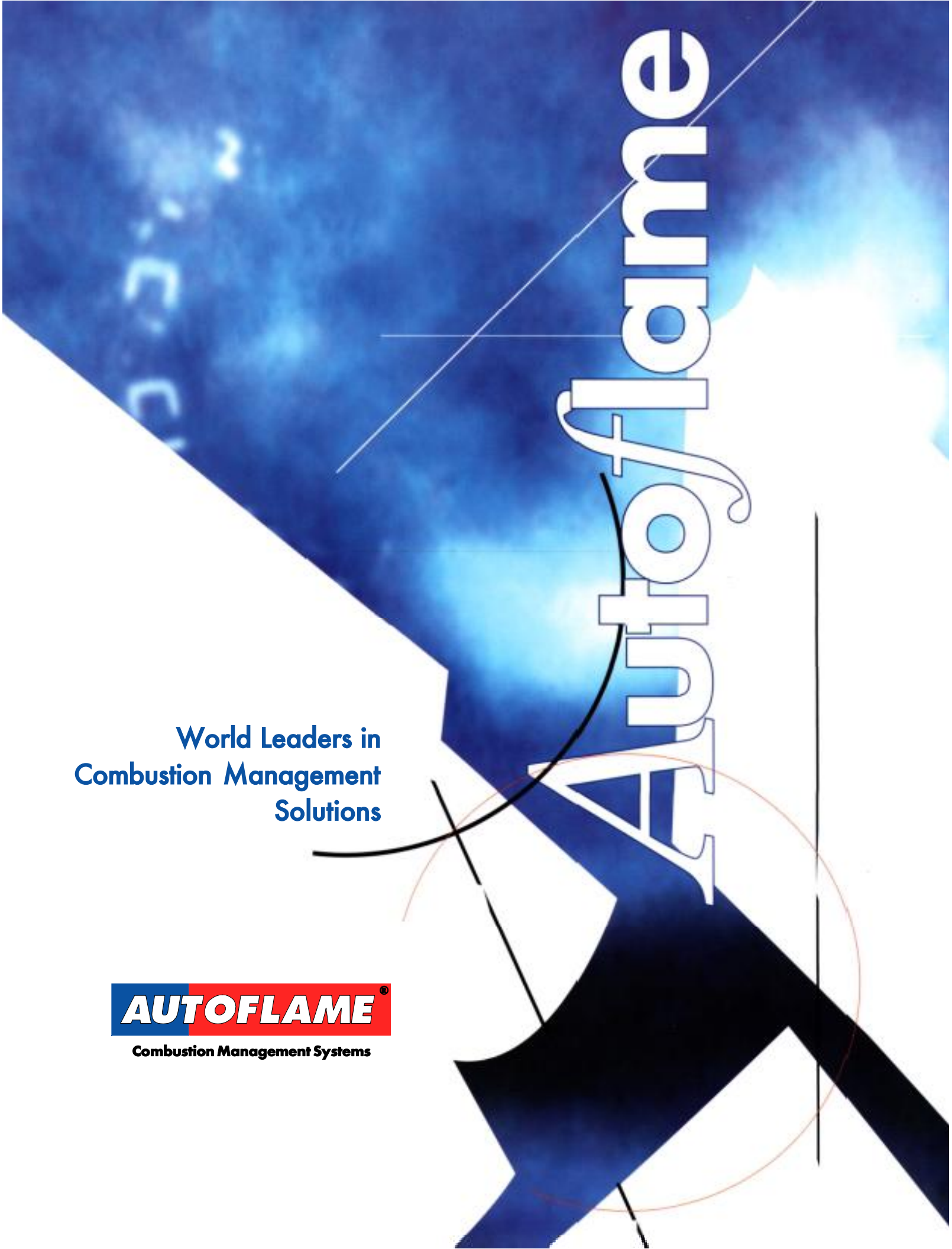
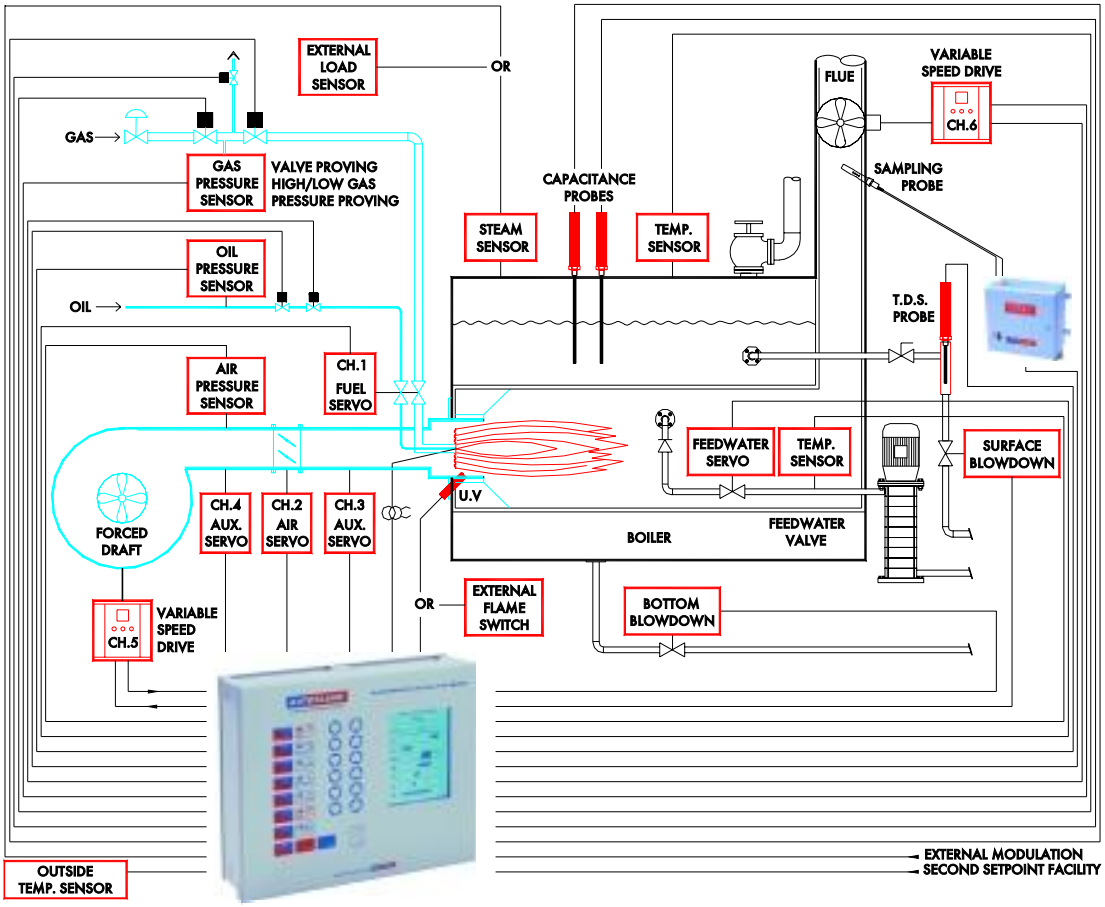


World Leaders in
Combustion Management
Solutions

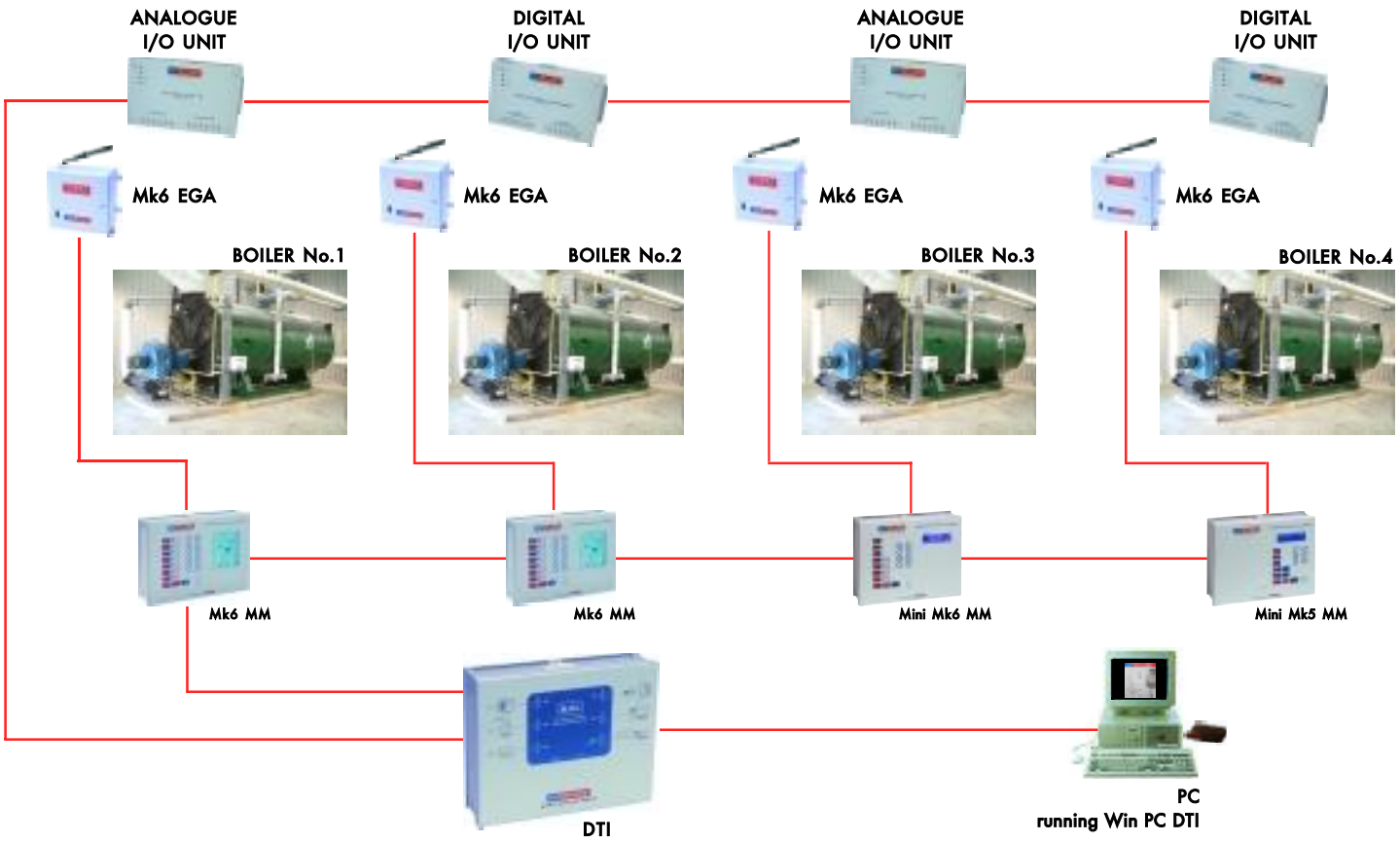
AUTOFLAME®

Combustion Management Systems

Mk6 Burner Management System Application Schematic



Example of Data Acquisition from the Autoflame System



Micro Modulation

To maximise the efficiency of any boiler two requirements are of paramount importance.

First, the air to fuel ratio should be kept to a minimum that ensures complete combustion within the limitations of the combustion head design. Once these settings are arrived at they should be infinitely repeatable to an incredibly high degree of accuracy.

The second target is the temperature or pressure of the boiler, monitored by the combustion system. At all times, the exact amount of fuel and air are fired to achieve the target value and at no time, irrespective of load change, is this target exceeded or fallen short of.

Mechanical systems that have traditionally involved cams and linkages to characterise the fuel/air ratio have made this accuracy impossible. At most times, the accuracy of the fuel input response to the monitored temperature/pressure has meant that the target value set by the operator has been significantly exceeded or fallen short of. Autoflame Engineering were the first in the World to develop a system that overcomes all of these problems by utilising the latest microprocessor technology.

The Micro Modulation system provides an easily programmable and flexible means of optimising combustion quality throughout the load requirement range of the boiler/burner, whilst ensuring that temperature is accurate to within 1°C/2°F and pressure to within 1.5psi/0.1 bar. The maximum error in degrees angular rotation between the servomotors at any position in the load range is 0.1°.

At the heart of the system is the control module containing the microprocessor and power supply. The display panel features touch sensitive keypad data entry, VGA/LCD display and LED status indicators. The MM system displays the positioning data for up to six individually controlled channels. The status function will display the "required" and "actual" set point, burner firing rate % and the selected fuel. The MM can be calibrated to display instantaneous and totalled fuel flow measurements.

A voltage dividing system monitors each channel's position, enabling digitised position information to be encoded into the control module's memory. The relative positioning of the channels are constantly checked by the system at the rate of 50 times per second. The Autoflame burner control system achieves "Locked On" near stoichiometric air fuel mixing throughout the fuel input range of the boiler while maintaining exact temperature or pressure target values. The load control incorporates full user variable P.I.D. control.

Intelligent Boiler Sequencing (IBS)

Included as standard within every MM/EGA module is the IBS capability. This control form ensures the minimum number of boiler/burner units are in operation at any one time to satisfy the heat requirement imposed upon the boiler plant. Dedicated software exists within each module for steam and heating boiler sequencing. (Lead/Lag Control).

Exhaust Gas Analyser

The EGA trim system further expands the MM. It measures and displays O_2, CO_2, CO, NO, SO_2, exhaust temperature and boiler efficiency.

This data is fed back to the MM which inflicts minute corrections on the air damper position. This ensures that the originally entered commissioning data is adhered to irrespective of variations in stack pressure, barometric conditions or changes in fuel temperature and quality.

The trim function is achieved by every paired value of air and fuel having stored values for O_2, CO_2 and CO. Additional values for each of these gases are stored for "Fuel Rich" and "Air Rich" at a known deviation angle from the commissioned value. This data is processed and expressed as an angular correction value. In this way an exact amount of air damper trim may be inflicted at any time to return the system to its commissioned value at any load condition. The diagram on the right gives further explanation and outlines an example.

Each EGA module can be connected to an energy management system to track and record the information that is generated by the EGA system.

To expand the MM system to the EGA specification, the additional sampling unit and exhaust gas sampling probe is required. The MM/EGA control form uses P+I+D feed forward and interpolates between all entered data. It also carries error checking self-diagnostic software for self-identification of system component or data handling failure. With the Display Pod, an EGA can be used as a stand alone on-line exhaust gas analyser.

Data Transfer Interface

The DTI is a Data Acquisition system that can collect operational data from up to 10 MM modules on one site. This data can be transmitted via an RS232/422 link to a local computer or a building management system using the Modbus or Metasys protocol.

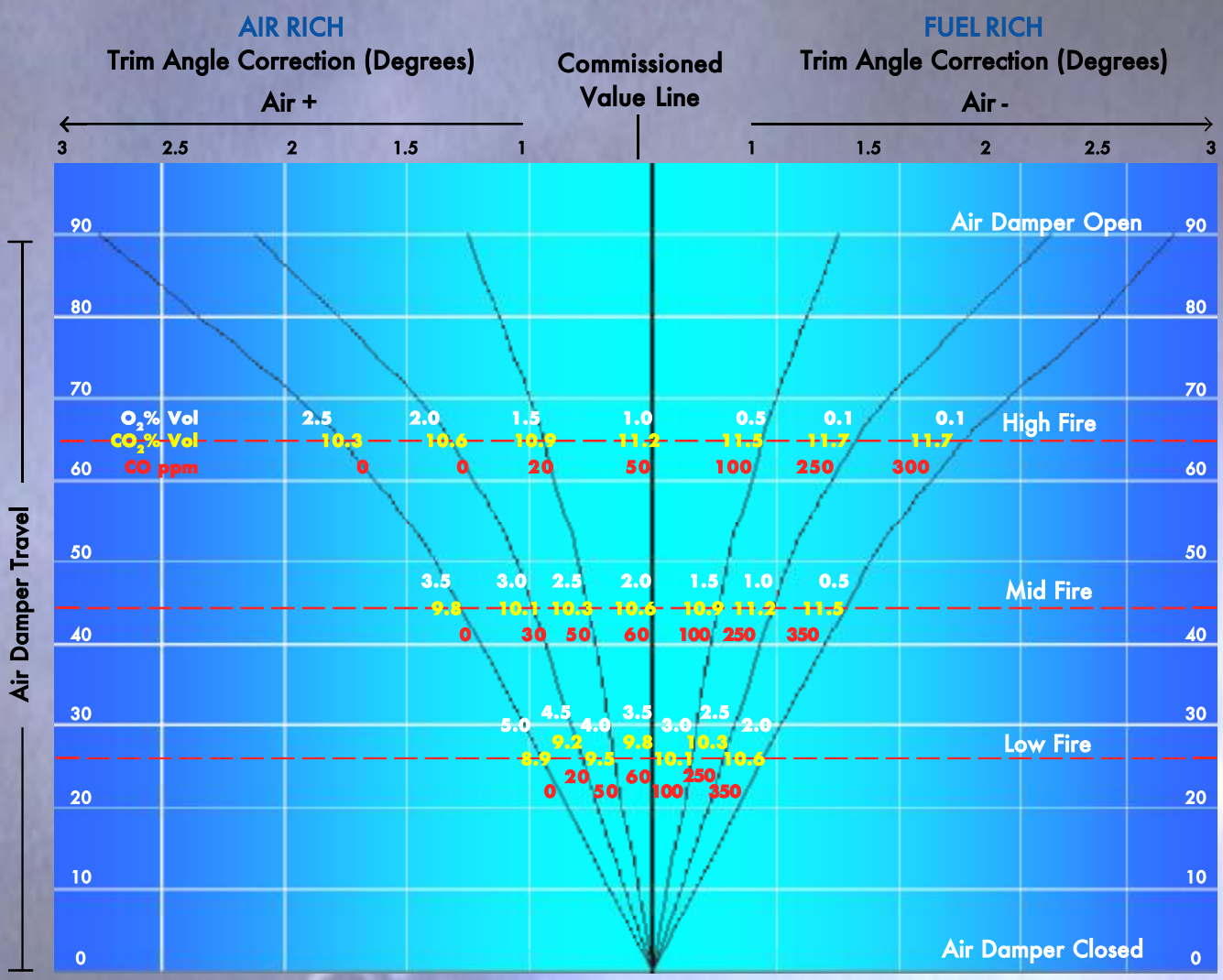
Autoflame's WinPCDTI software brings control of the Combustion Management System to a PC, providing on/off control as well as temperature and pressure set point adjustment of the burners. The PC can be local at the site or connected remotely by modem. Alarm conditions can be defined and, if triggered, the software can advise of the condition via a pager.

M.M./E.G.A. Efficiency

In today's climate we find ourselves under increasing pressure to burn fossil fuels more efficiently but at the same time keep within ever decreasing limits.

The MM system, with the majority of burners, is able to achieve and maintain 82% combustion efficiency on Natural Gas firing and 86% when firing on 35 seconds/#2 oil. If used in conjunction with the Exhaust Gas Analyser trim system it is possible to maintain commissioned values of combustion irrespective of changes of stack pressure, variations in fuel calorific value or barometric conditions.

Graphical Explanation of the Patented EGA 3 Parameter Trim System.



The above example shows the map of exhaust gas analysis values memorised during the commissioning process. The central vertical line represents the commissioned value. For each paired value of fuel and air positions, the unit also memorises values for O_2, CO_2 & CO.

For example, at high fire above, 65 degrees angular on the air damper, commissioned values for exhaust gases are: CO_2 = 11.2%, O_2 = 1 %, CO = 50 ppm.

At each entered commissioned position the MM adds on Air+ & Fuel+ at a pre-calculated angular deviation from the commissioned value.

The values to the right of the commissioned value line represent fuel rich combustion at it's pre-calculated angular deviation. Using the same high fire example, the fuel rich combustion values for exhaust gases are: CO_2 = 11.7 %, O_2 = 0.1 %, CO = 300 ppm.

The values to the left of the commissioned value line represent air rich combustion at its pre-calculated angular deviation, both fuel rich and air rich are at the same relative angular deviation.

At the same high fire example, air rich combustion values for exhaust gases are: CO_2 = 10.3 %, O_2 = 2.5 %, CO = 0 ppm.

This cycle is then repeated for each entered position, minimum 5, maximum 15. When commissioning is complete the MM has memorised not only the commissioned values of fuel/air ratio but also a complete map of the burner's combustion performance either side of the commissioned value line of data relative to the pre-calculated deviation from the commissioned value.

By this method the burner system knows how much trim is necessary to bring the burner back to it's commissioned value and from which side of the commissioned value line the trim adjustment must be made.

Autoflame Engineering

Autoflame Engineering Limited was founded in 1972 by Brendan Kemp specialising in total boilerhouse solutions - designing, manufacturing, installing and servicing boiler houses encompassing commercial, industrial and process applications.

In the late 1970s, Autoflame anticipated the requirement for more precise control over the boiler combustion process as an alternative to the conventional cam and linkage form. The microprocessor was the precise tool and development proceeded. Since 1984, Autoflame has been manufacturing and marketing the Micro Modulation Combustion Management System with the Exhaust Gas Analyser.

Patented MM/EGA Trim

No.'s 02169726 & 00195866

During commissioning, for every paired value of fuel and air, corresponding values of O_2, CO_2 & CO are stored. These are known as the commissioned values. The System then performs an **'autotrim'** cycle, where 10% of the open damper area, based on a rectangular duct, is added and subtracted to the angular position of the air damper. At each condition of fuel rich and then air rich combustion further values of O_2, CO_2 & CO are stored. This builds up a map of the burner's combustion performance, please see example opposite.

During normal run mode the on-line sample at any position within the burner's firing rate is compared to the commissioned values. There are now 3 individually sampled parameters to verify combustion performance combined with a map of performance either side of the commissioned value.

The on-line CO value is compared to the commissioned value. A higher CO can be attributed to both lean and rich combustion. Excess air around the flame envelope has the effect of chilling the flame edge causing incomplete combustion and hence higher CO levels.

An ingress of air through an ill fitting boiler door or flue section would drive the O_2 value up. Single parameter O_2 systems would see this as lean combustion, trimming back the air damper, but in reality this causes potentially dangerous combustion levels. Similarly single parameter CO_2 systems would see an ingress of air as lower CO_2 levels in the flue, inflicting similar dangerous conditions on the boiler.

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

An added benefit of mapped combustion is 'feed forward trim'. In a fuel rich situation where air is being added, as the burner modulates to a new position the deviation of the air damper is added to each air position thus maintaining optimum combustion during modulation.

As a safety feature during lean combustion, where air is being subtracted, when modulating the fuel/air ratio returns to commissioned values until the required firing rate is achieved. Only then will the trim function subtract air, ensuring safe combustion at all times. In this way safety is never compromised by efficiency.

There exist further options to set both upper and lower limits for any or all 3 of the Exhaust Gases, whereby the burner is shut down if limits are exceeded.

The above philosophy form is protected under Autoflame's patent numbers 02169726 & 00195866.

Patented Auto Adaptive UV Sensor

No. 09/234,391

The benefits of the Autoflame auto adaptive UV Sensor System:

- more accurate flame monitoring increasing plant safety
- prolonged UV bulb life
- increased plant reliability and reduced downtime
- Adjustable level of response to ignore background/ spurious radiation, e.g. spark ignition & refractory.

A conventional UV Flame Scanner works by applying an AC voltage across the bulb. In the presence of UV light the bulb discharges electrical pulses or counts. As the intensity of the UV light increases so the number of counts increase. On a fully modulating burner there is a great deal of difference in UV intensity between pilot flame and high fire. During pilot the minimum number of counts required to register a flame is nominally 40, on a high turndown burner at high fire the number of counts may reach 300. If the UV bulb is exposed to this intensity of UV light for a prolonged period, as little as three weeks, it fails closed circuit becoming a 'runaway cell', registering UV light when none is present.

Autoflame use a DC voltage supply to the UV bulb, controlling the amount of time and voltage that is applied to the bulb in one cycle. The user can set an optimum required count for the application. When the 'Auto adaptive UV software' commences on burner start-up, the DC voltage applied time and value are set to a maximum, as a UV count is registered the voltage applied and time are modulated to reach the optimum 40 count. Typically for pilot flame the voltage and applied time will be near maximum to register a small flame, as the burner moves to high fire the voltage and applied time are decreased as the intensity of UV light increases. Keeping the voltage and applied time to a minimum markedly increases the life of the UV bulb. Precise monitoring of individual counts primarily increases the safety and reliability of the flame safeguard and secondly prolongs the UV bulb life.

Burner Management System Components

Burner Management Systems

Precise fuel/air ratio control for up to 4 fuel programs. Controls and displays a maximum of 4 positioning motors (accuracy = 0.1° angular) and 2 variable speeds drives. The Mk.6 and Mini Mk.6 also include full flame supervision and control for burner start-up and run modes. The Mk.6 has the onboard facility for gas valve proving, air pressure proving, on-line gas, air and oil pressure supervision and first-out annunciation.

Positioning Motors

Small positioning motor	• 0.89 ft. lbf, 1.2 NM
Large positioning motor	• 11 ft. lbf, 15 NM
Industrial positioning motor	• 29-72 ft. lbf, 40-100 NM
Special positioning motors up to	• 295ft. lbf, 400 NM

Load Detectors

Boiler load detectors available for steam and hot water.

Steam sensor	• 1.5 to 445 psi, 0.2 to 30.7 bar
Temperature detector	• 50 to 700°F, 0 to 400°C
User configurable sensor	• 4-20 mA or 0-10 V

Flame Scanners

UV Flame Sensors

- Self Check
- Standard UL Approved/Standard European
- Side View Application
- High Sensitivity

Fuel/Air Supply Pressure Sensors & Outside Air Temperature Sensor

Gas pressure sensor	• 0.18 to 60 psi, 12.5 to 4140 mbar
Oil pressure sensor	• 0 to 600 psi, 0 to 40 bar
Air pressure sensor	• 0 to 1 psi, 0 to 65 mbar
Outside air temperature sensor	• -40 to 104°F, -40 to +40°C

Fuel Control Valves

Gas Control Valve - Sizes: screwed 1" to 3" NPT, flanged 2.5" to 6" 150lb/PN16, 30mm or 50mm thick.
Oil Control Valve - Mild steel, nickel plate body with bronze bobbin, suitable for all commercially available oil fuels. Various capacities in both metering and spillback format.
Dual Fuel Valves - Innovative design allows oil and gas valves to be mounted together utilising only one servo.

Exhaust Gas Analyser

Using individual sensors, the EGA monitors and displays CO_2, O_2, CO, NO, SO_2 or NO_2, efficiency and exhaust gas temperature. On-board self diagnostic software includes self calibration and fully user configurable setup via PC software. In conjunction with an MM the unit provides full 3 parameter trim for CO_2, O_2, CO maintaining commissioned values of combustion irrespective of variations in fuel supply or barometric conditions.

Data Transfer

Data Transfer Interface & Win PC DTI software	Remote monitoring & control for up to 10 sets of MM's and peripherals. Change setpoint, enable/disable burners, select lead/lag. Up to 150 items of information per MM/EGA System can be accessed from via the DTI with the Modbus or Metasys protocols. Autoflame Win PC DTI software allows PC-based on-site control and remote control of up to 255 sites.
Digital I/O Module	16 line voltage inputs and 8 volt free contacts.
Analogue I/O Module	6 inputs/6 outputs - 0-20mA, 4-20mA or 0-10V - user configurable via PC.
IR Upload/Download	Transfer commissioning data via the MM's IR port to PC. Store commissioning data on PC and print report - includes all positions entered in each fuel program, full EGA trim data and options and parameters settings.

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