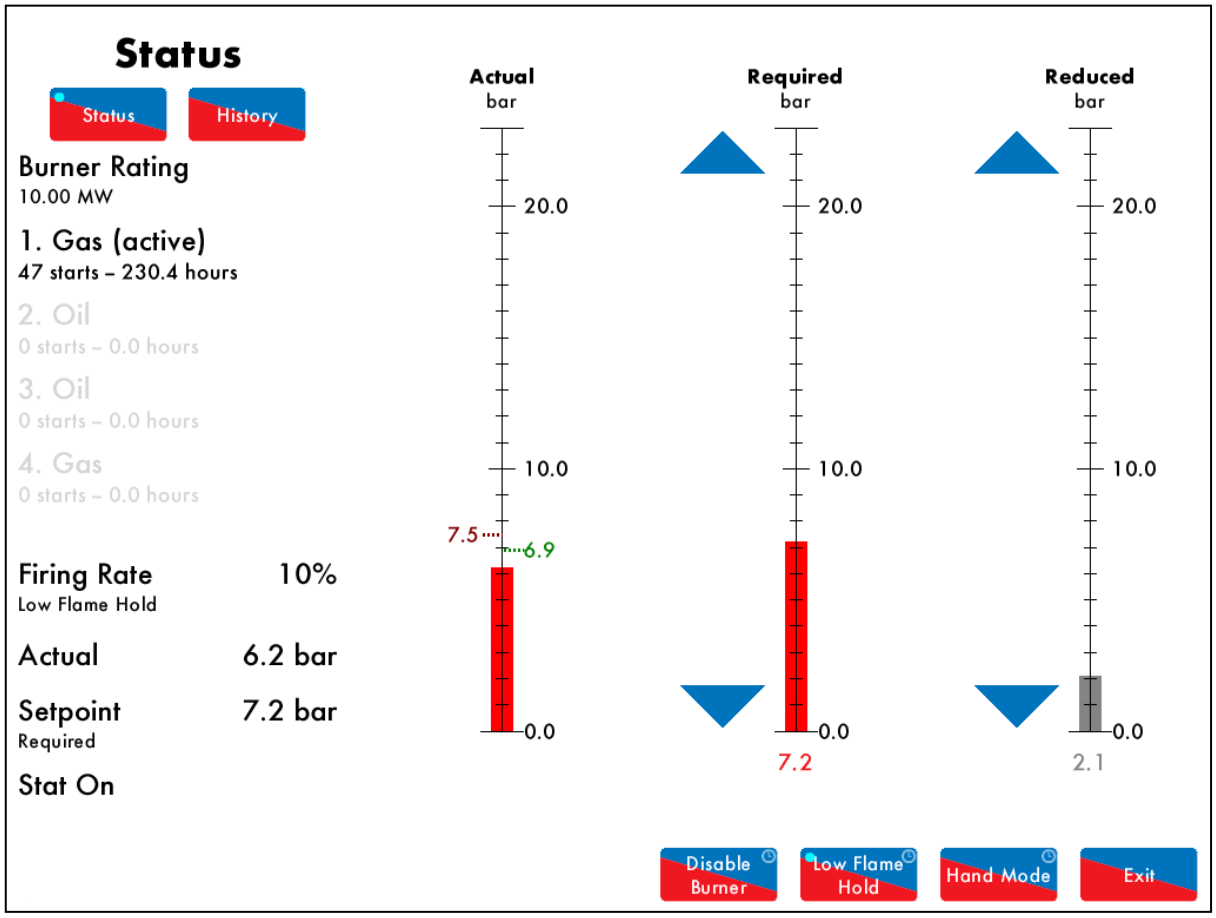


Figure 18.2.4.i Status – Low Flame Hold

Press and hold Low Flame Hold for 3 seconds in the Status screen in Figure 18.2.2.i to put the MM in low flame hold. Press and hold this button again to return to normal modulation.

Alternatively, the Mk8 MM can also be put in low flame hold via an input on terminal 95.

If low flame hold or hand mode is selected on the MM screen, this will override an input made on terminal 94 or 95.

Note: If using intelligent boiler sequencing, then putting the MM into low flame hold will remove the MM from the sequence loop. It will resume sequencing once low flame hold is deselected and after the next scan time elapses.

Note: If low flame hold and hand mode are both selected, then hand mode takes priority.

18.2.5 Status – Hand Mode

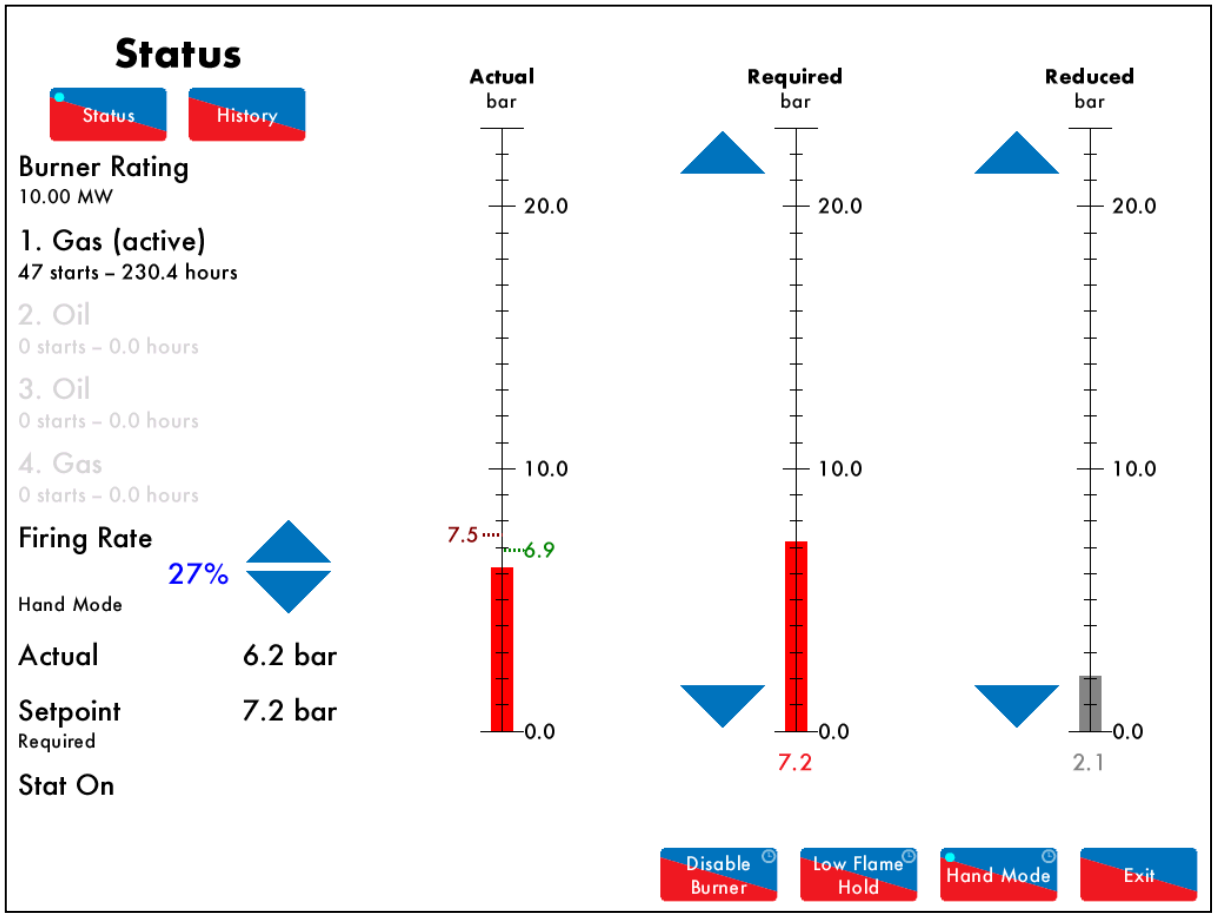


Figure 18.2.5.i Status – Hand Mode

Press and hold Hand Mode for 3 seconds in the Status screen in Figure 18.2.1.i to put the MM into hand mode, where the firing rate can be driving up or down by using the arrows.

Alternatively, the MM can be put into hand mode by an input on terminal 94.

If low flame hold or hand mode is selected on the MM screen, this will override an input made on terminal 94 or 95.

Note: If using intelligent boiler sequencing, then putting the MM into hand mode will remove the MM from the sequence loop. It will resume sequencing once hand mode is deselected and after the next scan time elapses.

Note: If low flame hold and hand mode are both selected, then hand mode takes priority.

Note: If a firing rate limit is set (option 66), then the firing cannot be driven past this in hand mode.

18.3 Fuel-Air Screen

18.3.1 Fuel-Air – Curve

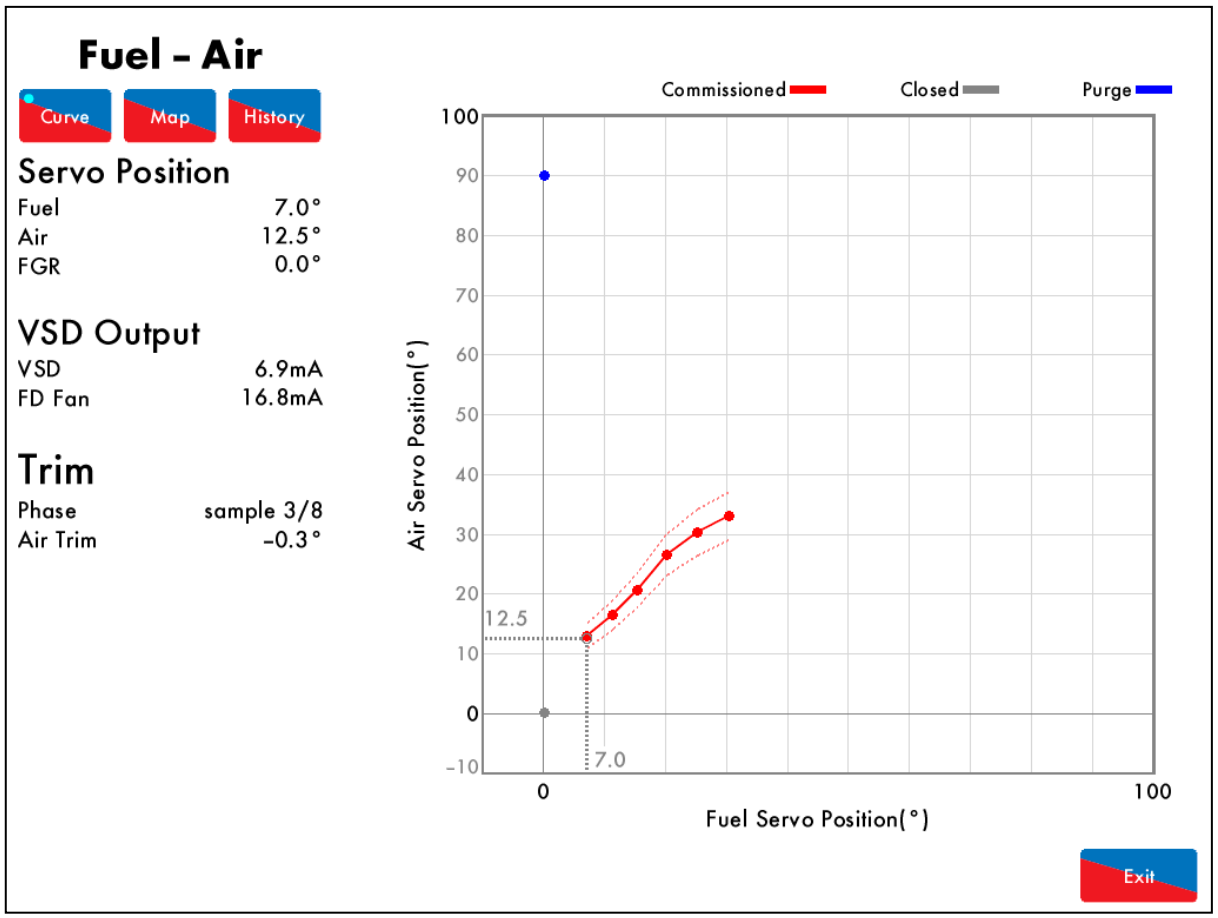


Figure 18.3.1.i Fuel-Air – Curve

Press the flame in the Home screen in Figure 18.1.i to view the Fuel-Air screen, which shows current servomotor and VSD output positions, the trim status and the commission curve graph.

18.3.2 Fuel-Air – Map

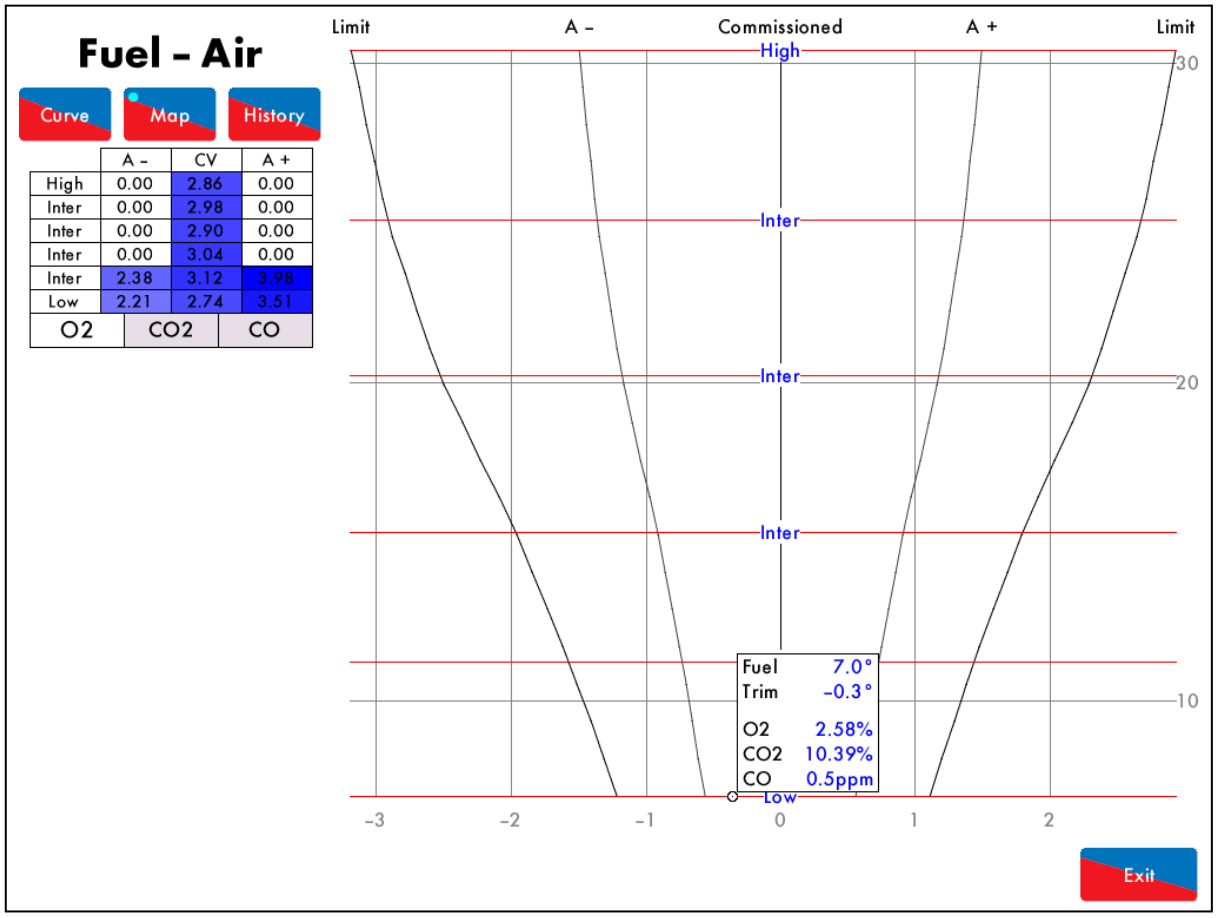


Figure 18.3.2.i Fuel-Air – Map

Press Map in the Fuel-Air screen in Figure 18.3.1.i to view the commissioned trim values if an EGA has been enabled with trim. The air rich (A+) and fuel rich (A-) values are shown for each commissioned point on the fuel-air curve, for the O_2, CO and CO_2. The graph shows the EGA's current readings and if there is any trim correction on the air damper. The circle on the fuel-air map indicates the current position of the trim correction, and how far the current combustion values are from the commissioned values.

Note: Option 12 must be set to 2 or 3 for the 3-parameter trim function to be activated.

18.3.3 Fuel-Air – History

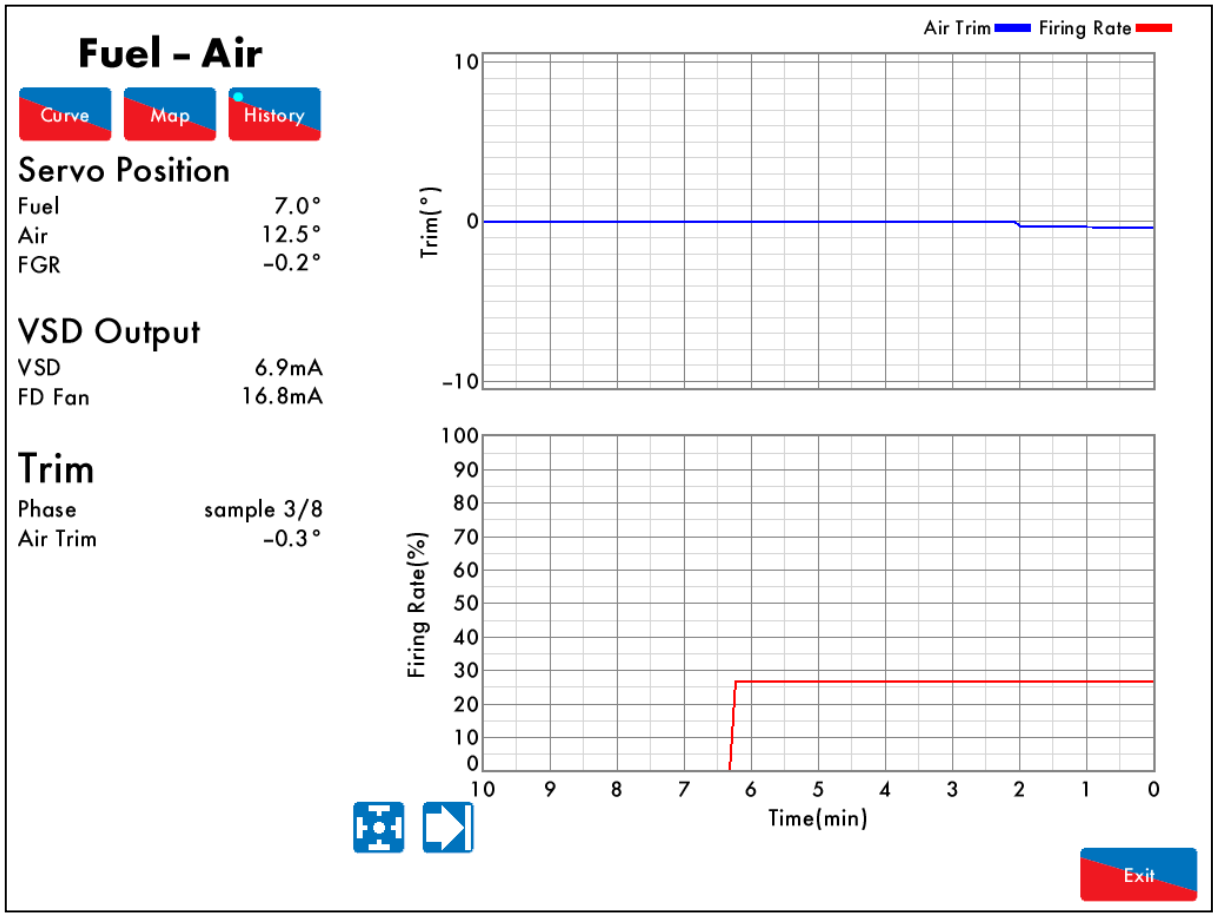


Figure 18.3.3.i Fuel-Air – History

Press 

in the Fuel-Air screen in Figure 18.3.1.i to view the Fuel-Air History screen, which shows the firing rate and air trim history.

Note: Option 12 must be set to 2 or 3 for the 3-parameter trim function to be activated.

This data is logged for 24 hours on the MM. Use the  buttons to change the timescale of the data displayed, and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24 hour history data log on the MM.

18.4 Flame Safeguard Screen

18.4.1 Flame Safeguard

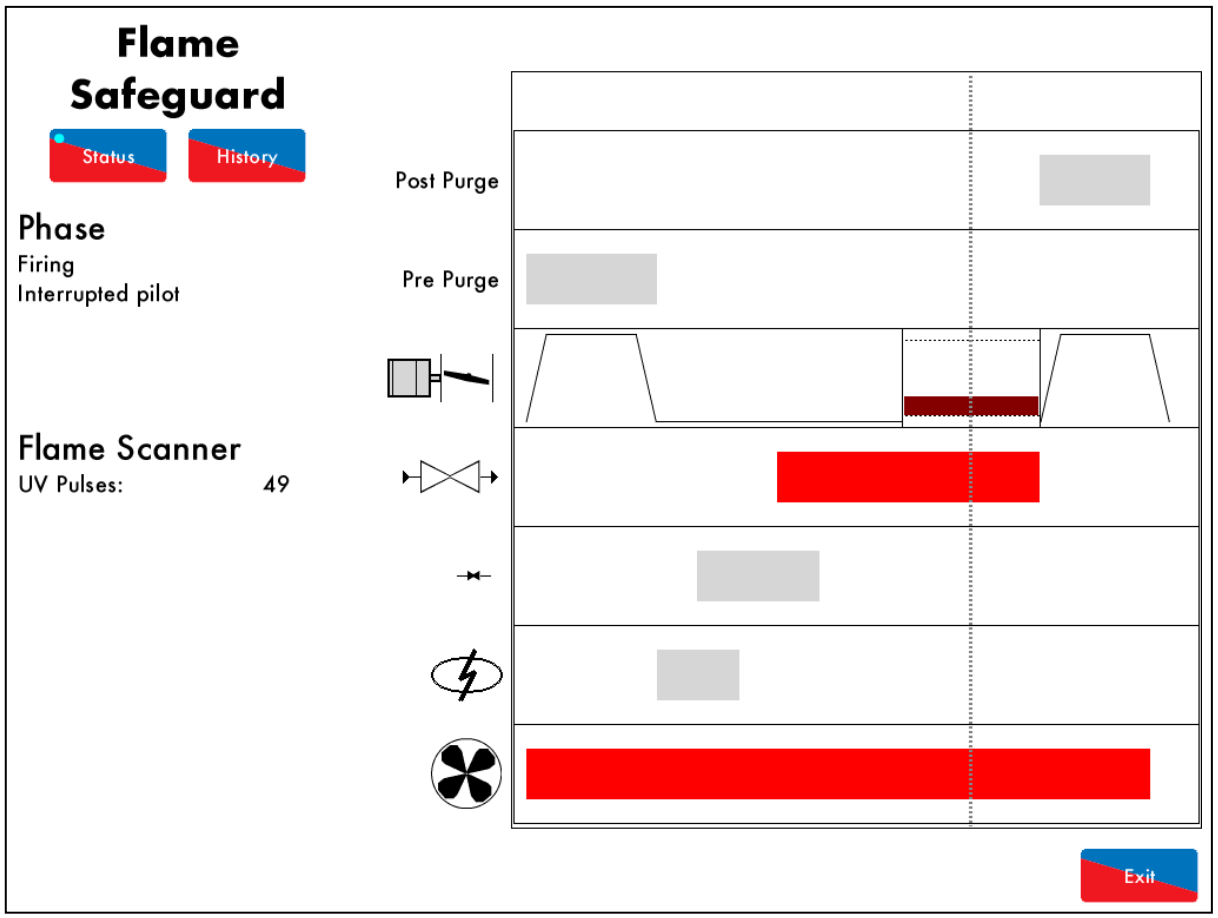


Figure 18.4.1.i Flame Safeguard

Press on the flame scanner in the Home screen in Figure 18.1.i to view the Flame Safeguard screen, which shows the current firing phase of the MM, pilot type and flame scanner signal strength.

Throughout the entire burner start-up and firing sequence, the vertical dotted line will move horizontally showing which phase the burner is at currently. The rows refer to:

- Post purge.
- Pre purge.
- Air damper position.
- Main fuel valve.
- Pilot fuel valve.
- Ignition.
- Blower motor.

Note: If a flame switch is used for flame detection, then flame switch show as either on (flame detected) or off (no flame detected).

18.4.2 Flame Safeguard – History

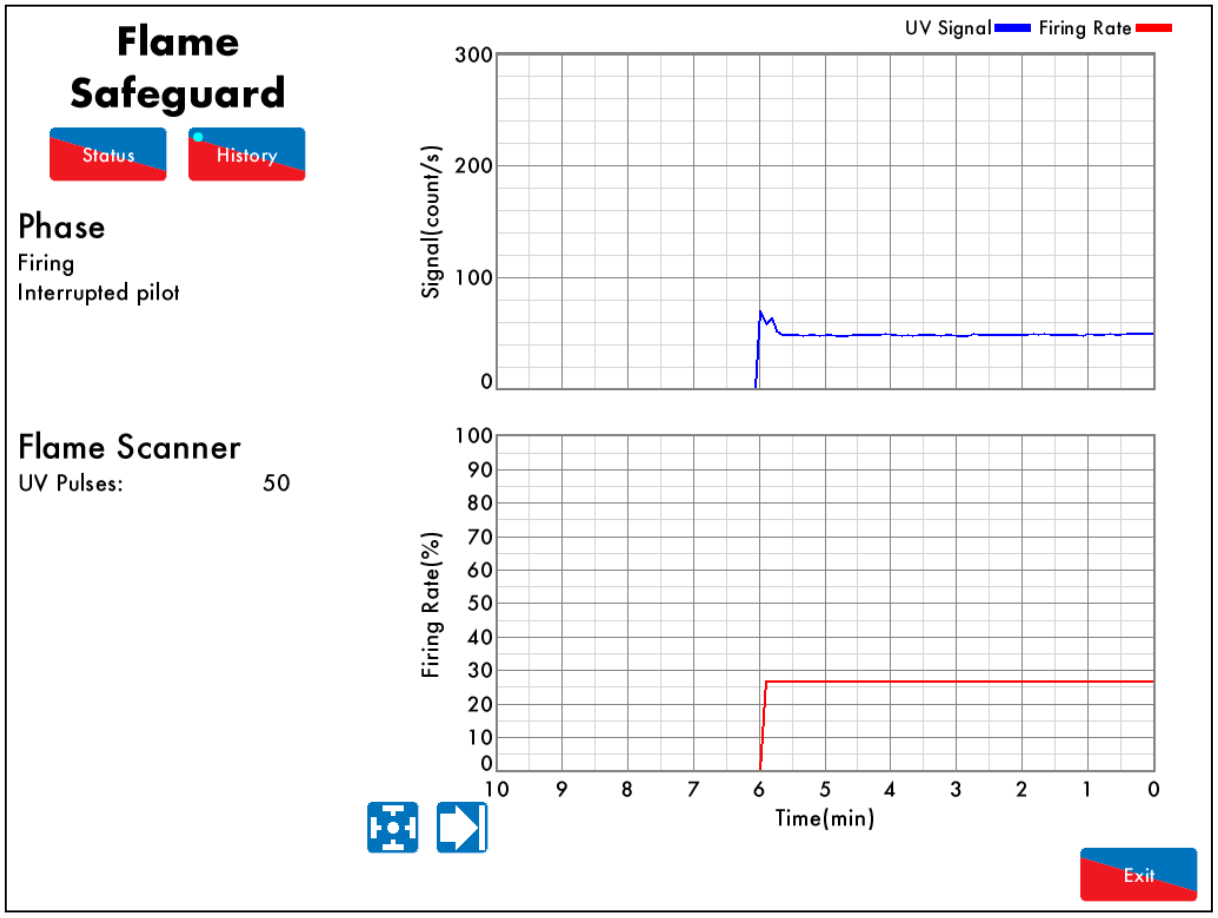


Figure 18.4.2.i Flame Safeguard – History

Press History in the Flame Safeguard screen in Figure 18.4.1.i to view the Flame Safeguard History, showing the flame scanner signal and firing rate.

This data is logged for 24 hours on the MM. Use the buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

18.5 Channels Screen

18.5.1 Servomotor

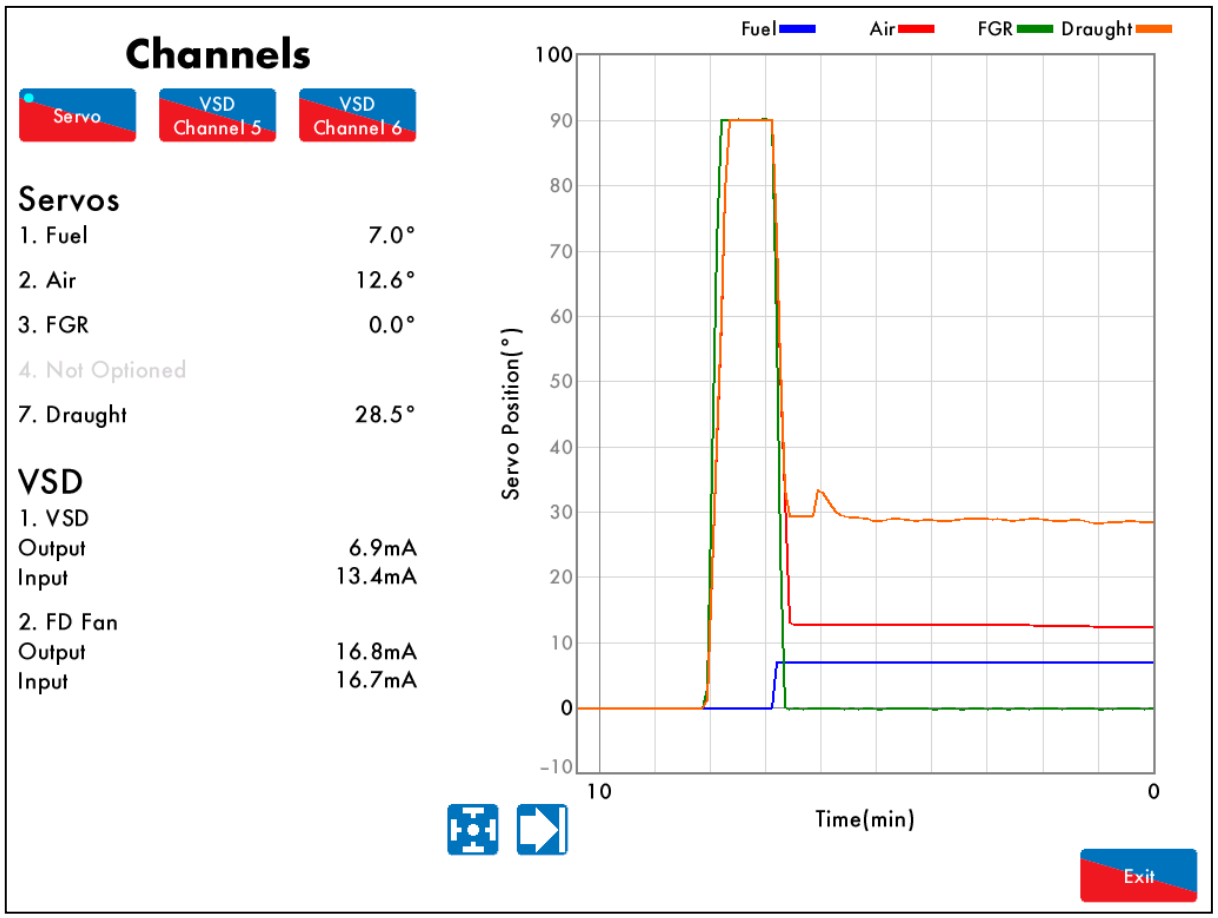


Figure 18.5.1.i Servomotor

Press on a servomotor in the Home screen in Figure 18.1.i to view the Channels screen, which shows the current servomotor positions and VSD outputs and inputs.

This data is logged for 24 hours on the MM. Use the  buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

18.5.2 VSD Channel

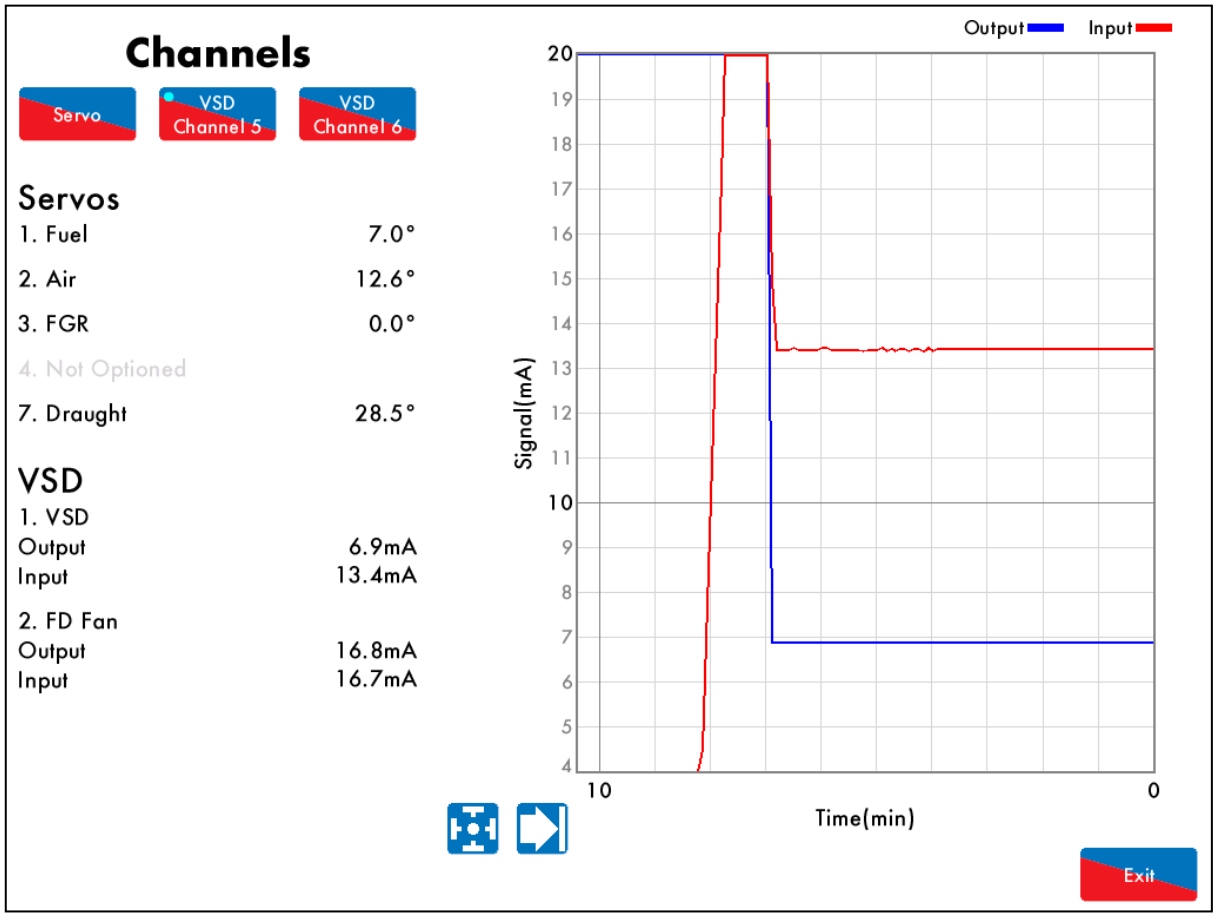


Figure 18.5.2.i VSD Channel

Press VSD Channel 5 or VSD Channel 6 in the Channels screen in Figure 18.5.1.i to view the VSD Channel 5 or VSD Channel 6 output and input history, respectively. Alternatively, pressing on the VSD in the Home screen in Figure 3.1.i will also display the VSD Channel screen.

This data is logged for 24 hours on the MM. Use the buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

18.6 Gas Pressure Sensor Screen

18.6.1 Gas Pressure

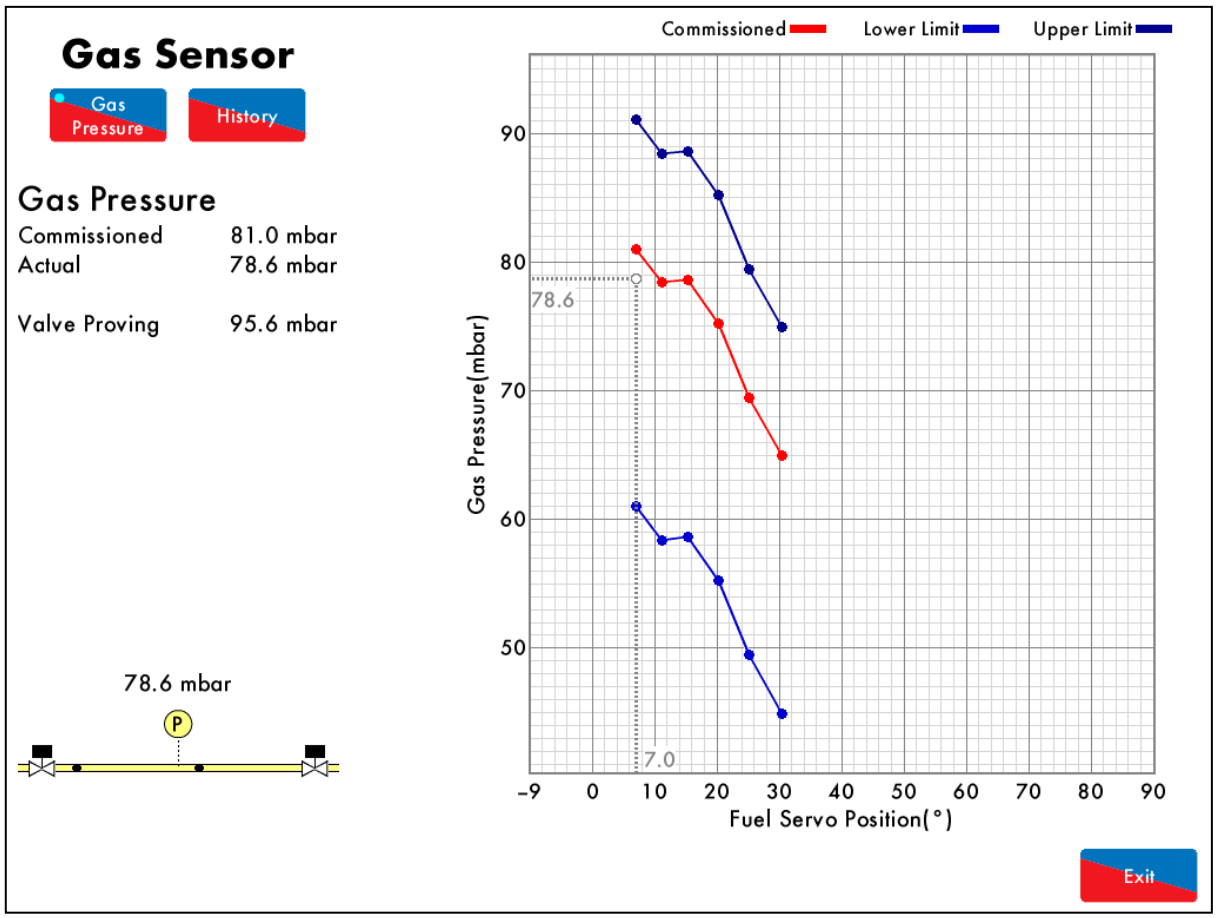


Figure 18.6.1.i Gas Pressure

Press on the gas pressure sensor (if enabled) in the Home screen in Figure 18.1.i to view the gas pressure screen, which shows the following information:

- Commissioned gas pressure for the corresponding point on fuel-air curve.
- Actual (current) gas pressure.
- Valve proving gas pressure.
- Status of main gas and vent valves.
- Upper/lower offset gas pressure limits for fuel-air curve.

18.6.2 Gas Sensor – History

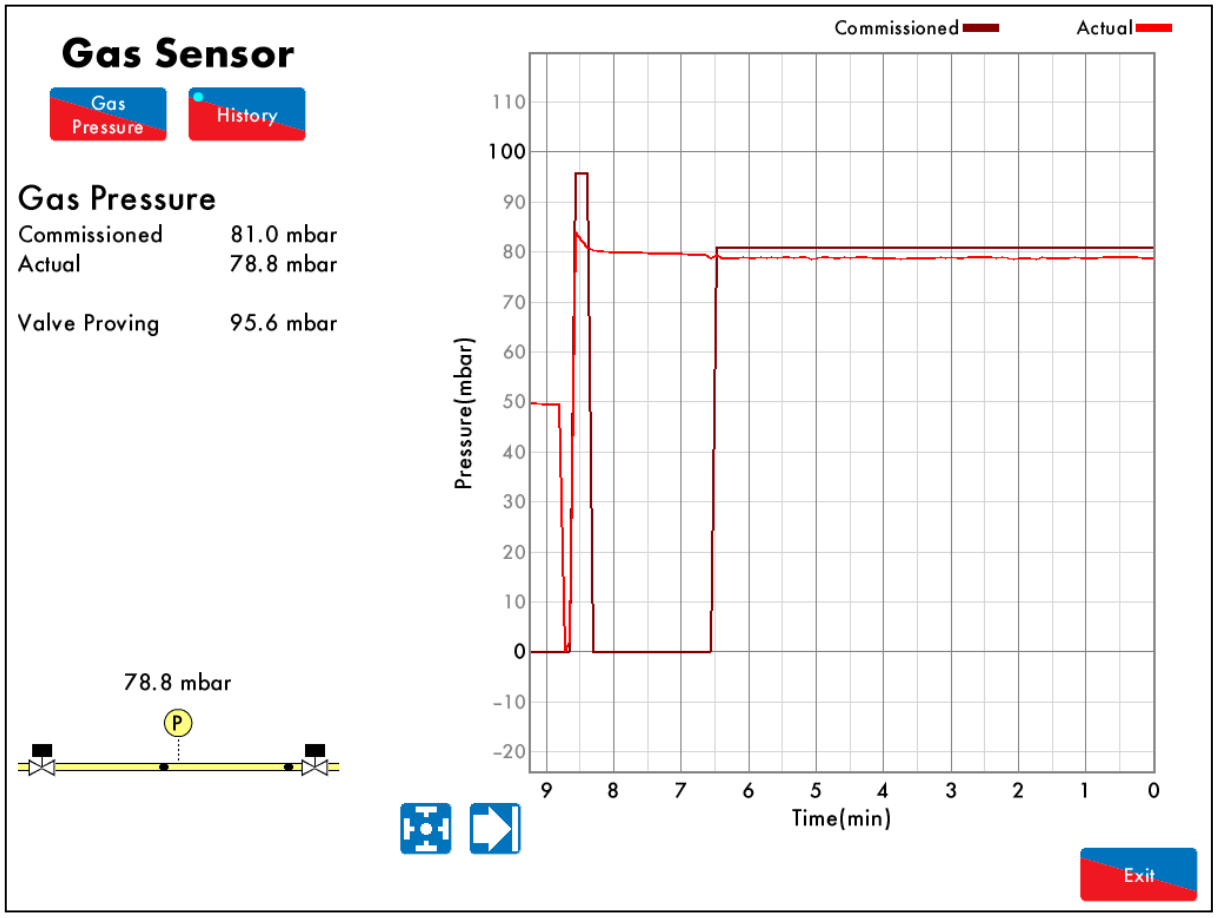


Figure 18.6.2.i Gas Sensor – History

Press History in the Gas Pressure screen in Figure 18.6.1.i to view the Gas Pressure History screen, showing the commissioned and actual gas pressure histories.

This data is logged for 24 hours on the MM. Use the buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

18.7 Air Pressure Sensor Screen

18.7.1 Air Pressure

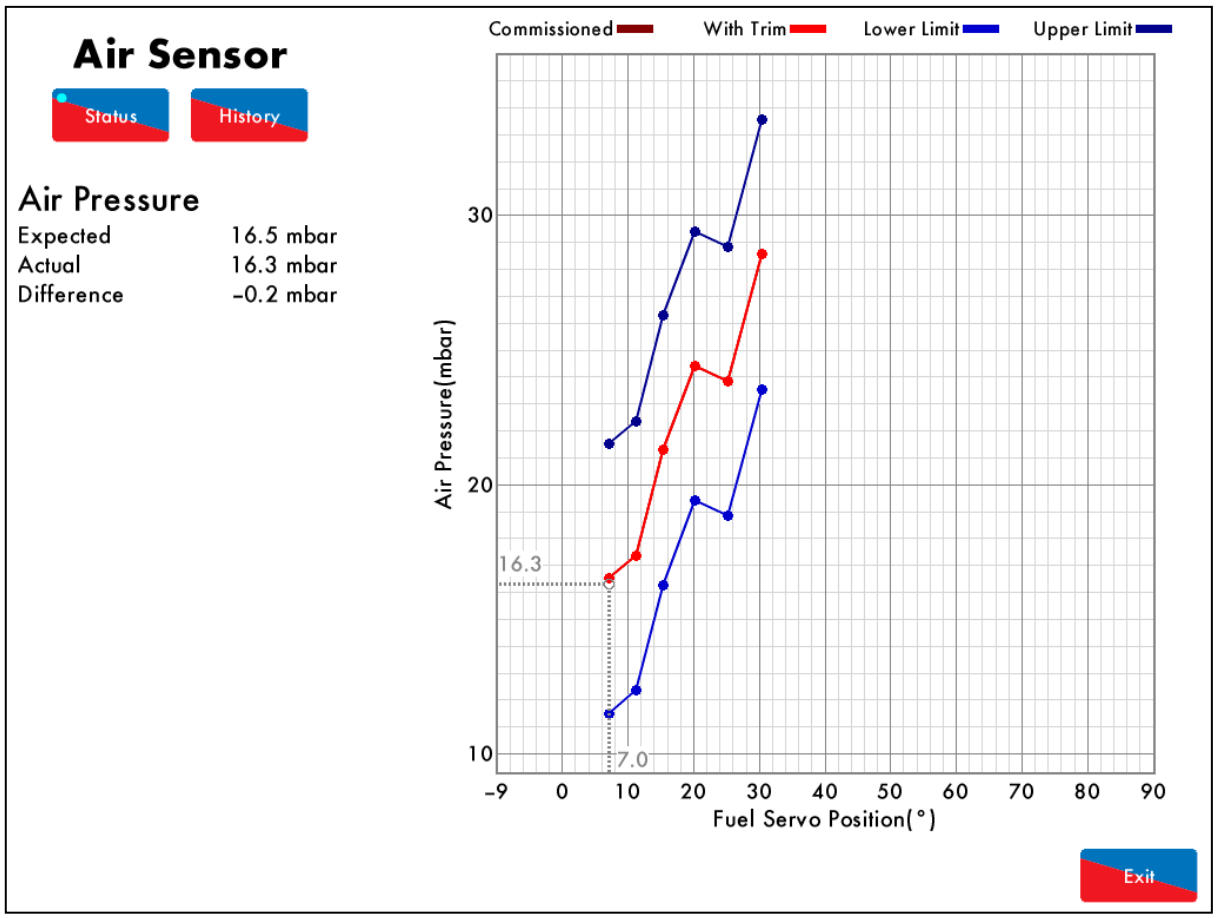


Figure 18.7.1.i Air Pressure

Press on the air pressure sensor in the Home screen in Figure 3.1.i to view the Air Pressure screen, which shows the expected air pressure, actual (current) air pressure and the difference between these values, for the corresponding point on the fuel-air curve.

The graph shows the commissioned air pressure for the fuel-air curve and the upper/lower offset limits, as well as the air pressure values with trim function enabled on the air damper.

If commissioned with an EGA, the air pressure is stored during the commissioning of the trim function and shown as the red line on the graph.

18.7.2 Air Sensor – History

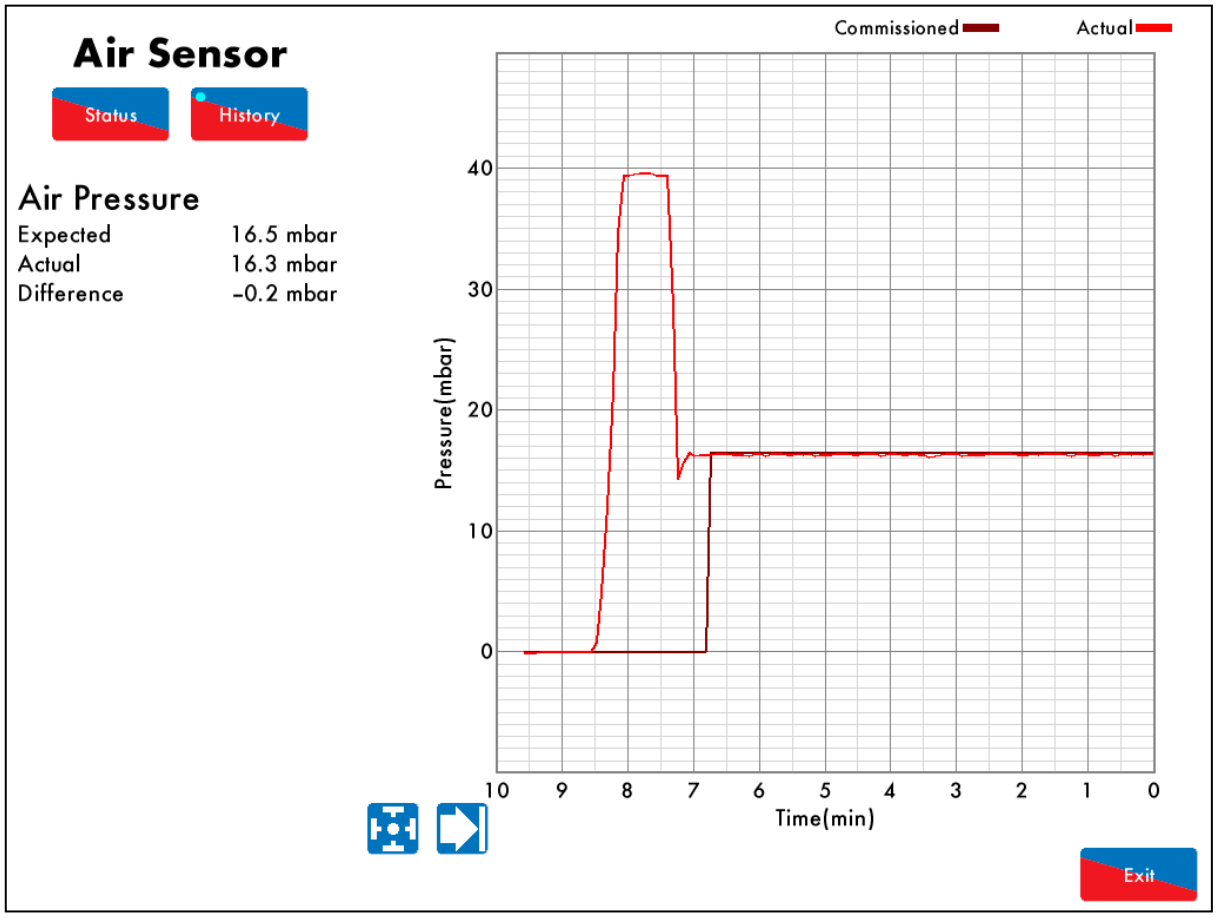


Figure 18.7.2.i Air Sensor – History

Press 

in the Air Pressure screen in Figure 18.7.1.i to view the Air Pressure History screen, showing the commissioned and actual air pressure histories.

This data is logged for 24 hours on the MM. Use the  buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

18.8 Fuel Flow Screen

18.8.1 Fuel Flow

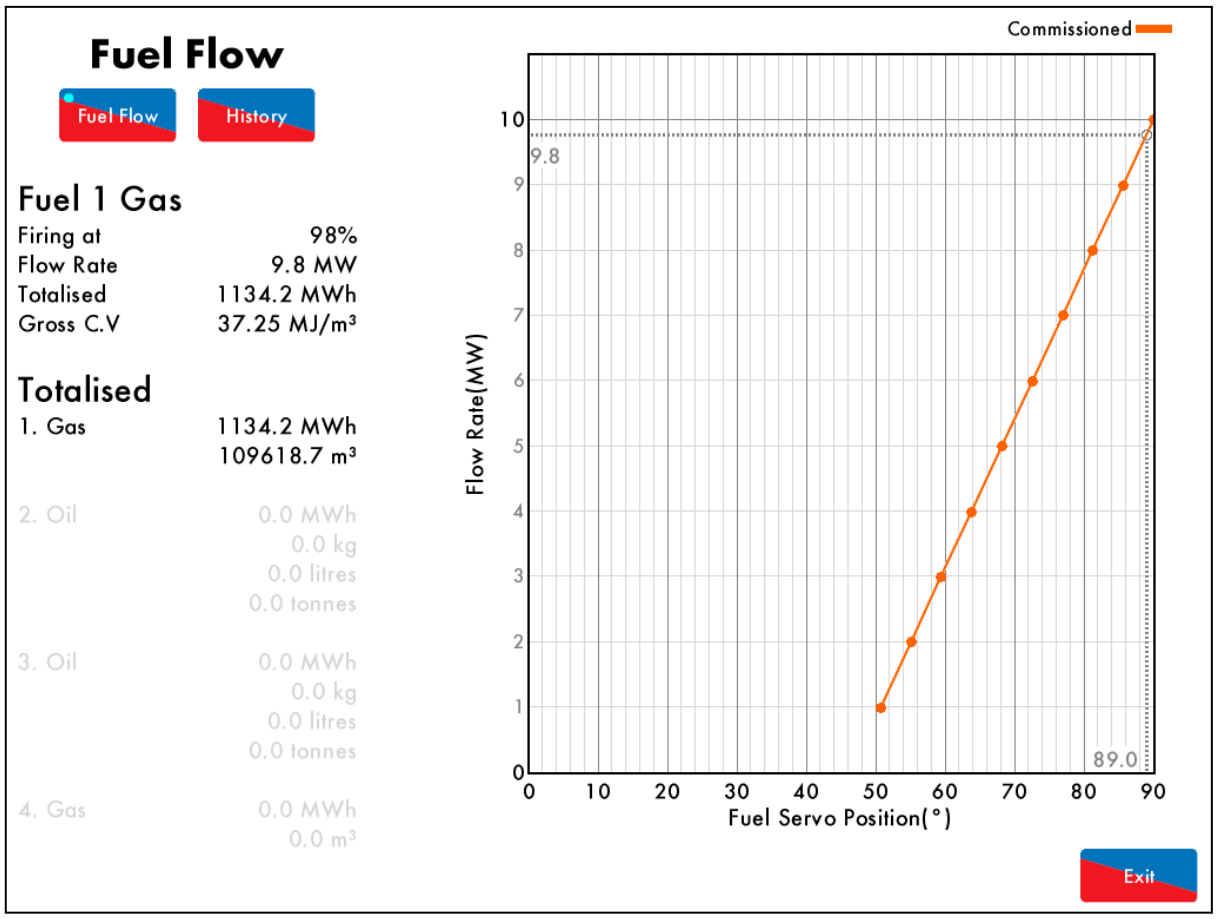


Figure 18.8.1.i Fuel Flow

Press on the main gas/oil pipe in the Home screen in Figure 18.1.i to view the Fuel Flow screen, which shows the following information:

- Current firing rate.
- Current fuel flow.
- Totalised fuel flow.
- Gross calorific value of fuel.
- Totalised fuel used.

Note: If option 57 is disabled, then no fuel flow information will be displayed.

18.8.2 Fuel Flow – History

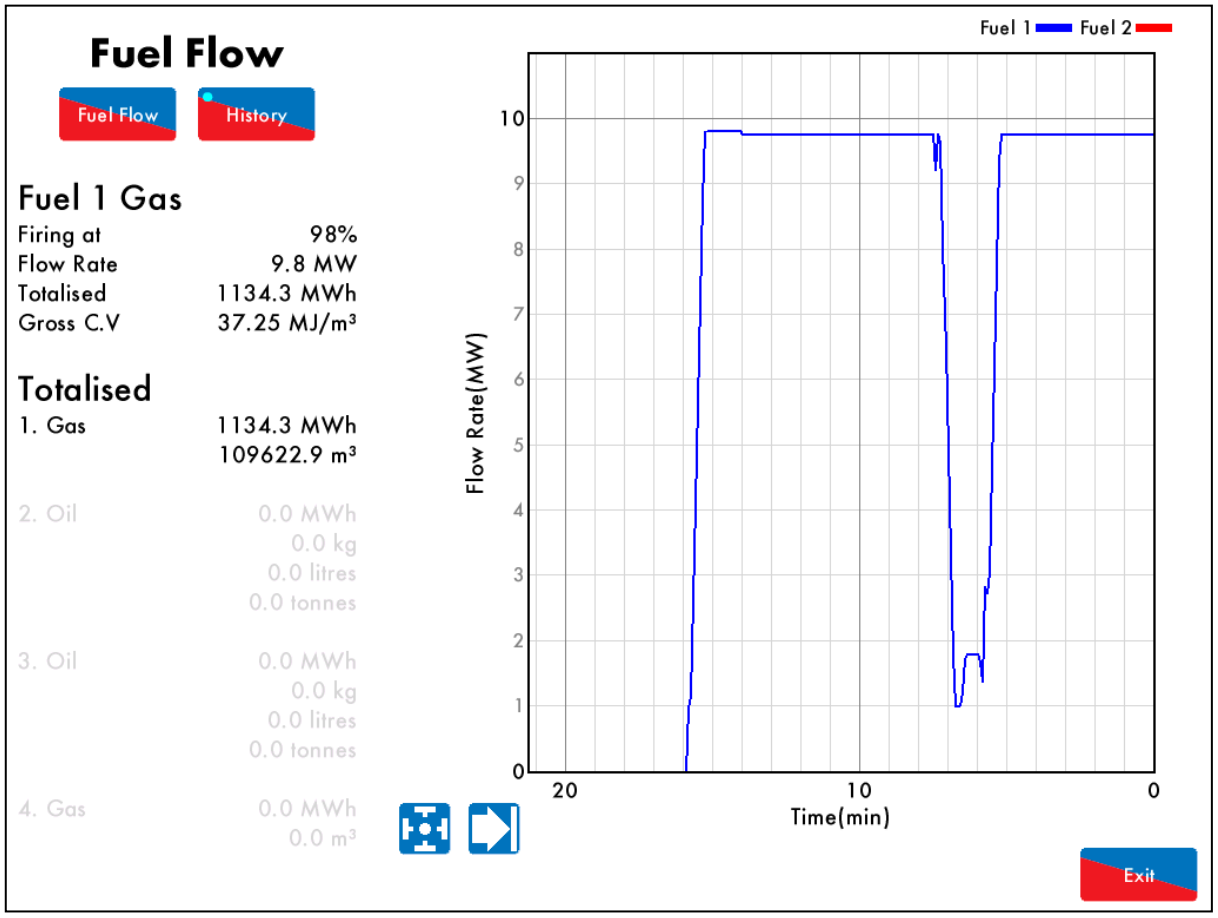


Figure 18.8.2.i Fuel Flow – History

Press History in the Fuel Flow screen in Figure 18.8.1.i to view the Fuel Flow History.

This data is logged for 24 hours on the MM. Use the buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

18.9 Sequencing Screen

18.9.1 IBS – Status

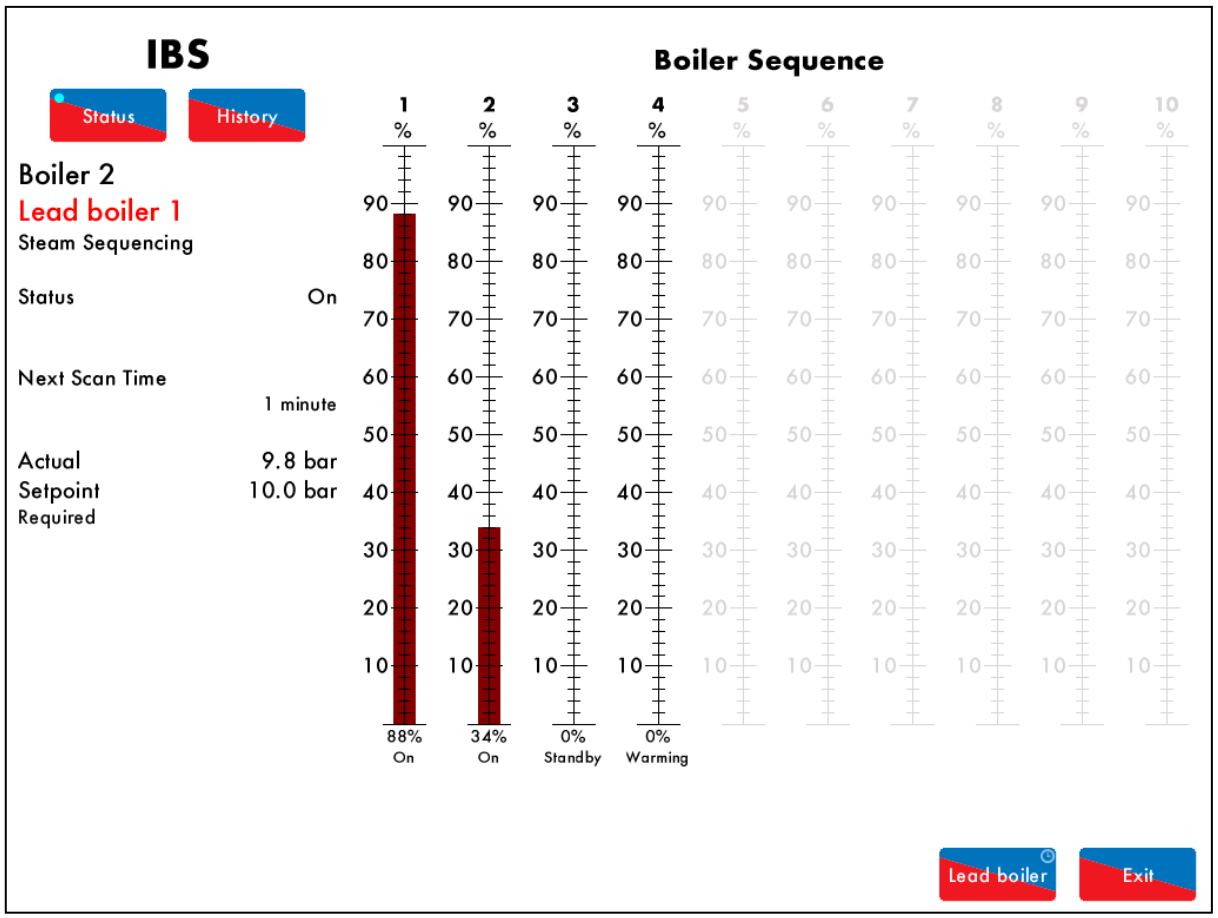


Figure 18.9.1.i IBS – Status

Press on the IBS (Intelligent Boiler Sequencing) box in the Home screen in Figure 18.1.i to view the IBS Status screen. The following information is displayed:

- MM boiler ID number.
- Lead boiler ID number.
- Type of sequencing (steam/ hot water).
- Current sequencing state.
- Next scan time due.
- Actual temperature/ pressure.
- Setpoint value and setpoint type (required/ standby).
- Number of boilers in sequencing loop.
- Current firing rates of all boilers in sequencing loop.
- Current sequencing states of all boilers in sequencing loop.
- Warming off and on times shown on screen for boilers which are in Warming sequencing state.

Note: Sequencing must be enabled in option 16 for IBS information to display.

Note: Any bars showing in pink indicate that the MM has dropped out of the sequencing loop,

Note: Up to 10 boilers can be sequencing together. If multi-burner is used on a boiler, then it is the master MM which will communicate in the sequencing loop.

18.9.2 IBS – Lead Boiler

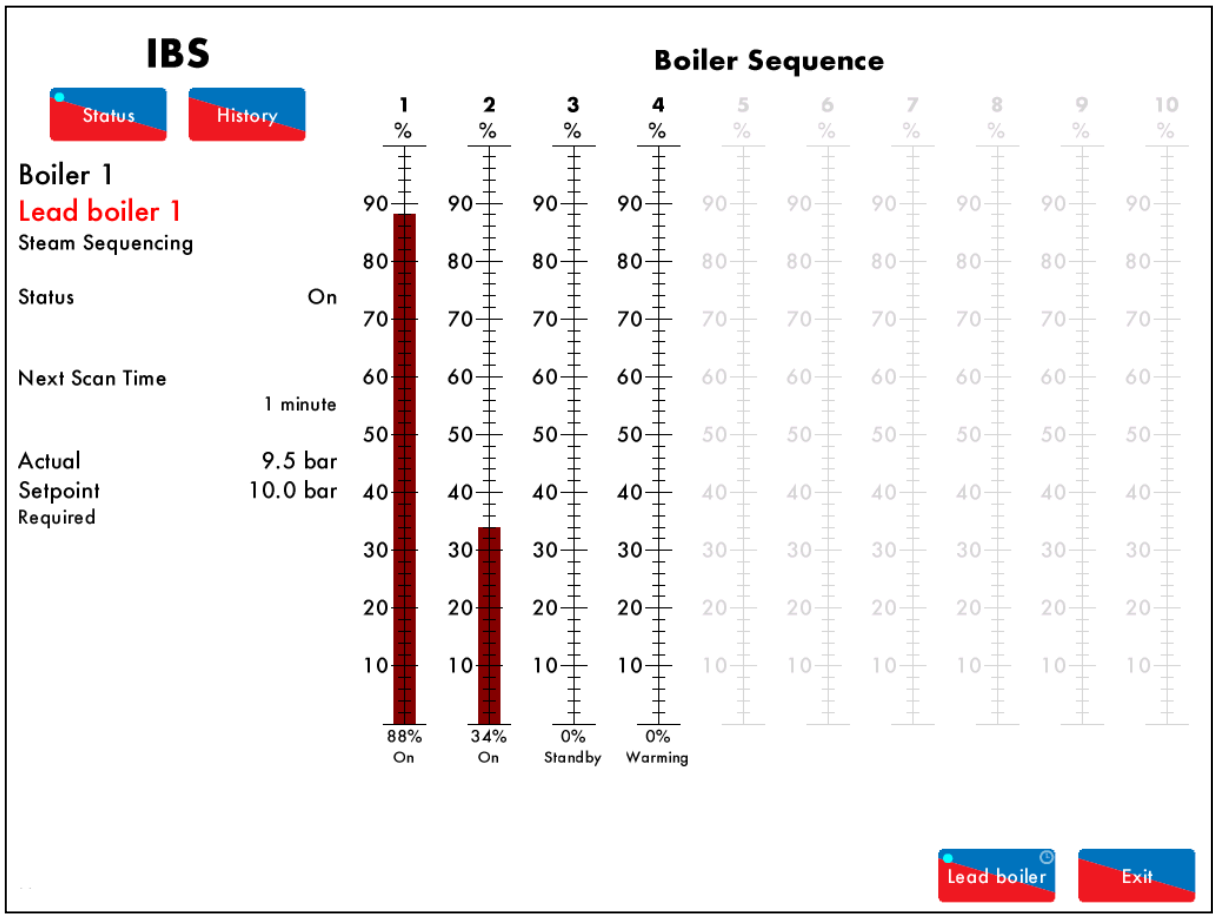


Figure 18.9.2.i IBS – Lead Boiler

A boiler can be selected as a lead boiler by the following ways:

1. Press and hold 

for 3 seconds in the IBS Status screen in Figure 18.9.1.i.
2. An input on terminal 88.
3. If a DTI is enabled, then the lead boiler can be selected remotely either through Autoflame PC CEMS Audit Software, DTI Manager Software, or via a Modbus address via the DTI.

Note: If another MM has already been selected as lead boiler, or no boilers have been selected as lead boiler, then the MMs will fire independently until just one lead boiler is selected.

18.9.3 IBS – History

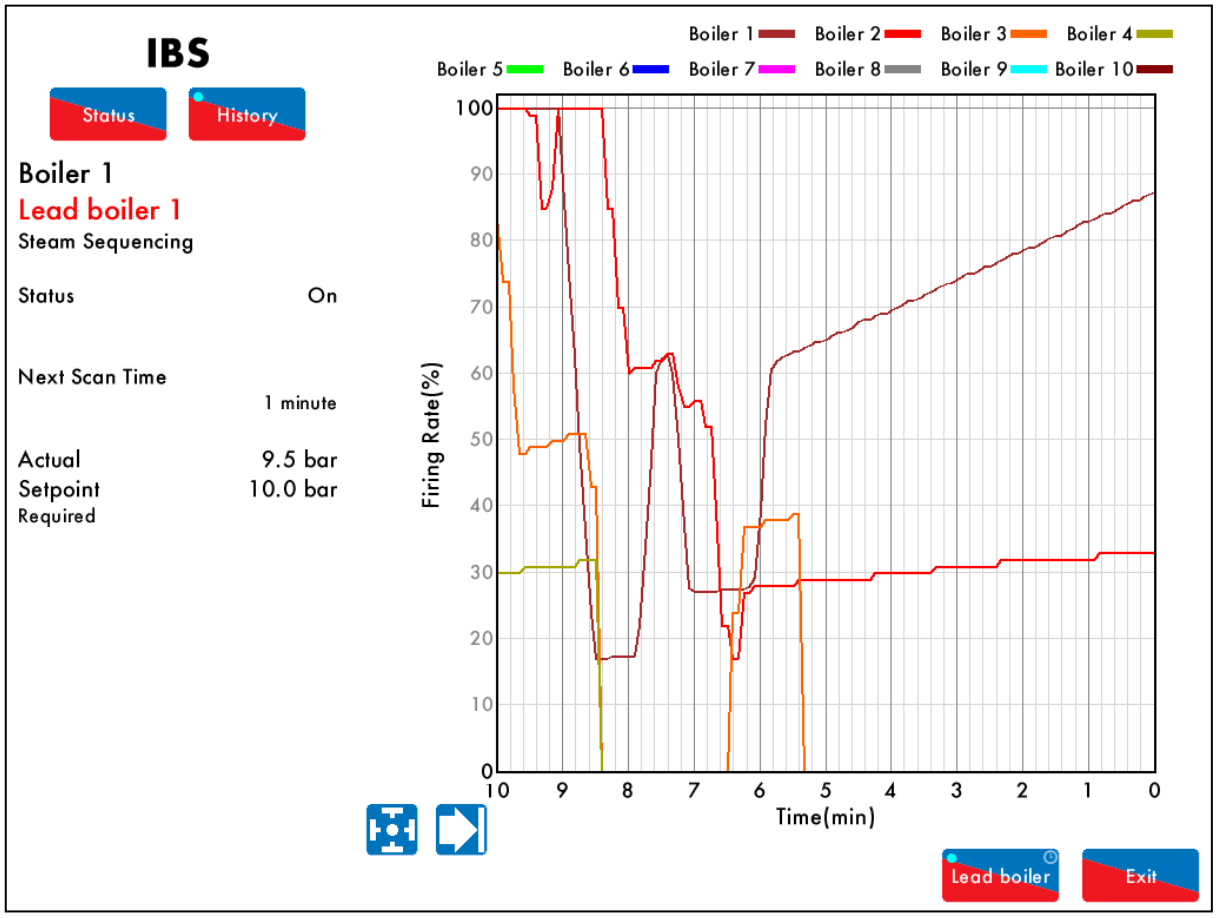


Figure 18.9.3.i IBS – History

Press 

in the IBS Status screen in Figure 18.9.1.i to view the IBS History screen, which shows the firing rates histories for all the boilers in the sequencing loop.

This data is logged for 24 hours on the MM. Use the  buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

18.10 EGA Screen

18.10.1 EGA – Gas

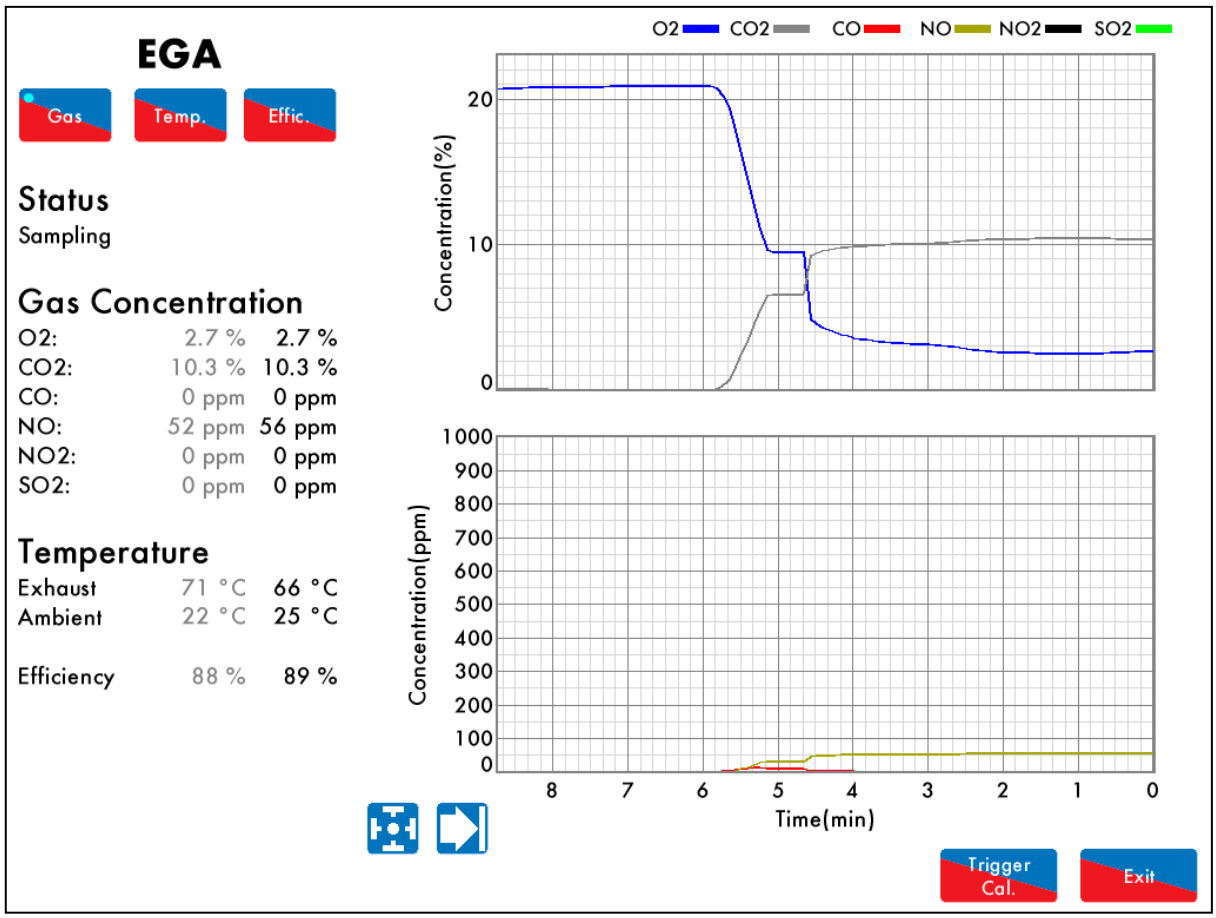


Figure 18.10.1.i EGA – Gas

Press the EGA box (if enabled) in the Home screen in Figure 18.1.i to view the EGA Gas screen, which shows the following information:

- EGA current status.
- Current exhaust gases, temperature and efficiency values (in black).
- Commissioned exhaust gases, temperature and efficiency values if trim is enabled (in grey)

The graphs show the exhaust gas concentrations histories.

This data is logged for 24 hours on the MM. Use the  buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

Press 

to force the EGA into an air calibration when it is next in a safe condition (not trimming and span gas calibration).

18.10.2 EGA – Temperature

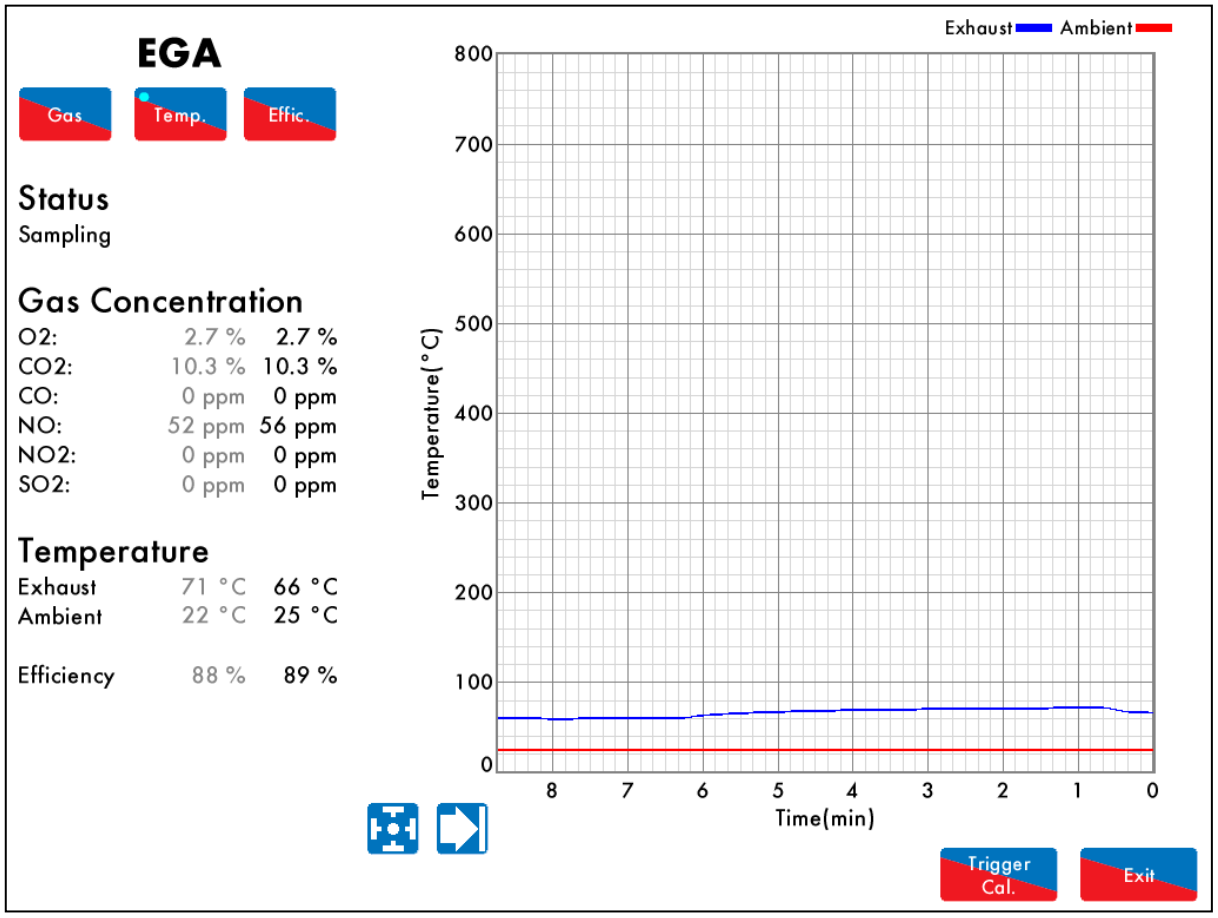


Figure 18.10.2.i EGA – Temperature

Press 

in the EGA Gas screen in Figure 18.10.1.i to view the EGA Temperature screen, which shows the exhaust and ambient temperature histories.

This data is logged for 24 hours on the MM. Use the  buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

Press 

to force the EGA into an air calibration when it is next in a safe condition (not trimming and span gas calibration).

18.10.3 EGA – Efficiency

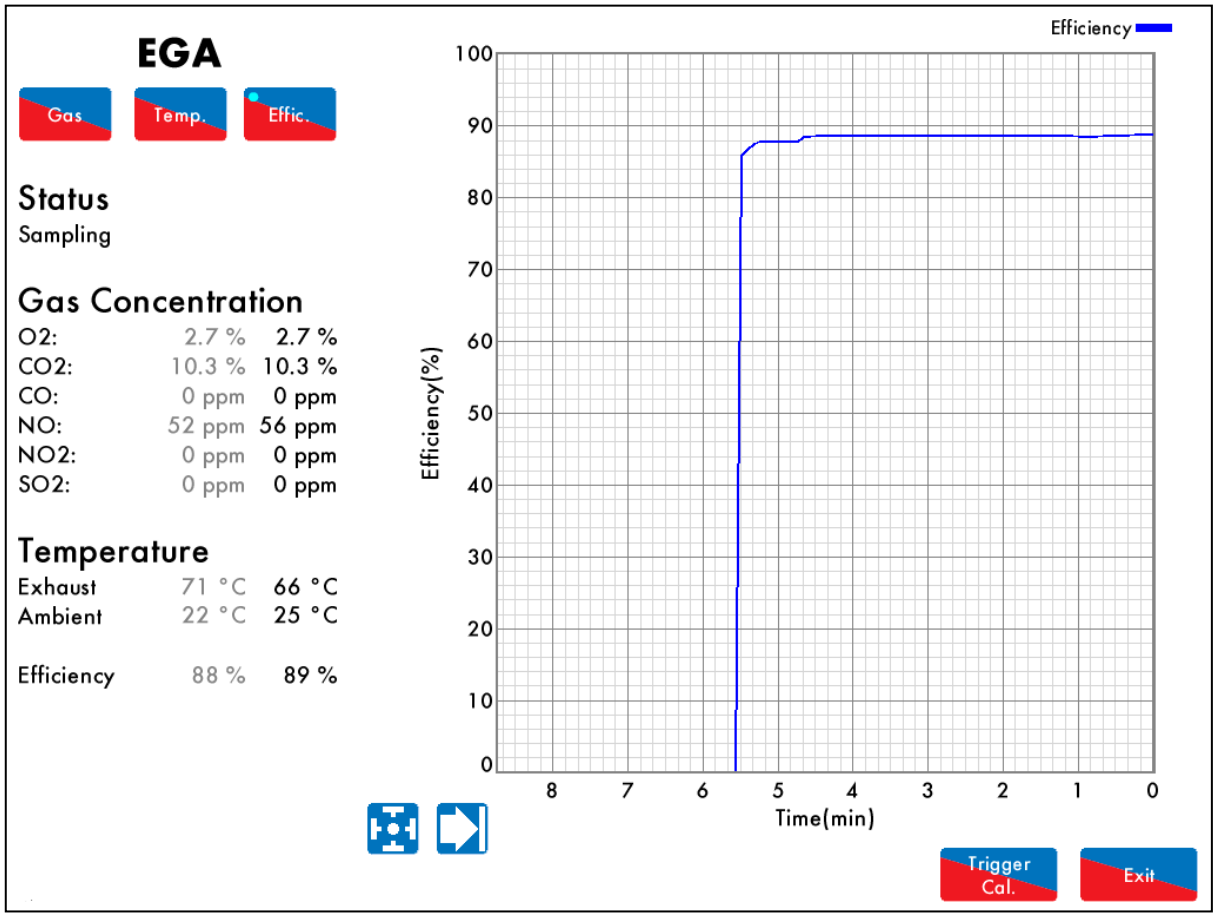


Figure 18.10.3.i EGA – Efficiency

Press 

in the EGA Gas screen in Figure 18.10.1.i to view the EGA Efficiency screen, which shows the combustion efficiency history calculated by the EGA.

The combustion efficiency is not displayed when the O_2 value is above 15.0% O_2.

Note: The combustion efficiency calculated by the EGA can be displayed as a net or gross value, dependingon the setting on the EGA.

This data is logged for 24 hours on the MM. Use the  buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

Press 

to force the EGA into an air calibration when it is next in a safe condition (not trimming and span gas calibration).

18.11 Outside Temperature Compensation Screen

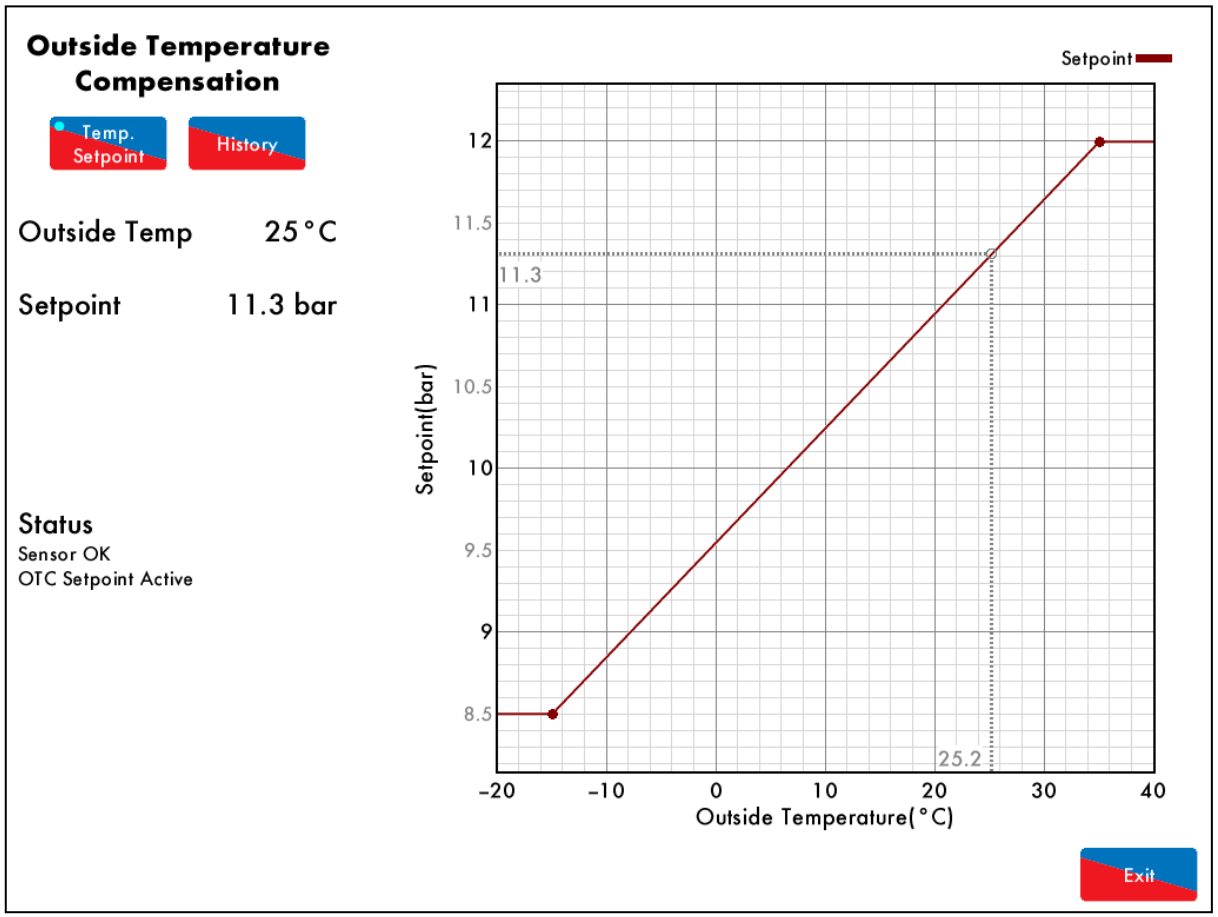


Figure 18.11.i Outside Temperature Compensation

Press on the outside temperature sensor (if enabled) in the Home screen to view the Outside Temperature Compensation screen. The following information is displayed:

- Current outside temperature
- Current required setpoint
- Status of the OTC sensor/ module
- Status of the OTC required setpoint

The required setpoint will adjust according to the outside temperature, based on the minimum and maximum outside temperature and setpoints set.

Press History to view the outside temperature and setpoint histories.

This data is logged for 24 hours on the MM. Use the buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

18.12 Water Level Screen

18.12.1 Water Level – Status

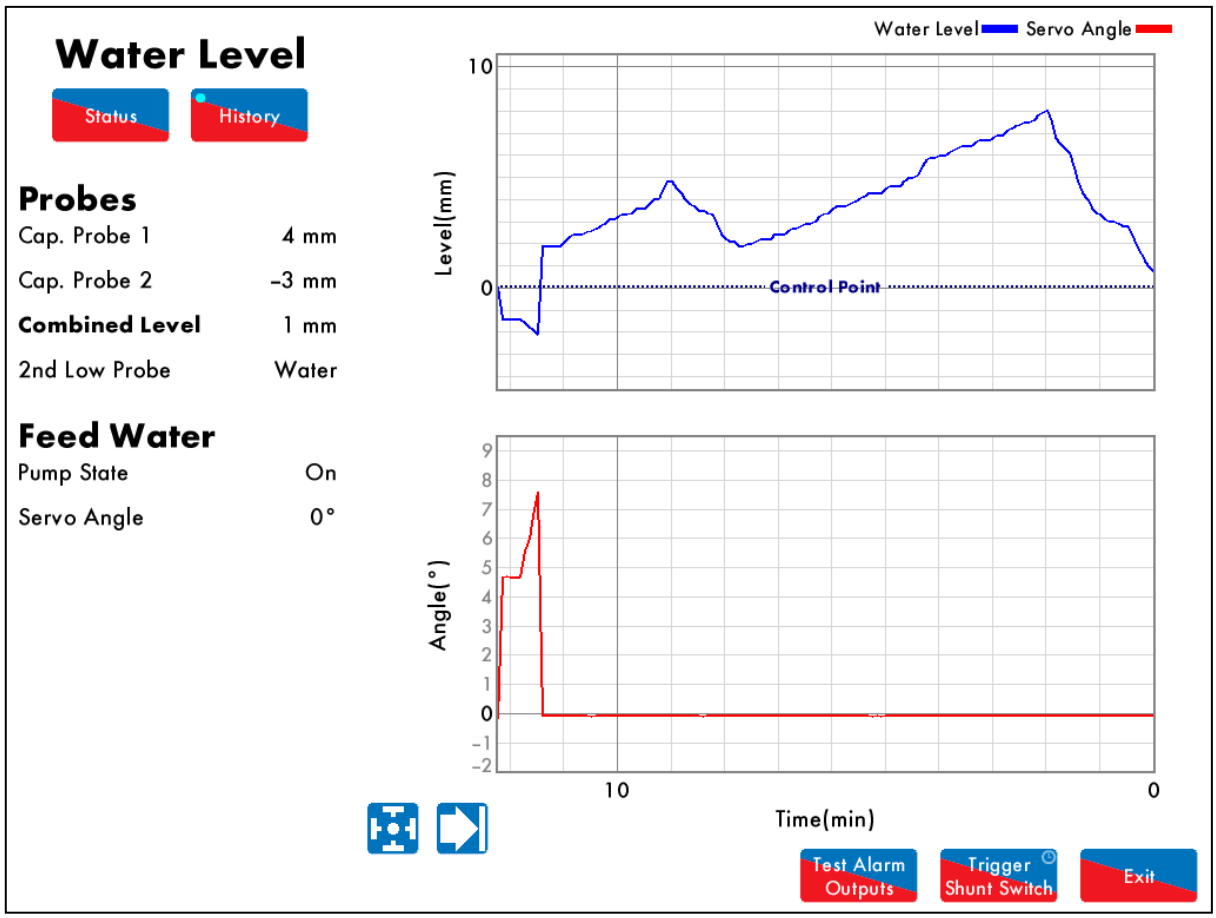


Figure 18.12.1.i Water Level

Press on the water level probes or the feed water pump (if enabled) in the Home screen in Figure 18.1.i to view the Water Level Status screen, which shows the following information:

- Capacitance probe, external level sensor readings.
- Auxiliary alarm inputs and 2nd low probe water detection.
- Combined water level reading.
- Feed water pump state on/off, VSD output, servomotor position.
- Feed water pump bypass on/off, pump on/off levels.
- Feed water temperature.
- Commissioned 2nd low, 1st low, pre 1st low, control point, pre high and high water levels.

Press Test Alarm Outputs to continuously cycle the alarm outputs every 2 seconds without shutting the burner down.

Press Trigger Shunt Switch to check the water level alarms. There is time delay for the burner to reach 1st low (expansion option 22), allowing the operator to decrease the water level to check the 1st low alarm. If the water does not drop to 1st low within this time, the shunt switch test is cancelled, and the MM reverts to normal operation. There is additional delay (expansion option 23) to allow the operator to decrease the water to 2nd low to check the 2nd low alarm. If the water level does not drop in this time, the MM leaves shunt switch test and the burner will turn off. The timer will display when doing these tests. After reaching 2nd low, if the water level does not rise to control point within 10 minutes, alarms will occur.

18.12.2 Water Level – History

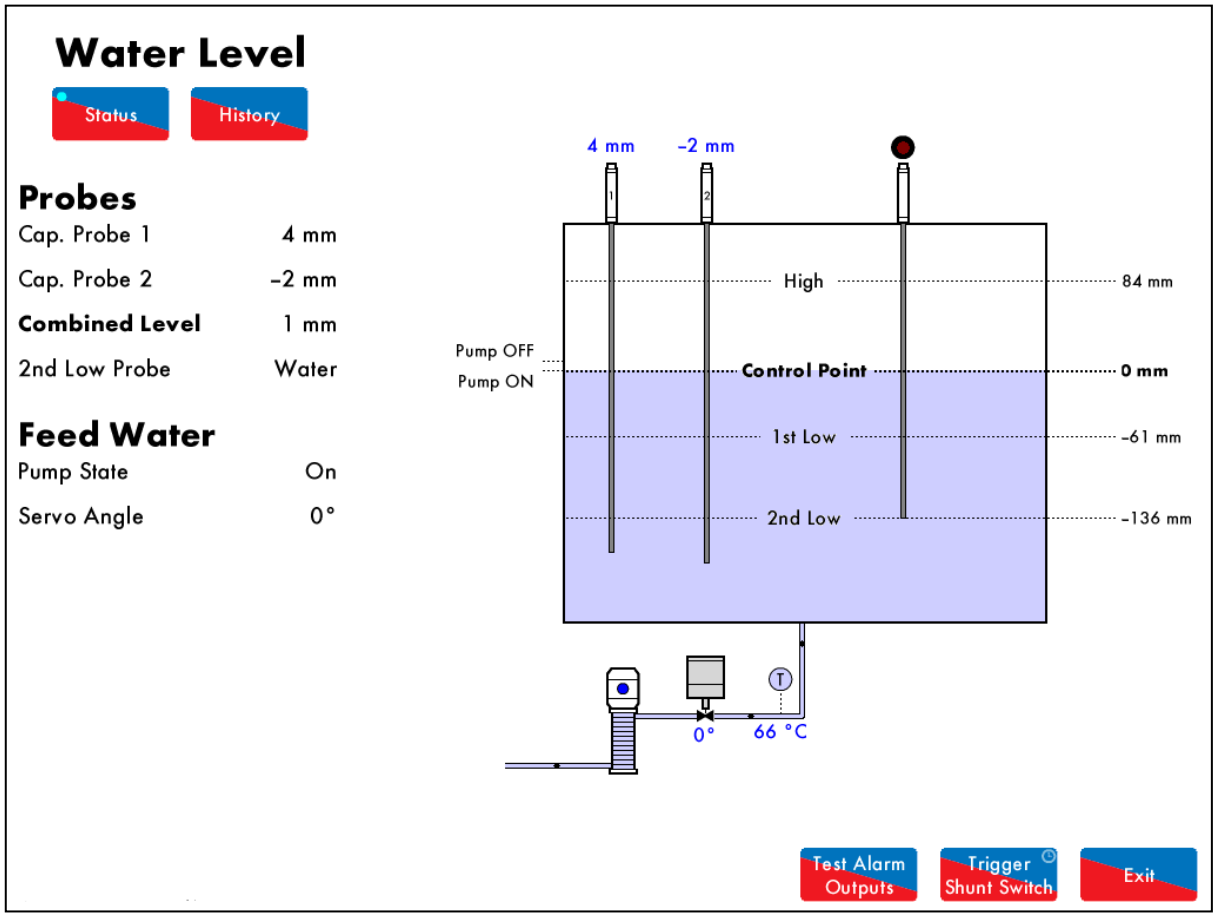


Figure 18.12.2.i Water Level – History

Press  in the Water Level Status screen in Figure 18.12.1.i to view the Water History screen which shows the combined water level and feed water servomotor/ VSD histories.

This data is logged for 24 hours on the MM. Use the  buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

18.13 Top Blowdown Screen

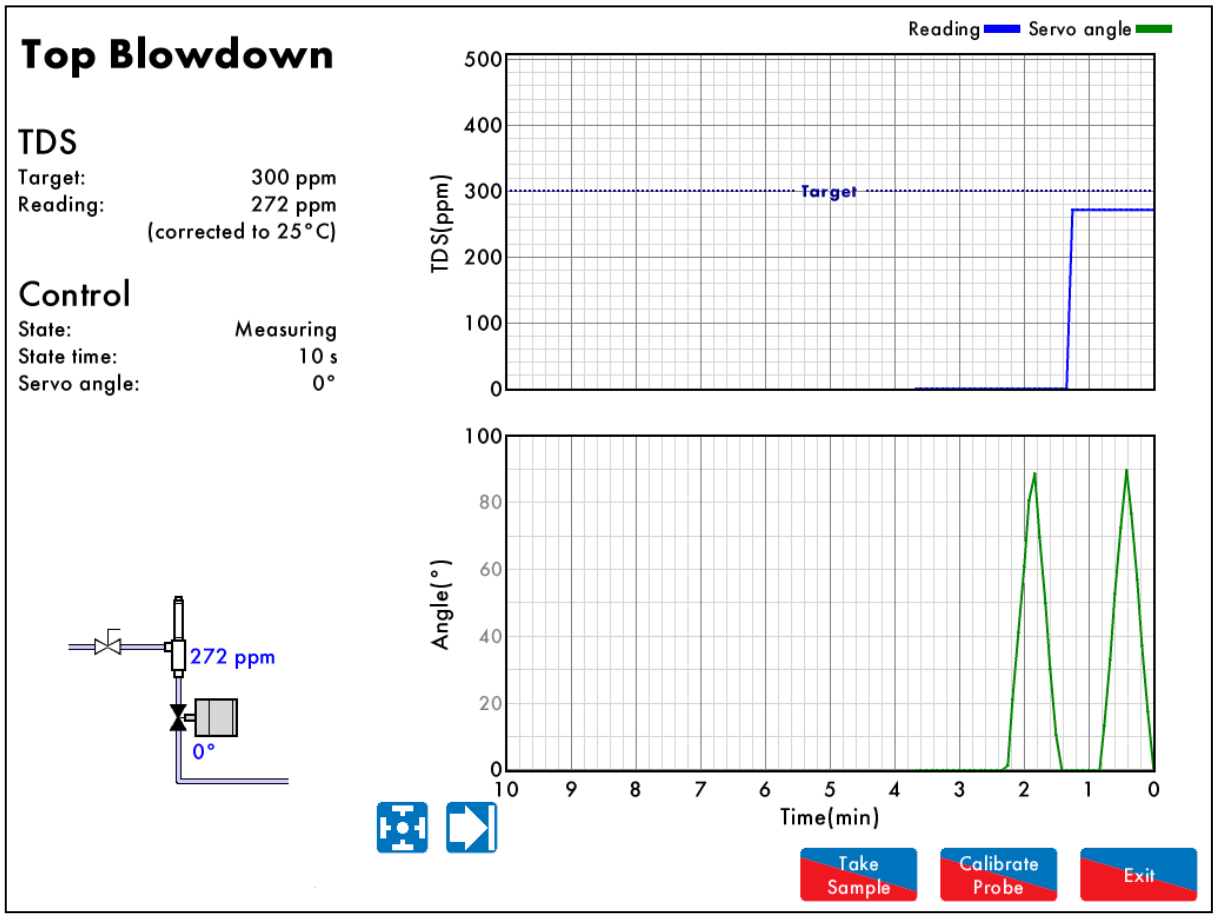


Figure 18.13.i Top Blowdown

Press on the TDS probe (if enabled) in the Home screen in Figure 18.1.i to view the Top Blowdown screen, which shows the following information:

- Target TDS value
- Current TDS reading
- Top blowdown control state and timing
- Top blowdown servomotor angle

This data is logged for 24 hours on the MM. Use the buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

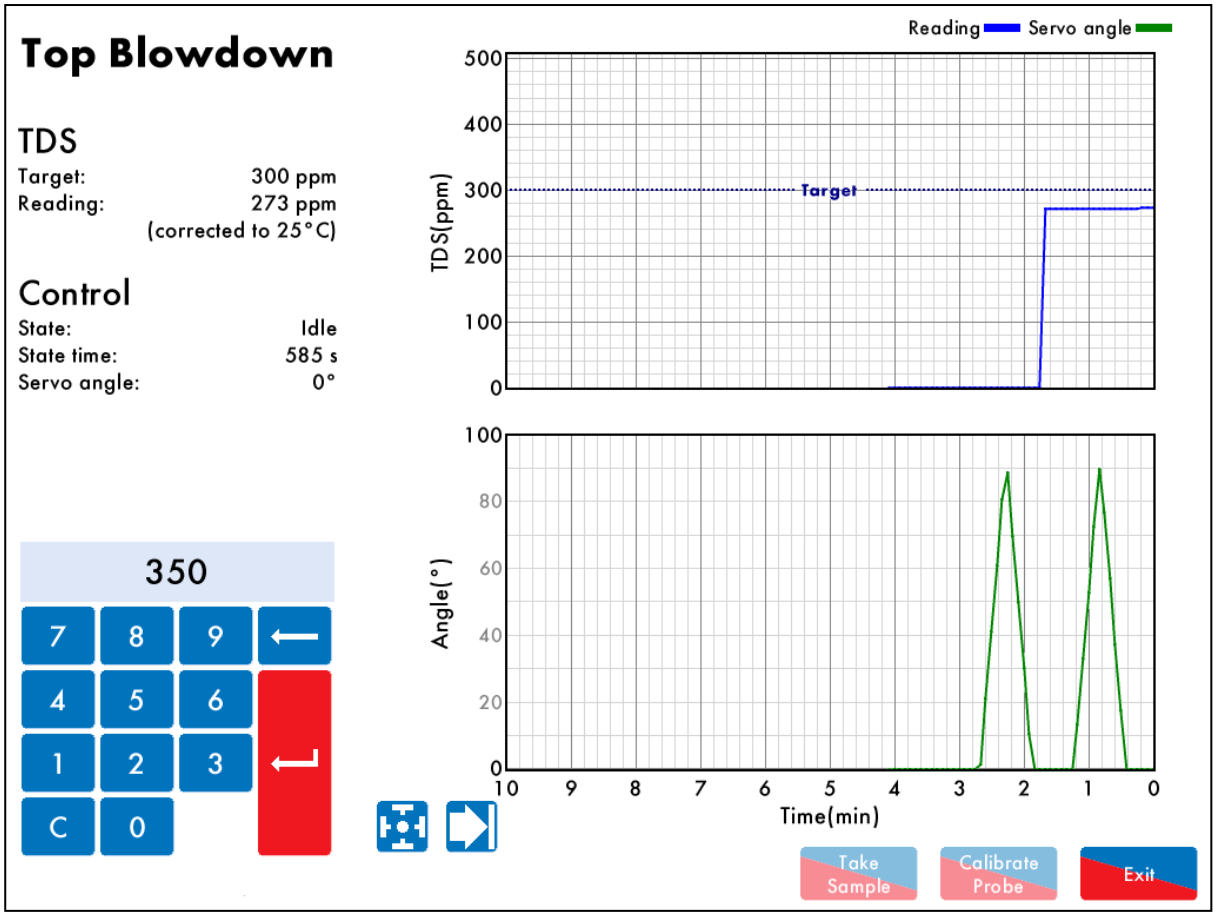


Figure 18.13.ii Calibrate TDS Probe

To calibrate the probe, press Calibrate Probe to calibrate the TDS probe. After taking a manual sample of the TDS, enter the value into the keypad and press ↵ to enter this value. This value must be within 10% - 990% of the probe reading to avoid incorrect calibration. If there is an air lock, the TDS probe will not be calibrated as the reading will be 0ppm. To check the manual sample value against the now calibrated probe value, press Take Sample to sample the TDS using the probe.

Note: Top blowdown control does not operate when the TDS probe is being calibrated, when a fresh sample is taken or when the burner is not firing.

18.14 Bottom Blowdown Screen

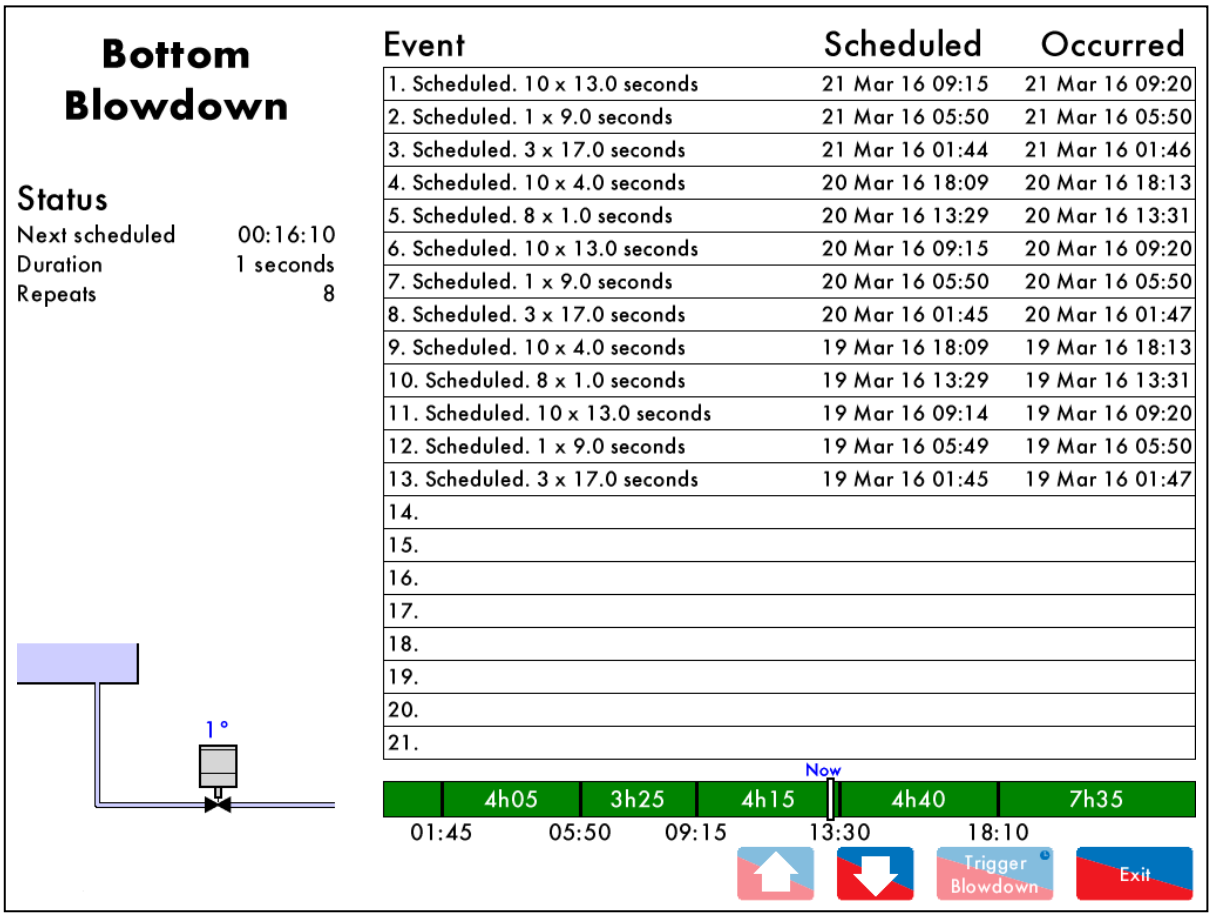


Figure 18.14.i Bottom Blowdown

Press on the bottom blowdown servomotor in the Home screen Figure 18.1.i to view the Bottom Blowdown screen, showing the bottom blowdown servomotor position, and when the next bottom blowdown is due. The bottom blowdown log stores the last 128 blowdowns, with the following information:

- Type of blowdown – scheduled, manual.
- Date and time blowdown scheduled.
- Date and time blowdown occurred.
- Number of repeats the and duration of blowdown.

If a manual trigger has been set for the bottom blowdown (expansion option 61), then when the next blowdown is due, the 

button must be pressed for the valve to blowdown. The status will then show 'waiting trigger' until this is pressed or a line voltage input is detected on terminal MB on the bottom blowdown module. If the blowdown is not triggered, the log will show the scheduled blowdown as being 'missed.'

To set the bottom schedule, please refer to section 18.19.9.

18.15 Steam Flow Screen

18.15.1 Steam Flow – Status

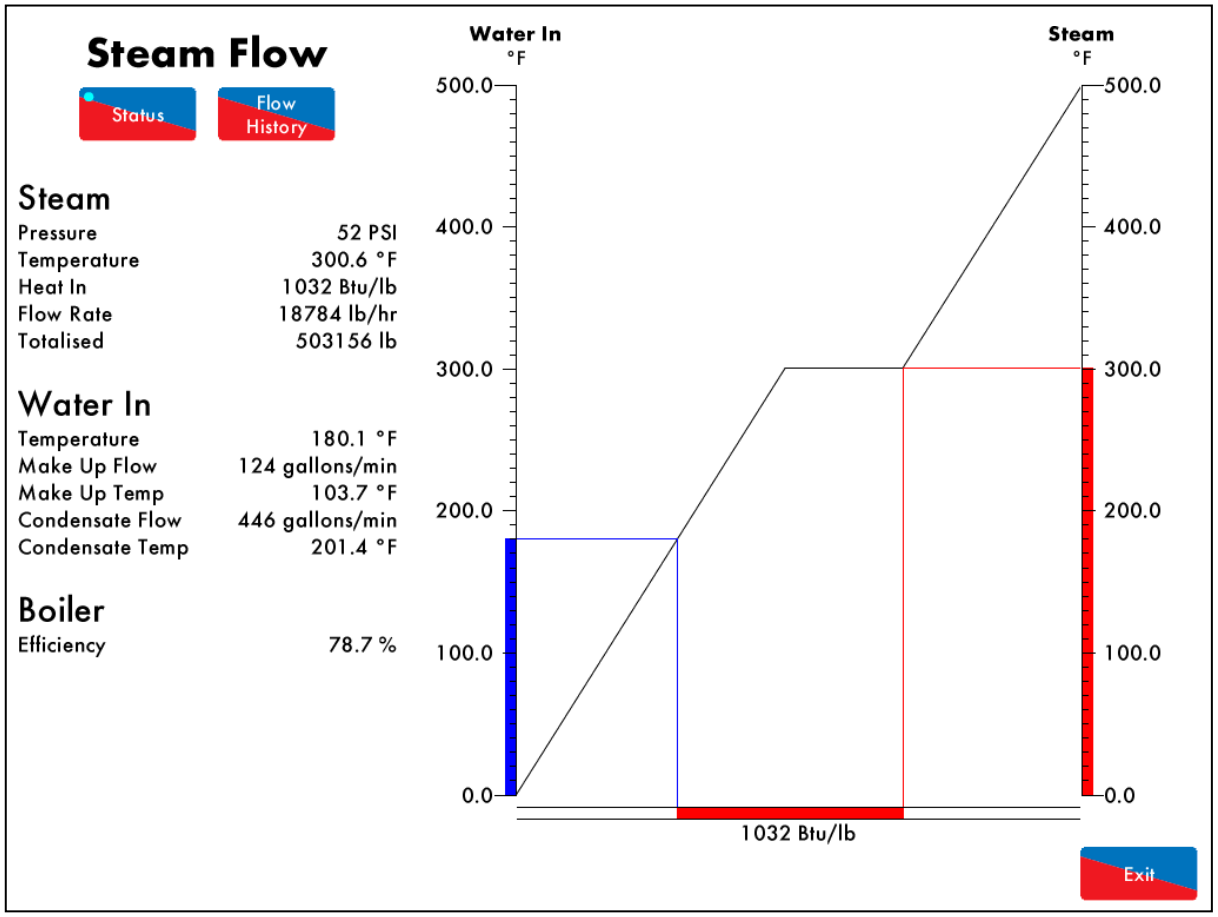


Figure 18.15.1.i Steam Flow

Press on the steam header (if enabled) in the Home screen in Figure 18.15.1.i to view the Steam Flow Status screen, which shows the following information:

- Current steam pressure.
- Current steam temperature.
- Heat in.
- Steam flow rate.
- Totalised steam flow.
- Feed water temperature.
- Make up water flow rate.
- Make up water temperature.
- Condensate water flow rate.
- Condensate water temperature.
- Boiler efficiency.

Note: The information displayed will depend on the steam/ hot water flow metering configuration (expansion option 120).

18.15.2 Steam Flow – History

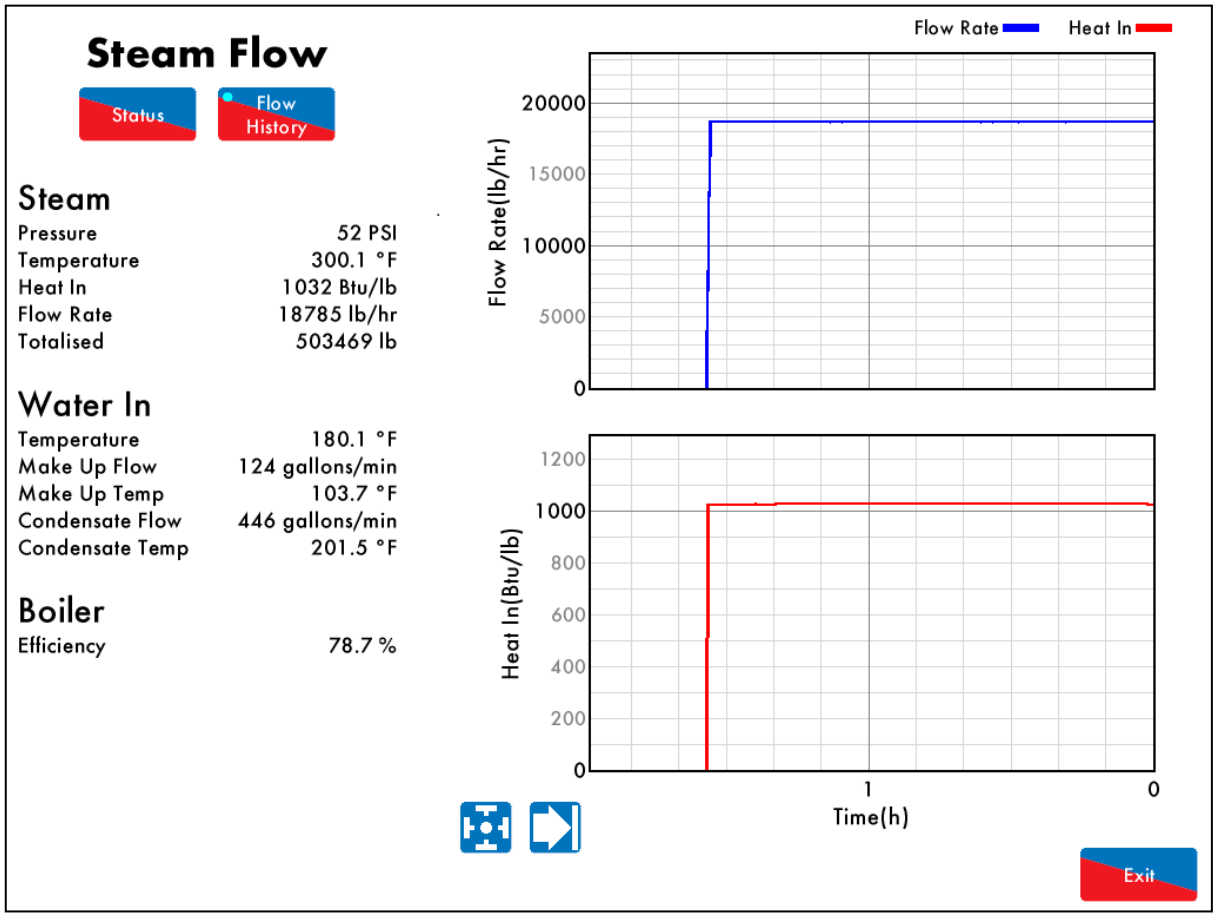


Figure 18.15.ii Steam Flow

Press Flow History in the Steam Flow Status screen in Figure 18.15.1.i to view the Steam Flow History screen, which shows the flow rate and heat in histories.

This data is logged for 24 hours on the MM. Use the buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

18.16 Draught Screen

18.16.1 Draught Control – Status

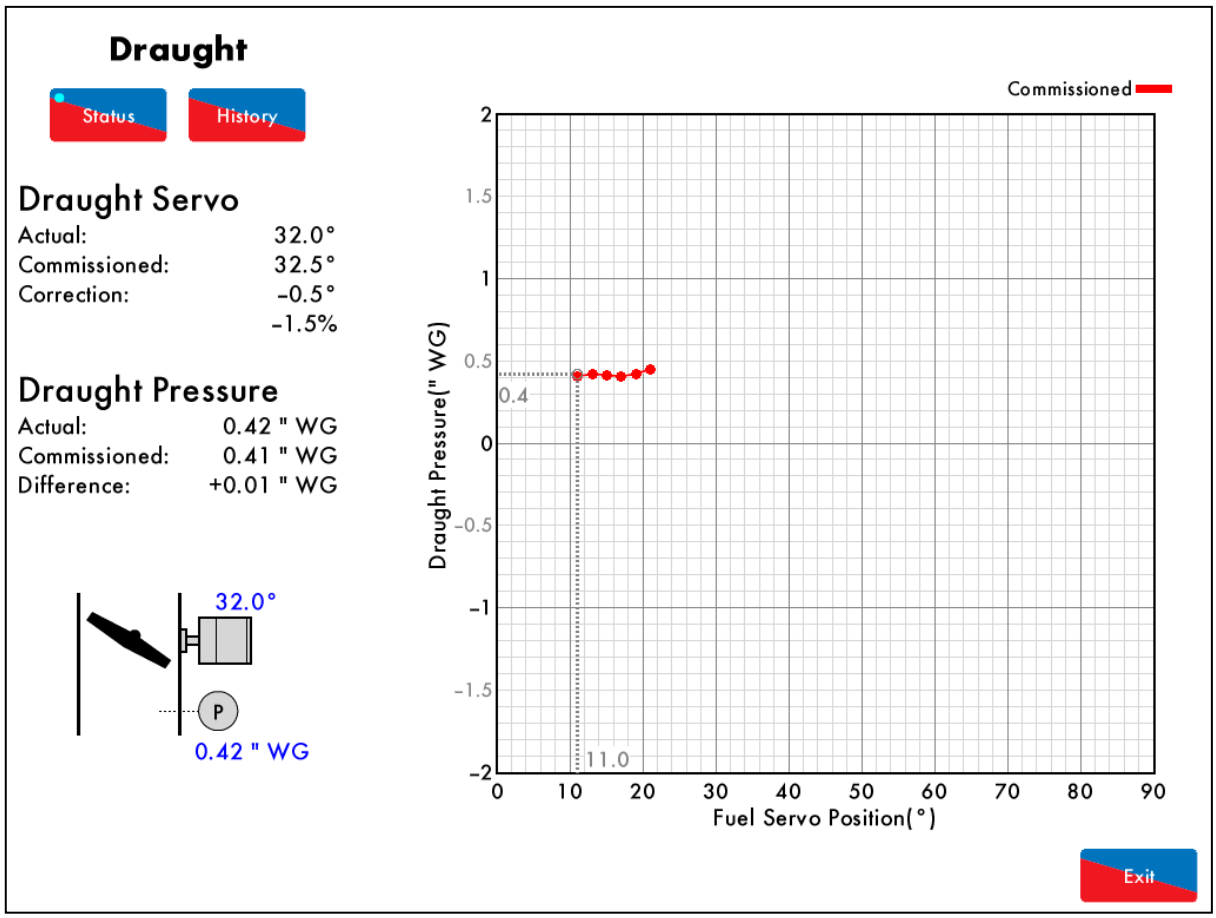


Figure 18.16.1.i Draught Control – Status

Press on the draught servomotor in the Home screen in Figure 18.1.i to view the Draught Control Status screen, which shows the following information:

- Actual draught servomotor angle.
- Commissioned draught servomotor angle.
- Draught servomotor correction.
- Actual draught pressure.
- Commissioned draught pressure.
- Difference between actual and commissioned draught servomotor.

18.16.2 Draught Control – History

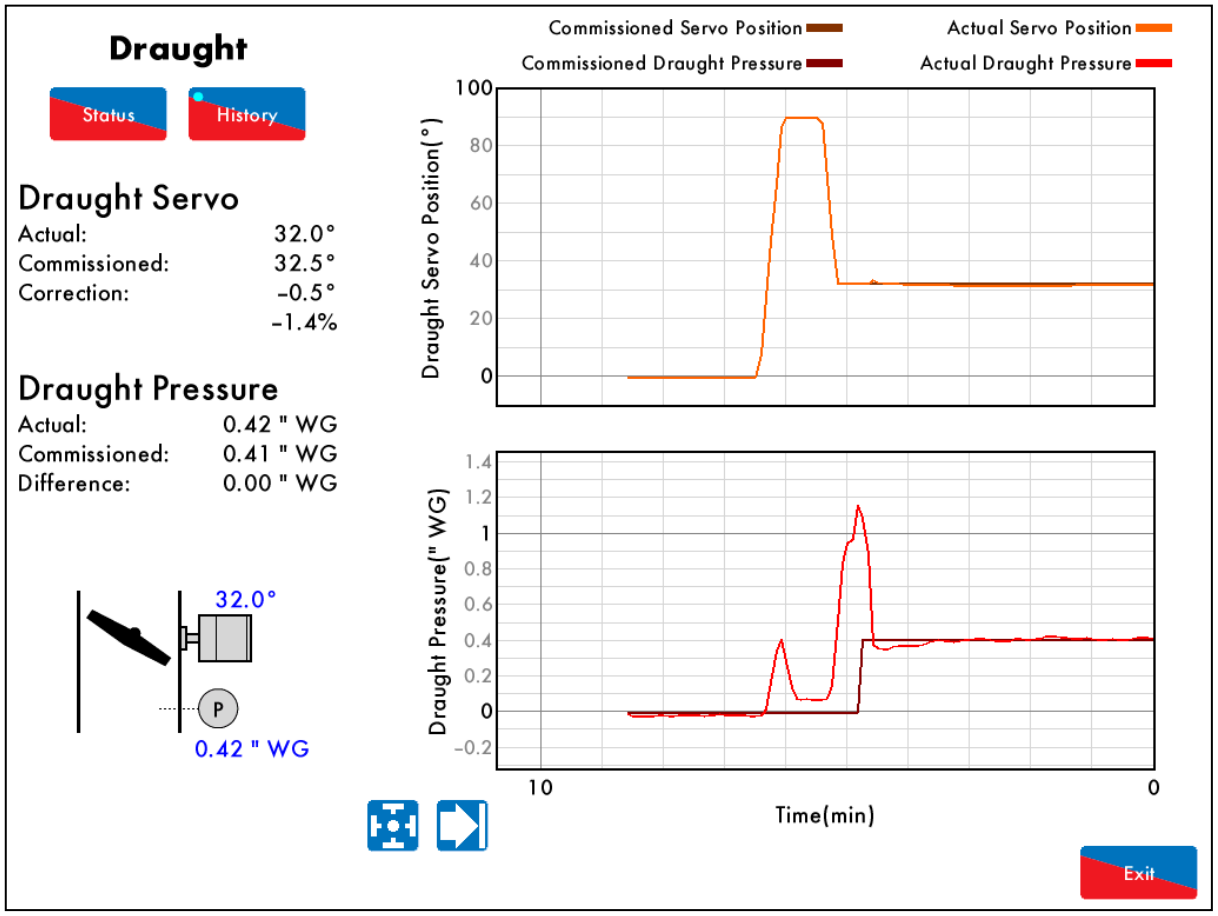


Figure 18.16.2.i Draught Control – History

Press History in the Draught Control Status screen in Figure 18.16.1.i to view the Draught Control History screen, showing the draught servomotor and draught pressure histories.

This data is logged for 24 hours on the MM. Use the buttons to change the timescale of the data displayed and press and drag on the axis to zoom in/out of the graph.

This information is logged for 3 years on the DTI when connected with the MM.

Note: Power cycling the MM or changing fuel will reset the 24-hour history data log on the MM.

18.17 First Outs

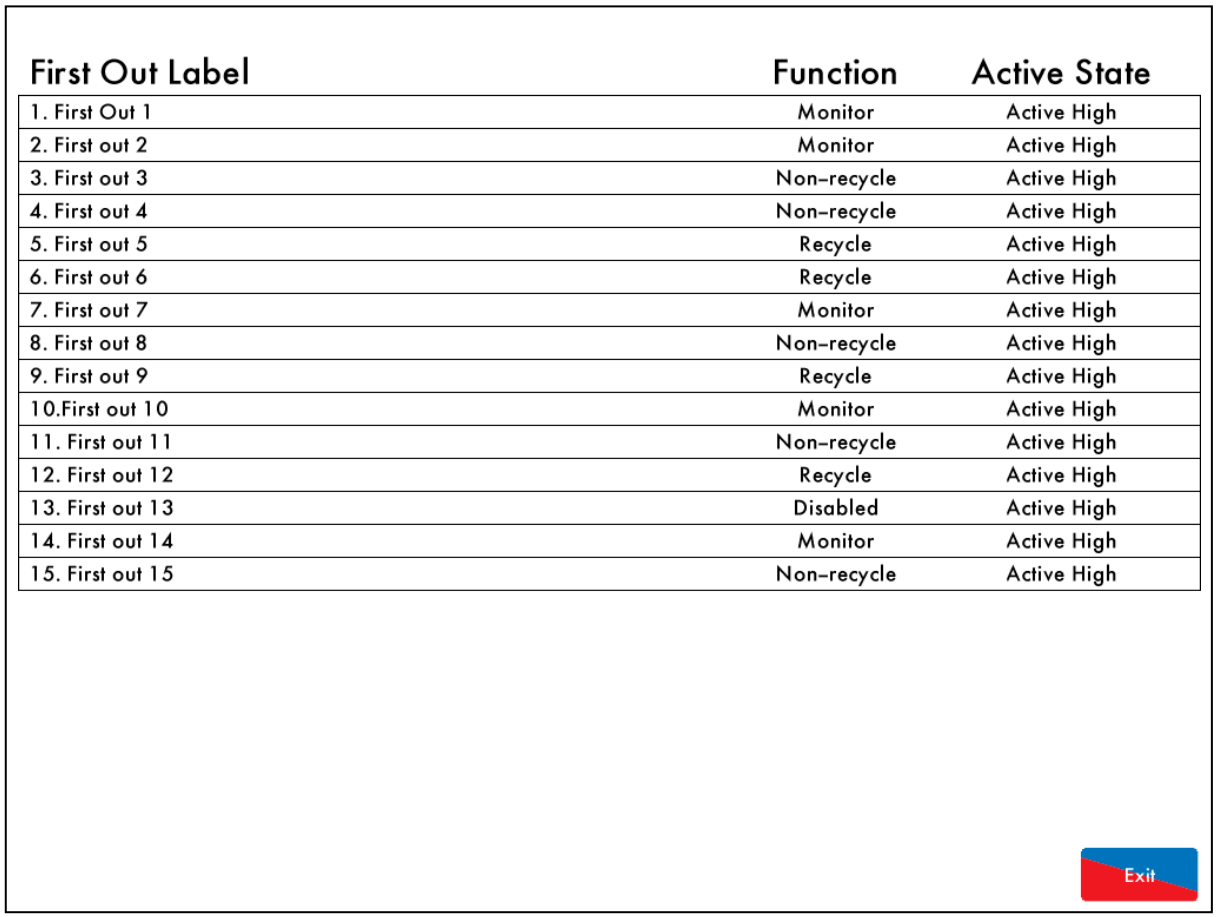


Figure 18.17.i First Outs

Press 

(if enabled) in the Home Screen in Figure 18.1.i to view the First Outs screen. The functions of a first out when active is summarised below:

Function When Active	Description
Disabled	Does not function.
Monitor	Burner continues firing, but the events will be logged.
Non-recycle	Burner stops firing and the first out must be reset for the burner to restart.
Recycle	Burner stops firing and restarts automatically when the input state changes.
Stop EGA Sampling	Burner continues firing, but the EGA stops sampling.
Stops EGA Trimming	Burner continues firing, but the EGA trim stops operating.

18.18 Fully Metered Combustion Control

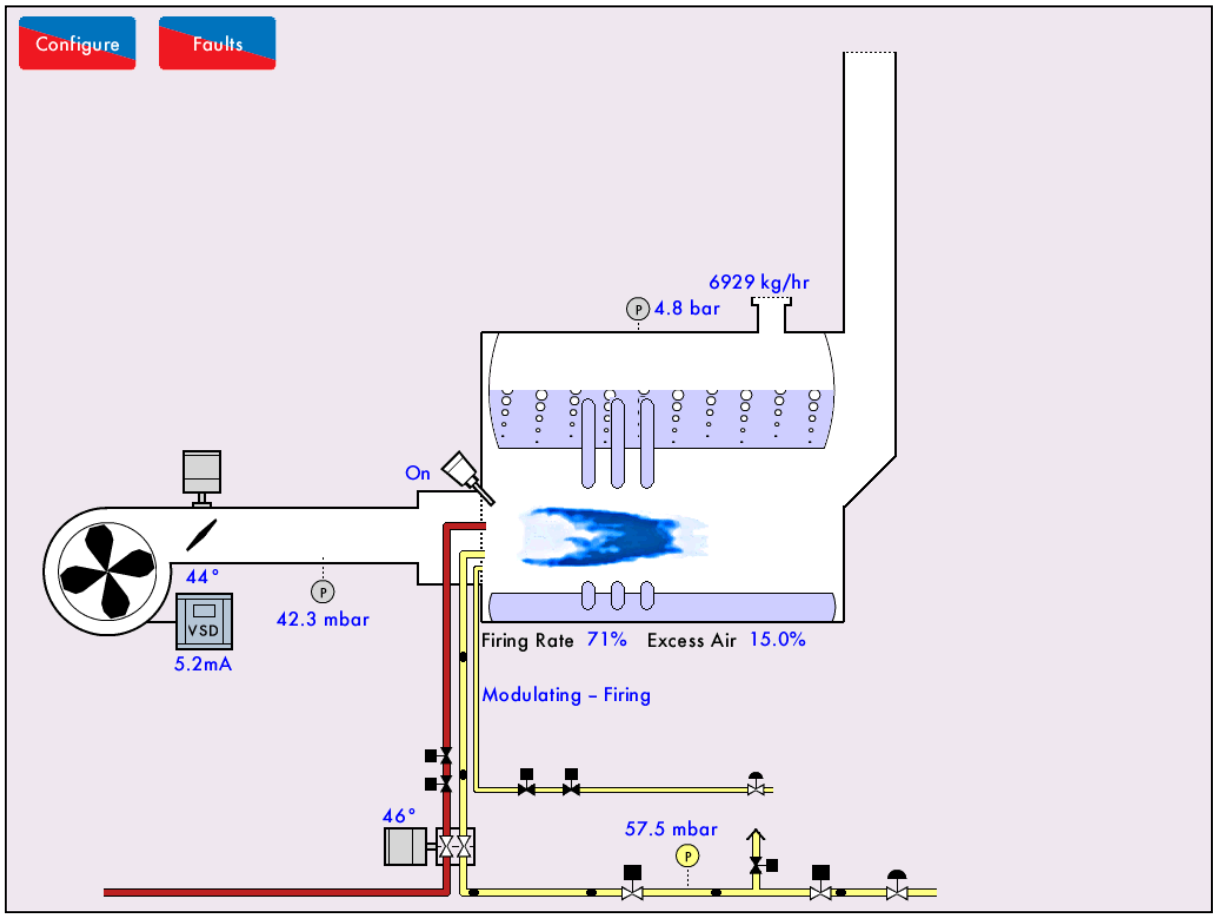


Figure 18.18.i Fully Metered Combustion Control

If fully metered combustion control is enabled, the Home screen will display the excess air going into the combustion process.

Pressing on the servomotors will show the fuel-air screens with the following information available:

- Current fuel and air mass flow rates.
- Current fuel and air volume flow rates.
- Current fuel and air temperatures.
- Current fuel and air pressures.
- Current fuel and air correction % to maintain the fuel-air ratio at that firing rate.
- Current equivalence ratio.
- Current excess air.
- Commissioned excess air.

18.19 System Configuration Screen

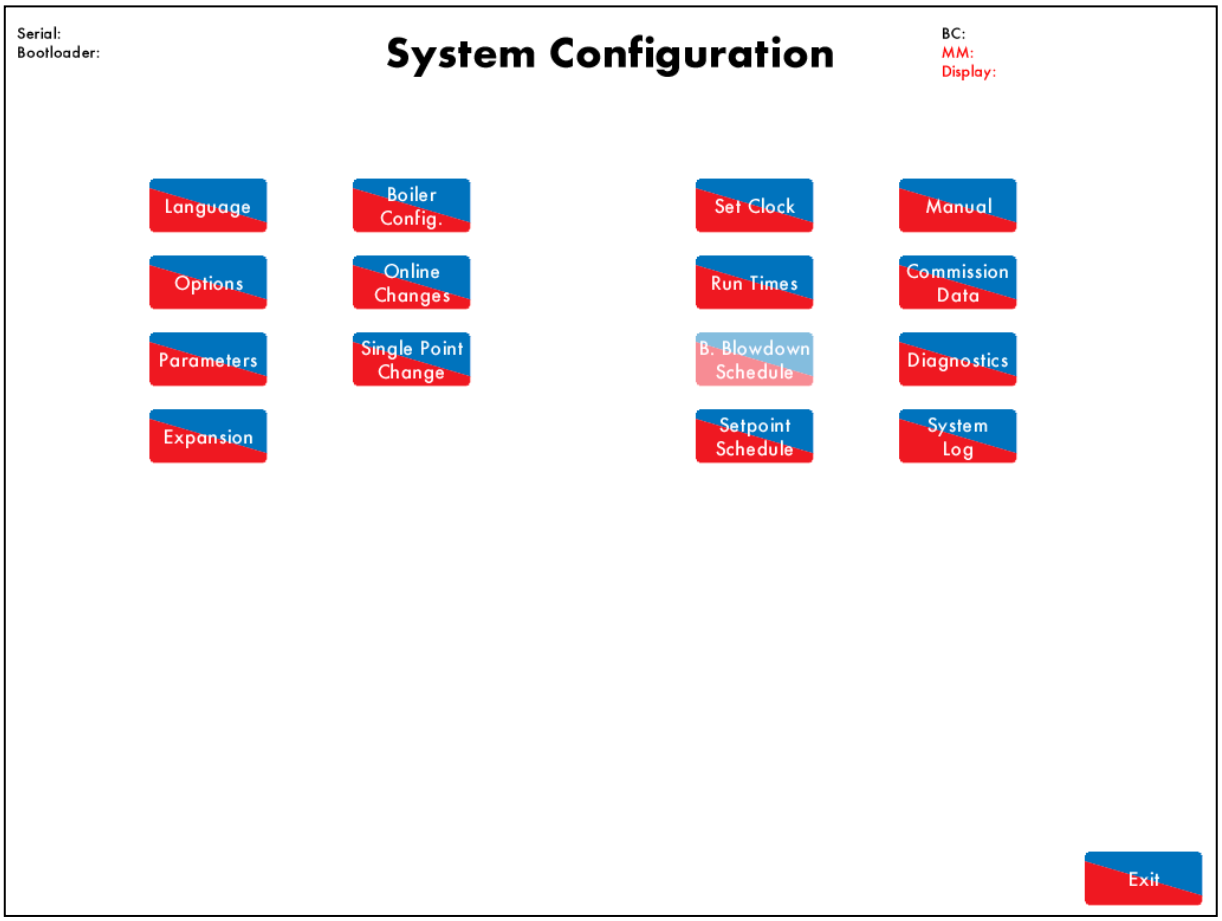


Figure 18.19.i

Press 

in the Home screen in Figure 18.1.i to access the System Configuration screen. From this screen it's possible to:

- Change language (password protected).
- View all options.
- View all parameters.
- View all expansion options.
- Change boiler configuration display in Home screen (password protected).
- Access online changes (password protected).
- Access single point change (password protected).
- Set clock (password protected).
- Set run times (password protected).
- Set bottom blowdown schedule if enabled (password protected).
- View operating manual.
- View commission data.
- View real-time diagnostics.
- View system log.

In the top left corner, the serial number and bootloader of the MM are shown, and in the top right, the BC, MM and Display software versions are shown.

18.19.1 Language Selection

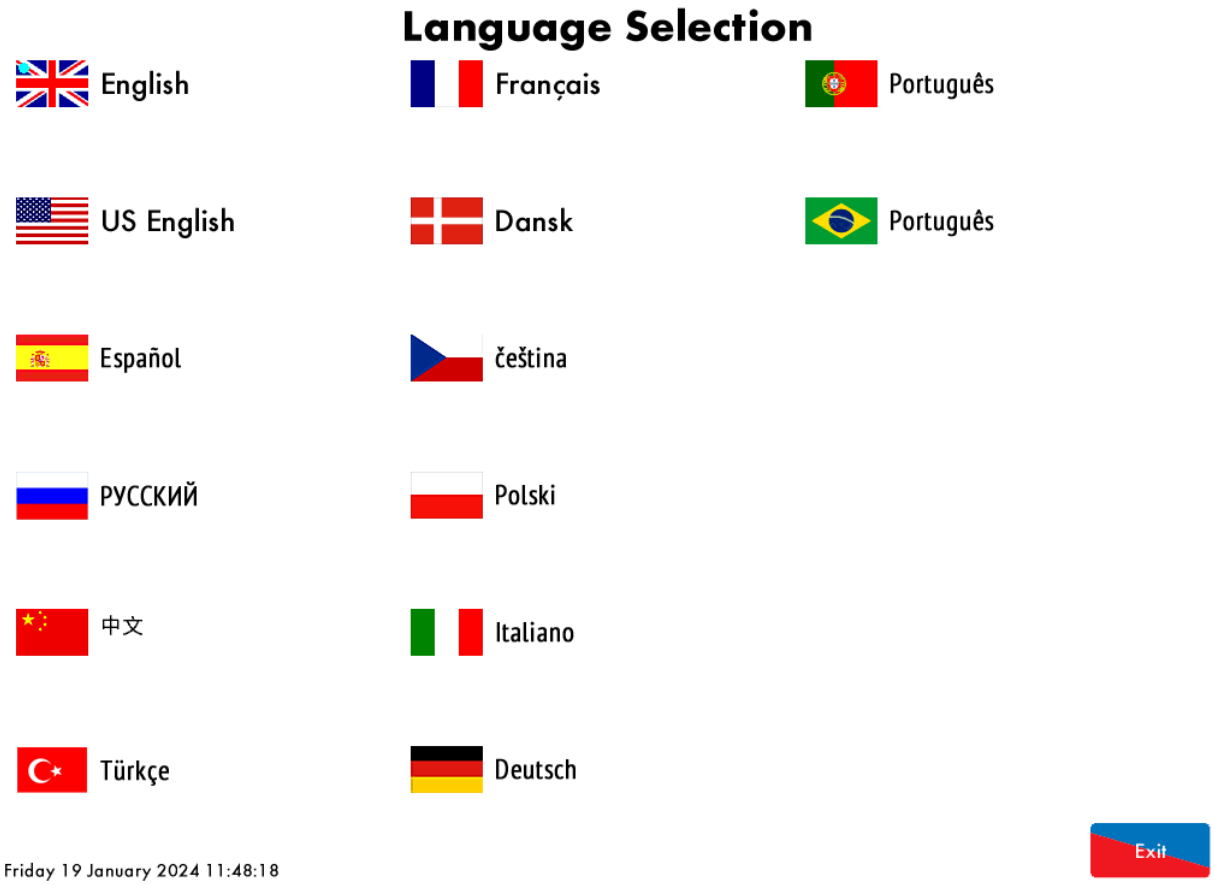


Figure 18.19.1.i Language Selection

Press 

in the System Configuration screen in Figure 18.19.i to access Language Selection screen; you will be prompted to enter the Online Changes password. Please contact your local approved Autoflame tech centre for this password.

Note: The SD card must contain the language file to be able to select the language. If a language required is not available, please contact the Autoflame office.

18.19.2 Options

Read Only

Options | Parameters | Expansion

#	Description	Value
1	MM: Boiler Temperature/Pressure Sensor Type	Medium pressure (MM10008, 0 – 20bar / 300psi)
2	MM: Modulating Motor Travel Speed Limit	1.5
3	MM: Return to Curve Mode	Return to curve at purge speed
4	MM: Flame Safeguard Mode	Enabled
5	MM: Purge Position	Channels 1 to 4 purge at OPEN position
6	PID: Proportional Band	1.0 bar
7	PID: Integral Time	60 seconds
8	MM: Servomotor Channels	Channels 1 & 2
9	MM: Internal Stat Operation	Burner operates below setpoint
10	MM: Burner Switch-Off Offset	2.0 bar
11	MM: Burner Switch-On Offset	1.0 bar
12	EGA: EGA Functionality	Not optioned
13	EGA: EGA Fault Response	EGA faults generate Alarms (Burner stops)
14	MM: Warning Response	Warnings drive Common System Alarm output (T79)
15	MM: User Control	Burner on/off and setpoint control enabled
16	DTI: Sequencing and DTI enable	Sequencing disabled
17	Unused: Option 17	0
18	EGA: Carry Forward of Trim	Enabled
19	EGA: O2 Upper Limit Offset	Disabled

All | MM | PID | EGA | DTI | BC

Exit

Monday 19 June 2023 12:17:50

Figure 18.19.2.i Options

Press Options in the System Configuration screen in Figure 18.19.i to view the Options screen, which displays all of the options and their ranges and settings. This is a read only mode, so no changes can be made to the options in this screen. Options highlighted in blue are ones which have been changed from the default values.

Press on the MM, PID, EGA, DTI and BC tabs to group together options in those categories.

18.19.3 Parameters

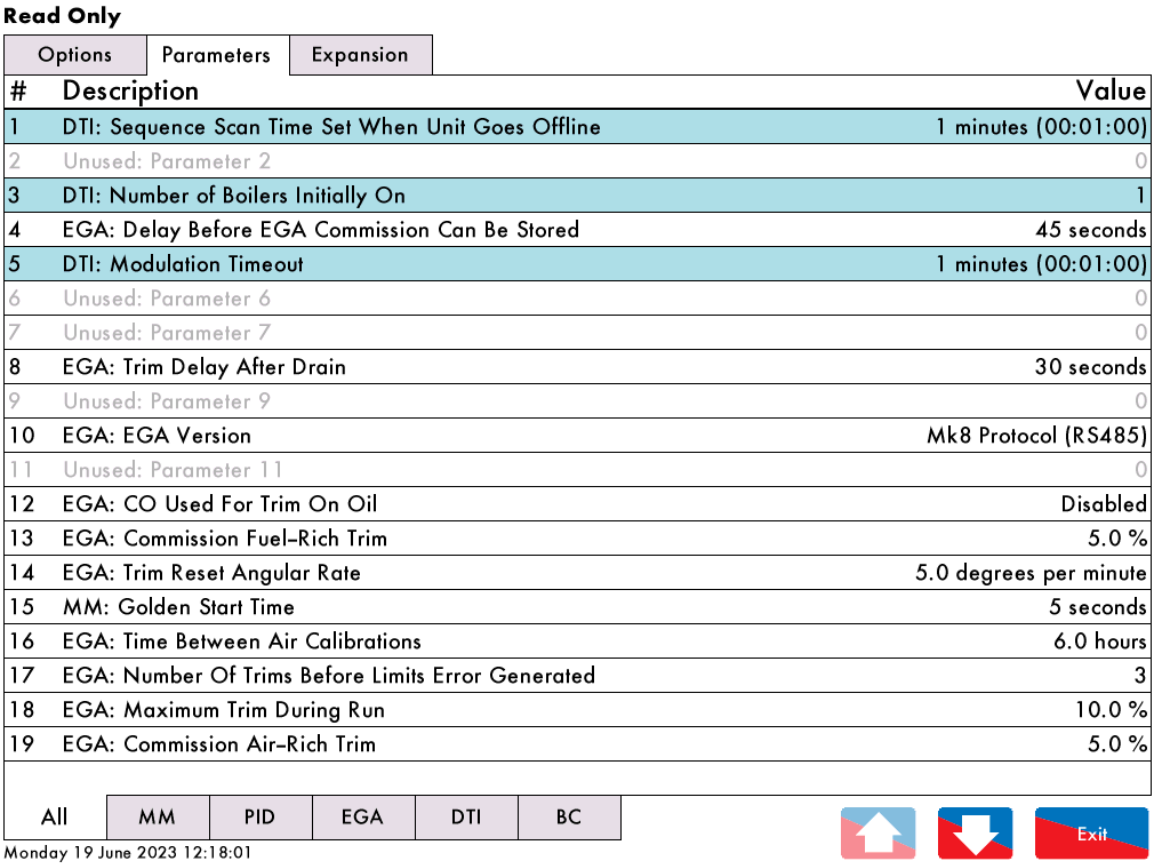


Figure 18.19.3.i Parameters

Press 

in the System Configuration screen in Figure 18.19.i to view the Parameters screen, which displays all of the parameters and their ranges and settings. This is a read only mode, so no changes can be made to the parameters in this screen. Parameters highlighted in blue are ones which have been changed from the default values.

Press on the MM, PID, EGA, DTI and BC tabs to group together parameters in those categories.

18.19.4 Expansion Options

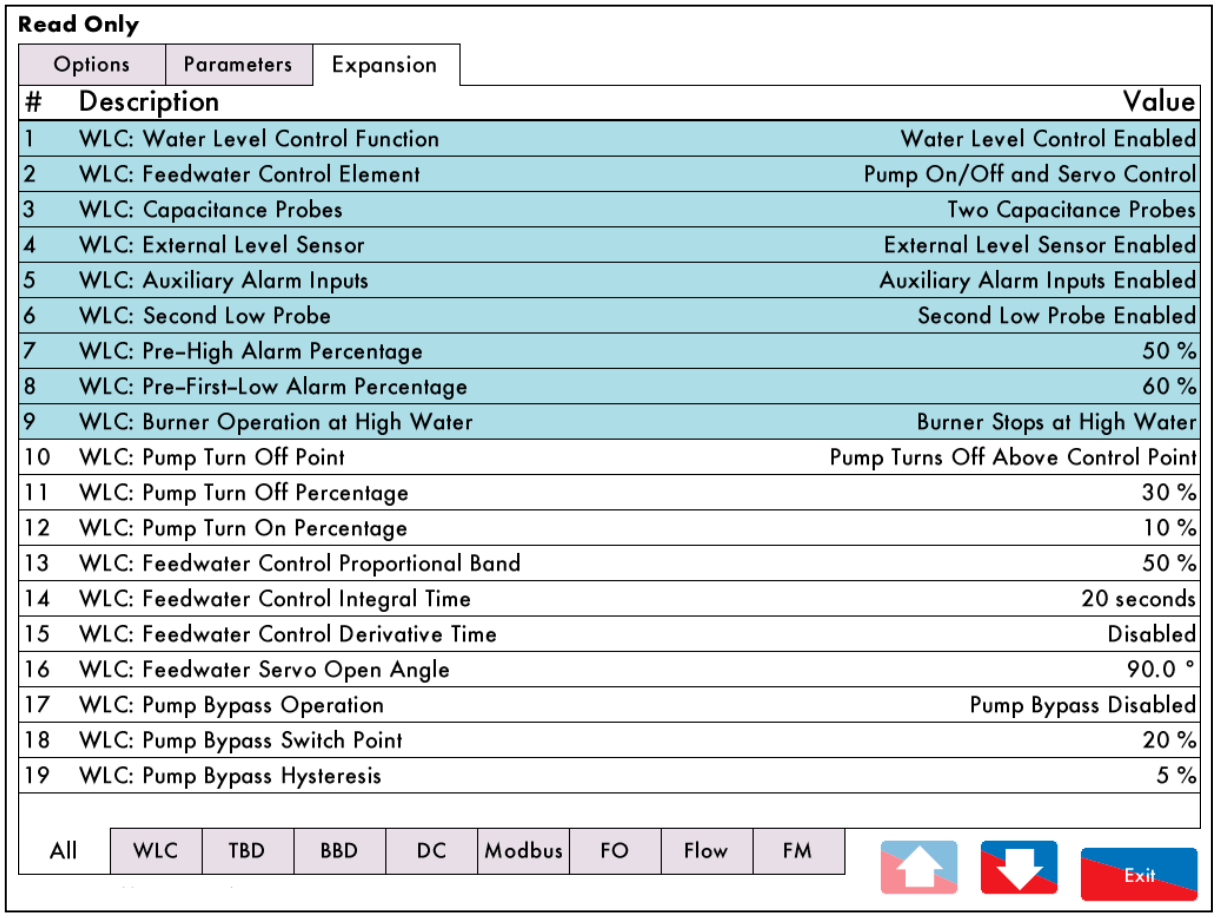


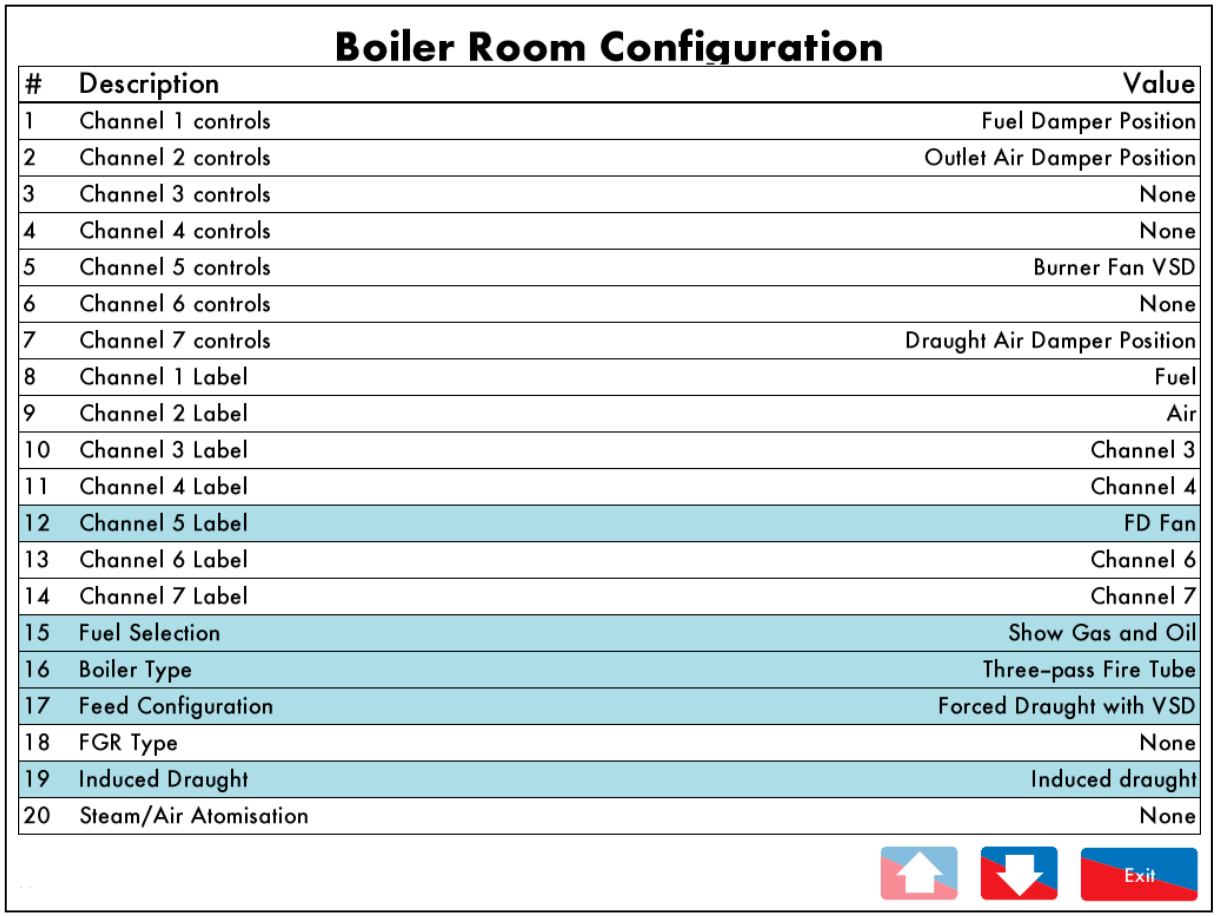
Figure 18.19.4.i Expansion Options

Press 

in the System Configuration screen in Figure 18.19.i to view the Expansion Options screen, which displays all of the expansion options and their ranges and settings. This is a read only mode, so no changes can be made to the expansion options in this screen. Expansion options highlighted in blue are ones which have been changed from the default values.

Press on the MM, PID, EGA, DTI and BC tabs to group together expansion options in those categories.

18.19.5 Boiler Room Configuration



Boiler Room Configuration

#	Description	Value
1	Channel 1 controls	Fuel Damper Position
2	Channel 2 controls	Outlet Air Damper Position
3	Channel 3 controls	None
4	Channel 4 controls	None
5	Channel 5 controls	Burner Fan VSD
6	Channel 6 controls	None
7	Channel 7 controls	Draught Air Damper Position
8	Channel 1 Label	Fuel
9	Channel 2 Label	Air
10	Channel 3 Label	Channel 3
11	Channel 4 Label	Channel 4
12	Channel 5 Label	FD Fan
13	Channel 6 Label	Channel 6
14	Channel 7 Label	Channel 7
15	Fuel Selection	Show Gas and Oil
16	Boiler Type	Three-pass Fire Tube
17	Feed Configuration	Forced Draught with VSD
18	FGR Type	None
19	Induced Draught	Induced draught
20	Steam/Air Atomisation	None

Figure 18.19.5.i Boiler Room Configuration

Press 

in the System Configuration screen in Figure 18.19.i to access the Boiler Room Configuration screen; you will be prompted to enter the Online Changes password. Please contact your local approved Autoflame tech centre for this password.

The boiler room configuration settings are used to customise the Home screen in Figure 18.1.i. Any settings which are highlighted in blue are ones which have been changed from the default value.

The table below shows the available Boiler Room Configuration settings:

Setting	Default	Range	Description
1	1		Channel 1 Controls
		1	Fuel damper position
2	3		Channel 2 Controls
		2	Inlet air damper position
		3	Outlet air damper position
		7	Rotary cup primary air damper position
3	0		Channel 3 Controls
		0	None
		2	Inlet air damper position
		3	Outlet air damper position
		4	FGR air damper position
		5	Draught air damper position
		6	Steam/air atomisation damper position
		7	Rotary cup primary air damper position
		8	Economiser bypass damper position
		9	Superheater Mixing Valve
4	0		Channel 4 Controls
		0	None
		2	Inlet air damper position
		3	Outlet air damper position
		4	FGR air damper position
		5	Draught air damper position
		6	Steam/air atomisation damper position
		7	Rotary cup primary air damper position
		8	Economiser bypass damper position
		9	Superheater Mixing Valve
5	1		Channel 5 Controls
		0	None
		1	Burner fan VSD
		2	FGR fan VSD
		3	Draught fan VSD
		4	Rotary cup primary air VSD
6	0		Channel 6 Controls
		0	None
		1	Burner fan VSD
		2	FGR fan VSD
		3	Draught fan VSD
		4	Rotary cup primary air VSD
7	5		Channel 7 Controls
		0	None
		2	Inlet air damper position
		3	Outlet air damper position
		4	FGR Air damper position
		5	Draught air damper position
		6	Steam/air atomisation damper position
		7	Rotary cup primary air damper position
		8	Economiser bypass damper position
		9	Superheater Mixing Valve

Setting	Default	Range	Description
8	1		Channel 1 Label
		0	Channel 1
		1	Fuel
		2	Gas
		3	Oil
		4	Air
		5	FGR
		6	P-Air
		7	S-Air
		8	T-Air
		9	ID fan
		10	FD fan
		11	Steam
		12	VSD
		13	Blower
		14	Sleeve
		15	Head
		16	Inlet
		17	Outlet
		18	Water
		19	Draught
9	4		Channel 2 Label
		0	Channel 2
		1	Fuel
		2	Gas
		3	Oil
		4	Air
		5	FGR
		6	P-Air
		7	S-Air
		8	T-Air
		9	ID fan
		10	FD fan
		11	Steam
		12	VSD
		13	Blower
		14	Sleeve
		15	Head
		16	Inlet
		17	Outlet
		18	Water
		19	Draught

Setting	Default	Range	Description
10	0		Channel 3 Label
		0	Channel 3
		1	Fuel
		2	Gas
		3	Oil
		4	Air
		5	FGR
		6	P-Air
		7	S-Air
		8	T-Air
		9	ID fan
		10	FD fan
		11	Steam
		12	VSD
		13	Blower
		14	Sleeve
		15	Head
		16	Inlet
		17	Outlet
		18	Water
		19	Draught
11	0		Channel 4 Label
		0	Channel 4
		1	Fuel
		2	Gas
		3	Oil
		4	Air
		5	FGR
		6	P-Air
		7	S-Air
		8	T-Air
		9	ID fan
		10	FD fan
		11	Steam
		12	VSD
		13	Blower
		14	Sleeve
		15	Head
		16	Inlet
		17	Outlet
		18	Water
		19	Draught

Setting	Default	Range	Description
12	12		Channel 5 Label
		0	Channel 5
		1	Fuel
		2	Gas
		3	Oil
		4	Air
		5	FGR
		6	P-Air
		7	S-Air
		8	T-Air
		9	ID fan
		10	FD fan
		11	Steam
		12	VSD
		13	Blower
		14	Sleeve
		15	Head
		16	Inlet
		17	Outlet
		18	Water
		19	Draught
13	0		Channel 6 Label
		0	Channel 6
		1	Fuel
		2	Gas
		3	Oil
		4	Air
		5	FGR
		6	P-Air
		7	S-Air
		8	T-Air
		9	ID fan
		10	FD fan
		11	Steam
		12	VSD
		13	Blower
		14	Sleeve
		15	Head
		16	Inlet
		17	Outlet
		18	Water
		19	Draught

Setting	Default	Range	Description
14	0		Channel 7 Label
		0	Channel 7
		1	Fuel
		2	Gas
		3	Oil
		4	Air
		5	FGR
		6	P-Air
		7	S-Air
		8	T-Air
		9	ID fan
		10	FD fan
		11	Steam
		12	VSD
		13	Blower
		14	Sleeve
		15	Head
		16	Inlet
		17	Outlet
		18	Water
		19	Draught
15	0		Fuel Selection
		0	Show gas train
		1	Show oil train
		2	Show gas and oil
		3	Show gas and oil close-coupled
16	0		Boiler Type
		0	Water tube
		1	Two-pass fire tube
		2	Three-pass fire tube
		3	Four-pass fire tube
		4	Cast-sectional tube
		5	Horizontal coil tube
		6	Vertical coil tube
		7	Kiln
		8	Vertical Condenser
		9	Crucible
17	0		Feed Configuration
		0	Forced draught
		1	Forced draught with VSD
		2	Rotary cup
18	0		FGR Type
		0	None
		1	Induced FGR with a motorised damper
		2	Forced FGR with a motorised damper
		3	Forced FGR with VSD
		4	Forced FGR with motorised damper and VSD
19	0		Induced Draught
		0	None
		1	Induced draught
		2	Induced draught with damper
		3	Induced draught with VSD
		4	Induced draught with motorised damper and VSD

Setting	Default	Range	Description
20	0		Steam/ Air Atomisation
		0	None
		1	Show steam/ air train
		2	Show steam/ air train with a servo
21	0		Two-Port Valve
		0	None
		1	Show two-port valve
22	0		Combustion Head Type
		0	Diffuser
		1	Mesh
23	0		Water Level Probes Display
		0	Display in boiler
		1	Display in pot
24	0		Boiler Pressure Metric Display Units
		0	bar
		1	kPa
25	0		Fuel 1 Configuration Override
		0	None
		1	Disable FGR fan animation
26	0		Fuel 2 Configuration Override
		0	None
		1	Disable FGR fan animation
27	0		Fuel 3 Configuration Override
		0	None
		1	Disable FGR fan animation
28	0		Fuel 4 Configuration Override
		0	None
		1	Disable FGR fan animation

18.19.6 Online Changes

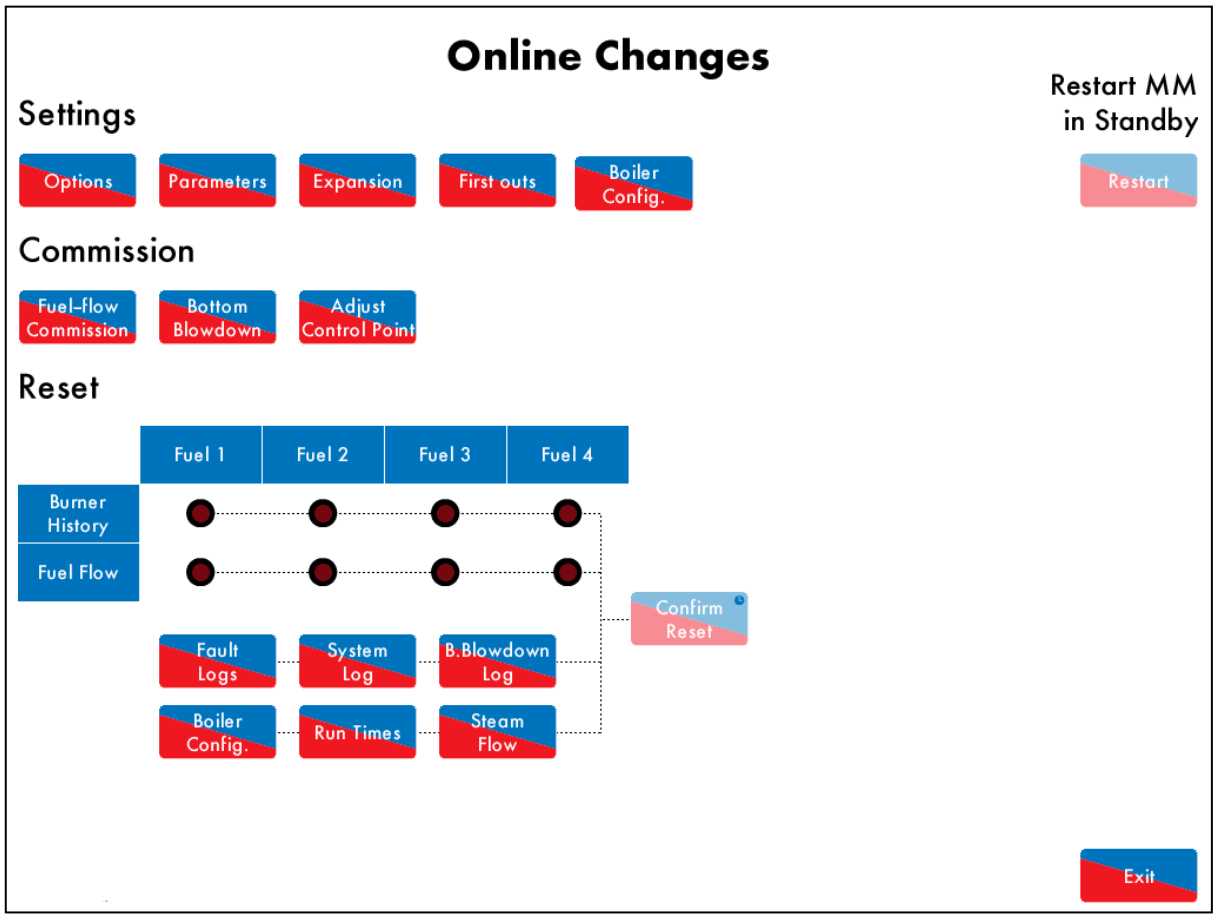


Figure 18.19.6.i Online Changes Screen

Press Online Changes in the System Configuration screen in Figure 18.19.i to access the Online Changes screen; you'll be prompted to enter the Online Changes password. Please contact your local approved Autoflame tech centre for this password. The Online Changes feature allows the following:

- Change non-safety critical options, parameters and expansion options.
- Configure settings and labels for first outs.
- Fuel flow commissioning.
- Set bottom blowdown servomotor positions.
- Adjust water level control point.
- Reset burner history.
- Reset fuel flow data.
- Reset fault logs.
- Reset system log.
- Reset bottom blowdown log.
- Reset boiler configuration.
- Reset run times.
- Reset steam flow metering.
- Restart MM if the burner is in standby.

18.19.7 Set Clock

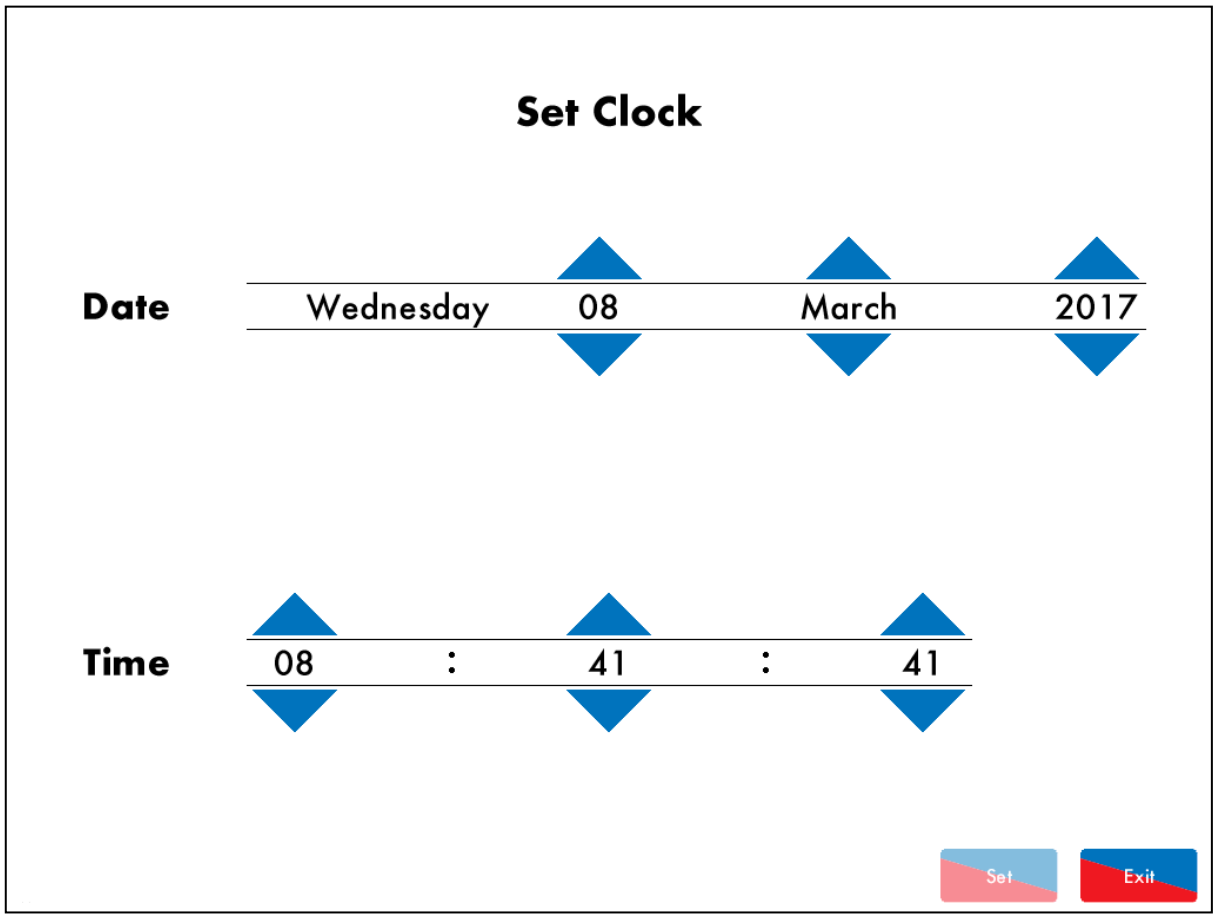


Figure 18.19.7.i Set Clock

Press Set Clock in the System Configuration screen in Figure 18.19.i to access the Set Clock screen; you will be prompted to enter the password (10, 10). Change the time and data using the ▼ ▲ arrows and then press Set and then press Exit.

Note: If the MM is connected to a DTI, then the time and data will be set by the DTI and cannot be adjusted on the MM. If the Mk8 MM has the following software (DI 8.17, FAR 8.21) & above. The Mk8 MM will ignore the date & time from the DTI.

18.19.8 Run Times

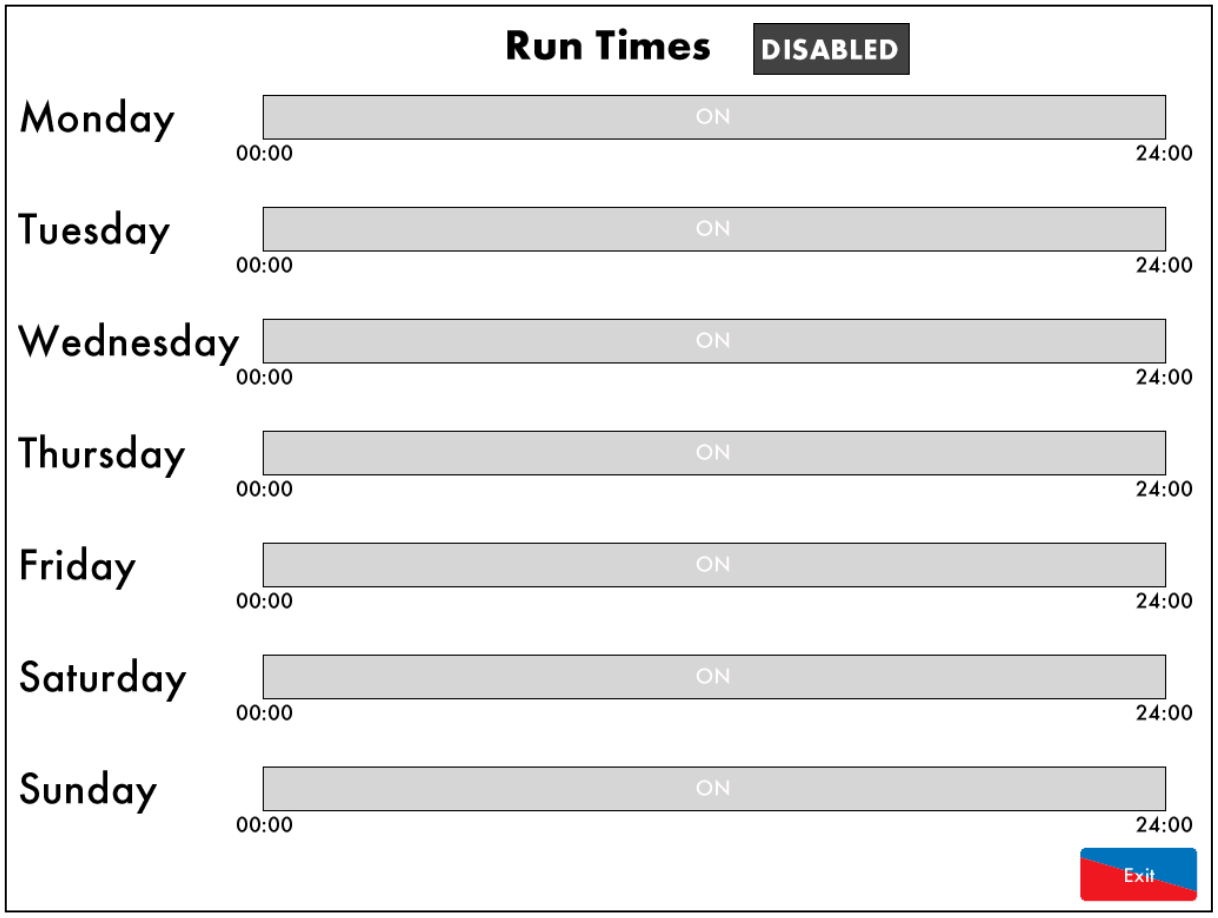


Figure 18.19.8.i Run Times – Disabled

Press 

in the System Configuration screen in Figure 18.19.i to access the Run Times screen, where a burner schedule can be set; you will be prompted to enter a password (11, 11). Run times sets when the MM is scheduled to be on and firing to meet the required setpoint, on and firing to meet the reduced setpoint or off.

The reduced setpoint is set in the Status screen in Figure 18.2.1.i.

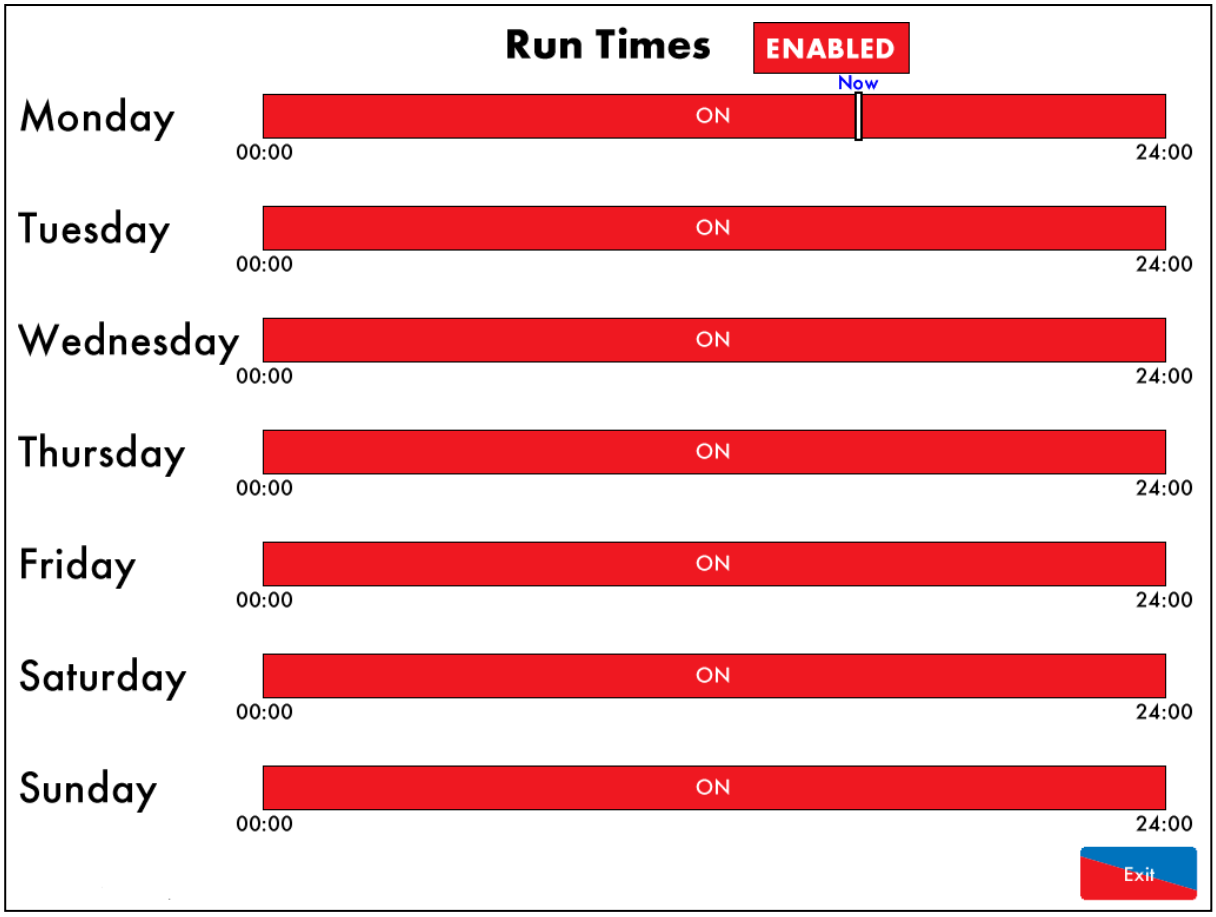


Figure 18.19.8.ii Run Times – Enabled

Press DISABLED in the Run Time screen in Figure 18.19.8.i to enable Run Times. Press on the bar next to the day to set the run times for that day of the week.

To disable the run times press ENABLED.

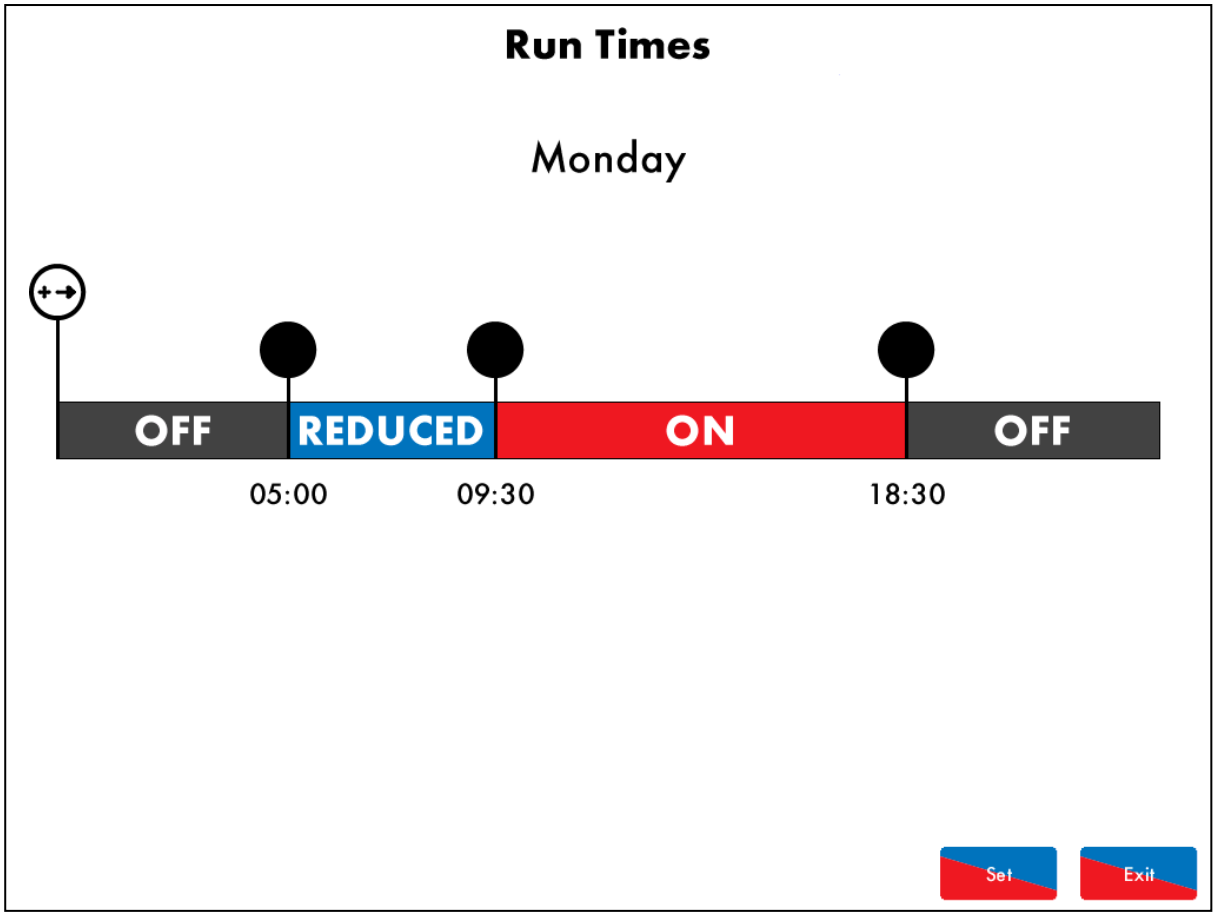


Figure 18.19.8.iii Run Times – Monday

To see the schedule press on the bar for that day in the Run Times screen in Figure 18.19.8.ii and press to add intervals, displayed as , then press on the bar to change the intervals to ON, OFF or REDUCED. Up to 10 time intervals can be set per day.

To remove an interval press on and drag upwards.

Press Set and then press Exit.

18.19.9 Bottom Blowdown Schedule

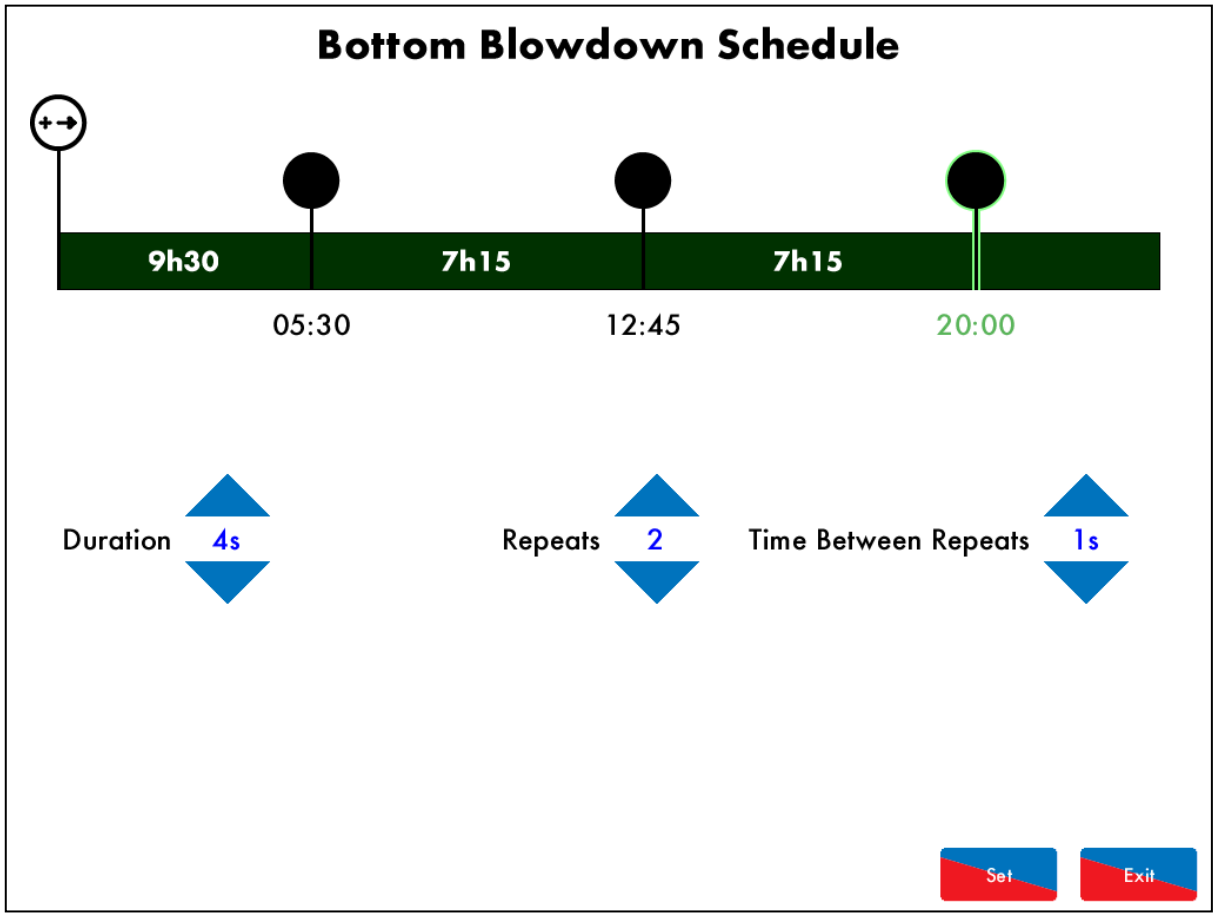


Figure i Bottom Blowdown Schedule

Press 

in the System Configuration screen in Figure 18.19.i to access the Bottom Blowdown Schedule screen; you will be prompted to enter a password.

Press on  to add a blowdown time. Press and drag to the left or right to adjust this time. Use the  buttons to increase and decrease the time/number of repeats. The bottom blowdowns can be schedule at 5 minute intervals within the following ranges:

Configuration	Range
Duration of blowdown	1 – 60s
Number of repeats for the blowdown	1 – 10
Time between repeats	1 – 60s
Number of schedule blowdowns	1 – 10 over 24hour period

To remove a blowdown time press on  and drag this up, and then press  to remove this blowdown time from the schedule.

Once the blowdown times have been set, press 

to save the blowdown times, and then press 

to leave the bottom blowdown configuration screen.

18.19.10 Manual

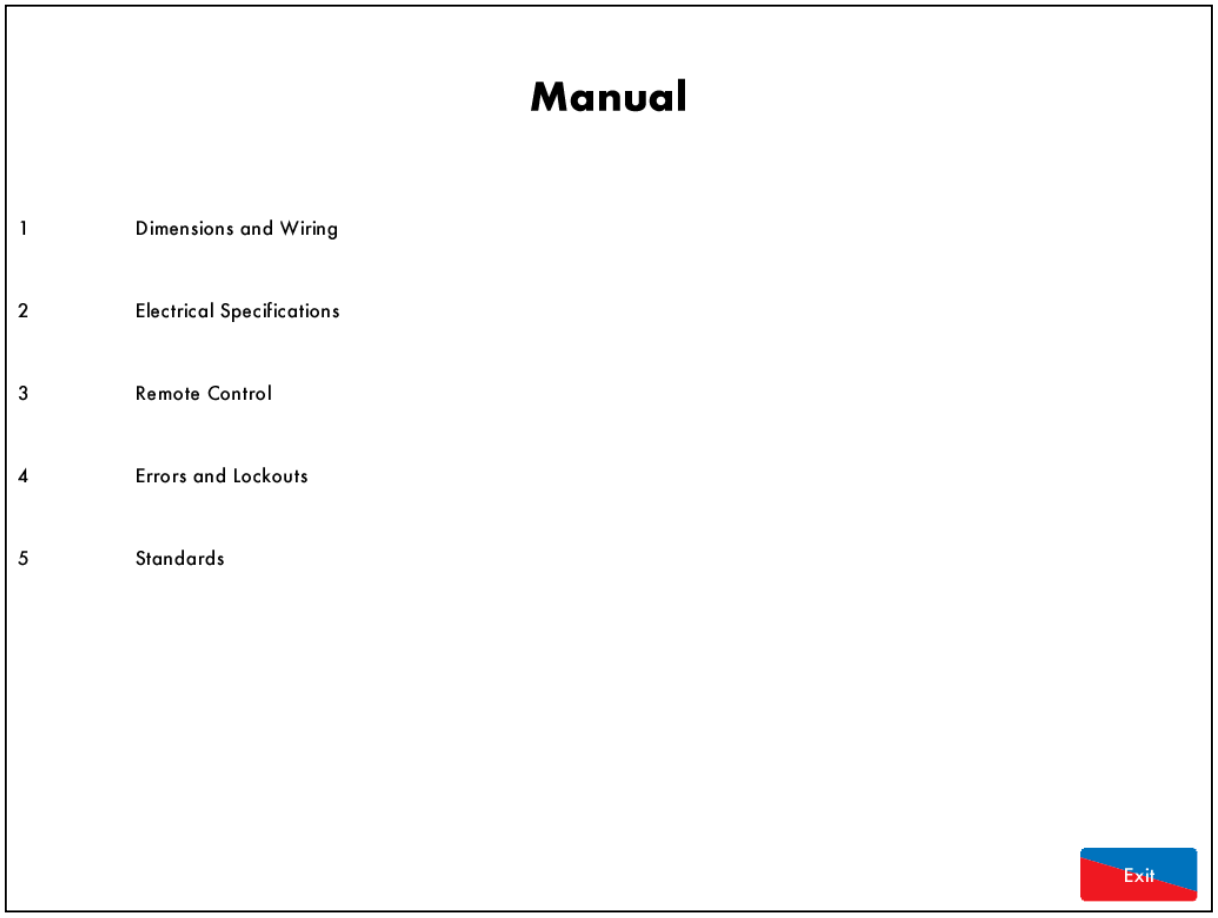


Figure 18.19.10.i Manual

Press 

in the System Configuration screen in Figure 18.19.i to view the Manual screen. Press on the section headings to navigate through the operating manual.

Note: The SD card must contain the manual file to be able to view the operating manual on the MM screen.

18.19.11 Commission Data

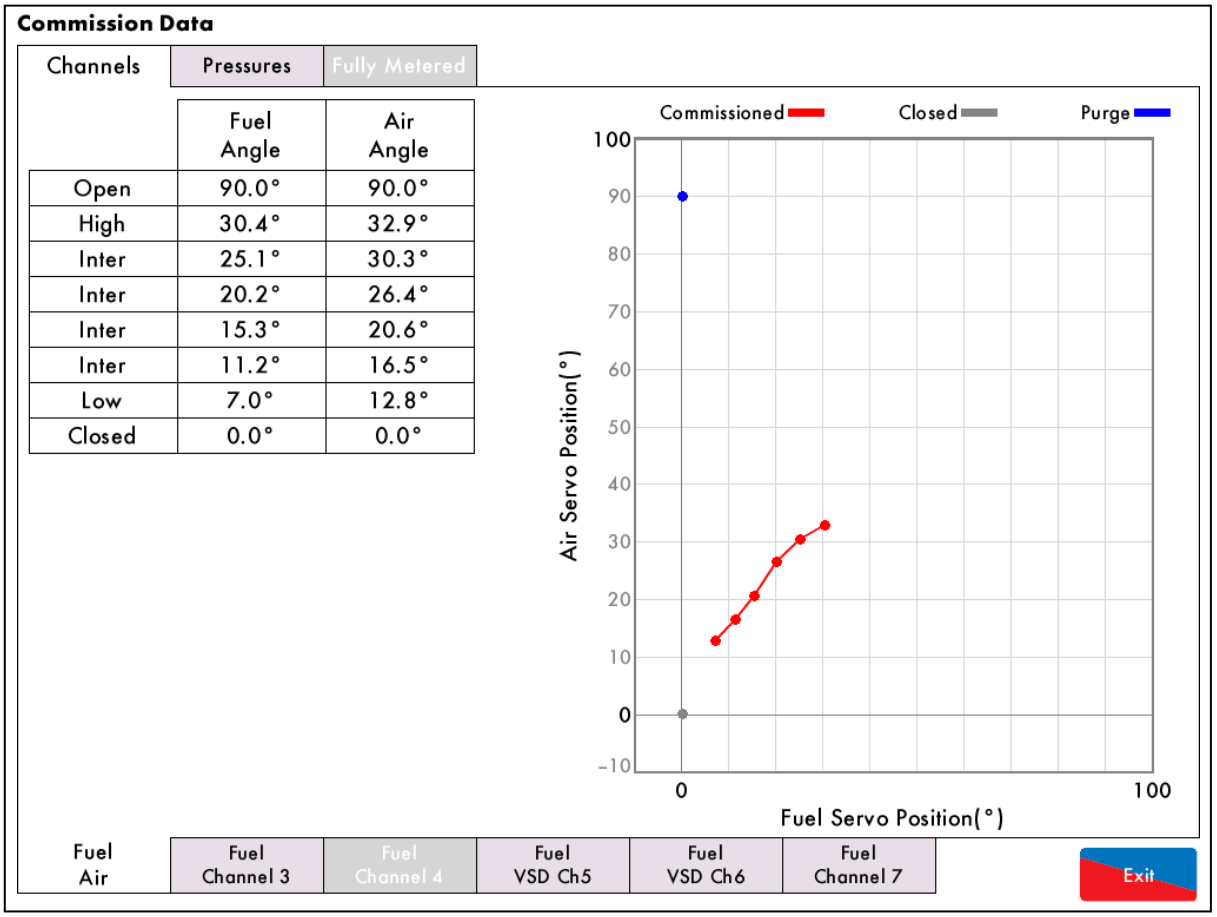


Figure 18.19.11.i Commission Data

Press Commission Data in the System Configuration screen in Figure 18.19.i to view the Commission Data screen.

18.19.12 Diagnostics

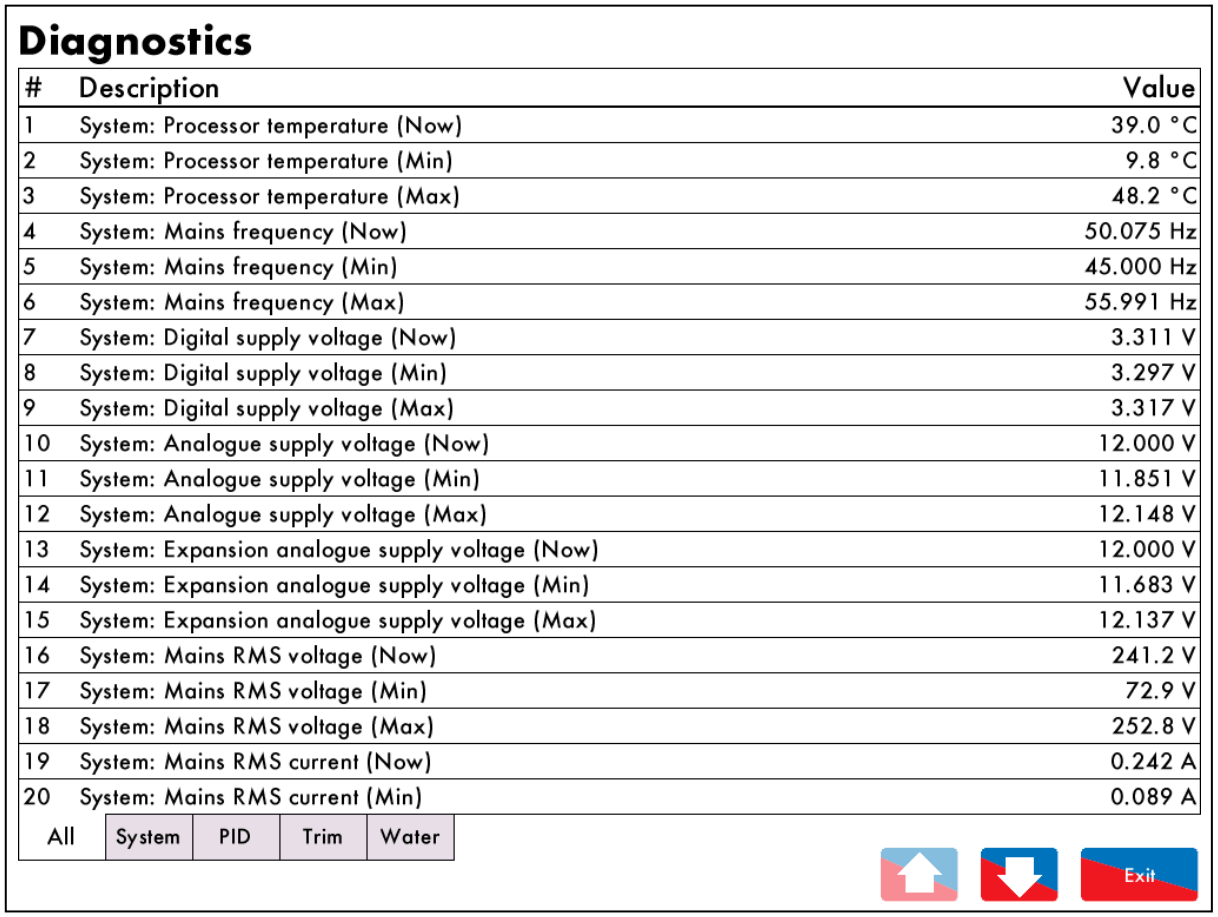


Figure 18.19.12.i Diagnostics

Press 

in the System Configuration screen in Figure 18.19.i to view the real-time diagnostics. This data is logged hourly on the SD card for up to 3 months. The minimum and maximum values are the lowest and highest values the MM as detected for this measurement.

18.19.13 System Log



Figure 18.19.13.i System Log

Press 

in the System Configuration screen in Figure 18.19.i to view the System Log screen, which stores 1000 entries of the following information:

- Stat on/ off.
- Setting changes.
- Commission/single point change.
- Fuel flow commission.
- MM restart.
- Setpoint changes.

18.20 Burner Control Sequence Diagrams

The time to achieve safety shutdown where a fault is detected is within 4 seconds. The resulting safety shutdown state is defined by the shut-off valve terminals being de-energised.

The maximum flame failure response time is 1second.

Diagram Notes

If VPS is not optioned on the fuel selected, the VPS phases are bypassed.

Point idle – this phase is set at power up when no fuel selected on exit from lockout.

Point recycle – this phase is set on exit from firing and post purge if VPS has not operated after burner run.

Point post purge – this phase is set only if post purge is optioned.

Point standby – this phase is set if VPS has operated after burner run.

Normal lockout is reset when either the mains lockout reset input is set for 2 seconds or the display screen lockout reset button is pressed for 2 seconds.

Prolonged lockout reset is set if either the mains lockout reset input or display screen lockout reset input is set for 10 or more seconds. Normal lockout is set on exit from permanent lockout reset after 20 seconds and is reset in the normal way.

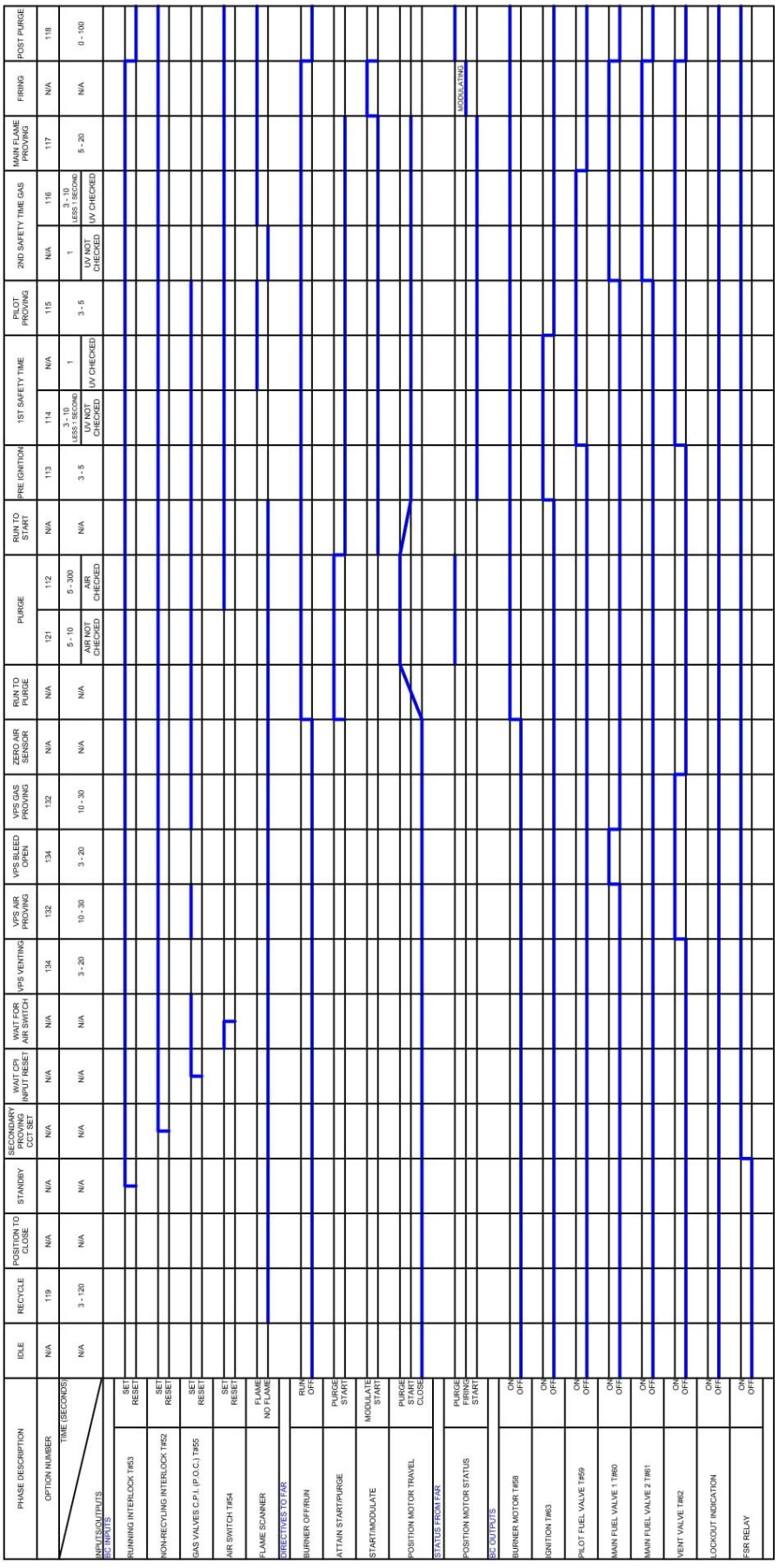
Blue waveforms indicate required condition. Values above/below waveform are time in seconds that the state must be continuously incorrect after which a lockout is set. If the waveform is not bold then the status is not important.

The following burner control sequence diagrams are shown with example timings:
- 3 second window (±1 second) for UV detection for simulated flame
- 1 second window for UV loss for flame failure
- 3 second window (±1 second) for CPI loss for CPI input wrong state/ no CPI reset
- 3 second window (±1 second) for air switch loss for no air proving

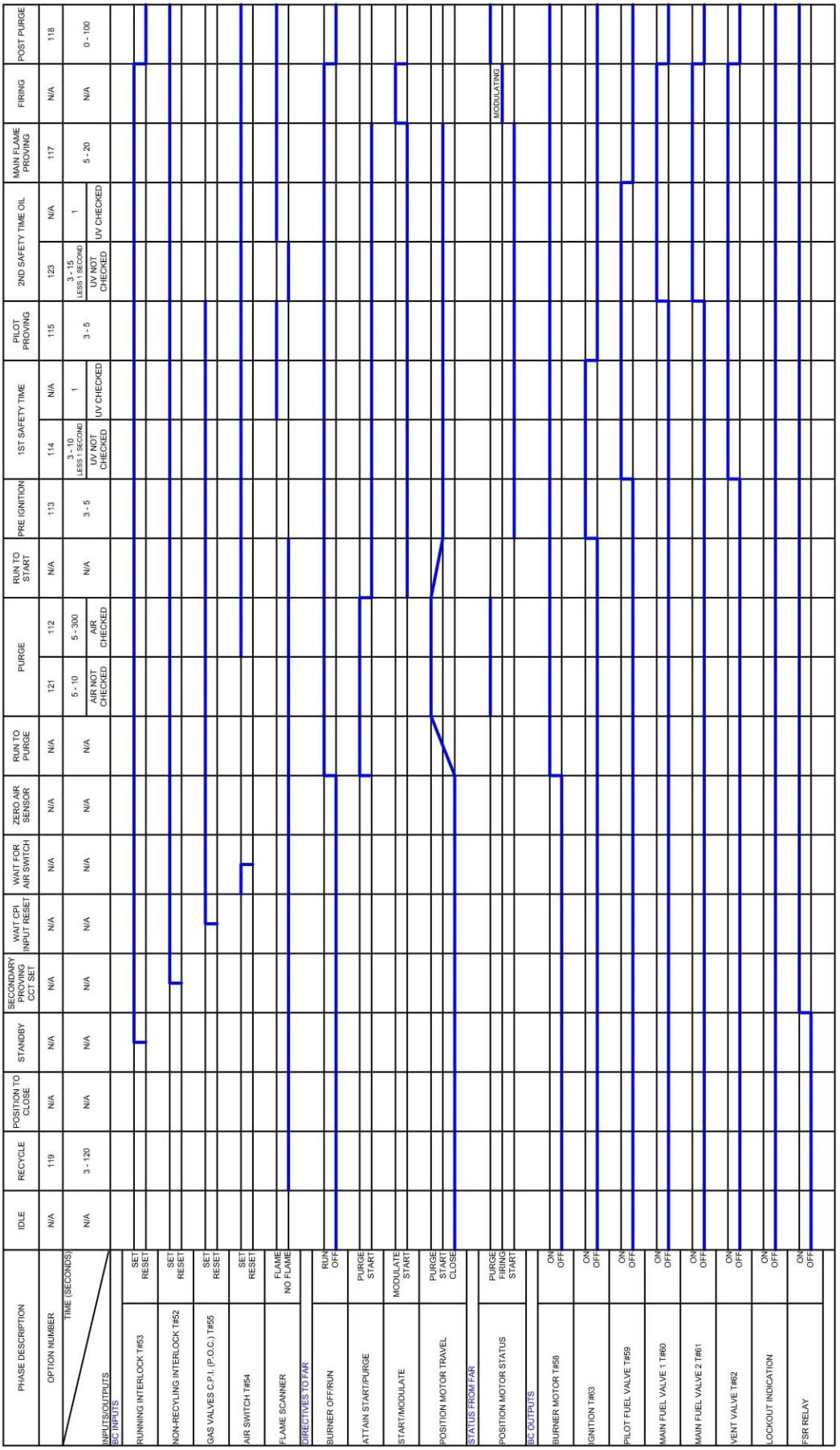
The Mk8 MM has the following default timings:

Burner control default timings	Seconds
Flame failure response time	< 1
Time to achieve safety shutdown	< 4
Time to achieve lockout	< 1

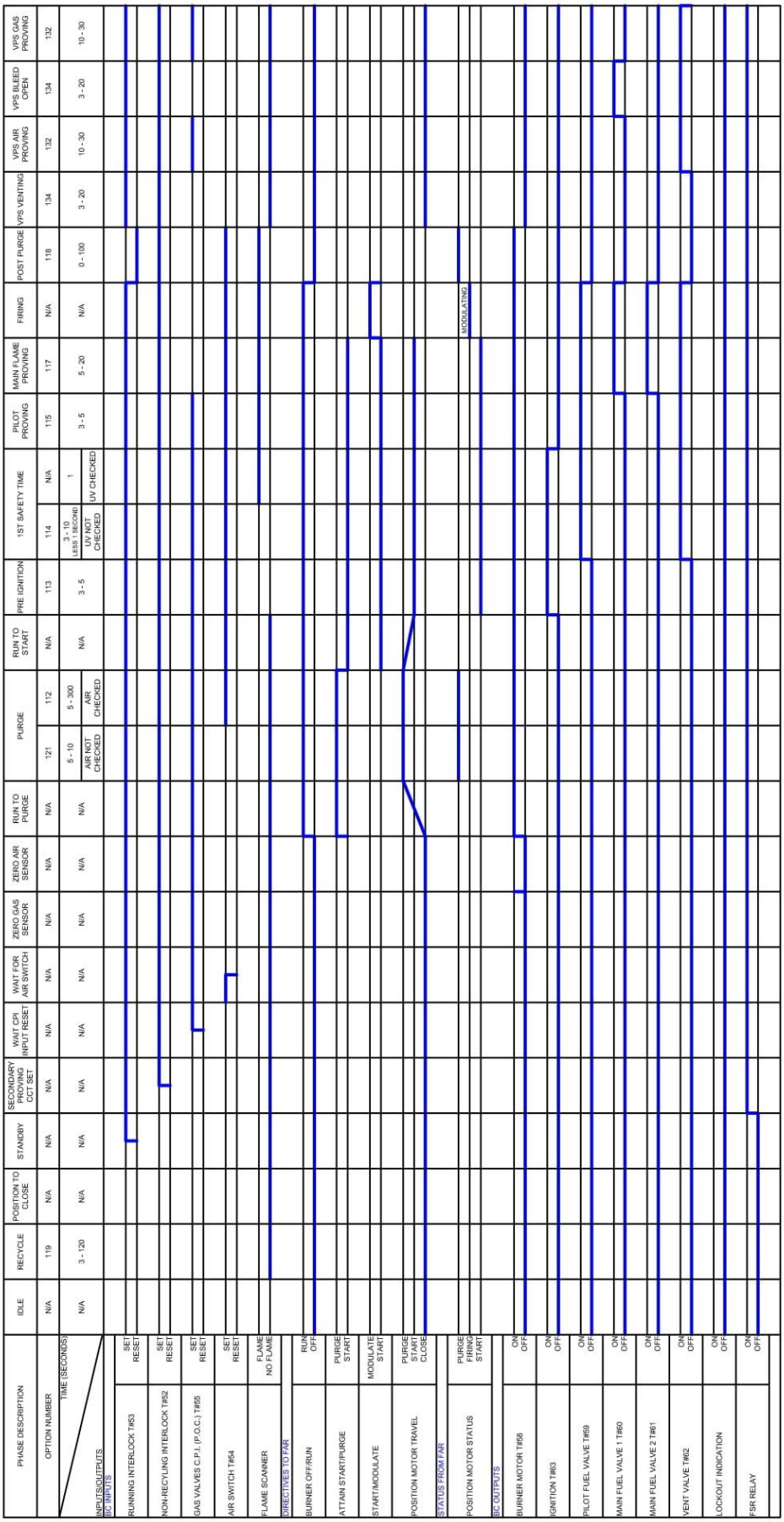
18.20.1 Interrupted Pilot – Gas



18.20.2 Interrupted Pilot – Oil



18.20.3 Intermittent Pilot – Gas with Post VPS



19 ERRORS AND LOCKOUTS

19.1 Errors

Errors occur when the MM detects an internal fault, component out of range, internal check failure or power supply issue. To clear an error, the MM must be restarted.

Error	Message	Description
1	Channel 1 Positioning Error	Servomotor is outside of the commissioned range
	• Check wiring on terminals 40 – 42 • Check signal cable from the MM to the servomotor is screened at one end • Check potentiometer is zeroed correctly • Go into Commissioning mode, check the servomotor position and ensure that closed is at 0.0°	
2	Channel 2 Positioning Error	Servomotor is outside of the commissioned range
	• Check wiring on terminals 40, 41, 43 • Check signal cable from the MM to the servomotor is screened at one end • Check potentiometer is zeroed correctly • Go into Commissioning mode, check the servomotor position and ensure that closed is at 0.0°	
3	Channel 3 Positioning Error	Servomotor is outside of the commissioned range
	• Check wiring on terminals 44, 46, 47 • Check signal cable from the MM to the servomotor is screened at one end • Check potentiometer is zeroed correctly • Go into Commissioning mode, check the servomotor position and ensure that closed is at 0.0°	
4	Channel 4 Positioning Error	Servomotor is outside of the commissioned range
	• Check wiring on terminals 45 – 47 • Check signal cable from the MM to the servomotor is screened at one end • Check potentiometer is zeroed correctly • Go into Commissioning mode, check the servomotor position and ensure that closed is at 0.0°	
5	Channel 7 Positioning Error	Servomotor is outside of the commissioned range
	• Check wiring on terminals DP-, DP+, DPW • Check signal cable from the MM to the servomotor is screened at one end • Check potentiometer is zeroed correctly • Go into Commissioning mode, check the servomotor position and ensure that closed is at 0.0°	
6	Channel 1 Gain Error	Servomotor position measurement hardware error
	• Check wiring and voltages on terminals 40 – 42 and 70 – 71	
7	Channel 2 Gain Error	Servomotor position measurement hardware error
	• Check wiring and voltages on terminals 40, 41, 43 and 72 – 73	
8	Channel 3 Gain Error	Servomotor position measurement hardware error
	• Check wiring and voltages on terminals 44, 46, 47 and 74 – 75	
9	Channel 4 Gain Error	Servomotor position measurement hardware error
	• Check wiring and voltages on terminals 45 – 47 and 76 – 77	
10	Channel 7 Gain Error	Servomotor position measurement hardware error
	• Check wiring and voltages on terminals DP-, DP+, DPW and DCI, DCD	
11	Channel 1 Movement Error	Servomotor moves when not expected and vice versa
	• Check wiring and voltages on terminals 70 & 71 • Check servomotors drive in correct direction and valve is not stuck	
12	Channel 2 Movement Error	Servomotor moves when not expected and vice versa
	• Check wiring and voltages on terminals and 72 and 73 • Check servomotors drive in correct direction and damper is not stuck	

Error	Message	Description
13	Channel 3 Movement Error	Servomotor moves when not expected and vice versa
• Check wiring and voltages on terminals and 74 and 75 • Check servomotors drive in correct direction and valve is not stack		
14	Channel 4 Movement Error	Servomotor moves when not expected and vice versa
• Check wiring and voltages on terminals and 76 and 77 • Check servomotors drive in correct direction and valve is not stuck		
15	Channel 7 Movement Error	Servomotor moves when not expected and vice versa
• Check wiring and voltages on terminals DCI and DCD • Check servomotor drives in correct direction and damper is not stuck		
16	Analogue Power Supply Error	ADC measured 12V supply out of range
• Check wiring for shorts on terminals 41, 47 and 39		
17	Digital Power Supply Error	ADC measured 3.3V supply out of range
• Check for noise on the mains input, wiring and voltages on all terminals		
18	EEPROM Error	Fault communicating with the on board EEPROM
• Contact Autoflame approved local tech centre		
19	ADC Error	Internal fault
• Contact Autoflame approved local tech centre		
20	Watchdog Timeout	Internal fault
• Contact Autoflame approved local tech centre		
21	Processor Clock Error	Internal fault
• Contact Autoflame approved local tech centre		
22	System Error	Internal fault
• Contact Autoflame approved local tech centre		
23	Flash Data Error	Internal fault
• Re-install software SD card		
24	Processor Temperature Error	Internal fault
• Check ambient temperature of unit does not exceed maximum recommended temperature		
25	Burner Control Comms Error	Internal fault
• Contact Autoflame approved local Tech Centre		
26	Burner Control Reset	Internal fault
• Contact Autoflame approved local Tech Centre		
27	Software Error	Internal fault
• Contact Autoflame approved local Tech Centre		
29	Mains Input Detection Error	Mains input stuck on
• Check wiring and voltages on terminals 89 – 92		
30	Channel 5 VSD Error	Feedback incorrect
• Check VSD feedback against commissioned VSD and ensure the feedback is stable		
31	Channel 6 VSD Error	Feedback incorrect
• Check VSD feedback against commissioned VSD and ensure the feedback is stable		
32	VSD Feedback Change Too Small	Feedback change detected during commissioning is too small
• Check VSD feedback during commissioning • Check option 99 for VSD on channel 5 and option 109 for VSD on channel 6 • Check wiring on terminals 1 – 3, 4 – 6, 10 – 12 and 13 – 15		
33	Missing Commissioning Data	Internal fault
• Check there is commissioning data for all options servomotors/VSD		

Error	Message	Description
34	FAR Execution Speed	Internal fault
• Contact Autoflame approved local Tech Centre		
35	Software Error	Internal fault
• Contact Autoflame approved local Tech Centre		
36	Software Error	Internal fault
• Contact Autoflame approved local Tech Centre		
37	Software Error	Internal fault
• Contact Autoflame approved local Tech Centre		
38	Software Error	Internal fault
• Contact Autoflame approved local Tech Centre		
39	VSD Sampling Error	VSD feedback current/ voltage too high on channel 5/6
• Check wiring on terminals 1 – 3, 4 – 6, 10 – 12 and 13 – 15		
40	VSD Feedback Too Low	VSD feedback value is too low during commissioning on channel 5/6
• Check VSD feedback while commissioning		
41	APS Commission Data Fault	No air pressure trim data for a point with EGA trim
• Check EGA trim and air pressure trim in fuel-air curve		
42	Comm VPS Gas Pressure Low	Commissioned gas pressure during VPS below option/ parameter 133 threshold
• Check option/ parameter 133 and check gas pressure • Re-commission gas pressure sensor		
43	Comm Running Gas Pressure Low	Commissioned gas pressure during running below option/ parameter 136
• Check option/ parameter 136 and check gas pressure • Re-commission gas pressure sensor		
44	Comm Air Pressure Low	Commissioned air pressure during running below option/ parameter s 147 and 149
• Check option/parameters 147 and 149 • Re-commission air pressure sensor		
45	Software Error	Internal fault
• Contact Autoflame approved local tech centre		
46	Software Error	Internal fault
• Contact Autoflame approved local tech centre		
47	Expansion PF Output (Check F5)	Internal fault
• Check wiring on terminal PF • Check fuse 5 (2A) on expansion board		
48	WL Alarm Output Internal Fault	Internal fault
• Check expansion option 5 • Check wiring and voltages on terminals HAI, 1AI, 2AI		
49	Expansion Servo Hardware Fault	Internal fault
• Contact Autoflame approved local tech centre		
50	Triac Power Supply Error (Check F2)	Internal fault
• Check wiring on terminal 69 • Check fuse 2 (2A T)		
51	Fused 12V Supply Error (CheckF4)	Internal fault
• Check gas/air pressure sensor wiring on terminals 31 – 34, and load detector on 37 – 39 • Check fuse 4 (500mA)		

Error	Message	Description
52	Fused 13.5V Supply Error (Check F3)	Internal fault
• Check IR scanner wiring on terminals 29, 30, 48, 49 and oil pressure sensor on 48, 49 • Check fuse 3 (500mA)		
53	Air Pressure Zeroing Fault	Commissioned air zero pressure is more than 5mbar from sensor's zero value
• Check air pressure sensor value during VPS		
54	Software error	Internal fault
• Contact Autoflame approved local Tech Centre		
55	Software error	Internal fault
• Contact Autoflame approved local Tech Centre		
56	Software error	Internal fault
• Contact Autoflame approved local Tech Centre		
57	Software error	Internal fault
• Contact Autoflame approved local Tech Centre		
58	Software error	Internal fault
• Contact Autoflame approved local Tech Centre		
59	Software error	Internal fault
• Contact Autoflame approved local Tech Centre		
60	Software error	Internal fault
• Contact Autoflame approved local Tech Centre		
61	Software error	Internal fault
• Contact Autoflame approved local Tech Centre		
62	Software error	Internal fault
• Contact Autoflame approved local Tech Centre		
63	Software error	Internal fault
• Contact Autoflame approved local Tech Centre		
64	ADC Reference Voltage Error	Hardware fault
• Contact Autoflame approved local Tech Centre		
65	Software error	Internal fault
• Contact Autoflame approved local Tech Centre		
66	Software error	Internal fault
• Contact Autoflame approved local Tech Centre		
67	Software error	Internal fault
• Contact Autoflame approved local Tech Centre		

19.2 Lockouts

Lockouts occur when the MM detects a fault with the burner operation such as VPS, gas/air pressure sensor and flame scanners. The lockout must be cleared and investigated on the MM.

Lockout	Message	Description
1	CPI Input Wrong State	Proof of closure switch opened during ignition sequence
	• Check wiring on terminal 55 • Check proof of closure switches	
2	No Air Proving	No air pressure during start/ firing
	• Check wiring on terminal 54 • Check air pressure switch • Check air pressure sensor • Check air pressures during running	
3	Ignition Output Fault	Voltage detected when output is off (and vice versa)
	• Check wiring and voltage on terminal 63	
4	Motor Output Fault	Voltage detected when output is off (and vice versa)
	• Check wiring and voltage on terminal 58	
5	Start Gas Output Fault	Voltage detected when output is off (and vice versa)
	• Check wiring and voltage on terminal 59	
6	Main Gas 1 Output Fault	Voltage detected when output is off (and vice versa)
	• Check wiring and voltage on terminal 60	
7	Main Gas 2 Output Fault	Voltage detected when output is off (and vice versa)
	• Check wiring and voltage on terminal 61	
8	Vent Valve Output Fault	Voltage detected when output is off (and vice versa)
	• Check wiring and voltage on terminal 62	
9	Failsafe Relay (Check F1)	Voltage detected when output is off (and vice versa)
	• Check wiring and voltage on terminal 57 • Check fuse 1 (6.3A T) and wiring on terminals 50 – 64	
10	Simulated Flame	Flame is present when it shouldn't be
	• Isolate gas/ oil immediately • Call a certified Commissioning Engineer to investigate • If this lockout occurs during shutdown a post-purge may be required for after burn	
11	VPS Air Proving Fail	Leak detected during 'air proving' part of VPS
	• Check main fuel valve • Call a certified Commissioning Engineer to investigate	
12	VPS Gas Proving Fail	Leak detected during 'gas proving' part of VPS
	• Check option/parameter 133 • Check 2nd main gas valve and vent valve • Check pilot valve if using single valve pilot • Isolate gas and call a certified Commissioning Engineer to investigate	
13	No Flame Signal	No flame detected during ignition/ firing
	• Visually check flame • Check the flame scanner • Call a certified Commissioning Engineer to investigate	
14	Shutter Fault	UV signal detected during shutter operation on self-check
	• Check wiring on terminals 21 and 22 • Check UV scanner type and check option/ parameter 110 is set accordingly	
15	NO CPI Reset	Proof of closure switch not made after valves closed
	• Check wiring on terminal 55 and check proof of closure switches	

Lockout	Message	Description
16	Prolonged Lockout Reset	Prolonged voltage detected on terminal 56/ lockout resetbutton permanently pressed
• Check lockout reset button is not pressed • Check wiring on terminal 56		
17	Gas Pressure Low	Gas pressure low limit exceeded while firing (gas sensor)
• Check gas pressure • Check option/ parameter 136		
18	Gas Pressure High	Gas pressure high limit exceeded while firing (gas sensor)
• Check gas pressure • Check option/ parameter 137		
19	RAM Test Failed	Hardware fault
• Contact Autoflame approved local tech centre		
20	PROM Test Failed	Hardware fault
• Contact Autoflame approved local tech centre		
21	FSR Test 1A	Internal relay test failed
• Check wiring and voltages on terminals 50 – 63		
22	FSR Test 2A	Internal relay test failed
• Check wiring and voltages on terminals 50 – 63		
23	FSR Test 1B	Internal relay test failed
• Check wiring and voltages on terminals 50 – 63		
24	FSR Test 2B	Internal relay test failed
• Check wiring and voltages on terminals 50 – 63		
25	Watchdog Fail 2A	Internal check failed
• Contact Autoflame approved local tech centre		
26	Watchdog Fail 2B	Internal check failed
• Contact Autoflame approved local tech centre		
27	Watchdog Fail 2C	Internal check failed
• Contact Autoflame approved local tech centre		
28	Watchdog Fail 2D	Internal check failed
• Contact Autoflame		
29	Input Fault	Power supply fault
• Check mains voltage to the MM		
32	Gas Pressure Low Limit	Gas pressure lower than commissioned VPS value
• Check gas pressure sensor value • Check option/parameter 136		
33	VPS Air Zeroing	Gas pressure sensor cannot be zeroed at VPS venting
• Check gas pressure is within zero range (see Autoflame Sensors Guide) • Check vent valve		
36	Oil Pressure Too Low	Oil pressure below offset lower limit during running
• Check option/parameter 139 • Check oil pressure sensor		
37	Oil Pressure Too High	Oil pressure above offset upper limit during running
• Check option/parameter 140 • Check oil pressure sensor		
39	Freeze Timeout	MM kept in Phase Hold for more than 10minutes
• MM kept in Phase Hold during commissioning for more than 10 minutes		
40	Purge Air Pressure Low	Insufficient air pressure during purge
• Check option/parameter 141 • Check air pressure sensor/ air pressure switch		

Lockout	Message	Description
42	Terminal 86 Inverse	Input detected on both terminals 85,86 where there shouldnot be, and vice versa
• Check option/parameter 122 • Check wiring and voltages on terminals 85, 86		
43	Terminal 85/86 Fault	Hardware fault on terminals 85/86
• Check wiring and voltages on terminals 85, 86 and contact Autoflame		
44	Proving Circuit Fail T52	Loss of input on terminal 52; MM must see input at all times from position to purge to post-purge
• Check wiring on terminal 52		
45	No Proving Circuit Set	Secondary proving timeout elapsed
• Check option/parameter 157 • Check wiring on terminal 52		
46	Proving Interlock Timeout	Purge interlock timeout elapsed
• Check option/ parameters 155 and 158 • Check wiring on terminal 81		
52	High IR Ambient	Flame detected when there should not be
• Visually check flame and check IR scanner • Call a certified Commissioning Engineer to investigate		
53	IR Comms Lost	Loss of comms with IR scanner
• Check wiring and screen on terminals 29, 30, 48 and 49 • Check that the IR scanner is not removed from the magnetic ring socket		
54	Watchdog Long X A	Internal check failed
• Contact Autoflame approved local tech centre		
55	Watchdog Long Y A	Internal check failed
• Contact Autoflame approved local tech centre		
56	Watchdog Off A	Internal check failed
• Contact Autoflame approved local tech centre		
57	Watchdog Short X B	Internal check failed
• Contact Autoflame approved local tech centre		
58	Watchdog Short Y B	Internal check failed
• Contact Autoflame approved local tech centre		
59	Watchdog Long X B	Internal check failed
• Contact Autoflame approved local tech centre		
60	Watchdog Long Y B	Internal check failed
• Contact Autoflame approved local tech centre		
61	Watchdog Off B	Internal check failed
• Contact Autoflame approved local tech centre		
62	UV Signal Too High	Internal check failed for UV
• Check wiring on terminals 21, 22, 50 and 51		
63	Purge Limit Switch	Interlock not made on terminal 81
• Check option/ parameter 155 • Check wiring on terminal 81		
64	Start Limit Switch	Interlock not made on terminal 80
• Check option/ parameter 154 • Check wiring on terminal 80		
65	FSR A	Internal check failed
• Check wiring and voltages on terminals 50 – 63		
66	FSR B	Internal check failed
• Check wiring and voltages on terminals 50 – 63		

Lockout	Message	Description
67	Gas Sensor Comms	Signal lost from gas pressure sensor
• Check wiring and screen on terminals 31 – 34		
68	Gas Sensor Type	Internal fault
• Contact Autoflame approved local tech centre		
69	Gas Sensor Fault	Internal pressure sensor fault
• Contact Autoflame approved local tech centre		
70	UV Pot Fault	Internal UV scanner fault
• Contact Autoflame approved local tech centre		
71	Air Sensor Comms	Signal lost from air pressure sensor
• Check wiring and screen on terminals 31 – 34		
72	Air Sensor Type	Internal fault
• Contact Autoflame approved local tech centre		
73	Air Sensor Fault	Internal pressure sensor fault
• Contact Autoflame approved local tech centre		
74	Air Sensor Zero	Air pressure is more than 5mbar from sensor's zero value
• Check air pressure sensor value during VPS		
75	Air Sensor Signal High	Air pressure is above 400mbar
• Check Autoflame approved local tech centre		
76	Air Sensor Error Window	Air pressure outside of these limits for 3 seconds
• Check air pressure • Check option/parameter 147		
77	Wait Air Switch Timeout	Voltage has not been reset for 2minutes
• Check air pressure sensor value during VPS • Check voltage has been reset on terminal 54 within 2minutes before run to purge • Check wiring and voltage on terminal 54		
78	Gas Proving Fail High	Gas pressure too high during VPS
• Isolate gas • Check 1st main valve and vent valve • Check option/ parameters 133 and 134 • Call a certified Commissioning Engineer to investigate		
79	FSR Test 1C	Hardware fault
• Contact Autoflame approved local tech centre		
80	Timeout on Reaching Purge	Time set in option/parameter 124 has elapsed
• Check option/parameter 124		
81	Oil Pressure Sensor Fault	No comms received from oil pressure sensor
• Check wiring and screen on terminals 48, 49		
82	Purge Pressure Proving Input	Input on T81 read high during relay test phases
• Input has been made before the blower starts; it should only be made continuously during purge. • Check wiring on terminal 81.		
83	Main Gas 3 Output Fault	Voltage detected when output is off (and vice versa)
• Check wiring and voltage on terminal 64		
84	Main Gas 4 Output Fault	Voltage detected when output is off (and vice versa)
• Check wiring and voltage on terminal 83		
85	Vent Valve 2 Output Fault	Voltage detected when output is off (and vice versa)
• Check wiring and voltage on terminal 84		
86	Gas Sensor 2 Comms	Signal lost from gas pressure sensor
• Check wiring and screen on terminals DT+, DT-, DP- and DP+ on the MM expansion board		

Lockout	Message	Description
87	Gas Sensor 2 Fault	Internal pressure sensor fault
• Contact Autoflame approved local tech centre		
88	VPS Air Proving Fail (Fuel 2)	Leak detected during ‘air proving’ part of VPS
• Check fuel 2 valve 1 • Call a certified Commissioning Engineer to investigate		
89	Gas Pressure Low Limit (Fuel 2)	Gas pressure lower than commissioned VPS value
• Check gas pressure sensor value • Check option/parameter 136		
90	VPS Gas Proving Fail (Fuel 2)	Leak detected during ‘gas proving’ part of VPS
• Check option/parameter 133 • Check fuel 2 gas valve 1 and vent valve • Check pilot valve if using single valve pilot • Isolate gas and call a certified Commissioning Engineer to investigate		
91	Gas Proving Fail High (Fuel 2)	Gas pressure too high during VPS
• Isolate gas • Check fuel 2 valve 1 and vent valve • Check option/ parameters 133 and 134 • Call a certified Commissioning Engineer to investigate		
92	Oil Pressure Too Low (Fuel 2)	Internal fault
• Check option/parameter 139 • Check oil pressure sensor		
93	Gas Pressure Low (Fuel 2)	Gas pressure low limit exceeded while firing (gas sensor)
• Check gas pressure • Check option/ parameter 136		
94	Oil Pressure Too High (Fuel 2)	Oil pressure above offset upper limit during running
• Check option/parameter 140 • Check oil pressure sensor		
95	Gas Pressure High (Fuel 2)	Gas pressure high limit exceeded while firing (gas sensor)
• Check gas pressure • Check option/ parameter 137		
96	NO CPI Reset	Proof of closure switch not made after valves closed
• Check wiring on terminal 55 and check proof of closure switches		
199	Lockout 199	Internal fault
• Contact Autoflame approved local tech centre		
200	Lockout Cleared	Lockout has been cleared
• MM status after lockout has been reset (Modbus)		
201	Power up CPU Test Fail	Internal check failed
• Contact Autoflame approved local tech centre		
202	Power up EEPROM Test Fail	Internal check failed
• Contact Autoflame approved local tech centre		

19.3 Alarms and Warnings

Alarms and warnings are faults detected with the system operation. If an alarm occurs, the burner will stop running, and if a warning occurs, the burner will continue to run. The following options/parameters set whether system operation faults are set as alarms or warnings:

Option 13	EGA Fault Response
Option 14	Warning Response
Expansion Option 9	Burner Operation at High Water
Expansion Option 20	Burner Operation on Feedwater Control Fault
Expansion Option 88	Action on Pressure Sensor Fault

Fault	Message	Description
1	EGA Internal Error	Fault on EGA
	• Alarm or warning depending on option 13 • Check EGA for fault description	
2	No EGA Communications	MM has lost communications with EGA
	• Alarm or warning based on option 13 (warning if option 12 is set to monitoring only) • Check parameter 10 is set to correct EGA version • Check EGA operating mode is selected as 'EGA with MM' • Check wiring between EGA and MM (terminals 25 and 26 on MM)	
3	O_2 Upper Limit	O_2 value is above upper limit offset of commissioned value*
	• Alarm or warning depending on option 13 • Check exhaust gas readings and option 19	
4	O_2 Absolute Limit	O_2 value is below absolute limit*
	• Alarm or warning depending on option 13 • Check exhaust gas readings and option 25	
5	O_2 Lower Limit	O_2 value is below lower limit offset of commissioned value*
	• Alarm or warning depending on option 13 • Check exhaust gas readings and option 22	
6	CO_2 Upper Limit	CO_2 value is above upper limit offset of commissioned value*
	• Alarm or warning depending on option 13 • Check exhaust gas readings and option 20	
7	CO_2 Absolute Limit	CO_2 value is above absolute limit*
	• Alarm or warning depending on option 13 • Check exhaust gas readings and option 26	
8	CO_2 Lower Limit	CO_2 value is below lower limit offset of commissioned value*
	• Alarm or warning depending on option 13 • Check exhaust gas readings and option 23	
9	CO Upper Limit	CO value is above upper limit offset of commissioned value*
	• Alarm or warning depending on option 13 • Check exhaust gas readings and option 21	
10	CO Absolute Limit	CO value is above absolute limit*
	• Alarm or warning depending on option 13 • Check exhaust gas readings and option 27	
11	NO Upper Limit	NO value is above upper limit offset of commissioned value*
	• Alarm or warning depending on option 13 • Check exhaust gas readings and parameter 94	
12	Exhaust Temperature Upper Limit	Exhaust temperature is above upper limit offset of commissioned value*
	• Alarm or warning depending on option 13 • Check exhaust gas readings and parameter 96	

Fault	Message	Description
13	Exhaust Temperature Absolute Limit	Exhaust temperature is above absolute limit*
• Alarm or warning depending on option 13 • Check exhaust gas readings and parameter 97		
50	Load Sensor Fault	Incorrect/no load sensor detected
• Alarm • Check option 1 • Check wiring on terminals 37 – 39		
51	Auxiliary Input Low	3mA or lower received from 4-20mA external modulation/external setpoint
• Alarm • Check parameter 69 • Check feedback from external modulation/ external setpoint controller • Check wiring on terminals 7 – 9		
52	Zero Crossing Detection	Irregular mains power
• Warning • Check mains supply to the MM is within acceptable voltage range		
63	Zero Crossing Detection	Internal fault in the MM's main board
• Alarm • Check all fuses on the MM's main board • Check the mains supply to the MM is within acceptable voltage range		
64	Zero Crossing Detection	Internal fault in the MM's expansion board
• Alarm • Check all fuses on the MM's expansion board • Check the mains supply to the MM is within acceptable voltage range		
73	High Limit Setpoint Breached	Actual setpoint has reached the High limit setpoint
• Alarm • Check Internal setpoint and parameter 28		
80	Oil Pressure Sensor Fault	No comms received from oil pressure sensor
• Warning (lockout 81 if oil pressure limits set in option/parameters 139 and 140) • Check wiring and screen on terminals 48, 49		
100	Cap Probe 1 Communications Fault	No comms with capacitance probe 1
• Alarm • Check wiring and screen on terminals 1P+, 1P-, 1T+ and 1T-		
101	Cap Probe 2 Communications Fault	No comms with capacitance probe 2
• Alarm • Check wiring and screen on terminals 2P+, 2P-, 2T+ and 2T-		
102	Cap Probe 1 Short Circuit	Hz reading is below 10kHz
• Alarm • Check water level Hz reading • Check wiring on terminals 1P+, 1P-, 1T+ and 1T-		
103	Cap Probe 2 Short Circuit	Hz reading is below 10kHz
• Alarm • Check water level Hz reading • Check wiring on terminals 2P+, 2P-, 2T+ and 2T-		
104	Cap Probe 1 Temp Compensation Error	Temperature corrected probe reference is not as expected
• Alarm • Re-commission capacitance probes at temperature		
105	Cap Probe 2 Temp Compensation Error	Temperature corrected probe reference is not as expected
• Alarm • Re-commission capacitance probes at temperature		

Fault	Message	Description
106	Cap Probe 1 Still Water Detected	Wave signature high to low peak distance is less than still water threshold
• Alarm • Check still water threshold in expansion option 28 • Check capacitance probe 1 reading history		
107	Cap Probe 2 Still Water Detected	Wave signature high to low peak distance is less than still water threshold
• Alarm • Check still water threshold in expansion option 28 • Check capacitance probe 2 reading history		
108	Cap Probe 1 Serial Number Mismatch	Probe serial number detected is not the commissioned probe serial number
• Alarm • If changing capacitance probe 1, re-commission is required		
109	Cap Probe 2 Serial Number Mismatch	Probe serial number detected is not the commissioned probe serial number
• Alarm • If changing capacitance probe 2, re-commission is required		
110	Cap Probe 1 Detected But Not Optioned	Probe connected but not optioned
• Alarm • Check expansion options 1 and 3 • Check wiring on terminals 1P+, 1P-, 1T+ and 1T-		
111	Cap Probe 2 Detected But Not Optioned	Probe connected but not optioned
• Alarm • Check expansion options 1 and 3 • Check wiring on terminals 2P+, 2P-, 2T+ and 2T-		
112	External Level Sensor InputLow	3mA or lower received from 4-20mA external level sensor
• Alarm • Check feedback from external level sensor • Check wiring on terminals EX- and EX+		
113	Probe Reading Mismatch	Reading of one of the probes/sensor is less than or equal to its end-of-probe value or the difference between probes/sensor readings is greater than the mismatch threshold
• Alarm • Check expansion option 27 • Check capacitance probes and sensor readings		
114	Probe Serial Numbers are the Same	One capacitance probe detected on both capacitance probe terminals
• Alarm • If using two capacitance probes, then two individual probes must be connected • Check wiring on terminals 1P+, 1P-, 1T+, 1T-, 2P+, 2P-, 2T+ and 2T-		
120	Aux WL Inputs Mismatch	High water and 1st or 2nd low auxiliary level inputs detected simultaneously
• Alarm • Check wiring on terminals HAI, 1AI and 2AI		
121	Water Levels Diverse	Probes/ sensor detects 1st or 2nd low and high water simultaneously
• Alarm • Check water level readings for probes and sensor if optioned • Re-commission probes/sensor		
122	Permanent Alarm Reset Input	Input held on alarm reset terminal for more than 10 seconds
• Alarm • Check input on terminal M/R		

Fault	Message	Description
123	Second Low Probe Communications Fault	No comms with second low probe
• Alarm • Check wiring and screen on terminals 5T+, 5T-, 4P- and 4P+		
124	Second Low Probe Hardware Fault	Internal check failed
• Alarm • Contact Autoflame approved local tech centre		
125	Permanent Test Input	Input held on test terminal for more than 60 seconds
• Alarm • Check input on terminal TST		
126	Second Low Probe Detected But Not Optioned	Second low probe connected but not optioned
• Alarm • Check expansion option 6 • Check wiring on terminals 5T+, 5T-, 4P- and 4P+		
127	Aux WL Inputs Detect But Not Optioned	Mains detected on auxiliary WL inputs but not optioned
• Alarm • Check expansion option 5 • Check wiring on terminals HAI, 1AI and 2AI		
130	Feed Water Servo Position Error	Servomotor is outside of the commissioned range
• Alarm or warning or depending on expansion option 20 (if set to warning, feed water pump will continue to operate as normal) • Check wiring on terminals P-, FW and P+ • Check signal cable form the MM to the servomotor is screened at one end • Check that the servomotor is zeroed correctly		
131	Feed Water Servo Movement Error	Servomotor moves when not expected and vice versa
• Alarm or warning depending on expansion option 20 • Check wiring and voltages on terminals MVI and MVD • Check servomotor drives in correct direction • Check feed water valve is not stuck		
150	High Water	Probes/sensor detect water level above commissioned highwater
• Alarm or warning depending on expansion option 9 • Check water level reading		
151	Pre-High Water	Probes/sensor detect water level above set pre-high water
• Warning • Check water level reading • Check expansion option 7		
152	Pre-1st Low	Probes/sensor detect water level below set pre-1st low
• Warning • Check water level reading • Check expansion option 8		
153	1st Low	Probes/sensor detect water level below commissioned 1st low
• Alarm • Check water level reading • 1st low alarm will automatically clear if water level increases above 1st low		
154	2nd Low	Probes/sensor detect water level below 2nd low
• Alarm • Check water level reading • 2nd low alarm requires manual reset		

Fault	Message	Description
155	Shunt Switch Time Expired	Once shunt switch time expires, system goes to normally running
• Warning • If water drops after shunt switch time expires, system will generate 1st or 2nd low as relevant		
200	Top Blowdown Sensor Communications Fault	No comms with the top blowdown sensor
• Warning • Check wiring and screen on terminals 3P+, 3P-, 3T+ and 3T-		
201	Top Blowdown Servo Position Error	Servomotor is outside of the commissioned range
• Warning • Check wiring on terminals P-, TW, P+ and TBI, TBD • Check signal cable form the MM to the servomotor is screened at one end • Check that the servomotor is zeroed correctly		
202	Top Blowdown Servo Movement Error	Servomotor moves when not expected and vice versa
• Warning • Check wiring on terminals TBI and TBD • Check servomotor drives in correct direction • Check top blowdown valve is not stuck		
250	Top Blowdown Reading High	TDS value detected too high
• Warning • Check expansion option 46 and TDS value		
300	Bottom Blowdown Controller Comms	No comms with bottom blowdown controller
• Warning • Check bottom blowdown controller is powered on and enabled • Check wiring and screen on terminals 5T+ and 5T-		
301	Bottom Blowdown Controller Software Fault	Internal check failed
• Warning • Contact Autoflame approved local tech centre		
302	Bottom Blowdown Servo Closing Fault	No movement detected when bottom blowdown valve goes to close
• Warning • Check wiring on terminals 5T+ and 5T- • Check bottom blowdown valve is not stuck		
303	Bottom Blowdown Servo Opening Fault	No movement detected when bottom blowdown valve goes to open
• Warning • Check wiring on terminals 5T+ and 5T- • Check bottom blowdown valve is not stuck		
304	Bottom Blowdown ServoBattery Drive Fault	Battery has failed on bottom blowdown controller
• Warning • Contact Autoflame approved local tech centre		
305	Bottom Blowdown Controller Main Power Fault	Main power has failed on bottom blowdown controller
• Warning • Contact Autoflame approved local tech centre		
350	Bottom Blowdown Servo Not Commissioned	Bottom blowdown controller has not been requested to drive servomotor to closed since it was powered on
• Warning • Commission bottom blowdown servomotor		
400	Draught Pressure Sensor Timeout	No comms within 2 seconds from draught pressure sensor
• Alarm or warning depending on option 88 • Check wiring and screen on terminals DT+, DT-, DP- and DP+		

Fault	Message	Description
410	Draught Pressure Outside Tolerance	Pressure is outside of set tolerance
• Alarm or warning depending on option 88 • Check expansion option 87		
420	Fuel flow Feedback Input Low	3mA or lower received from 4-20mA external fuel flow input
• Warning • Check feedback from external fuel flow input • Check wiring on terminals EX- and EX+		
430	Fuel flow Feedback Below Tolerance	Fuel flow signal below fuel flow feedback fault tolerance
• Warning • Check feedback from external fuel flow input • Check option 60		
431	Fuel flow Feedback Above Tolerance	Fuel flow signal above fuel flow feedback fault tolerance
• Warning • Check feedback from external fuel flow input • Check option 60		
440	Temperature Sensor T1 Fault	Fault or no comms with T1 sensor
• Warning • Check wiring and screen on terminals –and T1		
441	Temperature Sensor T2 Fault	Fault or no comms with T2 sensor
• Warning • Check wiring and screen on terminals – and T2		
442	Temperature Sensor T3 Fault	Fault or no comms with T3 sensor
• Warning • Check wiring and screen on terminals – and T3		
443	Make Up Flow Meter Fault	Fault or no comms with make up flow meter
• Warning • Check wiring and screen on terminals F- and MF		
444	Condensate Flow Meter Fault	Fault or no comms with condensate flow meter
• Warning • Check wiring and screen on terminals F- and CF		
445	Deaerator IO Comms Fault	Fault or no comms with deaerator IO
• Warning • Check wiring and screen on terminals 6T+ and 6T-		
500	Multi-Burner Communications Fault	Loss of comms between MMs in multi-burner loop
• Alarm • Check wiring on terminals 23 and 24 on all MMs in multi-burner loop		
501	Multi-Burner Version Mismatch	Software versions of MMs in multi-burner loop do not match
• Alarm • Check that software versions of MMs in multi-burner loop match		
502	Multi-Burner Not Polled	MM in multi-burner loop has been detected but not polled
• Alarm • Check option 51 on master MM • Check wiring on terminals 23 and 24		
503	Multi-Burner Config (Multi-Burner Mode)	Multi-burner mode is not the same for all MMs in loop
• Alarm • Check option 43 on all MMs in multi-burner loop		

Fault	Message	Description
504	Multi-Burner Config (Fuel Index)	Same fuel number must be selected on all MMs in multi-burner loop
• Alarm • Check which fuel is selected on all MMs in multi-burner loop • Check wiring on terminals 89, 90, 91 and 92		
505	Multi-Burner Config (Fuel Type)	Fuel type is not the same for all MMs in multi-burner loop
• Alarm • Check option/parameters 150 – 153 on all MMs in multi-burner loop		
506	Multi-Burner Config (Pilot Type)	Pilot type not the same for all MMs multi-burner loop
• Alarm • Check option/parameter 111 on all MMs in multi-burner loop		
507	Multi-Burner Config (Load Sensor)	Load sensor not set the same for all MMs in multi-burner loop
• Alarm • Check option 1 on all MMs in multi-burner loop		
510	Multi-Burner Differential Firing Rate	Slave MM firing rate differs from the Master MM firing rate by1.5x the Differential Firing Rate Limit (Option 52) value
• Alarm • Check modulation speed of the slave MMs		
550	Fuel Flow Meter Fault	Less than 3mA signal received from fuel flow meter
• Alarm or warning depending on expansion option 152 (if set to warning, the MM will use the commissioned value without any fuel or air servomotor adjustment) • Check wiring and screen on terminal MF and F-		
551	Air Flow Meter Fault	Less than 3mA signal received from air flow meter
• Alarm or warning depending on expansion option 152 (if set to warning, the MM will use the commissioned value without any fuel or air servomotor adjustment) • Check wiring and screen on terminal EX+ and EX-		
552	Fuel Temperature Sensor Fault (T2)	Fault or no comms with T2 sensor
• Warning (MM will use commissioned temperature) • Check wiring and screen on terminals – and T2		
553	Air Temp Sensor Fault (T3)	Fault or no comms with T3 sensor
• Warning (MM will use commissioned temperature) • Check wiring and screen on terminals – and T3		
554	Fuel Pressure Sensor Fault	Fault or no comms with fuel pressure sensor
• Warning or lockout if VPS and/or pressure limits enabled in option/parameters 125 – 128 (if warning, MM uses commissioned pressure) • Check wiring and screen on terminals 31 – 34		
555	Air Pressure Sensor Fault	Fault or no comms with air pressure sensor
• Warning/Lockout –option 148 • Check wiring and screen on terminals 31 – 34 • Lockout if option 148 is set for air pressure sensor in flame safeguard		
560	Fully Metered Air Adjustment Failure	Air adjustment has reached limit and fuel-air ratio still not met
• Alarm/Warning – exp option 151 • Check for changes affecting combustion including fuel/air pressure, temperature etc. • Warning if expansion option 151 is set to 1 • Warning and air adjustment is disabled if expansion option 151 is set to 2		
580	Servo Control I/O Unit Communications Fault	Fault or no comms with the servo control IO module
• Alarm • Check for wiring on terminals 6T+ and 6T-		

Fault	Message	Description
581	Servo Control I/O Unit Channel 1 Output Fault	4-20mA output detects open circuit
	• Alarm • Check wiring on output 1 on I/O module	
582	Servo Control I/O Unit Channel 2 Output Fault	4-20mA output detects open circuit
	• Alarm • Check wiring on output 2 on I/O module	
583	Servo Control I/O Unit Channel 3 Output Fault	4-20mA output detects open circuit
	• Alarm • Check wiring on output 3 on I/O module	
584	Servo Control I/O Unit Channel 4 Output Fault	4-20mA output detects open circuit
	• Alarm • Check wiring on output 4 on I/O module	
585	Servo Control I/O Unit Channel 7 Output Fault	4-20mA output detects open circuit
	• Alarm • Check wiring on output 5 on I/O module	
586	Servo Control I/O UnitChannel 1 Input Fault	4-20mA input less than 3mA
	• Alarm • Check wiring on input 1 on I/O module	
587	Servo Control I/O UnitChannel 2 Input Fault	4-20mA input less than 3mA
	• Alarm • Check wiring on input 2 on I/O module	
588	Servo Control I/O UnitChannel 3 Input Fault	4-20mA input less than 3mA
	• Alarm • Check wiring on input 3 on I/O module	
589	Servo Control I/O UnitChannel 4 Input Fault	4-20mA input less than 3mA
	• Alarm • Check wiring on input 4 on I/O module	
590	Servo Control I/O UnitChannel 7 Input Fault	4-20mA input less than 3mA
	• Alarm • Check wiring on input 5 on I/O module	
600	Low gas pressure before fuel changeover	Selected fuel gas pressure is too low and therefore not ready to run
	• Warning • Check selected Fuel Gas Pressure • Check gas pressure sensor wiring	
601	Selected fuel cannot be run	Selected fuel is not fully commissioned
	• Warning • Check that selected fuel is properly commissioned for Dual Fuel Output Mode • Check if FGR and/or Golden Start points are optioned but not commissioned	

*When option 12 is set to 3 for trim and combustion limits, the combustion limits are evaluated once per trim cycle. A combustion limit error will occur if the current exhaust value has crossed the combustion limit for the number of trim cycles set in parameter 17 (the default value is 3 cycles).

19.4 Settings Conflicts

Some of the options, parameters and expansion options may require another option, parameter or expansion option to be set. Please see the below table for these settings conflicts. A setting conflict will result in the MM being forced into Commission mode.

Setting Conflict Message
(1) (P53, P54, P55, P56) External load sensor incorrectly configured • The external load sensor must be set with the minimum and maximum values and voltages. • Check option 1 and parameters 53 – 56.
(1) (81, 83) OTC setpoints too high for optioned load sensor • If minimum and maximum setpoints OTC setpoints must be set within the possible range of the optioned load detector. • Check option 1, 81 and 83.
(4) (154) Flame Safeguard Mode requires Start position Interlock • If Flame Safeguard mode is enabled. Start position interlock must be enabled. • Check Option/Parameter 154
(4) (155) Flame Safeguard Mode requires Purge position Interlock • If Flame Safeguard mode is enabled. Purge position interlock must be enabled. • Check Option/Parameter 155
(4) (43) Multiburner cannot be used with Flame Safeguard mode • If Flame Safeguard is enabled, Multi-burner cannot be used. • Check options 4 & 43
(4) (148) Air Pressure Sensor cannot be used with Flame Safeguard mode • If Flame Safeguard is enabled, an Air pressure sensor cannot be used. Only an Air switch is used. • Check option 4 & 148
(4) (E1) Water Level cannot be used with Flame Safeguard mode • If Flame Safeguard is enabled, Water Level features cannot be used. • Check option 4 & Expansion option 1
(4) (E40) TDS cannot be used with Flame Safeguard mode • If Flame Safeguard is enabled, TDS features cannot be used. • Check option 4 & Expansion option 40
(4) (E60) Bottom Blowdown cannot be used with Flame Safeguard mode • If Flame Safeguard is enabled, Bottom Blowdown features cannot be used. • Check option 4 & Expansion option 60
(4) (E80) Draught Servo cannot be used with Flame Safeguard mode • If Flame Safeguard is enabled, Draught Servo features cannot be used. • Check option 4 & Expansion option 80
(4) (E120) Heat Flow cannot be used with Flame Safeguard mode • If Flame Safeguard is enabled, Heat flow features cannot be used. • Check options 4 & Expansion option 120
(4) (E130) Spare Temperature Sensor cannot be used with Flame Safeguard mode • If Flame Safeguard is enabled, Spare Temperature sensor cannot be used. • Check options 4 & Expansion option 130
(4) (E140) Fully Metered cannot be used with Flame Safeguard mode • If Flame Safeguard is enabled, Fully Metered features cannot be used. • Check options 4 & Expansion option 140
(9) (45) Internal stat must be disabled if load sensor not present • If external modulation is enabled without a load sensor, the internal stat must always be closed. • Check options 9 and 45.

Setting Conflict Message
(30) (31) Invalid remote setpoint configuration • The Minimum Remote Setpoint (DTI/Modbus/External) cannot be set higher than the Maximum RemoteSetpoint (DTI/Modbus/External) and vice versa. • Check options 30 and 31.
(43) (44) (E1) Water level control only be on the multi-burner master • Water level control should only be enabled on the master (multi-burner ID 1 set in option 44), when using the multi-burner function. • Check options 43, 44 and expansion option 1.
(43) (44) (16) Sequencing only be only the multi-burner master • Only the master (multi-burner ID 1 set in option 44) can be set for sequencing. • Check options 16, 43 and 44.
(43) (44) (12) EGA and trim can only be on the multi-burner master • Only the master (multi-burner ID 1 set in option 44) can be optioned with an EGA. • Check options 12, 43 and 44.
(43) (44) (E110) First Outs can only be on the multi-burner master • Only the master (multi-burner ID 1 set in option 44) can have first outs enabled. • Check options 43, 44 and expansion option 110.
(43) (44) (E120) Heat-flow can only be on the multi-burner master • Only the master (multi-burner ID 1 set in option 44) can have heat flow function enabled. • Check options 43, 44 and expansion option 120.
(43) (44) (45) External modulation can only be on the multi-burner master • Only the master (multi-burner ID 1 set in option 4) can be set for external modulation. • Check options 43 – 45.
(43) (44) (E82) Draught control can only be on the multi-burner master. • Only the master (multi-burner ID 1 set in option 44) can be set for draught control. • Check options 43, 44 and expansion option 82.
(43) (44) (47) Cold Start should only be optioned on the Multi-Burner Master • Only the master (multi-burner ID 1 set in option 44) can be se for cold start. • Check options 43, 44 and 47
(43) (52) Differential Firing Rate Limit requires Fully-Linked Multi-Burner • Differential Firing Rate Limit requires Fully- Linked Multi-Burner operation • Check options 43 and 52
(43) (57) Fuel flow metering must be enabled for multi-burner • The multi-burner function requires fuel flow metering. • Check options 43 and 57.
(43) (111) Continuous Pilot is not supported for Fully-Linked Multi-Burner • Continuous pilot cannot be used in Fully-Linked Multi-Burner operation • Check options 43 and 111
(43) (135) NFPA Post Purge cannot be optioned with multi-burner • The multi-burner function can only use standard, not NFA post-purge. • Check option 43 and option/parameter 135.
(43) (P100) Assured Low-Fire Shut Off not supported for Fully-Linked Multi-Burner • Assure Low-Fire Shut Off cannot be used with Fully-Linked Multi-Burner operation • Check option 43 and parameter 100
(44) (52) Differential Firing Rate Limit should only be set on the Multi-Burner master • Only the Multi-Burner master (multi-burner ID 1 set on option 44) can have Differential Firing Rate Limit enabled • Check options 44 and 52
(45) (55) External modulation option conflict • Switched T88 external modulation is not set with permanent external modulation. • Check options 45 and 55.

Setting Conflict Message
(45/55) (16) External modulation cannot be used with sequencing • External modulation cannot be used on any MMs in sequencing. • Check options 16, 45 and 55
(45) (P72) External modulation and external setpoint both optioned • External modulation and external setpoint cannot be used simultaneously. • Check option 45 and parameter 72.
(81, 82, 83, 84) OTC Configuration invalid • Setpoints at minimum and maximum outside temperatures cannot be set the same. • Minimum and maximum outside temperatures cannot be set the same. • Check options 81, 82, 83 and 84
(111) (122) Flame scanner changeover cannot be optioned with no pilot. • If no pilot is set, then flame scanner changeover cannot be used. • Check option/parameters 111 and 122.
(111) (130) Single valve pilot cannot be optioned with no pilot. • If no pilot is set, then gas valve configuration cannot be set for single valve pilot. • Check option/parameters 111 and 130.
(112, 135) (158) Purge pressure proving timeout shorter than pre-purge time. • Purge pressure proving timeout must be longer than the pre-purge time • Check option/parameters 112, 135 and 158.
(118, 135) (158) Purge pressure proving timeout shorter than post-purge time. • Purge pressure proving timeout must be longer than the post-purge time • Check option/parameters 118, 135 and 158.
(118) (135) NFPA Post Purge must be at least 15 seconds. • If NFPA Post-Purge is enabled, then this time must be set to a minimum of 15 seconds. • Check option/parameters 118 and 135
(125) (150) Valve proving cannot be optioned when fuel type is oil (fuel 1) • Valve proving can only be used for gas • Check option/parameters 125 and 150
(126) (151) Valve proving cannot be optioned when fuel type is oil (fuel 2) • Valve proving can only be used for gas • Check option/parameters 126 and 151
(127) (152) Valve proving cannot be optioned when fuel type is oil (fuel 3) • Valve proving can only be used for gas • Check option/parameters 127 and 152
(128) (153) Valve proving cannot be optioned when fuel type is oil (fuel 4) • Valve proving can only be used for gas • Check option/parameters 128 and 153
(125, 126, 127, 128) (129) (135) Post VPS cannot be optioned with NFPA Post Purge. • If NFPA post-purge is enabled for gas, VPS can only be set for operating before burner start-up. • Check option/parameters 125, 126, 127, 128, 129 and 135.
(145) (E110) First Out Interlock requires First Outs to be enabled • To use First Out Interlock, First Outs functionality has to be enabled in expansion option 110 • Check option 145 and expansion option 110
(P28) (9) High Limit Setpoint cannot be used when internal stat is disabled. • High Limi • Check parameter 28 and option 9
(P28) (9) High Limit Setpoint requires Stat-On Offset below setpoint. • High Limi • Check parameter 28 and option 9
(P85) (16) Modulation exerciser cannot be used with sequencing. • Modulation exerciser should be used for test purposes and cannot be used with sequencing. • Check option 16 and parameter 85.
(P89) (16) Stat exerciser cannot be used with sequencing.

• Stat exerciser should be used for test purposes and cannot be used with sequencing. • Check option 16 and parameter 89.
(P99) (P100) Graceful shutdown and assured low fire shut off not allowed.
• If graceful shutdown is set, then assured low fire shut off cannot be used. • Check parameters 99 and 100.

Setting Conflict Message
(E1) (1) Water level control requires a boiler pressure sensor. • Water level control cannot be used with a hot water boiler (load/external temperature detector). • Check expansion option 1 and option 1.
(E1) (E3, E4) At least one analogue level sensor required. • If water level is enabled with one capacitance probe, then an external level sensor is required. • Check expansion options 1, 3 and 4.
(E1) (E3, E4, E5, E6) Sensor enabled but water level control disabled. • Water level control enabled must be enabled if capacitance probes, external level sensor, 2nd low probe or auxiliary water level alarm inputs are set. • Check expansion options 1, 3, 4, 5 and 6.
(E3, E4, E5, E6) At least two level sensing elements are required. • A minimum of two of the following level sensing elements is required: capacitance probe, external level sensor, auxiliary water level alarm input or second low probe. • Check expansion options 3, 4, 5 and 6.
(E4) (E30) External level sensor without scaling requires a capacitance probe. • Check expansion options 4 & 30
(E4) (57) External level sensor cannot be optioned with fuel flow feedback • External level sensor cannot be used with fuel flow feedback, as they use same terminals. • Check expansion option 4 and option 57.
(E11) (E12) Pump turn off point must be above pump turn on point. • Pump turn off point cannot be set lower than pump turn on point. • Check expansion options 11 and 12.
(E17) (E40) Bypass valve cannot be optioned with solenoid top blowdown. • Bypass and solenoid top blowdown cannot be used together, as they use same terminals. • Check expansion options 17 and 40.
(E28) (E3) External level sensor without scaling requires a capacitance probe. • If external level sensor does not have a scale to indicate what level the 4-20mA signal represents, a capacitance probe is required. • Check expansion options 3 and 38.
(E30) External probe scaling must be less than 8 inches/mA. • Check expansion option 30
(E40) (1) Top blowdown requires a boiler pressure sensor. • Top blowdown cannot be used with a hot water boiler (load/external temperature detector). • Check expansion option 40 and option 1.
(E42) (E46) TDS warning level less than TDS target. • TDS warning level cannot be set lower than the TDS target value. • Check expansion options 42 and 46.
(E60) (1) Bottom blowdown requires a boiler pressure sensor. * • Bottom blowdown cannot be used with a hot water boiler (load/external temperature detector). • Check expansion 60 and option 1.
(E62) (E64) Bottom blowdown reduction boiler steam production rating not set. • If bottom blowdown reduction is enabled, then steam production rating must be set. • Check expansion options 62 and 64.
(E62) (E120) Bottom blowdown reduction requires steam flow to be enabled. • If bottom blowdown reduction is enabled, then steam flow metering must be enabled. • Check expansion options 62 and 120.
(E80) (E82) Draught control enabled but draught servo disabled. • Draught servomotor must be enabled for draught control. • Check expansion options 80 and 82.
(E80) (E115) Draught Servo configured as commissioned servo and for temperature PID • If Draught servo is enabled, then CH7 temperature PID must be disabled. • Check expansion options 80 and 115

Setting Conflict Message
(E115) (E118, E119) Draught Servo configured for temperature PID but PID not configured • Check expansion options 115, 118 & 119
(E115) (E120) Sensor Selected for Draught Servo temperature PID is not available • Check expansion options 115 & 120
(E120) (57) Heat flow requires fuel flow to be optioned and commissioned. • If heat flow function is set, fuel flow metering must be optioned and commissioned. • Check expansion 120 and option 57.
(E120) (1) Steam flow requires a boiler pressure sensor. • A boiler load/external pressure detector must be set for steam flow metering. • Check expansion option 120 and option 1.
(E120) (1) Water flow requires a boiler temperature sensor. • A boiler load/external temperature detector must be set for hot water flow metering. • Check expansion option 120 and 1.
(E127) (E128) Steam flow start pressure offset must be less than stop offset. • The steam flow start pressure offset cannot be set higher than the steam flow stop pressure offset. • Check expansion options 127 and 128.
(E140) (12) Fully metered cannot be optioned with EGA trim. • Fully metered control can be used with the EGA set as monitoring only, but not 3-parameter trim. • Check expansion option 140 and option 12.
(E140) (E4) Fully metered cannot be optioned with external water level probe. • Fully metered control cannot be used with external water level probe (terminals EX- and EX+ are required for both features). • Check expansion options 140 and 4.
(E140) (E120, E129) Fully metered cannot be optioned with local heat flow. • Fully metered control cannot be used with steam or hot water flow metering. • Check expansion options 140, 120 and 129.
(E140) (E141, E145) Fuel temperature cannot be optioned with mass flow meter. • Fuel temperature sensor cannot be used with a fuel mass flow meter in fully metered control. • Check expansion options 140, 141 and 145.
(E140) (E141, E147) Fuel pressure cannot be optioned with mass flow meter. • Fuel pressure sensor cannot be used with a fuel mass flow meter in fully metered control. • Check expansion options 140, 141 and 147.
(E140) (E143, E146) Air temperature cannot be optioned with mass flow meter. • Air temperature sensor cannot be used with an air mass flow meter in fully metered control. • Check expansion options 140, 142 and 146.
(E140) (E143, E148) Air pressure cannot be optioned with mass flow meter. • Air pressure sensor cannot be used with an air mass flow meter in fully metered control. • Check expansion options 140, 142 and 148.
(E140) (150, E154) Fully metered requires gas fuel 1 to have non-zero density. • Density must be set for gas in fully metered control. • Check option 150 and expansion options 140 and 154.
(E140) (151, E155) Fully metered requires gas fuel 2 to have non-zero density. • Density must be set for gas in fully metered control. • Check option 151 and expansion options 140 and 155.
(E140) (152, E156) Fully metered requires gas fuel 3 to have non-zero density. • Density must be set for gas in fully metered control. • Check option 152 and expansion options 150 and 156.

Setting Conflict Message
(E140) (153, E157) Fully metered requires gas fuel 4 to have non-zero density. • Density must be set for gas in fully metered control. • Check option 153 and expansion options 140 and 157.
(E140) (E142) Fully metered requires non-zero fuel flow meter scaling. • Fuel flow meter must be scaled in fully metered control. • Check expansion options 140 and 142.
(E140) (E144) Fully metered requires non-zero air flow meter scaling. • Air flow meter must be scaled in fully metered control. • Check expansion options 140 and 144.
(E140) (60) Fully metered does not function with fuel flow feedback tolerance. • Fully metered control cannot be used with fuel flow feedback tolerance (terminals EX- and EX+ are required for both features). • Check option 60 and expansion 140.
(E140) (57) Fully metered requires fuel flow metering to be enabled (1). • Fuel flow metering must be enabled when using fully metered control. • Check option 57 and expansion option 140.
(E140) (76) Fully metered cannot use air trim on channel 5 (VSD). • Air trim cannot be used on channel 5 VSD in fully metered control. • Check option 76 and expansion option 140.
(86) (E129) Servo channel 1 via I/O unit cannot be optioned with heat flow sensors via I/O unit. • Heat flow sensors from the I/O unit cannot be optioned with servo channel via I/O unit. • Check option 86 and expansion 129.
(87) (E129) Servo channel 2 via I/O unit cannot be optioned with heat flow sensors via I/O unit. • Heat flow sensors from the I/O unit cannot be optioned with servo channel via I/O unit. • Check option 87 and expansion 129.
(88) (E129) Servo channel 3 via I/O unit cannot be optioned with heat flow sensors via I/O unit. • Heat flow sensors from the I/O unit cannot be optioned with servo channel via I/O unit. • Check option 88 and expansion 129.
(89) (E129) Servo channel 4 via I/O unit cannot be optioned with heat flow sensors via I/O unit. • Heat flow sensors from the I/O unit cannot be optioned with servo channel via I/O unit. • Check option 89 and expansion 129.
(E81) (E129) Servo channel 7 via I/O unit cannot be optioned with heat flow sensors via I/O unit. • Heat flow sensors from the I/O unit cannot be optioned with servo channel via I/O unit. • Check expansion options 81 and 129.

* If the MK8 MM has the following software (DI 8.16, FAR 8.21) & above. You can use Bottom Blowdown on a hot water boiler (load/external temperature detector).

19.5 Forced Commission Reasons

In addition to when there is a setting conflict, the MM will be forced into commission mode if any of the forced commission reason occurs.

Forced Commission Message
Fuel not commissioned. • Selected fuel must be commissioned.
Servo configuration does not match commissioning. • Option 8 and/or expansion option 80 do not match the last commission settings.
VSD configuration does not match commissioning. • VSD settings for channels 5 and 6 must be the same as the last commission settings.
Golden start optioned but not commissioned. • Commission golden start position (see section 3.4.8).
FGR optioned but not commissioned. • Commission FGR start position (see section 3.4.9).
Trim channel does not match commissioning. • Option 76 trim channel must be the same as the last commission settings.
Fuel/air-rich trim ranges changed. • Parameter 13 and/or parameter 19 do not match last commission settings.
BC Option/parameter mismatch. • BC options 110 – 160 must be set the same as their corresponding parameters.
Invalid option value. • An option value is outside the allowed range.
Invalid parameter value. • A parameter value is outside the allowed range.
Invalid expansion option value. • An expansion option value is outside the allowed range.
Options have been reset. • Option settings have been reset due to data lost in an EEPROM error.
Parameters have been reset. • Parameter settings have been reset due to data lost in an EEPROM error.
Expansion options have been reset. • Expansion option settings have been reset due to data lost in an EEPROM error.
VPS sensor not commissioned. • Gas pressure sensor has been enabled but not commissioned.
Commissioned gas pressure during valve proving too low. • Gas pressure stored during valve proving is less than option/parameters 133 and/or 136.
Commissioned running gas pressure too low. • Gas pressure at one or more commissioned points is less than option/parameter 136.
APS sensor not commissioned. • Air pressure has been enabled but not commissioned.
Commissioned air pressure too low. • Air pressure at one or more commissioned points is less than option/parameters 147 and/or 149.
IR Upload was completed successfully, check configuration then restart. • Check data has uploaded successfully before restarting in run mode.

Forced Commission Message
Options and/or parameters reset to default values. Check configuration then restart.
• Reset of setting using option/parameter 160. Set/check settings and restart.
First outs are optioned but not configured. Check configuration then restart.
• Configure first outs and restart.
Too many sensors require commissioning.
• Gas and air pressure sensors can be optioned on after fuel has been commissioned, but only one at a time before completing commissioning process for each.
Draught servo minimum angle greater than a commissioned draught servo angle.
• One or more commissioned points for draught servomotor is lower than expansion option 83.
Capacitance probe not commissioned.
• Capacitance probe has been enabled but not commissioned.
Capacitance probe serial number does not match commissioning.
• Capacitance probes have changed, recommission water level.
External level sensor not commissioned.
• External level sensor has been enabled but not commissioned.
VSD 1 Feedback variation too small. Maximum VSD fault tolerance is ---
• Difference between smallest and largest channel 5 VSD feedback is less than option 99 (this message will display required value for option 99 to run).
VSD 2 Feedback variation too small. Maximum VSD fault tolerance is ---
• Difference between smallest and largest channel 6 VSD feedback is less than option 109 (this message will display a required value for option 109 to run).
Draught control optioned but not commissioned.
• Draught control has been enabled but not commissioned.
Fully metered optioned but not commissioned.
• Fully metered control has been enabled but not commissioned.
Fully metered configuration does not match commissioning.
• One or more sensors used for fully metered control that were not present during commissioning are now enabled.

MK8 MM MANUAL
MM80001
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Autoflame Engineering Ltd.
Unit 1-2 Concorde Business Centre
Airport Industrial Estate, Wireless Road
Biggin Hill, Kent TN16 3YN
United Kingdom

Tel: +44 (0)1959 578 820
Email: technicalsupport@autoflame.com
Website: www.autoflame.com

AUTOFLAME®
Combustion Management Systems