Expansion Board
End User Guide

AUTOFLAME®

Expansion Board End User Guide

THE QUEEN'S AWARDS FOR ENTERPRISE: INNOVATION 2007

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Important Notes

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

Short Form - General Terms and Conditions

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

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

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

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

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

Contents

1 INTRODUCTION

1.1 Overview of Water Level Control

1.1.1 Water Level Control Philosophy

The Autoflame water level control focuses on safety and accuracy in controlling the water level in a steam boiler. The system has a typical level control accuracy of ± 2mm in still water. This accuracy is maintained during normal operation by Autoflame's patented "wave signature and turbulence management" software.

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.

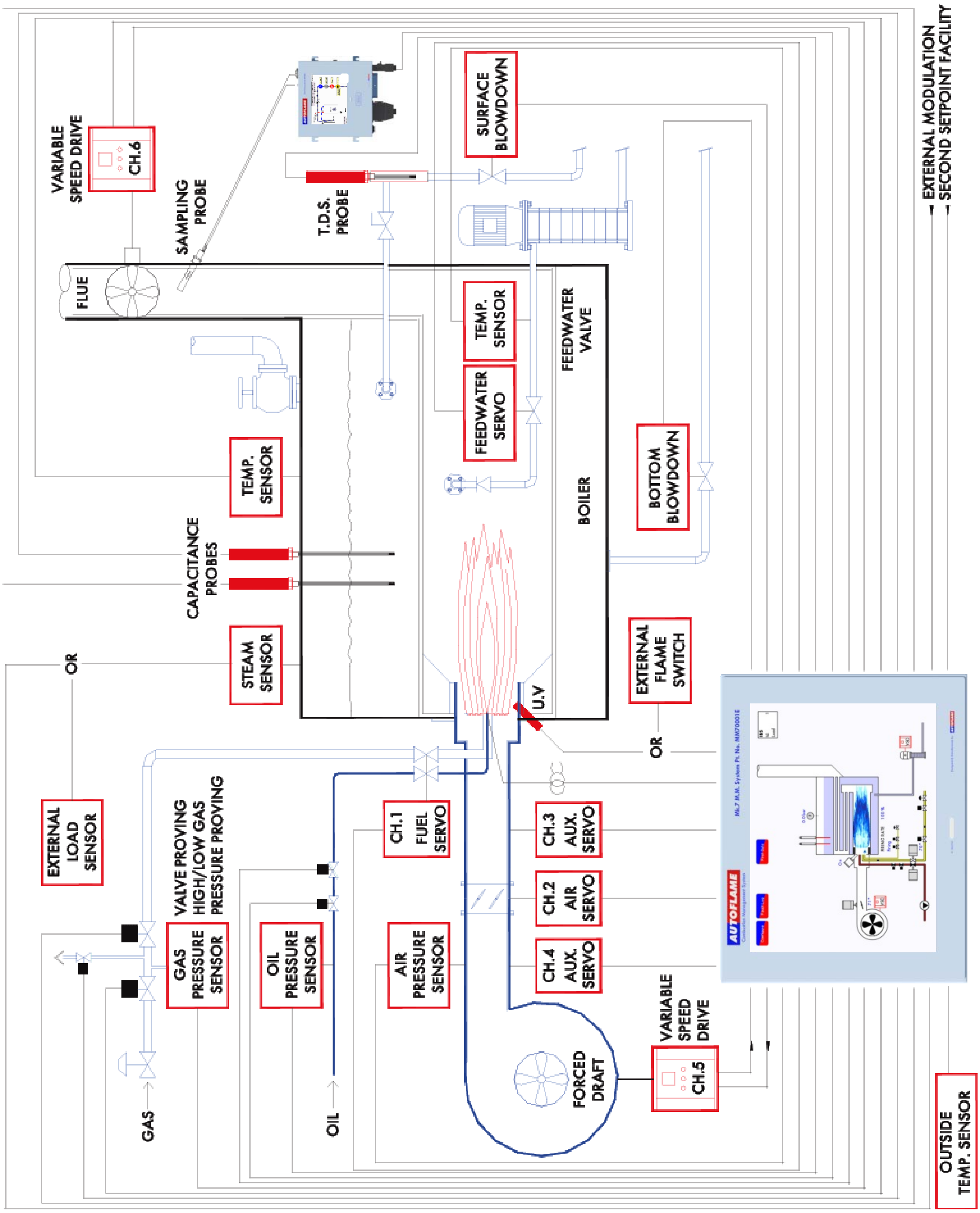
Both probes control typically "high level", "required level", "first low" and "second low". The actual water level readings taken from both the probes are constantly compared and checked against each other, as well the commissioned water levels. When controlling the required level this data stream is 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" takes into account 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.

<u>Movement Detection of Water</u>
When the burner is running it is expected that a wave turbulence signature of in excess of 20Hz / 1mm will always be present (due to vibration of thermal energy). Both probes are checked for this value. The default setting is 20Hz, a range of 0-100Hz is possible, if set to '0' this feature is turned off. 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.

<u>Swell Management</u>
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 water feed 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 normal "required level" and "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 shut downs 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.

1.1.2 Water Level Schematic



1.1.3 Water Level Features

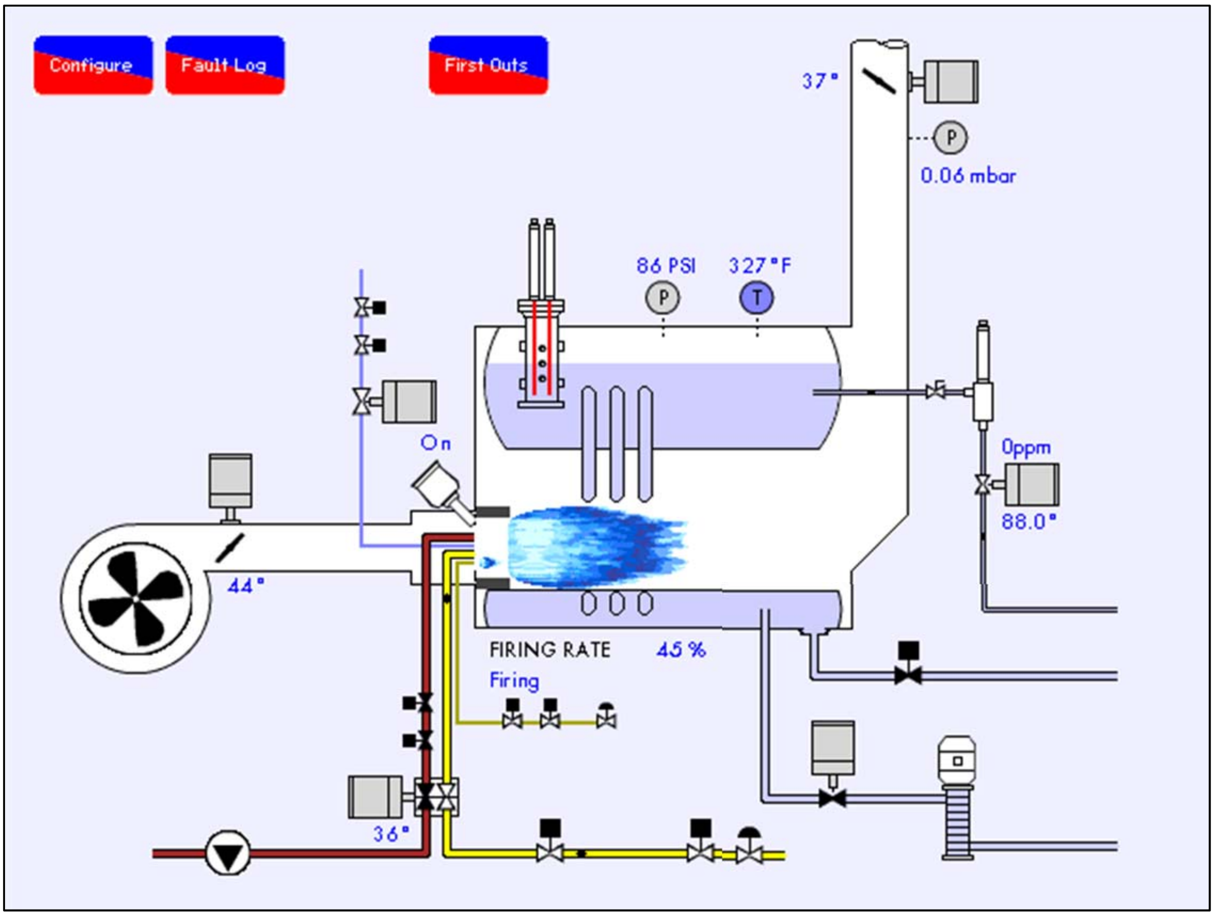


Figure 1.1.3.i Home Screen

The Mk7 Expansion Board is used in conjunction with the Mk7 Micro-Modulation (M.M.) burner controller to report and control levels of water within industrial steam boilers. 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 predetermined level. These levels vary with each installation, and must therefore be programmed on site by a qualified commissioning engineer.

<u>Intelligent Water Level Control</u>

The feed water flow is managed by 3-element control, in response to the water level measured by the capacitance/frequency readings, boiler pressure and the burner's firing rate. The flow is controlled by a fully modulating feed water/VSD or by using an on/off signal from a feed water pump. 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 feed water control. Safety, accuracy and integrity are guaranteed.

The two capacitance probes control up to six operational levels including:

- High high level
- High level
- Pre-high level
- Control point or pump on/off levels
- Pre-1st low level
- 1st low level
- 2nd low level
- End of probe level

The capacitance readings are constantly checked between both of the probes, the commissioned value and an internal hardware reference capacitor (to account for long term drift and temperature variations).

Both probes have a self-checking feature for mechanical and electrical integrity. The commissioned levels by the capacitance probes have an accuracy of ± 2mm repeatability.

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 Autoflame Micro-Modulation (M.M.) module knows the firing rate and boiler pressure, and accommodates for this transient condition by increasing the 'control point' level.

The commissioning procedure for water level control, with a Mk7 M.M. unit and Mk7 Expansion Board, is extremely time-efficient and can be performed at operating pressure.

It is ideal to maintain an amount of water in the boiler 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.

In extreme cases there is the potential for the boiler to explode. 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.

These are the main water levels:

- High Water:

A high water level, although not dangerous is undesirable as water 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 high water audible and visual indicators are activated to notify the user. The audible indicator may be muted by means of the mute/reset push button.

- Pre High

A pre high level, is a pre warning before the water level reaches the high level. A visible alarm is shown. The alarm will reset once the water level is below the commissioned value.

- Control Point:

Ideal water level regulation point. There are no audible or visual indicators active.

- Pre Low

A pre low level, is a pre warning before the water level reaches 1st low. An audible and visual alarm is indicated. The alarm can be muted via the mute/reset button. The burner will not turn off; alarms will be reset once the water level is above the commissioned value.

- 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 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 2nd low audible and visual indicators are activated. 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.

- 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.

Figure 1.1.3.i Capacitance Probe

1.2 Draft Control

Draft control is used to manage the excess draft from stacks, in both fire-tube and water-tube applications, 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 be stack temperature and wind velocity.

The main benefits of maintain stack pressure through draft 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

1.2.1 Autoflame Fully Integrated Draft Control

The Autoflame draft control stores 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 of the conditions that effect 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 draft 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 1.2.1.i Stack with Draft Control

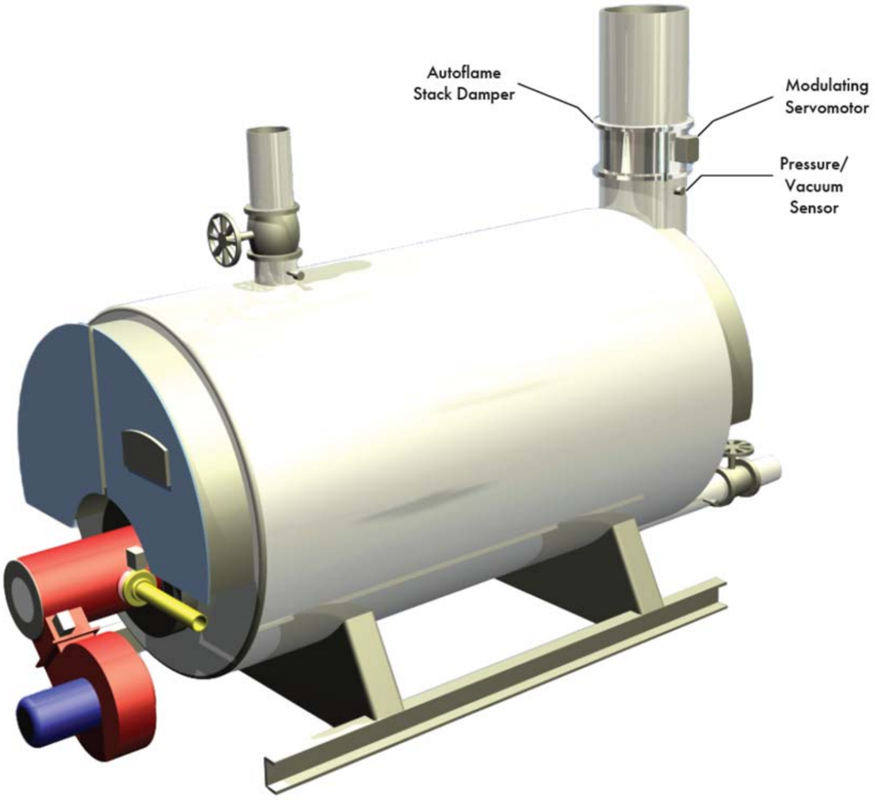


Figure 1.2.1.ii Autoflame draft control

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 draft 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.

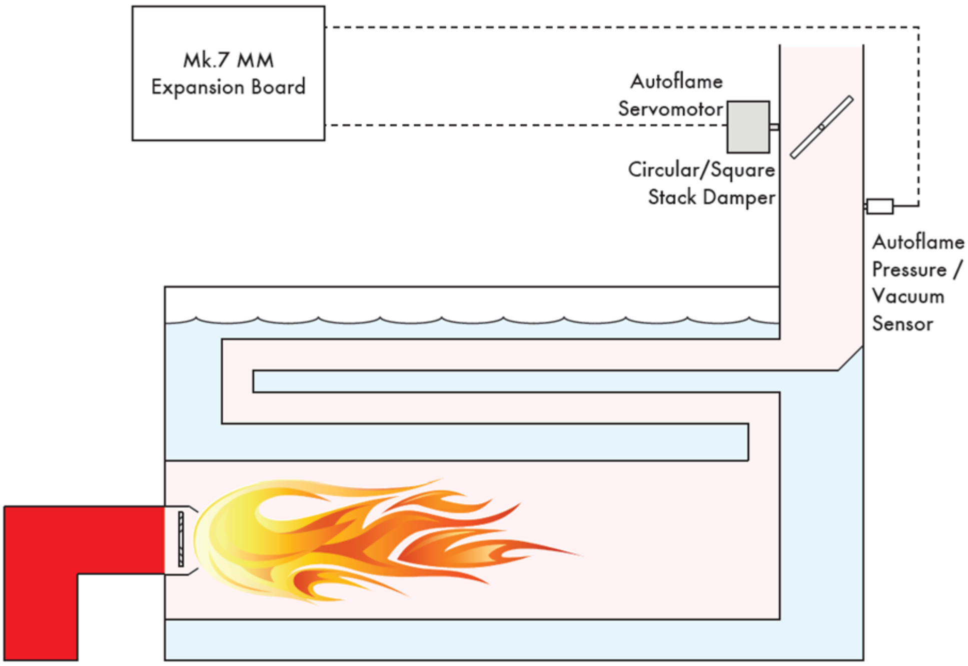


Figure 1.2.1.iii Draft Control Schematic

1.2.2 Draft Control Screens

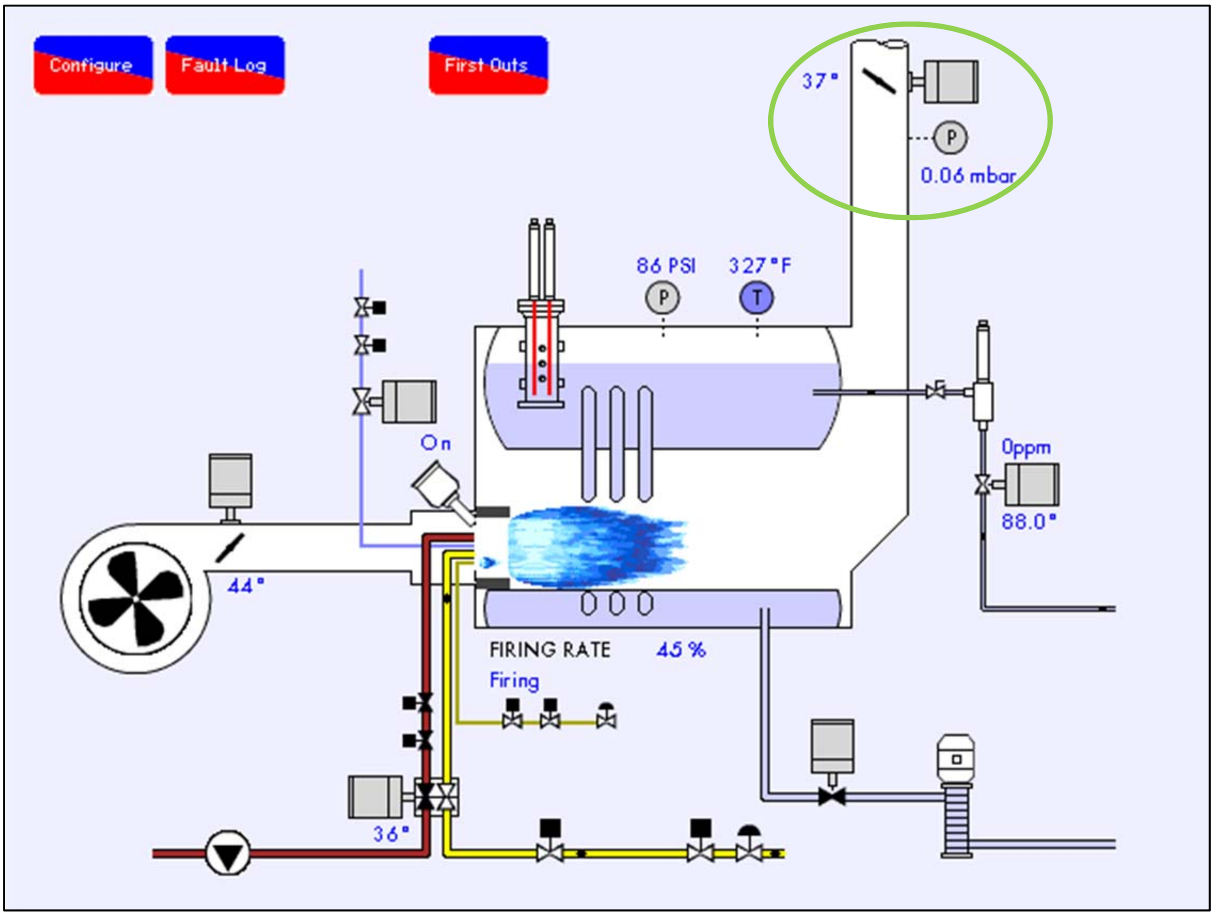


Figure 1.2.2.i Home Screen

Draft control information can be viewed on the M.M. screen by pressing on the pressure sensor located on the stack in the boiler home screen.

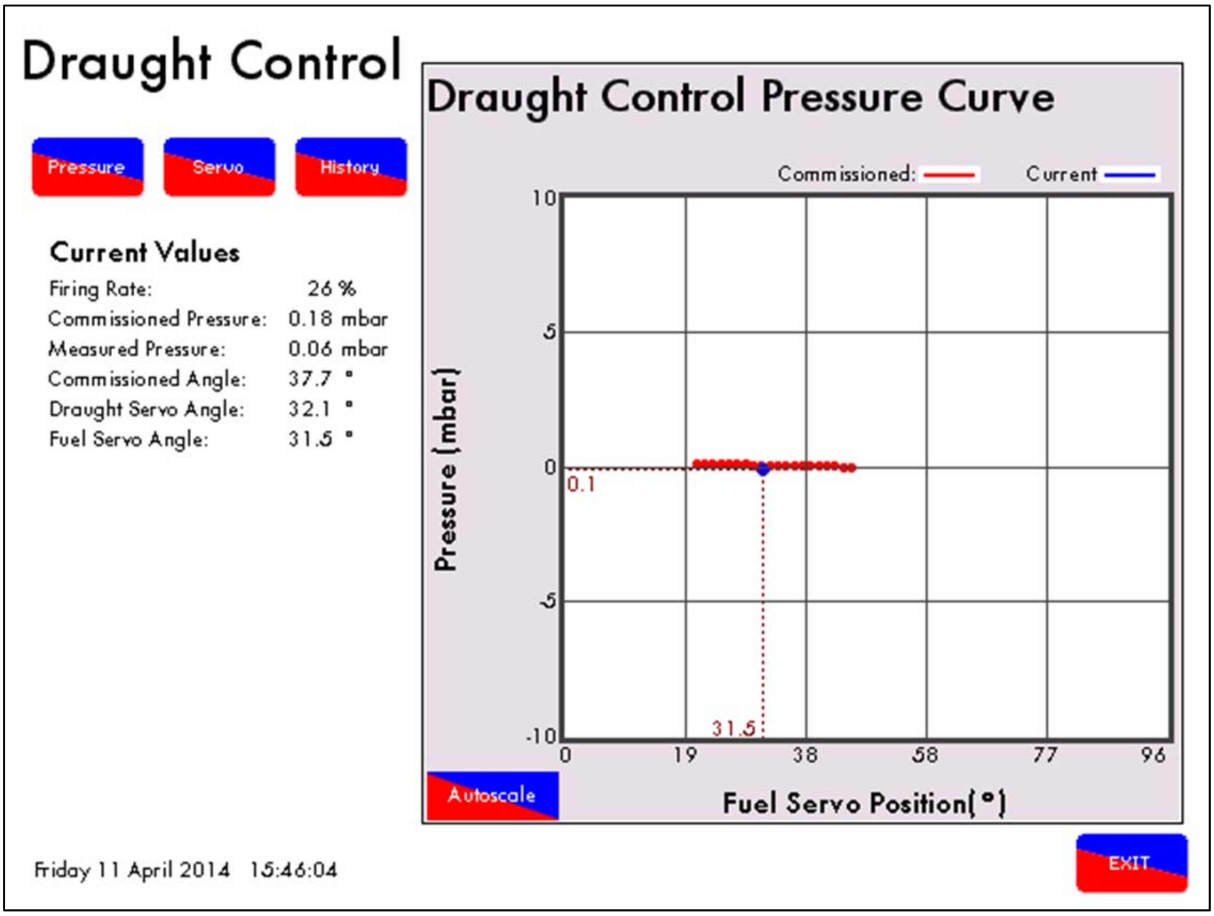


Figure 1.2.2.ii Draft Control Pressure Curve

In the draft control screens, you are able to view instantaneous data in comparison to the commissioned data. The draft control pressure curve displays the current draft pressure in comparison to the commissioned value in relation to the current fuel valve position. In addition the pressure trend for the whole firing rate is visible.

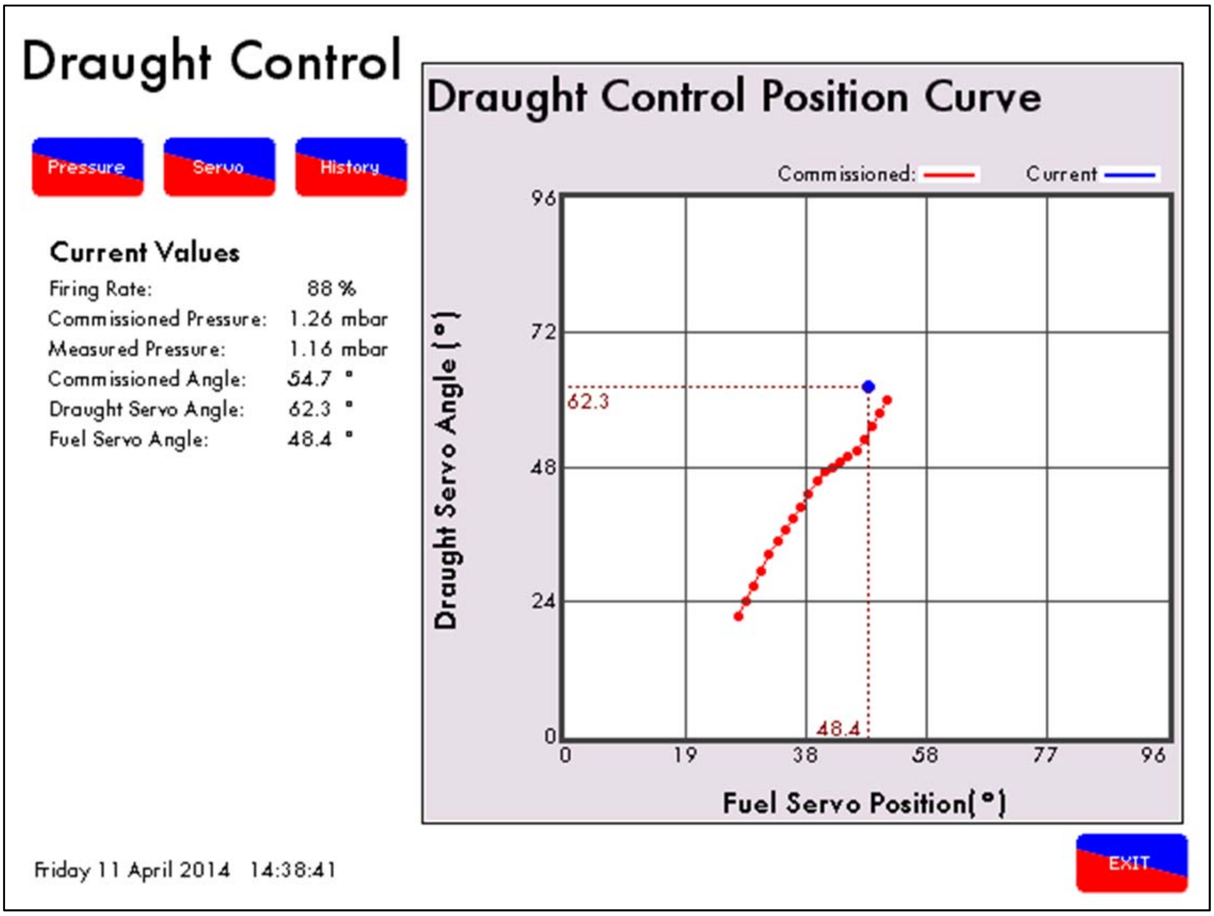


Figure 1.2.2.iii Draft Control Position Curve

The draft control position curve displays the commissioned stack damper values, and displays the amount that the damper is trimming to maintain the commissioned stack pressure in relation to the current fuel valve position. In addition the commissioned servomotor positions for the whole firing rate are visible.

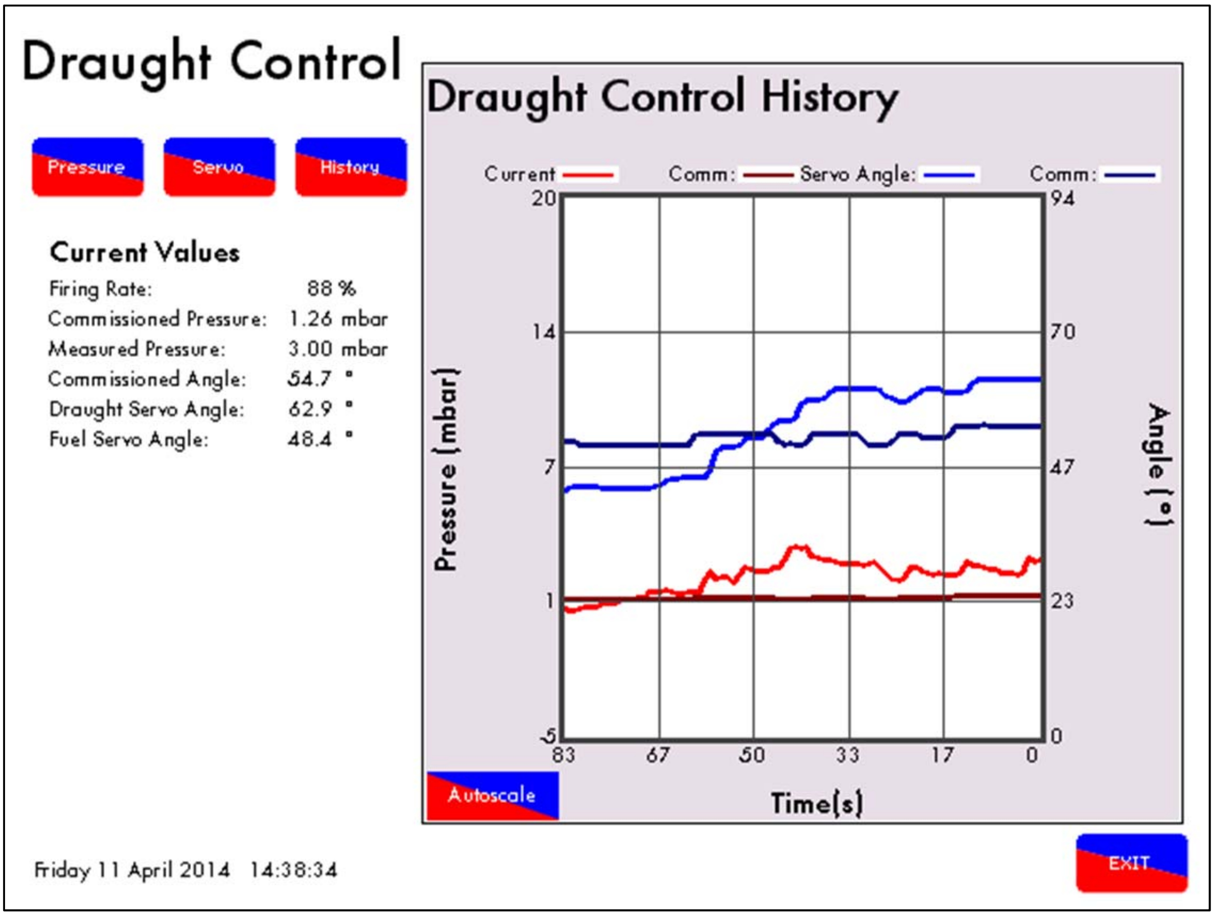


Figure 1.2.2.iv Draft Control History Screen

The draft control history, displays the draft pressure and servomotor position, running values and respective commissioned values at that stage, over a 96 minute period.

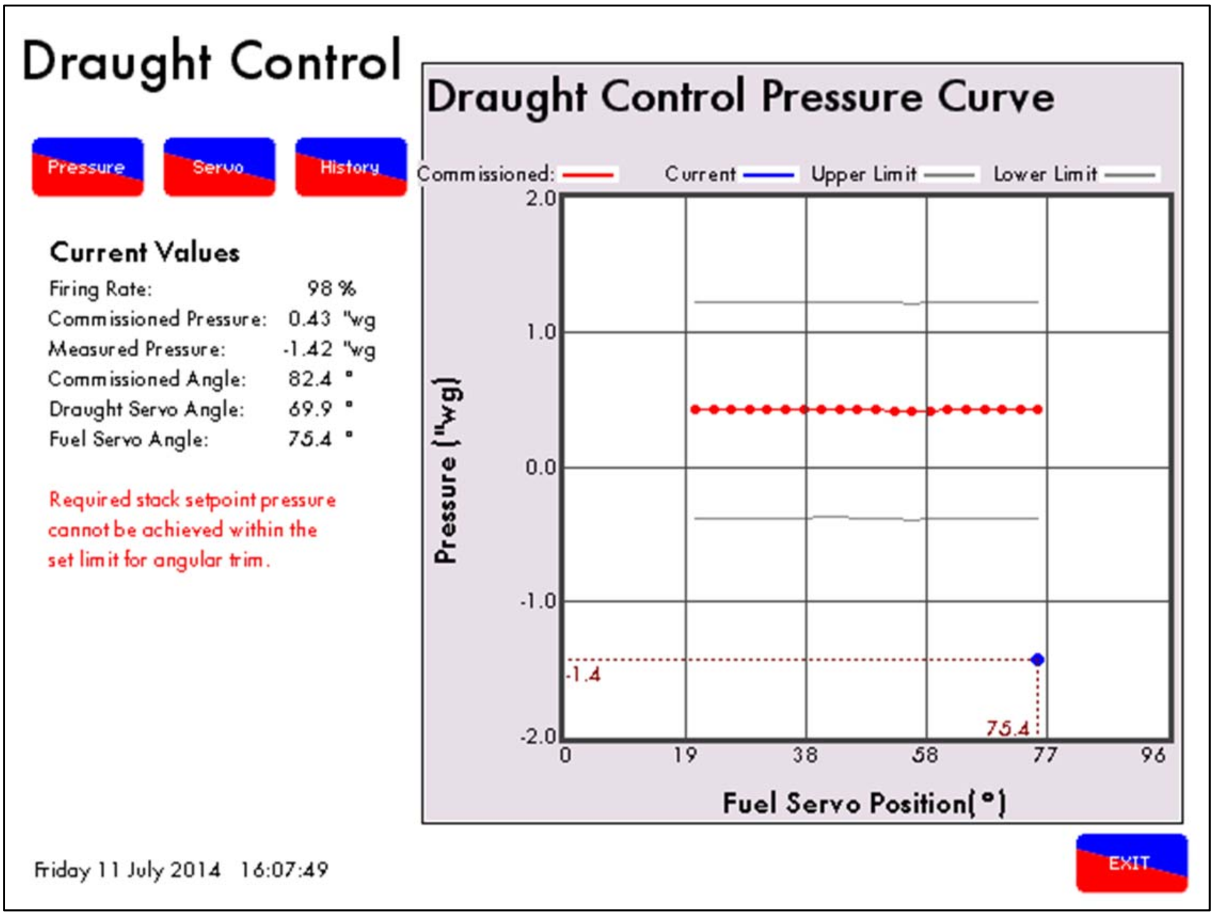


Figure 1.2.2.v Pressure Not Maintained

If the air pressure sensor fails, or the pressure has reached its limit set through expansion option 40.8, a message will appear on the draft control screens. Expansion option 40.8 sets the maximum pressure tolerance before a fault occurs; if the current stack pressure exceeds this maximum change from the commissioned stack pressure over 2 minutes, than an error message will appear.

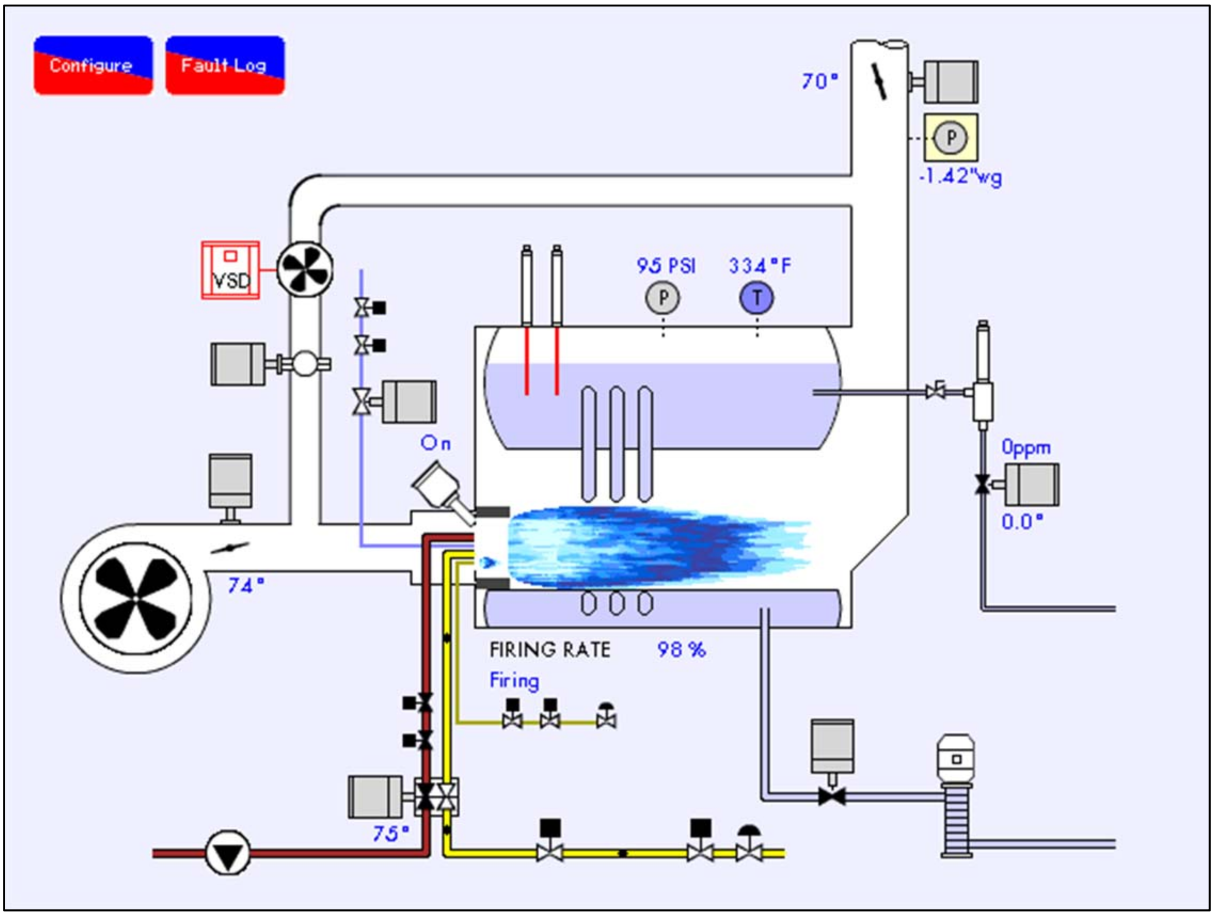
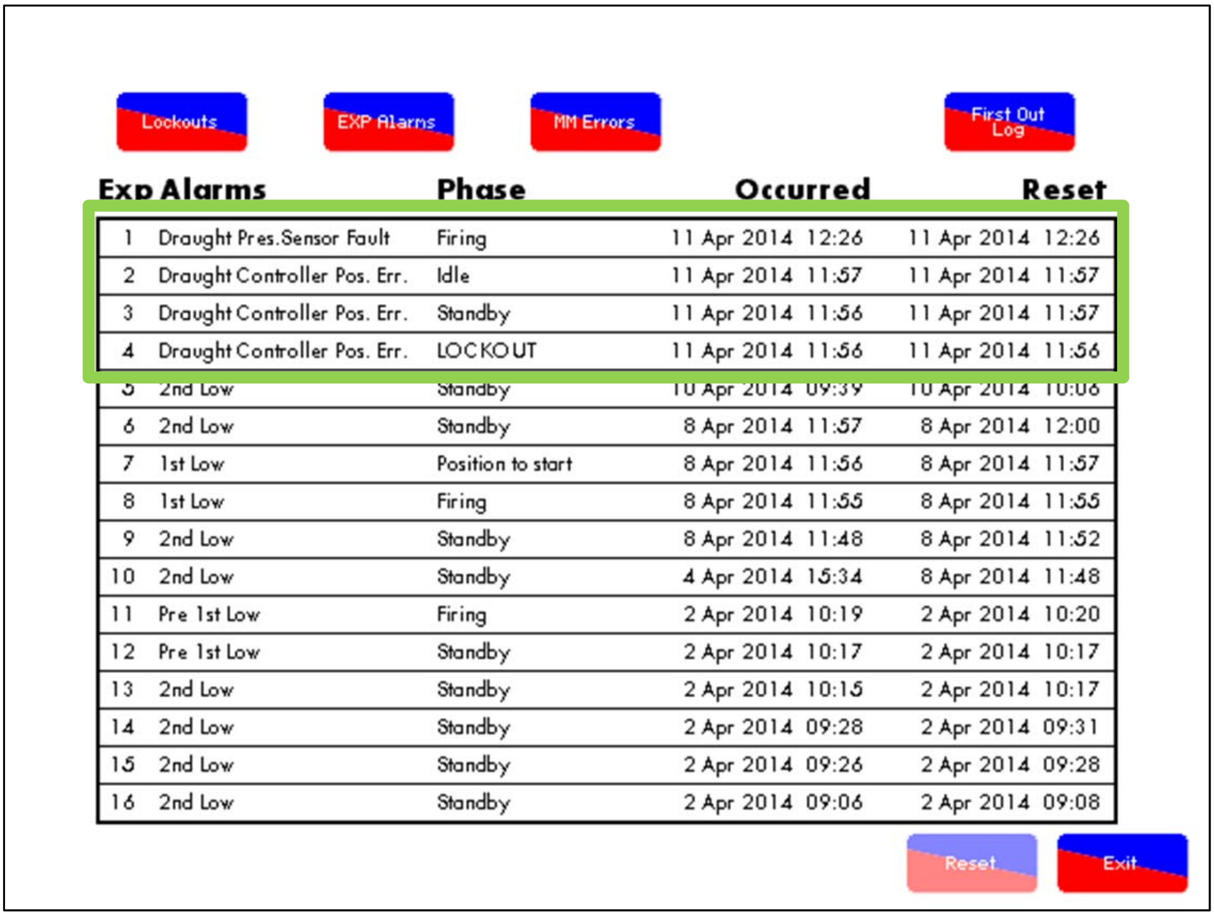


Figure 1.2.2.vi Pressure Not Maintained – Home

When the pressure cannot be maintained, the pressure a yellow box will flash as an indication that the air pressure sensor in the stack is reading outside of limits.



Exp Alarms		Phase	Occurred	Reset
1	Draught Pres.Sensor Fault	Firing	11 Apr 2014 12:26	11 Apr 2014 12:26
2	Draught Controller Pos. Err.	Idle	11 Apr 2014 11:57	11 Apr 2014 11:57
3	Draught Controller Pos. Err.	Standby	11 Apr 2014 11:56	11 Apr 2014 11:57
4	Draught Controller Pos. Err.	LOCKOUT	11 Apr 2014 11:56	11 Apr 2014 11:56
5	2nd Low	Standby	10 Apr 2014 09:39	10 Apr 2014 10:06
6	2nd Low	Standby	8 Apr 2014 11:57	8 Apr 2014 12:00
7	1st Low	Position to start	8 Apr 2014 11:56	8 Apr 2014 11:57
8	1st Low	Firing	8 Apr 2014 11:55	8 Apr 2014 11:55
9	2nd Low	Standby	8 Apr 2014 11:48	8 Apr 2014 11:52
10	2nd Low	Standby	4 Apr 2014 15:34	8 Apr 2014 11:48
11	Pre 1st Low	Firing	2 Apr 2014 10:19	2 Apr 2014 10:20
12	Pre 1st Low	Standby	2 Apr 2014 10:17	2 Apr 2014 10:17
13	2nd Low	Standby	2 Apr 2014 10:15	2 Apr 2014 10:17
14	2nd Low	Standby	2 Apr 2014 09:28	2 Apr 2014 09:31
15	2nd Low	Standby	2 Apr 2014 09:26	2 Apr 2014 09:28
16	2nd Low	Standby	2 Apr 2014 09:06	2 Apr 2014 09:08

Figure1.2.2.vii Draft Control Alarms

The draft control alarms will appear in the Expansion Alarm log. Draft pressure sensor alarms can be configured so that they either lockout the burner, or keep the burner running with the draft servomotor position returned to its commissioned position along the firing curve. Any servomotor errors will result in a burner shutdown which will not permit the burner to be restarted until rectified.

1.3 First Outs

When the control circuit has a long series chain of various thermostat and switching elements, it is sometimes difficult to identify which element has opened the control circuit.

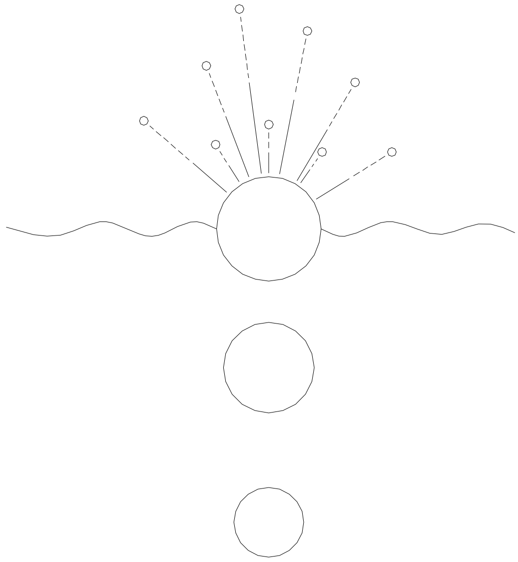
It is possible to monitor a maximum of 15 different inputs in a series control circuit. Each input responds to a signal voltage of between 100V to 250Vac. The first element in the loop that changes state will alter from "normal" to "fail" as detailed above. This first out fail status will remain until reset.
When using First Out Annunciation with a Mk7 M.M. it is not always necessary to tie in switches to the burners run circuits as the Mk7 M.M. is fully capable of turning off the burner if the First Out has been set to Recycle or Non-Recycle. However, local codes may require some First Outs to be tied to the burner run circuit. In this instance it is good practice to tie in the First Out switches into Terminal 53 (Burner On/Off) as shown in the diagram below.

The reason for wiring the First Out Annunciation into Terminal 53 is because a break in this circuit will turn off the burner but will not cause a lockout on the M.M. Here, the First Out Annunciation will appear with what First Out has failed for better diagnosis of the problem. Wiring the First Out Annunciation into Terminal 54 (Air Proving Switch) for example, will cause the burner to turn off but the M.M. will lockout on having no air pressure rather than displaying the First Out that has failed.

2 WATER LEVEL PROBES

2.1 Breaking Bubbles/Spray

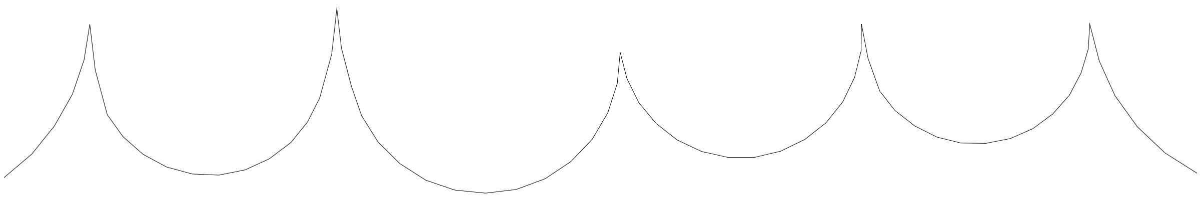
Breaking bubbles/spray refers to the bubbles of steam breaking at the boiler water level surface. These precipitate little droplets as spray several inches above the water surface in an upwards direction.



The droplets tend to coat the surface of the level probe which in turn will read as an increase in the water level. This situation is largely avoided by fitting anti surge pots inside the boiler shell. When the probes are fitted externally to the boiler shell this situation can not arise.

2.1.1 Thermal Currents (heat energy in water)

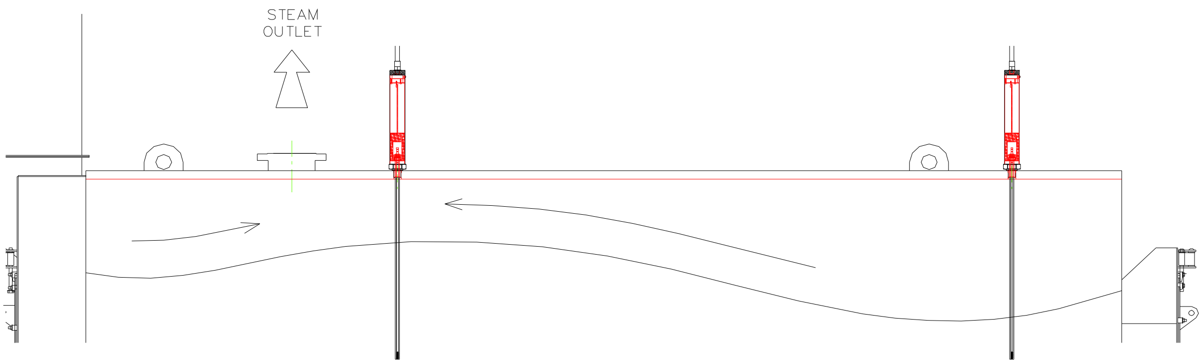
Many bubbles breaking simultaneously and thermal currents from the furnace tube and 2nd, 3rd, 4th pass smoke tube create their own turbulence/wave signature on the surface of the water. The typical result is short choppy/peaky wave patterns as below.



A second set of turbulence is the wave reflections off the sides of the boiler. The whole of the above is largely attenuated away by mounting the probes externally to the main boiler shell in a separate pot or pots.

2.1.2 Steam Flow Induced Surge

When the boiler is producing high quantities of steam, this steam is travelling over the surface and can produce swells and surging motions (long wave).



The above situation will be shown in high relief when the steam outlet is at one end of the boiler and one level probe is sited adjacent to the steam outlet and the second probe is sited at the opposite end of the boiler. The user adjustable probe disparity value may have to be increased to take this situation into account.

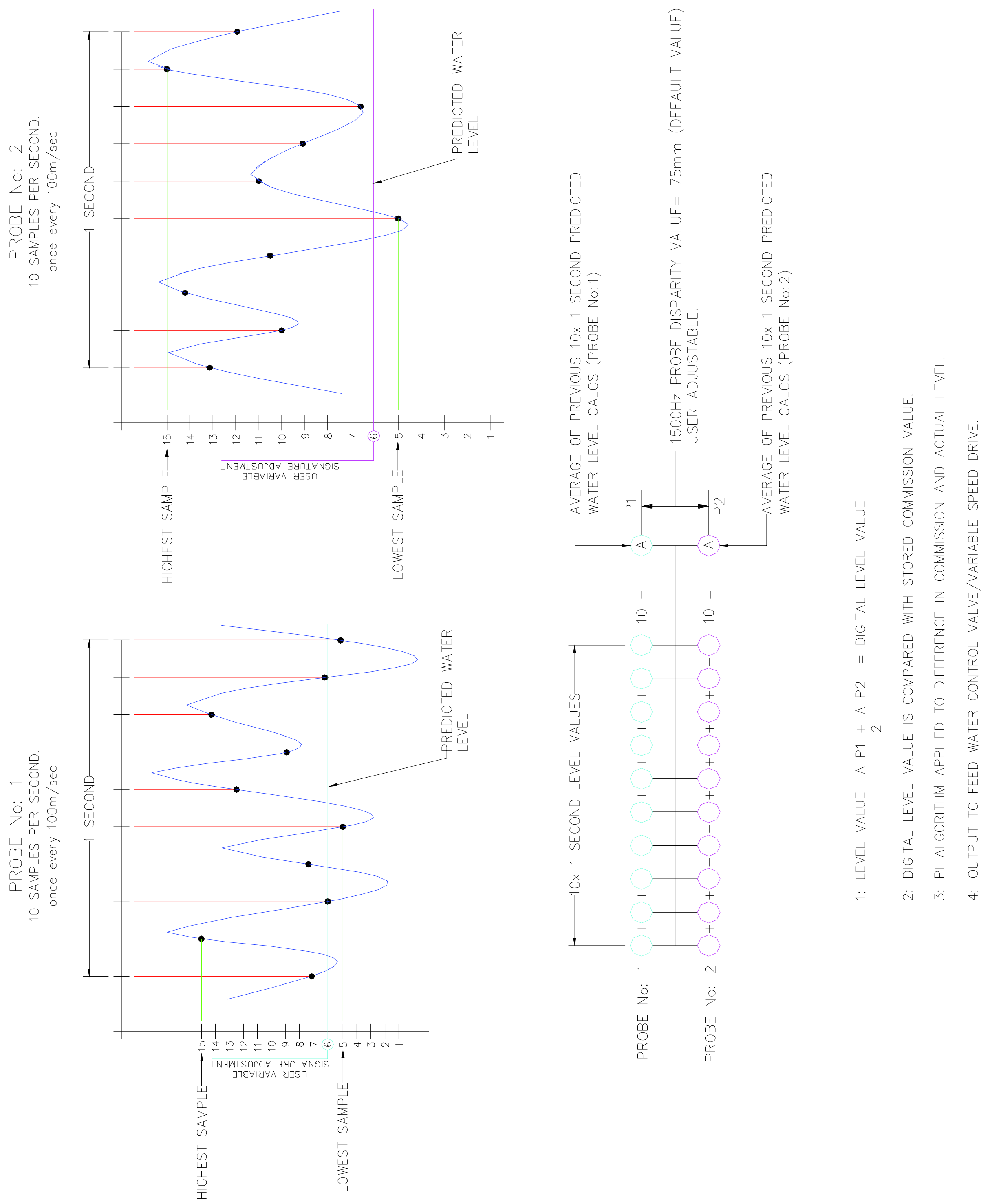
2.1.3 Foaming

Foaming on the surface of the boiler is brought about by a less than adequate blow down regime and/or not controlling and managing TDS in the appropriate manner. Incorrect or insufficient water treatment will exacerbate all of the above. Foaming will read as a step increase in water level. This situation should only ever occur in a badly managed boiler plant.

It can be seen from the above examples that wave signature will tend to be very installation specific. It is driven by boiler size, water treatment regime, position of heat transfer surface relative to water level and the load pattern imposed on boiler.

The Autoflame system takes into account all of these variables and uses them to create a control algorithm that produces perfect level control with absolute safety.

2.2 Schematic Explanation of the Water Level Probe Operation

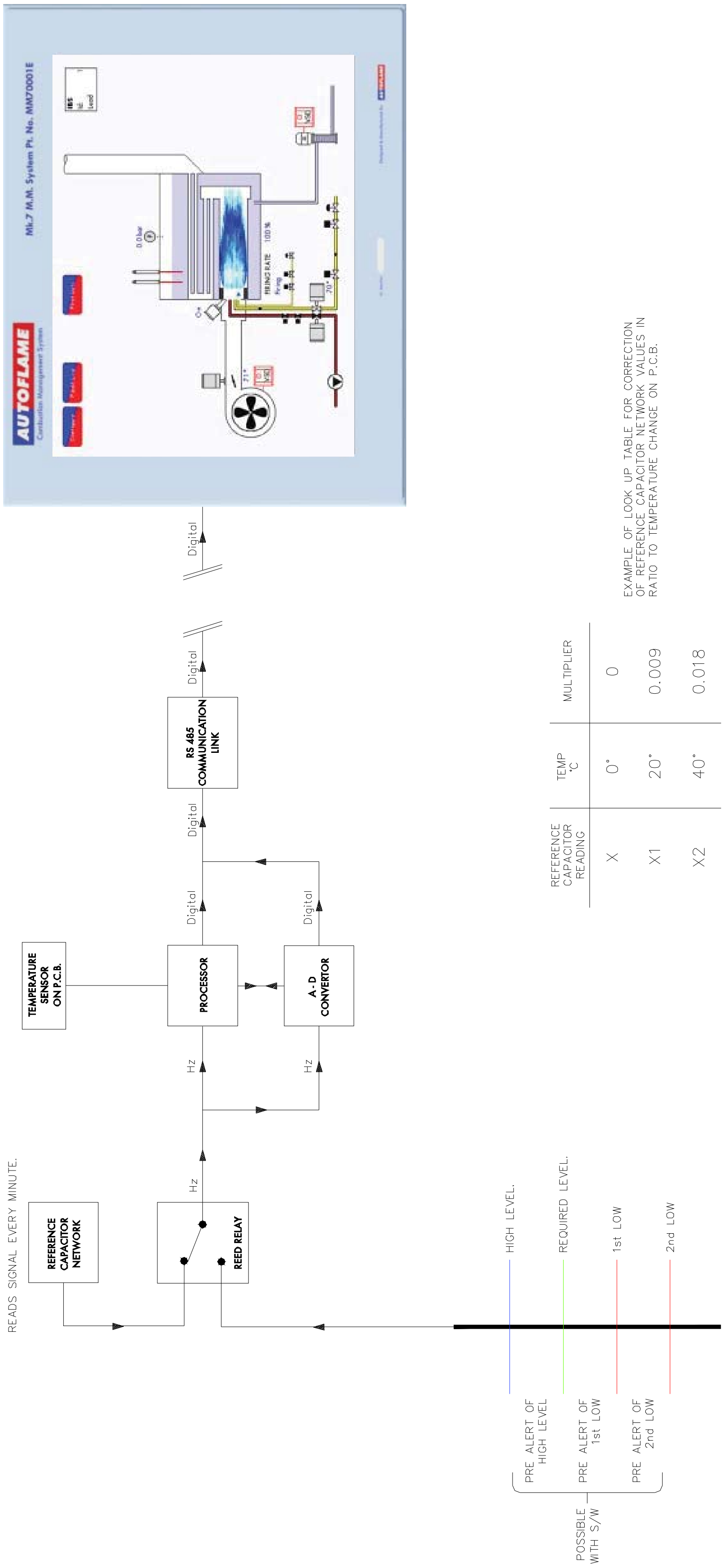


2.2.1 Capacitance Probe

Figure 2.2.1.i Capacitance Probe – External View

Figure 2.2.1.ii Capacitance Probe – Internal View

2.3 Schematic of the Probe Sampling Software



REFERENCE CAPACITOR READING	TEMP °C	MULTIPLIER
X	0°	0
X1	20°	0.009
X2	40°	0.018

EXAMPLE OF LOOK UP TABLE FOR CORRECTION OF REFERENCE CAPACITOR NETWORK VALUES IN RATIO TO TEMPERATURE CHANGE ON P.C.B.

2.4 Water Level Treatment

The water treatment regime in any boiler installation has an effect on the life of the boiler and poor water quality can also affect the performance of capacitance probes. 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. The water level treatment will also affect the long term operational life of the Autoflame capacitance probes. Water treatment companies should be able to assist with the selection and implementation of a suitable water treatment regime.

Generally, guidelines and standards for correct water treatment will be provided by your boiler manufacturer. The Autoflame water level 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.

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 your boiler and increasing ongoing maintenance requirements.

2.5 2nd Low Probe

2.5.1 2nd Low probe

The 2nd low probe measures the water level by a conductive technology, rather than the capacitance technology. This patented technology feature enables 2nd low electronic safety control with continuous software, electrical and mechanical self-checking.

The features and benefits of the 2nd low probe include:

- Certified low water cut off probe
- Internal relay self-checking
- Can be used with the Autoflame system, or as standalone
- Volt free contacts for external safety devices or circuits
- Stainless steel and PTFE construction
- Probe can be cut to length to suit application
- Quick connect multi-pin flying lead
- Offsite status logging via Mk7 D.T.I.
- Conductive technology completely different to capacitance probes

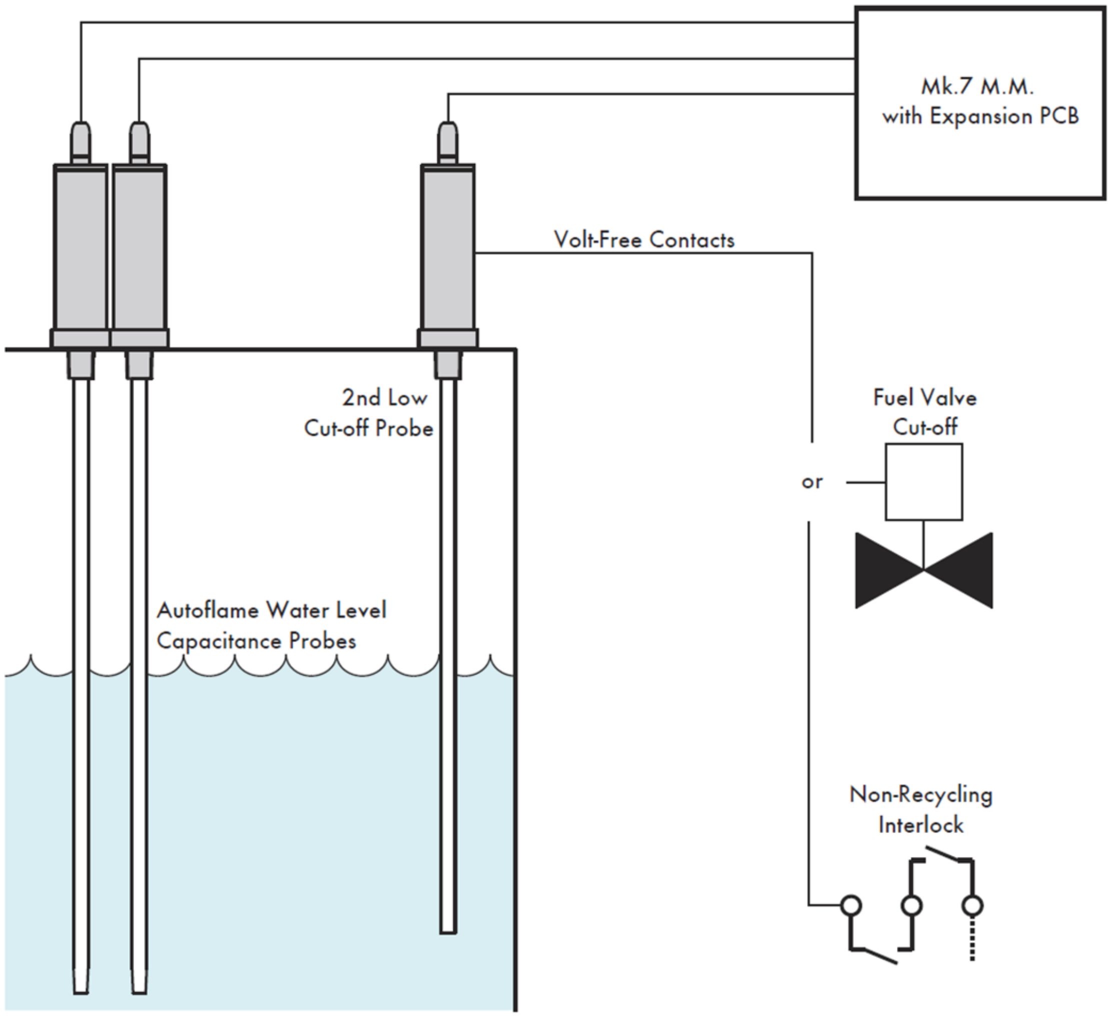


Figure 2.5.1.i 2nd Low Probe Diagram

To install the 2nd low probe, no commissioning is required; just simply enable expansion option 37.1. The bottom of the 2nd low probe should be at the capacitance probes 2nd low level or higher.3

3 TOTAL DISSOLVED SOLIDS MANAGEMENT

3.1 Philosophy of TDS Control System

Figure 3.1.i TDS Probe

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 smoke 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.

1. 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 data stream is used to constantly correct the conductivity value.

2. 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 10x 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!

3. 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.

4. 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 – 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.

3.2 TDS Probe Calibration

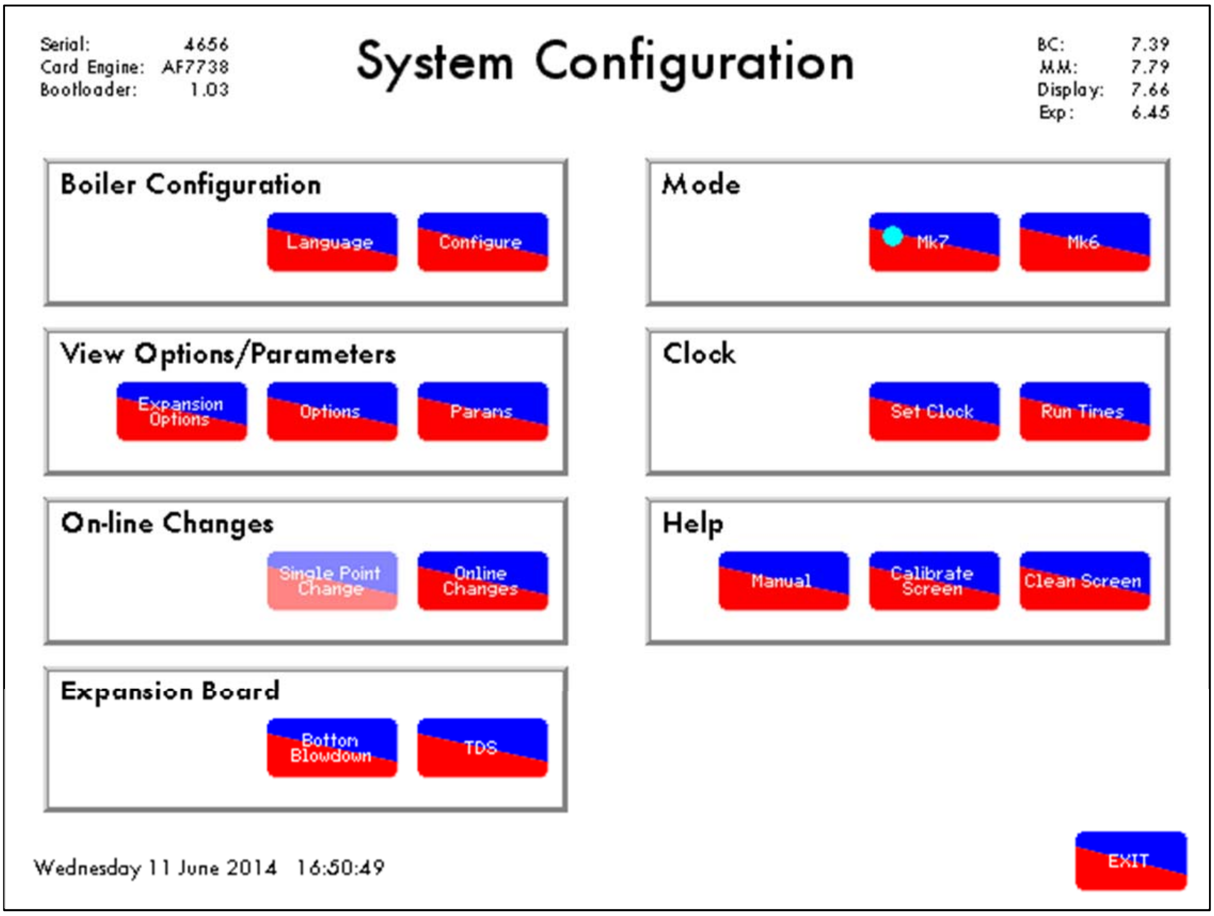
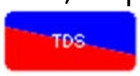


Figure 3.2.i System Configuration

Once the expansions have been set for the TDS probe, the probe must be calibrated. While the M.M. is in Run mode, press 

and then press 

in the System Configuration screen as in Figure 3.2.i.

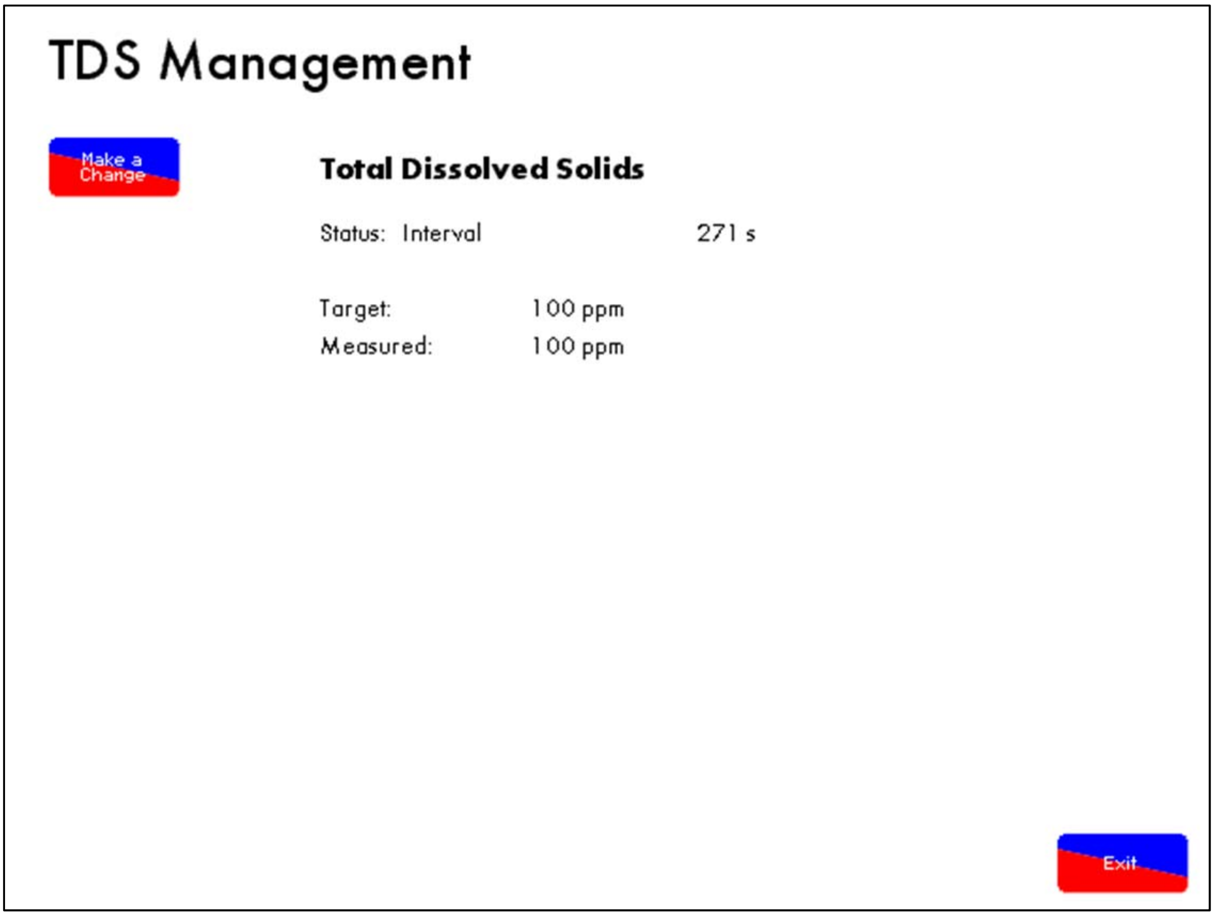


Figure 3.2.ii TDS Management Screen

Figure 3.2.ii shows the TDS management screen.

Press 

to calibrate the TDS probe. The TDS probe does not operate when the M.M. is in Make a Change mode or when the burner is not firing.

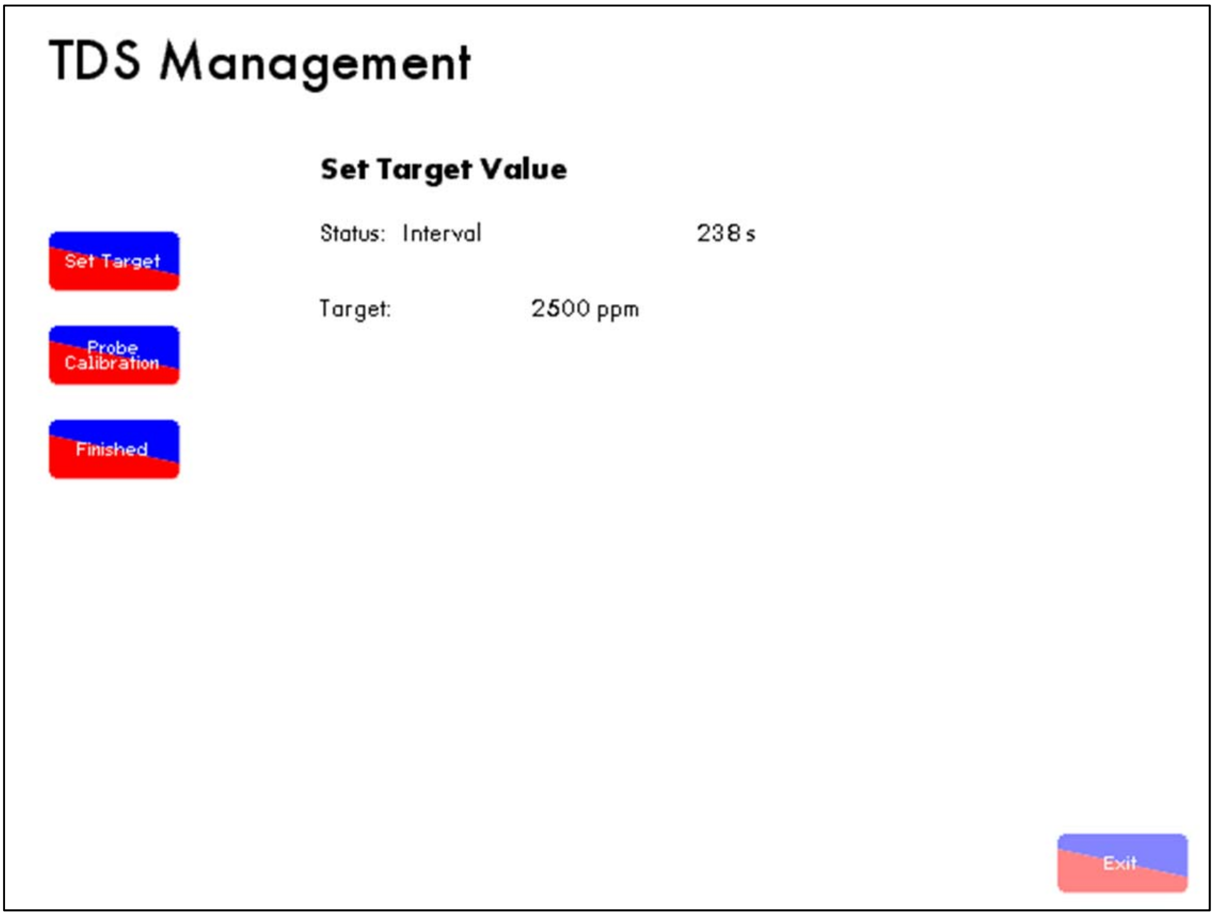


Figure 3.2.iii Set Target Value

In the Make a Change screen, pressing the 

button will allow you to type in a required TDS value, see Figure 3.2.iii. This TDS value is based on the boiler manufacturer's requirements.

Pressing 

allows the user to calibrate probes. After taking a manual sample of the TDS, press 

to take a fresh sample for the TDS probe. If TDS management is set-up for solenoid operation, the valve will open and close for the duration of the sample time set in the TDS adjusters. If the TDS management is set-up for continuous operation, the TDS valve will go to the fully open position for the sample time duration, and then go to fully closed. The sample settlement time is set in the TDS adjusters; once this time has elapsed, the sample measurement is recorded.

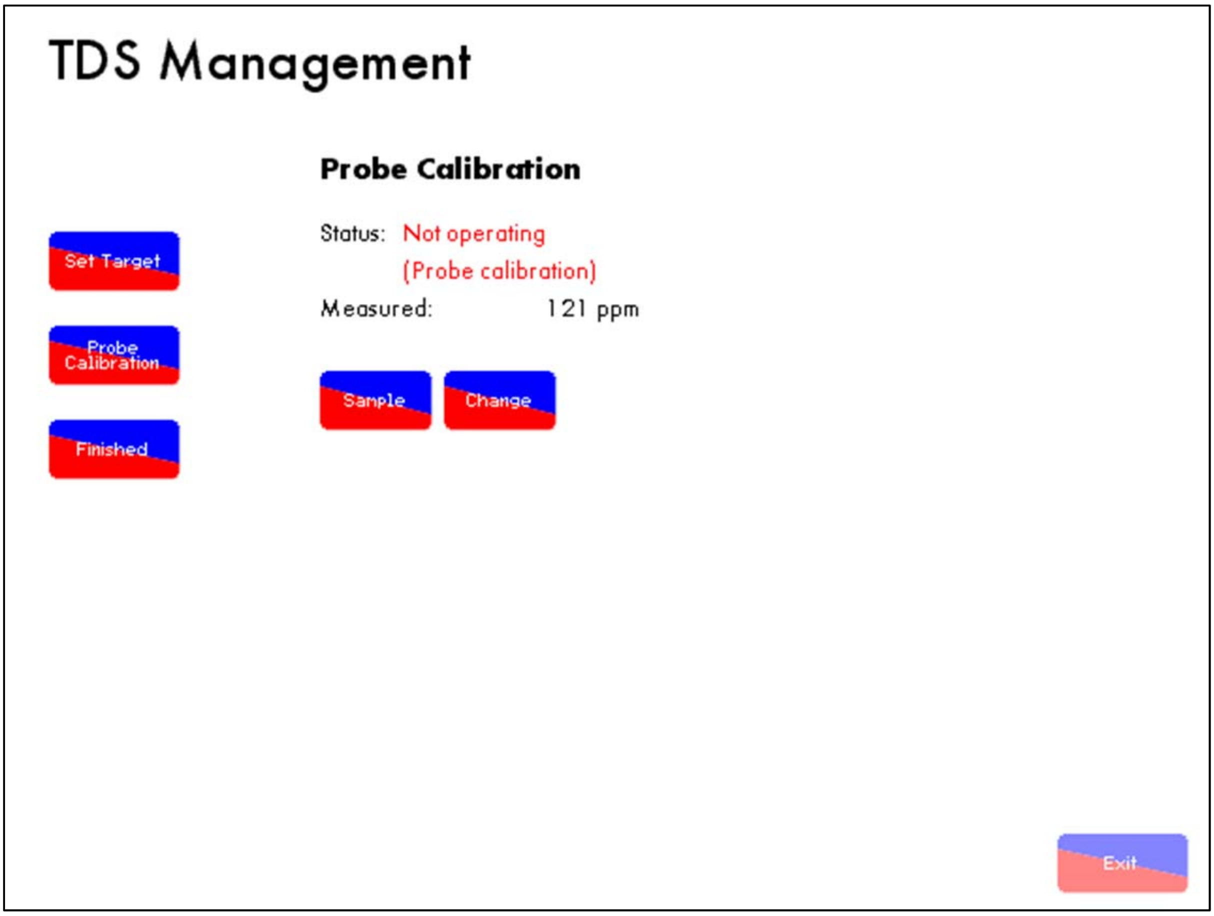


Figure 3.2.iv Probe Calibration

Once a fresh sample has been taken, press 

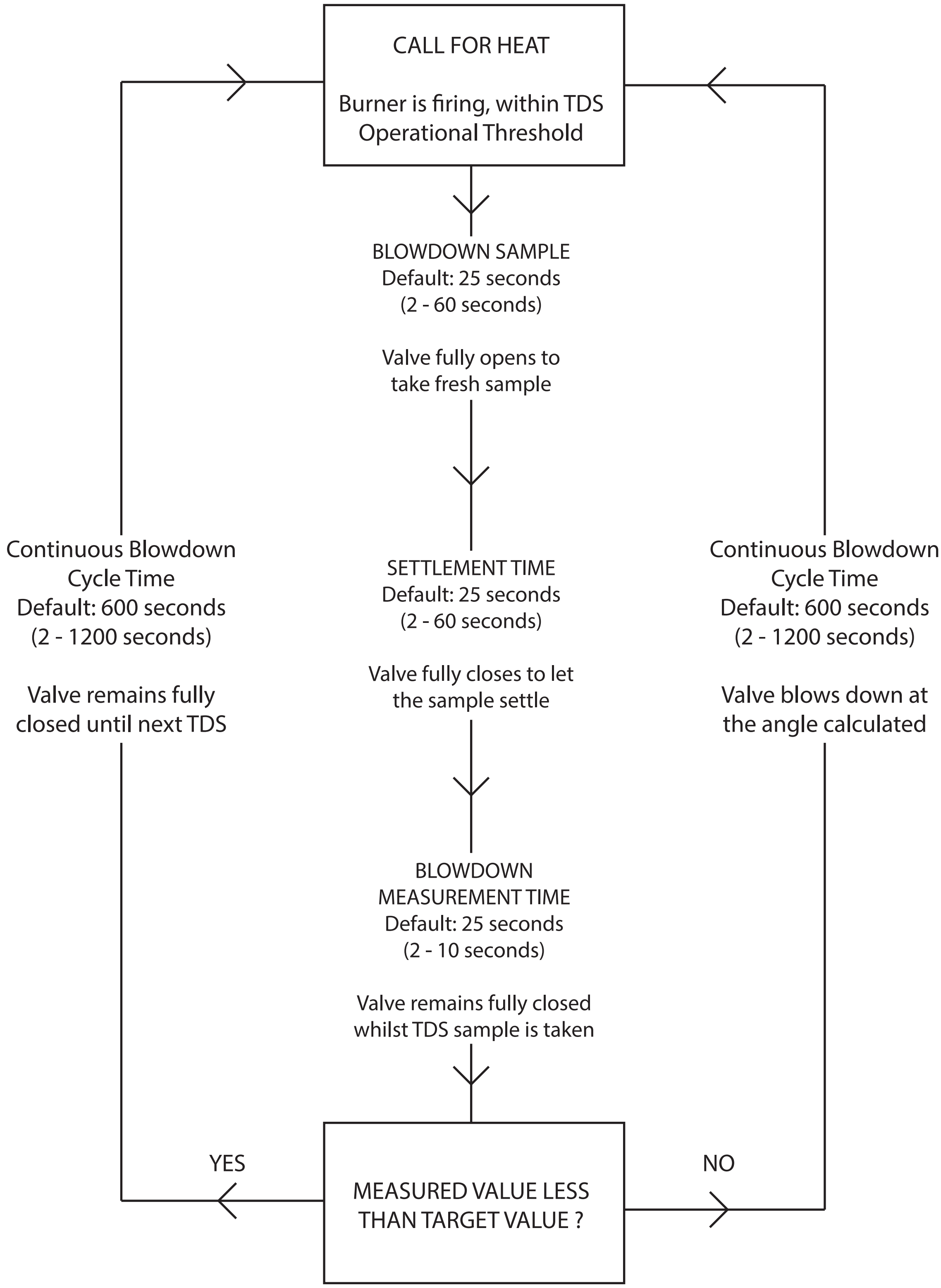
shown in Figure 3.2.iv, to enter a new calibrated value taken from the manual sample, which the probe will now be calibrated to. This value must be within 10% - 990% of the probe reading to avoid incorrect calibration. If there is an air lock, the TDS probe will not be calibrated as the reading will be 0ppm.

When the probe calibration is completed, press 

and exit this screen.

3.3 Method of TDS Control

3.3.1 Timing Diagram



3.3.2 Continuous TDS Blowdown

The new continuous TDS blowdown operates as continuous cycle; the interval timing is set via only one setup in the TDS adjusters, rather than two set-ups as before.

Note: The interval time setup is still available in the TDS adjusters, however this is only active when the solenoid valve is optioned and has no effect on the continuous blowdown cycle.

1. At the point of sample, the TDS valve fully opens to gain a fresh sample.

2. The valve then fully closes, and a after a settle time, the sample is then measured. This reading is used to evaluate the required valve position according to the internal PI control and the target value.

3. If the measured TDS value is above the target TDS value, the valve will open to its calculated position for the set blowdown cycle time (this will be displayed as 'blowdown time' on the screen). At the end of the cycle time, the sampling will be repeated and the cycle starts again.

4. If the measured TDS value is below the target TDS value, the valve will remain closed for the duration of the blowdown cycle time (this will be displayed as 'interval time' on the screen). At the end of the cycle time, the sampling will be repeated and the cycle starts again.

5. Once the TDS value has been reached or decreased to below the target TDS value, the valve shall remain closed for the duration of the blowdown cycle time.

6. Once the valve has been opened due to the measured TDS value being above the target TDS value, the valve will continue to drive open until the measured TDS value is more than 100ppm below the target TDS value.

3.3.3 Solenoid Valve TDS Blowdown

The sampling and control sequence of the top blowdown using the solenoid valve is detailed below:

1. If the boiler water sample is above the required TDS value the system will open the top blowdown control valve for 5-300 seconds. This time duration is user variable and is designated blowdown time.

2. After blow down the system invokes a 5 second settlement interval.

3. After the settlement period a 5 second measurement routine is carried out to establish the current TDS level.

4. If the boiler water sample is still above the required TDS value the system will repeat the top 'Blowdown Time' routine as detailed above in 1) BDT.

5. When the boiler water sample is measured as below the required TDS level, the system will then take a sample every 60-300 seconds. This sample time interval is user variable.

6. The duration of the sample time is 3-10 seconds. This is user variable.

7. The system then repeats this cycle.

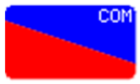
3.4 Top Blowdown Adjusters

By setting expansion option 23.1, and M.M. parameter 83 to 1 the following TDS adjusters are available in Mk6 mode.

The TDS Adjusters allow the Top Blowdown Operation to be adjusted to suit boiler's conditions.

These must be accessed in Mk6 mode. In Mk6 Mode, press the 

button until the day to day Top Blowdown Management screen is displayed.

Whilst the day to day Top Blowdown Management screen is being displayed press the 

button for 2 seconds so that the SET TDS TARGET VALUE screen is shown.

Press the 

button twice. The ADJUSTERS screen shown below should be displayed. Note while in this screen there is no top blowdown operation.

Use the channel 

buttons to select the item to be adjusted.

Use the channel 

buttons to adjust the value units. Where appropriate the channel 

buttons can also be used to change the value by 10.

Press RUN to return to normal operation. When the run button is pressed, all Adjuster values are stored in memory.

Factory Setting	Value	Description
600		**Blowdown Time:**
		The continuous blowdown cycle time or time the solenoid valve is opened.
	2 - 1200	Seconds
60		**Continuous Blowdown Cycle Time or Solenoid Valve Blowdown Time:**
		The blowdown cycle time for continuous TDS blowdown or the blowdown time for solenoid valve only.
	2 - 900	Seconds
0		**Sample Time Interval (Solenoid Valve Only):**
	0	Disabled
	1	The blowdown time is in prorportion to the firing valve for solenoid valve operation only.
70		**MicroSiemens to ppm factor (x100):**
		The TDS probe measures conducitivity in microSiemens. This factor derives the TDS value in ppm.
	20 - 100	
10		**Steam Pressure Threshold Offset Below Required:**
		If the M.M. actual value is less than the required value minus this offset, then the top blowdown does not operate.
	0 - 50	PSI. (0.0 -10.0 Bar)
0		**Reset Defaults:**
		Resets all TDS adjusters to the default values and the TDS probe to preset calibraiton. Select YES and then press RUN.
	0 - 1	
2500		**TDS Target Value:**
	50 - 9990	ppm
180		**Temperature Correction Value:**
	20 - 300	
1000		**Calibration Correction:**
	100 - 9990	
25		**Settlement Interval Time:**
		After a blowdown measure, this is a period where the sample can settle before the TDS is measured.
	2 - 60	Seconds
5		**Measurement Time:**
		This is how long the sample is measured to get an accurate TDS value.
	2 - 10	Seconds
0		**ppm or µS**
	0	ppm
	1	µS
0		**Upper Limit Offset**
	0	Disabled
	1 - 5000	Once this limits has been exceeded, terminal #79 will be set. On the top blowdown screen, a light blue dot will flash on the water level button. Press the water level button to mute the alarm. This will continue to flash until the measured TDS value has fallen below the limit value. Another alarm will not be generated until the measured TDS value has been continuously below the limit value for 10 minutes.

4 BOTTOM BLOWDOWN

4.1 Overview of Bottom Blowdown

4.1.1 Features and Benefits

Bottom blowdown is used to remove solids which build up at the bottom of steam boilers. 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 benefits of the Autoflame bottom blowdown system include:

- Full stainless steel valve construction with replaceable bronze liner
- 24V DC Autoflame Unic 5 servomotor 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
- Timed blowdown with manual/automatic operation
- Bottom blowdown sequence logging
- Up to 4 timed blowdowns over a 24 hour period
- Repeatable up to 10 times from 1 to 60 seconds for each blowdown
- 'Parked' position to reduce valve opening time
- Quick servomotor disconnect facility for manual actuation
- Rotary operation ensures water tight shutoff
- Sealing design concept ensures no leaks

<u>Valve Specifications</u>
Power Supply: 24V DC
Flange Connection: 400lb/ PN40
Valve Sizes: 1", 1 ½", and 2"

Figure 5.1.1.i Bottom Blowdown Valve and Industrial Unic 5 Servomotor

Note: Please Valves and Servomotors manual for water level valve dimensions, drawings and information on service and maintenance.

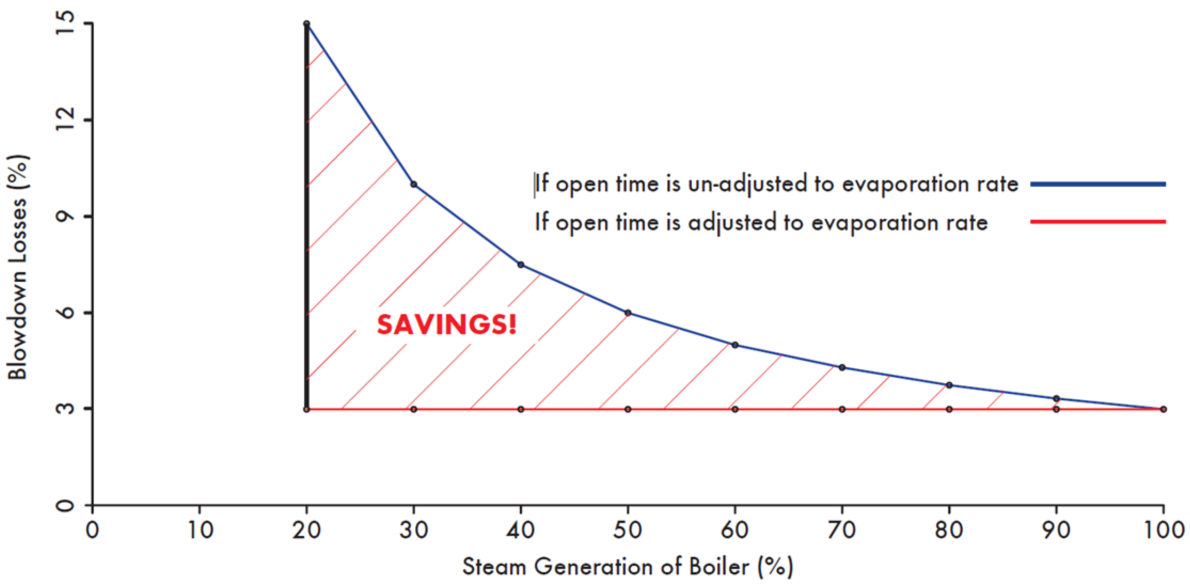
4.1.2 Bottom Blowdown Time Reduction

Calculated Bottom Blowdown Losses

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 is required, this can be set through expansion option 38.1. The accurate burner rating must be set through M.M. options 33 and 77, as well accurate fuel flow metering through M.M. option 57.

4.2 Bottom Blowdown Timer Configuration

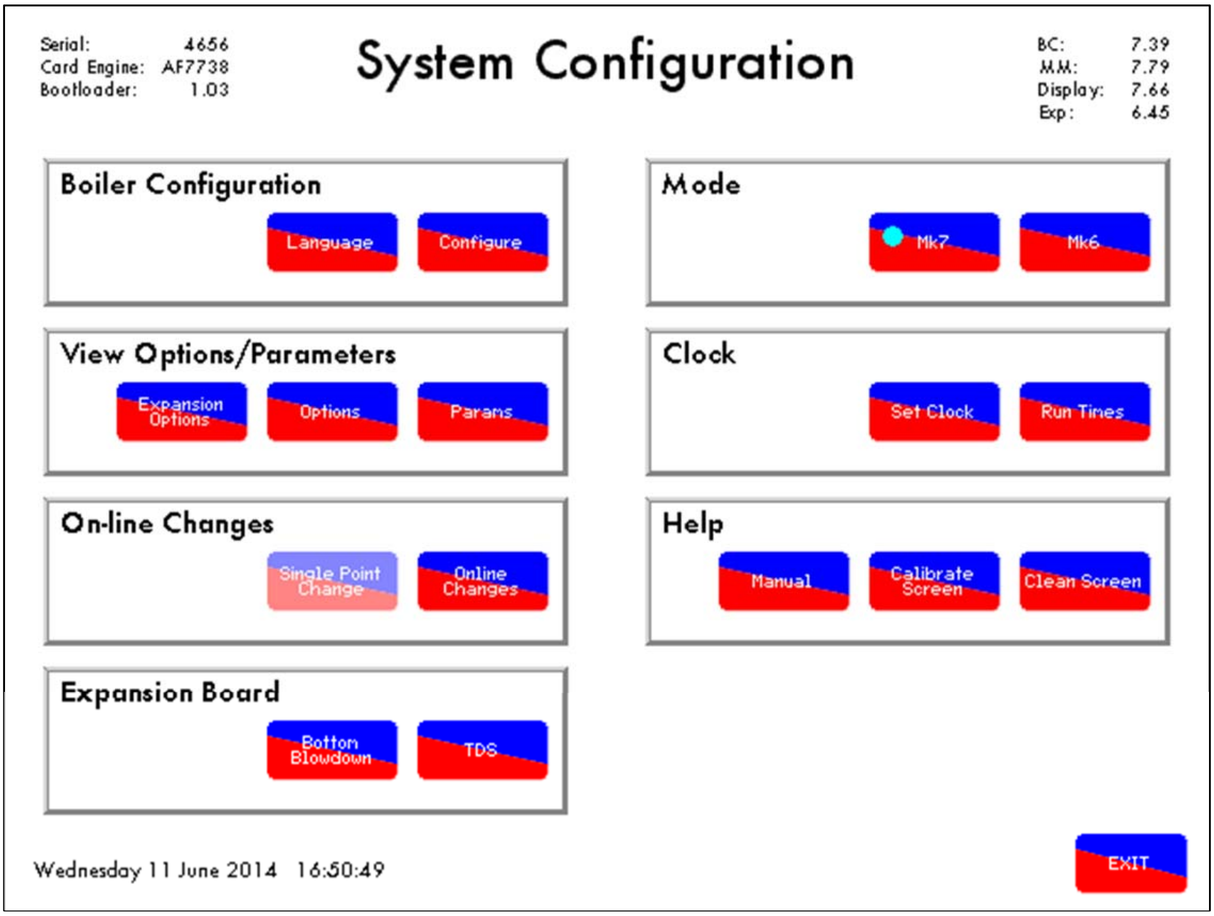


Figure 4.2.i Configure Screen – Run Mode

In the Configure screen of Run mode, a 

button will appear, see Figure 4.2.i. Pressing this button will take you to the timings and intervals adjustment screen.

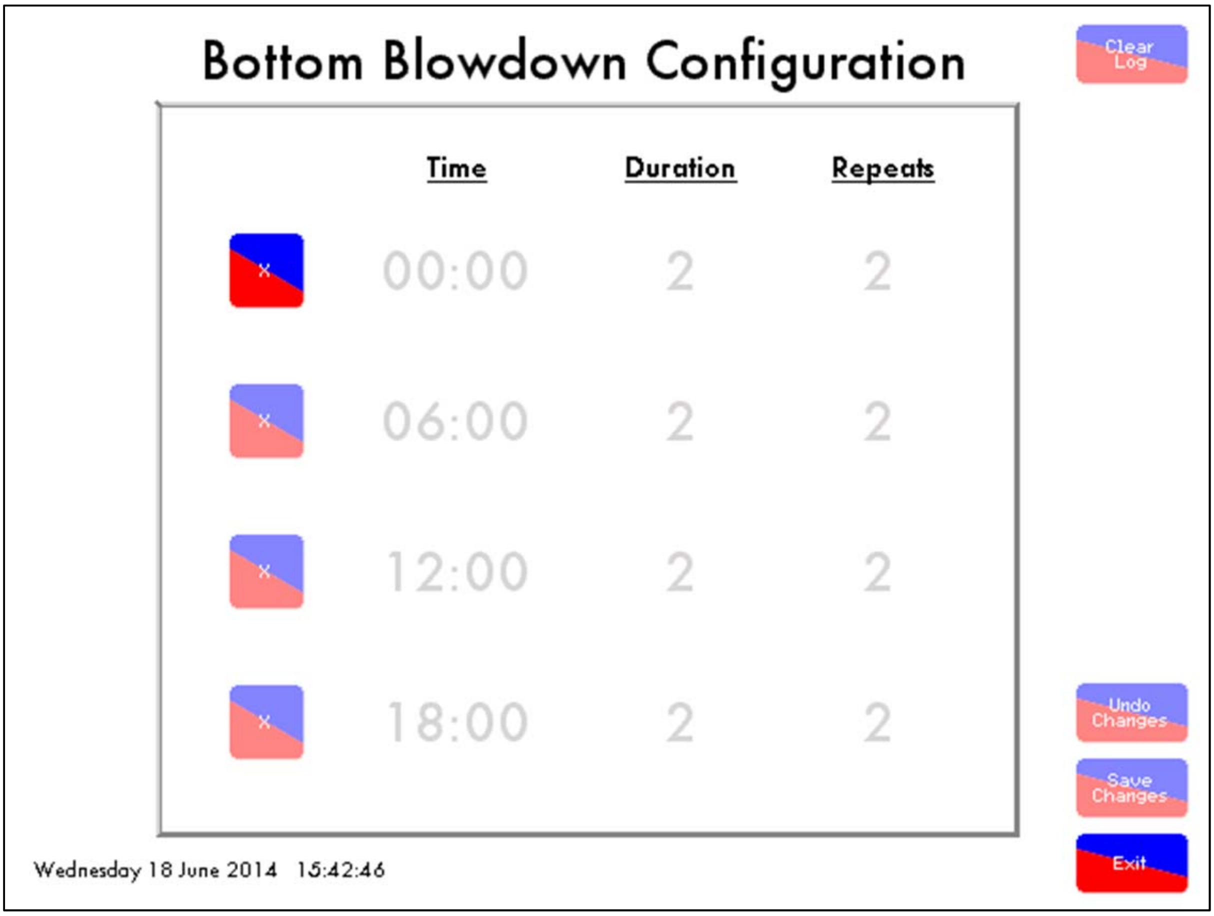


Figure 4.2.ii Bottom Blowdown Configuration Screen

Figure 4.2.ii shows the Bottom Blowdown Configuration screen, here up to 4 blowdowns can be selected with their corresponding times, durations and repeats. Each blowdown can be a maximum of 60 seconds, with a maximum of 10 repeats. Press 

and then 

.

Figure 4.2.iii Setting Blowdowns

To activate a blowdown, press 

, then press the time for that blowdown, ± will appear above and below the time. Use these + and - buttons to adjust the timing. Then press ± buttons on the duration and repeats to set the total blowdown time required.

Once all the required blowdown times have been configured, press 

before exiting the screen.

4.3 Bottom Blowdown Operation

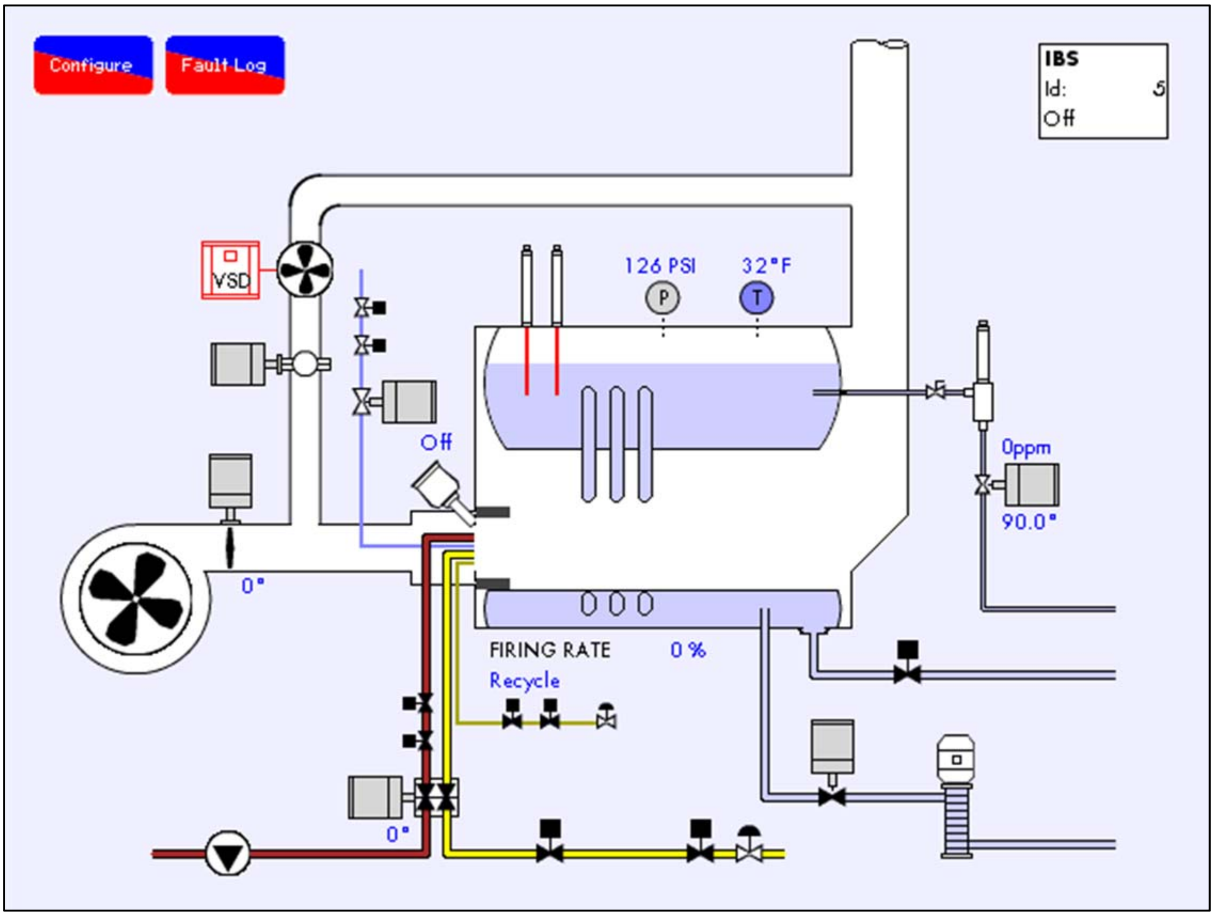


Figure 4.3.i Boiler Screen

Go into the water level screen on the M.M. to see what stage the bottom blowdown is in. Press the feed water valve in the bottom right corner of the main boiler screen to access the bottom blowdown status information

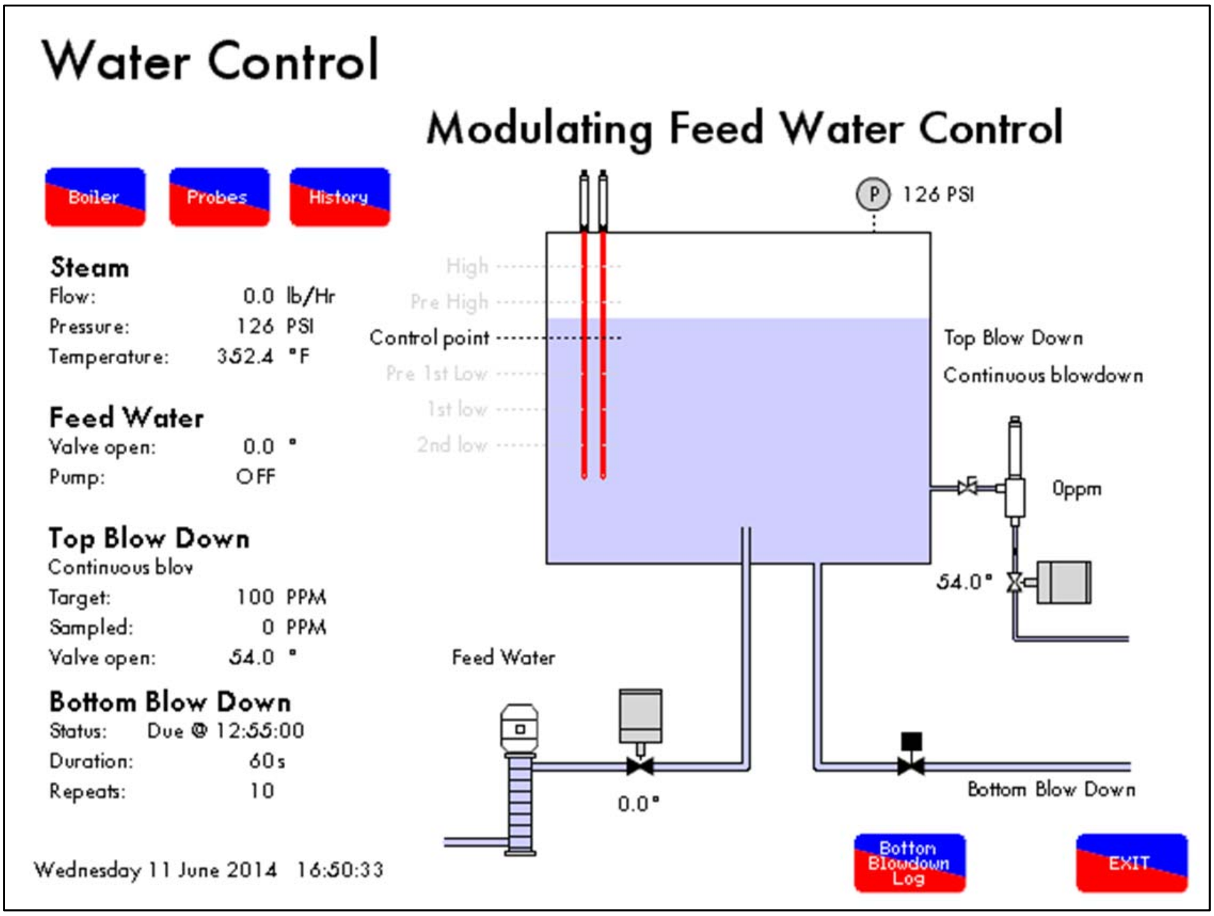
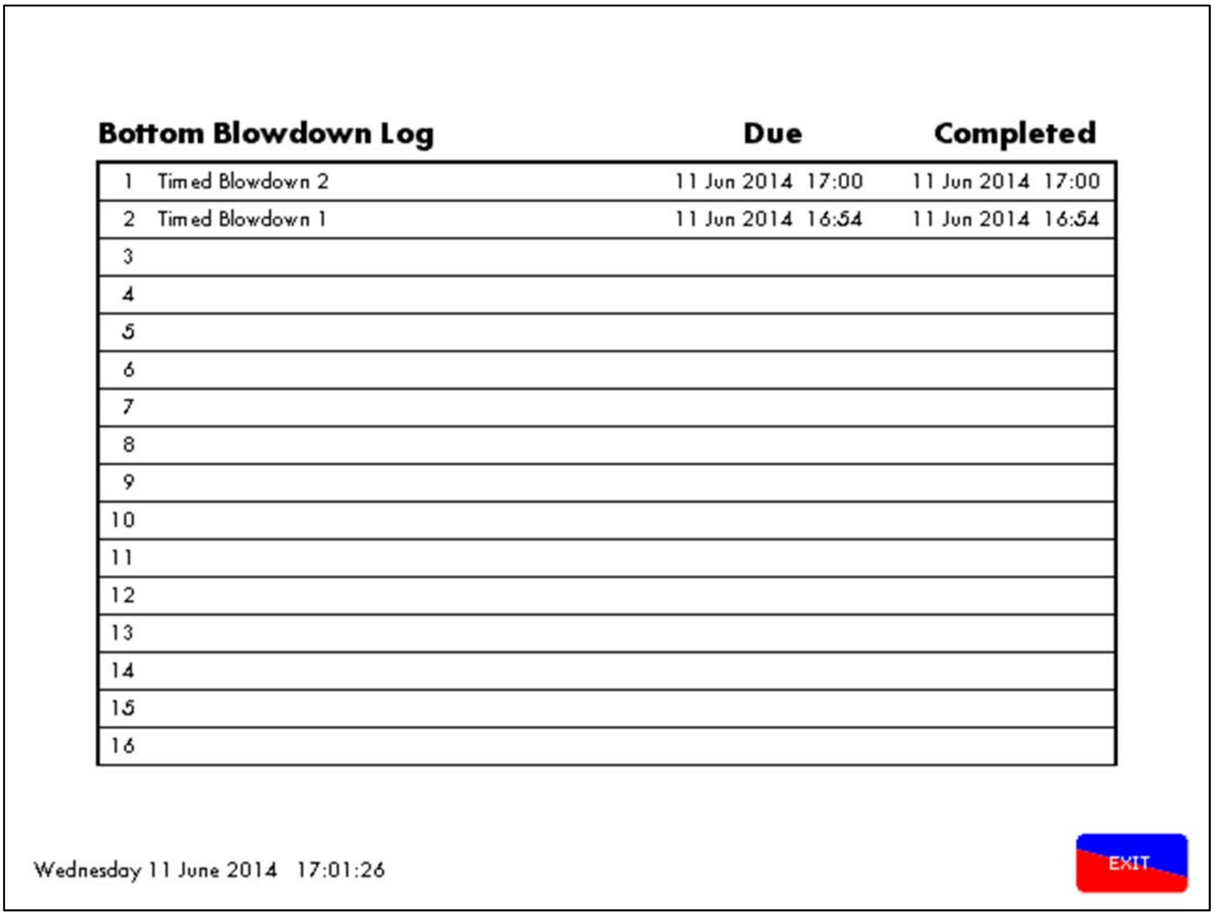


Figure 4.3.ii Water Level Screen

The next time for the bottom blowdown will show in the bottom right corner of the screen, see Figure 4.3.ii, as well as the duration of that next blowdown with its repeats. When it is due, the status will show IMMINENT, and when it begins this will change to IN PROGRESS.



	Bottom Blowdown Log	Due	Completed
1	Timed Blowdown 2	11 Jun 2014 17:00	11 Jun 2014 17:00
2	Timed Blowdown 1	11 Jun 2014 16:54	11 Jun 2014 16:54
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

Figure 4.3.iii Bottom Blowdown Log

To go to the bottom blowdown sequence log screen, press 

, see Figure 4.3.iii.

4.4 Shunt Switch

4.4.1 Shunt Switch Philosophy

The ability to implement a controlled by-pass of the low water cut off's during a manual water column blowdown, boiler blowdown or evaporation test is available on the Mk7 M.M. with water level control. This is incorporated into the Autoflame controller so as to avoid the requirement for any additional push buttons/key switches on the control panel. The operation of the shunt switch can only be accessed in Mk6 mode. Please follow this procedure:

1. While the burner is either firing or in the standby state, press the 'Water Level' and 'Enter Memory' buttons simultaneously.

2. The Mk.6 screen will show "Implement level Control Test Procedure".

3. The operator will have to either confirm that he wanted to proceed by pressing 'Water Level' and 'Enter Memory' simultaneously or press 'Run' to exit.

4. If the operator proceeded to press the 'Water Level' and 'Enter Memory' button, the Mk.6 screen would then display 'Feed Water Valve Shut' and close the feed water valve.

5. The burner would continue to operate. At this time the operator would either let the water evaporate automatically or physically blow down the water column or boiler. A user-definable amount of time (time A) is set in expansion option 25.1, during which time the 1st Low must be reached. If not, the burner will revert back to the run condition.

6. The 1st Low Alarm would be initiated and the alarm would sound. The operator has the option of muting the alarm. The burner continues to operate.

7. The operator would continue to decrease the water level in the column or boiler or allow the water to continue evaporating. A user-definable amount of time (time B) is set in expansion option 25.2, during which time the 2nd Low must be reached. If not, the burner will turn off.

8. The 2nd Low Alarm would be initiated and the alarm would sound. The operator again has the option of muting the alarm. The burner continues to operate.

9. 3 seconds after the 2nd Low Alarm has been initiated the Mk.6 screen would display 'Feed Water Valve Open'. The water level would start to increase.

10. The Mk.6 would expect to see the water level rise above the 2nd Low Level within 300 seconds (default value) or time B of the valve opening. Should the level not increase a 2nd Low Alarm will be initiated, causing the burner to turn off and a lockout to occur, requiring a manual reset to recycle the system.

11. Once the water level increased above the 2nd Low Level the Mk.6 would allow a further 300 seconds (default value) or time A for the water level to rise above the 1st Low Level. Again should the level not increase a 1st Low Alarm will be initiated, causing the burner to turn off and an alarm to sound. The system would automatically recycle the system once the water level is above the 1st Low Level.

12. Once the level returns to above the 1st Low Level the screen would display 'Test Complete, Normal Operating Level Restored'.

5 STEAM AND HEAT FLOW METERING

5.1 Steam Flow Metering

Autoflame steam flow metering is available in the water level control; it has been granted an international patent. 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 expansion board, avoiding the cost of an expensive steam flow meter and orifice plate that is typically accurate at the higher firing rates only.

An explanation of this is detailed below in the example:

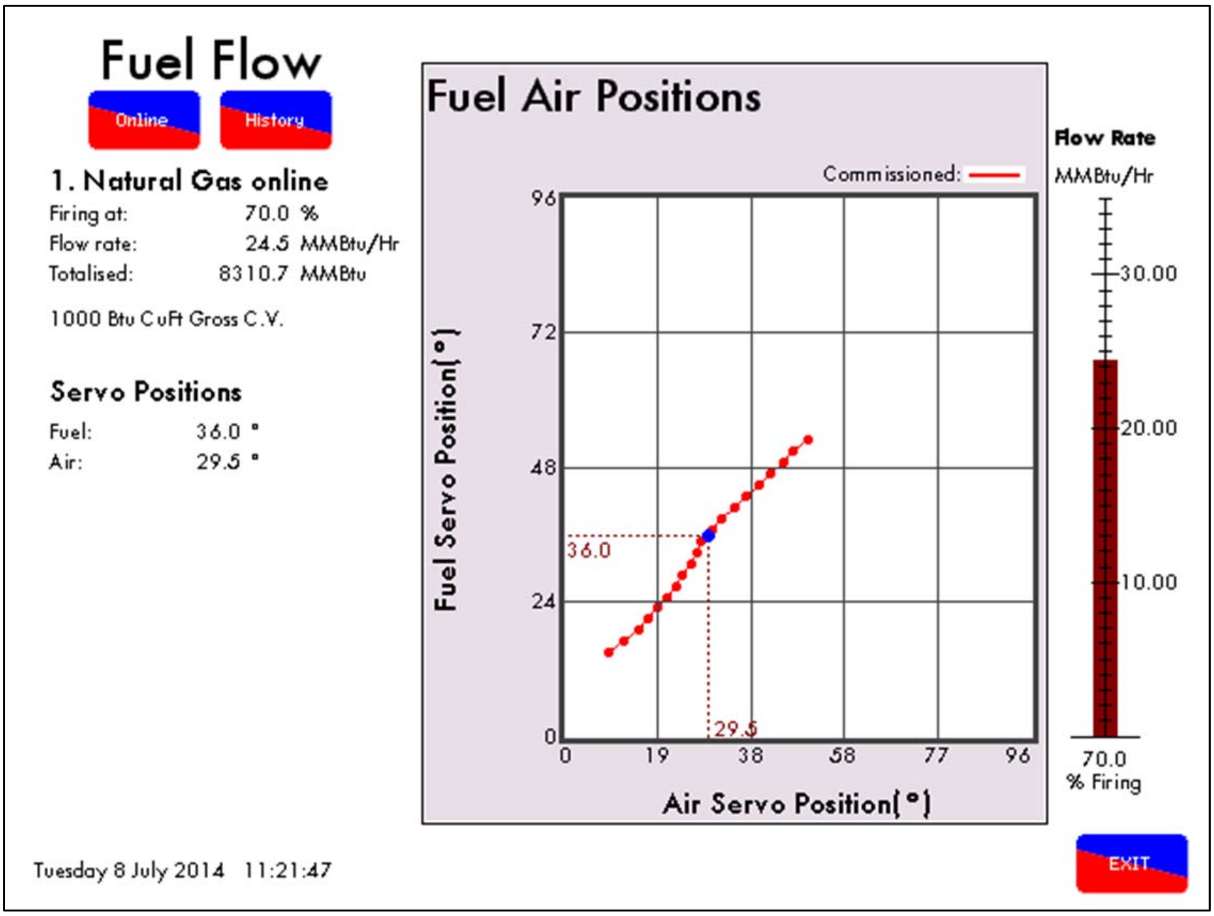


Figure 5.1.i Fuel Air Positions

From Fuel Flow Metering it can be seen that the fuel gross calorific heat input is 24.5 million BTU/hr.

Therefore	24,500,000	BTU/hr	(gross fuel calorific value)
Less	245,000	BTU/hr	(1% loss standing losses, expansion option 9.1)
Less	4,410,000	BTU/hr	(18% stack loss)
Equals	19,845,000	BTU/hr	(net calorific value of the fuel into the wet side of the boiler)

Note: If an E.G.A. is used, the stack loss is taken from the E.G.A. greater accuracy.

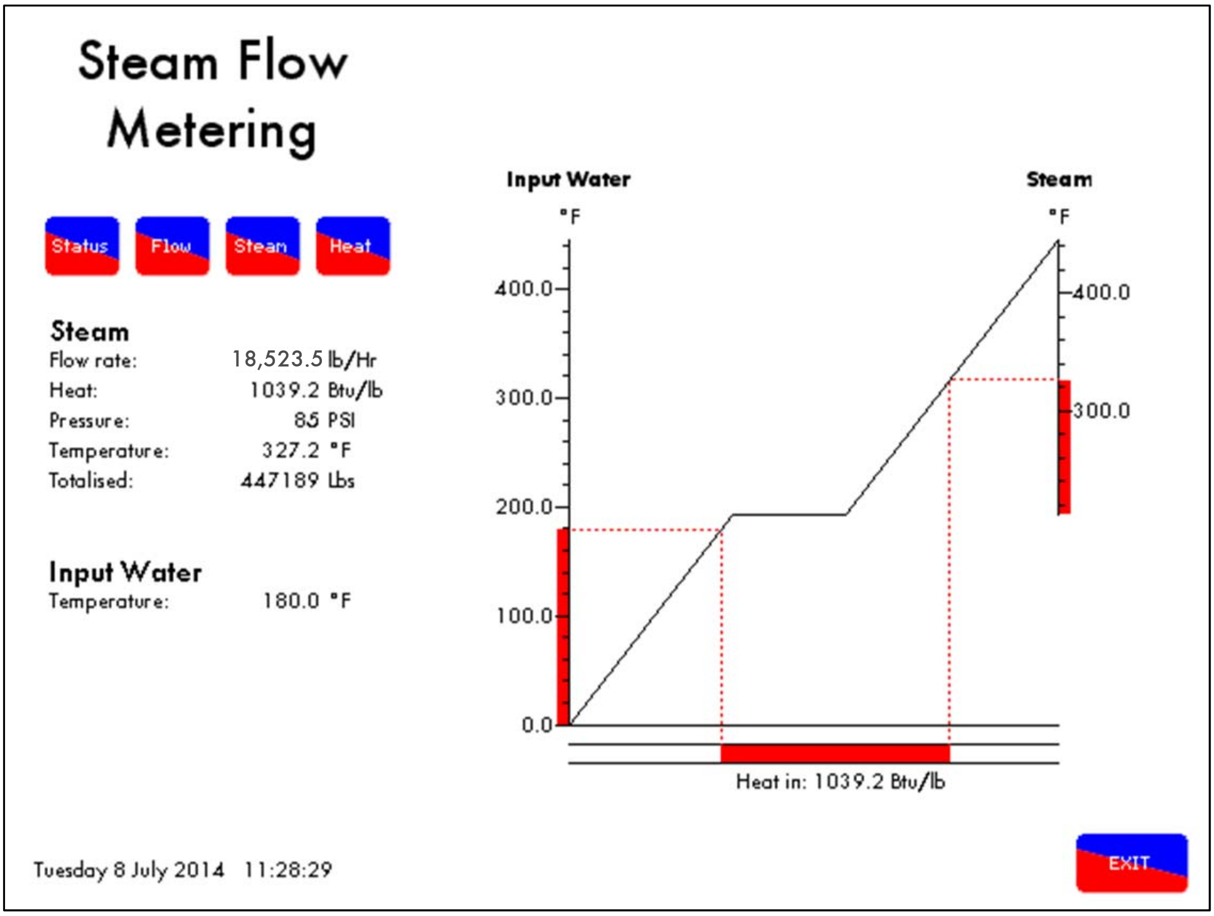


Figure 5.1.ii Steam Flow Metering Status

The steam flow metering status gives information on the flow rate, pressure, temperature, input water and the totalised steam production.

From Steam Flow Metering it is possible to calculate the amount of heat necessary to raise 1lb of water from 180 degrees F (feed water temp) to 85 PSI G steam at 327 degrees F. From standard steam tables the amount of heat required is calculated to be 1039.2 BTU for 1lb. This figure is the latent heat of liquid into steam (gas) plus the sensible heat components.

Note: Feed water temperature can be measured by the temperature sensors for greater accuracy.

$$\frac{19{,}845{,}000 \text{ BTU}}{1039.2 \text{ BTU/lb/hr of steam}} = 19{,}096.4 \text{ lb/hr}$$

If blow down losses are set as 3% through expansion option 10.1 the system allows this correction to be entered.

$$19{,}096.4 \times 0.97 = 18{,}523.5 \text{ lbs/hr Steam Flow}$$

Instantaneous values are calculated using the above. Totalized values for steam flow use the same mechanism but sample values are taken every 5 seconds and integrated over the run time of the boiler burner system.

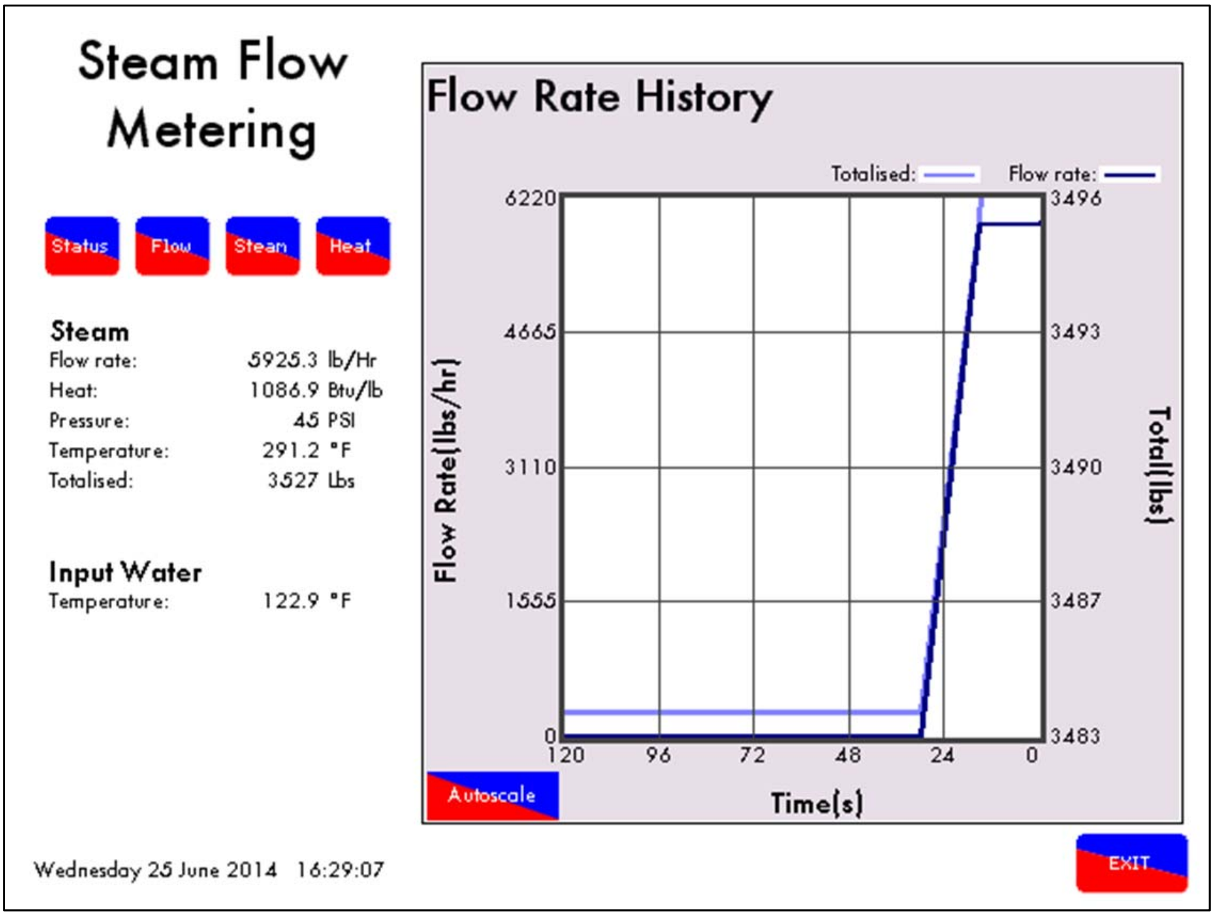


Figure 5.1.iii Steam Flow Rate History

The steam flow rate history screen logs the flow rate and totalised steam production for up to 24 hours.

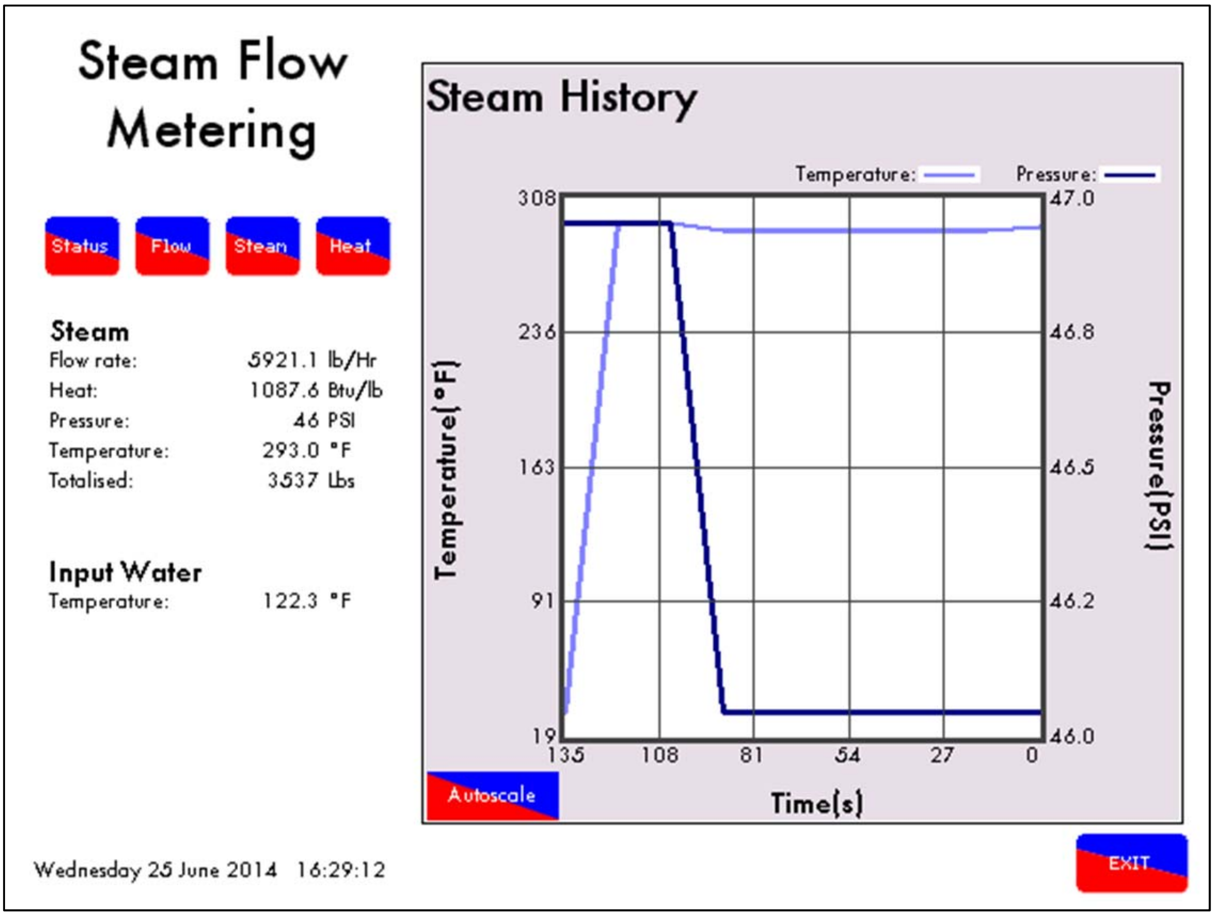


Figure 5.1.iv Steam Flow Metering Steam History

The steam history logs the boiler actual pressure and the calculated temperature from the steam tables.

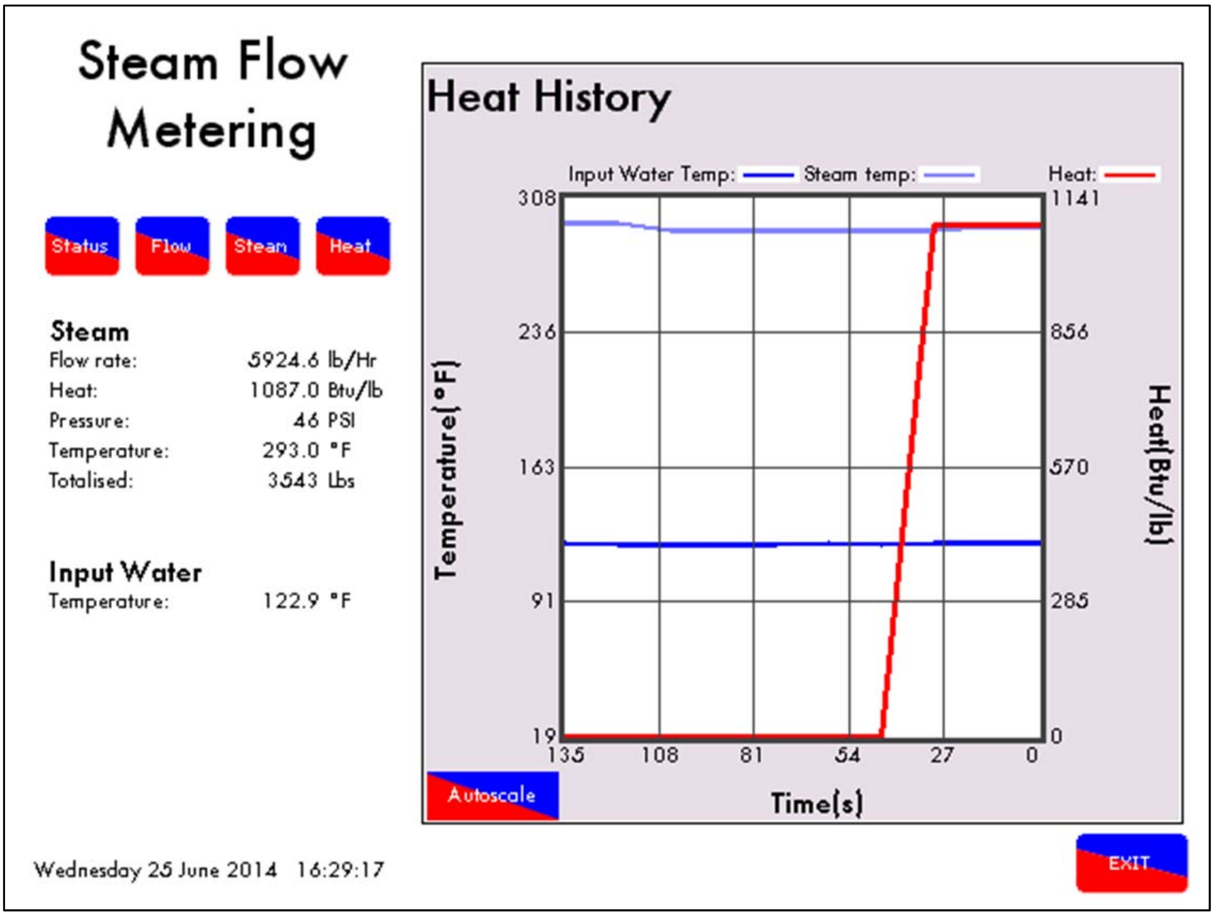


Figure 5.1.v Steam Flow Metering Heat History

The heat history screen logs the input water temperature, steam temperature and the heat value for up to 24 hours.

5.1.1 Steam Flow Metering Incorporating a Deaerator

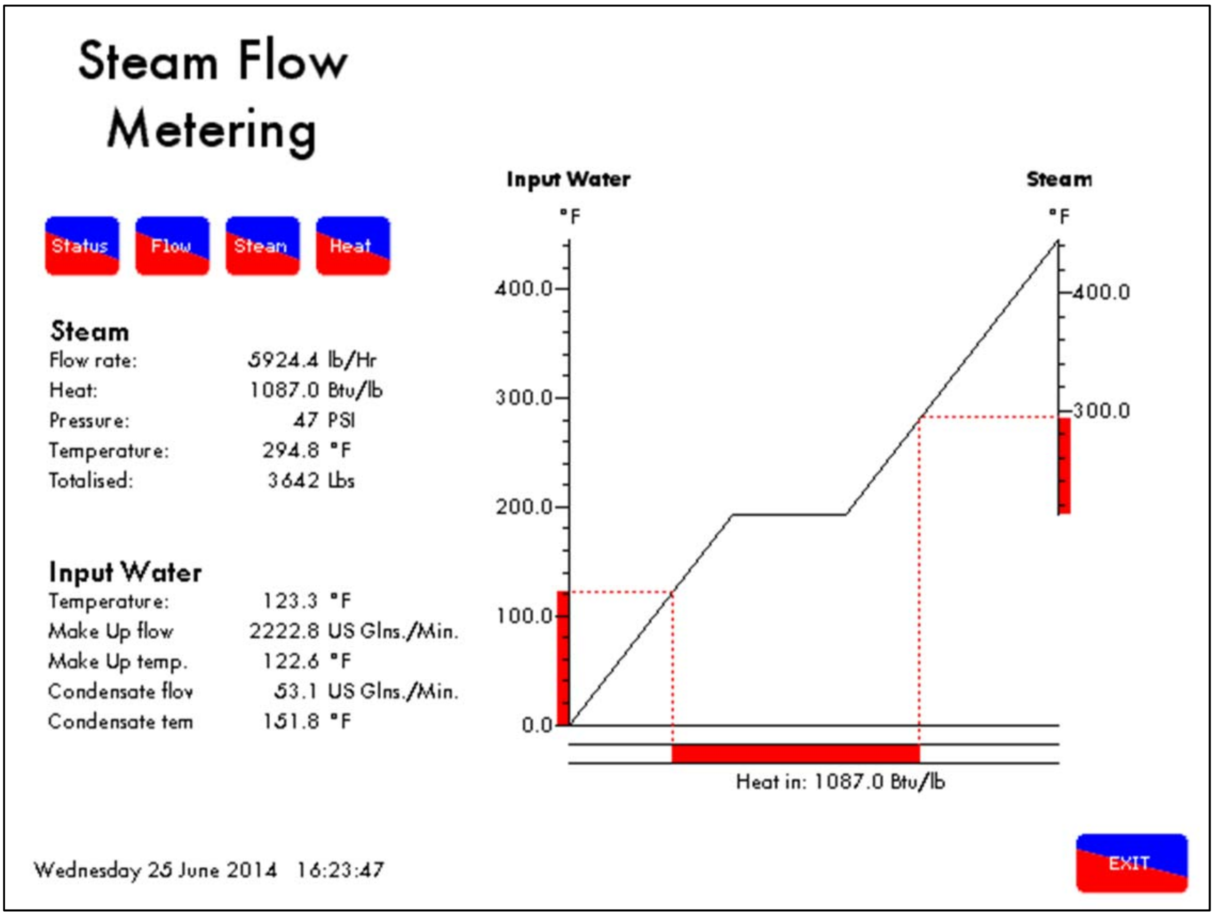


Figure 5.1.1.i Steam Flow Metering with Deaerator

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, steam and condensate pipe work.

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 to 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.

5.1.2 Calculations for Steam Flow Metering with Deaerator

1: First the percentage "Make up" in the "Feed water" must be calculated.

Where %Mu = % Cold make up water
V1 = Volume of condensate return water
V2 = Volume of cold make up water

$$\%Mu = \frac{100 \times V2}{(V2+V1)}$$

<u>Example: 1</u>
Steam boiler with a volume of condensate return at 40 GPM and make up water at 8 GPM

$$\text{Make up } \% = \frac{100 \times 8}{(8+40)} = 16.7\%$$

To calculate the second part to establish the "Weighted Average Temperature" the following equation is used.

Where Tave = Weighted Average temperature
T1A = Temperature of condensate
T1 = Temperature of make up water
%Mu = Percentage of make up water

$$Tave = T1A - \frac{(\%Mu \times (T1A\text{-}T1))}{100}$$

Steam boiler with condensate return temperature of 176°F and a make up water temperature of 41°F. From the above example (1) the make up percentage is 16.7%

$$\text{Weighted Average} = 176 - \frac{(16.7 \times (176 - 41))}{100} = 153.4°F$$

To implement the above control form the following calculations have been imbedded in the revised software to obtain the "Weighted Average Temperature" (T ave).

5.2 Heat Flow Metering

Heat Flow Metering is simply measuring the amount of heat being transferred to the water by a hot water boiler. If we know the stack losses and the standing losses of the boiler at any moment then whatever energy is left over must be going into the water.

From the E.G.A. stack losses = 100 – combustion efficiency

Radiation losses are specific to the boiler, 1% radiation losses are typical for a packaged boiler operating at maximum continuous rating. The loss is constant regardless of boiler output so at 50% firing rate it would be 2% of the energy input.

The total heat in at any time is given by the heat flow metering so we can calculate the instantaneous heat going into water. By integrating these values we can get a totalised value.

5.2.1 Calculation for Heat Output and Volume Flow

$$\text{Efficiency \%} = 100\% - \left(\text{Stack loss} + \frac{\text{Radiation Losses} \times 100}{\text{Firing Rate}}\right)$$

$$\text{Useful Heat into Water} = \text{Total Heat} \times \frac{\text{Efficiency}}{100}$$

$$\text{Volume Flow in lbs/hr} = \frac{\text{Useful heat MBTU/Hr}}{\text{SP Ht BTU/lb/°F} \times (\text{Flow Temp} - \text{Return Temp})}$$

$$\text{Volume Flow in cu ft Hr} = \frac{\text{Volume Flow in lbs/hr}}{\text{Density of Water at Return Temperature}}$$

$$\text{Since 1 cu ft Hr} = 0.124676 \text{ US G.P.M.}$$

$$\text{Volume Flow in US G.P.M.} = \text{Volume Flow in cu ft Hr} \times 0.124676$$

5.2.2 Heat Flow Metering Calculation

Set out below is an example together with relevant calculation, these calculations are embedded in to the software in the Mk7 version of the expansion PCB.

Example

A boiler firing at 75% has an input of 20,472,840 BTU/Hr (6MW). The temperature of the flow (MM Temperature detector) out is 185°F and the temperature of the return T1 is 167°F. The combustion efficiency is 82% (Mk7), Radiation losses are 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 Ht water	1.0 BTU/lb/°F	4.18KJ/KG/°C
Density Water	60.68lb/cuft @176°F	972 kg M^3 @80°C
Combustion Efficiency	82%	82%

$$\text{Efficiency }\% = 100\% - \left(18\% + \frac{1\% \times 100}{75\%}\right)$$
$$= 80.67\%$$

$$\text{Useful Heat into Water} = \text{Total Heat } \times \frac{\text{Efficiency}}{100} = 20{,}472{,}840 \times \frac{80.67}{100}$$

$$= 16{,}514{,}440 \text{ BTU/hr}$$

$$\text{Volume Flow in lbs/hr} = \frac{16{,}515{,}440}{1 \times (185 - 167)}$$

$$= 917{,}524.4 \text{ lbs/hr}$$

$$\text{Volume Flow in cu ft Hr} = \frac{\text{Volume Flow in lbs/hr}}{\text{Density of Water at Return Temperature}}$$

$$= \frac{917{,}524.4}{60.68} = 15{,}120.7 \text{ cu ft Hr}$$

$$\text{Volume Flow in US G. P. M.} = 15{,}120.7 \text{ cu ft Hr} \times 0.124676 = 1{,}885.2 \text{ US G. P. M.}$$

It can be seen from the above that by adding the expansion P.C.B. and a return temperature detector to the Mk7 M.M. system that you get the following additional useful information.

"Useful heat into water" (BTU/hr) &
"Volume flow" (US G.P.M)

This is displayed on the screen of the Mk7 M.M.
The direct benefit is that you have a "Heat meter" and "Flow meter" for any hot water boiler.

6 TROUBLESHOOTING

6.1 Expansion Alarms

The M.M. will display up to 16 expansion alarms. Please find to the expansion alarms bellow:

1	**2nd Low Level**	The water level has fallen below the commissioned 2nd Low position. If the alarm was preceded by a 1st Low alarm, the 1st Low entry will be automatically replaced within the alarm log.
2	**Probe 1 Comms Fault**	The communications between the water level control and probe 1 have failed, exceeding the maximum allowed period of 3 seconds. Check probe wiring/ failed probe.
3	**Probe 2 Comms Fault**	The communications between the water level control and probe 2 have failed, exceeding the maximum allowed period of 3 seconds. Check probe wiring/ failed probe.
4	**Probe 1 Short**	Probe 1 has short circuit failure. This probe's water level is currently outside of the normal operating limits range. This may be caused by a probe hardware failure. Contact an Autoflame technology centre.
5	**Probe 2 Short**	Probe 2 has short circuit failure. This probe's water level is currently outside of the normal operating limits range. This may be caused by a probe hardware failure. Contact an Autoflame technology centre.
6	**Probe Mismatch**	The probe levels are not currently in line with commissioned levels suggesting a probe failure or alteration. This can also be caused by overheating of the electronics. It is important to lag the flanges if the probes are mounted directly into the boiler shell. Try cleaning and re-commissioning the probes.
7	**Probe 1 TC**	Probe 1 has a temperature compensation failure. This probe's water level is currently outside of normal operating conditions when compensating the water level. Check the wiring, clean the probes, and re-commissioning the probes. This could be probe hardware failure.
8	**Probe 2 TC**	Probe 2 has a temperature compensation failure. This probe's water level is currently outside of normal operating conditions when compensating the water level. Check the wiring, clean the probes, and re-commissioning the probes. This could be probe hardware failure.
9	**Permanent Reset**	The water level control or M.M. mute/reset button was pressed for longer than 10 seconds. To reset this alarm ensure that both buttons are not pressed for at least 10 seconds. This will become a keystuck-reset alarm.
10	**Permanent Test**	The water level control test input button was pressed for longer than 60 seconds.

11	**Perm Reset Cleared**	This is now a keystuck-reset alarm.
12	**EEprom PU Corrupt**	On power up, the EEprom test has failed; the water level control has not been used before, has a faulty EEprom. If the problem persists after resetting the error, contact Autoflame.
13	**Bogus PU State**	The EEProm is in a bogus state, if the problem persists after resetting the error, contact Autoflame.
14	**Control Cfg Mismatch**	The configuration and commission data do not have matching control type options. This would occur if the configuration has been changed after commissioning.
15	**Probe 1 Com Data**	Probe 1 has corrupt commissioning data. Restart and re-commission the probes if error persists after resetting error.
16	**Probe 2 Com Data**	Probe 2 has corrupt commissioning data. Restart and re-commission the probes if error persists after resetting error.
17	**Config Range Check**	One or more of the configuration options is outside of the allowed range.
18	**1st Low Level**	The water level is currently below the commissioned 1st Low position. If the alarm precedes a 2nd Low alarm, it will be automatically replaced by a 2nd Low alarm in the log. Once the water returns to a level above the commissioned 1st Low, the error will remain within the log but it will be automatically reset.
19	**High Water Level**	The water level is currently above the commissioned High Water position. This alarm will clear automatically when the water level is reduced below the commissioned High Water position.
20	**Probe 1 Still Water**	The signal from probe 1 appears static indicating that the probe is not in the water.
21	**Probe 2 Still Water**	The signal from probe 2 appears static indicating that the probe is not in the water.
22	**Probes Diverse**	One probe is reading above high water, the other is below 1st Low water. Usually caused by auxiliary inputs incorrectly connected/ optioned. See expansion option 12.1
23	**Pre 1st Low**	The water level is below the commissioned Pre 1st Low position.
24	**Pre High Water**	The water level is above the commissioned Pre High Water position.
25	**Btm Blowdn Software Fault**	Bottom blowdown software fault. Please contact Autoflame.
26	**Btm Blowdn Comms Fault**	Bottom blowdown board has a comms failure.
27	**Btm Blowdn 24V Fault**	Bottom blowdown board – main power failed

28	**Btm Blowdn Battery Fault**	Bottom blowdown board – battery power failed
29	**Btm Blowdn Opening Fault**	Bottom blowdown valve failed to move while opening
30	**Btm Blowdn Closing Fault**	Bottom blowdown valve failed to move while closing
31	**2nd Low Probe – No Water**	The 2nd Low probe detects no water.
32	**2nd Low Probe System Error**	Please contact Autoflame.
33	**2nd Low Probe Comms Fault**	The 2nd Low probe has a communications failure, check wiring.
34	**TDS Probe Comms Error**	The TDS probe has a communications failure, check wiring.
35	**TDS Limit Breached**	The TDS limit has been breached, check configuration options and water conditions.
36	**TDS Valve Position Error**	The TDS valve has a positioning error, check wiring.
37	**Feed water Valve Position Error**	The feed water valve has a positioning error, check wiring.
38	**Draft Controller Position Error**	The draft control servomotor has a positioning error, check wiring and feedback.
39	**Sensor T1 Fault**	The temperature sensor wired in terminal #T1 has a fault.
40	**Sensor T1A Fault**	The temperature sensor wired in terminal #T1A has a fault.
41	**Sensor T2 Fault**	The temperature sensor wired in terminal #T2 has a fault.
42	**Flow meter fault**	The steam flow meter has a fault.
43	**Draft Pressure Sensor Fault**	The draft control pressure sensor has a fault, check wiring.
44	**Draft Pressure Tolerance Fail**	The draft control pressure tolerance is outside the configured tolerance band for longer than 2 minutes.
45	**Bottom BD Not Commissioned**	The bottom blowdown operation has not been commissioned.
254	**WL Board Reset**	Please contact Autoflame.

Notes

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