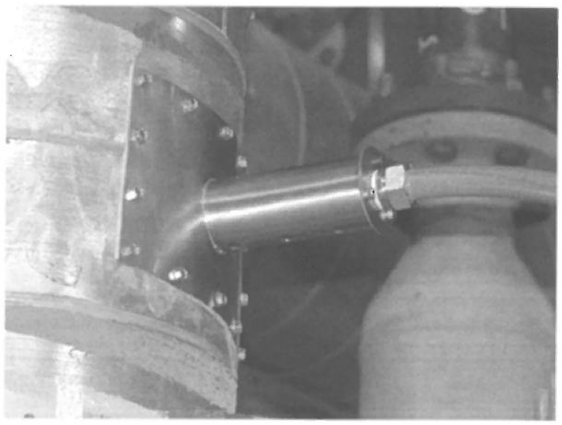
CleaverBrooks®

O2 TRIM

Hawk ICS

Operation and Maintenance Manual



750-224
03/2010

SAFETY PRECAUTIONS AND ABBREVIATIONS

Safety Precautions

It is essential to read and understand the following safety precautions before attempting to operate the equipment. Failure to follow these precautions may result in damage to equipment, serious personal injury, or death. A complete understanding of this manual is required before attempting to start-up, operate or maintain the equipment. The equipment should be operated only by personnel who have a working knowledge and understanding of the equipment.

The following symbols are used throughout this manual:

⚠WARNING

This symbol indicates a potentially hazardous situation which, if not avoided, could result in serious personal injury, or death.

⚠ CAUTION

This symbol indicates a potentially hazardous situation which, if not avoided, could result in damage to the equipment.

Note: This symbol indicates information that is vital to the operation of this equipment.

Abbreviations

Following is an explanation of the abbreviations, acronyms, and symbols used in this manual.

AC	Alternating Current
AR	Automatic Reset
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
BHP	Boiler Horsepower
BTU	British Thermal Unit
°C	Degrees Celsius
CFH	Cubic Feet per Hour
Cu Ft	Cubic Feet
DC	Direct Current
°F	Degrees Fahrenheit
FM	Factory Mutual
FS	Flame Safeguard
ft	Feet
GPM	Gallons per Minute
Hd	Head
HT	Height
HTB	High Turndown Burner
HZ	Hertz
In H_2O	Inches of Water
IRI	Industrial Risk Insurance
Lb	Pound
LWCO	Low-Water Cut-Off
M	Million
MFD	Micro-Farad
MR	Manual Reset
NEC	National Electric Code
No.	Number
pH	Measure of acidity or basicity of a solution
P/N	Part Number
PPM	Parts Per Million
PR	Program Relay
psi	Pounds Per Square Inch
SAE	Society of Automotive Engineers
scfh	Standard Cubic Feet per Hour
T	Temperature
TC	Temperature Control
TI	Temperature Gauge
UL	Underwriter's Laboratories
V	Volt
WC	Water Column
WSI	Watts Per Square Inch

O2 Trim

Operation and Maintenance Manual

HAWK ICS O2 trim option (addendum to the manual 750-229)

Please direct purchase orders for replacement manuals to your local Cleaver-Brooks authorized representative

Manual Part No. 750-224
03/2010

Printed in U.S.A.

⚠ WARNING

DO NOT OPERATE, SERVICE, OR REPAIR THIS EQUIPMENT UNLESS YOU FULLY UNDERSTAND ALL APPLICABLE SECTIONS OF THIS MANUAL.

DO NOT ALLOW OTHERS TO OPERATE, SERVICE, OR REPAIR THIS EQUIPMENT UNLESS THEY FULLY UNDERSTAND ALL APPLICABLE SECTIONS OF THIS MANUAL.

FAILURE TO FOLLOW ALL APPLICABLE WARNINGS AND INSTRUCTIONS MAY RESULT IN SEVERE PERSONAL INJURY OR DEATH.

TO: Owners, Operators and/or Maintenance Personnel

This operating manual presents information that will help to properly operate and care for the equipment. Study its contents carefully. The unit will provide good service and continued operation if proper operating and maintenance instructions are followed. No attempt should be made to operate the unit until the principles of operation and all of the components are thoroughly understood. Failure to follow all applicable instructions and warnings may result in severe personal injury or death.

It is the responsibility of the owner to train and advise not only his or her personnel, but the contractors' personnel who are servicing, repairing or operating the equipment, in all safety aspects.

Cleaver-Brooks equipment is designed and engineered to give long life and excellent service on the job. The electrical and mechanical devices supplied as part of the unit were chosen because of their known ability to perform; however, proper operating techniques and maintenance procedures must be followed at all times. Although these components afford a high degree of protection and safety, operation of equipment is not to be considered free from all dangers and hazards inherent in handling and firing of fuel.

Any "automatic" features included in the design do not relieve the attendant of any responsibility. Such features merely free him of certain repetitive chores and give him more time to devote to the proper upkeep of equipment.

It is solely the operator's responsibility to properly operate and maintain the equipment. No amount of written instructions can replace intelligent thinking and reasoning and this manual is not intended to relieve the operating personnel of the responsibility for proper operation. On the other hand, a thorough understanding of this manual is required before attempting to operate, maintain, service, or repair this equipment.

Because of state, local, or other applicable codes, there are a variety of electric controls and safety devices which vary considerably from one boiler to another. This manual contains information designed to show how a basic burner operates.

Operating controls will normally function for long periods of time and we have found that some operators become lax in their daily or monthly testing, assuming that normal operation will continue indefinitely. Malfunctions of controls lead to uneconomical operation and damage to the equipment. In most cases, these malfunctions can be traced directly to carelessness and deficiencies in testing and maintenance.

It is recommended that a boiler room log or record be maintained. Recording of daily, weekly, monthly and yearly maintenance activities and recording of any unusual operation will serve as a valuable guide to any necessary investigation.

Most instances of major boiler damage are the result of operation with low water. We cannot emphasize too strongly the need for the operator to periodically check the low water controls and to follow good maintenance and testing practices. Cross-connecting piping to low water devices must be internally inspected periodically to guard against any stoppages which could obstruct the free flow of water to the low water devices. Float bowls of these controls must be inspected frequently to check for the presence of foreign substances that would impede float ball movement.

The waterside condition of the pressure vessel is extremely important. Waterside surfaces should be inspected frequently to check for the presence of any mud, sludge, scale or corrosion.
The services of a qualified water treating company or a water consultant to recommend the proper boiler water treating practices are essential.
The operation of this equipment by the owner and the operating personnel must comply with all requirements or regulations of their insurance company and/or other authority having jurisdiction. In the event of any conflict or inconsistency between such requirements and the warnings or instructions contained herein, please contact Cleaver-Brooks before proceeding.

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Section 1

O_2 Trim with Yokogawa Sensor/Analyzer

HAWK ICS O_2 trim option (addendum to the manual 750-229)

This addendum covers the Oxygen Trim option to be used with Cleaver-Brooks HAWK ICS boiler control. Oxygen trim programming is an integral part of the HAWK ICS control system.

The purpose of the O_2 trim system is to maintain optimum excess air through the firing range of the burner.

The O_2 trim system uses one of two O_2 sensor/analyzers:

Option A: CBO_2-ICSA

Option B: Yokogawa

The following table outlines the method by which O_2 trim is accomplished (fuel trim or air trim), based on type of control system supplied.

CONTROL SYSTEM	O2 TRIM METHOD	PNEUMATIC PANEL
No VSD, No Integral Parallel Positioning combustion control	Fuel	Yes
Integral Parallel Positioning, No VSD	Air (Air actuator)	No
VSD	Air (VSD Speed)	No

A. O_2 Fuel Trim (Pneumatic Control) Components (Yokogawa)

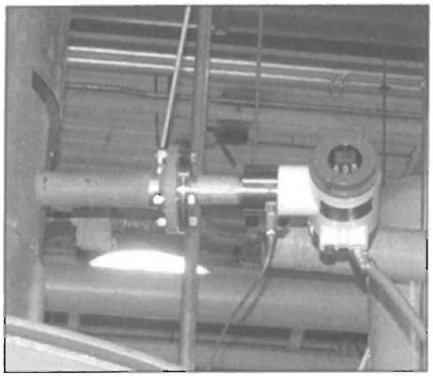


Figure 1-1 O_2 Analyzer

1. Oxygen Probe and Analyzer

A- Sensor- The sensor senses the oxygen level in the flue gases and communicates the information to the controller.

B- Analyzer- The analyzer analyzes the signal from the sensor and converts it to linear 4-20 mA (Yokogawa) or 0-6 Volts (CBO_2-ICSA).

Note: Yokogawa analyzer is build into the sensor.

Notice

For the Yokogawa analyzer please read and understand the analyzer manufacturer's O&M Manual to familiarize yourself with unit operation (http://www.yokogawa.com).

2. Pneumatic Panel

Panel contains the necessary components to convert the 4-20 mA control signal to a 3-15 psig pneumatic signal that is supplied to the actuator(s).

ITEM	QTY	PART NO.	DESCRIPTION
1	1	848-01399	ENCLOSURE 14"x12"x6"
2	1	797-02301	PRESSURE REGULATOR, AIR
3	1	959-00245	I/P TRANSDUCER,4-20ma TO 3-15 PSI
4	1	434-00057	TERMINALS (5)
5	3	845-00978	BULKHEAD FITTING, 1/4" ODT x 1/4" FNPT.
6	3	858-01084	PLUG, BRASS, 1/4" NPT
7	1	845-00279	EL., MALE, COMP., BRASS, 1/4"ODT x 1/4"NPT
8	1	845-01058	TEE,FEMALE BRANCH,1/4"ODT x 1/4"ODT x 1/4"FNPT
9	3 FT	939-00025	COPPER TUBING, 1/4"
10	2	845-00728	EL., FEMALE, COMP., BRASS, 1/4"ODT x 1/4"NPT
11	3	857-00129	NIPPLE, PIPE, 1/4"NPT x 1-1/2"LG. SCH.40

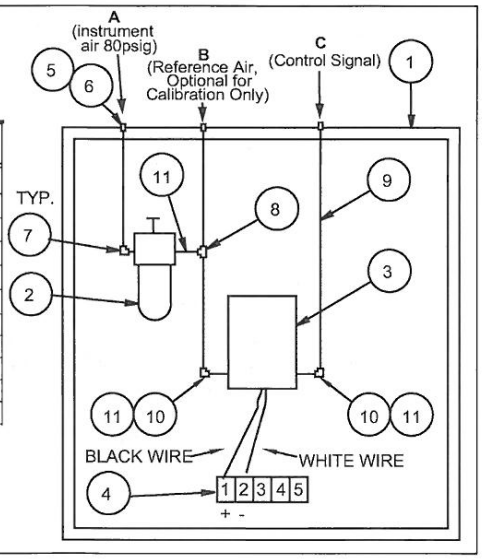


Figure 1-2 Pneumatic Control Panel.

3. Controller

The Controller is a set of modular devices that easily mount on DIN rail in the boiler control panel. The controller consists of the PLC (Programmable Logic Controller) and associated input/output, communication, and power modules.

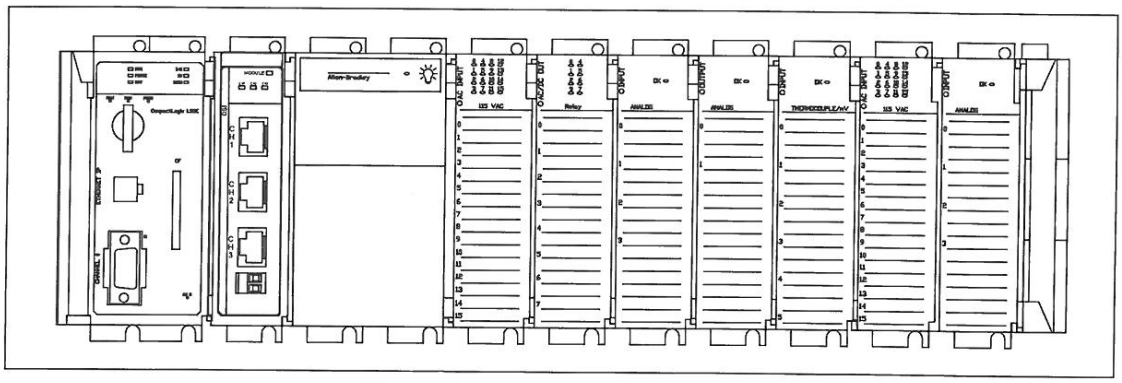


Figure 1-3 Hawk ICS Controller

1. PLC	(Slot 0)
2. Modbus Module*	(Slot 1)
3. Power Supply	
4. Digital Input Module (16 Ch.)	(Slot 2)
5. Digital Output Module (8 Ch.)	(Slot 3)
6. Analog Input Module (4 Ch.)	(Slot 4)
7. Analog Output Module (2 Ch.)	(Slot 5)
8. Thermocouple Input Module (6 Ch.)	(Slot 6)
9. Digital Input Module (16 Ch.)	(Slot 7)
10. Analog Input Module (4 Ch.)	(Slot 8)
11. Analog Output Module (2 Ch.)	(Slot 9)
12. Right End Cap Terminator	

*Devicenet™ scanner on some systems

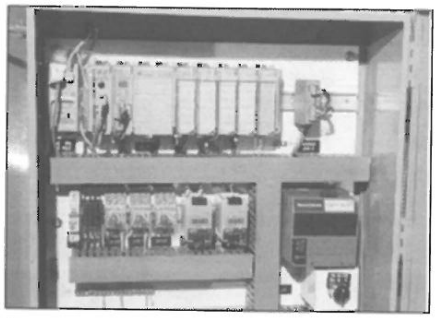


Figure 1-4 Hawk ICS Panel Open

Figure 1-5 Pneumatic Actuator

4. Control Actuator (gas fuel only)

The pneumatic actuator is mounted on the gas pressure regulator. Actuator size varies with the gas pressure requirements and pressure regulator model.

5. Human Machine Interface (HMI)

The 10" touch screen HMI is used when the O_2 trim option is provided. Screen layout is almost identical to the one being described in the HAWK ICS O&M. Additional screens are added specifically for Oxygen Trim option.

B. Determining Location

Refer to **Figure 1-6** for the general layout of equipment. The general instructions for determining location are.

1. The interconnecting signal cables between the Control Panel, Pneumatic Panel, and Analyzer should be located as far as possible from high voltage wiring and large electrical equipment. Items like ignition cables and combustion air motor wiring can introduce voltage spikes, which could upset control operation. The signal cables should be run at right angles to any power wiring and must not be routed with any boiler wiring.

2. The pneumatic controls should be as close as possible to the trim actuator. A long air line (greater than 60 feet) will delay the response of the system and cause pressure drops. In such cases, 3/8" tubing and minimum number of elbows should be used.

3. The Analyzer should be located as close to the boiler flue outlet as possible. If there are additional flue mounted items (damper, economizer, smoke detectors, etc) the Analyzer should be closest item to the boiler.

4. It is recommended to make electrical connections to the analyzer using flexible type conduit. The conduit's length and flexibility should allow for easy removal of the sensor from the stack.

C. Installation

The following is the recommended sequence for installing the O_2 trim system. Do not attempt to proceed with installation and start-up until you have read this manual and understand its content.

1. Check Boiler and Burner

The burner must be capable of firing within normal values for CO_2, O_2, CO, and smoke spots. O_2 trim system will not compensate for abnormal combustion settings. The range of values for properly adjusting the burner may vary depending on the model.

As a rule of thumb, these values at high fire are:

Oxygen 2 –4% Vol

Carbon Monoxide (natural gas fuel) 0 – 200 ppm

smoke spot 0-2 (#2 oil) or 0-4 (#6 oil).

The boiler, breaching, and stack MUST be tightly sealed against air infiltration. Mechanically, all linkages should be in good operating condition. Any warn components should be replaced.

⚠ Warning

Do not proceed unless the above conditions have been met.

2. Component Mounting

Mount, pipe and wire the Control Panel, Analyzer, Pneumatic Panel, and pneumatic components per instructions in this chapter.

3. Mount Trim Actuator

Mount the Fuel Trim components as described in the commissioning chapter of this manual. At the time the actuator is installed, the burner must be able to achieve proper combustion characteristics.

4. Final Adjustments

Make the final combustion adjustments per the Commissioning chapter, and the Operating Manual for the burner

.

⚠ Warning

Combustion adjustments should only be done by a fully qualified technician familiar with the boiler and burner and equipped with proper instrumentation and tools.

D. System Requirements

Oxygen Fuel trim system requires electrical power and a source of air.

Electrical

Power Supply Voltage:120 VAC (+10%/-15%)
Power Supply Frequency:50/60 Hz
Power Consumption:Max. 300 W

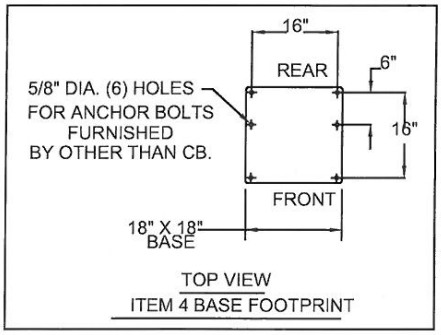
Air Supply

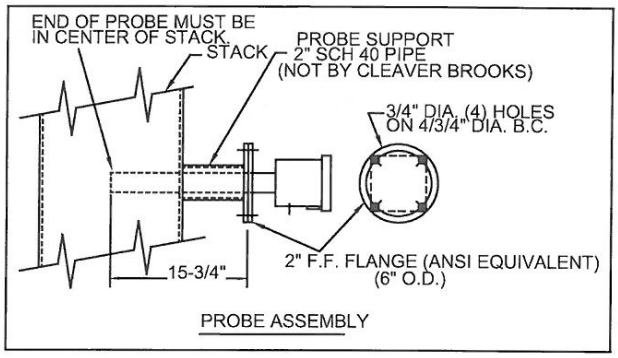
25 – 125 PSIG, 2 SCFM

Clean, dry, instrument quality air required. Oil content 1 ppm maximum. Dew point 35°F or less at line pressure.

ITEM	QTY	PART NO.	DESCRIPTION
1	1	985-00130	PROBE/ANALYZER
2	1	283-03183	PNEUMATIC PANEL
3	1	985-00174	CALIBRATION UNIT (OPTIONAL)
4	1	527-01305	STAND (OPTIONAL) (66" HIGH)
5	1	269-00010	ACTUATOR, GAS REGULATOR

CONNECTIONS	
A	AIR SUPPLY: 1/4" CONN., 125 PSIG MAX./25 PSIG MIN. 2.0 CFM, (SEE NOTE #4)
B	CALIBRATION LINE (CAL GAS) 1/4" CONNECTION (OPTIONAL)



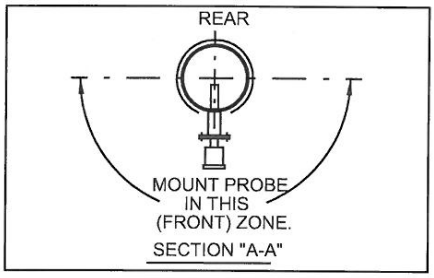


NOTES:

1. Mounting of pneumatic panel, probe, and gas pressure actuator by others.
2. Mount pneumatic panel in vibration free environment.
3. Sizing of signal lines to conform to the below referenced chart.

LENGTH IN FEET	AIR ACTUATOR TUBING SIZE	PROBE TUBING SIZE
0-50	1/4" ODC.	1/4" ODC.
51-100	3/8" ODC.	3/8" ODC.

4. Air supply is to be clean, dry instrument quality air. This is air which is free of water, oil and any other particulate material. If needed, add oil and/or water filters as required upstream of pressure regulator.
5. Probe support is not standardly supplied by Cleaver Brooks, but is available as an option.



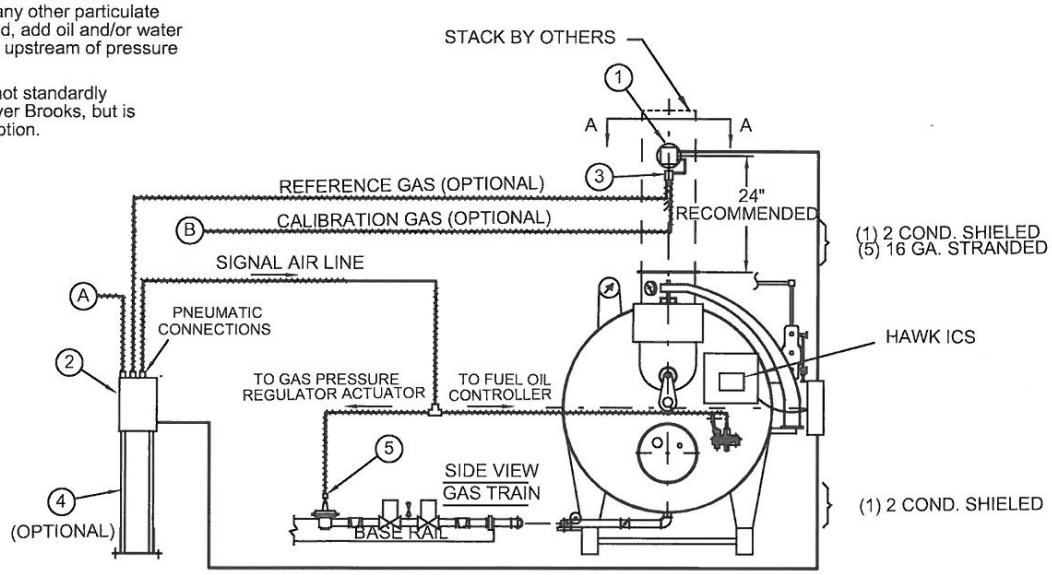


Figure 1-6 General Arrangement Yokogawa O_2 trim & HAWK ICS (Fuel Trim

E. Wiring

Always reference specific project wiring diagram. All wiring must conform to the National Electrical Code (NEC) and all applicable local codes.

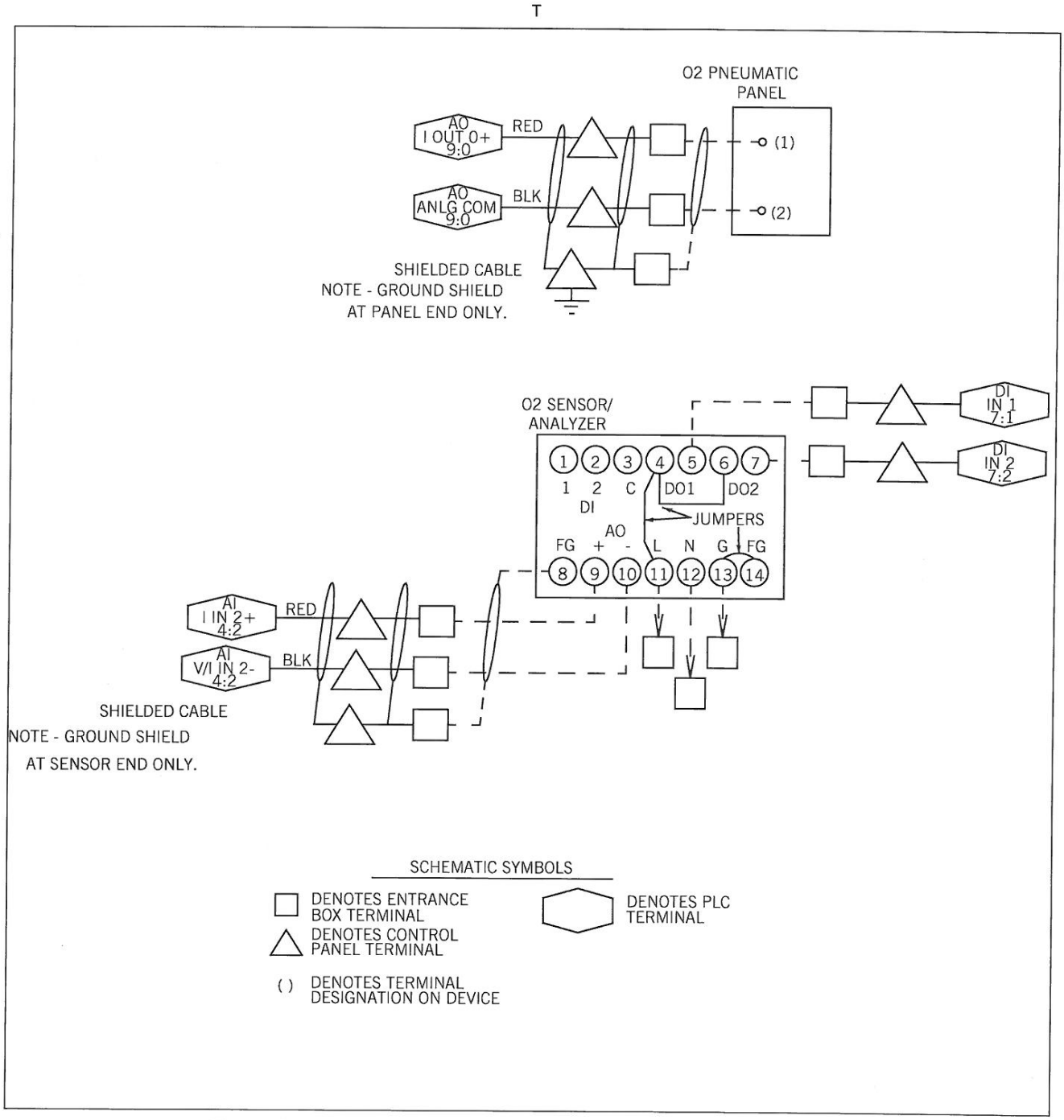


Figure 1-7 Typical Wiring O_2 Trim (Yokogawa ZR202G is shown)

F. System Set up and Configuration

Probe/Analyzer

Table 1-1 shows settings for Yokogawa ZR202G Integrated type Zirconia Oxygen Analyzer.

Table 1-1 Yokogawa Analyzer Settings

Parameter Name	Code	Set Value
Output-related items		
Analog Output	C01	0: Oxygen Concentration
Output Mode	C03	0: Linear
Output During Warm UP	C04	0: Held at 4 mA
Output during maintenance	C05	1: Held output just before maintenance service
Output during calibration	C06	1: Held output just before calibration
Output in abnormal state	C07	1: Held output just before abnormal state occurs
Min. oxygen concentration	C11	0% O2
Max. oxygen concentration	C12	25% O2
Output damping factor	C30	0 seconds
Set value during warm up	C31	4mA
Set value during maintenance	C32	4mA
Set value during calibration	C33	4mA
Set value during in abnormal state	C34	4mA
Output Contact 1 Setting		
Operation	E10	1
Error	E20	1
High High Limit alarm	E21	0
High Limit alarm	E22	0
Low Limit alarm	E23	0
Low Low Limit alarm	E24	0
Maintenance	E25	1
Calibration	E26	1
Range change	E27	0
Warm-up	E28	1
Calibration-gas pressure drop	E29	0
Unburnt gas detection	E32	0

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Section 2

O2 Fuel Trim (Pneumatic Control) with CB-O2-ICSA

Milwaukee, Wisconsin
www.cleaver-brooks.com

A. O2 Fuel trim (Pneumatic Control) Components (CB-O2-ICSA)

Notice

Do not use with # 6 Oil

Probe/Analyzer

PART NUMBER	DESCRIPTION
817-04030	O2 ANALYZER
817-04031	ANALYZER HARNESS
817-04032	SENSOR HARNESS
817-04034	O2 SENSOR (PROBE)
832-02404	24 VDC POWER SUPPLY

Housing

PART NUMBER	DESCRIPTION
939-01113	TUBE
976-00635	SHEET, 24 GAUGE x 6 x 6
976-00459	SHEET, 11 GAUGE x 2" O.D. x 1.06" I.D.

NOTE: Power Supply part number 832-02404 to replace the auxiliary power supply part number 832-2037, when the CB02-ICSA is installed with the Hawk ICS.

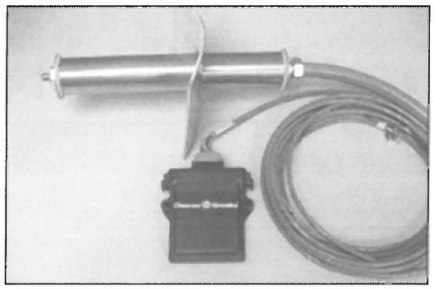

Figure 2-1 CB02-ICSA Controller and sensor

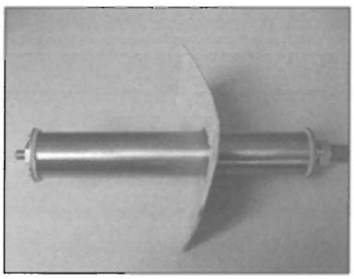

Figure 2-2 CBO2-ICSA Sensor Probe

1. Oxygen Probe and Analyzer

1. A sensor on the end of the oxygen probe senses the oxygen level in the flue gases and communicates the information to the controller.
2. The analyzer processes the signal from the sensor and converts it to a linear 4-20 mA (Yokogawa) or 0-6 Volts CB-O2-ICSA

Figure 2-3 CBO2-ICSA Analyzer

2. Boiler Controller

The Controller is a set of modular devices that easily mount on DIN rail in the boiler control panel. The controller consists of the PLC (Programmable Logic Controller) and associated input/output, communication, and power modules.

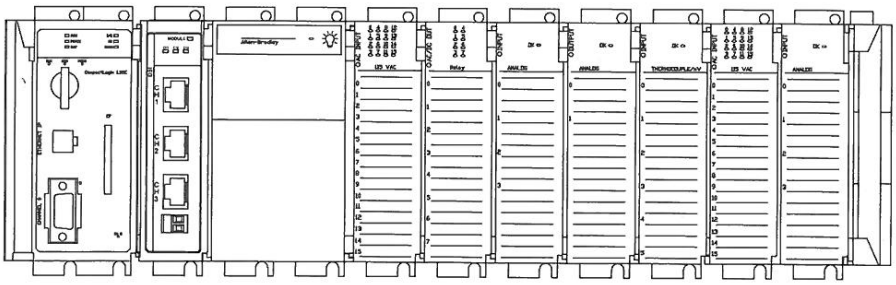

Figure 2-4 PLC Rack

1. PLC	(Slot 0)
2. Modbus Module*	(Slot 1)
3. Power Supply	
4. Digital Input Module (16 Ch.)	(Slot 2)
5. Digital Output Module (8 Ch.)	(Slot 3)
6. Analog Input Module (4 Ch.)	(Slot 4)
7. Analog Output Module (2 Ch.)	(Slot 5)
8. Thermocouple Input Module (6 Ch.)	(Slot 6)
9. Digital Input Module (16 Ch.)	(Slot 7)
10. Analog Input Module (4 Ch.)	(Slot 8)
11. Analog Output Module (2 Ch.)	(Slot 9)
12. Right End Cap Terminator	

*Devicenet™ scanner on some systems

3. Control Actuator (gas fuel only)

This pneumatic actuator is mounted on the gas pressure regulator. Actuator size varies with the gas pressure requirements and pressure regulator model.

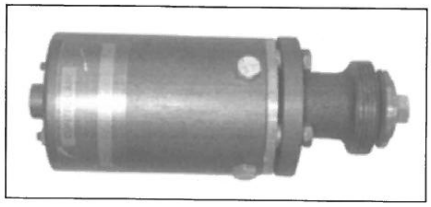

Figure 2-5 Control Actuator (Typical)

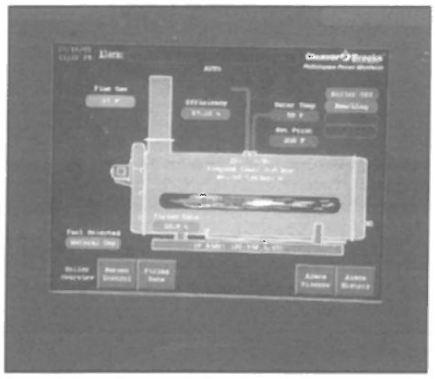

Figure 2-6 HMI

4. Human Machine Interface (HMI)

10" touch screen HMI is used when O2 trim option is provided. Screen layout is almost identical to that described in the HAWK ICS manual. Additional screens are added specifically for Oxygen Trim option.

B. Determining Sensor Probe Location

Refer to Figure 1-7 for the general layout of equipment.

It is recommended to make electrical connections to the analyzer using flexible type conduit. The conduit's length and flexibility should allow for easy removal of the sensor from the stack.

C. System Requirements

The oxygen trim system requires electrical power and a source of air.

Electrical requirements:

Controller Supply Voltage - 24 VDC
Power Consumption - Max. 100W

Air supply requirements:

25 – 125 PSIG, 2 SCFM

Clean, dry instrument quality air required. Oil content 1 ppm maximum. Dew point 35°F or less at line pressure.

D. Installation

The following is the recommended sequence for installing the O2 trim system. Do not attempt to proceed with installation and start-up until you have read this manual and understand its contents.

1. Check Boiler and Burner
2. Component Mounting
   Mount, sensor ventilation holes down, and wire the Control Panel, Analyzer, Pneumatic Panel, and pneumatic components per instructions in this section.
3. Mount Trim Actuator
4. Final Adjustments

⚠ Warning

Setting combustion, should only be done by a fully qualified technician familiar with the boiler and burner and equipped with proper instrumentation and tools.

⚠ Caution

Do not proceed unless section 2 conditions have been met.

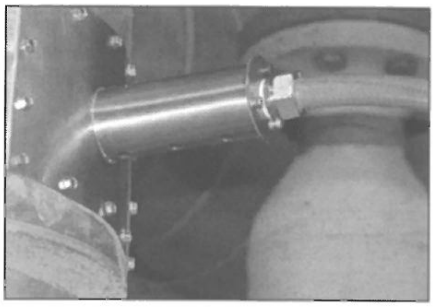

Figure 2-7 CB02-ICSA Mounted in the stack

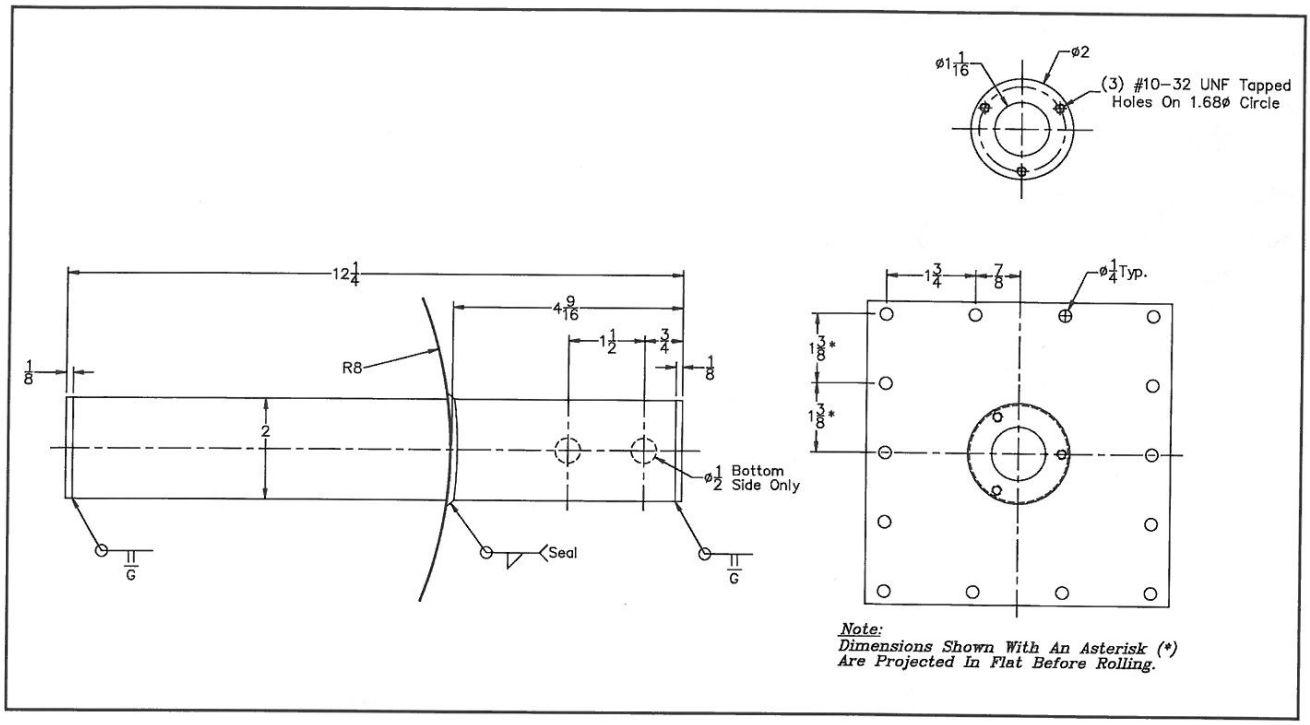

Figure 2-8 Housing Dimensions

E. Sensor and controller installation and connections

1. Cut a two and half to three inch hole in the stack
2. Insert sensor probe assembly into the stack and secure with sheet metal screws.
3. Remove the sensor housing back plate, which has the seal tight connector.
4. Connect the conduit to the seal tight connector onto the sensor housing back plate.
5. Attach the other side of the conduit to the control panel where the O2 analyzer is mounted.
6. Insert the controller (cable) Harness part number 817-04031 through the back plate, seal tight connector, and through the conduit.
7. Wire the harness to the control panel terminal. Follow provided Boiler wiring diagram for proper wiring.

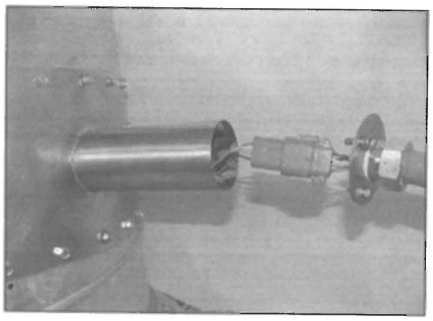

Figure 2-9 Connecting the Harness

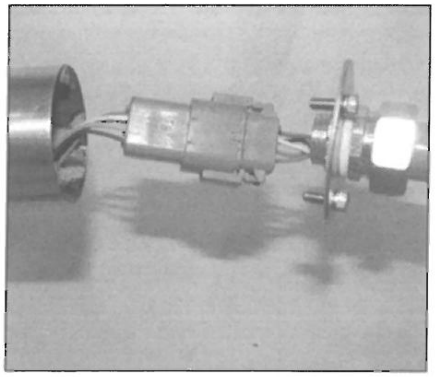

Figure 2-10 Connecting Harness

8. Connect the connector, which is attached to the controller harness to the mating connector that was exposed at the sensor housing.
9. Insert connectors into sensor housing
10. Secure back plate to the sensor housing.
11. Refer to **Figure 2-9** and **Figure 2-10**

⚠ Warning

Always reference specific project wiring diagram. All wiring must conform to the National Electrical Code (NEC) and all applicable local codes.

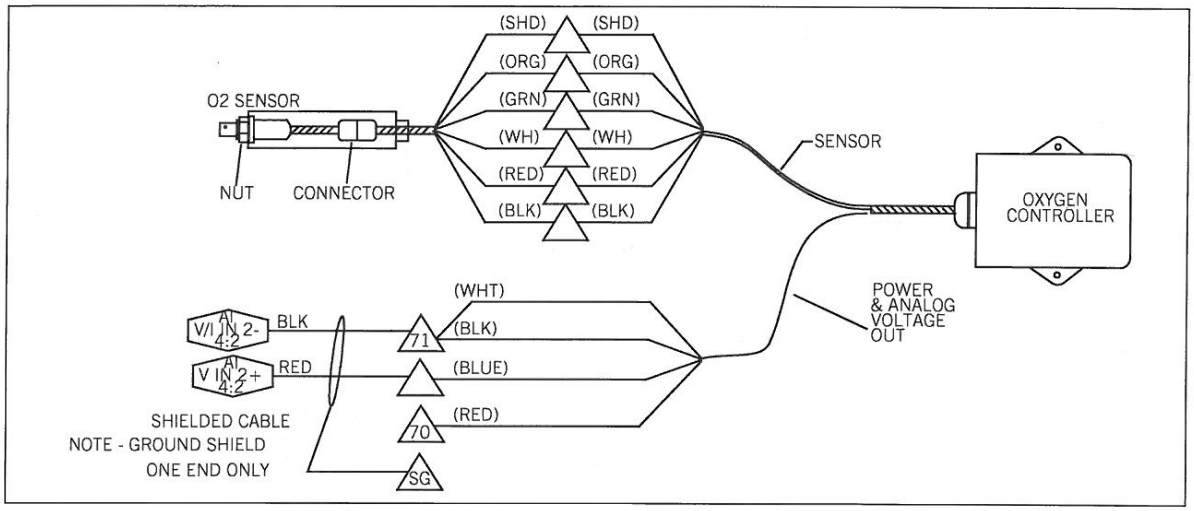

Figure 2-11 Typical Wiring O2 Trim (CBO2-ICSA as shown)

CleaverBrooks

Section 3

O2 Trim Commissioning

Systems without integrated parallel positioning

Milwaukee, Wisconsin
www.cleaver-brooks.com

A. O2 Trim Commissioning (systems without integrated parallel positioning)

Wire the system as shown in the wiring diagram. Configuration of the sensor analyzer will not be required for the CB-O2-ICSA sensor controller. Follow Human Machine Interface (HMI) instructions for the overall system set up.

Human Machine Interface (HMI) Screens

A 10" touch screen HMI is used when the O2 trim option is provided. Screen layout is almost identical to the one described in the HAWK ICS parallel positioning O&M 750-217.

Additional screens are added specifically for Oxygen Trim option.

This section describes screens applicable to the O2 trim option only. For other screens, please refer to the HAWK ICS manual. Please note that O2 trim option is available with 10" screen only.

Screen Selector

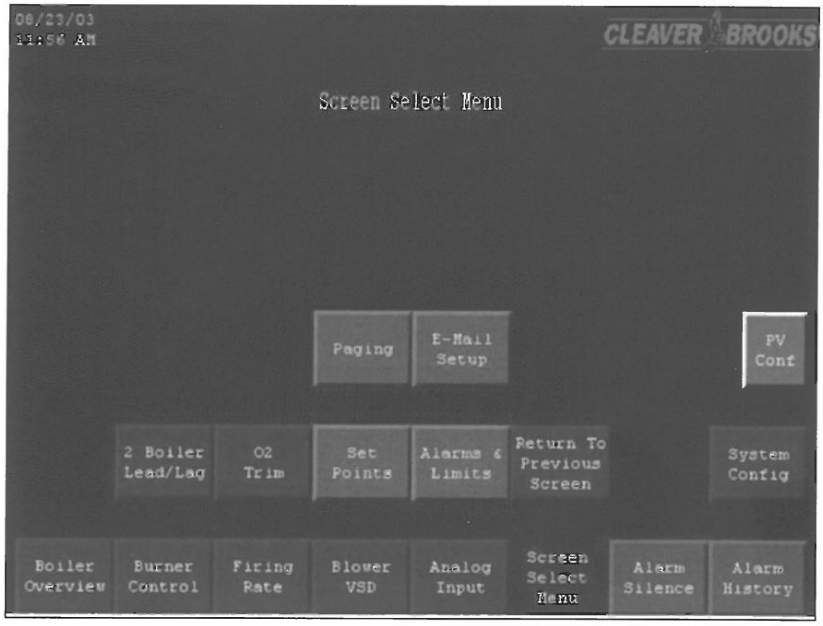

Figure 3-1 Screen Selector

This screen is used for ease of navigation between screens. Some screen selector pushbuttons maybe hidden, based on the Hawk ICS selected options.

Select "System Config". Enter password "3232".

On Configuration screen 1 and select O2 trim option (O2 analyzer option will be selected automatically). Make selection of what type of O2 analyzer is used. The selections are Yokogawa or CB.

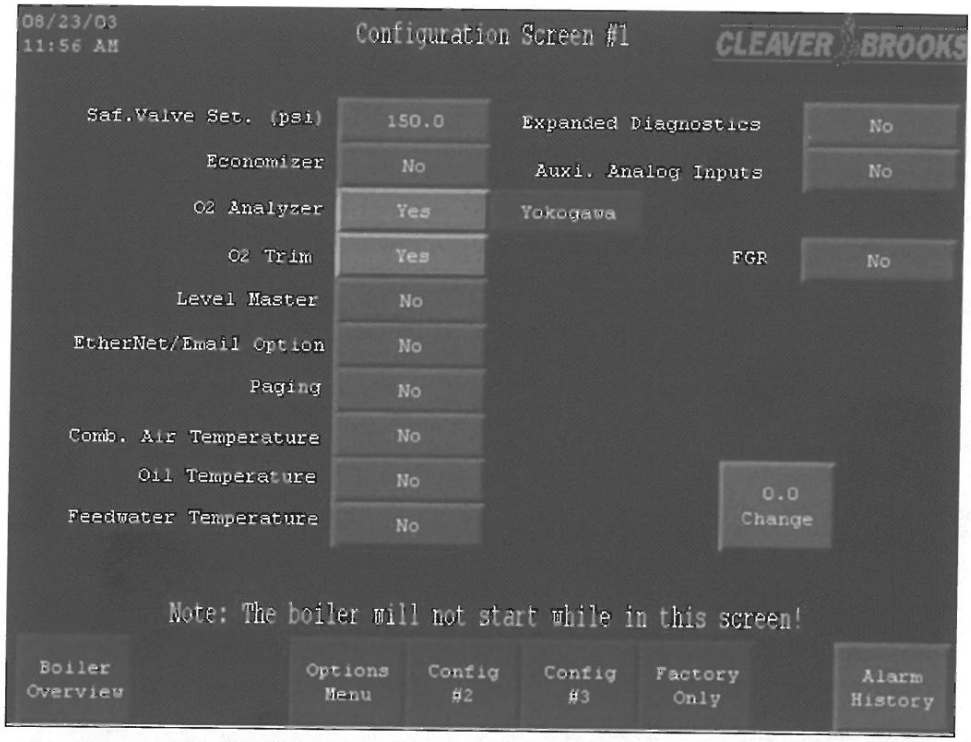

Figure 3-2 Configuration 1 screen (Yokogawa analyzer is selected)

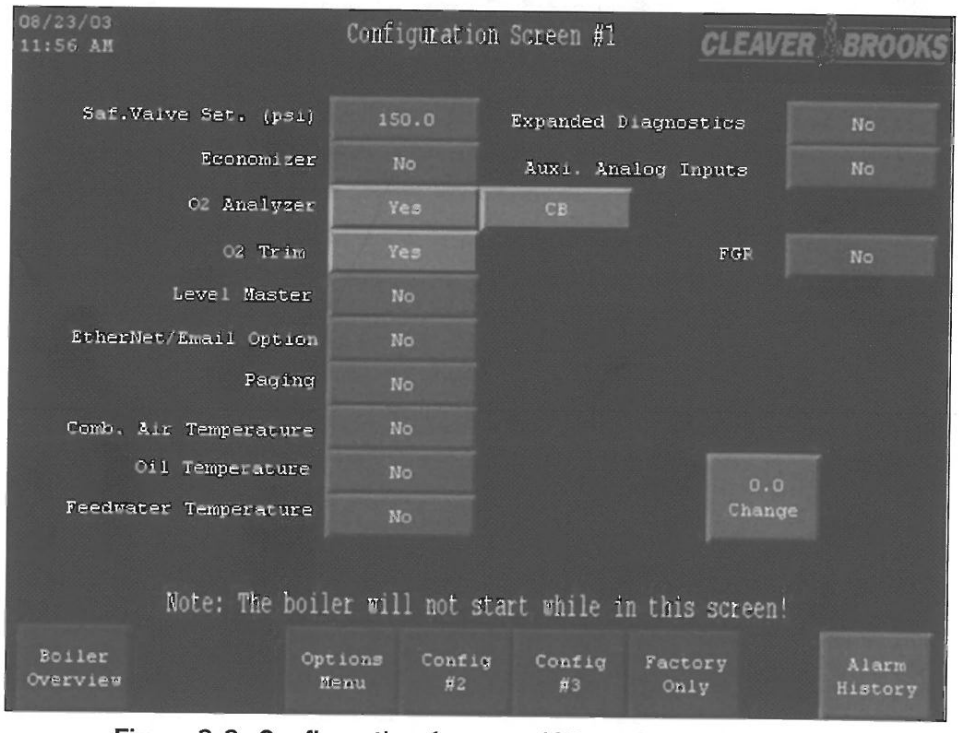

Figure 3-3 Configuration 1 screen (CB analyzer is selected)

O2 TRIM SCREEN.

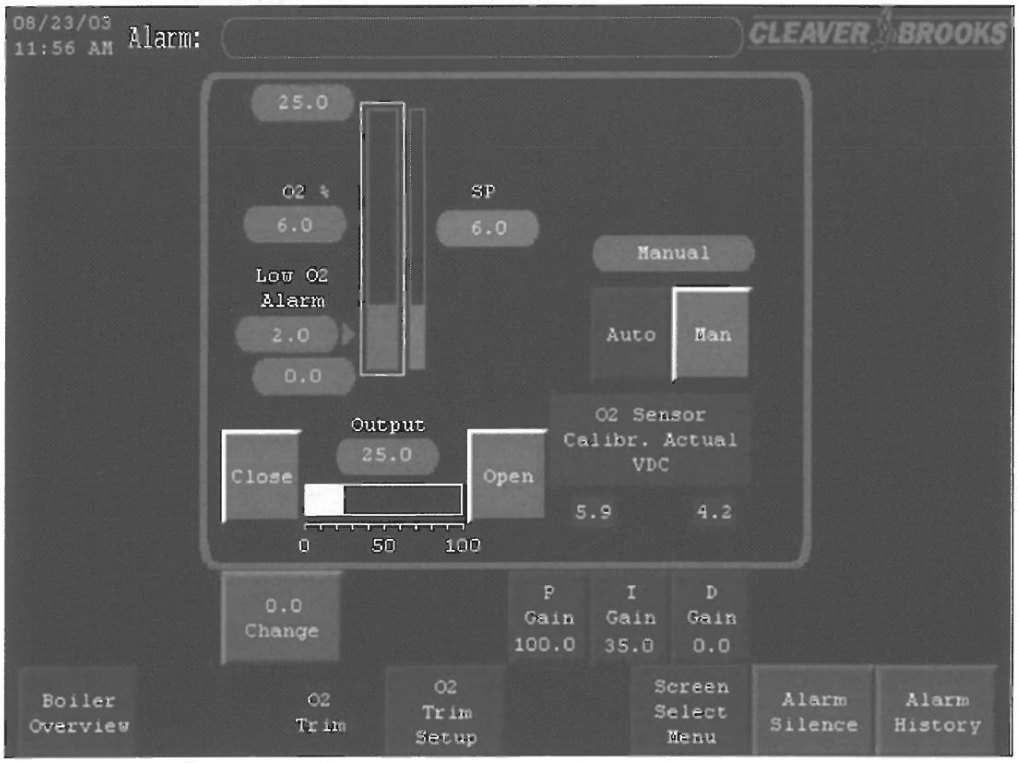

Figure 3-4 O2 trim Screen

The O2 trim screen provides the operator with access to the control functions of the O2 trim option.

<**Auto**> - Output of the O2 trim varies according to the oxygen level in the flue gas compared to the set point.

<**Manual**> - The output of the O2 trim control loop can be varied with <**Close**> and <**Open**> buttons.

It is recommended to use <**Auto**> selection during normal operation. To prevent unauthorized personnel from selecting <**Manual**> operation, the <**Manual**> button has to be pressed for more than 2.5 seconds to allow switching to manual mode.

The control output is shown on the horizontal bar graph as well as a numerical value.

The following information is also displayed on the O2 trim screen.

O2 – Actual Oxygen level content in the flue gases at the boiler outlet.

Output – A bar graph represents the output signal being sent to the O2 trim actuator (gas) or oil pressure controller (oil). The control output is represented from 0 to 100%. The actual number is repeated above the bar graph.

SP – O2 trim set point. The set point is based on the firing rate and fuel fired.

Low O2 Alarm – The value at which the low O2 alarm is activated.

O2 trim loop uses advanced PID control algorithm. The following buttons are provided for control tuning.

P Gain - Proportional gain value.

I Gain - Integral gain value.

D Gain - Derivative gain value.

Change button is used to modify PID parameters.

O2 Sensor calibration and actual signals value - This field displays voltage signal from O2 analyzer. Two values are displayed, i.e. signal used for calibration and actual value (Note: This field is visible only if CB O2 analyzer is selected).

VSD SCREEN

When Variable Speed Drive (VSD) is installed for the combustion air fan, oxygen trim is done by applying a correction factor to the motor speed. Combustion air fan speed is controlled by the PLC and varies linearly based on the firing rate signal.

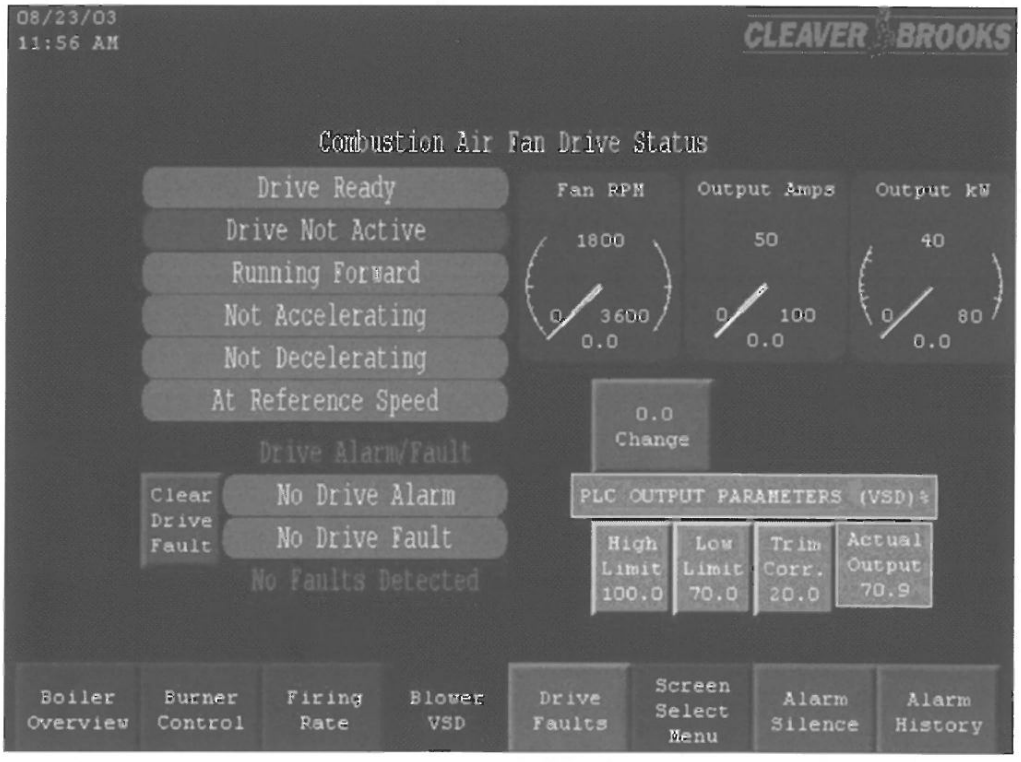

Figure 3-5 VSD Screen

High limit	This maximum frequency for combustion air fan motor with no O2 trim correction applied. 100% = 60 Hz. Default value is 100%.
Low limit	This is minimum frequency for combustion air fan motor with no O2 trim correction applied. Default value (also the lowest limit) is 70% = 42 Hz.
Trim Corr.	This is maximum O2 trim correction value. Default value is 20%. This means that maximum correction to the combustion air fan speed is +/-10%.
Actual Output	Output from the PLC to control the VSD, where 0% = 4 ma, 100% = 20 ma

The following equations are used to calculate control output to VSD.

No O2 trim:

$$COno\ O2 = ((High\ Limit - Low\ Limit)/100 \times FR + Low\ Limit) \times (60/66)$$

Where COno O2 = Control Output with no O2 trim correction in%.

FR = Firing rate control signal%

60 = Motor nominal frequency HZ

66 = Motor maximum frequency HZ

With O2 trim.

$$COwO2 = COno\ O2 \times (1 + (TrimCorr/100) \times (O2\ PID\ OUT\ /100)) - ((TrimCorr)/(100*2))$$

Where COwO2 = Control Output with 2 trim correction in%

O2 PID OUT = O2 trim controller PID output

Example: High Limit = 100.0% Low Limit = 70.0% Trim Corr. = 20% Firing rate control output = 100%. O2 trim output = 100%

$$COno\ O2 = ((100-70)/100 \times 100 + 70) \times (60/66) = 90.9\% = 18.55\ ma = 60\ Hz$$

$$COwO2 = 90.9 \times (1 + (20/100) \times (100)) - ((20)/(100/2)) = 100\% = 20\ MA = 66\ Hz$$

O2 TRIM SET UP SCREEN.

The O2 trim setup screen is used for commissioning of the O2 trim system.

Top row of the screen displays fuels used for this specific project.

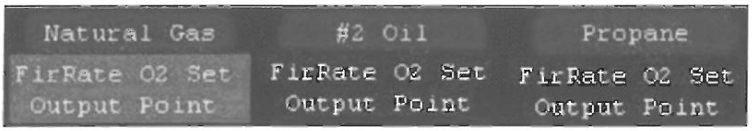

Figure 3-7 O2 Trim Setup Screen details

Under the name of the fuel there are columns for setting set points for O2 trim control. First column is for the firing rate output. Second column is set point, which corresponds to the firing rate output on the left. Active fuel is highlighted with green color.

There are total of 12 break points for setting set point.

Under the last set point row, there are indicating push buttons for setting low and high O2 trim control output limits. Each fuel has its own set of high and low output limits push buttons.

To the right of the third set of set points columns there is a column with "Store" push buttons. These push buttons are used for setting O2 trim set points.

Notice

"Store" push buttons are displayed only when O2 trim control is in a manual mode, O2 analyzer is active (Maintenance Mode is not displayed) and fuel valve (valves) are energized.

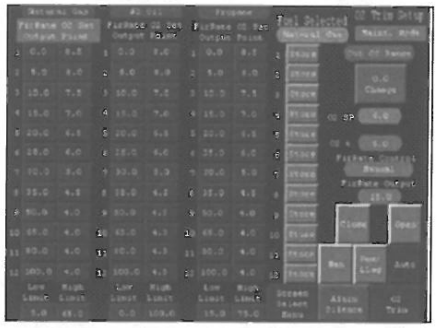

Figure 3-6 O2 Trim Setup Screen

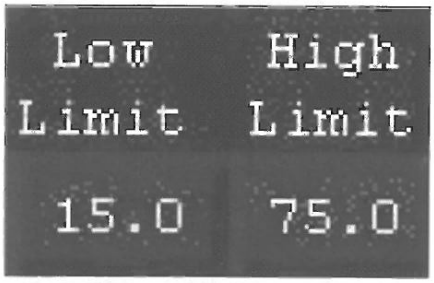

Figure 3-8 O2 Trim Setup Screen details

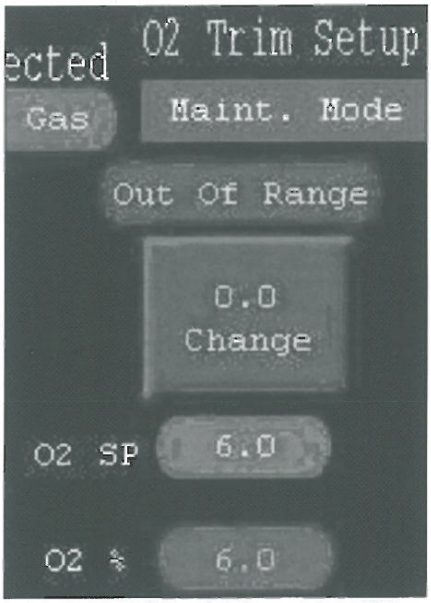

Figure 3-9 O2 Trim Setup Screen details

Right side of the Set Up Screen.

Screen name is displayed on the top. Under the screen name there is a "Maintenance Mode" indicator. If this display is active it is an indication that Oxygen Analyzer is not in normal operating mode. Please refer to the Analyzer manual to correct this problem.

Change button is used for changing set point value.

O2 SP is an indicator of the O2 trim set point at the present firing rate output.

O2% is an indicator of the actual Oxygen value in the flue gases.

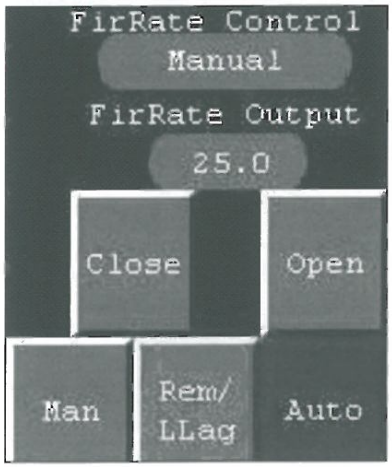

Figure 3-10 O2 Trim Setup Screen details (Firing Rate Control)

Below the O2 value indication is the firing rate control functions. Firing rate control can be switched between "Auto", "Manual" and "Remote/LeadLag" (if used). There are also "Close" and "Open" push buttons to control firing rate in the manual mode.

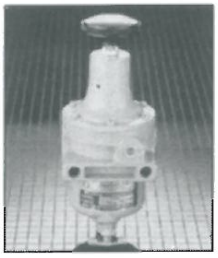

Figure 3-11 Air Pressure Regulator

Loosen the lock nut on the air pressure regulator. Set the instrument air to 20 psig by rotating the adjustment screw on the top of air pressure regulator. Tighten the lock nut.

B. Checking the setting of the analyzer (Yokogawa analyzer only)

Please refer to the analyzer manual for procedures for setting O2 calibration. Set analyzer's parameters similar to Table 1-1

It is recommended to perform a two point calibration prior to placing O2 trim system into operation.

C. I/P Transducer Calibration (Fuel trim only)

1. Turn the boiler off.
2. Select O2 trim screen.
3. Place O2 trim in "manual" mode.
4. Decrease control output until control output is equal 0.0.
5. The pressure gauge on the I/P transducer must display 3 psig. If not, adjust pressure by turning transducer's "zero" adjustment screw.
6. Increase control output until control output is equal 100.0. The pressure gauge on the I/P transducer must display 15 psig. If not adjust pressure by turning the I/P transducer's "span" adjustment screw.

Repeat steps 5 and 6 until stable readings are achieved.

Figure 3-12 I/P Transducer

Notice

When performing I/P transducer's calibration, make sure that "Low Limit" and "High Limit" on O2 trim set up screen are set to 0.0 and 100.0 respectfully.

D. Installation – Oil (Fuel trim only)

Connections A and B are used to add atomizing air pressure to the adjustment spring of the fuel oil pressure regulator. A light oil unit normally does not have a back pressure regulator or connection B.

If the boiler uses these feedback connections, disconnect and remove tubes from connections A and B. Plug the opening in the main atomizing line. Because of this disconnection, the oil flow cam setting and fuel pressure will also have to be readjusted. The pneumatic signal line from the I/P transducer is connected to the spring housing of the oil pressure regulator. If the burner is equipped with a backpressure-regulating valve, leave the unplugged fitting in the cover so it is open to the atmosphere. If the fitting is not facing down, aim it downward to eliminate possible plugging with dust.

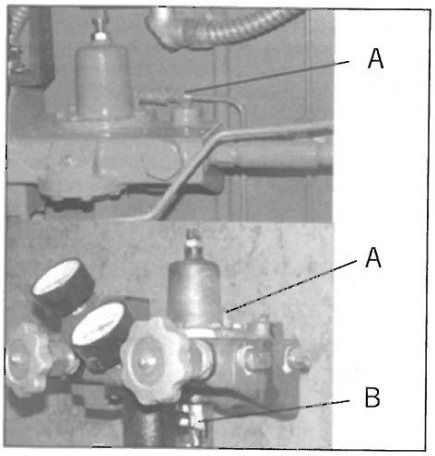

Figure 3-13 Fuel Trim Oil (Typical)

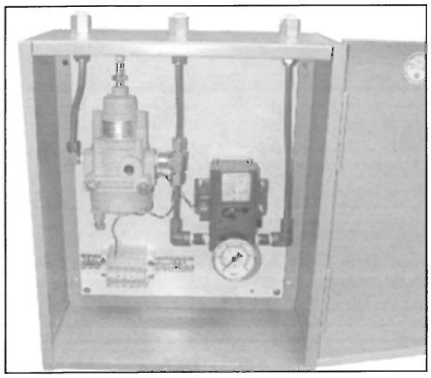

Figure 3-14

E. Adjustment – Oil (fuel trim only)

The air pressure signal from the I/P transducer is applied to the upper side of the PRV diaphragm in the Cleaver-Brooks Fuel Oil Controller. The full 3 to 15 psig span of the output is used to vary the fuel flow to the burner. A change of approximately ±9% in fuel flow is expected from the range of force applied.

⚠ Caution

The following adjustments must ONLY be performed by a qualified burner service technician fully familiar with burner operation.

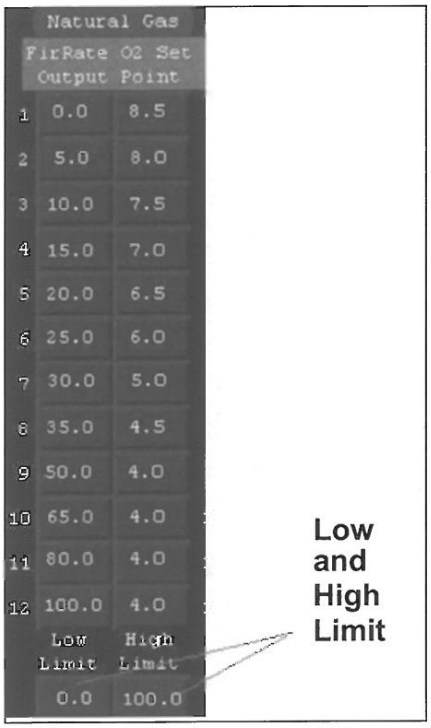

Figure 3-15 Low and High limit

1. Select "O2 Trim Set Up" screen. Make sure that "Low Limit" and "High Limit" are set to 0.0 and 100.0 respectfully. If not set them to these values using change and low and high limits push buttons.
2. Select "O2 Trim" screen. Switch controller to the manual control. Adjust control output to 50.0%.
3. Select "O2 Trim Set Up" screen. **Figure 3-4**
4. Switch firing rate control to the "Manual" mode **Figure 3-16**

5. Turn the boiler ON and slowly increase firing rate by pressing "OPEN" push button.

Note: If combustion air ratio has not been previously set up, make rough adjustments at each cam screw position.

6. When the firing rate control is increased to 100.0% (burner at high fire), adjust oil flow to get desired O2 level. Press "Store" push button at the row 12.

Figure 3-17 Store

Firing rate output and O2 set point values in row 12 in the Oil column should change to the desired numbers.

7. Decrease firing rate one screw at the time. Once the fuel/air ratio at the given firing rate is adjusted, press "Store" push button at the respective row.

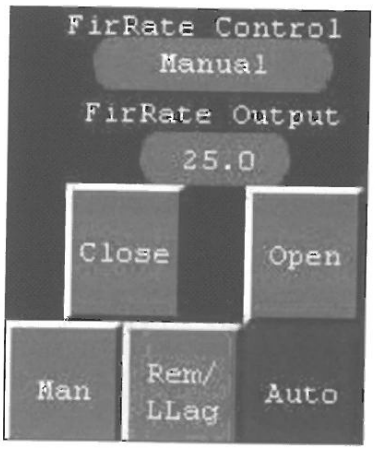

Figure 3-16 Manual Indication

Notice

Set point value can be stored only when control output value at given point is greater than control output at the lower point and less than the value at the higher point. Example: Adjustment is made at the screw #5 with firing rate control output 14.5%. Firing rate control output default value at screw #4 is 15%. This point is invalid since firing rate control output at the previous point is greater than at the point being adjusted. There are two ways to correct it:

a Increase firing rate to the greater than 15%.

b Change firing rate control output value at the screw #4. To do it, press "Change" push button. Key in value less than 14.5% and press enter. Press push button corresponding to the firing rate control output in row 4 under Oil column.

8. Points have to be set at all 12 cam screw positions.
9. Run the burner between low and high fire several times to insure that settings are correct.
10. Select "O2 trim" screen and change control to "Auto" mode. If necessary make adjustments to Pgain and Igain to get desired control response.

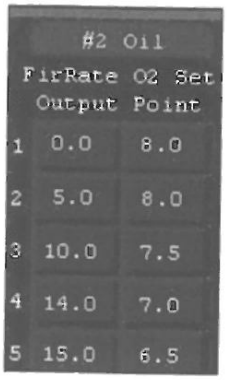

Figure 3-18 Output

Alternate method of O2 trim adjustment

1. Repeat steps 1 through 5 from above.
2. When firing rate control is increased to 100.0% (burner at the high fire), adjust oil flow to get desired O2 level.
3. Make adjustments at each cam screw position. Fill in the following table.

Screw #	Firing Rate Control Output%	O2%
12 (High Fire)		
11		
10		
9		
8		
7		
6		
5		
4		
3		
2		
1 (Low Fire)		

4. Manually input points using "Change", "Firing Rate Output" and "O2 Set Point" push buttons.
5. Points have to be set at all 12 cam screw positions.
6. Run the burner between low and high fire several times to insure that settings are correct.
7. Select "O2 trim" screen and change control to "Auto" mode. If necessary make adjustments to Pgain and Igain to get desired control response.

F. Adjustment – Gas (Fuel trim only)

A pneumatic actuator (**Figure 3-19**) is attached to the gas pressure regulator to provide the means of increasing and decreasing the regulated gas pressure by relatively small amounts. Before mounting the actuator, rough adjustments of the combustion must be made. When the actuator is ready to be installed, shut the burner down or operate it on oil if it is a combination fired burner. For safety's sake, eliminate gas pressure on the regulator's diaphragm by shutting off the upstream gas cock. Remove the cap from regulator. If an actuator extension is necessary, measure the distance from the top of the regulator neck to the spring retainer (dimension "X" on **Figure 3-19**). Mark this distance on the actuator adapter (the distance from the top of the actuator spring retainer to the actuator adapter). Remove the regulator spring tension screw. Screw the actuator adapter into the regulator, neck up, to the mark that was just made. Attach the pneumatic signal line to the top of the actuator.

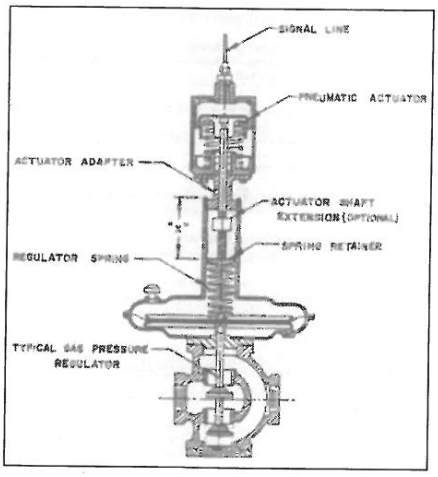

Figure 3-19 Gas Pressure Regulator with pneumatic actuator

For some specific regulators, an actuator shaft extension is supplied to compensate for a long regulator neck. The shaft extension may have to be shortened with a hacksaw to an appropriate length. This length is determined by the previous method of locating the distance from the regulator neck down to the spring screw. Also allow additional shaft extension length so that when the actuator adapter is screwed into the regulator neck, there will be at least four threads exposed on the regulator neck. Once the shaft extension length is fixed, remove the regulator spring tension screw. Screw the actuator adapter into the regulator neck down to where approximately four threads are engaged. Attach the pneumatic signal line to the top of the actuator.

When trimming gas, the output air pressure signal is applied to the air cylinder mounted on a top of the gas pressure regulator. The shaft of the cylinder exerts a force on the regulator spring to provide small changes in the regulated gas pressure. This pressure change is sufficient to cause a maximum change of ±9% in gas flow.

⚠Caution

The following adjustments must ONLY be performed by qualified burner service technician fully familiar with burner operation.

1. Select "O2 Trim Set Up" screen. Make sure that "Low Limit" and "High Limit" are set to 0.0 and 100.0 respectfully. If not, set them to these values using change and low and high limits push buttons.

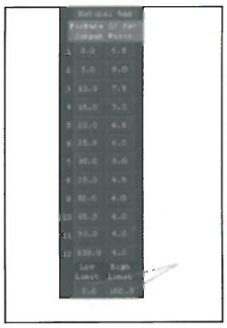

Figure 3-20 Low High Limit

2. Switch firing rate control to the "Manual" mode.
3. Turn the boiler ON and slowly increase firing rate by pressing "OPEN" push button.

Note: If the combustion air ratio has not been previously set up, make rough adjustments at each cam screw position.

4. Increase the firing rate to approximately screw #4. Make a record of the gas pressure at the gas train inlet and O2 level in flue gas.
5. Select "O2 trim screen". Put the control in manual mode. Make sure that control output is 0.0.
6. Slowly increase output of the O2 trim control until the gas pressure starts to change. Make a record of the O2 trim control output at this point. This is a low limit of O2 trim control output for gas fuel. Make a record of the O2 level.
7. Slowly increase output of the O2 trim controller until the O2 level reaches the level per the table **Table 3-1**. This is the high limit of O2 trim control output for gas fuel.

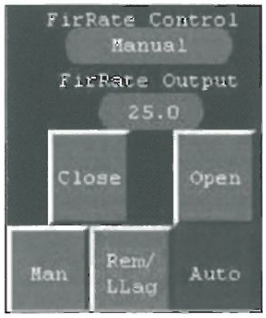

Figure 3-21 Firing Rate Control

Table 3-1 Initial O2 Trim Maximum Limits

Initial O2%	O2% at maximum limit
10	8.85
9.5	8.24
9	7.62
8.5	7.00
8	6.37
7.5	5.73
7	5.09
6.5	4.44
6	3.79
5.5	3.13
5	2.46
4.5	1.78

Example: Initial O2 = 6.5%. Locate 6.5 value in the "Initial O2%" column. O2 value at the maximum actuator travel is in the same row to the right. In this example it is 4.44%.

8. Select "O2 Trim Set Up" screen.
9. Change the "Low Limit" for the gas fuel to the value recorded in the step 6. Change the "High Limit" for the gas fuel to the value recorded in the step 7. This can be done by using the "Change", "Low Limit" and "High Limit" push buttons.
10. Select "O2 Trim" screen. Set control output to 50%.
11. Select "O2 Trim Set Up" screen.
12. Slowly increase firing rate.

Note: If combustion air ratio has not been previously set up, make rough adjustments at each cam screw position.

13. When firing rate control is increased to 100.0% (burner at the high fire), adjust gas flow to get desired O2 level. Press "Store" push button at row 12.

Figure 3-23 Press Store

Firing rate output and O2 set point values in row 12 in the Gas column should change to the desired numbers.

14. Decrease the firing rate one screw at the time. Once the firing rate at the given position is adjusted, press the "Store" push button at the respective row.

Notice

Set point value can be stored only when control output value at a given point is greater than control output at the lower point and less than the value at the higher point. Example: Adjustment is made at the screw #5 with firing rate control output 14.5%. Firing rate control output default value at screw #4 is 15%. This point is invalid since firing rate control output at the previous point is greater than at the point being adjusted. There are two ways to correct it:

a Increase the firing rate to greater than 15%.

b Change the firing rate control output value at screw #4. To do this, press the "Change" screen button. Key in the value less than 14.5% and press enter. Press the push button corresponding to the firing rate control output in row 4 under the Gas column.

15. Points have to be set at all 12 cam screw positions.
16. Run the burner between low and high fire several times to insure that settings are correct.
17. Select the "O2 trim" screen and change the control to "Auto" mode. If necessary make adjustments to Pgain and Igain to get desired control response.

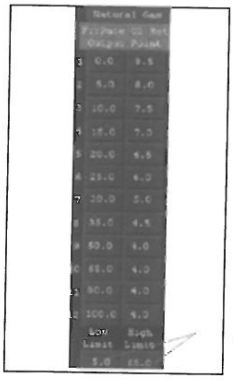

Figure 3-22 Low Limit and High Limit Set

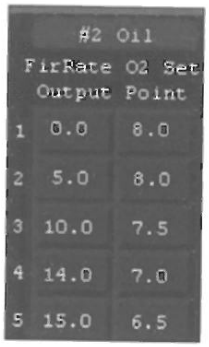

Figure 3-24 Input

Alternative method of O2 trim adjustment.

1. Repeat steps 1 through 4 from above.
2. When firing rate control is increased to 100.0% (burner at the high fire), adjust gas flow to get desired O2 level.
3. Make adjustments at each cam screw position. Fill in the following table.

Screw #	Firing Rate Control Output%	O2%
12 (High Fire)		
11		
10		
9		
8		
7		
6		
5		
4		
3		
2		
1 (Low Fire)		

4. 8) Manually input points using "Change", "Firing Rate Output" and "O2 Set Point" push buttons.
5. Points have to be set at all 12 cam screw positions.
6. Run burner between low and high fire several times to insure that settings are correct.
7. Select "O2 trim" screen and change control to "Auto" mode. If necessary make adjustments to Pgain and Igain to get desired control response.

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Section 4

O2 Trim Commissioning

Systems with integrated parallel positioning

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A. O2 trim commissioning (systems with integrated parallel positioning)

Please refer to the integrated parallel positioning manual (O&M part number 750-217) for setting combustion curves, including the O2 trim curve.

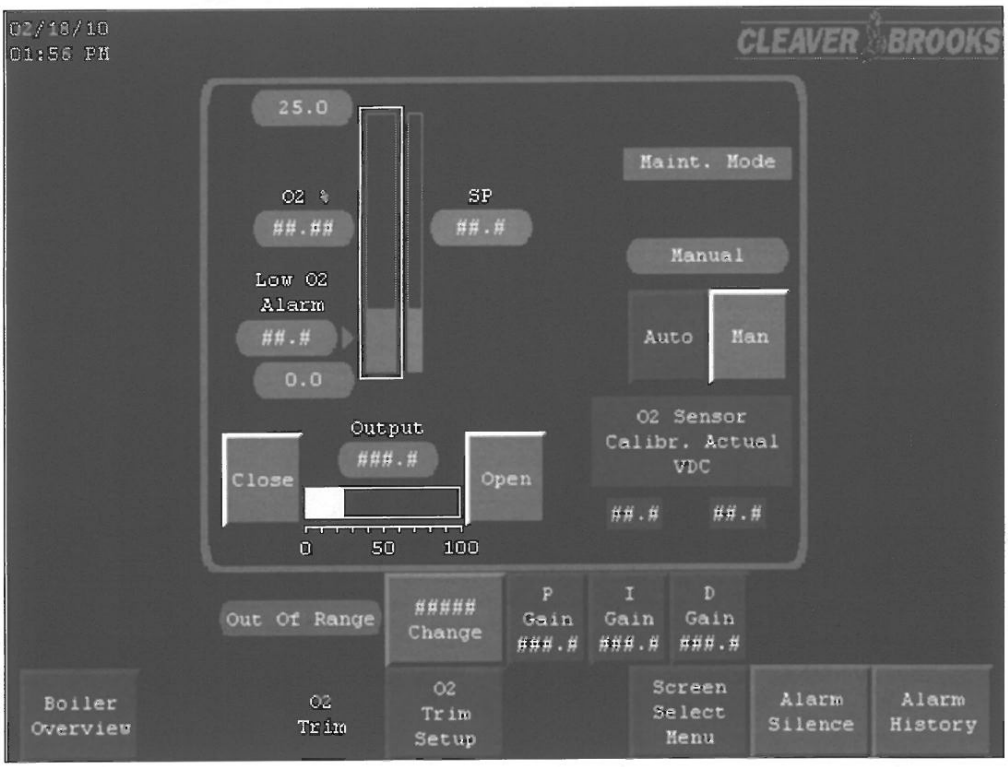

Figure 4-1 O2 Trim Screen

The Hawk ICS O2 trim screen provides the operator with access to the control functions of the O2 trim option.

<**Auto**> - Output of the O2 trim varies according to the oxygen level in the flue gas compared to the set point.

<**Manual**> - The output of the O2 trim control loop can be varied with <**Close**> and <**Open**> buttons.

It is recommended to use <**Auto**> selection during normal operation. To prevent unauthorized personnel from selecting <**Manual**> operation, the <**Manual**> button has to be pressed and held for more than 2.5 seconds to allow the switch to manual mode.

The control output is shown on the horizontal bar graph as well as a numerical value.

The following information is also displayed on the O2 trim screen.

O2 – Actual Oxygen level content in the flue gases at the boiler outlet.

Output – A bar graph represents the output signal being sent to the O2 trim actuator (gas) or oil pressure controller (oil). The control output is represented from 0 to 100%. The actual number is repeated above the barograph.

SP – O2 trim set point. Set point is based on the firing rate and fuel fired.

Low O2 Alarm – Value at which low O2 alarm is activated.

O2 trim loop uses advanced PID control algorithm. The following buttons are provided for control tuning.

P Gain - Proportional gain value.
I Gain - Integral gain value.
D Gain - Derivative gain value.

Change button is used to modify PID parameters.

PLC Output Parameters (VSD %)

High limit	This is the maximum frequency for the combustion air fan motor with no O2 trim correction applied. 100% = 60 Hz. Default value is 100%.
Low limit	This is the minimum frequency for combustion air fan motor with no O2 trim correction applied. Default value (also the lowest limit) is 70% = 42 Hz
Trim Corr.	This is the maximum O2 trim correction value. Default value is 20%. This means that the maximum correction to the combustion air fan speed is +/-10%.
Actual Output	Output from the PLC to control the VSD, where 0% = 4 ma , 100% = 20 ma

B. CB Voltage O2 trim system only

If the **CB Voltage O2 trim** is selected, the **Auto air calibration** will appear on the O2 trim Screen, See **Figure 4-2**. At the end of the purge cycle the Voltage output of the controller gets recorded (4.0 to 6.0 VDC) and gets stamped by 20.8 % O2. That would be the O2 air calibration. The Hawk ICS takes the measured voltage and makes it, the calibrated voltage for sensor in air. This calibration always takes place at the end of each and every purge cycle.

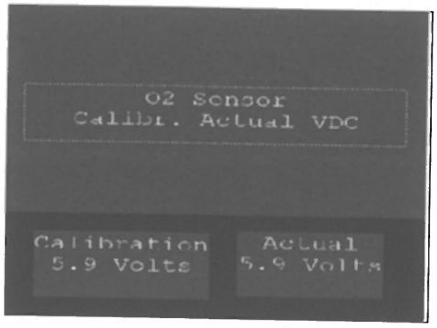

Figure 4-2 O2 Sensor Calibration and Actual Analyzer Voltage

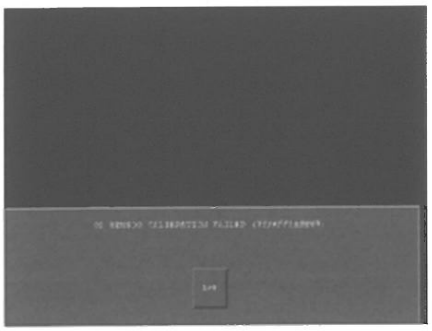

Figure 4-3 Alarm Banner

If the reported voltage is bellow 4.0 Volts the Hawk ICS fails the sensor and displays an Alarm Banner stating the Calibration Failure (**O2 SENSOR CALIBRATION FAILED**), and the Hawk ICS disables the O2 trim and displays zero (0) for all O2 levels.

The boiler will continue operating without activating the O2 Trim controls.

Make sure to check the root cause of the failure, refer to troubleshooting section of this manual.

C. Troubleshooting

This section applies only to the O2 trim system. For general HAWK ICS troubleshooting or for other features of the system please refer to the following table for manual part numbers.

Table 4-1 Manual Part Numbers

	Manual Name	Manual Part Number
1	Hawk ICS Boiler Controls	750-229
2	Parallel positioning Combustion Control	750-217
3	Variable Speed Drive	750-198

Problem	Possible Cause	Corrective Action
"O2 measurement " Indicator is not present on the Boiler Overview screen or any other screen.	O2 trim control is not selected.	From "Configuration 1 Screen" Select "yes" for O2 Analyzer.
"O2 trim" screen selector pushbutton is not on the Screen Select Menu	O2 trim control is not selected.	From "Configuration 1 Screen" Select "yes" for O2 trim.
No O2 measurement	Wrong wiring, bad electrical connections, O2 Sensor or analyzer failure.	Check for proper wiring, Check for solid electrical connections. Make sure that the analyzers outputs to the Hawk ICS are detecting 20mA when sensor in Air, if not follow sensor and analyzers troubleshooting instruction to resolve and fix the failure.
No O2 trimming	O2 trim control is not selected.	From "Configuration 1 Screen" Select "yes" for O2 trim
O2 Trim Control OK, but all Data points for O2 on the set up tables are filled with Zeros	O2 trim Option is not selected	Select O2 trim option from "Config. 1" Screen.
CBO2-ICSA Failed Calibration	Sensor failure	Replace sensor
Yokogawa Calibration Failure	Sensor is out of calibration	Perform sensor calibration with zero and span calibrated gases, refer to Yokogawa manual for O2 calibrations instructions
Yokogawa Sensor Analyzer Erroneous O2 signal	Yokogawa Sensor Anaylzer Failure	Refer to Yokogawa manual for troubleshooting and proper sensor analyzer operations
Maintenance mode is displayed on O2 trim screen (Yokogawa sensor)	There is no input to PLC indicating normal state for analyzer.	Check for alarms on analyzer. Make sure that analyzer is operational. Check analyzer configuration. Check wiring to input 1 on slot 7. Make sure jumper is installed from terminal L1 to 6 on the analyzer.

Note: Refer to the Hawk ICS manual for all Hawk ICS related O2 trim or O2 monitoring failures attributed to the overall system integration. Check all Hawk ICS system modules and connections before you proceed in commissioning, starting O2 trim set up or boiler start up.

Notes

Notes

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