Flo-Cal

Online Calorimeter
User Guide
P/N 90-1208-0

Revision K

Part of Thermo Fisher Scientific

Thermo SCIENTIFIC

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Document Label Definitions		
Symbol	**Label**	**Description**
	**WARNING:**	Consists of conditions, practices, or procedures that must be observed to prevent personal injury.
	**CAUTION:**	Consists of conditions, practices, or procedures that must be observed to prevent injury or equipment damage.
	**CAUTION:**	Risk of electric shock or high temperature parts may result in injury if proper precautions are not taken.
	**CAUTION:**	Static Sensitive component. Appropriate handling required to prevent damage.
	**NOTE:**	Emphasizes important or essential information.

Please refer to Chapter 1 (page 1) for important safety information and instructions on how to use this manual.

Flo-Cal On-Line Calorimeter User Guide

Revision date **October 2007 – Rev K**
Part number **90-1208-0**

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Chapter 1

How to Use This Manual

This chapter includes important information that must be read and understood by all persons installing, using, or maintaining this equipment.

Safety Considerations

WARNING: ***Failure to follow appropriate safety procedures or inappropriate use of the equipment described in this manual can lead to equipment damage or injury to personnel.***

Any person working with or on the equipment described in this manual is required to evaluate all functions and operations for potential safety hazards before commencing work. Appropriate precautions must be taken as necessary to prevent potential damage to equipment or injury to personnel.

The information in this manual is designed to aid personnel in the correct and safe installation, operation, and maintenance of the systems described. However, personnel must consider all actions and procedures for potential hazards or conditions that may not have been anticipated in the written procedures. If a procedure cannot be performed safely, it must not be performed until appropriate actions can be taken to ensure the safety of equipment and personnel. The procedures in this manual are not designed to replace or supersede required or common sense safety practices. All safety warnings listed in any documents applicable to equipment and parts used in or with the system described in this manual must be read and heeded before commencing work on any part of the system.

Failure to correctly perform the instructions and procedures in this manual or other documents pertaining to this system can result in equipment malfunction, equipment damage, and injury to personnel.

The following symbols are used throughout this manual to alert users to potential hazards or important information. ***Failure to heed the warnings and cautions listed herein can lead to injury and equipment damage.***

Document Label Definitions		
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	**WARNING:**	Consists of conditions, practices, or procedures that must be observed to prevent personal injury.
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	**NOTE:**	Emphasizes important or essential information.

Figure 1. Symbols used to indicate potential hazards.

Locating Information

NOTE: *In the interest of completeness, manuals and drawings included with the system may provide information pertaining to options not included with your system. Information in application notes supersedes general information in these documents.*

Information can be located in this manual using any of the following aids.

Table of Contents

The Table of Contents (page i) provides information about the overall layout and organization of this manual. It should be used to locate major categories such as start up information and maintenance requirements.

List of Illustrations

The List of Illustrations (page v) should be consulted to locate drawings or other figures included in this manual.

Index

The Index (page 83) should be used for locating detailed information.

Getting Help

For information on how to contact Thermo Fisher service personnel by telephone, fax, or the internet, see the Getting Help chapter (page 63).

Glossary

The Glossary chapter provides general definitions for many of the technical terms used in this manual (see page 65).

Appendix

Appendices are included to provide detailed or supporting information related to the equipment described in this manual. The appendices can be found after the Getting Help chapter in this manual.

Instructions and Procedures

This manual makes extensive use of step-by-step instructions and procedures. The listed functions should be performed in the order shown to ensure proper functioning of the equipment. Particular attention must be paid to any safety warnings or cautions that may be listed.

WARNING: *Deviation from the specified instruction or procedure steps may result in equipment malfunction, equipment damage, or injury to personnel.*

General Safety and Operating Information

This section contains general safety and operating information applicable to analyzers and sample systems. This information must be understood by all persons installing, using, or maintaining the analyzer or sample system. This information is designed to aid personnel in safe installation, operation, and service of the analyzer and sample systems. It is not designed to replace or limit appropriate safety measures applicable to work performed by personnel. Any additional safety and operating measures that are required must be determined by and followed by personnel performing work on the system.

WARNING: ***Failure to heed the following information may lead to equipment damage or injury to personnel.***

General Precautions

Protective eyewear (glasses with side shields or goggles as appropriate) must be worn when servicing any part of the analyzer or sample system. When servicing the sample system, chemical resistant gloves appropriate for the materials in the system must be worn. When servicing the hot analyzer components (e.g., burner), or hot sample system components, appropriate gloves must be worn. Heated components should be allowed to cool before servicing if possible. Other appropriate equipment or clothing must be used as required by the type of work performed.

WARNING: *Ovens, internal components, and sample system components may be hot even when power is not applied to the unit. Take appropriate precautions to prevent injury from contact with hot items.*

All applicable regulations and procedures must be followed for the work performed. **Before** beginning any work on the system, carefully consider all the potential hazards and ensure that appropriate measures are taken to prevent injury to personnel or equipment damage.

Electrical Power

The system uses AC power at 115 or 230 volts. The AC power is converted to DC at several voltage levels including high voltage for the sparking unit. Appropriate precautions must be taken to prevent sparks that may ignite combustible materials that may be present in the analyzer environment. Precautions must also be taken to prevent electrical shock if the analyzer or sample system enclosures are opened.

The AC power to the system must be free from noise, surges, sags, and spikes for proper operation of the system. AC power circuit breakers and wiring must be sized properly for the required current. All wiring installations must meet applicable electrical codes.

System Location

The analyzer and sample system must be installed in a suitable location. The system must not be installed in an area classification for which it is not rated. The equipment must be protected from temperature and humidity extremes. The analyzer must not be mounted in an area with potentially corrosive atmosphere or high vibration. The system components must be attached securely and appropriately to a floor or wall. The system must be mounted to permit adequate access for operation and maintenance.

Bottle Gas

WARNING: *Flo-Cal applications may use bottled gases. These bottles may have very high pressures and may result in serious injury to personnel if the bottle valve is opened without a regulator attached or if the valve is broken off the bottle. See the following paragraphs for more information.*

WARNING: *Flo-Cal sample and calibration gases are highly combustible. Sample or calibration gas leaks in confined spaces can lead to explosive concentrations. Appropriate precautions must be taken to ensure the safety of personnel.*

The Flo-Cal system may use one or more bottle gases. The bottle gases may contain very high pressure. Severe injury to personnel and equipment can occur if the bottle gas valve is damaged or opened without installing an appropriate regulator. A protective cap must be in place over the bottle valve any time the bottle is moved. Do not move a bottle with the regulator attached or if the protective cap is missing. Bottles must be securely chained in place at all times when the protective cap is removed.

Gas type and locations must be clearly marked to prevent connecting the wrong gas type to the system. Bottles with combustible gases must not be installed in confined areas. Appropriate measures must be taken to ensure that explosive mixtures are not produced in case of bottle gas leaks.

Air for fueling the flames must be free from hydrocarbons, moisture, or other contaminants to prevent noisy operation, inaccurate readings, or other problems.

Sample and Calibration Standard

The measured sample and calibration standard are flammable and may be otherwise hazardous to humans or the environment. Appropriate precautions must be taken to avoid ignition of the sample, exposure of personnel, or environmental contamination. Sample and calibration standard is typically pressurized. Special precautions must be taken any time the sample or calibration systems must be opened for service to ensure that all pressure is removed from the system and that hazardous material is removed.

Sample and calibration standard must be representative of actual conditions. Process sample must be delivered to the analyzer in a timely manner while ensuring that component concentrations are not modified by sample conditioning. Lag times must be small enough to ensure a fresh sample for analysis.

Filters

Filters may be used to reduce sample system maintenance requirements by removing particulate material from the sample. Periodically, filters must be replaced or cleaned. All pressure must be removed from the filter before servicing. The filter and associated sample system must be decontaminated appropriately before removal or service. Used filters or filter elements must be disposed in compliance with all applicable regulations for the potential materials filtered and the material from which the filter was constructed. Replacement filters or elements must be of the correct porosity and material for the application.

Valves

Valves must be properly labeled to prevent incorrect alignment. Valves can leak through or leak out. When opening the sample system, precautions must be taken to prevent injury to personnel or damage to equipment in the event that a valve leaks or is misaligned.

Before removing or disconnecting any valve, hazardous materials must be thoroughly removed from the valve internals and all pressure must be relieved. When installing a new or serviced valve, all fittings and surfaces must be checked for leaks.

Vents

Vents are used to expel the spent gases from the analyzer system. The vents must be routed to a safe location as necessary to prevent injury to personnel. Backpressure on vents must be kept to an absolute minimum to prevent degrading system performance. Long vent runs must be avoided. Precautions must be taken to ensure that condensate cannot accumulate in vent lines.

Chapter 2

Specifications

Results may vary under different operating conditions.

Features
Fast response for Wobbe Index and Calorific Value measurements
Specific Gravity measurement (optional on Calorific Value instruments only)
High reliability and low maintenance
Modbus® protocol
Menu driven parameter entry
Non-intrusive magnetic keypad
Remote Windows® workstation option
Dual level alarms
4 - 20 mA analog output
Enhanced accuracy with optional microprocessor Auto-Calibration
Auto switching capabilities for external sample calibration checks
Flame safety automatic interlock

Hardware Specifications	
Dimensions	42" H, 22" W, 14.5" D (1.07m H, 0.56m W, 0.37m D), general purpose unit (Model 7000) 77" H, 38" W, 27" D (1.9m H, 0.95m W, 0.68m D), explosion proof unit (Model 5000)
Weight	≈ 150 lbs. (68 kg), general purpose unit ≈ 550 lbs. (250 kg), explosion proof unit
Mounting	Wall mounting enclosure, standard. Freestanding rack, freestanding enclosure, or temperature controlled enclosure, optional.
Ambient Temperature	Temperature controlled ± 15° F. Suitable enclosures are available as options.
Area Classification	General purpose or Class 1, Div 1, Group B optional
Process Sample Connection	1/4" tube fittings
Instrument Air Connection	1/2" tube fittings
Power & Signal Inlets	1/2" NPTF (each)

Analytical Specifications	
Modes of Operation	Wobbe Index or Calorific value (BTU/SCF, MJ/Nm^3 or Kcal/Nm^3)
Measuring Range	Up to 2500 BTU/SCF (25,000 Kcal/Nm^3), standard, where the upper value is twice the lower value. Extended range is available (40 - 100% of scale).
Accuracy	± 1.0% of upper range value, ± 0.5% of upper range value with optional auto calibration
Repeatability	± 0.3% of upper range value
Linearity	± 0.2% of upper range value
Response Time	6-8 seconds plus sample transport time, typical (Units measuring heat values below about 800 BTU may have longer response time.)
Automatic Calibration	Optionally available

I/O Specifications	
Display	Local display for maintenance use: 2-line, 16-character alphanumeric, backlit LCD
Operator Control	Uses non-intrusive magnetic sensors behind the keypad for operation
Network Output	2- or 4-wire RS-485 or RS-232, Modbus protocol
Analog Output	Continuous, isolated 4-20 mA DC, maximum load of 750 ohms.
Alarm Contacts	Dry contacts, 1 amp @ 30 volts or 0.5 amp @ 125 volts resistive loads (standard). (flame out, over range, and user defined alarms)

Sample Requirements	
Flow Rate	500 - 2500 cc/min (depending on gas heating value). There must be no liquid in the sample. Use a membrane filter if necessary.
Pressure	For general purpose (Model 7000), 3 - 60 psig constant pressure (7 - 414 kPa). Consult Thermo Fisher for other conditions. For Class I, Div 1 (Model 5000, explosion proof), the unit's inlet pressure cannot exceed 5 psig and it cannot work properly with less than 3 psig constant pressure. For fluctuating pressures less than 3 psig, use of a sample pump is recommended. Consult Thermo Fisher for other conditions.

Utility Requirements	
AC power	115 ± 10% VAC, 50/60 Hz @ 5 amps maximum, standard 220 ± 10% VAC, 50/60 Hz, optional
Instrument Air	For the Model 7000, 60 - 125 psig (414 - 862 kPa) @ 2.5 to 6.0 SCFM (71 - 170 l/m) depending on gas heating value. Air must be dry and oil free. An optional air blower is available for general purpose models.

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Chapter 3

Introduction

Description

Flo-Cal On-Line Calorimeters are used in feed forward control and high-speed gas blending operations where continuous measurement of the gas heating value is required. The fast response, reliable operation, and ease of maintenance and calibration of the Flo-Cal have made Thermo Fisher the world leader in Wobbe Index and Calorific Value calorimeters.

Recent enhancements to the physical and electronic design of the Flo-Cal have resulted in an even more stable and versatile instrument. For example, ambient temperature variations have even less effect on Flo-Cal measurements than before. In addition, the new Modbus output capabilities make the Flo-Cal easier to integrate into plant control systems.

This manual covers the general purpose Model 7000 and the explosion proof Model 5000.

Applications

Where the fuel gas composition varies, the heating characteristics vary. The Flo-Cal is a necessary tool to efficiently use the available energy of the fuel gas. Because of its rapid response and reliability, the Flo-Cal is typically used in the following applications.

- Feed Forward Combustion Control
- Mixing and Blending of Gas Streams
- Gas Quality Monitoring for manual adjustments, cost checking of gas suppliers, and for burning equipment testing

The industries that have successfully used Flo-Cal calorimeters include the following.

- Refining and Petrochemical
- Steel Gas Production and Distribution
- Coal Gas
- Cogen Plants
- Fiberglass
- Carbon Black
- Landfill Gas
- Flare Gas
- and many other applications

Modes of Operation

The Flo-Cal has two basic modes or operation: Wobbe Index and Calorific Value. Wobbe Index provides a meaningful measure of the actual heating characteristics of fuel gas. It is derived from the basic heat flow equation with Wobbe Index defined as the Calorific Value divided by the square root of the specific gravity. Wobbe Index measures the combined effects of fuel gas composition changes.

Calorific Value is the heat value of the gas at standard conditions expressed as Gross Heating Value or Net Heating Value. Gross Heating Value is the theoretical heat value of the gas at standard conditions. Net Heating Value is the actual available heat value of the gas at standard conditions. Net Heating Value is frequently used in calculations to determine the heat potential for the gas.

Theory of Operation

Standard Operation, Wobbe Index

The Flo-Cal Calorimeter is a high-speed (6 to 8 seconds response) instrument. The variations in the rate of heat released from a continuously burning gas are fed back via a thermal expansion element to a flapper-nozzle control system, which adjusts the flow of cooling air to the air orifice and subsequently the burning chamber. The varying flow of air is used to control the temperature of the combustion products. This yields an air flow rate that varies according to the heat released by the gas. Measuring the airflow provides a direct measurement of the heat value of the burning gas.

A continuous stream of gas enters a precision gas regulator in the Flo-Cal calorimeter. This precision gas regulator controls the pressure of the gas flowing into the calibrated gas orifice of the burner.

Air is delivered to the air control valve by either a blower or an air regulator supplied by an instrument air source. The air control valve regulates the flow of air through the air orifice to the burner. Part of the air supplied to the burner is mixed with the gas for combustion while the remainder serves as a heat exchange medium around the burning chamber.

A safety shutdown system prevents gas flow to the burner in the event of low air inlet pressure, or low gas inlet pressure. The air and gas pressure switches are normally open. When air and gas minimum pressures are reached, the switches close to energize the gas solenoid valve allowing gas flow to the burner.

A mixing baffle at the top of the burning chamber mixes the heat exchange air with the products of combustion. The hot mixture passes over a thermal expansion element, the length of which varies as a direct function of temperature. A freely hinged lever held by a spring in contract with the thermal expansion element has a vane attached to it at its lower end. The vane and control jet are called a flapper-nozzle system. The flapper-nozzle system works as follows.

The vane restricts the flow of air from the control jet. The latter is fed from the air inlet line through a restriction orifice. A change in the vane restriction causes a change in the airflow rate out of the control jet. The backpressure generated by this change results in a load alteration within the air control valve. An increase in the load on the air control valve diaphragm causes an increase in the airflow through the valve. The airflow varies to maintain a constant temperature at the thermal expansion tube. Compensation tubes adjust for temperature changes in the incoming air, so that the net effect is a constant differential temperature of the air.

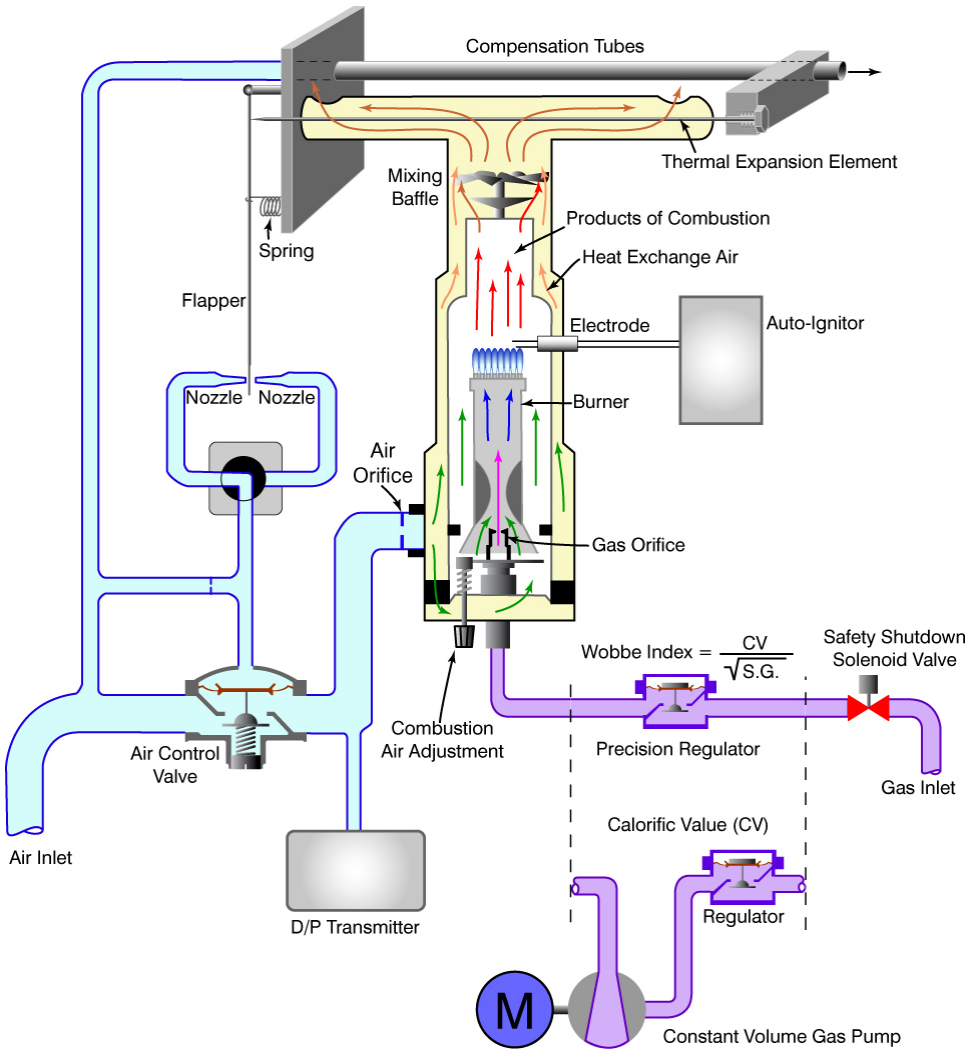

Figure 2. Flo-Cal functional diagram.

The pressure across the air orifice is measured by a differential pressure transducer. The pressure differential across the air orifice is an indication of a change in flow rate of the air. This is proportional to the measured heat value within the calibrated range of the Calorimeter. A meaningful measure of the actual heating characteristics of the sample gas is the Wobbe Index. The Wobbe Index is derived from the basic heat flow equation and is defined by the following equation.

$$\text{Wobbe Index} = \frac{\text{Calorific Value}}{\sqrt{\text{Specific Gravity}}}$$

In this equation, Calorific Value is defined as the unit of heat energy per unit standard volume and can be measured in BTU/SCF, MJ/Nm^3, or Kcal/Nm^3.

The standard Calorimeter measures the Wobbe Index value of a sample gas. The measured heat value is output as a 4-20 mA DC signal with an optional Modbus output available. Alarm outputs are also available.

The Calorimeter has an auto-ignitor to re-light the burner in case of a flame-out. A flame-out may occur when the system is subjected to power dips or loss of gas or air pressure. This causes the sample gas heat value to go below the low range of the instrument. The auto-ignitor will relight the burner and put the instrument back in operation within a few seconds.

The auto-ignitor was designed to operate in conjunction with a protection interlock system within the calorimeter to ensure positive lighting of the flame and shutdown of the instrument as the conditions dictate. When a flame-out occurs, the system checks the inlet air and gas pressure switches. If both pressures are above the minimum, a solenoid valve opens allowing gas to flow into the burner, and the auto-ignitor sparks to light the flame. The auto-ignitor stops sparking when the flame-out pressure switch indicates a pressure above 0.6" WC.

Calorific Value Instruments

The Flo-Cal Calorimeter may be configured to measure Calorific Value instead of Wobbe Index. This configuration includes a constant volume (CV) positive displacement metering pump on the gas inlet. The Calorimeter measures the net calorific value of the sample gas or, with a calculated offset, the gross calorific value. As with the Wobbe Index, the Calorific Value is usually measured in BTU/SCF, MJ/Nm^3, or Kcal/Nm^3. The calorific value is defined as the heat value of a gas per unit volume at standard conditions. Unit volume is measured for 30" Hg at 60° F for BTU/SCF measurements and 760 mm Hg at 0° C (i.e., STP) for Kcal/Nm3 or MJ/Nm3 measurements.

Calorific value is expressed as Gross Heating Value or Net Heating Value. Gross Heating Value is the theoretical heat value of the sample gas at standard conditions. Net Heating Value is the actual available heat value of the gas at standard conditions. This is the gross heating value minus the latent heat of vaporization of the water vapor formed during the combustion process.

The heating value of the gas being measured is affected by its moisture content. The calorimeter is typically calibrated for dry gas. It can be calibrated for a saturated gas.

Pressure Transmitter

The Calorimeter uses a programmable low-pressure transmitter for accurate pressure measurement. The microprocessor-based transmitter monitors the pressure at the air orifice and produces a continuous 4-20mADC output signal that is proportional to the heat value of the measured gas. See page 47 for more information on the pressure transmitter.

Safety Features

The Flo-Cal calorimeter includes several safety features as described in the following paragraphs.

Low Inlet Air Pressure

If the inlet air pressure drops too low, the calorimeter will shutdown and close a solenoid to shut off gas flow to the burner. See page 30 for inlet air pressure switch adjustment.

Low Inlet Gas Pressure

If the inlet gas pressure drops too low, the calorimeter will shutdown and close a solenoid to shut off gas flow to the burner. See page 31 for inlet gas pressure switch adjustment.

Flame-Out Detection and Relight

The pressure of the air entering the burner is monitored. When the burner flame goes out, the air pressure drops to 0.4" WC. This pressure drop is sensed by the flame-out pressure switch to initiate attempts to relight the flame. If the sparking unit fails to relight the flame in a few minutes (see page 33), the calorimeter closes the solenoid valve on the gas inlet, removes power from the CV pump (if installed), and turns off the sparking ignitor. The instrument must be reset (with a push-button on non-explosion proof units or by cycling the power to explosion proof units) before the flame will attempt to relight after a flame-out shutdown. See the appendix beginning on page 69 for more information on the flame-out system.

Overrange Detection

If the measured heat value exceeds the maximum range of the unit, the system will automatically extinguish the burner. After five minutes, the system will relight the burner. Alarm 2 on the transmitter is used to set the overrange value. See the appendix beginning on page 69 for more information on the overrange detection system.

System Options

Following are some of the options available with the Flo-Cal calorimeter.

- Constant volume gas pump for Calorific Value measurements
- Auto-calibration with auto switching sampling system
- Gas enrichment system for expanded range, low quality gas, or hard to light gas
- Pumping station for applications with < 3 psig sample gas pressure.
- Pressure reduction for applications with high sample pressures.
- Sample conditioning systems
- CSA approval
- Specific gravity measurement with typical range of 0.2-0.6 at an accuracy of better than ± 1% of full scale value.

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Chapter 4

Installation

WARNING: *Before attempting to install the Flo-Cal analyzer, review the material in chapter one in this manual and all safety information in this manual and all other applicable documents.*

WARNING: *Applicable permits must be obtained and appropriate precautions must be taken to prevent possible injury to personnel or equipment damage when installing the system.*

System Mounting

The Flo-Cal is shipped with the *Flo-Cal User Guide*, application notes, drawings, and applicable vendor data sheets. Review all of the material prior to installing the instrument. If you have any questions, please contact your local representative or the factory (see page 63).

Unpacking and Inspection

The Thermo Scientific Flo-Cal is typically packaged in one crate for shipment. Other boxes may be included in some applications. Open all the boxes carefully. Unpack each box and check the contents against the packing list found in each box to be sure that all of the parts are included.

WARNING: *The Flo-Cal is large and heavy. Do not attempt to unpack or move the analyzer without appropriate mechanical or personnel assistance.*

Check and tighten all parts inside the instrument as applicable. Although the Flo-Cal was thoroughly inspected prior to shipment, some parts may loosen during shipment. If any parts are missing or damaged, contact Thermo Fisher immediately for prompt replacement (see page 63). If the unit arrives damaged or opened, ensure that a claim is made with the freight carrier.

Wall Mount Preparation and Procedure

Review the proposed mounting area for suitability. The area should be clean and free from moisture, dust, excessive drafts and vibrations. Refer to the dimension and connection drawings provided with the system. Ensure that the proposed mounting location provides the required clearances for opening enclosure doors and access by personnel. Also ensure that power, gases, and samples can be routed to the proposed location.

The five major types of wall construction include the following.

- Plaster board with wood studs
- Plaster board with aluminum studs
- Cinder block
- Concrete
- Fiberglass

Each type of wall should be treated differently. The proper mounting procedure for each type of wall is discussed in the following paragraphs.

Plaster Board with Wood Studs

Due to the weight of the Flo-Cal, Thermo Fisher does not recommend mounting to this type of wall. The freestanding rack should be used.

Plaster Board with Aluminum Studs

Due to the weight of the Flo-Cal, Thermo Fisher does not recommend mounting to this type of wall. The freestanding rack should be used.

Cinder Block

Wall Rack Mounting

Place the Flo-Cal rack against the wall in an appropriate mounting location. Mark the rack mounting hole center positions on the wall with a pencil. Remove the rack from the wall. Drill four holes into the wall with a masonry bit. Insert four molley studs (spring-loaded nuts), one in each hole. Move the Flo-Cal rack against the wall with the wall mounting bracket holes aligned with the molley studs. Insert a molley bolt with a flat and lock washer through the rack into the molley stud. Hand-tighten the bolt. Repeat for the remaining holes. Tighten the bolts evenly and securely.

Wall Enclosure Mounting

The wall mount preparation for mounting an enclosure requires the horizontal mounting of two pieces of channel (Uni-Strut P3300 or equivalent) to the wall. The Flo-Cal enclosure will be mounted to these channels. The channel should be approximately 36" long. For mounting the channel to the wall, we recommend using a 1/2-13 x 1" long (minimum) bolt with matching molley stud. For mounting the enclosure to the channel, we recommend using a 3/8-16 x 1" long (minimum) bolt with matching channel nut. All bolts require flat and lock washers.

Place the two mounting channels against the wall in an appropriate mounting location. Ensure that the spacing and positioning of the channels will permit proper attachment of the enclosure. Mark the channel mounting hole center positions on the wall with a pencil. Remove the channels from the wall. Drill four holes into the wall with a masonry bit (two per channel). Insert four molley studs (spring-loaded nuts), one in each hole. Mount each channel to the wall with bolts (with flat and lock washers) inserted into the molley studs. Tighten the bolts evenly and securely.

Once the Uni-Strut P3300 or equivalent channel has been mounted to the wall, the Flo-Cal enclosure unit may be mounted. Move the enclosure unit so that it lines up with the channels. Mark the enclosures top and bottom mounting hole center positions on the channel with a pencil. Move the enclosure away from the wall and channel. Install suitable channel nuts aligned with the enclosure mounting hole center positions (the pencil marks). Secure the nuts in the channel. Position the Flo-Cal enclosure unit so that its mounting holes line up with the channel nuts. Insert a bolt with a flat and lock washer through one of the mounting holes into the channel's nut. Hand-tighten the bolt. Repeat this procedure for the remaining three mounting holes. Tighten the bolts evenly and securely.

Concrete

Wall Rack Mounting

Place the Flo-Cal rack against the wall in an appropriate mounting location. Mark the rack mounting hole center positions on the wall with a pencil. Remove the rack from the wall. Drill and mount lag shields into the wall. Move the Flo-Cal rack against the wall with the wall mounting bracket holes aligned with the lag shields. Insert a lag bolt with a flat and lock washer into the lag shield and hand tighten the bolt. Repeat for the remaining holes. Tighten the bolts evenly and securely.

Wall Enclosure Mounting

The wall mount preparation for mounting an enclosure requires the horizontal mounting of two pieces of channel (Uni-Strut P3300 or equivalent) to the wall. The Flo-Cal enclosure will be mounted to these channels. The channel should be approximately 36" long. For mounting the enclosure to the channel, we recommend using a 3/8-16 x 1" long (minimum) bolt with matching channel nut. All bolts require flat and lock washers.

Place the two mounting channels against the wall in an appropriate mounting location. Ensure that the spacing and positioning of the channels will permit proper attachment of the enclosure. Mark the channel mounting hole center positions on the wall with a pencil. Remove the channels from the wall. Drill and mount lag shields into the wall. Mount each channel to the wall with lag bolts (with flat and lock washers) inserted into the lag shield. Tighten the bolts evenly and securely.

Once the Uni-Strut P3300 or equivalent channel has been mounted to the wall, the Flo-Cal enclosure unit may be mounted. Move the enclosure unit so that it lines up with the channels. Mark the enclosures top and bottom mounting hole center positions on the channel with a pencil. Move the enclosure away from the wall and channel. Install suitable channel nuts aligned with the enclosure mounting hole center positions (the pencil marks). Secure the nuts in the channel. Position the Flo-Cal enclosure unit so that its mounting holes line up with the channel nuts. Insert a bolt with a flat and lock washer through one of the mounting holes into the channel's nut. Hand-tighten the bolt. Repeat this procedure for the remaining three mounting holes. Tighten the bolts evenly and securely.

Fiberglass

Wall rack mounting

Place the Flo-Cal rack against the wall in an appropriate mounting location. Mark the rack mounting hole center positions on the wall with a pencil. Remove the rack from the wall. Drill four holes through the fiberglass wall. Mount the Flo-Cal rack to the fiberglass wall using a doubler plate and nut on the backside of the wall. Flat and lock washers must be used at both ends of the bolts. Insert the top bolts first and hand tighten. Repeat for the bottom bolts. Tighten all the bolts evenly and securely.

Wall enclosure mounting

The wall mount preparation for mounting an enclosure requires the horizontal mounting of two pieces of channel (Uni-Strut P3300 or equivalent) to the wall. The Flo-Cal enclosure will be mounted to these channels. The channel should be approximately 36" long. For mounting the enclosure to the channel, we recommend using a 3/8-16 x 1" long (minimum) bolt with matching channel nut. All bolts require flat and lock washers.

Place the two mounting channels against the wall in an appropriate mounting location. Ensure that the spacing and positioning of the channels will permit proper attachment of the enclosure. Mark the channel mounting hole center positions on the wall with a pencil. Remove the channels from the wall. Drill four holes through the fiberglass wall. Mount the channels to the fiberglass Insert the top bolts first and hand tighten. Repeat for the bottom bolts. Tighten all the bolts evenly and securely.

Once the Uni-Strut P3300 or equivalent channel has been mounted to the wall, the Flo-Cal enclosure unit may be mounted. Move the enclosure unit so that it lines up with the channels. Mark the enclosures top and bottom mounting hole center positions on the channel with a pencil. Move the enclosure away from the wall and channel. Install suitable channel nuts aligned with the enclosure mounting hole center positions (the pencil marks). Secure the nuts in the channel. Position the Flo-Cal enclosure unit so that its mounting holes line up with the channel nuts. Insert a bolt with a flat and lock washer through one of the mounting holes into the channel's nut. Hand-tighten the bolt. Repeat this procedure for the remaining three mounting holes. Tighten the bolts evenly and securely.

Free Standing Mount Instructions

The Flo-Cal is often attached to a freestanding rack. This rack should be bolted to the floor. Review the proposed mounting area for suitability. The area should be clean and free from moisture, dust, excessive drafts and vibrations. Refer to the dimension and connection drawings provided with the system. Ensure that the proposed mounting location provides the required clearances for opening enclosure doors and access by personnel. Also ensure that power, gases, and samples can be routed to the proposed location.

Install lead anchors or threaded studs in the floor to secure the enclosure at the desired location. When installing the lag bolts or nuts, use a flat and lock washer for each. Tighten the bolts or nuts securely.

Electrical Installation

AC Power

AC power to the Flo-Cal is connected by the customer at the analyzer. Power wiring and circuit breakers must be sized appropriately. Refer to drawings provided with the system for connection information and power requirements. A suitable power switch should also be provided by the customer near the system for use by maintenance personnel.

CAUTION: *Electrical power must be free of spikes, sags, surges, or electrical noise.*

Analog Output Signal

The Flo-Cal includes a 4-20 mA DC current loop output. Refer to drawings included with the system for information on connecting the 4-20 mA output signal.

Alarm Signal

The Flo-Cal may include optional digital alarm output signals. Refer to drawings included with the system for information on connecting alarm devices to these outputs.

Modbus Network

The Flo-Cal includes provisions for connection to a standard Modbus protocol network. Typically, this is configured to use 4-wire RS-485. Alternately, the Flo-Cal can be configured to support 2-wire RS-485 or RS-232. Consult the wiring drawings included with the system for information on the configuration type used and details for wiring connection.

Gas & Air Supply Installation

WARNING: *Flo-Cal applications may use bottled gases. These bottles may have very high pressures and may result in serious injury to personnel if the bottle valve is opened without a regulator attached or if the valve is broken off the bottle. See chapter one for more information.*

Sample Gas Inlet

Sample gas is typically connected to the system using ¼ inch tubing. Refer to drawings included with the system for more information on the sample gas connection and requirements.

Instrument Air

Instrument air is used for burner air. Instrument air must have the following qualities to be acceptable for use: clean, dry, -40° C dew point, oil free, particles ≤ 5µ, ISA grade hydrocarbon free. Plant instrument air is typically used if it meets these qualifications. An optional air blower is available for use where adequate instrument air is not available. Instrument air is connected to the system using ½ inch tubing. Refer to the drawings and application notes included with the system for more information on instrument air connection and requirements.

Chapter 5

Start Up & Shut Down

Start Up Procedure

One or both of the following procedure must be performed when starting up the Flo-Cal.

WARNING: *Before initially starting the system, electrical power wiring must be checked for correct size and routing. In addition, all sample system plumbing must be thoroughly tested for leaks.*

CAUTION: *If the sample may contain liquid, a membrane separator (FD pn 47-1177-0) must be installed to prevent liquid from getting into the Flo Cal. Liquid in the sample will damage the instrument.*

Initial Start Up

When starting up a new installation or after major service work is performed, the following start up procedure must be followed. Otherwise, perform the start up procedure on page 24.

1. Check all power wiring for the following.
   a. Proper wire size.
   b. Correct breaker size.
   c. Proper installation (routing, conduit, seals poured, etc.).
   d. Proper system grounding.
2. Check the sample system as follows
   a. Ensure that all trash and contaminants are removed from the tubing (blow out with air or other suitable utility).
   b. Check for proper routing and valve arrangement.
   c. Test for leaks at a pressure greater than the highest expected operating pressure under normal and abnormal conditions.
   d. Test for proper valve operation.
   e. Ensure that the correct porosity filter elements are installed.
   f. Ensure that all relief valves are routed to safe locations.
3. Ensure that all drains and vents for the analyzer and sample system are routed to appropriate and safe locations. Analyzer vents cannot tolerate significant backpressure.
4. Check instrument air as follows.
   a. Ensure that all trash and contaminants are removed from all tubing.

   b. Test the tubing for leaks at a pressure higher than the expected operating pressure.
   c. Ensure that any bottle gases are properly secured and regulated. Relief valves must be installed downstream of the regulators to prevent damage to tubing or equipment in case of a bottle regulator failure. Ensure that any relief valves are routed to safe locations.
   d. Check the air for moisture, hydrocarbons, or other contaminants. Ensure that the air meets the requirements listed in the specifications chapter (page 7).
   e. Ensure adequate airflow is available (see specs beginning on page 7).
5. Ensure that the entire analyzer system installation meets all requirements for the area in which it is installed (e.g., all equipment rated for the area classification).
6. Locate the white cardboard box containing an envelope that is mounted securely inside the enclosure prior to shipment from the factory. Remove the calibration weight(s) from the envelope.
7. Remove the clear Plexiglas cover from the top of the precision gas regulator (see page 30 for location). Two screws hold the cover in place. Place the weight(s) (from the envelope) on the diaphragm disc. Make sure that they slide easily over the shaft. Reinstall the cover and tighten the screws.
8. Start the analyzer system using the following start up procedure only when all of the above steps are successfully completed.

Start Up

This start up procedure should be used for normal start up of the instrument. If this is the initial startup or if major service was performed on the system, use the initial startup procedure (page 23).

WARNING: *Before initially starting the Flo-Cal analyzer or if major service was performed, use the Initial Start Up procedure on page 23.*

1. Open the instrument air inlet valve to allow air to flow into the unit. If a blower is used instead of instrument air, apply power to the blower.
2. Adjust the air inlet pressure to 8" WC (see page 30) if necessary.
3. Open the sample gas inlet valve and allow gas to flow into the unit.
4. Adjust the gas inlet pressure to 5.5" WC (see page 31) if necessary.
5. Check all connections for leaks. Shut down the system and correct leaks if found.
6. Apply power to the instrument.
7. Ensure that the sparking unit ignites the flame. (The sparking unit may continue to spark for a few minutes after the flame is ignited.
8. Check the flame-out pressure switch operation (page 31).
9. Check the inlet air pressure switch operation (page 31).
10. Check the inlet gas pressure switch operation (page 32).
11. Adjust the flame primary air (see page 28).
12. Allow the unit to stabilize, and then perform calibration verification (see page 42).
13. If an automatic calibration unit is installed, consult the *Auto-Cal User's Guide* for additional start up information.

Shut Down Procedures

The Flo-Cal will shut down automatically if a flame-out occurs, if sample gas pressure is lost, or if inlet air pressure is lost. To manually shut down the system, perform the following steps.

Manual Shutdown

1. Close the valve supplying sample gas to the Flo-Cal and wait until the flame goes out.
2. Close the valve supplying instrument air to the instrument or turn off power to the air blower as appropriate.
3. Turn off the main power to the Flo-Cal.
4. If an automatic calibration unit is installed, consult the *Auto-Cal User's Guide* for additional shutdown information.

WARNING: *Pressure must be completely removed from the sample lines before attempting to open the sample system for any reason.*

WARNING: *Appropriate precautions must be taken to prevent personnel or environmental exposure when depressurizing or opening the sample system.*

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Chapter 6

Maintenance

This chapter includes basic maintenance information for the system. Additional details can be found in vendor documents and other manuals provided with the system.

Maintenance Schedule

Following is a suggested maintenance schedule. Specific applications may require additional maintenance steps or different frequencies.

Daily

1. Visually inspect the system for leaks.
2. Check for proper operation of the system.

Weekly

1. Perform a verification of the system calibration (see page 42).

Monthly

1. Check all tubing for leaks or damage.
2. Lubricate the CV pump on Calorific Value instruments (see page 36).
3. Replace filter elements.
4. Check the inlet gas pressure (selector valve position 2, see page 29).
5. Check the delta P pressure (selector valve position 5, see page 29).
6. Check the inlet air pressure (selector valve position 4, see page 29).
7. Check the heat value pressure (selector valve position 3, see page 29).
8. Dust and wipe off the analyzer and associated equipment.

Yearly

1. Perform a full calibration (see page 43).

After Major Maintenance

1. Visually inspect the system for leaks.
2. Check the inlet gas pressure (selector valve position 2, see page 29).
3. Check the delta P pressure (selector valve position 5, see page 29).
4. Check the inlet air pressure (selector valve position 4, see page 29).
5. Check the heat value pressure (selector valve position 3, see page 29).
6. Perform a full calibration (see page 43).

Maintenance Procedures

Flame Primary Air Adjustment

Proper operation of the Flo-Cal instrument requires correct primary burner airflow. Perform the following to adjust the primary air.

1. Locate the knob for adjusting the primary airflow at the bottom of the burner.
2. Determine the type burner installed from the application notes provided with the instrument. Use the appropriate procedure below to adjust the primary airflow.
    a. For burner p.n. 30-1001-0 with ceramic meta jets, adjust the primary air knob so that the inner flame cone (dark blue) rises and merges with the outer flame cone (light blue). Then increase the primary airflow by turning the knob ¼ turn clockwise.
    b. For burner p.n. 30-1006-0 with ceramic screen, adjust the primary air knob so that the inner flame cone (dark blue) rises and merges with the outer flame cone (light blue). Then increase the primary airflow by turning the knob ¼ turn clockwise.
    c. For burner p.n. 30-1005-0 with glass burner, adjust with a gas that has a heat value equal to the lowest value expected from the sample gas. Adjust the primary air knob so that the inner flame cone (dark blue) rises and merges with the outer flame cone (light blue). Do not increase the primary airflow beyond this point. As gas with higher heat value is measured, the inner flame cone will separate from the outer flame cone. This is acceptable.
    d. For burner p.n. 30-1003-0 with metal burner, adjust with a gas that has a heat value equal to the lowest value expected from the sample gas. Adjust the primary air knob so that the inner flame cone (dark blue) rises and merges with the outer flame cone (light blue). Do not increase the primary airflow beyond this point. As gas with higher heat value is measured, the inner flame cone will separate from the outer flame cone. This is acceptable.
2. Allow the unit to stabilize after adjusting the primary airflow.

Relighting the Flame

If air or sample pressure is lost, the system gets an overrange alarm, or the flame fails to relight after flame-out, the Flo-Cal system automatically shuts down. Automatic shut down closes a solenoid valve to shut off sample gas to the analyzer. The sparking ignitor and constant volume (CV) pump (Calorific Value units only) are also shut off. To relight the flame, perform the following.

1. Determine and correct the cause of the automatic shut down of the Flo-Cal system.
2. Ensure that instrument air and sample gas are available to the analyzer.
3. For standard (non-explosion proof) Flo-Cal calorimeters, momentarily depress, then release the Auto-Ignitor Relay Reset push-button on the front door of the instrument. Cycle power to an explosion proof Flo-Cal model to reset the system.
4. If the system fails to restart or if it shuts down again soon after restart, the problem must be investigated and corrected before attempting to restart the Flo-Cal. Check the following items.
    a. Ensure that the electrode sparks during the relight attempt.
    b. Ensure that the electrode sparks are jumping between the electrode points and not from the electrode point to ground.

c. Check all pressure measurements (see the next section) against the normal values recorded in the application notes or system logbook.
d. Ensure that the weights are properly installed on the precision gas regulator.
e. If these steps fail to isolate the cause, contact Thermo Fisher for assistance (see page 63).

Pressure Measurement

During normal operation, the measurement selector value is set to position 3 so that the pressure transmitter measures the heat value of the sample gas. The other selector valve positions can be used to check other pressures in the Flo-Cal for use in troubleshooting and calibration. The following chart shows the function and typical pressures for each of the selector valve positions.

Valve Position	Measured Component	Typical Value
2	Inlet gas pressure	5.5" ± ½" WC
3	Heat Value (normal operating position)	Depends on gas and range
4	Inlet air pressure	8" ± ½" WC
5	Delta P, outlet pressure of CV pump	See application notes

A temporary range change push-button is provided to momentarily extend the pressure transmitter's range when necessary. This momentary push-button is located on the pressure transducer board inside the Flo-Cal (see page 34). While the push-button is depressed, the transmitter measures from 0 to 8.3 inches WC. However, the display shows a number that is a percentage of the module range settings. To determine the actual measured value when the range push button is depressed, the following formulas can be used. Appendix B (page 73) also includes cross-reference charts for translating the readings based on the instrument range used.

To determine the actual measured pressure for a displayed value with the push button depressed, use the following formula…

$$\frac{\text{Displayed Pressure}}{\text{Instrument Full Scale Setting}} \text{ X 8.3“ WC } = \text{ Actual Pressure}$$

To determine the displayed pressure for a desired pressure with the push button depressed, use the following formula…

$$\frac{\text{Desired Pressure X Instrument Full Scale Setting}}{\text{8.3“ WC}} = \text{ Displayed Pressure}$$

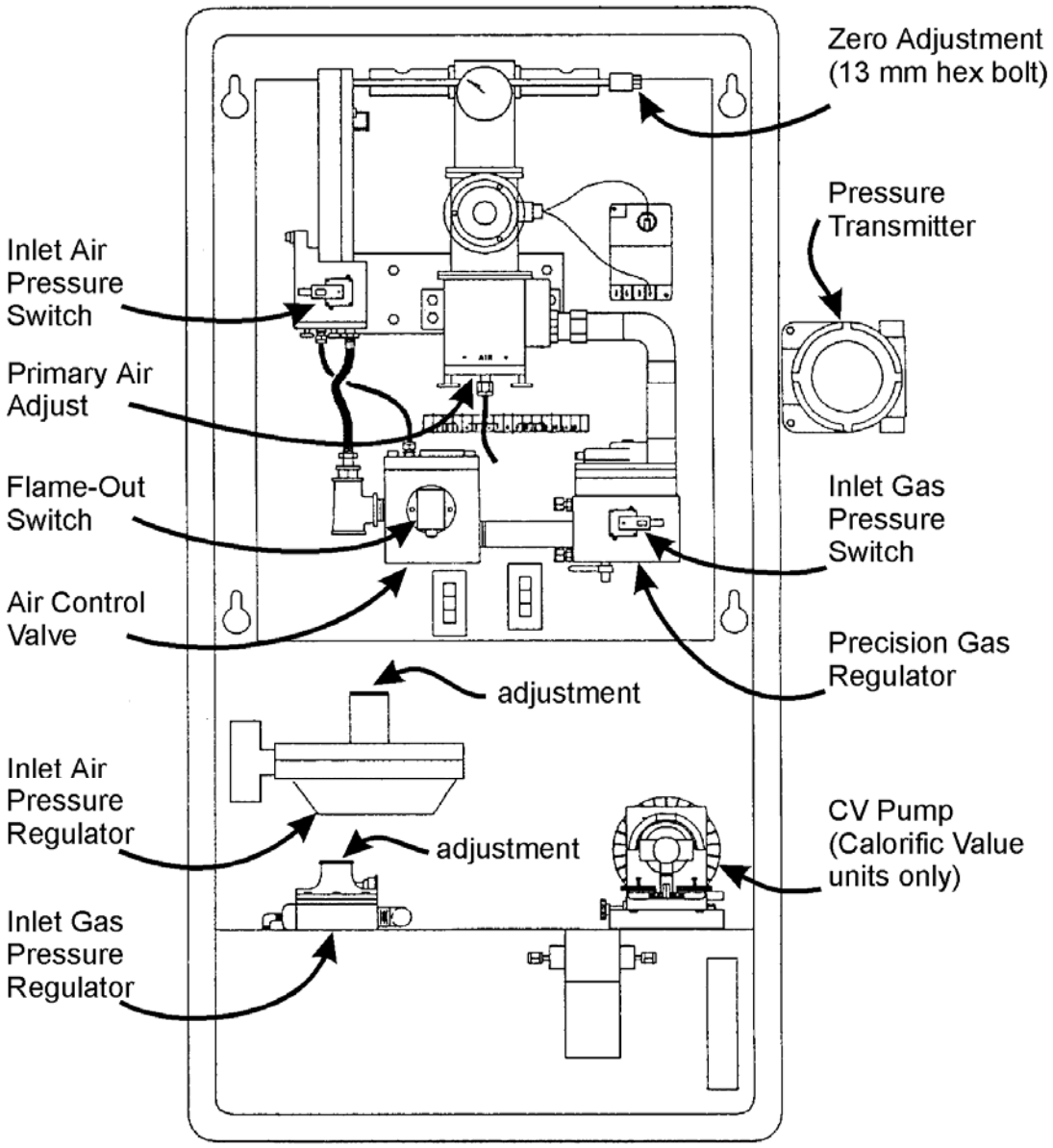

Figure 3. Typical component and adjustment locations.

Inlet Air Pressure Adjustment

The inlet air pressure is typically controlled by the Inlet Air Pressure Regulator (see above). Perform the following to set the pressure.

1. Set the selector valve to position 4 to read the inlet air pressure.
2. Remove the adjustment cap from the Inlet Air Pressure Regulator.
3. Adjust the regulator for 8.0 ± 0.5 inches water column while depressing the Test Point Switch. See appendix B (page 73) for instructions to determine the transmitter reading that represents 8.0" WC when the Test Point Switch is depressed. The instrument range can be determined from the application notes provided with the Flo-Cal.
4. Replace the adjustment cap on the Inlet Air Pressure Regulator.

Inlet Gas Pressure Adjustment

The inlet gas (sample) pressure is typically controlled by the Inlet Gas Pressure Regulator (see above). Perform the following to set the pressure.

1. Set the selector valve to position 2 to read the inlet gas pressure.
2. Remove the adjustment cap from the Inlet Gas Pressure Regulator.
3. Adjust the regulator for 5.5 ± 0.5 inches water column while depressing the Test Point Switch. See appendix B (page 73) for instructions to determine the transmitter reading that represents 5.5" WC when the Test Point Switch is depressed. The instrument range can be determined from the application notes provided with the Flo-Cal.
4. Replace the adjustment cap on the Inlet Gas Pressure Regulator.

Switch Test and Adjustment

Inlet Air Pressure Switch

The inlet air pressure switch is used to automatically shut down the Flo-Cal if the inlet air pressure is lost. This switch is set to open at 3.0" WC with decreasing pressure. The following procedure can be used to test for proper operation.

1. Mark and disconnect the electrical leads to the inlet air pressure switch (see page 30 for location).
2. Connect an ohmmeter to the normally open and common terminals of the pressure switch.
3. Open the instrument airline to the instrument.
4. Set the selector valve to position 4 to monitor the inlet air pressure. Adjust the air inlet pressure (page 30) to read 3.0" WC.
5. Adjust the air inlet pressure above and below 3.0" WC while watching the ohmmeter. The ohmmeter should indicate an open circuit below 3.0" ± 0.05" WC and a closed circuit above 3.0" ± 0.05" WC.
6. If the pressure switch does not open at the correct pressure, adjust the small Allen set screw on the switch and retest.
7. After the air pressure switch successfully passes the test, adjust the air pressure regulator for a pressure of 8.0" ± 0.5" WC (for general purpose and Group D instruments). For area classification Groups B & C, adjust for a pressure of 22.0" ± .5" WC and adjust the maxitrol for an air inlet pressure of 8.0" ± 0.5" WC. See appendix B (page 73) for instructions to determine the transmitter reading that represents 5.5" WC when the Test Point Switch is depressed.
8. Disconnect the ohmmeter and reconnect the electrical leads to the inlet air pressure switch.

Flame-Out Pressure Switch

The flame-out pressure switch is used to shut down the Flo-Cal if the flame is extinguished. This switch is set to close at 0.6" WC with decreasing pressure. (Typically, the pressure with no flame is 0.4" WC.) Proper operation and adjustment of this switch can be performed with the following procedure.

1. Mark and disconnect the electrical leads to the flame-out pressure switch (see page 30 for location).
2. Connect an ohmmeter to the normally closed and common terminals of the pressure switch.

3. Rotate the selector valve to position 3 to measure the heat value.
4. Adjust the air control valve so that the pressure transmitter reads 0.6" WC. The air control valve adjustment is located on the bottom of the air control valve. Loosen the lock nut and rotate the adjusting screw clockwise to decrease or counter-clockwise to increase.
5. Vary the pressure up and down while watching the ohmmeter and pressure. The ohmmeter should indicate an open circuit above 0.6" WC and a closed circuit below 0.6" WC.
6. If the switch set point is incorrect, remove the switch cover and adjust the switch using the set point adjustment located at top left of switch. Retest the switch operation after adjustment.
7. When the switch is properly set, adjust the air control valve for a pressure reading of 0.4" ± 0.05" WC. (This is the “flame-out air pressure.”)
8. Disconnect the ohmmeter and reconnect the electrical leads to the flame-out pressure switch.

Inlet Gas Pressure Switch

The gas pressure switch is used to automatically shut down the Flo-Cal if the sample gas pressure is lost. The gas pressure switch is set to open at 3.0" WC with decreasing pressure. Proper operation and adjustment of this switch can be performed with the following procedure.

1. Mark and disconnect the electrical leads to the gas pressure switch (see page 30 for location).
2. Connect an ohmmeter to the normally open and common terminals of the pressure switch.
3. Rotate the selector valve to position 2 to measure the inlet gas pressure.
4. Adjust the gas pressure regulator (see page 31) for a pressure reading of 3.0" WC.
5. Vary the pressure up and down while watching the ohmmeter and pressure. The ohmmeter should indicate a closed circuit above 3.0" WC and an open circuit below 3.0" WC.
6. If the pressure switch does not open at the correct pressure, adjust the small Allen set screw on the switch and retest.
7. Disconnect the ohmmeter and reconnect the electrical leads to the inlet air pressure switch.
8. Adjust the inlet gas pressure regulator to 5.5 ± 0.5 inches WC (see page 31).

Flame-Out Timer Settings

The flame-out timer is used to set the length of time that the Flo-Cal will automatically attempt to relight the flame after a flame out. The time delay is set using switches on top of the relay housing. Consult the following table for correct time delay settings.

Instrument Range	Time Delay	Relay Switch Settings
Standard BTU range	3.2 minutes	64 and 128
High BTU range	3.2 minutes	64 and 128
Low BTU range	6.4 minutes	128 and 256

Precision Gas Regulator Diaphragm Replacement

The precision gas regulator controls the sample gas pressure to the burner. If necessary, the regulator diaphragm can be replaced as follows.

1. Shut down the Flo-Cal (see page 25).
2. Remove the two slotted screws and lift off the clear cover.
3. Remove the four hex head bolts to separate the Teflon discs and diaphragm from the block.
4. Remove the small brass nuts and the tappet valve from the bottom of the discs.
5. Remove the four Allen head bolts to separate the two Teflon discs.
6. Remove the brass nut, lock washer, and aluminum disc.
7. Remove the diaphragm
8. Install a new diaphragm.
9. Reassemble the regulator in the reverse order while ensuring that the O-rings are in place on the bottom of the lower disc. These O-rings must be oriented properly in relation to the gas transfer ports on the block.

Air Control Valve Diaphragm Replacement

The air control valve controls the airflow to the burner. If necessary, the control valve diaphragm can be replaced as follows.

1. Shut down the Flo-Cal (see page 25).
2. Remove the 1/4" Tygon tubing and nut from the cover.
3. Remove the four Allen head bolts and cover.
4. Remove the 5/16" brass hex nut, flat washer, and sealing washer from the shaft.
5. Remove the brass disc and the upper diaphragm.
6. Remove the second brass disk and spacer.
7. Remove the four slotted screws from the retaining ring. Remove the retaining ring.
8. Remove the small aluminum disc and lower diaphragm.
9. Reassemble the regulator in the reverse order. Do not allow the shaft to turn when installing the 5/16" brass hex nut.

CAUTION: *Do not allow the shaft to turn when installing the 5/16" brass hex nut.*

Measurement Range Change

The measurement range of the Flo-Cal calorimeter can be easily changed in the field by replacing a single, plug-in resistor (R1) and selecting the appropriate transmitter range menu setting. The following procedure should be followed to change the instrument range.

1. Obtain a replacement 1% metal film resistor with the value shown in the following chart for the desired measurement range.

Range Configuration Parameters		
Desired Range	**R1 Value**	**Module Range Menu Setting**
0.80 - 3.2 inches WC	90.9 ohms	40 - 100% (standard)
0.64 - 4.0 inches WC	124 ohms	33 - 100%

2. Locate the pressure transducer board. This board is located on the right inside surface of the non-explosion proof model enclosure and in the bottom of the main enclosure for the explosion-proof models. The following illustration shows the board layout.

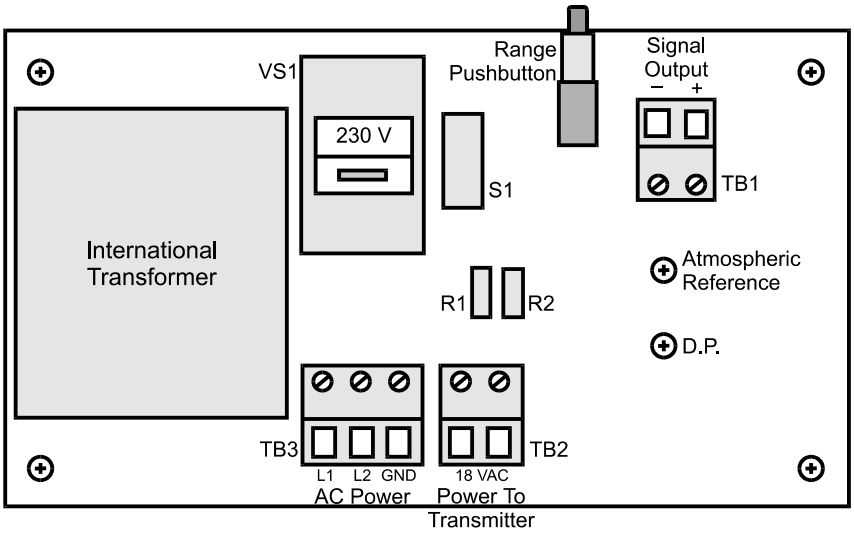

Figure 4. Pressure transducer board with resistor location.

3. Shut down the Flo-Cal (see page 25) and remove power from the system.
4. Unplug the existing resistor R1 from the pressure transducer board.
5. Plug the replacement resistor R1 into the socket on the pressure transducer board.
6. Apply power to the Flo-Cal system as outlined in the start up procedure (see page 23).
7. Set the transmitter module range menu settings to the appropriate values as shown in the table above. See the Transmitter chapter (page 47) for instructions on setting these parameters.
   a. Set the Module Range to the appropriate zero and span percentages shown in the table above.
   b. Set the Alarms as appropriate for your configuration.
   c. Set the Zero Value to the low inches WC from the range selected in the table above.

d. Set the Span Value to the high inches WC from the range selected in the table above.

8. Calibrate the Flo-Cal as described in the Calibration chapter (page 41).

Constant Volume (CV) Pump

A positive displacement pump is used with Calorific Value instruments to provide a constant volume of sample gas to the burner. The CV pump is not used on instruments designed to measure Wobbe Index.

Description

The Constant Volume (CV) gas pump consists of an electric motor, a piston type pump head, a spindle assembly, mounting base and a pump cylinder carrier. The pump cylinder carrier also acts as a flow rate indicator. It is used to set the gas flow rate between 0 and 10 (10 being the setting for maximum flow), on the scale located on the mounting base. The flow rate is adjusted with the stroke length adjustment knob on the side of the pump base.

CAUTION: *The stroke length adjustment of the CV pump must never be set to a value below zero on the indicator.*

Adjustment

Increasing the pump flow rate increases the calorific value measured by the calorimeter, which increases the milliamp output signal. This increases the span of the calorimeter.

Decreasing the pump flow rate decreases the measured calorific value and the milliamp output signal. This decreases the span of the calorimeter.

The pump flow rate may require adjustment during a full calibration of the Flo-Cal as described beginning on page 43. To adjust the stroke length (and flow rate), loosen the two knurled lock nuts, then turn the black knob on the pump head assembly (CW to decrease and CCW to increase). Tighten the two knurled lock nuts when the stroke length setting is completed.

Pump Maintenance

The pump should be lubricated monthly using the following procedure. Refer to the following diagrams while performing this procedure.

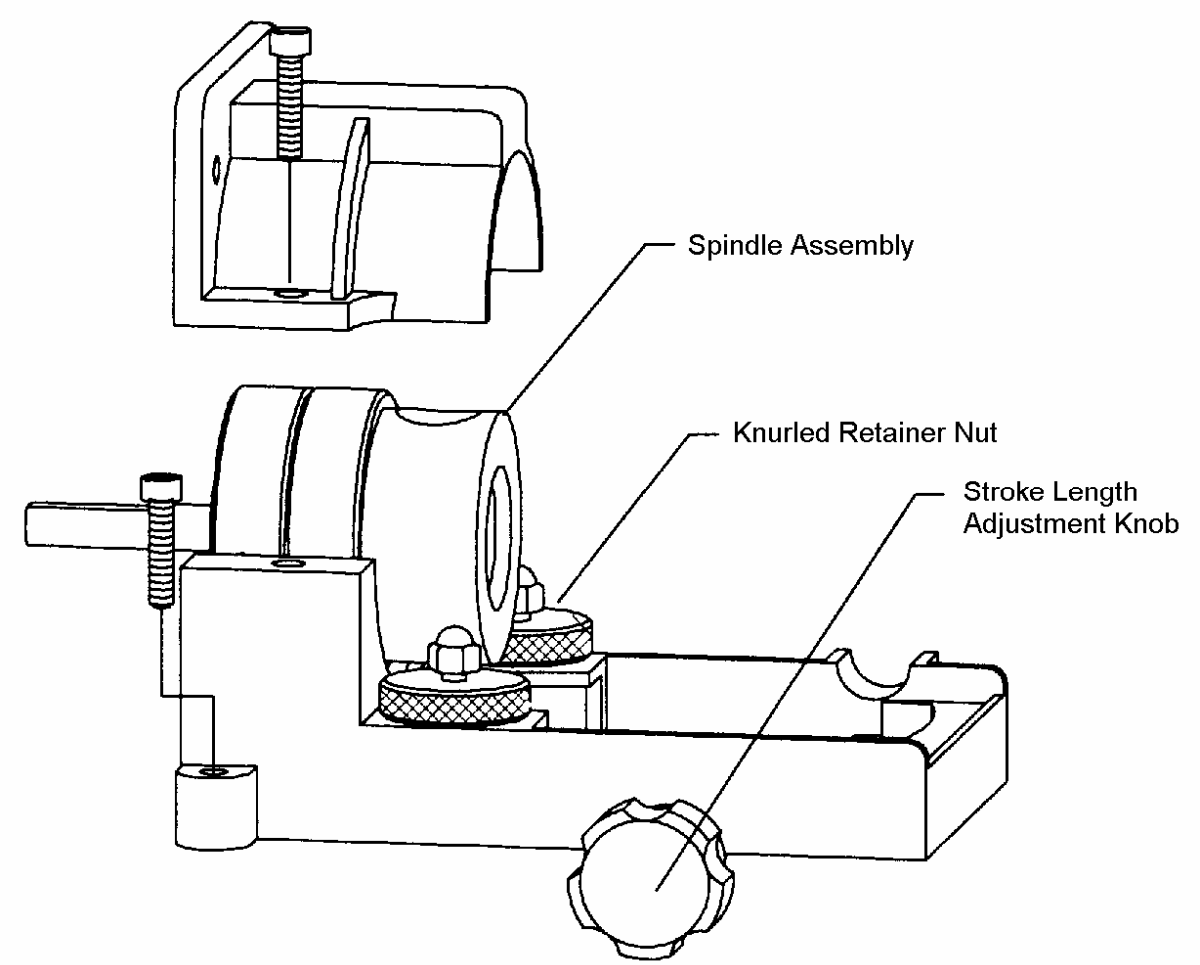

Figure 5. CV pump base.

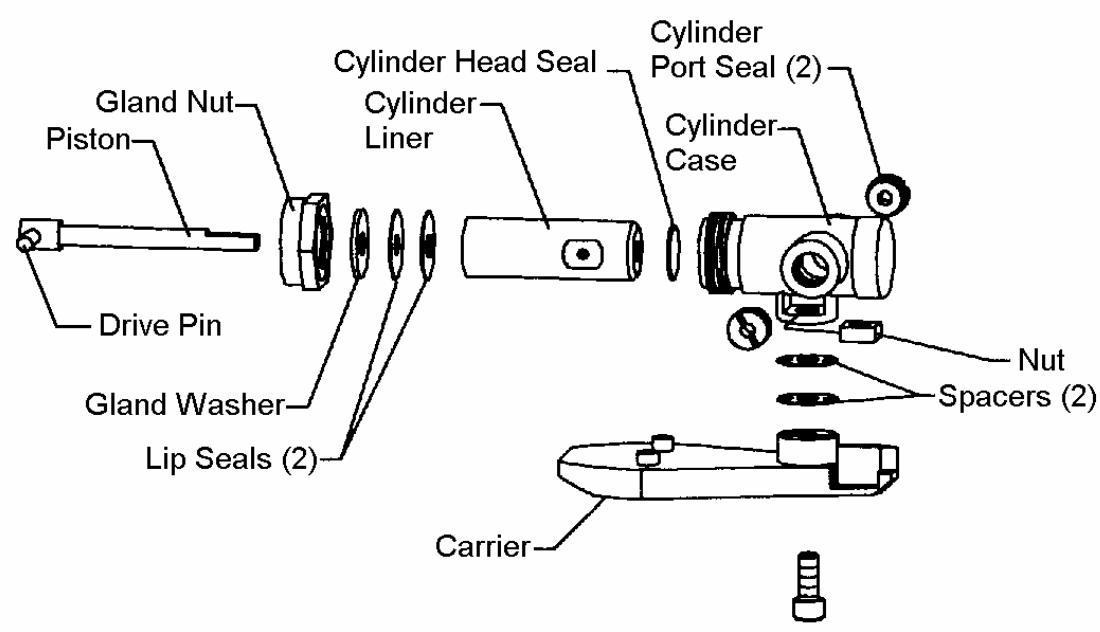

Figure 6. CV pump head, exploded view.

CAUTION: *Use a light grade of G.P. (General Purpose) grease that does not contain any fillers for lubricating the bearings and surfaces of the CV pump.*

1. Record the stroke length indicator setting.
2. Turn power off to the pump.

CAUTION: *When disassembling, if the piston is withdrawn more that 2" from the cylinder, remove the lip seals and install them one at a time (see page 38). Lip Seals will be damaged if this is not done.*

3. Remove the pump head module as follows.
   a. Adjust the stroke length adjustment to position the indicator to the extreme right of the scale.
   b. Rotate the spindle assembly to place the piston drive pin at the 3 o'clock position when facing the cylinder head.
   c. Loosen the two knurled nuts.
   d. Lift the cylinder assembly up and to the right to disengage the piston drive pin from the radial bearing. ***If the piston is withdrawn more than 2" from the cylinder, the cylinder must be disassembled and the lip seals installed one at a time (see page 38) to prevent lip seal damage.***
4. Remove old grease from the radial bearing using a small brush or cotton swab. (The bearing can be flipped over while still in the unit to access the back side).
5. Apply a thin coating of a light, general purpose grease (without filler) to the bearing surfaces.
6. Wipe the steel spindle to remove old grease and dirt.

7. Clean the area around the lip seal of the piston and gently withdraw the ceramic piston no more than 1 ¼ inch. (The piston may look dirty or like a smeared pencil mark, but that is normal since it is made of a hard, crystalline carbon.) ***If the piston is withdrawn more than 2" from the cylinder, the cylinder must be disassembled and the lip seals installed one at a time (see page 38) to prevent lip seal damage.***
8. Coat the drive pin on the end of the piston with a thin coating of light grease.
9. Turn the spindle so the radial bearing is at the 3 o'clock position.
10. Carefully insert the piston drive pin into the hole in the radial bearing while positioning the cylinder assembly back into its normal operating position. ***Do not permit the piston to extend from the cylinder more than 2 inches.***
11. Ensure that the cylinder carrier is properly engaged with the slotted portion of the follower.
12. Set the stroke length indicator to the correct setting.
13. Tighten the two knurled lock nuts.
14. Start up the system (page 24) and perform a calibration verification (page 42).

Lip Seal Replacement

The piston seals are precisely cut and hot formed from sheets of a chemically inert fluorocarbon, specifically formulated for resistance to wear, abrasion, heat, and chemical attack. Each lip seal possesses an exceptional mechanical memory which allows it to maintain a relatively constant wiping pressure on the piston, compensating for seal wear as it occurs. Properly maintained in clean condition, the original seals provided with the CV pump may be expected to last the life of the pump.

Reinstalling Lip Seals

If the pump piston is withdrawn more than 2 inches, the following procedure must be performed to reassemble the pump. Failure to follow this procedure will result in damage to the lip seals.

1. If necessary, remove the cylinder assembly as outlined in the pump maintenance procedure (page 36).
2. Remove the gland nut from the pump cylinder.
3. Carefully clean all contaminants from the gland washer, the two lip seals, and the piston.
4. Position the gland nut and gland washer on the piston up against the drive pin.
5. Carefully place one of the lip seals on the piston with the lip side first. Rotate the seal while inserting it on the piston until it is past the flat and on the piston neck.
6. Carefully place the second lip seal on the piston with the lip side last. Rotate the seal while inserting it on the piston until it is past the flat and on the piston neck.
7. Insert the piston into the cylinder about one inch.
8. Screw the gland nut onto the cylinder threads and tighten.

Installing New Lip Seals

If the lip seals are to be replaced with new units, the following procedure must be performed.

1. If necessary, remove the cylinder assembly as outlined in the pump maintenance procedure (page 36).
2. Remove the gland nut from the pump cylinder.
3. Carefully clean all contaminants from the gland washer, the two lip seals, and the piston.
4. Position the gland nut and gland washer on the piston up against the drive pin.
5. Form a lip around the piston on one of the lip seals by gently placing the lip seal on the piston lip side last. Carefully rotate the seal on the piston while passing it over the flat to the piston neck.
6. Remove the “formed” seal from the piston.
7. Carefully install the “formed” seal back on the piston, lip side first, while carefully rotating the seal on the piston until it is past the flat and on the neck of the piston.
8. Gently place the second lip seal on the piston, lip side last, while carefully rotating the seal on the piston until it is past the flat and on the neck of the piston.
8. Insert the piston into the cylinder about one inch.
9. Screw the gland nut onto the cylinder threads and tighten.
10. Set the seals as outlined in the next procedure.

Piston Seal Setting

After installing new lip seals, it is recommended that the seals be set (i.e., formed in place) by fluid pressures generated by pump action using the following procedure.

1. Block or close off the suction side (left) of the pump.
2. Set the stroke to the maximum setting.
3. Operate the pump spindle clockwise 10 to 20 turns (strokes) to create a vacuum in the pump head. This will cause atmospheric pressure to shape the outer seal member tightly around the piston.
4. Open the suction side of the pump.
5. Set the stroke indicator to the minimum setting to reverse the pumping direction.
6. Operate the pump while intermittently blocking the pump output (left port). This will generate pressure in the seal area of the pump head causing the inner seals to form around the piston.
7. Set the stroke length indicator to the normal operating position and reconnect all tubing.

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Chapter 7

Calibration

Calibration Gases

Calibration verification requires one calibration gas. This calibration gas should have a Wobbe Index or Calorific Value (as appropriate) close to the typical value of the measured gas.

Full calibration requires two calibration gases. The high calibration gas should have a Wobbe Index or Calorific Value (as appropriate) that is at about 80% of the instrument measurement range. The low calibration gas should have a Wobbe Index or Calorific Value (as appropriate) that is at about 20% of the instrument measurement range.

Output Signal Calculation

The 4-20 mA signal output of the pressure transmitter is a calculated value providing a linear representation of the heat value of the measured gas based on the range and type of measurement. The displayed pressures on the front of the pressure transmitter are the raw pressure measurements in inches of water column (WC). The expected milliamp output signal for a particular instrument and a known heat value sample can be calculated using the following equation.

Milliamp (mA) Output Value = (((H - A)/(B - A)) x 16 mA) + 4mA

where,

A = the lower range of the Flo-Cal

B = the higher range of the Flo-Cal

H = the Calibration Gas Heat Value

For example, if the Flo-Cal unit has a range of 750 to 1500 BTU/SCF and the Calibration Gas value is 973.4 BTU/SCF, then,

A = 750, B = 1500, B - A = 750, H = 973.4

The expected milliamp signal output value for the calibration gas would be

(((973.4 - 750)/750) x 16 mA) + 4 mA = **8.77 mA**

Manual Calibration Procedures

Calibration Verification

Calibration verification requires a single calibration standard with a heat value near that of the sample gas. The following procedure should be performed for calibration verification.

1. Determine the expected milliamp output for the heat value of the calibration standard. Refer to the Output Signal Calculation section above (page 41) for the calculation procedure. (Note: This value corresponds to a pressure reading on the pressure transmitter when set to measure heat value, position 3. Future calibration verifications with the same calibration standard can use the pressure rather than the milliamp reading if desired.)
2. Connect the calibration standard to the Flo-Cal and allow to stabilize for at least 30 minutes.
3. Connect a digital ammeter in series with the 4-20 mA output of the pressure transmitter. (This is not required if the expected transmitter pressure reading is accurately known for the calibration standard used.)
4. Compare the actual milliamp output against the expected milliamp output as calculated in step 1. (Alternately, compare the pressure displayed on the transmitter with the value recorded for this particular calibration standard.)
5. If the output (or pressure) is high, adjust the 13 mm hex bolt on the expansion unit (at the top right of the analyzer, see page 30) counterclockwise to produce a milliamp reading (or pressure) within ± 0.16 mA of the expected value (or ± 0.024" WC for pressure with a 0.8 to 3.2" WC range instrument). Make small adjustments and allow the unit to stabilize between changes.
6. If the output (or pressure) is low, adjust the 13 mm hex bolt on the expansion unit clockwise to produce a milliamp reading (or pressure) within ± 0.16 mA of the expected value (or ± 0.024" WC for pressure with a 0.8 to 3.2" WC range instrument). Make small adjustments and allow the unit to stabilize between changes.
7. If the unit cannot be adjusted to the correct value, perform a full calibration (see below).
8. Remove the digital ammeter from the 4-20 mA current loop output (if used).
9. Switch the Flo-Cal back to measure sample gas.

Full Calibration

Full calibration sets the instrument span and zero points. It is typically required at initial startup, after major maintenance, and once a year thereafter. At other times, calibration verification and zero adjustment are all that is required. Full calibration requires two calibration standards with heat values at 20% and 80% of the instrument measurement range. The following procedure should be followed to perform a full calibration.

1. Determine the expected milliamp output for the heat value of each of the two calibration standards. Refer to the Output Signal Calculation section above (page 41) for the calculation procedure.
2. Ensure that the Flo-Cal is stable before proceeding. Non-explosion proof units require at least 45 minutes after start-up for stabilizing. Explosion proof units require at least 2 hours after start-up for stabilizing (8 or more hours are recommended).
3. Connect the high (80%) calibration standard to the Flo-Cal and allow to stabilize for at least 30 minutes.
4. Connect a digital ammeter in series with the 4-20 mA current loop output of the Flo-Cal transmitter.
5. Record the actual milliamp output for the high calibration gas.
6. Connect the low (20%) calibration standard to the Flo-Cal and allow to stabilize for at least 30 minutes.
7. Record the actual milliamp output for the low calibration gas.
8. Calculate the expected difference between the milliamp measurements of the two calibration standards using the following equation and the values calculated in step 1.

   $$\text{expected output}_{(\text{cal } 80\%)} - \text{expected output}_{(\text{cal } 20\%)} = \text{expected milliamp signal span}$$

9. Calculate the actual difference between the milliamp measurements of the two calibration standards using the following equation.

   $$\text{actual output}_{(\text{cal } 80\%)} - \text{actual output}_{(\text{cal } 20\%)} = \text{actual milliamp signal span}$$

10. If the actual milliamp signal span is not within ± 1% of the expected milliamp signal span, adjust the span as follows.
    a. If the actual span is smaller than the expected span, the unit is under spanned and should be corrected as follows.
       1) On Wobbe Index units, increase the gas flow to the burner by adding weights to the precision gas regulator.
       2) On Calorific Value units with a CV pump, adjust the pump stroke length (see page 35) to increase the gas flow by setting the stroke length indicator to a larger number at the pump.
       3) Recheck the actual milliamp signal span and compare it to the expected span. If it is within 1%, then continue to step 11 below. If the span cannot be adjusted to within 1% of the expected, the gas or air (or both) orifice must be replaced. Contact Thermo Fisher for assistance.
    b. If the actual span is larger than the expected span, the unit is over spanned and should be corrected as follows.
       1) On Wobbe Index units, decrease the gas flow to the burner by removing weights to the precision gas regulator.
       2) On Calorific Value units with a CV pump, adjust the pump stroke length (see page 35) to decrease the gas flow by setting the stroke length indicator to a smaller number at the pump.

CAUTION: *Never set the stroke length of the CV pump to a value below zero on the pump indicator scale.*

3) Recheck the actual milliamp signal span and compare it to the expected span. If it is within 1%, then continue to step 11 below. If the span cannot be adjusted to within 1% of the expected, the gas or air (or both) orifice must be replaced. Contact Thermo Fisher for assistance.

11. Connect the high (80%) calibration standard to the Flo-Cal and allow to stabilize for at least 30 minutes.
12. If the output is high, adjust the 13 mm hex bolt on the expansion unit (at the top right of the analyzer) counterclockwise to produce a milliamp reading within ± 0.16 mA of the expected value. Make small adjustments and allow the unit to stabilize between changes.
13. If the output is low, adjust the 13 mm hex bolt on the expansion unit (at the top right of the analyzer) clockwise to produce a milliamp reading within ± 0.16 mA of the expected value. Make small adjustments and allow the unit to stabilize between changes.
14. Connect the low (20%) calibration standard to the Flo-Cal and allow to stabilize for at least 30 minutes.
15. Ensure that the milliamp output signal is within ± 0.16 mA of the expected value. If not, repeat the full calibration procedure from the beginning.
16. Remove the digital ammeter from the 4-20 mA current loop output.
17. Switch the Flo-Cal back to measure the sample gas.

Automatic Calibration

The Flo-Cal analyzer can be supplied with an Auto-Cal unit to perform automatic calibration verification and adjustment. Consult the *Auto-Cal User's Guide* provided with your Flo-Cal if it includes that option.

Specific Gravity Calibration

Flo-Cal analyzers with optional specific gravity measurement typically require specific gravity calibration if the instrument range needs to be changed or if the transmitter is replaced. The following procedure should be followed to perform a specific gravity calibration. (See page 47 for information about NORM DISPLAY and SETUP MODE screens.)

1. Determine the expected milliamp output for the heat value of each of the two calibration standards. Refer to the Output Signal Calculation section (page 41 for the calculation procedure.
2. Make sure MODULE RANGE (5th SETUP MODE screen.) is set at 30% - 100%.
3. If possible, measure the pressure difference in inches of water column (W.C.) between the high and low specific gravity calibration gases. If you cannot measure the pressure difference, use 1" W.C. for the zero value and 2" W.C. for the span value as a starting point.

NOTE: *These numbers are used as starting points for the zero and span values. For example, if the low specific gravity gas reads 0.6" W.C. and the high reads 1.1" W. C., then set the zero value (10th SETUP MODE screen) at about 0.5" W.C. and set the span value (11th SETUP MODE screen) at about 1.2-1.3" W.C.*

4. Connect the low (20%) calibration standard to the Flo-Cal and allow it to stabilize for at least 15 minutes. Make sure the temperature has stabilized at *102° F, then continue to the next step.*
5. Select ***EDIT*** and ***FUNCTION*** to return to NORM DISPLAY, and check the low specific gravity gas reading on the display or milliamp output,
6. Enter CAL MODE (1st SETUP MODE screen) and use ZERO CAL MODE and adjust the setting to the calculated value for the low specific gravity gas calibration standard.

NOTE*: If you can not raise or lower ZERO VALUE, increase SPAN VALUE in CAL MODE.*

7. Connect the high (80%) calibration standard to the Flo-Cal and allow it to stabilize for at least 15 minutes. Make sure the temperature has stabilized at 102° F, then continue to the next step.
8. Select ***EDIT*** and ***FUNCTION*** to return to NORM DISPLAY, and check the high specific gravity gas reading on the display or milliamp output.
9. Reduce SPAN VALUE in MODULE RANGE (5th SETUP MODE screen) as necessary to allow changes to ZERO VALUE.
10. Repeat steps 4 through 9, until both the high and low readings do not require further adjustment. When the span value drops below 70%, make adjustments to MODULE RANGE 1% or 2% at a time.
11. When the high and low specific gravity gases read close, change ZERO VALUE and SPAN VALUE (10th and 11th SETUP MODE screens) one at a time in small steps (example: .500" W.C. to .550" W.C.) to decide which value to raise or lower to get best results. (Both can be changed if necessary.)

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Chapter 8

Transmitter

Description

The pressure transmitter used with the Flo-Cal provides simultaneous display and alarm functions. A 4-20mA analog output is provided for transmitting to other remote devices. The transmitter is also equipped with a jumper selectable RS232 and RS485 Modbus bi-directional serial interface. Utilizing this serial port permits up to 128 Flo-Cal transmitters to be connected to a single RS485 multidrop data highway.

System parameters are entered using a magnetic, non-intrusive keypad or a serial port. Menu driven prompts allow easy setup of the many options including alarm set points and reset options. Alarms may be high or low and latching or non-latching. A CAL MODE permits setting of ZERO and SPAN from the keypad. Measurement ranges and engineering units are also programmable from the keypad. An AUTHORIZATION MODE locks access to critical parameters by requiring an access code.

The transmitter displays the inches of water column (WC) measured at various points in the Flo-Cal. When operating in normal mode, the transmitter converts the pressure measurement to a 4-20 mA current output that represents the range of the instrument measurement values. Square root extraction is performed by the transmitter when calculating the appropriate current loop output.

Operation

System Configuration Procedures

The transmitter is very simple to operate and user friendly. In minutes, an operator can configure all variables to the desired settings. Following is a description of how to change each transmitter variable.

Entering Variables Using the Magnetic Keypad

More detail about specific menu items follows in this section. The discussion here is intended as generic instructions for utilizing the magnetic keypad for changing variables within each menu. The following figure should be consulted while reading the instructions in this section.

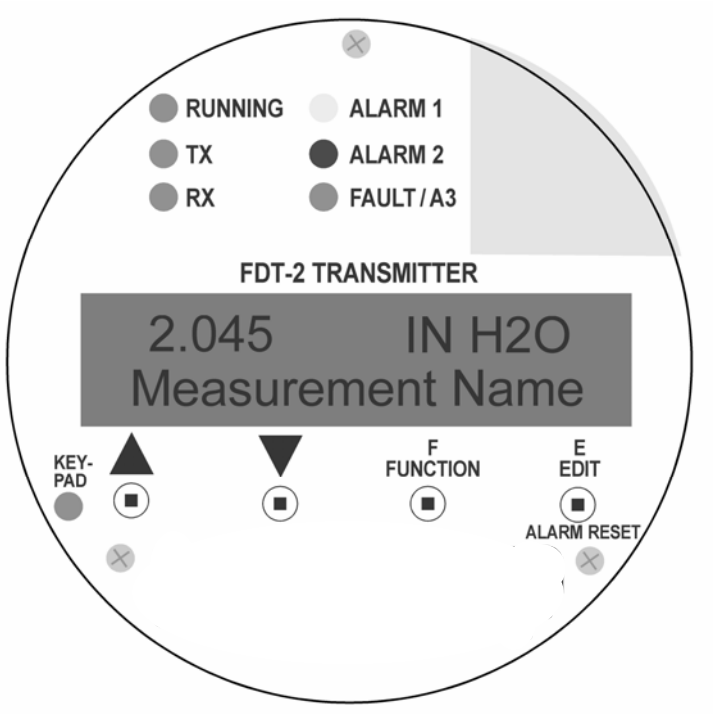


Figure 7. Flo-Cal transmitter front panel with NORM display.

There are two modes of operation into which the transmitter display may be placed. These are the NORM DISPLAY mode (see figure above) and the SETUP MODE. NORM DISPLAY is the usual mode in which the 4 digit VALUE and 6 digits of ENGINEERING UNITS are shown on the top line and the 16 digit MEASUREMENT NAME is shown on the bottom line.

NORM DISPLAY may be exited and SETUP MODE entered at any time by passing the magnetic wand over the ***FUNCTION*** key.

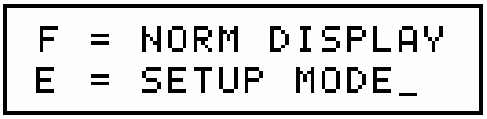
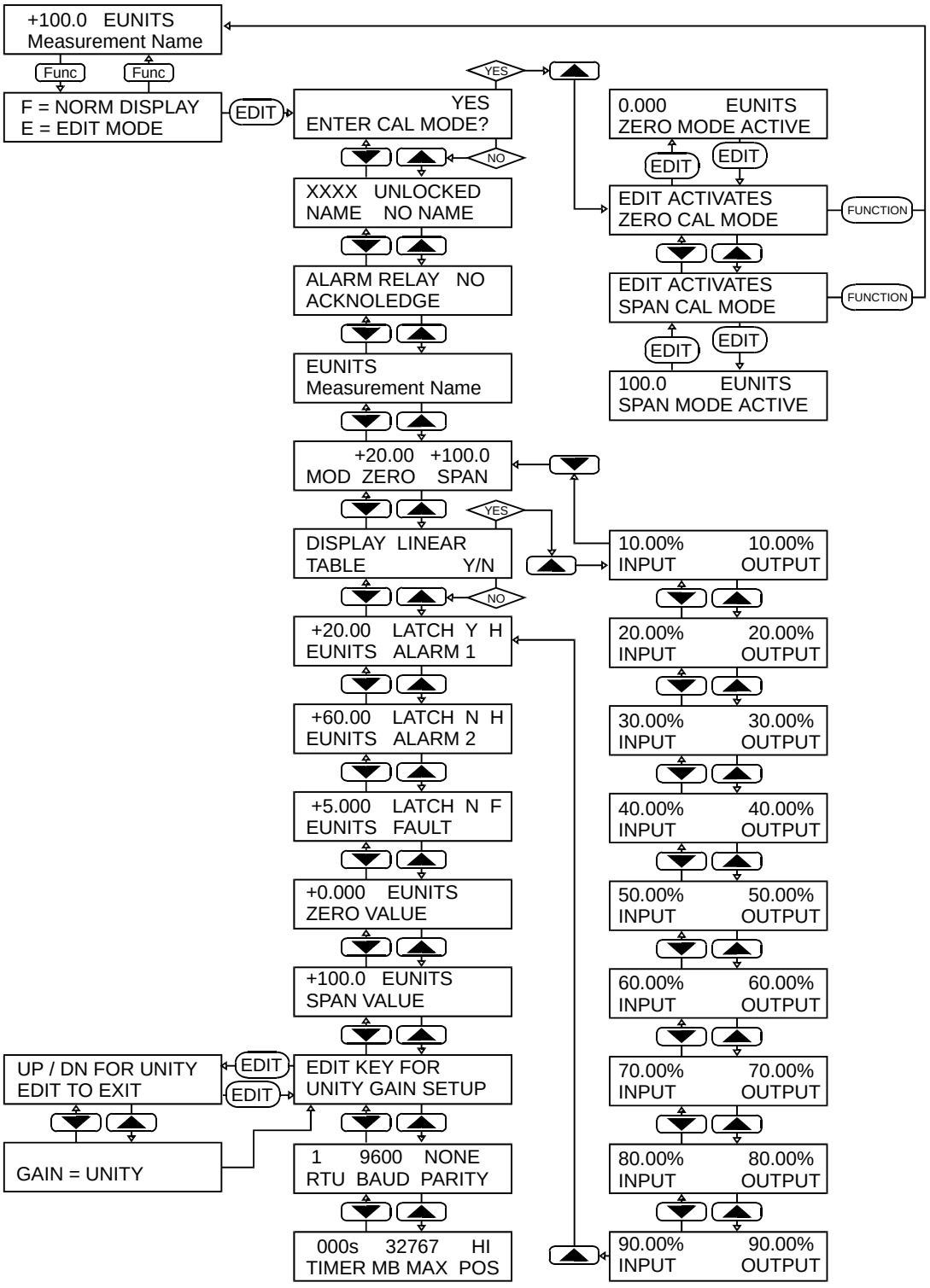


Figure 8. Setup Mode display.

On the display, “F” represents the ***FUNCTION*** key and “E” the EDIT key on all transmitter setup screens. Passing the magnetic wand over ***FUNCTION*** again returns to NORM DISPLAY mode. Passing the magnetic wand over ***EDIT*** enters the SETUP MODE at the top of the list of configurable menu variables shown in the flow chart below.

To escape from any menu and return to NORM DISPLAY, depress the function key, or, after approximately 2 minutes without a keystroke the transmitter will return to norm display automatically.



Note: When not in an edit mode, the ***FUNCTION*** key will return the display to the NORM DISPLAY mode.

Figure 9. Menu flow chart.

After entering the SETUP MODE, configuration of all transmitter variables is accomplished by selecting the appropriate SETUP MODE screen by passing the magnetic wand over the or keys until it is displayed. Variables with few possible entries, such as YES/NO, may be changed by passing the magnetic wand over ***EDIT***, which causes a flashing cursor to appear over the variable. Passing the magnetic wand over the or keys will step through the available entries. Variables requiring many different characters to be entered are also changed by passing the magnetic wand over ***EDIT***. ***EDIT*** begins the flashing cursor, but then passing the magnetic wand over ***FUNCTION*** causes the cursor to move from one character within the variable to the next. Continue to pass the magnetic wand over ***FUNCTION*** until the cursor is under the character to be changed and use the or keys to change it. Number only variables, such as alarm levels**,** may be set quickly since the only possible entries for each character are the 10 decimal numbers and a decimal point. Other more descriptive entries have many more characters that are possible. With the cursor under the character to be changed, pass the magnetic wand over the or key to step through the available character string in the order listed below

ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz !"#$%& `( )*+,-./0123456789:;<=>?@

Passing the magnetic wand over the key steps through the above character string from left to right and the key from right to left. Continue this until the desired character appears, then pass the magnetic wand over ***FUNCTION*** to move the cursor to the next position within a field. When each character of the variable appears as desired, pass the magnetic wand over ***EDIT*** to enter it. The cursor will jump to the next variable on this screen (if there is another) and begin flashing over it. Move to the next SETUP MODE screen by passing the magnetic wand over or when the flashing cursor is not present.

Please remember that variable configuration is a one time task that takes only a few minutes to complete. It does not require repeating after power off conditions since all variables are stored in non-volatile RAM.

Setup Screen Descriptions

Cal Mode

The 1st SETUP MODE screen provides a path into the transmitter CAL MODE, shown below. This feature allows readings to be corrected electronically at the transmitter keypad even when the error may exist at the remote sensor or transmitter. To begin the CAL MODE, toggle the YES / NO option to YES and pass the magnetic wand over ***EDIT***. Another screen appears which instructs the operator to pass the magnetic wand over ***EDIT*** in order to activate the ZERO CAL mode. This will bring the current engineering unit reading to the transmitter display. The input should have a ZERO stimulus applied so that a known ZERO value is present at the transmitter input. The or keys may be used to apply a positive or negative offset to cause the engineering unit value to match the ZERO stimulus. When the ZERO is complete, passing the magnetic wand over ***EDIT*** and then the key brings the display to the entrance of the SPAN CAL mode. Passing the magnetic wand over ***EDIT*** again enters the SPAN CAL mode. The display again reflects the correct engineering unit values for the input signal presently being applied. A SPAN stimulus should be applied to the input so that a known SPAN engineering unit value is present. The or keys may be used to increase or decrease the transmitter gain settings until the engineering unit value matches the SPAN stimulus. Passing the magnetic wand over ***EDIT*** again returns to the SETUP MODE.

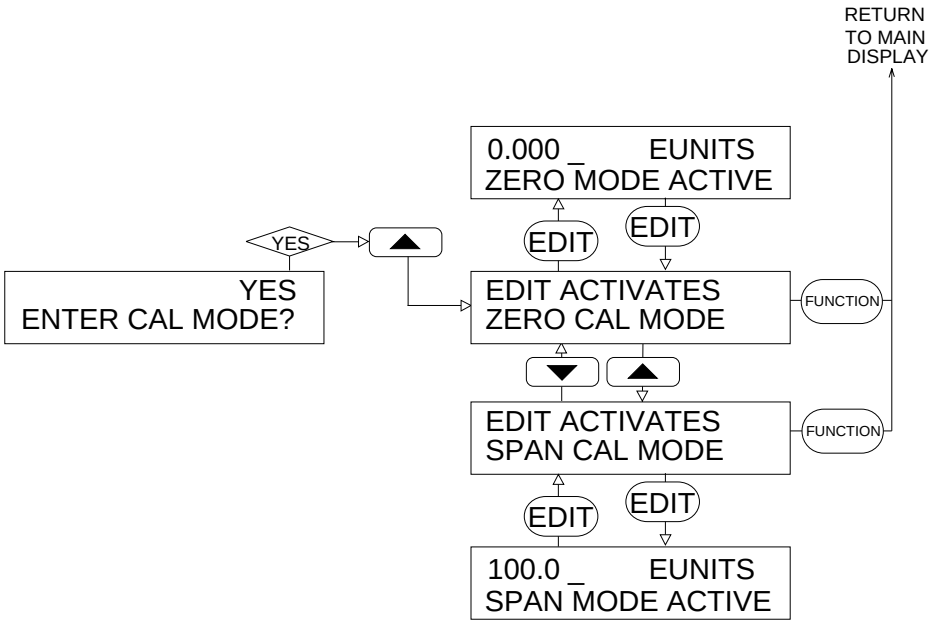


Figure 10. Cal mode flow chart.

Supervisor System Lock

A method for preventing unauthorized personnel from tampering with the configuration of any of the transmitter variables has been provided in the first SETUP MODE screen. If an attempt is made to change any variable after the system is locked, a MODE IS LOCKED message will appear and none of the variables may be altered. To check the status of this feature, enter the SETUP MODE and view the AUTHORIZATION SCREEN shown below.

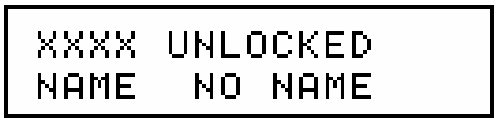


Figure 11. Authorization screen.

The CODE field, displayed as XXXX, is where the 4 digit authorization code is entered. If the status is UNLOCKED, a code may be entered as described in section 3.2. After entering the code once, a prompt will appear asking it to be repeated. If it is not entered correctly the second time, a CODE MISMATCH message will appear. After it is entered properly the second time, the cursor will flash over the U in the UNLOCKED field. Passing the magnetic wand over or will lock the SETUP MODE. NAME is a 10 character field where a supervisory contact should be entered who knows the authorization code.

Always enter the name of an individual with the authorization code in this field. The procedure for resetting a transmitter with a lost authorization code requires all configuration data to be erased and reentered. This reset procedure is not described in this manual for security reasons. Contact Thermo Fisher if this becomes necessary.

To change the MENU status back to UNLOCKED, enter the 4 digit code again and pass the magnetic wand over ***ENTER***.

Alarm Relay Acknowledge Feature

It is sometimes desirable to have a method by which alarm trips may be “acknowledged” while the problem causing the alarm is serviced. This is often the case when an annoying horn or strobe light is driven from the alarm's relay output. The second SETUP MODE screen allows enabling of the RELAY ACKNOWLEDGE feature, which only applies to the ALARM 2 relay. It is shown below.

Figure 12. Alarm 2 relay acknowledge feature screen.

The RELAY ACKNOWLEDGE screen has a YES/NO option field. If the field is set to NO, the relay for each alarm is always activated when that alarm is on. If the field is set to YES, the ALARM 2 relay activates initially when the alarm is on, but may then be de-activated by the ***ALARM RESET*** function. Applying an ***ALARM RESET*** function does not affect the ALARM 2 LED. If the ALARM 2 condition goes away and then returns, the ***ALARM RESET*** function must be applied again to deactivate the relay.

ALARM RESET may be applied in 3 different ways; by passing the magnetic wand over the ***ALARM RESET*** key on the keypad, by applying a contact closure to the remote ***ALARM RESET*** input terminals on TB1, or by applying an ***ALARM RESET*** code to the Modbus® serial interface.

Measurement Description and Engineering Units

The 4th SETUP MODE screen is where the 6 digit engineering unit and the 16 digit MEASUREMENT DESCRIPTION labels are entered. It is shown below.

Figure 13. Measurement description.

Engineering Units

This 6 character field is where the units of measure for the input are entered. For example, if an input module is installed for 100 ohm platinum RTD that is calibrated for 0-100 degrees centigrade, then Deg C might be entered here. Deg F could also be entered if it is desired to display the data this way. When this field is entered, it will appear throughout the remainder of the menus in places where the entry needs to be in engineering units of measure.

Measurement Description

This is a 16 character field that the user can utilize as an ID tag to describe the monitored variable using familiar terminology. This ID tag will appear on the lower line of the NORM DISPLAY screen. It is especially useful when several transmitters are monitoring variables from different locations since it may be used to identify each location. It may also be read from the serial port.

Module Range

This very important entry allows flexible use of an input module's range. It is the 5th SETUP MODE screen and is shown below.

Figure 14. Module zero and span.

The percentage of the input's range to be utilized may be entered on this screen. Any value between 0-100% may be entered, but it is recommended that no less than a 20% of full scale range be used in order to avoid noise problems caused by over amplifying the input signal. This means the difference between the ZERO % value and the SPAN % value should be no less than 20%.

For example, if a 7B module for an RTD input had a calibrated range of 0-100 degrees C, and if we want to measure 0-100 degrees C, we must enter 0-100% into the MOD ZERO & SPAN menu entries. However, if we are only interested in 20-40 degrees C, we may enter only 20-40% into these menu entries and the transmitter display will focus on this narrower range. The same 7B module may be used in both examples. that 20° C (or 68° F) must be entered in the ZERO VALUE and 40° C (or 104° F) must be entered for the SPAN VALUE when configuring the measurement range in the 9th and 10th SETUP MODE screens as described in sections 4.9 & 4.10 of this manual.

Activating Linearization

The 6th SETUP MODE screen is provided to allow non-linear inputs to be linearized by the manual keypad entry of a 10 breakpoint linearization curve. This screen is shown below.

Figure 15. Display linear table screen.

This screen asks DISPLAY LINEAR TABLE, which is followed by a YES / NO option. Entering NO does not mean that linearization is not being applied. It is possible to have a curve entered and not display it when scrolling through the SETUP MODE. Entering YES and displaying the curve means that 9 additional screens must be scrolled through when traversing the SETUP MODE. If the curve does not require frequent modification, it is recommended that it be displayed only during the initial setup. The 9 screens that make up the LINEAR TABLE are shown below.

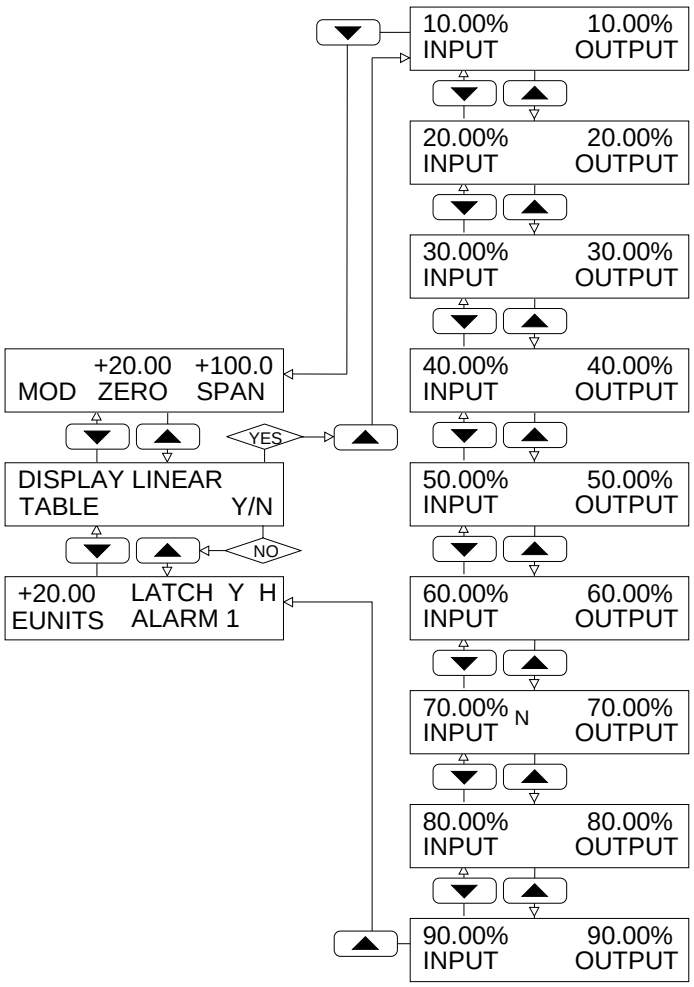


Figure 16. Linear table flow chart.

The OUTPUT values, in percent of full scale, are constants that may not be modified. The INPUT values, also in percent of full scale, must be entered by the user. Transmitter users wishing to utilize the linearization feature are responsible for correctly entering breakpoint values. Typically, the nine breakpoint values are available to the user on a graph or table depicting the curve to be linearized. For example, if the input signal was at 70% of full scale when the correct engineering unit values were only 50% of full scale, 70% should be entered as the INPUT for the 50% OUTPUT. The INPUT and OUTPUT signals are expected to match at 0% and 100%. Therefore, there is no menu entry for entering these points.

Alarm 1 Setup

The 7th SETUP MODE screen, shown below, determines for alarm 1, the trip point level, if it is latching or nonlatching, and if it trips on high or low going signals.

Figure 17. Alarm 1 parameters.

The trip point must be entered within the active range of engineering units being monitored. If it is desired that ALARM 1 reset automatically when the alarm condition clears, enter N after LATCH. If it is desired that an ***ALARM RESET*** function must be applied before allowing ALARM 1 to reset, enter L after LATCH.

The last character position on the top line may be toggled to either an H for high level trips, or an L for low level trips. H causes the alarm to trip as the reading exceeds the trip point and L as the reading falls below the trip point. There is 1 percent deadband to prevent the alarms from chattering when the reading is equal to the trip point.

Alarm 2 Setup

The 8th SETUP MODE screen, shown below, determines the ALARM 2 trip point level and if it is latching or nonlatching and high or low. It is identical to ALARM 1 in respect to deadband.

Figure 18. Alarm 2 parameters.

Fault / Alarm 3 Setup

The 9th SETUP MODE screen, shown in the figure below, determines if the FAULT / ALARM 3 alarm functions as a third *level* alarm or as an *underrange* indicating FAULT alarm.

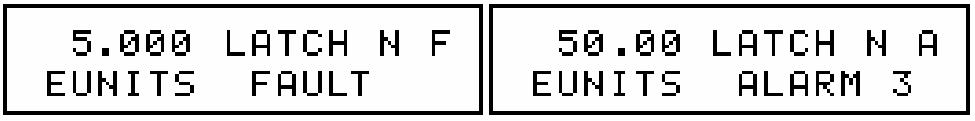


Figure 19. Fault or Alarm 3 parameters.

To configure it for a level alarm requires that the last character on the top line be set to an A as shown in the figure above. The trip point and latching / nonlatching options are then configured the same as for ALARM 2.

To configure as a FAULT alarm requires that the last character on the top line be set to an F as shown in the figure above. The trip point entered will represent how far below the defined measurement range may the signal stray before the FAULT alarm is tripped. In the earlier example of 0-100 DEG C for the signal range; if 3.000 were entered for the FAULT THRESHOLD, then a FAULT alarm would occur when the signal fell below -3.000 DEG C.

Zero Value

The 10th SETUP MODE screen, shown below, determines the low end of the measurement range. In the above example, using 100% of the 0-100 degrees C 7B module (it is possible to use smaller portions of 7B module spans, as discussed in section 4.4), the ZERO VALUE would be 0.000 deg C or 32.00 deg F.

Figure 20. Zero value.

Span Value

The 11th SETUP MODE screen, shown below, determines the upper end of the measurement range. In the example above, 100.0 deg C or 212.0 deg F would be entered here if 100% of the 7B module span were to be used. It is important to understand that the ZERO VALUE and the SPAN VALUE entries must define 0-100% of full scale in engineering units for the display.

Figure 21. Span value.

Unity Gain Setup

The 12th SETUP MODE screen, shown below, provides a means of instantly placing the CAL MODE (described in section 4.12) into UNITY GAIN. UNITY GAIN means there are no offset or gain factors being applied to the input. It is being displayed same as it is received. To apply UNITY GAIN, bring the screen on the right below up and pass the magnetic wand over ***EDIT*** and then either or . The transmitter will briefly show the GAIN = UNITY screen.

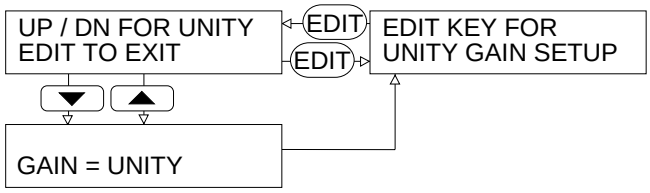


Figure 22. Unity Gain function.

Serial Port Setup

The 13th and 14th SETUP MODE screens are for configuring the Modbus serial port. The 13th is for RTU address number, baud rate and parity. The 14th is for entering the Modbus maximum which may be either 9999 or 32767, and the ASCII position of the data which may be either high byte or low byte. The 000s TIMER field allows activation of a hardware switch that may be used to enable two external serial ports. The transmitter will wait for this delay period, upon loss of serial port activity, before switching to another external port in an attempt to re-establish communications. These variables must be set to conform to requirements of the specific host computer system that receives the transmitter serial data.

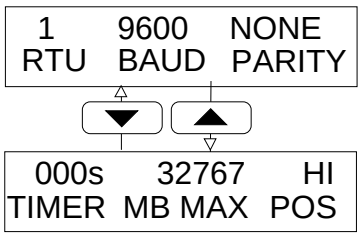


Figure 23. Modbus serial port configuration.

System Hardware

The transmitter consists of four round circuit board assemblies. The CPU, MEMORY and DISPLAY boards mate together *piggy back* in a *stack* assembly with 44 pin board to board connectors. The CPU board is on the bottom of the stack, farthest from the front panel, and has a 12 pin heavy duty male connector mounted on its solder side. This connector mates with a similar female connector on the I/O board. Removal of the stack with power applied conditions will not damage the unit.

WARNING: ***Do not open the transmitter housing with power applied unless the area is known to be non-hazardous. Do not attempt to connect or disconnect components with power applied unless the area is known to be non-hazardous.***

CPU Board

The transmitter CPU is an Intel 80C196KB 16 bit microcontroller with a clock frequency of 12MHZ.

The CPU board, farthest from the front panel in the 3 board stack, contains the 16 bit micro-controller (U2), preamplifier (U4), D/A Converter (U7), 4-20mA output circuit (U10), along with circuitry for the 5 volt reference and watchdog timer. The preamplifier includes ZERO (R4) and SPAN (R8) adjustments. In addition, the D/A Converter includes a SPAN (R10) adjustment that is used to set the full scale value of the analog output signal. The calibration procedure for these adjustments follows.

Calibration

Note: The 3 potentiometers located on the CPU board are set at the factory and normally need no further adjustment. The following procedure is provided in the event that a major component is replaced or the adjustments are inadvertently tampered with.

1. Since the transmitter is equipped with an *electronic* CAL MODE, it is important that prior to calibrating the potentiometers, the electronic CAL MODE be placed into UNITY GAIN. Otherwise, it is possible that readings may have offset and gain applied electronically. Place the transmitter into UNITY GAIN by following the procedure on page 58.
2. Return to the NORM DISPLAY screen for viewing the input value in engineering units. Apply a stable 0% full scale analog signal to the analog input terminals. Adjust the ZERO potentiometer R4 until the transmitter displays the correct ZERO reading.
3. Apply a stable 100% full scale signal to the analog input terminals. Adjust the SPAN potentiometer R8 until the transmitter displays the correct SPAN value.
   Note: The next step may be skipped if the analog output is not utilized.
4. Measure the analog output using a digital multimeter. The standard analog output from the transmitter is 4-20mA. Therefore, with the 100% full scale input applied, adjust the analog SPAN potentiometer (R10) for 20mA at the analog output terminals.

Memory Board

The MEMORY board, middle in the 3 board stack, contains the socketed EPROM firmware (U3 & U4) and PAL (U6), the NON-VOLATILE RAM (U5), and the RAM IC's (U7 & U8). It is the middle of the three “stack” boards connected by the 44 pin connector.

Display Board

The Display board, top of the 3 board stack, contains the 16-character, 2-line alphanumeric LCD display and supporting circuitry including the contrast adjustment potentiometer (R1). Indicating LED's showing the condition of discrete variables such as alarms, serial port transmit and receive lines, keypad, and CPU operation are on the DISPLAY board. The magnetic keypad switches allowing non-intrusive control of the transmitter are on this board.

Input/Output Board

The Input/Output board (I/O) has the optional plug in Input signal conditioning module and the alarm relays mounted on the solder side. No signal conditioning module is required for non-isolated 4-20 mA or 1-5VDC inputs. The component side has the RS232 port (U4), RS485 port (U2 & U3), and the jumpers for configuring the serial port to be either RS232 or RS485. In addition, the 5 volt switching power supply and TB1 & TB2 are on the I/O board.

RS-232 / RS-485 Configuration

The transmitter is equipped with RS232 and RS485 serial interface circuits. Either may be selected by placement of jumpers on the I/O PCB.

Terminal Block Connections

Terminal block connection assignments are shown in the following tables.

TB1 Connections	
1	Power Plus
2	Alarm 1 NO
3	Power Minus (COMMON with SB1 installed)
4	Alarm 1 Common
5	Analog Output Plus
6	Alarm 1 NC
7	Analog Output Minus
8	Alarm 2 NO
9	Remote Alarm Reset
10	Alarm 2 Common
11	RS-485 RXB / RS-232 COMMON
12	Alarm 2 NC
13	RS-485 RXA
14	*Fault / Alarm 3 NO
15	RS-485 TXB / RS-232 RXD
16	*Fault / Alarm 3 Common
17	RS-485 TXA / RS-232 TXD
18	*Fault / Alarm 3 NC

**Fail Safe; NO opens on alarm*

TB2 Connections	
1	Excitation Plus (24VDC with JP7 installed)
2	Analog Input Plus
3	Analog Input Minus (circuit COMMON with JP6 installed)

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Chapter 9

Getting Help

Additional Information

NOTE: *In the interest of completeness, manuals and drawings included with the system may provide information pertaining to options not included with your system. Information in application notes supersedes general information in these documents.*

Additional information can be obtained from the following sources.

Flo-Cal User Guide
Auto-Cal II User's Guide
System drawings
Application notes for the supplied system
Manuals and data sheets for other equipment

The application notes supplied with each system include information specific to the configuration of the installed system. These notes will typically include pressure settings, flow settings, temperature settings and other special situations or adjustments.

Getting Help

Answers to many questions concerning the analyzer system can be found in this manual and other documentation provided with the system. If a problem or question is encountered that is not covered in the documentation, assistance is available Monday through Friday (except holidays), from 8 a.m. to 5 p.m. Central time. To obtain assistance, please call Thermo Fisher at (713) 272-0404, or fax us at (713) 272-2272.

For assistance during times other than normal business hours, consult our web site at **http://www.thermofisher.com**. This site includes equipment information, news releases, and other information. Alternately, you can call (713) 272-0404 and leave a voice message or you can send a fax to (713) 272-2272.

To contact Thermo Fisher:

Address: Thermo Fisher Scientific
Process Instruments Division
1410 Gillingham Lane
Sugar Land, TX 77478
USA

Phone: 713-272-0404

Fax: 713-272-2272

Web: www.thermofisher.com

Chapter 10

Glossary

Auto-Cal

An automatic calibration option available with the Flo-Cal calorimeter.

BTU/SCF

British Thermal Unit per Standard Cubic Foot measured at 60° F and 30" Hg.

Calorific Value (CV)

The heat value of a gas at standard conditions expressed as Gross Heating Value (HHV) or Net Heating Value (LHV).

CCW

Counter-clockwise

CPU

central processing unit (computer)

CV

Calorific Value or Constant Volume (pump).

CW

clockwise

Density

Density denotes the ratio of the mass of a substance to its volume, expressed in grams per cubic centimeter or pounds per cubic foot.

Fault

An error condition.

Flame-Out

Indicates that the burner flame is extinguished.

Field

A category of information in a table. Fields contain such information as component names, elution times, Alarm numbers, etc.

Gross Heating Value

The theoretical heat value of a gas at standard conditions.

Heat Value

A term used interchangeably for Calorific Value or Wobbe Index. It expresses the heat energy per unit volume of a fuel gas. It can be expressed as BTU/SCF, MJ/Nm^3, or $Kcal/Nm^3$.

HHV

Gross Heating Value.

$Kcal/Nm^3$

Kilocalories per normal cubic meter measured at 0° C and 760 mm Hg.

LED

Light Emitting Diode. Often used as an alarm or status indicator for electronic equipment. Colors available include red, green, yellow, and orange.

LHV

Net Heating Value.

MJ/Nm^3

Megajoules per normal cubic meter measured at 0° C and 760 mm Hg.

Net Heating Value

The actual available heat value of a gas at standard conditions. This is frequently used to determine the heat potential of a fuel gas.

PCB

Printed circuit board containing the electronic components performing one or more functions.

Specific Gravity

Specific gravity, a term being replaced by *relative density*, is the ratio of the density of a given substance to the density of a standard of reference at standard temperature and pressure. The standard of reference for solids and liquids is the density of water. For gases, it is the density of air.

STP

Standard temperature and pressure conditions (0° C and 760 mm Hg).

WC

Water column, a measurement of gas pressure expressed in inches of water.

Wobbe Index

A measure of the combined effects of fuel gas, heat value, and specific gravity changes to provide a meaningful measure of a gas's actual heating characteristics.

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Appendix A

Flame-Out & Overrange

Flame-Out System

The flame-out system automatically shuts off the gas source, CV pump (Calorific Value units only), and sparking ignitor if the burner flame fails to light within the preset time limit (3.2 or 6.4 minutes depending on BTU range of instrument). Refer to the Flame-Out Control Matrix table (below) and the electronic schematic at the end of this appendix.

If electrical power, gas flow, or air flow to the Flo-Cal analyzer is lost, the burner flame will extinguish. When the lost power or flow is restored, the flame-out time-delay relay is energized to allow the burner flame to re-light. If the flame does not re-light within the delay time, a solenoid valve in the gas supply line is de-energized and the flame-out alarm contact is closed. The CV pump (where used) and sparking unit are also de-energized. The system functions in a similar manner when power is first applied to the analyzer.

To re-light the flame after the time-delay relay trips, the reset button must be momentarily depressed and released or the electrical power to the analyzer must be cycled. If the flame still fails to light, consult the maintenance chapter (page 27).

Flame-Out Control Matrix

	Input				Control		Output		
CONDITION	**air press sw**	**inlet gas press sw**	**flame out press sw**	**over range sw**	**flame out relay**	**over range relay**	**inlet gas solenoid**	**sparking unit**	**CV pump**
initial power on	closed✠	closed✠	closed	open	off delaying	off	open	on	on
normal, flame on	closed✠	closed✠	open	open	off	off	open	off	on
initial flame out	closed✠	closed✠	closed	open	off delaying	off	open	on	on
3.2 or 6.4 minutes after flame out	closed✠	closed✠	closed	open	on	off	closed	off	off
Reset pushed w/flame out	system goes to initial flame-out states								

✠ These switches will be open if the air or inlet gas pressure is too low.

Overrange system

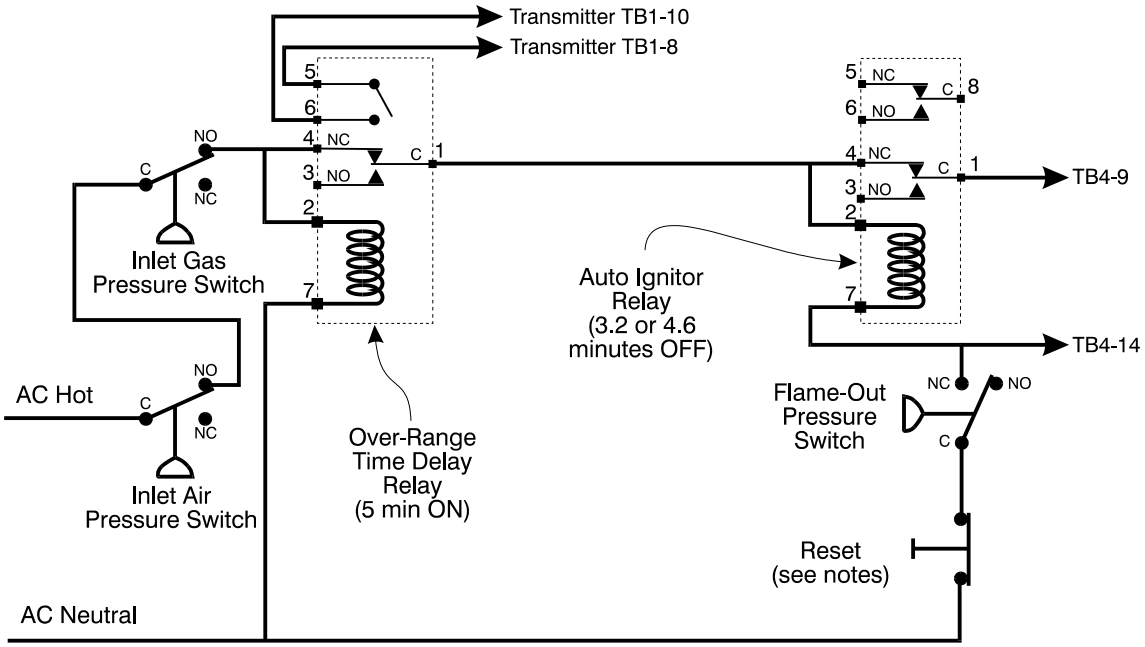
If an over-range condition develops, the Flo-Cal calorimeter automatically extinguishes the burner flame. After five minutes, the flame is automatically allowed to re-ignite. Refer to the Over-Range Control Matrix (below) and the electronic schematic at the end of this appendix.

If an over-range condition develops, the over range alarm output on the transmitter closes and initiates the over range time-delay relay. The relay immediately closes the inlet gas solenoid and turns off power to the sparking unit and the CV pump (where used). When the inlet gas solenoid closes, burner gas is lost and the analyzer flame goes out. After a delay of five minutes, the over range relay turns off. The inlet gas solenoid is then opened and power is applied to the sparking unit and the CV pump. The flame-out circuit then attempts to re-light the flame (see the description on the flame-out system on the preceding page).

Over-Range Control Matrix

	INPUT				CONTROL		OUTPUT		
CONDITION	**air press sw**	**inlet gas press sw**	**flame out press sw**	**over range sw**	**flame out relay**	**over range relay**	**inlet gas solenoid**	**sparking unit**	**CV pump**
initial power on	closed✠	closed✠	closed	open	off delaying	off	open	on	on
normal, range ok	closed✠	closed✠	open	open	off	off	open	off	on
initial over range	closed✠	closed✠	open	closed	off	on delaying	closed	off	off
5 min after over range	closed✠	closed✠	closed	open	off delaying	off	open	on	on
flame-out conditions	When the over range relay times out (after 5 minutes), the conditions become identical to an initial flame out as shown in the Flame-Out Control Matrix (above).								

✠ These switches will be open if the air or inlet gas pressure is too low.



Notes:

TB4-9 supplies AC power (hot) to the following:

- Sparking unit
- Inlet gas shut-off solenoid
- CV pump assembly (opt.)
- Aux gas shut-off solenoid (opt.)
- H_2 addition solenoid (opt.)

TB4-14 supplies AC neutral to the following:

- Sparking unit
- Aux gas shut-off solenoid (opt.)

Reset switch is only available on general purpose units. System reset on hazardous area units is accomplished by manually cycling unit power.

Figure 24. Electronic schematic of the Flo-Cal Flame-out and Over-range circuits.

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Appendix B

Pressure Conversion Charts

Typically, the Flo-Cal pressure transmitter measures up to 3.2" WC. This range is not high enough setting the inlet air or inlet gas pressures. Therefore, a Test Point Switch push-button is available to momentarily extend the range of the pressure transmitter when setting the inlet pressures. This momentary push-button is located on the pressure transducer board inside the Flo-Cal (see page 34). When the Test Point Switch is depressed, the range is changed to 0 – 8.3 inches WC. The range returns to the normal values when the push-button is released.

When in the extended range mode (i.e., the push-button depressed), the actual pressure measurement must be calculated from the transmitter reading. The following equations can be used to determine the pressure when the push-button is depressed.

To determine the actual measured pressure for a displayed value with the push button depressed, use the following formula.

$$\frac{\text{Displayed Pressure}}{\text{Instrument Full Scale Setting}} \text{ X 8.3“ WC } = \text{ Actual Pressure}$$

To determine the displayed pressure for a desired pressure with the push button depressed, use the following formula…

$$\frac{\text{Desired Pressure X Instrument Full Scale Setting}}{\text{8.3“ WC}} = \text{ Displayed Pressure}$$

The following pressure conversion tables can also be used to determine measured pressures. To use, select the table that corresponds to the normal measurement range, and then find the measured pressure that corresponds to the transmitter reading.

Table for 0.80 - 3.2" WC instruments

Actual Pressure	Displayed Pressure
0.00	0.000
0.10	0.039
0.20	0.077
0.30	0.116
0.40	0.154
0.50	0.193
0.60	0.231
0.70	0.270
0.80	0.308
0.90	0.347
1.00	0.386
1.10	0.424
1.20	0.463
1.30	0.501
1.40	0.540
1.50	0.578
1.60	0.617
1.70	0.655
1.80	0.694
1.90	0.733
2.00	0.771
2.10	0.810
2.20	0.848
2.30	0.887
2.40	0.925
2.50	0.964
2.60	1.002
2.70	1.041
2.80	1.080
2.90	1.118
3.00	1.157
3.10	1.195
3.20	1.234
3.30	1.272
3.40	1.311
3.50	1.349
3.60	1.388
3.70	1.427
3.80	1.465
3.90	1.504
4.00	1.542
4.10	1.581
4.20	1.619
4.30	1.658
4.40	1.696
4.50	1.735
4.60	1.773
4.70	1.812
4.80	1.851
4.90	1.889
5.00	1.928
5.10	1.966
5.20	2.005
5.30	2.043
5.40	2.082
5.50	2.120
5.60	2.159
5.70	2.198
5.80	2.236
5.90	2.275
6.00	2.313
6.10	2.352
6.20	2.390
6.30	2.429
6.40	2.467
6.50	2.506
6.60	2.545
6.70	2.583
6.80	2.622
6.90	2.660
7.00	2.699
7.10	2.737
7.20	2.776
7.30	2.814
7.40	2.853
7.50	2.892
7.60	2.930
7.70	2.969
7.80	3.007
7.90	3.046
8.00	3.084
8.10	3.123
8.20	3.161
8.30	3.200

Table for 0.64 - 4.0" WC instruments

Actual Pressure	Displayed Pressure
0.00	0.000
0.10	0.048
0.20	0.096
0.30	0.145
0.40	0.193
0.50	0.241
0.60	0.289
0.70	0.337
0.80	0.386
0.90	0.434
1.00	0.482
1.10	0.530
1.20	0.578
1.30	0.627
1.40	0.675
1.50	0.723
1.60	0.771
1.70	0.819
1.80	0.867
1.90	0.916
2.00	0.964
2.10	1.012
2.20	1.060
2.30	1.108
2.40	1.157
2.50	1.205
2.60	1.253
2.70	1.301
2.80	1.349
2.90	1.398
3.00	1.446
3.10	1.494
3.20	1.542
3.30	1.590
3.40	1.639
3.50	1.687
3.60	1.735
3.70	1.783
3.80	1.831
3.90	1.880
4.00	1.928
4.10	1.976
4.20	2.024
4.30	2.072
4.40	2.120
4.50	2.169
4.60	2.217
4.70	2.265
4.80	2.313
4.90	2.361
5.00	2.410
5.10	2.458
5.20	2.506
5.30	2.554
5.40	2.602
5.50	2.651
5.60	2.699
5.70	2.747
5.80	2.795
5.90	2.843
6.00	2.892
6.10	2.940
6.20	2.988
6.30	3.036
6.40	3.084
6.50	3.133
6.60	3.181
6.70	3.229
6.80	3.277
6.90	3.325
7.00	3.373
7.10	3.422
7.20	3.470
7.30	3.518
7.40	3.566
7.50	3.614
7.60	3.663
7.70	3.711
7.80	3.759
7.90	3.807
8.00	3.855
8.10	3.904
8.20	3.952
8.30	4.000

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Appendix C

Modbus

Modbus communication is an option available with the Flo-Cal for connection to a Distributed Control System (DCS). Consult the application notes included with the instrument for information on Modbus address mapping when included.

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Appendix D

Toxic & Hazardous Substances Tables*

*English and Chinese versions.

The Toxic & Hazardous Substances tables for Flo-Cal (ATEX and Safe Area) can be found on the following pages.

Toxic & Hazardous Substances Table – Flo-Cal (ATEX)

For Chinese Regulation: Administrative Measure on the Control of Pollution Caused by Electronic Information Products

Names and Content of Toxic and Hazardous Substances or Elements

Parts Name	Toxic and Hazardous Substances or Elements (Flo-Cal ATEX)					
	Pb	Hg	Cd	Cr6+	PBB	PBDE
ATEX Housing	x	o	o	x	o	o
Pressure Sensor Board	x	o	o	o	o	o
Air Regulator Assembly	x	o	o	x	o	o
Air Control Block	x	o	o	x	o	o
Gas Control Block	x	o	o	o	o	o
Air/Heat Valve Regulator	x	o	o	x	o	o
Spark Igniter	x	o	o	x	o	o
Pump	x	o	o	o	o	o
Sample Regulator	o	o	o	o	o	o
Customer Connection	x	o	o	o	o	o
Transmitter	x	o	o	x	o	o
Cabling	x	o	o	o	o	o

○ : Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in **SJ/T11363-2006**

x: Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in **SJ/T11363-2006**

有毒有害物质名称及含量的标识格式

部件名称	有毒有害物质或元素 (Flo-Cal ATEX)					
	铅（Pb）	汞（Hg）	镉（Cd）	六价铬（Cr6+）	多溴联苯（PBB）	多溴二苯醚（PBDE）
外壳 (ATEX)	x	o	o	x	o	o
压力传感器电路板	x	o	o	o	o	o
空气调节器组件	x	o	o	x	o	o
空气控制器组件	x	o	o	x	o	o
燃气控制器组件	x	o	o	o	o	o
空气加热阀调节器	x	o	o	x	o	o
火花点火极	x	o	o	x	o	o
泵	x	o	o	o	o	o
采样调节器	o	o	o	o	o	o
客户连接终端	x	o	o	o	o	o
发射机	x	o	o	x	o	o
缆线连接	x	o	o	o	o	o

○：表示该有毒有害物质在该部件所有均质材料中的含量均在**SJ/T 11363-2006**标准规定的限量要求以下

x: 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出**SJ/T 11363-2006**标准规定的限量要求

Figure 25. Toxic & Hazardous Substances Tables – Flo-Cal (ATEX)

Toxic & Hazardous Substances Table – Flo-Cal (Safe Area)

For Chinese Regulation: Administrative Measure on the Control of Pollution Caused by Electronic Information Products

Names and Content of Toxic and Hazardous Substances or Elements

Parts Name	Toxic and Hazardous Substances or Elements (Flo-Cal SA)					
	Pb	Hg	Cd	Cr6+	PBB	PBDE
Housing	x	o	o	x	o	o
Pressure Sensor Board	x	o	o	o	o	o
Air Regulator Assembly	x	o	o	x	o	o
Air Control Block	x	o	o	x	o	o
Gas Control Block	x	o	o	o	o	o
Air/Heat Valve Regulator	x	o	o	x	o	o
Spark Igniter	x	o	o	x	o	o
Pump	x	o	o	o	o	o
Sample Regulator	o	o	o	o	o	o
Customer Connection	x	o	o	o	o	o
Transmitter	x	o	o	x	o	o
Cabling	x	o	o	o	o	o

○ : Indicates that this toxic or hazardous substance contained in all of the homogeneous materials for this part is below the limit requirement in **SJ/T11363-2006**

x: Indicates that this toxic or hazardous substance contained in at least one of the homogeneous materials used for this part is above the limit requirement in **SJ/T11363-2006**

有毒有害物质名称及含量的标识格式

部件名称	有毒有害物质或元素 (Flo-Cal SA)					
	铅（Pb）	汞（Hg）	镉（Cd）	六价铬（Cr6+）	多溴联苯（PBB）	多溴二苯醚（PBDE）
外壳	x	o	o	x	o	o
压力传感器电路板	x	o	o	o	o	o
空气调节器组件	x	o	o	x	o	o
空气控制器组件	x	o	o	x	o	o
燃气控制器组件	x	o	o	o	o	o
空气加热阀调节器	x	o	o	x	o	o
火花点火极	x	o	o	x	o	o
泵	x	o	o	o	o	o
采样调节器	o	o	o	o	o	o
客户连接终端	x	o	o	o	o	o
发射机	x	o	o	x	o	o
缆线连接	x	o	o	o	o	o

○：表示该有毒有害物质在该部件所有均质材料中的含量均在**SJ/T 11363-2006**标准规定的限量要求以下

x: 表示该有毒有害物质至少在该部件的某一均质材料中的含量超出**SJ/T 11363-2006**标准规定的限量要求

Figure 26. Toxic & Hazardous Substances Tables – Flo-Cal (Safe Area)

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