# User's Guide

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ΩE OMEGA®

# FC-22
# SERIES
# Flow Computer

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# SAFETY INSTRUCTIONS

**The following instructions must be observed.**

- This instrument was designed and is checked in accordance with regulations in force EN 60950 ("Safety of information technology equipment, including electrical business equipment").
  A hazardous situation may occur if this instrument is not used for its intended purpose or is used incorrectly. Please note operating instructions provided in this manual.

- The instrument must be installed, operated and maintained by personnel who have been properly trained. Personnel must read and understand this manual prior to installation and operation of the instrument.

- The manufacturer assumes no liability for damage caused by incorrect use of the instrument or for modifications or changes made to the instrument.

**Technical Improvements**

- The manufacturer reserves the right to modify technical data without prior notice.

# 1. Introduction

## 1.1 Unit Description:

The FC-22 (FC-22) Flow Computer satisfies the instrument requirements for a variety of flowmeter types in liquid, gas, steam and heat applications. Multiple flow equations are available in a single instrument with many advanced features.

The alphanumeric display offers measured parameters in easy to understand format.  Manual access to measurements and display scrolling is supported.

The versatility of the Flow Computer  permits a wide measure of applications within the instrument package. The various hardware inputs and outputs can be "soft" assigned to meet a variety of common application needs. The user "soft selects" the usage of each input/output while configuring the instrument.

The isolated analog output can be chosen to follow the volume flow, corrected volume flow, mass flow,  heat flow, temperature, pressure, or density by means of a menu selection. Most hardware features are assignable by this method.

The user can assign the standard RS-232 Serial Port for data logging, or transaction printing, or for connection to a modem for remote meter reading.

A PC Compatible software program is available which permits the user to rapidly redefine the instrument configuration.

Language translation option features also permit the user to define his own messages, labels, and operator prompts. These features may be utilized  at the OEM level to creatively customize the unit for an application or alternately to provide for foreign language translations.  Both English and a second language reside within the unit.

NX-19 option

Advanced ordering options are available for Natural Gas calculations where the user requires compensation for compressibility effects. Compensation for these compressibility effects are required at medium to high pressure and are a function of the gas specific gravity, % $CO_2$, % Nitrogen, as well as temperature and pressure. The compressibility algorithm used is that for NX-19.

Stacked differential pressure transmitter option

This option permits the use of a low range and high range DP transmitter on a single primary element to improve flow transducer and measurement accuracy.

Peak demand option

This option permits the determination of an hourly averaged flow rate. Demand last hour, peak demand and time/date stamping for applications involving premium billing.

Data logging option

This option provides data storage information in 64k of battery backed RAM. Items to be logged, conditions to initiate the log and a variety of utilities  to clear and access the data via the RS-232 port are provided.

Peak Demand Option

There are applications where customer charges are determined in part by the highest hourly averaged flowrate observed during a billing period.

The peak demand option for the FC-22 is intended for applications where it is important to compute such an hourly average flowrate, to note the value of the peak occurrence and the corresponding time and date of that event.

The demand last hour rate is computed based on the current total and the total  60 minutes prior. This value is recomputed every 5 minutes.

The peak demand is the highest value observed in the demand last hour.

The time and date stamp is the time and date at which the highest peak demand occurred.

The Demand Last Hour and/or Peak Demand can be directly viewed on the display by pressing the RATE key and then scrolling through the rates with the ^/v arrow key until the desired item is viewed.

The Peak Time and Date stamp can be viewed on the display by pressing the TIME and then scrolling through the time related parameters using the ^/v arrow keys until the desired item is viewed.

All of these items can be included into the scrolling display list along with the other process values and totalizers in a user selectable list.

The peak demand may be cleared by pressing the CLEAR key while viewing the PEAK DEMAND or by means of a command on the serial port.

The Peak Time and Date stamp can be viewed on the display by pressing the TIME and then scrolling through the time related parameters using the ^/v arrow keys until the desired item is viewed.

The Demand Last Hour and Peak Demand can be assigned to one of the analog outputs. The demand last hour or peak demand could thusly be output on a recording device such as a strip chart recorder or fed into a building energy automation system.

The Demand Last Hour and Peak Demand can be assigned to one of the relays. The customer can be notified that he is approaching or exceeding a contract high limit by assigning the demand last hour to one of the relays and setting the warning point into the set point. A warning message would also be displayed.

The peak demand may be used in conjunction with the print list and data logger to keep track of hourly customer usage profiles. The Demand Last Hour, Peak Demand, and Time and Date Stamp information can be accessed over the serial ports. The Peak Demand may also be reset over the serial ports.

The peak demand option may also be used as a condition to call out in remote metering by modem.

**EZ Setup**

The unit has a special EZ setup feature where the user is guided through a minimum number of steps to rapidly configure the instrument for the intended use. The EZ setup prepares a series of questions based on  flow equation, fluid, and flowmeter type desired in the application.

# 1.2 Specifications:

**Environmental**
Operating Temperature:  0 to +50 C
Storage Temperature: -40 to +85 C
Humidity : 0-95% Non-condensing
Materials: UL, CSA, VDE approved

**Approvals:**   CE Approved Light Industrial, UL/CSA Pending

**Display**
Type: 2 lines of 20 characters
Types: Backlit LCD, OLED and VFD ordering options
Character Size: 0.2" nominal
User selectable label descriptors and units of measure

**Keypad**
Keypad Type: Membrane Keypad
Keypad Rating: Sealed to Nema 4
Number of keys: 16
Raised Key Embossing

**Enclosure**
Enclosure Options: Panel, Wall, Explosion Proof
Size: See Chapter 2; Installation
Depth behind panel: 6.5" including mating connector
Type: DIN
Materials: Plastic, UL94V-0, Flame retardant
Bezel: Textured per matt finish
Equipment Labels: Model, safety, and user wiring

**NX-19 Compressibility Calculations**

| | |
|---|---|
| Temperature | -40 to 240 F |
| Pressure | 0 to 5000 psi |
| Specific Gravity | 0.554 to 1.0 |
| Mole % CO2 | 0 to 15% |
| Mole % Nitrogen | 0 to 15% |

**Power Input**
The factory equipped power options are internally fused. An  internal line to line filter capacitor is provided for added transient suppression.  MOV protection for surge transient is also supported

Universal AC Power Option:
85 to 276 Vrms, 50/60 Hz
Fuse: Time Delay Fuse,  250V, 500mA
DC Power Option:
24 VDC (16 to 48 VDC)
Fuse: Time Delay Fuse,  250V, 1.5A
Transient Suppression: 1000 V

**Flow Inputs:**
**Flowmeter Types Supported:**
Linear:
Vortex, Turbine, Positive Displacement, Magnetic, GilFlo, GilFlo 16 point, ILVA 16 Point, Mass Flow and others
Square Law:
Orifice, Venturi, Nozzle, V-Cone, Wedge, Averaging Pitot, Target, Verabar, Accelabar and others
Multi-Point Linearization:
May be used with all flowmeter types. Including: 16 point, UVC and dynamic compensation.

**Analog Input:**
Ranges
Voltage: 0-10 VDC, 0-5 VDC, 1-5 VDC
Current: 4-20 mA, 0-20 mA
Basic Measurement Resolution: 16 bit
Update Rate: 2 updates/sec minimum
Accuracy: 0.02% FS
Automatic Fault detection:   Signal over/under-range, Current Loop Broken
Calibration:   Operator assisted learn mode.  Learns Zero and Full Scale of each range
Fault Protection:
Fast Transient: 1000 V Protection (capacitive clamp)
Reverse Polarity: No ill effects
Over-Voltage Limit:   50 VDC Over voltage protection
Over-Current Protection:   Internally current limited protected to 24 VDC
Optional: Stacked DP transmitter 0-20 mA or 4-20 mA
**Pulse Inputs:**
Number of Flow Inputs: one
Input Impedance: 10 kΩ nominal
Trigger Level: (menu selectable)
High Level Input
Logic On:   2 to 30 VDC
Logic Off:   0 to .9 VDC
Low Level Input (mag pickup)
Selectable sensitivity: 10 mV and 100 mV
Minimum Count Speed: 0.25 Hz
Maximum Count Speed: Selectable: 0 to 40 kHz
Overvoltage Protection: 50 VDC
Fast Transient: Protected to 1000 VDC (capacitive clamp)

**Temperature, Pressure, Density  Inputs**
The compensation inputs usage are menu selectable for temperature, temperature 2, pressure,  density, steam trap monitor  or not used.

Calibration: Operator assisted learn mode
Operation: Ratiometric
Accuracy: 0.02% FS
Thermal Drift: Less than 100 ppm/C
Basic Measurement Resolution: 16 bit
Update Rate: 2 updates/sec minimum
Automatic Fault detection:
Signal Over-range/under-range
Current Loop Broken
RTD short
RTD open
Transient Protection: 1000 V (capacitive clamp)
Reverse Polarity: No ill effects
Over-Voltage Limit (Voltage Input): 50 VDC
Over-Current Limit (Internally limited to protect input to 24 VDC)
Available Input Ranges
(Temperature / Pressure / Density / Trap Monitor)
Current: 4-20 mA, 0-20 mA
Resistance: 100 Ohms DIN RTD

100 Ohm DIN RTD (DIN 43-760, BS 1904):
Three Wire Lead Compensation
Internal RTD linearization learns ice point resistance
1 mA Excitation current with reverse polarity protection
Temperature Resolution: 0.1°C
Temperature Accuracy: 0.5°C

**Datalogger (optional)**
Type: Battery Backed RAM
Size: 64k
Initiate: Key, Interval or Time of Day
Items Included: Selectable List
Data Format: Printer or CSV Access via RS-232 command

**Stored Information (ROM)**
Steam Tables (saturated & superheated), General Fluid Properties, Properties of Water, Properties of Air, Natural Gas

**User Entered Stored Information (EEPROM / Nonvolatile RAM)**
Transmitter Ranges, Signal Types
Fluid Properties
    (specific gravity, expansion factor, specific heat, viscosity,
    isentropic exponent, combustion heating value, Z factor,
    Relative Humidity)
Units Selections (English/Metric)

**RS-232 Communication**
Uses: Printing, Setup, Modem, Datalogging
Baud Rates: 300, 1200, 2400, 9600
Parity: None, Odd, Even
Device ID: 0 to 99
Protocol: Proprietary, Contact factory for more information
Chassis Connector Style: DB 9 Female connector
Power Output: 8V (150 mA max.) provided to Modem

**RS-485 Communication** (optional)
Uses: Network Communications
Baud Rates: 300, 600, 1200, 2400, 4800, 9600, 19200
Parity: None, Odd, Even
Device ID: 1 to 247
Protocol: ModBus RTU
Chassis Connector Style: DB 9 Female connector (standard)

**Excitation Voltage**
24 VDC @ 100 mA overcurrent protected

**Relay Outputs**
The relay outputs usage is menu assignable to (Individually for each relay) Hi/Lo Flow Rate Alarm, Hi/Lo Temperature Alarm, Hi/Lo Pressure Alarm, Pulse Output (pulse options), Wet Steam or General purpose warning (security).
(Peak demand and demand last hour optional)

Number of relays: 2 (3 optional)
Contact Style: Form C contacts (Form A with 3 relay option)
Contact Ratings: 240 V, 1 amp
Fast Transient Threshold: 2000 V

**Analog Outputs**
The analog output usage is menu assignable to correspond to the Heat Rate, Uncompensated Volume Rate, Corrected Volume Rate, Mass Rate, Temperature, Density, or Pressure.
(Peak demand and demand last hour optional)

Number of Outputs: 2
Type: Isolated Current Sourcing (shared common)
Isolated I/P/C: 500 V
Available Ranges: 0-20 mA, 4-20 mA (menu selectable)
Resolution: 16 bit
Accuracy: 0.05% FS at 20 Degrees C
Update Rate: 5 updates/sec
Temperature Drift: Less than 200 ppm/C
Maximum Load: 1000 ohms
Compliance Effect: Less than .05% Span
60 Hz rejection: 40 dB minimum
EMI: No effect at 10 V/M
Calibration: Operator assisted Learn Mode
Averaging:    User entry of DSP Averaging constant to
                    cause an smooth control action

**Isolated Pulse output**
The isolated pulse output is menu assignable to Uncompensated Volume Total, Compensated Volume Total, Heat Total or Mass Total.
Isolation I/O/P: 500 V
Pulse Output Form (menu selectable): Open Collector NPN or
        24 VDC voltage pulse
Nominal On Voltage: 24 VDC
Maximum Sink Current: 25 mA
Maximum Source Current: 25 mA
Maximum Off Voltage: 30 VDC
Saturation Voltage: 0.4 VDC
Pulse Duration: User selectable
Pulse output buffer: 8 bit

**Real Time Clock**
The Flow Computer is equipped with either a super cap or a battery backed real time clock with display of time and date.
Format:
        24 hour format for time
        Day, Month, Year format for date
        Daylight Savings Time (optional)

**Measurement**
The Flow Computer can be thought of as making a series of measurements of flow, temperature/density and pressure sensors and then performing calculations to arrive at a result(s) which is then updated periodically on the display. The analog outputs, the pulse output, and the alarm relays are also updated. The cycle then repeats itself.

Step 1:    Update the measurements of input signals-
Raw Input Measurements are made at each input using equations based on input signal type selected. The system notes the "out of range" input signal as an alarm condition.

Step 2:    Compute the Flowing Fluid Parameters-
The temperature, pressure, viscosity and density equations are computed as needed based on the flow equation and input usage selected by the user.

Step 3 : Compute the Volumetric Flow-
Volumetric flow is the term given to the flow in volume units. The value is computed based on the flowmeter input type selected and augmented by any performance enhancing linearization that has been specified by the user.

Step 4: Compute the Corrected Volume Flow at Reference Conditions-
In the case of a corrected liquid or gas volume flow calculation, the corrected volume flow is computed as required by the selected compensation equation.

Step 5 : Compute the Mass Flow-
All required information is now available to compute the mass flow rate as volume flow times density. A heat flow computation is also made if required.

Step 6: Check Flow Alarms-
The flow alarm functions have been assigned to one of the above flow rates during the setup of the instrument. A comparison is now made by comparing the current flow rates against the specified hi and low limits.

Step 7: Compute the Analog Output-
This designated flow rate value is now used to compute the analog output.

Step 8: Compute the Flow Totals by Summation-
A flow total increment is computed for each flow rate. This increment is computed by multiplying the respective flow rate by a time base scaler and then summing. The totalizer format also includes provisions for total rollover.

Step 9: Pulse Output Service-
The pulse output is next updated by scaling the total increment which has just been determined by the pulse output scaler and summing it to any residual pulse output amount.

Step 10: Update Display and Printer Output-
The instrument finally runs a task to update the various table entries associated with the front panel display and serial outputs.

**Instrument Setup**
The setup is password protected by means of a numeric lock out code established by the user. The help line and units of measure prompts assure easy entry of parameters.

An EZ Setup function is supported to rapidly configure the instrument for first time use. A software program is also available which runs on a PC using a RS-232 Serial for connection to the Flow Computer. Illustrative examples may be down loaded in this manner.

The standard setup menu has numerous subgrouping of parameters needed for flow calculations. There is a well conceived hierarchy to the setup parameter list. Selections made at the beginning of the setup automatically affect offerings further down in the lists, minimizing the number of questions asked of the user.

In the setup menu, the flow computer activates the correct setup variables based on the instrument configuration, the flow equation, and the hardware selections made for the compensation transmitter type, the flow transmitter type, and meter enhancements (linearization) options selected. All required setup parameters are enabled. All setup parameters not required are suppressed.

Also note that in the menu are parameter selections which have preassigned industry standard values. The unit will assume these values unless they are modified by the user.

Most of the process input variables have available a "default" or emergency value which must be entered. These are the values that the unit assumes when a malfunction is determined to have occurred on the corresponding input.

It is possible to enter in a nominal constant value for temperature or density, or pressure inputs by placing the desired nominal value into the default values and selecting "manual". This is also a convenience when performing bench top tests without simulators.

The system also provides a minimum implementation of an "audit trail" which tracks significant setup changes to the unit. This feature is increasingly being found of benefit to users or simply required by Weights and Measurement Officials in systems used in commerce, trade, or "custody transfer" applications.

**Simulation and Self Checking:**
This mode provides a number of specialized utilities required for factory calibration, instrument checkout on start-up, and periodic calibration documentation.

A service password is required to gain access to this specialized mode of operation. Normally quality, calibration, and maintenance personnel will find this mode of operation very useful.

Many of these tests may be used during start-up of a new system. Output signals may be exercised to verify the electrical interconnects before the entire system is put on line.

The following action items may be performed in the Diagnostic Mode:

Print Calibration/Maintenance Report
View Signal Input (Voltage, Current, Resistance, Frequency)
Examine Audit Trail
Perform a Self Test
Perform a Service Test
View Error History
Perform Pulse Output Checkout / Simulation
Perform Relay Output Checkout / Simulation
Perform Analog Output Checkout / Simulation
Calibrate Analog Inputs using the Learn Feature
Calibrate Analog Output using the Learn Feature
Schedule Next Maintenance Date

Note that a calibration of the analog input/output will advance the audit trail counters since it effects the accuracy of the system.

**Operation of Steam Trap Monitor**
In applications on Saturated Steam, the otherwise unused Compensation Input may be connected to a steam trap monitor that offers the following compatible output signal levels:
4mA = trap cold
12 mA = trap warm and open (blowing)
20 mA = trap warm and closed

In normal operation a steam trap is warm and periodically opens and closes in response to the accumulation of condensate. A cold trap is indication that it is not purging the condensate, a trap that is constantly blowing is an indication that it is stuck open. To avoid a false alarm, the FC-22 permits the user to program a delay, or time period, which should be considered normal for the trap to be either cold, or open. An alarm will only be activated if the trap is detected as continuously being in the abnormal states for a time period greater than this TRAP ERROR DELAY time.

The user selects to use the Compensation Input for Trap Monitoring by selecting "4-20mA TRAP STATUS as the INPUT SIGNAL for OTHER INPUT1.

The user can program the ERROR DELAY time in HH:MM format into both the TRAP ERROR DELAY (cold trap error) menu and the TRAP BLOWING DELAY (trap stuck open) menu.

The FC-22 will warn the operator of a TRAP ERROR when an abnormal condition is detected. The error can be acknowledged by pressing the ENTER key. However, the problem may reassert itself if there is a continued problem with the steam trap.

In addition, the event is noted in the ERROR LOG.

It is also possible for the user to program a trap malfunction as one of the conditions worthy of a CALL OUT of a problem by selecting this error in the ERROR MASK.

The Data-Logging option of the FC-22 can also be used to log the performance of the trap by storing the % of time the trap has been cold, and/or blowing open during the datalog interval.

**Datalogging Option**
The Datalogging Option for the FC-22 permits the user to automatically store sets of data items as a record on a periodic basis. A datalog record may be stored as the result of either a PRINT key depression, or an INTERVAL, or a TIME OF DAY request for a datalog.

The user defines the list of items to be included in each datalog by selecting these in the PRINT LIST menu located within the COMMUNICATIONS SUBMENU.

The user selects what will trigger a datalog record being stored in the PRINT INITIATE menu. The choices are PRINT KEY, INTERVAL, and TIME OF DAY.

The user can select the datalog store interval in a HH:MM format in the PRINT INTERVAL menu.

The user can also select the store time of day in a 24 hr HH:MM format in the PRINT TIME menu.

The user can also define whether he just wants the data stored into the datalogger, or if he wants the data both stored in the datalogger and sent out over the RS232 port in the DATALOG ONLY menu.

The user can define the format he wishes the data to be output in using the DATALOG FORMAT menu. Choices are PRINTER and DATABASE. PRINTER format will output the data records in a form suitable to dump to a printer. DATABASE format will output the values in a CSV, or Comma Separated Variable with Carriage return delimiting of each record.

A number of serial commands are also included to access and manipulate information stored with in the datalogger. Among these RS232 command capabilities are the following actions:
    Clear Data Logger
    Send all Data in Datalogger
    Send Only New Data since Datalogger was last Read
    Send Data for the date included in the request
    Send the column heading text for the CSV data fields
    Send the column units of measure text for the CSV data
        fields
    Store one new record into datalogger now
    Read Number of New Records in the datalogger
    Read number of records currently in the datalogger
    Read the maximum number of records capacity of the
        datalogger
    Move Pointer Back N records
    Dump Record at Pointer
    Dump records newer than pointer
    Dump data from N records back

The datalogger option is used in conjunction with the RS-232 port in remote metering applications.

The technical details associated with the serial commands are listed in Universal Serial Protocol Manual available upon request.

**RS-232 Serial Port**
The Flow Computer has a general purpose RS-232 Port which may be used for any one of the following purposes:

        Transaction Printing
        Data Logging
        Remote Metering by Modem
        Computer Communication Link
        Configuration by Computer
        Print System Setup
        Print Calibration/Malfunction History

**Instrument Setup by PC's over Serial Port**
A Diskette program is provided with the Flow Computer that enables the user to rapidly configure the Flow Computer using an Personnel Computer. Included on the diskette are common instrument applications which may be used as a starting point for your application. This permits the user to have an excellent starting point and helps speed the user through the instrument setup.

**Operation of Serial Communication Port with Printers**
The Flow Computer's RS-232 channel supports a number of operating modes. One of these modes is intended to support operation with a printer in metering applications requiring transaction printing, data logging and/or printing of calibration and maintenance reports.

For transaction printing, the user defines the items to be

included in the printed document. The user can also select what initiates the transaction print generated as part of the setup of the instrument. The transaction document may be initiated via a front panel key depression.

In data logging, the user defines the items to be included in each data log as a print list. The user can also select when or how often he wishes a data log to be made. This is done during the setup of the instrument as either a time of day or as a time interval between logging.

The system setup and maintenance report list all the instrument setup parameters and usage for the current instrument configuration. In addition, the Audit trail information is presented as well as a status report listing any observed malfunctions which have not been corrected.

The user initiates the printing of this report at a designated point in the menu by pressing the print key on the front panel.

**Operating Serial Communication Port with Modems**

The FC-22 offers a number of capabilities that facilitate its use with modems. The FC-22's RS232 port can be connected to a modem in order to implement a remote metering system that uses either the phone companies standard phone lines or cellular telephone system. In addition to remote meter readings, the serial commands may also be used to examine and/or make setup changes to the unit, and to check for proper operation or investigate problems. Several hundred commands are supported. A compatible industrial modem accessory and interconnecting cabling is offered in the MPP2400N specifically designed for use with the FC-22.

The FC-22 and Modem can be used together to create systems with one or more of the following capabilities:
1. Poll the FC-22 unit for information from a remote PC.
2. Call Out from the FC-22 unit to a remote PC on a scheduled reading time and/or crisis basis
3. Some combination of the above two descriptions where the unit is polled by one PC and calls into to a different PC if a problem is detected.

In fact, up to five FC-22 units can share the same modem. Each FC-22 must have a unique DEVICE ID. This multidropping of flow computers on a single modem is popular when there are several flow computers mounted near each other.

In most applications using modem communications, the FC-22's RS232 USAGE is first set equal to MODEM. Each FC-22 on a shared modem cable is given a unique serial device address or DEVICE ID. The BAUD RATE is commonly set to 2400, the PARITY set to NONE, and the HANSHAKING set to NONE to complete the basic setup. The remote PC's communication settings are chosen to match these.

The level of complexity of the FC-22 to Modem connection can range from simple to more complex.

In a simple system a remote PC will call into the telephone number of the modem. The modem will answer the call, and establish a connection between the FC-22 and the remote PC. An exchange of information can now occur. The FC-22 will act as a slave and respond to commands and requests for information from the remote MASTER PC. The MASTER PC will end the exchange by handing up.

However, it is more common that the FC-22 will be used to control the modem. In these applications the following communication menu settings would be used:
RS232 USAGE = MODEM
DEVICE ID, BAUD RATE, PARITY, and HANDSHAKING are set
MODEM CONTROL = YES
DEVICE MASTER = YES (When multidropping several FC-22's, only one unit will be the DEVICE MASTER)
MODEM AUTO ANSWER = YES (This instructs the unit to answer incoming calls)
HANG UP IF INACTIVE = YES (This instructs the unit to hang up the line if no activities occur within several minutes).

A more complex form of a remote metering system can be implemented where the FC-22 will initiate a call to contact the remote PC at a scheduled time and/or in the event of a problem that has been detected. In these applications the FC-22 has additional setup capabilities including:
The FC-22 must have a unique identifier assigned to it (using the TAG NUMBER)
Call Out Telephone number must be entered in the CALL OUT NUMBER
The scheduled call out time for the daily reading must be entered in CALL OUT TIME
A decision must be made whether the unit will be used to call on error(s) in CALL ON ERROR
The particular error conditions to call out on must be defined in the ERROR MASK
The NUMBER OF REDIALS to be attempted if line is busy must be entered in that cell
HANG UP IF INACTIVE= YES will disconnect the call if remote computer does not respond.

Consult the Universal Serial Commands User Manual for details on the individual commands supported by the FC-22. Contact the Flow Applications Group for a discussion on the remote metering system capabilities you are considering.

NOTE: Some modems can be configured in advance to answer incoming calls, terminate phone connections if communications is lost. In such applications there may be no need for the FC-22 to be functioning to "control" the modem. Setting the RS233 USAGE = COMPUTER will likely work.

**RS-485 Serial Port (optional)**

The RS-485 serial port can be used for accessing flow rate, total, pressure, temperature, density and alarm status information. The port can also be used for changing presets and acknowledging alarms.

# 2. Installation

**General Mounting Hints**

## 2.1 General Mounting Hints:

The FC-22 Flow Computer should be located in an area with a clean, dry atmosphere which is relatively free of shock and vibration. The unit is installed in a 5.43" (138mm) wide by 2.68" (68mm) high panel cutout. (see Mounting Dimensions) To mount the Flow Computer, proceed as follows:

**Mounting Procedure**

a. Prepare the panel opening.
b. Slide the unit through the panel cutout until the it touches the panel.
c. Install the screws (provided) in the mounting bracket and slip the bracket over the rear of the case until it snaps in place.
d. Tighten the screws firmly to attach the bezel to the panel.  3 in. lb. of torque must be applied and the bezel must be parallel to the panel.

**NEMA4X / IP65 Specifications**

**NOTE:** To seal to NEMA4X / IP65 specifications, supplied bezel kit must be used and panel cannot flex more than .010".
When the optional bezel kit  is used, the bezel adaptor must be sealed to the case using an RTV type sealer to maintain NEMA4X / IP65 rating.

## 2.2 Mounting Diagrams:



**Standard Mounting**

FC-22

Mounting Bracket

**Bezel Kit Mounting**

FC-22
Bezel Adaptor
Gasket

Mounting Bracket

**Dimensions**

Dotted Line Shows Optional Bezel Kit

Dimensions are in inches (mm)
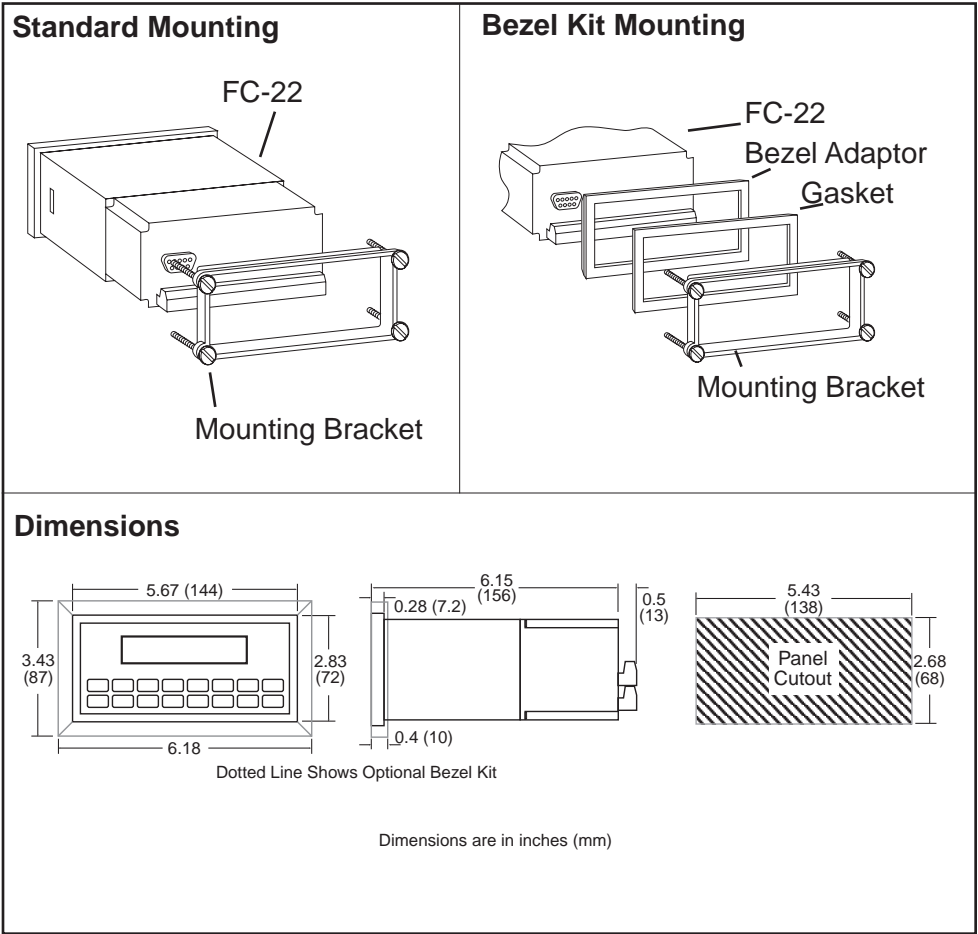
## 2.2 Mounting Diagrams:
(continued)

**Wall Mount** (mounting option W)
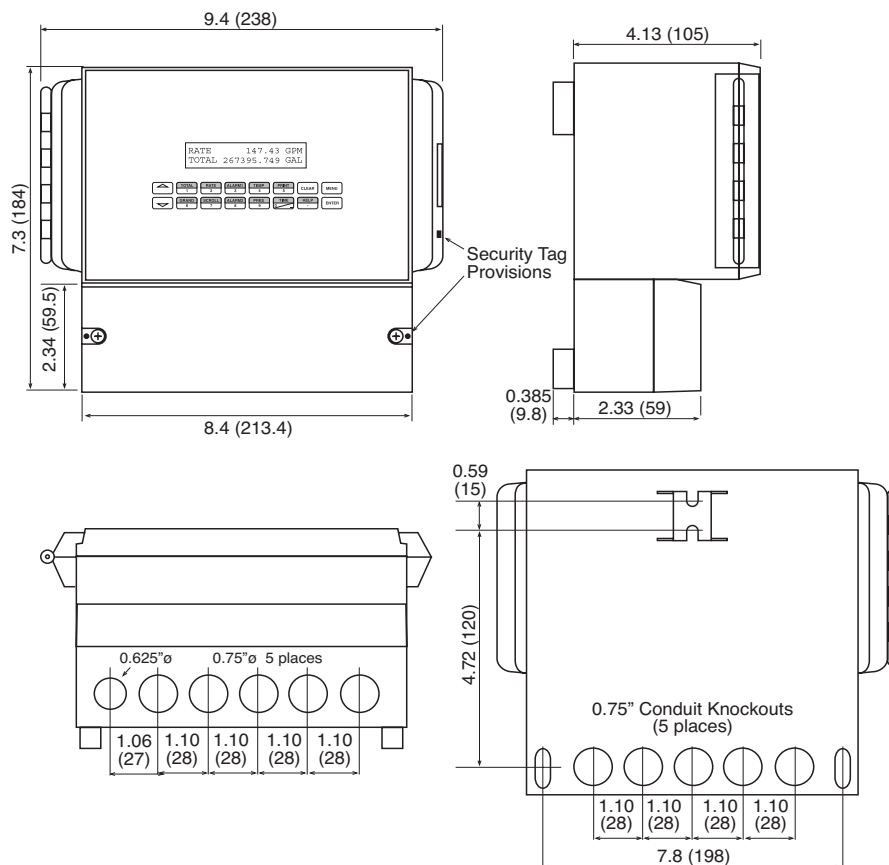


**NEMA4 Wall Mount** (mounting option N)

## 2.2 Mounting Diagrams:
(continued)

**Explosion Proof Mount** (mounting option E)

6.25 (158.8)

10.5 (266.7)

7.75 (196.9)

9.125 (231.8)

6.75 (171.5)

7.75 (196.9)

11.5 (292.1)

1/2" - 14 NPT Plugs
(2 Places)

2.25
(57.2)

3.25
(82.6)

2.25
(57.2)
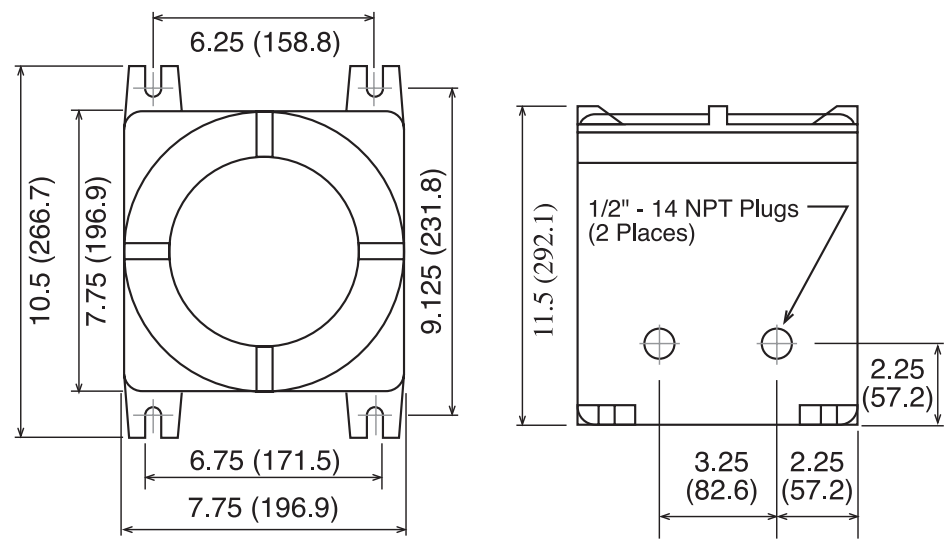
# 3. Applications

**STEAM MASS**

## 3.1 Steam Mass

**Measurements:**

A flowmeter measures the actual volume flow in a steam line.  A temperature and/or pressure sensor is installed to measure temperature and/or pressure.

**Calculations:**

- Density and mass flow are calculated using the steam tables stored in the flow computer.
- With square law device measurement  the actual volume is calculated from the differential pressure, taking into account temperature and pressure compensation.
- Saturated steam requires either a pressure or temperature measurement with the other variable calculated using the saturated steam curve.
- Optional steam trap monitoring using Compensation Input 1.

**Input Variables:**

*Superheated Steam:* Flow, temperature and pressure
*Saturated Steam:* Flow, temperature or pressure

**Output Results:**

- Display Results
    Mass or Volume Flow Rate, Resettable Total, Non-Resettable Total, Temperature, Pressure, Density (optional: peak demand, demand last hour, time/date stamp)
- Analog Output
    Mass or Volume Flow Rate, Temperature, Pressure Density, Peak Demand, Demand Last Hour
- Pulse Output
    Mass or Volume Total
- Relay Outputs
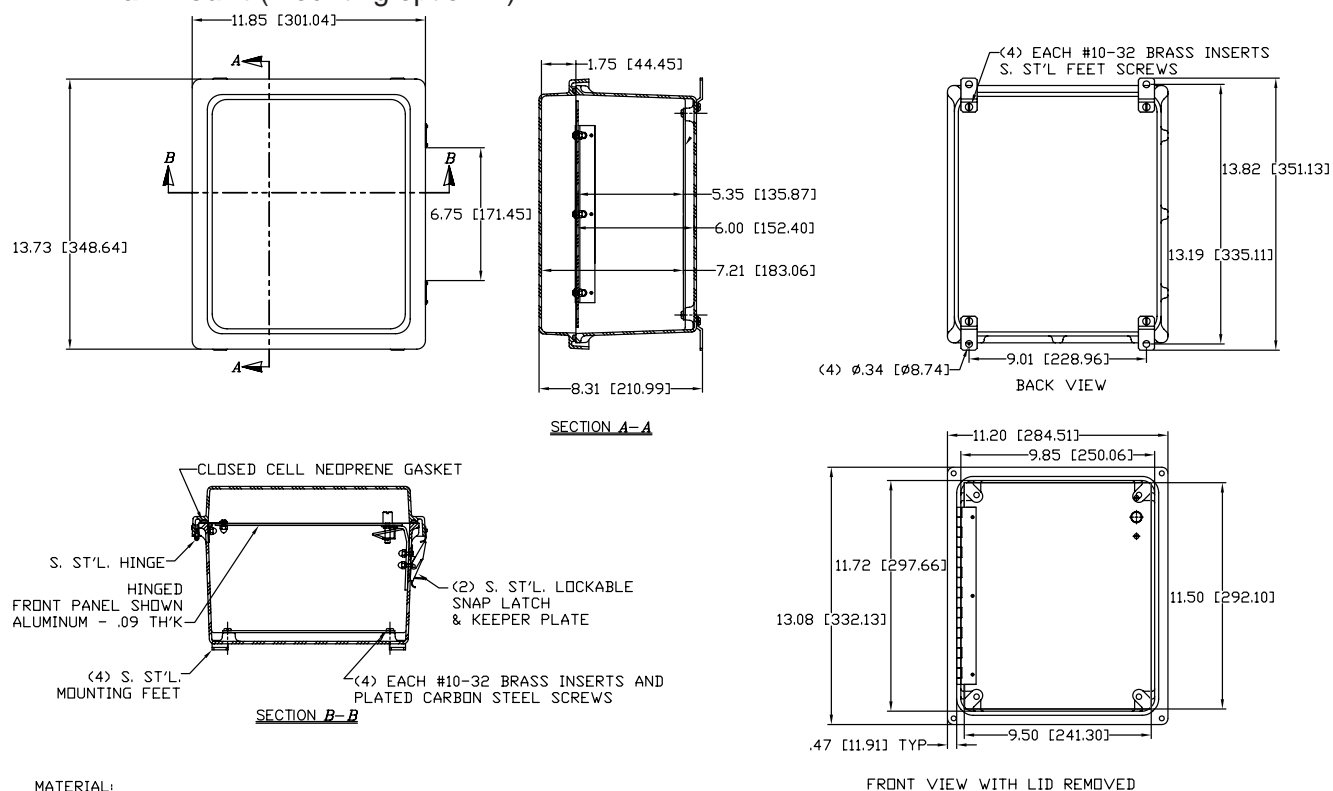    Mass or Volume Flow Rate , Total, Pressure, Temperature, Alarms, Peak Demand, Demand Last Hour

**Applications:**

Monitoring mass flow and total of steam. Flow alarms are provided via relays and datalogging is available via analog (4-20mA) and serial outputs.

**Steam Mass Illustration**



Pressure Transmitter — Orifice Plate with DP Transmitter — Temperature* Transmitter
* or Steam Trap Monitor

Pressure Transmitter — Flowmeter — Temperature* Transmitter
* or Steam Trap Monitor

**Calculations**

### Mass Flow

Mass Flow = volume flow • density (T, p)

**STEAM HEAT**

## 3.2 Steam Heat

**Measurements:**

A flowmeter measures the actual volume flow in a steam line.  A temperature and/or pressure sensor is installed to measure temperature and/or pressure.

**Calculations:**

• Density, mass flow and heat flow are calculated using the steam tables stored in the flow computer. The heat is defined as the enthalpy of steam under actual conditions with reference to the enthalpy of water at T=0°C.
• With square law device measurement  the actual volume is calculated from the differential pressure, taking into account temperature and pressure compensation.
• Saturated steam requires either a pressure or temperature measurement with the other variable calculated using the saturated steam curve.
• Optional steam trap monitoring using compensation input.

**Input Variables:**

*Superheated Steam:* Flow, temperature and pressure
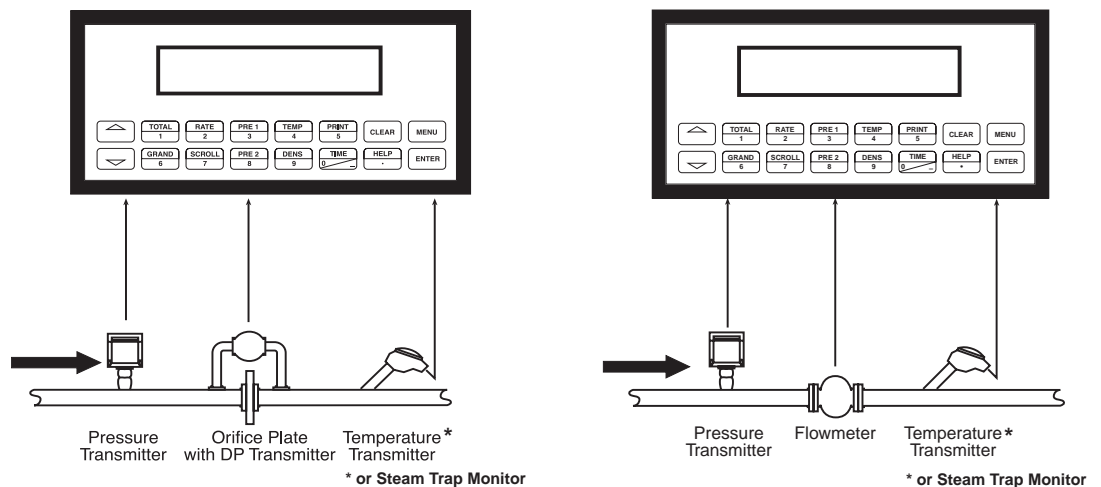*Saturated Steam:* Flow, temperature or pressure

**Output Results:**

• Display Results
    Heat, Mass or Volume Flow Rate, Resettable Total, Non-Resettable Total, Temperature, Pressure, Density (optional: peak demand, demand last hour, time/date stamp)
• Analog Output
    Heat, Mass or Volume Flow Rate, Temperature, Pressure, Density, Peak Demand, Demand Last Hour
• Pulse Output
    Heat, Mass or Volume Total
• Relay Outputs
    Heat, Mass or Volume Flow Rate , Total, Pressure, Temperature Alarms, Peak Demand, Demand Last Hour

**Applications:**

Monitoring heat flow and total heat of steam. Flow alarms are provided via relays and datalogging is available via analog (4-20mA) and serial outputs.

**Steam Heat Illustration**



Pressure Transmitter    Orifice Plate with DP Transmitter    Temperature * Transmitter

**\* or Steam Trap Monitor**

Pressure Transmitter    Flowmeter    Temperature * Transmitter

**\* or Steam Trap Monitor**

**Calculations**

*Heat Flow*

Heat Flow = Volume flow • density (T, p) • Sp. Enthalpy of steam (T, p)

**STEAM NET HEAT**

### 3.3 Steam Net Heat

**Measurements:**

A flowmeter measures the actual volume flow in a steam line.  A temperature and a pressure sensor are installed to measure temperature and/or pressure. All measurement are made on the steam side of a heat exchanger.

**Calculations:**

· Density, mass flow and net heat flow are calculated using the steam tables stored in the flow computer. The net heat is defined as the difference between the heat of the steam and the heat of the condensate. For simplification it is assumed that the condensate (water) has a temperature which corresponds to the temperature of saturated steam at the pressure measured upstream of the heat exchanger.
• With square law device measurement  the actual volume is calculated from the differential pressure, taking into account temperature and pressure compensation.
• Saturated steam requires either a pressure or temperature measurement with the other variable calculated using the saturated steam curve.
• Optional steam trap monitoring using compensation input.

**Input Variables:**

*Superheated Steam:* Flow, temperature and pressure
*Saturated Steam:* Flow, temperature or pressure
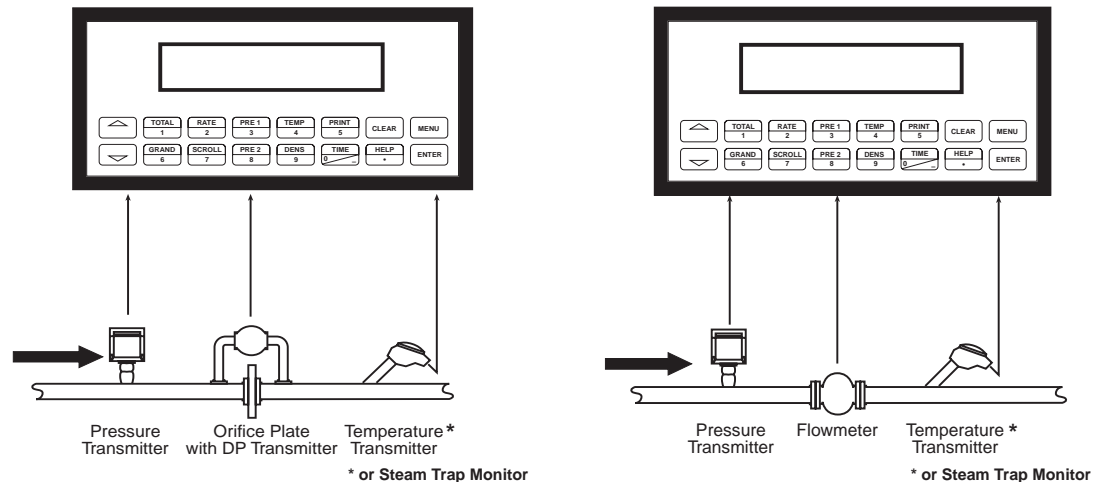
**Output Results:**

• Display Results
  Heat, Mass or Volume Flow Rate, Resettable Total, Non-Resettable Total, Temperature, Pressure, Density, (optional: peak demand, demand last hour, time/date stamp)
• Analog Output
  Heat, Mass or Volume Flow Rate, Temperature, Pressure, Density, Peak Demand, Demand Last Hour
• Pulse Output
  Heat, Mass or Volume Total
• Relay Outputs
  Heat, Mass or Volume Flow Rate , Total, Pressure, Temperature Alarms, Peak Demand, Demand Last Hour

**Applications:**

Monitoring  the thermal energy which can be extracted by a heat exchanger taking into account the thermal energy remaining in the returned condensate. For simplification it is assumed that the condensate (water) has a temperature which corresponds to the temperature of saturated steam at the pressure measured upstream of the heat exchanger.

**Steam Net Heat Illustration**



Pressure Transmitter   Flowmeter   Temperature Transmitter   *

\* or Steam Trap Monitor

**Calculations**

**_Net Heat Flow_**

Net Heat Flow = Volume flow • density (T, p) • [$E_D$ (T, p)– $E_W$ ($T_{S(p)}$)]

$E_D$ = Specific enthalpy of steam
$E_w$ = Specific enthalpy of water
$T_{S(p)}$ = Calculated condensation temperature
   (= saturated steam temperature for supply pressure)

**STEAM DELTA HEAT**

## 3.4 Steam Delta Heat

**Measurements:**

Measures actual volume flow and pressure of the saturated steam in the supply piping as well as the temperature of the condensate in the downstream piping of a heat exchanger.

**Calculations:**

- Calculates density, mass flow as well as the delta heat between the saturated steam (supply) and condensation (return) using physical characteristic tables of steam and water stored in the flow computer.
- With square law device measurement  the actual volume is calculated from the differential pressure, taking into account temperature and pressure compensation.
- The saturated steam temperature in the supply line is calculated from the pressure measured there.

**Input Variables:**

*Supply:* Flow and pressure (saturated steam)
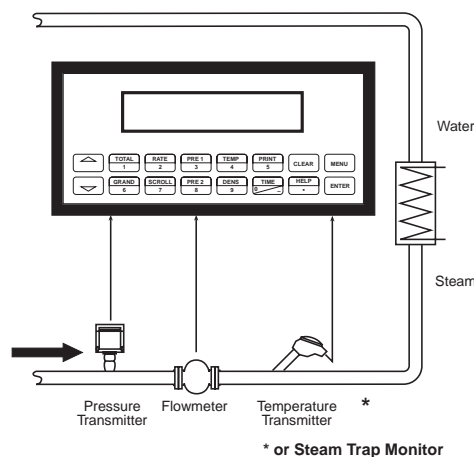*Return:* Temperature (condensate)

**Output Results:**

- Display Results
    Heat, Mass or Volume Flow Rate, Resettable Total, Non-Resettable Total, Temperature, Pressure, Density (optional: peak demand, demand last hour, time/date stamp)
- Analog Output
    Heat, Mass or Volume Flow Rate, Temperature, Pressure, Density, Peak Demand, Demand Last Hour
- Pulse Output
    Heat, Mass or Volume Total
- Relay Outputs
    Heat, Mass or Volume Flow Rate , Total, Pressure, Temperature Alarms, Peak Demand, Demand Last Hour

**Applications:**

Calculate the saturated steam mass flow and the heat extracted by a heat exchanger taking into account the thermal energy remaining in the condensate.

**Steam Delta Heat Illustration**
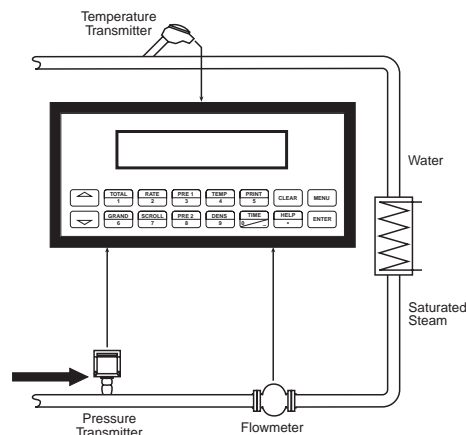


**Calculations**

*Delta Heat Flow*

Net Heat Flow = Volume flow $\cdot$ density (p) $\cdot$ [$E_D$ (p)– $E_W$ (T)]

$E_D$    =   Specific enthalpy of steam
$E_w$    =   Specific enthalpy of water

**Note:** Assumes a closed system.

**CORRECTED GAS VOLUME**

## 3.5 Corrected Gas Volume

**Measurements:**
A flowmeter measures the actual volume flow in a gas line. Temperature and pressure sensors are installed to correct for gas expansion effects.

**Calculations:**
· Corrected Volume is calculated using the flow, temperature and pressure inputs as well as the gas characteristics stored in the flow computer (see "FLUID DATA" submenu). Use the "OTHER INPUT" submenu to define reference temperature and reference pressure values for standard conditions.

**Output Results:**
• Display Results

  Corrected Volume or Actual Volume Flow Rate, Resettable Total, Non-Resettable Total, Temperature, Pressure, Density (optional: peak demand, demand last hour, time/date stamp)
• Analog Output

  Corrected Volume or Actual Volume Flow Rate, Temperature, Pressure, Density, Peak Demand, Demand Last Hour
• Pulse Output

  Corrected Volume or Actual Volume Total
• Relay Outputs

  Corrected Volume or Actual Volume Flow Rate, Total, pressure, Temperature Alarms, Peak Demand, Demand Last Hour

**Applications:**
Monitoring corrected volume flow and total of any gas. Flow alarms are provided via relays and datalogging is available via analog (4-20mA) and serial outputs.

**Corrected Gas Volume Illustration**
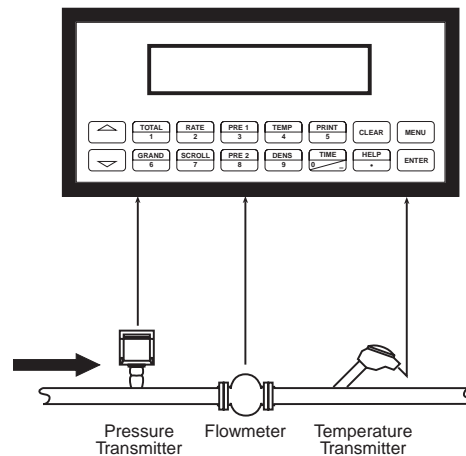


Pressure Transmitter    Flowmeter    Temperature Transmitter

**Calculations**

*Volume Flow*

*Pulse Input; Average K-Factor*

$$\text{Volume Flow} = \frac{\text{input frequency} \cdot \text{time scale factor}}{\text{K-Factor}}$$

*Analog Input; Linear*

$$\text{Volume Flow} = \%\text{ input} \cdot \text{Full Scale Flow}$$

*Corrected Volume Flow*

$$\text{Corrected Volume Flow} = \text{Volume Flow} \cdot \frac{P}{P_{ref}} \cdot \frac{T_{ref}}{T} \cdot \frac{Z_{ref}}{Z}$$

**GAS MASS**

### 3.6 Gas Mass
**Measurements:**
A flowmeter measures the actual volume flow in a gas line. Temperature and pressure sensors are installed to measure temperature and pressure.

**Calculations:**
- Density and mass flow are calculated using gas characteristics stored in the flow computer.
- With square law device measurement  the actual volume is calculated from the differential pressure, taking into account temperature and pressure compensation.

**Output Results:**
- Display Results
    Mass or Volume Flow Rate, Resettable Total, Non-Resettable Total, Temperature, Pressure, Density (optional: peak demand, demand last hour, time/date stamp)
- Analog Output
    Mass or Volume Flow Rate, Temperature, Pressure, Density, Peak Demand, Demand Last Hour
- Pulse Output
    Mass or Volume Total
- Relay Outputs
    Mass or Volume Flow Rate, Total, Pressure, Temperature, Density Alarms, Peak Demand, Demand Last Hour

**Applications:**
Monitoring mass flow and total of gas. Flow alarms are provided via relays and datalogging is available via analog (4-20mA) and serial outputs.

**Gas Mass Illustration**



Pressure Transmitter    Orifice Plate with DP Transmitter    Temperature Transmitter

Pressure Transmitter    Flowmeter    Temperature Transmitter

**Calculations**

*Mass Flow*

$$\text{Mass Flow} = \text{Actual Volume Flow} \bullet \rho_{ref} \bullet \frac{P}{P_{ref}} \bullet \frac{T_{ref}}{T} \bullet \frac{Z_{ref}}{Z}$$

$\rho_{ref}$ = Reference density
$T_{ref}$ = Reference temperature
$P_{ref}$ = Reference pressure
$Z_{ref}$ = Reference Z-factor

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# GAS COMBUSTION HEAT

## 3.7 Gas Combustion Heat

**Measurements:**
A flowmeter measures the actual volume flow in a gas line. Temperature and pressure sensors are installed to measure temperature and pressure.

**Calculations:**
- Density, mass flow and combustion heat are calculated using gas characteristics stored in the flow computer.
- With square law device measurement the actual volume is calculated from the differential pressure, taking into account temperature and pressure compensation.
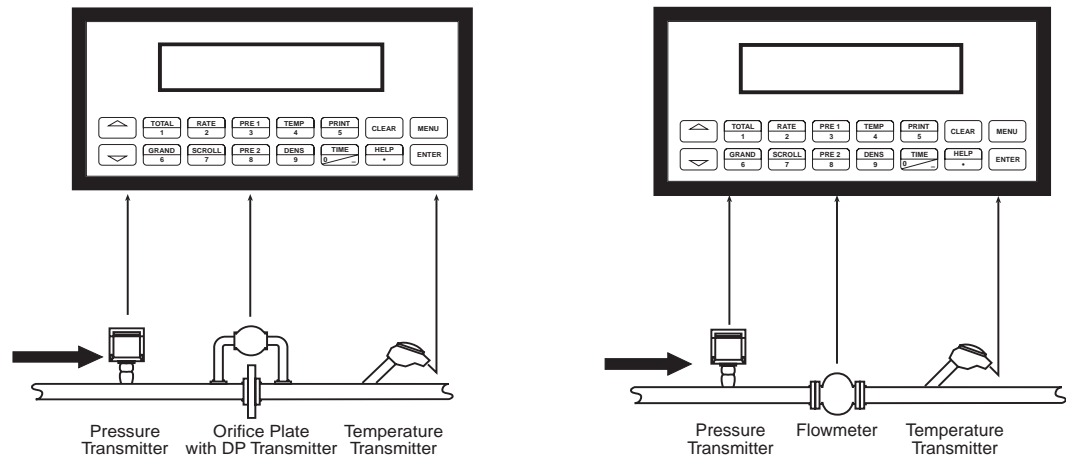
**Output Results:**
- Display Results
    Heat, Mass or Volume Flow Rate, Resettable Total, Non-Resettable Total, Temperature, Pressure, Density (optional: peak demand, demand last hour, time/date stamp)
- Analog Output
    Heat, Mass or Volume Flow Rate, Temperature, Pressure, Density, Peak Demand, Demand Last Hour
- Pulse Output
    Heat, Mass or Volume Total
- Relay Outputs
    Heat, Mass or Volume Flow Rate, Total, Pressure, Temperature Alarms, Peak Demand, Demand Last Hour

**Applications:**
Calculate the energy released by combustion of gaseous fuels.

## Gas Combustion Heat
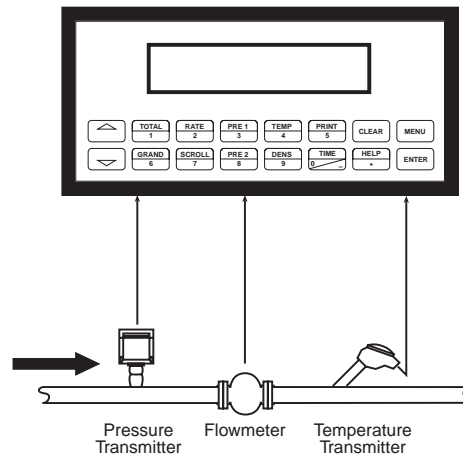


## Calculations

### *Combustion Heat Flow*

$$\text{Combustion Energy} = C \bullet \rho_{ref} \bullet Q \bullet \frac{P}{P_{ref}} \bullet \frac{T_{ref}}{T} \bullet \frac{Z_{ref}}{Z}$$

$C$ = Specific combustion heat
$\rho_{ref}$ = Reference density
$Q$ = Volume flow

**Corrected
Liquid Volume**

### 3.8 Corrected Liquid Volume

**Measurements:**
A flowmeter measures the actual volume flow in a liquid line.  A temperature sensor is installed to correct for liquid thermal expansion. A pressure sensor can be installed to monitor pressure. Pressure measurement does not affect the calculation.

**Calculations:**
· Corrected Volume is calculated using the flow and temperature inputs as well as the thermal expansion coefficient stored in the flow computer (see "FLUID DATA" submenu).  Use the "OTHER INPUT" submenu to define reference temperature and density values for standard conditions.

**Output Results:**
• Display Results
    Corrected Volume and Actual Volume Flow Rate, Resettable Total, Non-Resettable Total, Temperature, Pressure, Density (optional: peak demand, demand last hour, time/date stamp)
• Analog Output
    Corrected Volume and Actual Volume Flow Rate, Temperature, Pressure, Density, Peak Demand, Demand Last Hour
• Pulse Output
    Corrected Volume and Actual Volume Total
• Relay Outputs
    Corrected Volume and Actual Volume Flow  Rate , Total, Pressure, Temperature Alarms, Peak Demand, Demand Last Hour

**Applications:**
Monitoring corrected volume flow and total of any liquid. Flow alarms are provided via relays and datalogging is available via analog (4-20mA) and serial outputs.

**Corrected
Liquid Volume
Illustration**
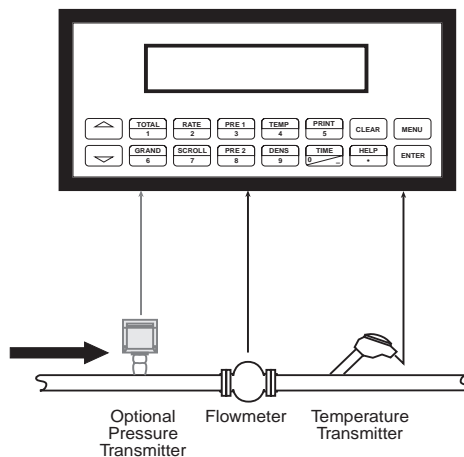


Optional Pressure Transmitter    Flowmeter    Temperature Transmitter

**Calculations**

*Volume Flow*

*Pulse Input; Average K-Factor*

$$\text{Volume Flow} = \frac{\text{input frequency} \bullet \text{time scale factor}}{\text{K-Factor}}$$

*Analog Input; Linear*

Volume Flow = % input  • Full Scale Flow

***Corrected Volume Flow***

Corrected Volume Flow = vol. flow $\cdot$ $(1 - \alpha \bullet (Tf - Tref))^2$

$\alpha$    =   Thermal expansion coefficient $\cdot$ $10^{-6}$

## Liquid Mass

### 3.9 Liquid Mass

**Measurements:**
Actual volume flow is measured by the flow element (DP transmitter, Flowmeter). Temperature is measured by the temperature transmitter. A pressure transmitter can be used to monitor pressure. Pressure measurement does not affect the calculation. A density transmitter may be used in place of a temperature transmitter for direct density measurement.

**Calculations:**
· The density and mass flow are calculated using the reference density and the thermal expansion coefficient of the liquid (see  "FLUID DATA" submenu)

**Output Results:**
• Display Results
    Mass or Volume Flow Rate, Resettable Total, Non-Resettable Total, Temperature, Pressure, Density (optional: peak demand, demand last hour, time/date stamp)
• Analog Output
    Mass or Volume Flow Rate, Temperature, Pressure, Density, Peak Demand, Demand Last Hour
• Pulse Output
    Mass or Volume Total
• Relay Outputs
    Mass or Volume Flow Rate, Total, Temperature, Pressure, Density Alarms, Peak Demand, Demand Last Hour

**Applications:**
Monitoring mass flow and total of any liquid. Flow alarms are provided via relays and datalogging is available via analog (4-20mA) and serial outputs.

## Liquid Mass Illustration
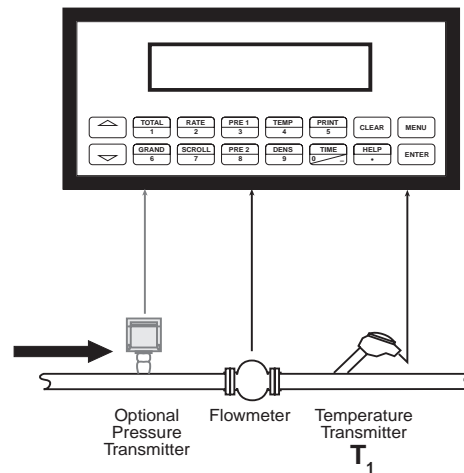


**NOTE:**
A density transmitter may be used for direct density measurement.

## Calculations

### *Volume Flow*

As calculated in section 3.8

### *Mass Flow*

Mass Flow = volume flow $\cdot$ $(1\text{-a} \cdot (T_1\text{-}T_{ref}))^2$ $\bullet$ ref. density

$\alpha$ = Thermal expansion coefficient $\cdot$ $10^{-6}$

## LIQUID COMBUSTION HEAT

## 3.10 Liquid Combustion Heat

**Measurements:**
Actual volume flow is measured by the flow element (DP transmitter, Flowmeter). Temperature is measured by the temperature transmitter. A pressure transmitter can be used to monitor pressure. Pressure measurement does not affect the calculation.

**Calculations:**
• The density, mass flow and combustion heat are calculated using the fluid characteristics stored in the flow computer. (see "FLUID DATA" submenu)

**Output Results:**
• Display Results
     Combustion Heat, Mass or Volume Flow Rate, Resettable Total, Non-Resettable Total, Temperature, Pressure, Density (optional: peak demand, demand last hour, time/date stamp)
• Analog Output
     Combustion Heat, Mass or Volume Flow Rate, Temperature, Pressure, Density, Peak Demand, Demand Last Hour
• Pulse Output
     Combustion Heat, Mass or Volume Total
• Relay Outputs
     Combustion Heat, Mass or Volume Flow Rate, Total, Temperature, Pressure Alarms, Peak Demand, Demand Last Hour

**Applications:**
Calculate the energy released by combustion of liquid fuels

## Liquid Combustion Heat Illustration
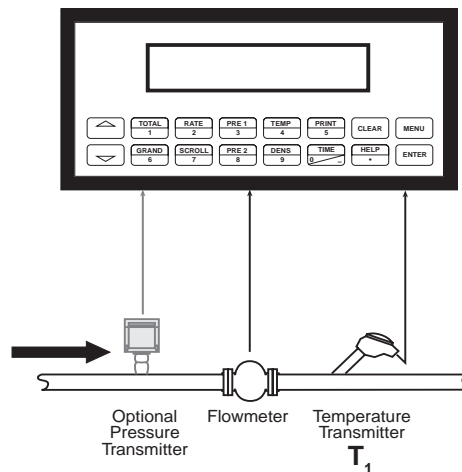


Optional Pressure Transmitter    Flowmeter    Temperature Transmitter $T_1$

## Calculations

*Volume Flow*

As calculated in section 3.8

*Heat Flow*

Heat Flow = C • volume flow • $(1-\alpha \bullet (T_1-T_{ref}))^2$ • ref. density

$\alpha$    =   Thermal expansion coefficient • $10^{-6}$
C     =   Specific combustion heat

**LIQUID SENSIBLE HEAT**

## 3.11 Liquid Sensible Heat

**Measurements:**
Actual volume flow is measured by the flow element (DP transmitter, Flowmeter). Temperature is measured by the temperature transmitter. A pressure transmitter can be used to monitor pressure. Pressure measurement does not affect the calculation.

**Calculations:**
• The density, mass flow and sensible heat are calculated using the fluid characteristics stored in the flow computer. (see "FLUID DATA" submenu)

**Output Results:**
• Display Results
    Sensible Heat, Mass or Volume Flow Rate, Resettable Total, Non-Resettable Total, Temperature, Pressure, Density (optional: peak demand, demand last hour, time/date stamp)
• Analog Output
    Sensible Heat, Mass or Volume Flow Rate, Temperature, Pressure, Density, Peak Demand, Demand Last Hour
• Pulse Output
    Sensible Heat, Mass or Volume Total
• Relay Outputs
    Sensible Heat, Mass or Volume Flow Rate, Total, Temperature, Pressure Alarms, Peak Demand, Demand Last Hour

**Applications:**
Calculate the energy stored in a condensate with respect to water at 32°F (0°C).

**Liquid Sensible Heat Illustration**
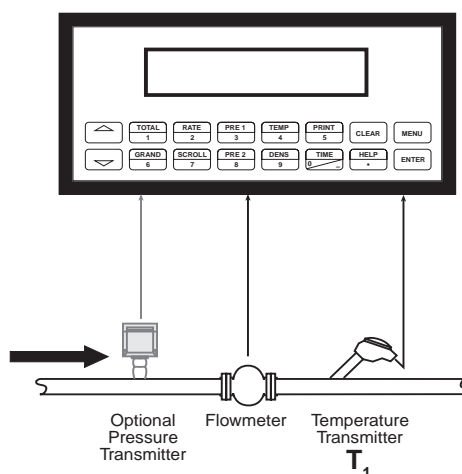


Optional Pressure Transmitter    Flowmeter    Temperature Transmitter
$T_1$

**Calculations**

*Volume Flow*

As calculated in section 3.8

*Heat Flow*

Heat Flow = $C \cdot$ volume flow $\cdot (1-\alpha \cdot (T_1 - T_{ref}))^2 \cdot$ ref. density $\cdot (T_1 - 32)$

$\alpha$ = Thermal expansion coefficient $\cdot 10^{-6}$
C = Specific heat

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**LIQUID DELTA HEAT**

### 3.12 Liquid Delta Heat

**Measurements:**
Actual volume flow is measured by the flow element (DP transmitter, Flowmeter). Temperature of the supply and return lines are measured by the temperature transmitters.

**Calculations:**
- The density, mass flow and delta heat are calculated using values of the heat carrying liquid stored in the flow computer. (see "FLUID DATA" submenu)

**Output Results:**
- Display Results
   Heat, Mass or Volume Flow Rate, Resettable Total, Non-Resettable Total, Temperature1, Temperature2, Delta Temperature, Density, (optional: peak demand, demand last hour, time/date stamp)
- Analog Output
   Heat, Mass or Volume Flow Rate, Temperature1, Temperature2, Delta Temperature, Density, Peak Demand, Demand Last Hour
- Pulse Output
   Heat, Mass or Volume Total
- Relay Outputs
   Heat, Mass or Volume Flow Rate, Total, Temperature Alarms, Peak Demand, Demand Last Hour

**Applications:**
Calculate the energy which is extracted by a heat exchanger from heat carrying liquids.

**Liquid Delta Heat Illustration**



*Meter Location = COLD*
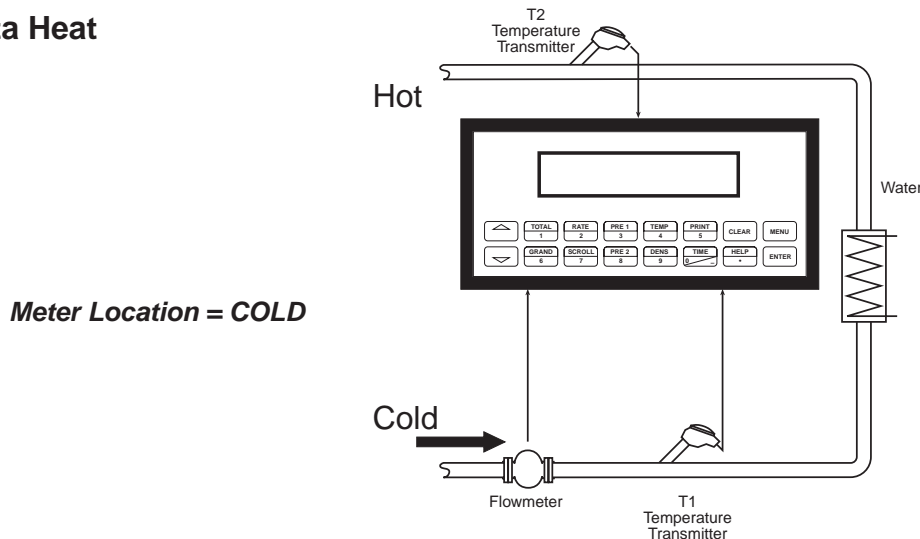
**Calculations**

*Water*

$$\text{Heat} = \text{Volume Flow} \bullet \rho(T1) \bullet [h(T_2) - h(T_1)]$$

*Other heat carrying liquids*

$$\text{Heat} = C \bullet \text{volume flow} \bullet (1 - \alpha \bullet (T_1 - T_{ref}))^2 \bullet \rho_{ref} \bullet (T_2 - T_1)$$

WHERE:  Delta T > Low Delta T Cutoff

| | | |
|---|---|---|
| $\alpha$ | = | Thermal expansion coefficient $\bullet$ $10^{-6}$ |
| C | = | Mean specific heat |
| $\rho(T1)$ | = | Density of water at temperature $T_1$ |
| $h(T1)$ | = | Specific enthalpy of water at temperature $T_1$ |
| $h(T2)$ | = | Specific enthalpy of water at temperature $T_2$ |
| $\rho_{ref}$ | = | Reference density |
| $T_{ref}$ | = | Reference temperature |

**STEAM –
CONDENSATE
ENERGY METER**

### 3.13 Steam – Condensate Heat

**Measurements:**
Actual condensate volume flow is measured by the flow element (DP transmitter, Flowmeter). Condensate temperature is measured by the temperature transmitter. A pressure transmitter is used to monitor steam pressure.

**Calculations:**
- The condensate density, volume flow, mass flow and saturated steam energy - condensate energy are calculated using the fluid characteristics stored in the flow computer. (see "FLUID DATA" submenu)

**Output Results:**
- Display Results
    Steam – Condensate Heat, Condensate Mass and Volume Flow Rate, Resettable Total, Non-Resettable Total, Temperature, Pressure, Condensate Density (optional: peak demand, demand last hour, time/date stamp)
- Analog Output
    Net Heat Flow, Mass and Volume Flow Rate, Condensate Temperature, Steam Pressure, Condensate Density, Peak Demand, Demand Last Hour
- Pulse Output
    Net Heat, Mass or Volume Total
- Relay Outputs
    Net Heat, Mass or Volume Flow Rate, Total, Condensate Temperature, Steam Pressure Alarms, Peak Demand, Demand Last Hour

**Applications:**
Calculate the energy stored in steam – the energy in returned condensate water.

**Steam – Condensate
Heat Illustration**
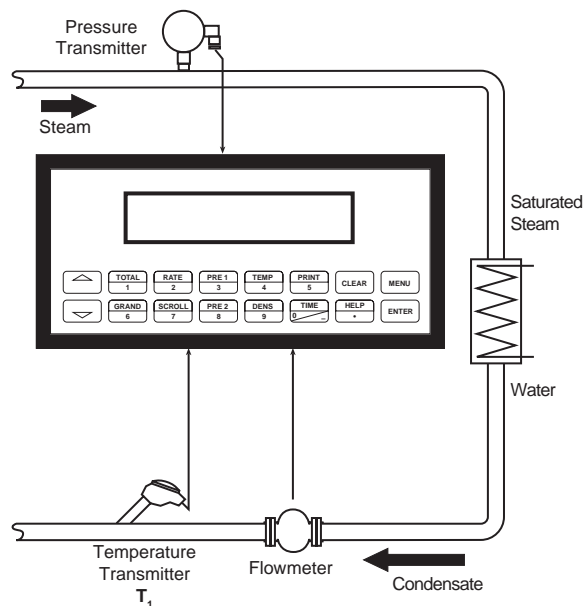


**Calculations**

*Volume Flow*

As calculated in section 3.8

*Net Heat Flow*

Net Heat Flow = condensate volume flow • condensate density • [enthalpy steam ($P_f$) – enthalpy water ($T_f$)]

# 4. WIRING

## 4.1 Terminal Designations

**Two Relay Terminations**

| 1 | DC OUTPUT | | |
|---|---|---|---|
| 2 | PULSE IN | Vin (+)* | FLOW IN |
| 3 | - - - - - - - - - - | Iin (+) | |
| 4 | COMMON | | |
| 5 | RTD EXCIT (+) | | TEMPERATURE IN |
| 6 | RTD SENS (+) | | |
| 7 | RTD SENS (-) | Iin (+)** | |
| 8 | DC OUTPUT | | |
| 9 | RTD EXCIT (+) | | PRESSURE (TEMP 2) IN |
| 10 | RTD SENS (+) | | |
| 11 | RTD SENS (-) | Iin (+) | |
| 12 | PULSE OUTPUT (+) | | |
| 13 | PULSE OUTPUT (-) | | |
| 14 | ANALOG OUTPUT  1 (+) | | |
| 15 | ANALOG OUTPUT  2 (+) | | |
| 16 | ANALOG OUTPUT  COMMON (-) | | |
| 17 | NO | | |
| 18 | COM RLY1 | | |
| 19 | NC | | |
| 20 | NC | | |
| 21 | COM RLY2 | | |
| 22 | NO | | |
| 23 | AC LINE | DC (+) | POWER IN |
| 24 | AC LINE | DC (-) | |

**Three Relay Option Terminations**

| 1 | DC OUTPUT | | |
|---|---|---|---|
| 2 | PULSE IN | Vin (+)* | FLOW IN |
| 3 | - - - - - - - - - - | Iin (+) | |
| 4 | COMMON | | |
| 5 | RTD EXCIT (+) | | TEMPERATURE IN |
| 6 | RTD SENS (+) | | |
| 7 | RTD SENS (-) | Iin (+)** | |
| 8 | DC OUTPUT | | |
| 9 | RTD EXCIT (+) | | PRESSURE (TEMP 2) IN |
| 10 | RTD SENS (+) | | |
| 11 | RTD SENS (-) | Iin (+) | |
| 12 | PULSE OUTPUT (+) | | |
| 13 | PULSE OUTPUT (-) | | |
| 14 | ANALOG OUTPUT  1 (+) | | |
| 15 | ANALOG OUTPUT  2 (+) | | |
| 16 | ANALOG OUTPUT  COMMON (-) | | |
| 17 | N.O.  RLY1 | | |
| 18 | COM.RLY1 | | |
| 19 | N.O.  RLY3 | | |
| 20 | COM.RLY3 | | |
| 21 | N.O.  RLY2 | | |
| 22 | COM.RLY2 | | |
| 23 | AC LINE | DC (+) | POWER IN |
| 24 | AC LINE | DC (-) | |

*In stacked DP mode, terminal 2 is used for Iin (+) DP Hi Range.
   Terminal 3 is used for Iin (+) DP Lo Range.

**In trap monitor mode, terminal 7 is used for Iin (+) from trap monitor.

### 4.2 Typical Wiring Connections:

#### 4.2.1 Flow Input

| Analog 4-20 mA Transmitter (i.e. DP Transmitter) | 4-20 mA | + | 1 | (+) 24 V Out |
| | | | 2 | |
| | | − | 3 | 4-20 mA In |

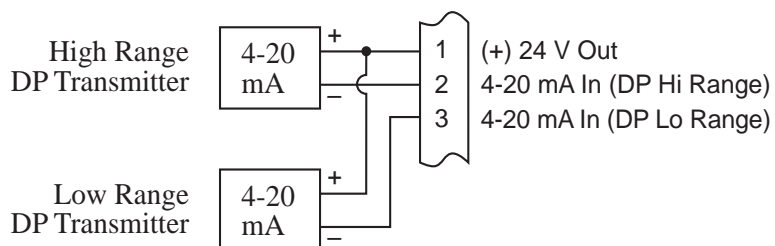| Analog Voltage Transmitter (i.e. Turbine Flowmeter with F/V Converter) | 0-5 VDC | | 1 | |
| | | + | 2 | (+) V In |
| | | | 3 | |
| | | − | 4 | Common |

| 10 mV or 100 mV Signal (i.e. Turbine Flowmeter with Magnetic Pickup) | Mag 10 mV | | 1 | |
| | | | 2 | Pulse In |
| | | − | 3 | |
| | | | 4 | Common |

| 3-30 VDC Pulses (i.e. Positive Displacement Flowmeter) | Pulse 3-30 V | + | 1 | (+) 24 V Out |
| | | | 2 | Pulse In |
| | | − | 3 | |
| | | | 4 | Common |

#### 4.2.2 Stacked DP Input

| High Range DP Transmitter | 4-20 mA | + | 1 | (+) 24 V Out |
| | | | 2 | 4-20 mA In (DP Hi Range) |
| | | − | 3 | 4-20 mA In (DP Lo Range) |
| Low Range DP Transmitter | 4-20 mA | + | | |
| | | − | | |

#### 4.2.3 Pressure Input

| | | | 8 | (+) 24 V Out |
| | | | 9 | |
| 4-20 mA Pressure Transmitter | 4-20 mA | + | 10 | |
| | | − | 11 | 4-20 mA In |

25

## 4.2.4 Temperature Input

RTD Connections
2, 3 & 4 wire RTD's

2-Wire
RTD

| 5 | RTD Excitation (+) |
| 6 | RTD Sense (+) |
| 7 | RTD Sense (−) |

3-Wire
RTD

| 5 | RTD Excitation (+) |
| 6 | RTD Sense (+) |
| 7 | RTD Sense (−) |

4-Wire
RTD

| 5 | RTD Excitation (+) |
| 6 | RTD Sense (+) |
| 7 | RTD Sense (−) |

4-20 mA Temperature
Transmitter

4-20
mA

| 7 | 4-20 mA In |
| 8 | (+) 24 V Out |

**\***

\* Or optional steam trap monitoring input in some saturated
  steam applications.

## 4.2.5 Temperature 2 Input

RTD Connections
2, 3 & 4 wire RTD's

2-Wire
RTD

| 9 | RTD Excitation (+) |
| 10 | RTD Sense (+) |
| 11 | RTD Sense (−) |

3-Wire
RTD

| 9 | RTD Excitation (+) |
| 10 | RTD Sense (+) |
| 11 | RTD Sense (−) |

4-Wire
RTD

| 9 | RTD Excitation (+) |
| 10 | RTD Sense (+) |
| 11 | RTD Sense (−) |

4-20 mA Temperature
Transmitter

4-20
mA

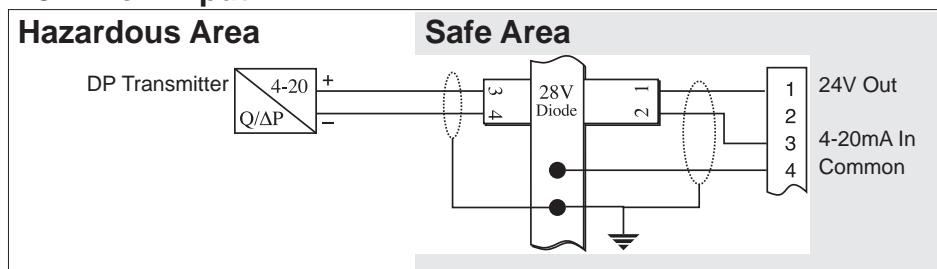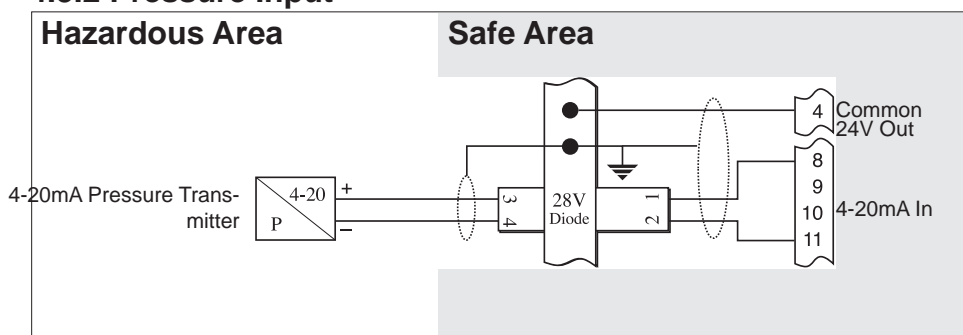| 8 | (+) 24 V Out |
| 9 | |
| 10 | |
| 11 | 4-20 mA In |
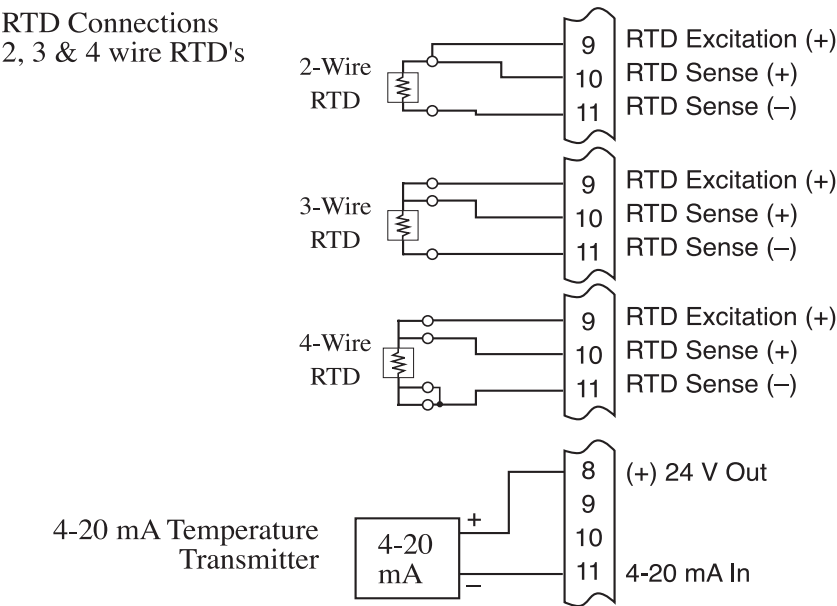
## 4.3 Wiring In Hazardous Areas

### Examples using MTL787S+ Barrier (MTL4755ac for RTD)
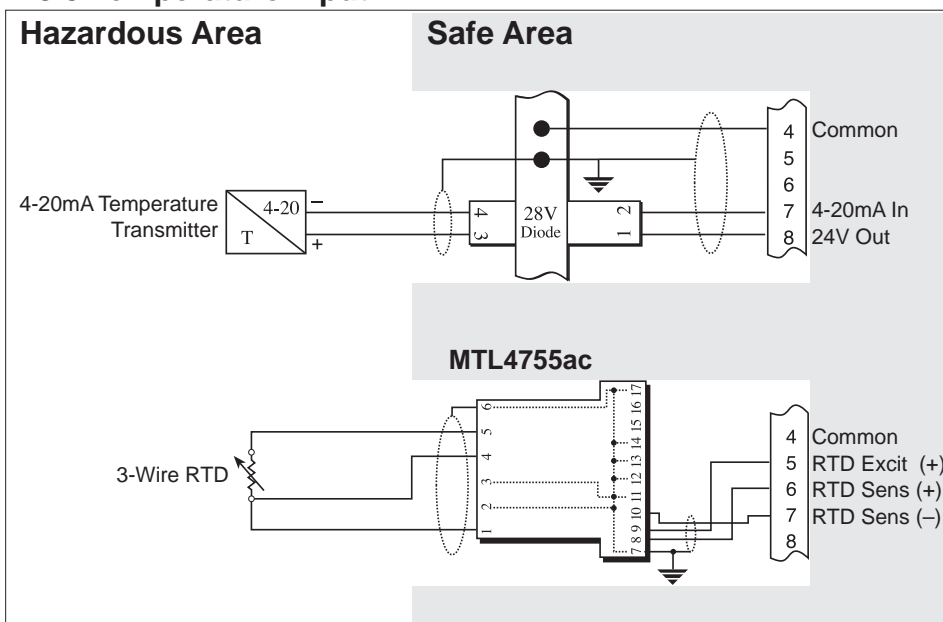
#### 4.3.1 Flow Input
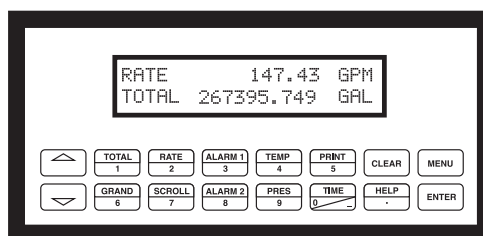


#### 4.3.2 Pressure Input



#### 4.3.3 Temperature Input

# 5. UNIT OPERATION

## 5.1 Front Panel Operation Concept for Operate Mode



**How To Use**
**On-Line Help**

**HELP**
On-line help is provided to assist the operator in using this product.  The help is available during OPERATE and SETUP modes simply by pressing the HELP key.  The HELP key is used to enter decimals when entering numeric values.

**How To View**
**Process Values**

**VIEWING PROCESS VALUES**
In the OPERATE mode, several keys have a special, direct access feature,  to display an item of interest (i.e. RATE, TOTAL, ALARM SETPOINT, etc.). Press the key to view your choice. Press the Δ ∇ keys to view other items in that group.

**How To Clear The**
**Totalizer**

**CLEARING TOTALIZER**
To clear the totalizers, you must press the TOTAL Function Key to select the totalizer group. Press the Δ ∇ keys to select the desired totalizer.  Once the desired totalizer is displayed, press the CLEAR key to reset the total.  The operator will be prompted to verify this action and to enter a password if the unit is locked.

**How To Clear The**
**Grand Total**

**CLEARING GRAND TOTAL**
To clear the grand totalizers, you must press the GRAND Function Key and use the Δ ∇ keys to select the desired grand total.  Once the grand total is selected, press the CLEAR key to reset the grand total.  The operator will be prompted to verify this action and to enter service password if the unit is locked.

**How To Enter Alarm**
**Setpoints**

**ALARM SETPOINT KEYS**
ALARM 1 & ALARM 2 keys are used to view and/or change the alarm setpoints.  To view the setpoints, simply press the desired Alarm setpoint key once.  Rapidly press the alarm setpoint keys several times for direct editing of the alarm setpoints. The operator will be prompted to enter password if the unit is locked. Press CLEAR, "###", ENTER to enter value.

**How To Activate The**
**Scrolling Display List**

**SCROLL**
Press the Scroll key to activate the scrolling display list.  See section 6 to setup the display list.

**How To Use**
**The Print Key**

**PRINT**
The PRINT key is used to print on demand when the communication port is set for printer. When the PRINT key is pressed, a user defined list of data (TOTAL, RATE, ALARM SETPOINT, etc.) is sent to the RS-232 port.  A timed message of "PRINTING" will be displayed to acknowledge the print request.

**How To Use**
**The Menu Key**

**MENU KEY**
The MENU key is used to view/enter the Instrument Setup  and Service Mode.  Press the MENU key to access the Setup and Service modes. (See section 6 for Setup mode). The MENU key is also used for a "Pop-Back" function. When the MENU key is pressed, the display will "Pop-Back" to the current submenu heading.  Multiple MENU key depressions will return the unit to the Operate Mode.

**How To**
**Acknowledge Alarms**

**ACKNOWLEDGING ALARMS**
Most alarm messages are self-clearing.  Press the ENTER key to acknowledge and clear latching alarms.

NOTE:  Some keys and functions are password protected.  Enter the password to gain access.  The passwords are factory set as follows:
**Private** = 1000, **Service** = 2000

**General Operation**

## 5.2 General Operation

This instrument is used primarily to monitor flowrate and accumulated total. The inputs can be software configured for a variety of flowmeter, temperature and pressure sensors. The standard output types include: Pulse, Relay, Analog and RS-232 The unit can display the flowrate, total and process variables. RS-485 is an available option for a second communication channel.

**Password Protection**

## 5.3 Password Protection

After an Private and/or Service Code is entered in the "System Parameters" Submenu Group. (see section 6.3, Private Code and Service Code sub-menus), the unit will be locked. The unit will prompt the user for the password when trying to perform the following functions:

      Clear Totals
      Clear Grand Totals (service code required)
      Edit a Setup Menu Item
      Edit Alarm Setpoints (ALARM 1 & ALARM 2 Keys)

The Service Code should be reserved for service technicians. The Service Code will allow access to restricted areas of the Service and Test menus. Changes in these areas may result in lost calibration information.

**Relay Operation**

## 5.4 Relay Operation

Two relay alarm outputs are standard. The relays may also be used for pulse outputs. The relays can be assigned to trip according to various rate, total, temperature or pressure readings. The relays can be programmed for low/high alarms, latch or unlatch, or as relay pulse outputs.
ALARM SETPOINT 1 (RLY1) and ALARM SETPOINT 2 (RLY2) are easily accessible by pressing the ALARM 1 or ALARM 2 key on the front panel.

**Pulse Output**

## 5.5 Pulse Output

The isolated pulse output is menu assignable to any of the available totals. The pulse output duration and scaling can be set by the user. The pulse output is ideal for connecting to remote totalizers or other devices such as a PLC. See section 1.2 for electrical specifications.

**Analog Outputs**

## 5.6 Analog Outputs

The analog outputs are menu assignable to correspond to any of the process parameters. The outputs are menu selectable for 0-20 mA or 4-20 mA. The analog outputs are ideal for "trend" tracking using strip chart recorders or other devices.

**Function Keys Display Grouping**

## 5.7 Function Keys; Display Grouping

| | |
|---|---|
| TOTAL | Press the ⬆⬇ keys to view HEAT TOTAL, MASS TOTAL, CORRECTED VOLUME TOTAL, VOLUME TOTAL |
| GRAND TOTAL | Press the ⬆⬇ keys to view GRAND HEAT, GRAND MASS, GRAND CORRECTED VOLUME, GRAND VOLUME |
| RATE | Press the ⬆⬇ keys to view HEAT, MASS , CORRECTED VOLUME, VOLUME, PEAK DEMAND, DEMAND LAST HOUR |
| TEMPERATURE | Press the ⬆⬇ keys to view TEMPERATURE 1, TEMPERATURE 2, DELTA TEMPERATURE, DENSITY |
| PRESSURE | Press the ⬆⬇ keys to view PRESSURE, DIFFERENTIAL PRESSURE, , $Y_1$, SPECIFIC ENTHALPY |
| TIME | Press the ⬆⬇ keys to view TIME/DATE, PEAK TIME/DATE, ACCUMULATIVE POWER LOSS TIME, TIME OF LAST POWER OUTAGE, TIME POWER WAS LAST RESTORED |

**RS-232 Serial Port Operation**

## 5.8 RS-232 Serial Port Operation
The RS-232 serial port can be used for programming (using the Setup Disk) or for communicating to printers and computers in the Operating Mode (Run Mode). Enhanced uses include remote metering by modem.

**PC Communications**

## 5.8.1 PC Communications:
The Setup Disk also allows the user to query the unit for operating status such as Flow Rate, Flow Total, Temperature, Pressure, Alarm Setpoints, etc.
In this mode of operation the RS232 port is assumed connected to a computer. The FC-22 will act as a slave and answer requests from the PC. See the Universal Protocol Users Manual for a complete listing of the commands set supported. A DDE/OPC Server is also available for use in exchanging information with DDE Clients such as Spread Sheets, Database Programs, and HMI software.

**RS-232 Serial Port Operation of RS-232 Serial Port with Printers**

## 5.8.2 Operation of RS-232 Serial Port with Printers:
Transaction Printing
For transaction printing, the user  defines the items to be included in the printed document (see section 6.13 COMMUNICATION, Print List). The transaction document can be initiated by pressing the PRINT key.

Data Logging
The user can select when (time of day) or how often (print interval) the data log is to be made (see section 6.13 COMMUNICATION, Print Initiate).  Information will be stored to the datalogger and optionally output to the RS-232 port.

System Setup and Maintenance Report
The system setup and maintenance report lists all of the instrument setup parameters and usage for the current instrument configuration.  The audit trail information and a status report is also printed.  This report is initiated in the Service and Analysis Group  (see section 6.15 SERVICE & ANALYSIS, Print System Setup).

**Operation of RS-232 Serial Port with Modems**

## 5.8.3 Operation of RS-232 Serial Port with Modems
In this mode of operation the RS232 port is assumed to be connected to a MPP2400N or similar telephone modem. The FC-22 is responsible for communicating to a remote computer through the modem to perform such actions as:
Answer incoming calls, process requests for information or action items or data log contents or change setup parameters, call out daily readings to designed phone number, call out to designated phone number in the case of a designated exception or malfunction in the unit, terminating telephone calls if a connection is lost.

**RS-485 Serial Port Operation**

## 5.9 RS-485 Serial Port Operation
The RS-485 serial port is intended to permit operation of the flow computer in a RS-485 network. Access is limited to reading process variables, totalizers, error logs and to executing action routines such as clearing totalizers, alarms, and changing setpoints.

**Pause Computations Prompt**

## 5.10 Pause Computations Prompt
The user will be prompted with a "Pause Computations" message when making significant setup changes to the instrument.  Pausing computations is necessary to make any significant changes.  With computations paused, all outputs assume a safe state equal to that of an unpowered unit.  Computations resume when exiting the setup menu.

# 6. PROGRAMMING

## 6.1 Front Panel Operation Concept for Program Mode

The FC-22 is fully programmable through the front panel.   The instrument setup menu structure is based on a number of topical submenu groups with one submenu group for each instrument function.  Each submenu contains all of the individual settings associated with that function. During the instrument setup, setup topics are shown on the bottom line of the display while the detailed selection options are shown on the top line. A help menu is available for each menu item.

Please review the following key usage summary before attempting to setup the instrument.
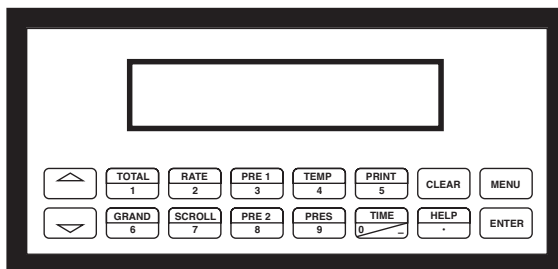


**CAUTION:**  When the computations are paused the instrument outputs will go to a safe state which is the same as if the unit lost power. All calculations stop.

### Key Usage Summary:

**Menu Key**

**MENU KEY**
Pressing the MENU key while in the "HOME" position will select the view setup parameters mode. Thereafter, the MENU key is used to "pop up" one menu level (i.e. return to the start of the submenu group). The unit will "pop up" one level for each time the **MENU key is pressed until finally returning to the "HOME" position of showing the "scroll" display list.**

**Up & Down Arrow Keys**

**UP & DOWN ARROW KEYS**
Use the UP and DOWN arrow keys to navigate through the submenu groups. The up and down arrow keys are also used to view the next/previous selection in a selection list within a submenu cell. When entering text characters, the UP and DOWN arrow keys are used to scroll through the available character sets for each individual character location.  Press the ENTER key to accept the character and advance to the next character.

**Help Key**

**HELP KEY**
On-line help is available to assist the user during instrument setup. A quick help is provided at each setup step.  Press the HELP key to display a help message for the current setup selection.  This key is also used to enter decimals during numeric entry sequences.

**Numeric Entry Keys**

**NUMERIC ENTRY KEYS**
The keys labeled "0 - 9", "–", ".", CLEAR and ENTER are used to enter numerical values.  A leading  0 will assume that you intend to enter a minus "–" sign.
The standard numeric entry sequence is: CLEAR, "###", ENTER.Numeric entry values are bounded or clamped by minimum and maximum permitted values.

**Clear Key**

**CLEAR KEY**
The CLEAR key is used to clear numeric values to "0".

**Enter Key**

**ENTER KEY**
The ENTER key is used to accept the current value and advance to the next selection (Successfully terminate the current numeric entry sequence).

**6.2**
**EZ**
**SETUP**

# EZ SETUP

**EZ SETUP**

The EZ Setup routine is a quick and easy way to configure the most commonly used instrument functions. We recommend first completing the EZ Setup routine for the flow equation and meter type for your initial application.  The setup can then be customized using the complete submenu groups described later in this chapter.

**Caution:**

Entering the EZ Setup mode automatically sets many features to a default value (without prompting the user). This may cause any previously programmed information to be lost or reset.

**Selection:**

YES, NO

**Display:**     EZ SETUP?    YES
                     PAUSE COMPUTATIONS

**EZ Setup**
**Example:**
**Steam Mass**
**Vortex Flowmeter**

**Note:**

The "Pause Computations" warning message informs the user that all computations are halted while programming EZ Setup.

---

**UNITS**

Select the desired units of measure.

**Selection:**

METRIC, ENGLISH

**Display:**     ENGLISH
                     UNITS?

---

**FLOW EQUATION**

Select the flow equation appropriate for your application.

**Selection:**

STEAM MASS, STEAM HEAT, STEAM NET HEAT, STEAM DELTA HEAT, GAS CORRECTED VOLUME, GAS MASS, GAS COMBUSTION HEAT, LIQ.CORRECTED VOLUME, LIQUID MASS, LIQ. COMBUSTION HEAT, LIQUID SENSIBLE HEAT, LIQUID DELTA HEAT, STM – CONDENSATE HEAT

**Display:**     STEAM MASS
                     FLOW EQUATION

**6.2
EZ
SETUP**
(Continued)

| **EZ SETUP** |
|---|

| **Fluid Type** | Select the type of fluid appropriate for your application. |
|---|---|

**Selection:**

SATURATED STEAM, SUPERHEATED STEAM

**Display:**   SATURATED STEAM
          FLUID TYPE

---

**FLOWMETER TYPE**    Select the flowmeter type used in your application.

**Selection:**

LINEAR, SQR LAW, SQR LAW-LIN., LINEAR 16 PT, SQR LAW 16 PT, SQR LAW-LIN. 16 PT, LINEAR UVC, GILFLO, GILFLO 16 PT, BYPASS, ILVA16PT, MASS FLOW

**Display:**      LINEAR
      FLOWMETER TYPE

---

**INPUT SIGNAL**    Select the appropriate input signal.

**Selection:**

4-20 mA, 0-20 mA, 0-5 Vdc, 1-5 Vdc, 0-10 Vdc, DIGITAL: 10 mV LEVEL, DIGITAL: 100 mV LEVEL, DIGITAL: 2.5 V LEVEL, 4-20mA STACKED, 0-20mA STACKED, 4-20mA LINEAR MANIFOLD, 0-20mA LINEAR MANIFOLD

**Display:**    DIGITAL 2.5 V LEVEL
       INPUT SIGNAL

---

**K-FACTOR**    Enter the K-Factor for the flowmeter.

**Input:**

Number with floating decimal point:
0.0001...999999

**Display:**     123.67 P/ft3
      K-FACTOR

---

**INPUT SIGNAL**
(PRESSURE)    Select the appropriate pressure input signal.

**Selection:**

MANUAL PRESSURE, 4-20 PRESSURE (ABS.), 0-20 PRESSURE (ABS.), 4-20 PRESSURE (G), 0-20 PRESSURE (G)

**Display:**    4-20 PRESSURE (ABS.)
       INPUT SIGNAL

**6.2
EZ
SETUP**
(Continued)

## EZ SETUP

**FULL SCALE VALUE**
(PRESSURE)

Enter the full scale value for the pressure input signal.

**Input:**

TOTAL 1 E 2

Number with fixed decimal point:
000.000 ... 999.999

**Display:**　　　　　　580.000 psia
　　　　　　FULL SCALE VALUE

**DEFAULT VALUE**
(PRESSURE)

Enter the default value for the pressure input signal.

**Input:**

TOTAL 1 E 2

Number with fixed decimal point:
000.000 ... 999.999

**Display:**　　　　　　14.696 psia
　　　　　　DEFAULT VALUE

**NOTE:** After the last entry has been saved, the display
automatically returns to the HOME position. The "EZ
Setup" routine is completed and the flow computations are
resumed.

**6.3
DETAILED
MENU
DESCRIPTION**

## DETAILED MENU DESCRIPTION

The menu organization for the unit is depicted in Appendix B.  The first
depiction is that available with the operator password. The second is that
available with supervisor password.

Please reference Appendix B while reviewing the detailed descriptions for each
menu location in the following sections.

**6.4
SYSTEM
PARAMETERS**

# SYSTEM PARAMETERS

**EZ SETUP**

The EZ Setup routine is a quick and easy way to configure the most commonly used instrument functions.

**Reference:**
Refer to Section 6.2 for EZ Setup Programming.

**Caution:**
Entering the EZ Setup mode automatically sets many features to default values without informing the user.  This may cause any previously programmed information to be lost or reset

**Selection:**

YES, NO

**Display:**     `EZ SETUP?    NO`
                    `PAUSE COMPUTATIONS`

**Note:**
The "Pause Computations" warning message informs the user that all computations are halted while programming EZ Setup.

**ACCESS CODE**

This is the menu location where the operator can unlock the unit by entering the correct password (operator or supervisor code), or lock the unit by entering the incorrect password.

**Selection:**

0 - 9999

**Display:**                    `0`
                    `ACCESS CODE`

**6.4
SYSTEM
PARAMETERS**
(Continued)

# SYSTEM PARAMETERS

**FLOW EQUATION**

The Flow Equation sets the basic functionality of the unit. Choose the Flow Equation for your particular application.

**Note:**

Various setup data is only available depending on the flow equation selected. The flow equation also determines the assignment of the inputs.

**Caution:**

Select the flow equation as the first step.  We recommend using the EZ Setup to select the proper flow equation.  The user can then enter the submenu groups and make additional changes as desired.

**Selection:**

GAS COMBUSTION HEAT, GAS MASS, GAS CORRECTED VOLUME, STEAM DELTA HEAT, STEAM NET HEAT, STEAM HEAT, STEAM MASS, LIQUID DELTA HEAT, LIQUID SENSIBLE HEAT, LIQ. COMBUSTION HEAT, LIQUID MASS, LIQ. CORRECTED VOLUME, STM – CONDENSATE HEAT

**Display:**      STEAM MASS
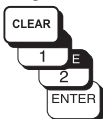              FLOW EQUATIONS

---

**ENTER DATE**

Enter the date in this format:  Day - Month - Year.

**Note:**

After prolonged breaks in the power supply (several days) or upon initial start-up of the unit, the date and time must be reset. This does not apply to units with the datalogger or language option.

**Input:**

Flashing selections can be changed.
Store and Confirm entries with the ENTER key

**Display:**      08 FEB 1996
              ENTER DATE

---

**DAYLIGHT SAVINGS TIME**

The "Daylight Savings" mode allows the unit to automatically adjust the time according to daylight savings time change

**Note:**

Select "Yes" to enable the Daylight Savings Mode

**Selection:**

Yes, No

**Display:**                    Yes
              DAYLIGHT SAVINGS

**6.4
SYSTEM
PARAMETERS**
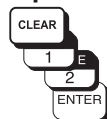(Continued)

## SYSTEM PARAMETERS

**ENTER TIME**

Enter the actual time in this format: Hours - Minutes

**Note:**

    After prolonged breaks in the power supply (several days) or upon initial start-up of the unit, the date and time must be reset.

**Input:**

CLEAR
1 E
2
ENTER

Flashing selections can be changed.
Store and Confirm entries with the ENTER key

**Display:**              `13:24`
                   `ENTER TIME`

---

**PRIVATE CODE**

**Special Note:**
After returning to the run mode, program editing is automatically locked after 60 seconds as long as no keys are pressed The program editing can also be disabled by entering a number other than the private code at the Access Code prompt.

A personal code may be defined. This code is used to enable program editing.

**Note:**

    • The private code is factory set to 1000
    • Entering a private code of "0" will always enable program editing (Turns automatic lock off)

**Input:**

CLEAR
1 E
2
ENTER
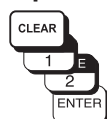
Maximum 4 digit number: 0...9999
Store and Confirm entries with the ENTER key

**Display:**                       `1000`
                 `PRIVATE CODE`

---
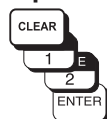
**SERVICE CODE**

**Note:**
The Service Code will allow access to the same information as the Private Code with the following additional functions:

• Change the Service Code
• Change the Order Code
• Change the Serial No.
• Clear Grand Total
• Clear Errors in Error Log
• View & Perform calibration in Service & Analysis Menu
• Restore Factory Calibration Information in Service & Analysis Menu
• Set Next Calibration Date
• Print Maint.Report
• Perform Service Test

A personal service code may be defined. This code is used to enable program menus that are normally reserved for factory and service personnel.
(i.e.: Service & Analysis Submenu Group)

**Note:**

    • The service code is factory set to 2000
    • The service code submenu will only appear if the service code was entered for the "Access Code".
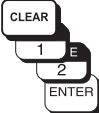
**Input:**

CLEAR
1 E
2
ENTER

Maximum 4 digit number: 0...9999
Store and Confirm entries with the ENTER key

**Display:**                       `2000`
                `SERVICE CODE`

**6.4
SYSTEM
PARAMETERS**
(Continued)

# SYSTEM PARAMETERS

### ENGINEERING CODE

**Note:**
The Engineering Code will allow access to the same information as the Private Code with the following additional functions:

• Change the Service Code
• Change the Order Code
• Change the Serial No.
• Clear Grand Total
• Clear Errors in Error Log
• View & Perform calibration in Service & Analysis Menu
• Restore Factory Calibration Information in Service & Analysis Menu
• Set Next Calibration Date
• Print Maint.Report
• Perform Service Test

A personal enginerring code may be defined.  This code is used to enable program menus that are normally reserved for engineering personnel.
(i.e.: Service & Analysis Submenu Group)

**Note:**
  • The engineering code is factory set to 3000
  • The engineering code submenu will only appear if the engineering code was entered for the "Access Code".

**Input:**

Maximum 4 digit number: 0...9999
Store and Confirm entries with the ENTER key

**Display:**                                    3000
                                SERVICE CODE

### TAG NUMBER

A personalized tag  can be entered for unit I.D. purposes.

**Note:**
  • Maximum of 10 characters.
  · Spaces are considered characters and must be confirmed by pressing the ENTER key.

**Input:**

Alphanumeric characters for each of 10 positions
1...9; A...Z;_, <, =, >, ?, etc.

Flashing selections can be changed.
Store and Confirm entries with the ENTER key.

**Display:**         FT101
                TAG NUMBER

**6.4**
**SYSTEM**
**PARAMETERS**
(Continued)

# SYSTEM PARAMETERS

**ORDER CODE**

The order code (part number) of the unit can be entered.  This will help in identifying what options were ordered.

**Note:**
- The order number is set at the factory and should only be altered if options are added in the field by an authorized service technician.
- Maximum of 10 characters.

**Input:**

Alphanumeric characters for each of 10 positions
1...9; A...Z;

Flashing selections can be changed.
Store and Confirm entries with the ENTER key

**Display:**     FC-22V10P
                 ORDER CODE

---

**SERIAL NUMBER**

The serial number of the unit is assigned at the factory.

**Note:**
Maximum of 10 characters.

**Input:**

Alphanumeric characters for each of 10 positions
1...9; A...Z;

**Display:**     SN 12345
                 SERIAL NUMBER

---

**SERIAL-NO. SENS.**

The serial number or tag number of the flowmeter can be entered.

**Note:**
Maximum of 10 characters.
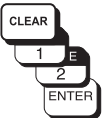
**Input:**

Alphanumeric characters for each of 10 positions
1...9; A...Z;_, <, =, >, ?, etc.
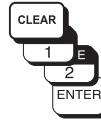
Flashing selections can be changed.
Store and Confirm entries with the ENTER key.

**Display:**     SN 12345
                 SERIAL-NO. SENS.

**6.5
DISPLAY**

# DISPLAY

**SCROLL LIST**

Select the variable that are to be displayed in the "HOME position" during normal operation.  Each variable can be assigned to line 1 (L1), line 2 (L2) or NO (removed from scroll list).

**Note:**
- To initiate the scroll list press the SCROLL key.  The list will be displayed in groups of two, each group is displayed for approximately 3 to 4 seconds.
- Any alarm messages will be displayed periodically, alternating throughout the scroll list.

**Selection (with Prompt):**

CHANGE? YES, NO
ADD TO LIST? L1, L2, NO

**Variable Selection:**
HEAT FLOW, MASS FLOW, VOLUME FLOW, STD. VOLUME FLOW, TEMP.1, TEMP.2, DELTA T, PRESSURE, DENSITY, SPEC. ENTHALPY, TIME, DATE, HEAT TOTAL, HEAT GRAND TOTAL, MASS TOTAL, MASS GRAND TOTAL, STD VOLUME TOTAL, STD.V. GRAND TOTAL, VOLUME TOTAL, VOL. GRAND TOTAL, PEAK DEMAND, DEMAND LAST HOUR, PEAK DEMAND TIME, PEAK DEMAND DATE

**Note:** Variable selection will vary depending on Flow Equation selected and options supplied.

**Display:**　　　ADD TO LIST?　　　L1
　　　　　　　　　　HEAT FLOW?

**DISPLAY
DAMPING**

The "display damping" constant is used to stabilize fluctuating displays.  The higher the constant, the less fluctuation will be displayed.

**Note:**　Relay response time is affected by the value entered for display damping. The larger the display damping value, the slower the relay response time will be. This is intended to prevent false triggering of the relays. Enter a display damping factor of zero (0) for fastest response time.

**Note:**
- Factory setting: 1

**Input:**

CLEAR
1  E
2
ENTER

2 digits max; 0...99

**Display:**　　　CONSTANT?　　　1
　　　　　　　　　　DISPLAY DAMPING

**6.5
DISPLAY**
(Continued)

# DISPLAY

**MAX. DEC. POINT**

Enter the number of decimal places for numerical values.

**Note:**
- The number of decimal places applies to all displayed variables and totalizers.
- The number of decimal places is automatically reduced if there is insufficient space available on the display for large numbers.
- The number of decimal places set here does not affect the functions set in the programming setup.

**Selection:**

```
CLEAR
 1   E
  2
 ENTER
```
0, 1, 2, 3 or 4 (decimal places)

**Display:**                              3
                              MAX. DEC. POINT

---

**LANGUAGE**

The language can be selected in which all text, parameters and operating messages are to be displayed.

**Note:**
- This function is supported by a special capability in the setup diskette.

**Selection:**

ENGLISH, OTHER

**Display:**        ENGLISH
                    LANGUAGE

---

**TOTAL ROLL OVER**

Some customer software can not handle very large numbers (such as 999,999,999) without going to scientific notation (such as 9.9999999E8). This menu can be used to force the totalizers to roll over at a lower numerical value (such as 999,999).

**Input:**

```
CLEAR
 1   E
  2
 ENTER
```
Maximum 9 digit number: 0...999999999
Store and Confirm entries with the ENTER key

**Display:**                999999999
                    TOTAL ROLL OVER

**6.6 SYSTEM UNITS**

# SYSTEM UNITS

| | |
|---|---|
| **TIME BASE** | Select "one" unit of time to be used as a reference for all measured or derived and time-dependant process variables and functions such as:<br><br>     • flowrate (volume/time; mass/time)<br>     • heat flow (amount of energy/time) etc.<br><br>**Selection:**<br><br>/s (per second), /m (per minute),<br>/h (per hour), /d (per day)<br><br>**Display:**       /h<br>          TIME BASE |
| **HEAT FLOW UNIT** | Select the unit for heat flow (amount of energy, combustion heat).<br><br>**Note:**<br>    The unit selected here also applies to the following:<br>       • Zero and full scale value for current.<br>       • Relay setpoints<br><br>**Selection:**<br><br>kBtu/time base, kW, MJ/time base, kCal/time base, MW, tons, GJ/h, Mcal/h, Gcal/h, Mbtu/h, Gbtu/h<br><br>**Display:**       kBtu/h<br>          HEAT FLOW UNIT |
| **HEAT TOTAL UNIT** | Select the unit of heat for the particular totalizer.<br><br>**Note:**<br>    The unit selected here also applies to the following:<br>       • Pulse value for pulse output<br>       • Relay setpoints<br><br>**Selection:**<br><br>kBtu, kWh, MJ, kCal, MWh, tonh,GJ, Mcal, Gcal, Mbtu, Gbtu<br><br>**Display:**       kBtu<br>          HEAT FLOW UNIT |

**6.6
SYSTEM
UNITS**
(Continued)

# SYSTEM UNITS

**MASS FLOW UNIT**     Select the unit of mass flowrate (mass/time base).

**Note:**
    The unit selected here also applies to the following:
        • Zero and full scale value for current
        • Relay setpoints

**Selection:**

lbs/time base, kg/time base, g/time base,
t/time base, tons(US)/time base,
tons(long)/time base

**Display:**            lbs/h
                MASS FLOW UNIT

---

**MASS TOTAL UNIT**     Select the unit of mass for the particular totalizer.

**Note:**
    The unit selected here also applies to the following:
        • Pulse value for pulse output
        • Relay setpoints

**Selection:**

lbs, kg, g, t, tons(US), tons(long), hlbs, Klbs, Mlbs

**Display:**            lbs
                MASS TOTAL UNIT

**6.6
SYSTEM
UNITS**
(Continued)

## SYSTEM UNITS

| | |
|---|---|
| **COR.VOL.<br>FLOW UNIT** | Select the unit of corrected volumetric flowrate<br>(corrected volume/time base).<br><br>**Note:**<br>    The unit selected here also applies to the following:<br>        • Zero and full scale value for current<br>        • Relay setpoints<br>*Corrected Volume* = volume measured under operating conditions<br>        converted to volume under reference conditions.<br><br>**Selection:**<br>The available selections will change depending on the flow equation<br>selected.<br><br>bbl/time base, gal/time base, l/time base, hl/time base, dm$^3$/time base, ft$^3$/time base, m$^3$/time base, scf/time base, Nm$^3$/time base, Nl/time base, igal/time base, mcf/time base<br><br>All units listed above apply to corrected volume.<br><br>**Display:**          scf/h<br>                COR.VOL. FLOW UNIT |
| **COR. VOLUME TOT.<br>UNIT** | Select the unit of volume for the particular totalizer.<br><br>**Note:**<br>    The unit selected here also applies to the following:<br>        • Pulse value for pulse output<br>        • Relay setpoints<br>*Corrected Volume* = volume measured under operating conditions<br>        converted to volume under reference conditions.<br><br>**Selection:**<br>The available selections will change depending on the flow equation<br>selected.<br><br>bbl, gal, l, hl, dm$^3$, ft$^3$, m$^3$, scf, Nm$^3$, Nl, igal, mcf<br><br>All units listed above apply to corrected volume.<br><br>**Display:**          scf<br>                COR.VOLUME TOT.UNIT |

**6.6
SYSTEM
UNITS**
(Continued)

# SYSTEM UNITS

### VOLUME FLOW UNIT

Select the unit for volumetric flowrate.

**Note:**
>    The unit selected here also applies to the following:
>        • Zero and full scale value for current
>        • Relay setpoints

**Selection:**
The available selections will change depending on the flow equation
selected.

bbl/time base, gal/time base, l/time base, hl/time base, dm$^3$/
time base, ft$^3$/time base, m$^3$/time base, acf/time base, igal/
time base

All units listed above apply to the actual volume measured under
operating conditions.

**Display:**                  ft3/h
                        VOLUME FLOW UNIT

### VOLUME TOTAL UNIT

Select the unit for uncorrected volume totalizer.

**Note:**
>    The unit selected here also applies to the following:
>        • Pulse value for pulse output
>        • Relay setpoints

**Selection:**
The available selections will change depending on the flow equation
selected.

bbl, gal, l, hl, dm$^3$, ft$^3$, m$^3$, acf,  igal

All units listed above apply to the actual volume measured under
operating conditions.

**Display:**                  ft3
                        VOLUME TOTAL UNIT

**6.6
SYSTEM
UNITS**
(Continued)

# SYSTEM UNITS

**DEFINITION bbl**

In certain countries the ratio of gallons (gal) per barrels (bbl) can vary according to the fluid used and the specific industry. Select one of the following definitions:
- US or imperial gallons
- Ratio gallons/barrel

**Selection:**.

US: 31.0 gal/bbl for beer (brewing)
US: 31.5 gal/bbl for liquids (normal cases)
US: 42.0 gal/bbl for oil (petrochemicals)
US: 55.0 gal/bbl for filling tanks
imp: 36.0 gal/bbl         for beer (brewing)
imp: 42.0 gal/bbl         for oil (petrochemicals)

**Display:**        US: 31.0 gal/bbl
                 DEFINITION bbl

**TEMPERATURE UNIT**

Select the unit for the fluid temperature.

**Note:**
The unit selected here also applies to the following:
- Zero and full scale value for current
- Relay setpoints
- Reference conditions
- Specific heat

**Selection:**

°C (Celsius), °F (Fahrenheit),
°K (Kelvin), °R (Rankine)

**Display:**             oF
                 TEMPERATURE UNIT

**6.6
SYSTEM
UNITS**
(Continued)

# SYSTEM UNITS

**PRESSURE UNIT**          Select the unit for process pressure.

**Note:**
        The unit selected here also applies to the following:
                • Zero and full scale value for current
                • Relay setpoints
                • Reference conditions

        Differential pressure is in mbar for Metric selections
        Differential pressure is in "H$_2$O f or English selections

**Selection:**

        bara, kpaa, kc2a, psia, barg, psig, kpag, kc2g

        Definitions:

        bara    bar
        kpaa    kpa         Absolute pressure
        kc2a    kg/cm$^2$   ("a" for absolute)
        psia    psi

        barg    bar         Gauge pressure compared to
        kpag    kpa         atmospheric pressure
        kc2g    kg/cm$^2$   ("g" for gauge)
        psig    psi

        Gauge pressure differs from absolute pressure by the
        atmospheric pressure, which can be set in the submenu
        group "OTHER INPUT".

**Display:**            psia
                    PRESSURE UNIT

**DENSITY UNIT**          Select the unit for the density of the fluid.

**Note:**
        The unit selected here also applies to the following:
                • Zero and full scale value for current
                • Relay setpoints

**Selection:**

        kg/m$^3$, kg/dm$^3$, #/gal, #/ft$^3$
        (# = lbs = 0.4536 kg)

**Display:**            #/ft3
                    DENSITY UNIT

47

**6.6
SYSTEM
UNITS**
(Continued)

# SYSTEM UNITS

**SPEC. ENTHALPY
UNIT**

Select the unit for the combustion value (spec. enthalpy).

**Note:**
    The unit selected here also applies to the following:
        • Specific thermal capacity
            (kWh/kg → kWh/kg - °C)

**Selection:**

btu/#, kWh/kg, MJ/kg, kCal/kg
(# = lbs = 0.4536 kg)

**Display:**                     Btu/#
                        SPEC. ENTHALPY UNIT

**LENGTH UNIT**

Select the unit for measurements of length.

**Selection:**

in, mm

**Display:**                     in
                        LENGTH UNIT

**6.7
FLUID DATA**

# FLUID DATA

**FLUID TYPE**

Select the fluid. There are three types:

**1. Steam / Water**
All information required for steam and water (such as saturated steam curve, density and thermal capacity) is permanently stored in the flow computer.

**2. Fluid Displayed**
Preset information for other fluids (such as air and natural gas) is stored in the flow computer and can directly adopted by the user.

If the preset values need to be changed to fit your specific process conditions, then proceed as follows:
Select the fluid (air or natural gas) and press the ENTER key (this sets all of the preset values).
Re-select the submenu group "FLUID TYPE", now choose "GENERIC" and ENTER.  Now the preset values for the previously selected fluid can be altered.

**3. Generic Fluid**
Select the setting "GENERIC" for the Fluid type submenu.  The characteristics of any fluid can now be defined by the user.

**Selection:**

GENERIC, WATER, SATURATED STEAM, SUPERHEATED STEAM, DRY AIR, HUMID AIR, HUMID GAS, NATURAL GAS, NATURAL GAS (NX-19), HYDROGEN, ARGON, METHANE, NITROGEN, CARBON DIOXIDE, PROPANE, OXYGEN, ETHANE, HELIUM

**Display:**       GENERIC
                FLUID TYPE

**REF. DENSITY**

Select the density for a generic fluid at reference temperature and pressure (see "STP REFERENCE" in "OTHER INPUT" submenu group).

**Input:**

Number with floating decimal point: 0.0001...10000.0

**Display:**       .0760 #/ft3
                REF. DENSITY

**6.7
FLUID DATA**
(Continued)

# FLUID DATA

**THERM. EXP. COEF.**

Enter the thermal expansion coefficient for a generic liquid. The coefficient is required for the temperature compensation of volume with various flow equations (i.e. Liquid Mass or Corrected Liquid Volume).

**Input:**

Number with floating decimal point: 0.000...100000 (e-6)

The thermal expansion coefficient can be calculated as follows:

$$ c = \frac{1 - \sqrt{\dfrac{\rho(T_1)}{\rho(T_o)}}}{T_1 - T_o} + 10^6 $$

c — Thermal expansion coefficient
$T_0, T_1$ — Temperatures at known points (see below)
$\rho\,(T_0, T_1)$ — Density of the liquid at temperature $T_0$ or $T_1$

For optimum accuracy, choose the reference temperatures as follows:
$T_0$: midrange temperature
$T_1$: choose a second point at or near the maximum process temperature

$10^6$ — The value entered is internally multiplied by a factor of $10^{-6}$ (display: e-6/temp. unit) since the value to be entered is very small.

**Display:**          104.300 (e-6/oF)
                        THERM.EXP.COEF.

**COMBUSTION HEAT**

Enter the specific combustion heat for generic fuels.

**Input:**

Number with floating decimal point: 0.000...100000

**Display:**          1000.000 kBtu/lbs
                        COMBUSTION HEAT

**SPECIFIC HEAT**

Enter the specific heat capacity for generic fluids. This value is required for calculating the delta heat of liquids.

**Input:**

Number with floating decimal point: 0.000...10.000

**Display:**          10.000 kBtu/lbs-°F
                           SPECIFIC HEAT

**6.7**
**FLUID DATA**
(Continued)

## FLUID DATA

| | |
|---|---|
| **FLOW. Z-FACTOR** | Enter a Z-factor for the gas at operating conditions.<br>The Z-factor indicates how different a "real" gas behaves from an "ideal gas" which exactly obeys the "general gas law" (P x V/T = constant; Z=1). The further the real gas is from its condensation point, the closer the Z-factor approaches "1".<br><br>**Note:**<br>    • The Z-factor is used for all gas equations.<br>    • Enter the Z-factor for the average process conditions (pressure and temperature).<br>**Input:**<br><br>Number with fixed decimal point: 0.1000...10.0000<br><br>**Display:**                  1.000<br>                   FLOW. Z-FACTOR |
| **REF. Z-FACTOR** | Enter a Z-factor for the gas at reference conditions.<br><br>**Note:**<br>    • The Z-factor is used for all gas equations.<br>    • Define the standard conditions in the submenu "STP REFERENCE" (OTHER INPUT submenu group).<br>**Input:**<br><br>Number with fixed decimal point: 0.1000...10.0000<br><br>**Display:**                  1.000<br>                   REF. Z-FACTOR |
| **ISENTROPIC EXP.** | Enter the isentropic exponent of the fluid. The isentropic exponent describes the behavior of the fluid when measuring the flow with a square law flowmeter.<br>The isentropic exponent is a fluid property dependent on operating conditions.<br><br>**Note:**<br>Select one of the "SQR LAW" selections in "FLOWMETER TYPE" of submenu group "FLOW INPUT" to activate this function.<br><br>**Input:**<br><br>Number with fixed decimal point: 0.1000...10.0000<br><br>**Display:**                  1.4000<br>                   ISENTROPIC EXP. |

**6.7
FLUID DATA**
(Continued)

# FLUID DATA

| MOLE % NITROGEN | Enter the Mole % Nitrogen in the anticipated natural gas mixture. This information is needed by the NX-19 computation |
|---|---|

**Note:**

Select "NATURAL GAS (NX-19)" in "FLUID TYPE" to activate this function.

**Input:**

Number with fixed decimal point: 0.00...15.00

**Display:**                    0.00
                       MOLE % NITROGEN

---

**MOLE % CO$_2$**

Enter the Mole % CO$_2$ in the anticipated natural gas mixture. This information is needed by the NX-19 computation

**Note:**

Select "NATURAL GAS (NX-19)" in "FLUID TYPE"  to activate this function.

**Input:**

Number with fixed decimal point: 0.00...15.00

**Display:**                    0.00
                       MOLE % CO2

---

**VISCOSITY COEF. A**

Enter the Viscosity coefficient A for  the anticipated fluid.  This information is needed by the viscosity computation for UVC and for Reynolds Number calculations.

**Note:**

Select "SQUARE LAW 16PT" or "LINEAR UVC" in "FLOWMETER TYPE"  to activate this function.

**Input:**

Number with fixed decimal point: 0.000000...1000000

**Display:**                    0.000444
                       VISCOSITY COEF. A

**6.7
FLUID DATA**
(Continued)

# FLUID DATA

**VISCOSITY COEF. B**     Enter the Viscosity coefficient B for the anticipated fluid. This information is needed by the viscosity computation for UVC and for Reynolds Number calculations.

**Note:**
Select "SQUARE LAW 16PT" or "LINEAR UVC" in "FLOWMETER TYPE" to activate this function.

**Input:**

TOTAL 1 E 2    Number with fixed decimal point: 0.000000...1000000

**Display:**                0.3850
                      VISCOSITY COEF. B

**Computation
of Viscosity
Coef. A and B**

**Computation of Viscosity Coef. A and B**

The flow computer solves an equation which computes the viscosity as a function of temperature. Two parameters must be entered for this calculation to be performed. These are the setup parameters Viscosity Coef. A and Viscosity Coef. B. A table listing these values for common fluids is available from the factory.

Alternately, if your intended fluid is not listed, the Viscosity Coef. A and B can be derived from two known temperature/viscosity pairs. Begin by obtaining this information for you intended fluid. Convert these known points to units of Degrees F and centipoise (cP)

The information is now in a suitable form to compute the Viscosity Coef. A and Viscosity Coef. B using the following equation based on the fluid state.

For a liquid, A and B are computed as follows:

$$B = \frac{(T1 + 459.67) \cdot (T2 + 459.67) \cdot \ln[cP1/cP2]}{(T2 + 459.67) - (T1 + 459.67)}$$

$$A = \frac{cP1}{\exp[B/(T1 + 459.67)]}$$

For a gas, A and B are computed as follows:

$$B = \frac{\ln[cP2/cP1]}{\ln[(T2 + 459.67)/(T1 + 459.67)]}$$

$$A = \frac{cP1}{(T1 + 459.67)^B}$$

**NOTE:** $cS = \dfrac{cP}{\text{Density (in kg/l)}}$

**% RELATIVE HUMIDITY**     Enter the % Relative Humidity in the anticipated gas mixture. This information is needed to more accurately compute the density of a Humid gas.

**nput:**

TOTAL 1 E 2    Number with fixed decimal point: 0.000000...100.0000

**Display:**                0.3850
                      % RELATIVE HUMIDITY

# FLOW INPUT

**FLOWMETER TYPE**

Select the flowmeter type. The flow equation (see SYSTEM PARAMETERS) and the flowmeter selected here determine the basic operation of the flow computer.

**Selection:**

| | | |
|---|---|---|
| LINEAR |  | Volumetric flowmeter with linear pulse or analog output. |
| SQR LAW | | Differential pressure transmitter without square root extraction, with analog output. |
| SQR LAW-LIN. | | Differential pressure transmitter with square root extraction and analog output. |
| LINEAR 16 PT* | | Volumetric flowmeter with nonlinear pulse or analog output; with 16 point linearization table. |
| SQR LAW 16 PT* | | Differential pressure transmitter without square root extraction, with analog output and 16 point linearization table. |
| SQR LAW-LIN. 16 PT* | | Differential pressure transmitter with square root extraction, analog output and 16 point linearization table. |
| LINEAR UVC | | Volumetric Turbine flowmeter with UVC calibration curve documentation and pulse output. |
| LINEAR MANIFOLD | | Linear manifold consists of 2 linear flowmeters used in conjunction with an external bypass/diverter value. It may be used with turbine, PD, Mag, Vortex flowmeters equipped with analog outputs to extend the allowable turndown range. |
| GILFLO | | Gilflo flowmeters are special purpose differential pressure type flowmeters with an analog output where the differential pressure is linear with flow. |
| GILFLO 16PT | | Gilflo 16 PT flowmeters are special purpose differential pressure type flowmeters with an analog output where the differential pressure is approximately linear with flow, but can be further enhanced by a 16 point linearization table. |
| BYPASS | | BYPASS is a selection for use with Bypass(Shuntflow) flowmeters equipped with a pulse output. |
| ILVA 16PT | | ILVA 16 PT flowmeters are special purpose differential pressure type flowmeters with an analog output where the differential pressure is approximately linear with flow, but can be further enhanced by a 16 point linearization table. |
| MASS FLOW METER | | Flowmeter type such as Coriolis, or Thermal Flowmeter whose output is directly proportional to mass flow. Multivariable transmitters whose output is proportional to a computed mass flow rate can also use this meter type selection. |

\* A linearization table must be entered by user.
  (see "LINEARIZATION" submenu).

**Display:**          `LINEAR`
                  `FLOWMETER TYPE`

# FLOW INPUT

| | |
|---|---|
| **SQUARE LAW FLOWMETER** | Select the type of square law flowmeter to be used with the instrument. |

**Note:**

This selection will only appear if one of the Square Law selections were made in "FLOWMETER TYPE".

**Selection:**

ORIFICE, V-CONE, ANNUBAR, PITOT, VENTURI, FLOW NOZZLE, BASIC SQRLAW/TARGET, WEDGE, VERABAR, ACCELABAR

**Display:**
```
        ORIFICE
   SQUARE LAW FLOWMETER
```

---

| | |
|---|---|
| **ILVA METER SIZE** | Select the size of the ILVA flowmeter. |

**Selection:**

DN50, DN80, DN100, DN150, DN200, DN250, DN300

---

| | |
|---|---|
| **ACCELABAR SIZE** | Select the size of the Accelabar flowmeter. |

**Selection:**

2 inch, 3 inch, 4 inch, 6 inch, 8 inch, 10 inch and 12 inch

---

**INPUT SIGNAL**   Select the type of measuring signal produced by the flowmeter.

**Selection:**

| | |
|---|---|
| DIGITAL, 10 mV LEVEL | Voltage pulses, 10mV trigger threshold. |
| DIGITAL, 100 mV LEVEL | Voltage pulses, 100mV trigger threshold. |
| DIGITAL, 2.5 V LEVEL | Voltage pulses, 2.5V trigger threshold. |
| | |
| 4-20 mA | 4-20 mA current signal |
| 0-20 mA | 0-20 mA current signal |
| 4-20 mA STACKED | 4-20 mA current signal |
| 0-20 mA STACKED | 0-20 mA current signal |
| | |
| 0-5 V | 0-5 V voltage signal |
| 1-5 V | 1-5 V voltage signal |
| 0-10 V | 0-10 V voltage signal |

**Display:**
```
       4-20 mA
     INPUT SIGNAL
```

**6.8
FLOW INPUT**
(Continued)

# FLOW INPUT

| | |
|---|---|
| **LOW SCALE** | Set the low scale value for the analog input signal.<br>The value entered here must be identical to the value set for the flowmeter.<br>**Note:**<br>    • For flowmeters with analog/linear output, the flow computer uses the selected system units for volumetric flowrate.<br>    • The units for differential pressure flowmeters are dependent on the system units selected for pressure:<br>    - Imperial units [inches H2O]<br>    - Metric units: [mbar]<br><br>**Input:**<br>Number with floating decimal point:  0.000...999999<br><br>**Display:**            .000 ft3/h<br>                LOW SCALE VALUE |
| **FULL SCALE** | Set the full scale value for the analog input signal.<br>The value entered here must be identical to the value set for the flowmeter.<br><br>**Note:**<br>    • For flowmeters with analog/linear output, Target, generic square law and Gilflo flowmeters, the flow computer uses the selected system units for volumetric flowrate.<br>    • The units for differential pressure flowmeters are dependent on the system units selected for pressure:<br>    - Imperial units [inches H2O]<br>    - Metric units: [mbar]<br><br>**Input:**<br>Number with floating decimal point:  0.000...999999<br><br>**Display:**        10000.00 ft3/h<br>              FULL SCALE VALUE |
| **LOW SCALE-HI RANGE** | Set the low scale value for the high range transmitter analog input signal.<br>The value entered here must be identical to the value set for the flowmeter.<br>**Note:**<br>    • The units for differential pressure flowmeters are dependent on the system units selected for pressure:<br>    - Imperial units [inches H2O]<br>    - Metric units: [mbar]<br>**Input:**<br>Number with floating decimal point:  0.000...999999<br><br>**Display:**            .000 ft3/h<br>            LOW SCALE-HIGH RANGE |

**6.8
FLOW INPUT**
(Continued)

# FLOW INPUT

**FULL SCALE-HI RANGE**

ll scale value for the high range transmitter analog input signal. The value entered here must be identical to the value set for the flowmeter.

**Note:**
- The units for differential pressure flowmeters are dependent on the system units selected for pressure:
- Imperial units [inches H2O]
- Metric units: [mbar]

**Input:**

TOTAL
1 E
2

Number with floating decimal point:  0.000...999999

**Display:**          10000.00 ft3/h
                FULL SCALE VALUE

---

**SWITCH UP DP**

Enter the value of delta P at which the unit will begin using the hi range delta P pressure transmitter signal.

**Input:**

TOTAL
1 E
2

Number with floating decimal point:  0.000...999999

**Display:**          0.000 in H2O
                SWITCH UP DP

---

**SWITCH DOWN DP**

Enter the value of delta P at which the unit will begin using the lo range delta P pressure transmitter signal.

**Input:**

TOTAL
1 E
2

Number with floating decimal point:  0.000...999999

**Display:**          0.000 in H2O
                SWITCH UP DP

---

**LOW FLOW CUTOFF**

Enter the low flow cutoff.  This is used as a switchpoint for creep suppression. This can be used to prevent low flows from being registered.

**Input:**

TOTAL
1 E
2

Number with floating decimal point:  0.000...999999

**Display:**          .000 ft3/h
                LOW FLOW CUTOFF

**6.8
FLOW INPUT**
(Continued)

# FLOW INPUT

| K-FACTOR | Enter the K-Factor of the flowmeter. |
|---|---|

**Note:**
- The K-Factor is expressed in pulses per unit volume (as defined by "total units")

**Input:**

Number with floating decimal point:  0.001...999999

**Display:**              .000 ft3/h
                    LOW FLOW CUTOFF

---

**INLET PIPE BORE** — Enter the inlet pipe diameter or bore for the piping section upstream of the flow measurement device.

**Input:**

Number with floating decimal point:  0.001...1000.00

**Display:**              4.090 in
                    INLET PIPE BORE

---

**ENTER BETA** — Enter the geometric ratio for the square law device being used.  This value is given by the manufacturer of the orifice plate, or other square law device.

**Note:**

"Beta" is only required for measuring gas or steam with some square law  flowmeters.

**Input:**

Number with fixed decimal point:  0.0000...1.0000

**Display:**              1.0000
                    ENTER BETA

---

**CAL. DENSITY** — Enter the calibration density.  This is the fluid density upon which the flowmeter's calibration is based.

**Input:**

Number with floating decimal point in requested units: 0.000...10.000

**Display:**              8.3372 (#/gal)
                    CAL. DENSITY

**6.8
FLOW INPUT**
(Continued)

# FLOW INPUT

**METER EXP. COEF.**

The flowmeter pipe expands depending on the temperature of the fluid. This affects the calibration of the flowmeter.
This submenu allows the user to enter an appropriate correction factor. This is given by the manufacturer of the flowmeter. This factor converts the changes in the measuring signal per degree variation from calibration temperature. The calibration temperature is entered into the flow computer to 70 F / 21 °C.

Some manufacturers use a graph or a formula to show the influence of temperature on the calibration of the flowmeter. In this case use the following equation to calculate the meter expansion coefficient:

$$K_{me} = \frac{1 - \dfrac{Q\,(T)}{Q\,(T_{CAL})}}{T - T_{CAL}} \cdot 1{,}000{,}000$$

$K_{ME}$    Meter expansion coefficient
$Q(T)$    Volumetric flow at temperature T resp. $T_{CAL}$
$T$       Average process temperature
$T_{CAL}$    Calibration temperature

**Note:**
- This correction should be set in either the flowmeter or in the flow computer.
- Entering the value "0.000" disables this function
- Value can be calculated from Fa factor

**Input:**

TOTAL 1 E 2

Number with floating decimal point:
0.000...999.9 (e-6/°X)

**Display:**      27.111 (E-6/oF)
                   METER EXP. COEF.

**6.8
FLOW INPUT**
(Continued)

# FLOW INPUT

**DP FACTOR**

The DP-Factor describes the relationship between the flowrate and the measured differential pressure.  The flowrate is computed according to one of the three following equations, depending on the selected flow equation:

Steam (or gas) mass flow:

$$M = \frac{K_{DP} \cdot \varepsilon_1 \cdot \sqrt{2 \cdot \Delta p \cdot \rho}}{1 - K_{ME} \cdot (T - T_{CAL})}$$

Liquid volume flow:

$$Q = \frac{K_{DP} \cdot \sqrt{(2 \cdot \Delta p)/\rho}}{(1 - K_{ME} \cdot (T - T_{CAL}))}$$

Gas corrected volume flow:

$$Q_{REF} = \frac{K_{DP} \cdot \varepsilon_1 \cdot \sqrt{2 \cdot \Delta p \cdot \rho}}{\rho_{REF} \cdot (1 - K_{ME} \cdot (T - T_{CAL}))}$$

| | |
|---|---|
| M | Mass flow |
| Q | Volumetric flow |
| $Q_{REF}$ | Corrected volumetric flow |
| $K_{DP}$ | DP-Factor |
| $\varepsilon_1$ | Gas expansion factor ($Y_1$) |
| T | Operating temperature |
| $T_{CAL}$ | Calibration temperature |
| $\Delta p$ | Differential pressure |
| $\rho$ | Density at flowing conditions |
| $K_{ME}$ | Meter expansion coefficient x $10^{-6}$ |
| $\rho_{REF}$ | Reference density |

**6.8
FLOW INPUT**
(Continued)

# FLOW INPUT

**DP FACTOR**
(Continued)

The DP-Factor ($K_{DP}$) can be entered manually or the flow computer can compute it for you. The information necessary for this calculation can be found on the sizing sheet from a flowmeter sizing program.

**Note:**
The following data must be entered before the flow computer can compute the DP-Factor.

1. Flow equation          see "SYSTEM PARAMETER"
2. Fluid Data          see "FLUID DATA"
3. Beta          see "FLOW INPUT"
4. Meter expansion coef. ref      see "FLOW INPUT"
5. STP Ref. temperature*, pressure    see "OTHER INPUT"
7. Inlet Pipe Bore          see "FLOW INPUT"
8. Calibration Temp.          see "OTHER INPUT"

* only for gas flow equations.

**Entries:**

CHANGE FACTOR?    NO
CHANGE FACTOR?    YES

If "YES" the flow computer will prompt you further:

COMPUTE FACTOR?    NO
COMPUTE FACTOR?    YES

If "NO":     Enter DP FACTOR
If "YES":     You will be prompted for the following:

ENTER DELTA P
ENTER FLOWRATE
ENTER DENSITY
ENTER TEMPERATURE
ENTER INLET PRESSURE
ENTER ISENTROPIC EXP

**6.8
FLOW INPUT**
(Continued)

# FLOW INPUT

**DP FACTOR**
(Continued)

The flow computer will then compute the gas expansion factor $(\varepsilon_1)$, $(Y_1)$ using one of the following equation:

Orifice Case:

$$Y_1 = \varepsilon_1 = 1 - \left[ (0.41 + 0.35\,\beta^4) \cdot \frac{\Delta p}{\kappa \cdot p_1 \cdot 27.7} \right]$$

Venturi, Flow Nozzle, Wedge Case:

$$R = 1 - \frac{\Delta p}{27.7 \cdot p_1}$$

$$Y_1 = \varepsilon_1 = \sqrt{\frac{(1 - \beta^4) \cdot \frac{\kappa}{\kappa - 1} \cdot R^{2/\kappa} \cdot (1 - R^{(\kappa-1)/\kappa})}{[(1 - (\beta^4 \cdot R^{2/\kappa})) \cdot (1 - R)]}}$$

V-Cone Case

NOTE: Y=1 for noncompressible  uids (e.g. water, oil etc.).

$$Y = 1 - (0.649 + 0.696\beta^4)\,\frac{P/27.7}{k \cdot P}$$

Note that  $\Delta P$  and  P can be in any units as long as they are the same.

Annubar, Pitot, Target Case;

$$Y_1 = \varepsilon_1 = 1.0$$

| | |
|---|---|
| $\varepsilon_1$ | Gas expansion factor |
| $\beta$ | BETA (geometric ratio) |
| $\Delta p$ | Differential pressure |
| $\kappa$ | Isentropic exponent |
| $p_1$ | Inlet pressure (absolute) |

**NOTE:** 27.7 is a units conversion constant from the absolute inlet pressure units to the differential pressure units. (27.7 is for psia to "H2O, use other units conversions as required.).

**6.8
FLOW INPUT**
(Continued)

# FLOW INPUT

**DP FACTOR**
(Continued)

The DP-Factor ($K_{DP}$) is then computed using one of the following equations:

**Steam:**

$$K_{DP} = \frac{M \cdot (1 - K_{ME} \cdot (T - T_{CAL}))}{\varepsilon_1 \cdot \sqrt{2 \cdot \Delta p \cdot \rho}}$$

**Liquid:**

$$K_{DP} = \frac{Q \cdot (1 - K_{ME} \cdot (T - T_{CAL}))}{\sqrt{\dfrac{2 \cdot \Delta p}{\rho}}}$$

**Gas:**

$$K_{DP} = \frac{Q_{REF} \cdot \rho_{REF} \cdot (1 - K_{ME} \cdot (T - T_{CAL}))}{\varepsilon_1 \cdot \sqrt{2 \cdot \Delta p \cdot \rho}}$$

| | |
|---|---|
| $K_{DP}$ | DP-Factor |
| M | Mass flow |
| Q | Volumetric flow |
| $Q_{REF}$ | Corrected volumetric flow |
| $\varepsilon_1$ | Gas expansion factor |
| T | Operating temperature |
| $T_{CAL}$ | Calibration temperature |
| $\Delta p$ | Differential pressure |
| $\rho$ | Density at flowing conditions |
| $\rho_{REF}$ | Reference density |

**Note:**
The computation accuracy can be enhanced by entering up to 16 values for Reynold's Number DP-Factor in a linearization table (see "LINEARIZATION"). Each DP-Factor can be calculated using the above procedure. For every calculation, a sizing sheet is required. The results have to be entered in the linearization table afterwards.

**LOW PASS
FILTER**

Enter the maximum possible frequency of a flowmeter with a digital output. Using the value entered here, the flow computer selects a suitable limiting frequency for low pass filter to help suppress interference from higher frequency signals.

**Input:**

Max. 5 digit number: 10...40000 (Hz):

**Display:**
```
              40000 Hz
        LOW PASS FILTER
```

**6.8**
**FLOW INPUT**
(Continued)

# FLOW INPUT

**LINEARIZATION**

With many flowmeters, the relationship between the flowrate and the output signal may deviate from an ideal curve (linear or squared). The flow computer is able to compensate for this documented deviation using a linearization table.
The appearance of the linearization table will vary depending on particular flowmeter selected.

**Linear flowmeters with pulse output**
The linearization table enables up to 16 different frequency & K-factor pairs. The frequency and corresponding K-factor are prompted for each pair of values. Pairs are entered in ascending order by frequency.

**Linear Flowmeters with pulse outputs and a UVC Curve:**
The linearization table enables up to 16 different Hz/cstks and K-Factor points. The Hz/cstks and corresponding K-Factors are prompted for each pair of values. Pairs are entered in ascending order by Hz/cstks.

**Linear flowmeters with analog output (excluding Gilflo, ILVA)**
The linearization table enables up to 16 different flowrate & correction factor pairs. The flowrate and corresponding correction factor are prompted for each pair of values. The correction factor ($C_f$) is determined as follows.

$$C_f \ = \ \frac{\text{actual flowrate}}{\text{displayed flowrate}}$$

**Linear/squared DP transmitters with analog output**
The linearization table enables up to 16 different Reynold's Number an DP factor pairs. The Reynold's Number and corresponding DP factor are prompted for each pair of values.

**Selection:**
CHANGE TABLE?        NO
CHANGE TABLE?        YES

If "YES" the linearization table sequence of prompts will begin.

Example (for linear flowmeters with analog output)
Enter flow rate:
FLOW ft3/h   3.60
POINT  0

Entry of corresponding correction factor:
COR.FACTOR        1.0000
POINT  0

**Note:**
Enter "0" for the value of a pair (other than point 0) to exit the linearization table routine and use the values stored up to that point.

**6.8**
**FLOW INPUT**
(Continued)

# FLOW INPUT

| | |
|---|---|
| **FLOWMETER LOCATION** | Enter the Flowmeter Location<br><br>**Selection:**<br><br>Hot, Cold:<br><br>**Display:**      COLD<br>    FLOWMETER LOCATION |
| **BYPASS CAL. FACTOR** | Enter the Bypass Calibration Factor.<br><br>**Input:**<br><br>Max. 6 digit number: 0.000001...999999<br><br>**Display:**      1.000000<br>    BYPASS CAL. FACTOR |
| **BYPASS EAm FACTOR** | Enter the Bypass EAm Factor.<br><br>**Input:**<br><br>Max. 6 digit number: 0.000001...999999<br><br>**Display:**      1.000000<br>    BYPASS EAM FACTOR |
| **BYPASS DC FACTOR** | Enter the Bypass DC Factor.<br><br>**Input:**<br><br>Max. 6 digit number: 0.1...10.0<br><br>**Display:**      1.000000<br>    BYPASS DC FACTOR |
| **BYPASS Ym FACTOR** | Enter the Bypass Ym Factor.<br><br>**Input:**<br><br>Max. 6 digit number: 0.001...1.0<br><br>**Display:**      1.000000<br>    BYPASS YM FACTOR |
| **VIEW INPUT SIGNAL** | This feature is used to see the present value of the flow input signal. The type of electrical signal is determined by the flowmeter input signal type selection.<br><br>**Display:**      150 Hz<br>    VIEW INPUT SIGNAL |
| **VIEW HIGH RANGE SIGNAL** | This feature is used to see the present value of the high range flow input signal. The type of electrical signal is determined by the flowmeter input signal type selection.<br><br>**Display:**      4 mA<br>    VIEW HIGH RANGE SIGNAL |

**6.9
OTHER
INPUT**

# OTHER INPUT

**SELECT INPUT**

In addition to the flow input, the flow computer provides two other inputs for temperature, density and/or pressure signals. In this submenu, select the particular input which is to be configured in the following submenus.  Input 1 may also be used in conjunction with a steam trap monitor.

**Selection:**

1 (input 1: Temperature or Steam Trap Monitor)
2 (input 2: Pressure, Temperature 2, Density)

**Display:**
```
                    1
            SELECT INPUT
```

**INPUT SIGNAL**

Determine the type of measuring signal produced by the temperature, pressure or density sensor.

**Note:**
When saturated steam is measured with only a pressure sensor, "INPUT 1 NOT USED" must be selected.  If only a temperature sensor is used, "INPUT 2 NOT USED" must be selected.

**Selection:**
Input 1 (Temperature):

INPUT 1 NOT USED, RTD TEMPERATURE,
4-20 TEMPERATURE, 0-20 TEMPERATURE, MANUAL
TEMPERATURE*, 4-20 mA TRAP STATUS

Input 2 (Process pressure, Temperature 2, Density):

INPUT 2 NOT USED, 4-20 PRESSURE (G),
0-20 PRESSURE (G), MANUAL PRESSURE*,
4-20 PRESSURE (ABS.), 0-20 PRESSURE (ABS.),
RTD TEMPERATURE 2, 4-20 TEMPERATURE 2,
0-20 TEMPERATURE 2, MANUAL TEMPERAT. 2*, 4-20
DENSITY, 0-20 DENSITY, MANUAL DENSITY*

* Select this setting if a user defined fixed value for the corresponding measuring value is required.

**Display:**
```
            4-20 TEMPERATURE
                INPUT SIGNAL
```

**6.9
OTHER
INPUT**
(Continued)

# OTHER INPUT

**LOW SCALE VALUE**

Set the low scale value for the analog current input signal (value for 0 or 4 mA input current). The value entered here must be identical to the value set in the pressure, temperature or density transmitter.

**Input:**

Number with fixed decimal point: -9999.99...+9999.99

**Display:**  32.00 of
LOW SCALE VALUE

---

**FULL SCALE VALUE**

Set the full scale value for the analog current input signal (value for 20 mA input current). The value entered here must be identical to the value set in the pressure, temperature or density transmitter.

**Input:**

Number with fixed decimal point: -9999.99...+9999.99

**Display:**  752.00 of
FULL SCALE VALUE

---

**DEFAULT VALUE**

A fixed value can be defined for the assigned variable (pressure, temperature, density). The flow computer will use this value in the following cases:
- In case of error (i.e. defective sensors). The flow computer will continue to operate using the value entered here.
- if "MANUAL TEMPERATURE", "MANUAL PRESSURE" or "MANUAL DENSITY" was selected for "INPUT SIGNAL".

**Input:**

Number with fixed decimal point: -9999.99...+9999.99

**Display:**  70.00 of
DEFAULT VALUE

---

**STP REFERENCE**

Define the STP reference conditions (standard temperature and pressure) for the variable assigned to the input. Presently, standard conditions are defined differently depending on the country and application.

**Input:**

Number with fixed decimal point:
-9999.99...+9999.99

**Display:**  60.00 of
STP REFERENCE

**6.9
OTHER
INPUT**
(Continued)

## OTHER INPUT

**BAROMETRIC PRESS.**

Enter the actual atmospheric pressure. When using gauge pressure transmitters for determining gas pressure, the reduced atmospheric pressure above sea level is then taken into account.

**Input:**

TOTAL
1  E
2

Number with floating decimal point:
0.0000...10000.0

**Display:**          1.013 bara
                BAROMETRIC PRESS.

---

**CALIBRATION TEMP.**

Enter the temperature at which the flowmeter was calibrated. This information is used in the correction of temperature induced effects on the flowmeter body dimensions.

**Input:**

TOTAL
1  E
2

Number with fixed decimal point:
-9999.99...+9999.99

**Display:**          68.00 of
                CALIBRATION TEMP.

---

**VIEW INPUT SIGNAL**

This feature is used to see the present value of the compensation input signal. The type of electrical signal is determined by the compensation input signal type selection.

**Display:**          20 mA
                VIEW INPUT SIGNAL

---

**TRAP ERROR DELAY**

Enter the TRAP ERROR DELAY (cold trap error) in HH:MM format. An alarm will only be activated if the trap is detected as continuously being in the abnormal states for a time period greater than this TRAP ERROR DELAY time.

**Display:**          HH:MM
                TRAP ERROR DELAY

---

**TRAP BLOWING DELAY**

Enter the TRAP BLOWING DELAY (trap stuck open) in HH:MM format. An alarm will only be activated if the trap is detected as continuously being in the abnormal states for a time period greater than this TRAP BLOWING DELAY time.

**Display:**          HH:MM
                TRAP BLOWING DELAY

**6.10
PULSE
OUTPUT**

# PULSE OUTPUT

**ASSIGN PULSE OUT-PUT**

Assign the pulse output to a measured or calculated totalizer value.

**Selection:**

HEAT TOTAL, MASS TOTAL,
CORRECTED VOL. TOTAL,
ACTUAL VOLUME TOTAL

**Display:**     ACTUAL VOLUME TOTAL
               ASSIGN PULSE OUTPUT

**6.10**
**PULSE**
**OUTPUT**
(Continued)

# PULSE OUTPUT

**PULSE TYPE**

The pulse output can be configured as required for an external device (i.e. remote totalizer, etc.).

| | |
|---|---|
| **ACTIVE:** | Internal power supply used (+24V). |
| **PASSIVE:** | External power supply required. |
| **POSITIVE:** | Rest value at 0V (active high). |
| **NEGATIVE:** | Rest value at 24V (active low) or external power supply. |

**Active:**



**Passive:**



**Positive Pulse:**



**Negative Pulse:**



**Selection:**

 PASSIVE-NEGATIVE, PASSIVE-POSITIVE, ACTIVE-NEGATIVE, ACTIVE-POSITIVE

**Display:**     `PASSIVE/POSITIVE`
                    `PULSE TYPE`

**6.10
PULSE
OUTPUT**
(Continued)

# PULSE OUTPUT

### PULSE VALUE

Define the flow quantity per output pulse. This is expressed in units per pulse (i.e. $ft^3$ / pulse).

**Note:**

Ensure that the max. flowrate (full scale value) and the pulse value entered here agree with one another. The max. possible output frequency is 50Hz. The appropriate pulse value can be determined as follows:

$$\text{Pulse value} > \frac{\text{estimated max. flowrate (full scale)/sec}}{\text{required max. output frequency}}$$

**Input:**

Number with floating decimal point: 0.001...10000.0

**Display:**
```
        1.000 ft3/P
      PULSE VALUE
```

---

### PULSE WIDTH

Set the pulse width required for external devices. The pulse width limits the max. possible output frequency of the pulse output. For a certain output frequency, the max permissible pulse width can be calculated as follows:

$$\text{Pulse width} < \frac{1}{2 \cdot \text{max. output frequency (Hz)}}$$

**Input:**

Number with floating decimal point:
0.01...9.999 s (seconds)

**Display:**
```
          .01 s
      PULSE WIDTH
```

---

### SIMULATION FREQ.

Frequency signals can be simulated in order to check any instrument that is connected to the pulse output. The simulated signals are always symmetrical (50/50 duty cycle).

**Note:**

• The simulation mode selected affects the frequency output. The flow computer is fully operational during simulation.
• Simulation mode is ended immediately after exiting this submenu.

**Selection:**

OFF, 0.0 Hz, 0.1 Hz, 1.0 Hz, 10 Hz, 50 Hz

**Display:**
```
          OFF
      SIMULATION FREQ>
```

**6.11
CURRENT
OUTPUT**

# CURRENT OUTPUT

| | |
|---|---|
| **SELECT OUTPUT** | Select the current output to be configured.  The flow computer offers two current outputs.<br><br>**Selection:**<br><br>1 (Current output 1)<br>2 (Current output 2)<br><br>**Display:**　　　　　　　　　　　　1<br>　　　　　　　　　SELECT OUTPUT |
| **ASSIGN CURRENT OUT** | Assign a variable to the current output.<br><br>**Selection:**<br><br>HEAT FLOW, MASS FLOW,<br>COR. VOLUME FLOW, VOLUME FLOW,<br>TEMPERATURE, TEMPERATURE 2,<br>DELTA TEMPERATURE, PRESSURE, DENSITY, PEAK DEMAND, DEMAND LAST HOUR<br><br>**Display:**　　　　　VOLUME FLOW<br>　　　　　ASSIGN CURRENT OUT. |
| **CURRENT RANGE** | Define the 0 or 4 mA low scale current value. The current for the scaled full scale value is always 20 mA.<br><br>**Selection:**<br><br>0-20 mA, 4-20 mA, NOT USED<br><br>**Display:**　　　　　4-20 mA<br>　　　　　CURRENT RANGE |
| **LOW SCALE** | Set the low scale value to the 0 or 4 mA current signal for the variable assigned to the current output.<br><br>**Input:**<br><br>Number with floating decimal point: -999999...+999999<br><br>**Display:**　　　　　.000 ft3/h<br>　　　　　LOW SCALE VALUE |
| **FULL SCALE** | Set the full scale value to the 20 mA current signal for the variable assigned to the current output.<br><br>**Input:**<br><br>Number with floating decimal point:<br>-999999...+999999<br><br>**Display:**　　　　　1000.00 ft3/h<br>　　　　　FULL SCALE VALUE |

**6.11
CURRENT
OUTPUT**
(Continued)

## CURRENT OUTPUT

**TIME CONSTANT**

Select the time constant to determine whether the current output signal reacts quickly (small time constant) or slowly (large time constant) to rapidly changing values (i.e. flowrate). The time constant does not affect the behavior of the display.

**Input:**

TOTAL
1 E
2   Max. 2 digit number: 0...99

**Display:**                               1
                            TIME CONSTANT

---

**CURRENT OUT VALUE**

Display the actual value of the current output.

**Display:**                          0.000 mA
                            CURRENT OUT VALUE

---

**SIMULATION
CURRENT**

Various output currents can be simulated in order to check any instruments which are connected.

**Note:**
  • The simulation mode selected affects only the selected current output. The flow computer is fully operational during simulation.
  • Simulation mode is ended immediately after exiting this submenu.

**Selection:**

OFF, 0 mA, 2 mA, 4 mA, 12 mA, 20 mA, 25 mA

**Display:**                            OFF
                            SIMULATION CURRENT

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**6.12
RELAYS**

# RELAYS

| | |
|---|---|
| **SELECT RELAY** | Set relay output to be configured.  Two or three relay outputs are available.<br><br>**Selection:**<br><br>1 (Relay 1)<br>2 (Relay 2)<br>3 (Relay 3, optional)<br>**Display:**  1<br>SELECT RELAY |
| **RELAY FUNCTION** | Both relays (1 and 2, and optional  3rd relay) can be assigned to various  functions as required:<br><br>**Alarm functions**<br>Relays activate upon exceeding limit setpoints. Freely assignable to measured or calculated variables or totalizers.<br><br>**Malfunction**<br>Indication of instrument failure, power loss, etc.<br><br>**Pulse output**<br>The relays can be defined as additional pulse outputs for totalizer values such as heat, mass, volume or corrected volume.<br><br>**Wet steam alarm**<br>The flow computer can monitor pressure and temperature in superheated steam applications continuously and compare them to the saturated steam curve. When the degree of superheat (distance to the saturated steam curve) drops below 5 °C, the relay switches and the message "WET STEAM ALARM" is displayed.<br><br>**NOTE:**<br>**Relay response time is affected by the value entered for display damping. The larger the display damping value, the slower the relay response time will be. This is intended to prevent false triggering of the relays. Enter a display damping factor of zero (0) for fastest relay response time.**<br><br>**Selection:**<br>Different selections are available depending on the flow equation and type of transmitter selected.<br><br>HEAT TOTAL, MASS TOTAL, CORRECTED VOL. TOTAL, ACTUAL VOLUME TOTAL, HEAT FLOW, MASS FLOW, COR. VOL. FLOW, VOLUME FLOW, TEMPERATURE, TEMPERATURE 2, DELTA TEMPERATURE, PRESSURE, DENSITY, WET STEAM ALARM, MALFUNCTION, PEAK DEMAND, DEMAND LAST HOUR<br><br>**Display:**  VOLUME FLOW<br>RELAY FUNCTION |

**6.12**
**RELAYS**
(Continued)

# RELAYS

**RELAY MODE**

Set when and how the relays are switched "ON" and "OFF". This defines both the alarm conditions and the time response of the alarm status.

**Selection:**

HI ALARM, FOLLOW
LO ALARM, FOLLOW
HI ALARM LATCH
LO ALARM LATCH
RELAY PULSE OUTPUT

**Note:**

• For relay functions "MALFUNCTION" and "WET STEAM ALARM". There is no difference between the modes "HI......" and "LO......":
(i.e. HI ALARM FOLLOW = LO ALARM FOLLOW,
HI ALARM LATCH = LOW ALARM LATCH)

· Relay mode "RELAY PULSE OUTPUT" defines the relay as an additional pulse output.

**Display:**      HI ALARM, FOLLOW
                         RELAY MODE

**LIMIT SETPOINT**

After configuring a relay for "Alarm indication" (limit value), the required setpoint can be set in this submenu. If the variable reaches the set value, the relay switches and the corresponding message is displayed.
Continuous switching near the setpoint can be prevented with the "HYSTERESIS" setting.

**Note:**

• Be sure to select the units (SYSTEM UNITS) before entering the setpoint in this submenu.
• Normally open or normally closed contacts are determined when wiring.

**Input:**

Number with floating decimal point: -999999...+999999

**Display:**           99999.0 ft3/h
                   LIMIT SETPOINT    1

**6.12
RELAYS**
(Continued)

# RELAYS

**PULSE VALUE**

Define the flow quantity per output pulse if the relay is configured for "RELAY PULSE OUTPUT"..  This is expressed in units per pulse (i.e. ft$^3$ / pulse).

**Note:**

Ensure that the max. flowrate (full scale value) and the pulse value entered here agree with one another. The max. possible output frequency is 5Hz.  The appropriate pulse value can be determined as follows:

$$\text{Pulse value} > \frac{\text{estimated max. flowrate (full scale)/sec}}{\text{required max. output frequency}}$$

**Input:**

Number with floating decimal point: 0.001...1000.0

**Display:**         1.000 ft3/P
                    PULSE VALUE

**PULSE WIDTH**

Enter the pulse width. Two cases are possible:

**Case A: Relay set for "MALFUNCTION" or limit value**
The response of the relay during alarm status is determined by selecting the pulse width.
- Pulse width = 0.0 s (Normal setting)
  Relay is latched during alarm conditions.
- Pulse width = 0.1...9.9 s (special setting)
  Relay will energize for selected duration, independent of the cause of the alarm. This setting is only used in special cases (i.e. for activating signal horns).

**Case B: Relay set for "RELAY PULSE OUTPUT"**
Set the pulse width required for the external device. The value entered here can be made to agree with the actual flow amount and pulse value by using the following:

$$\text{Pulse width} < \frac{1}{2 \cdot \text{max. output frequency (Hz)}}$$

**Input:**

Number with floating decimal point:
0.01...9.99 s (pulse output)
0.00...9.99 s (all other configurations)

**Display:**          .01 s
                    PULSE WIDTH

**6.12
RELAYS**
(Continued)

# RELAYS

**HYSTERESIS**

Enter a hysteresis value to ensure that the "ON" and "OFF" switchpoints have different values and therefore prevent continual and undesired switching near the limit value.

**Input:**

Number with floating decimal point:
0.000...999999

**Display:**          0.000 psia
                HYSTERESIS

---

**RESET ALARM**

The alarm status for the particular relay can be cancelled here if (for safety reasons) the setting "......, LATCH" has been selected in the submenu "RELAY MODE". This ensures that the user is actively aware of the alarm message.

**Note:**
- When in the HOME position, press the ENTER key to acknowledge and clear alarms.
- The alarm status can only be permanently cancelled if the cause of the alarm is removed.

**Selection:**

RESET ALARM? NO
RESET ALARM? YES

**Display:**     RESET?          NO
                RESET ALARM

---

**SIMULATE RELAY**

As an aid during start-up, the relay output may be manually controlled independent of it's normal function.

**Selection:**

NORMAL, ON, OFF

**Display:**          NORMAL
                SIMULATE RELAY

**6.13**
**COMMUNICATION**
(Continued)

# COMMUNICATION

| | |
|---|---|
| **RS-232 USAGE** | The flow computer can be connected via RS-232 interface to a personal computer or printer.<br><br>**Selection:**<br><br>COMPUTER, PRINTER, MODEM<br><br>**Display:** COMPUTER<br>RS-232 USAGE |
| **DEVICE ID** | Enter the unique unit I.D. tag number for the flow computer if a number of flow computers are connected to the same interface.<br><br>**Selection:**<br><br>Max. 2 digit number: 0...99<br><br>**Display:** 1<br>DEVICE ID |
| **BAUD RATE** | Enter the baud rate for serial communication between the flow computer and a personal computer, modem, or printer.<br><br>**Selection:**<br><br>9600, 2400, 1200, 300<br><br>**Display:** 9600<br>BAUD RATE |
| **PARITY** | Select the desired parity. The setting selected here must agree with the parity setting for the computer, modem, or printer.<br><br>**Selection:**<br><br>NONE, ODD, EVEN<br><br>**Display:** NONE<br>PARITY |
| **HANDSHAKE** | The control of data flow can be defined. The setting required is determined by the handshaking of the printer.<br><br>**Selection:**<br><br>NONE, HARDWARE<br><br>**Display:** NONE<br>HANDSHAKE |

**6.13**
**COMMUNICATION**
(Continued)

# COMMUNICATION

**PRINT LIST**

Select the variables or parameters which are to be logged or printed via the RS-232 interface.

**Selection (Procedure):**

CHANGE? NO
CHANGE? YES

If YES selected, the available variables are displayed one after another. Only some of the following options are available depending on the flow equation selected:

ENTER

Store option
advance to next

Print?

| | |
|---|---|
| PRINT HEADER? | NO(YES) |
| INSTRUMENT TAG? | NO(YES) |
| FLUID TYPE? | NO(YES) |
| TIME? | NO(YES) |
| DATE? | NO(YES) |
| TRANSACTION NO.? | NO(YES) |
| HEAT FLOW? | NO(YES) |
| HEAT TOTAL? | NO(YES) |
| HEAT GRAND TOTAL? | NO(YES) |
| MASS FLOW? | NO(YES) |
| MASS TOTAL? | NO(YES) |
| MASS GRAND TOTAL? | NO(YES) |
| COR. VOLUME FLOW? | NO(YES) |
| COR.VOL.GRAND TOTAL? | NO(YES) |
| VOLUME FLOW? | NO(YES) |
| VOLUME TOTAL? | NO(YES) |
| VOL. GRAND TOTAL? | NO(YES) |
| TEMPERATURE? | NO(YES) |
| TEMPERATURE 2? | NO(YES) |
| DELTA TEMPERATURE? | NO(YES) |
| PROCESS PRESSURE? | NO(YES) |
| DENSITY? | NO(YES) |
| SPEC. ENTHALPY? | NO(YES) |
| DIFF. PRESSURE? | NO(YES) |
| ERRORS? | NO(YES) |
| ALARMS? | NO(YES) |
| PEAK DEMAND? | NO(YES) |
| DEMAND LAST HOUR? | NO(YES) |
| PEAK TIME STAMP? | NO(YES) |
| PEAK DATE STAMP? | NO(YES) |
| TRAP MONITOR? | NO(YES) |

"YES" + ENTER: Parameter is added to the print list
"NO" + ENTER: parameter is not printed

After the last option the display advances to the next submenu.

# COMMUNICATION

| | |
|---|---|
| **PRINT INITIATE** | Datalogger and/or printing variables and parameters over the serial RS-232 interface can be initiated at regular intervals (INTERVAL) or daily at a fixed time (TIME OF DAY) or by front key depression. |

**Note:**
Printing can always be initiated by pressing the PRINT key.

**Selection:**

NONE, TIME OF DAY, INTERVAL, ENABLE PRINT KEY

**Display:**       TIME OF DAY
                           PRINT INITIATE

---

**DATALOG ONLY**    Select YES or NO for Datalog Only prompt.

**Selection:**
YES - Data is logged but no information is sent on print event.
NO - Data is logged and immediately transmitted.

**Display:**             YES
                           DATALOG ONLY

---

**PRINT INTERVAL**    Define a time interval.  Variables and parameters will be periodically logged at regular intervals of this value of time. The setting "00:00" deactivates this feature.

**Input:**

Time value in hours & minutes (HH:MM).

**Display:**             00:00
                           PRINT INTERVAL

---

**PRINT TIME**    Define the time of day that variables and parameters will be logged out daily.

**Input:**

Time of day in hours & minutes (HH:MM).

**Display:**             00:00
                           PRINT TIME

---

**DATALOG FORMAT**    Define the Datalog Format.

**Selection:**
DATABASE -    Data sets sent in comma seperated variable format.
PRINTER -    Individual output variables sent with text label and units suitable for printing.

**Display:**             PRINTER
                           DATALOG FORMAT

**6.13**
**COMMUNICATION**
(Continued)

# COMMUNICATION

| | |
|---|---|
| **SEND INC. TOT. ONLY** | Select YES or NO for Send Inc. Tot. Only |
| | **Selection:**<br>YES - Unit will send Inc. Tot. Only<br>NO - Unit will not send Inc. Tot. Only |
| | **Display:**  YES<br>SEND INC. TOT. ONLY |
| **INC ONLY SCALER** | Enter multiplying factor for  Inc Only Scaler |
| | **Selection:**<br>X1, X10, X100, X1000 |
| | **Display:**  X1<br>INC ONLY SCALER |
| **CLEAR DATALOG** | Select YES or NO for Clear Datalog |
| | **Selection:**<br>YES - Unit wil clear datalog contents<br>NO - Unit will not  clear datalog contents |
| | **Display:**  YES<br>CLEAR DATALOG |
| **MODEM CONTROL**<br>**(Modem)** | Select YES or NO for Modem Control. |
| | **Selection:**<br>YES - Modem initializationand dialing commands are sent during transactions.<br>NO - Modem initializationand dialing commands are NOT sent during transactions. |
| | **Display:**  YES<br>MODEM CONTROL |
| **DEVICE MASTER**<br>**(Modem)** | Select YES or NO for Device Master |
| | **Selection:**<br>YES - Sets sole master device responsible for initializing modem.<br>NO - Device will not be used to initialize modem. |
| | **Display:**  YES<br>DEVICE MASTER |

**6.13**
**COMMUNICATION**
(Continued)

# COMMUNICATION

| | |
|---|---|
| **MODEM AUTO ANSWER (Modem)** | Select YES or NO for Modem Auto Answer<br><br>**Selection:**<br>YES - Modem will answer incoming calls.<br>NO - Modem will not answer incoming calls.<br><br>**Display:**  YES<br>MODEM AUTO ANSWER |
| **CALL OUT NO (Modem)** | Define a Call Out Number. Enter the telephone number, or email address to be called.<br><br>**Input:**<br><br>max. 16 digit phone number<br><br>**Display:**  ### ### ### ### ####<br>CALL OUT NO |
| **CALL OUT TIME (Modem)** | Define the Call Out Time. Enter scheduled call out time (24 hr format), if you want the unit to call out to a remote PC.<br><br>**Input:**<br><br>Time of day in hours & minutes (HH:MM).<br><br>**Display:**  00:00<br>CALL OUT TIME |
| **CALL ON ERROR (Modem)** | Select YES or NO for Call On Error prompt.<br><br>**Selection:**<br>YES - Unit will call out to remote PC if a designated CSI error occurs.<br>NO - Unit will not call out to remote PC if error occurs.<br><br>**Display:**  YES<br>CALL ON ERROR |
| **NUMBER OF REDIALS (Modem)** | Enter the Number Of Redials desired in the event of a busy signal or communication problem.<br>**Input:**<br><br>max. 2 digit number<br><br>**Display:**  3<br>NUMBER OF REDIALS |

**6.13**
**COMMUNICATION**
(Continued)

## COMMUNICATION

**HANG UP IF INACTIVE
(Modem)**

Select YES or NO for Hang Up If Inactive

**Selection:**

YES - Unit will hang up if remote PC fails to respond within several minutes after connection is established.

NO - Unit will not hang up if remote PC fails to respond after connection is established.

**Display:**

```
              YES
HANG UP IF INACTIVE
```

## COMMUNICATION

**ERROR MASK
(Modem)**

Select YES or NO for Change Error Mask? prompt

**Selection:**

YES, NO

**Display:**  00:00
CALL OUT TIME

If YES selected, define the conditions that you wish to call out on. The possible conditions are displayed one after another.

ENTER

Store option
advance to next

Change?

| | |
|---|---|
| POWER FAILURE | NO(YES) |
| WATCHDOG TIMEOUT | NO(YES) |
| COMMUNICATION ERROR | NO(YES) |
| CALIBRATION ERROR | NO(YES) |
| PRINT BUFFER FULL | NO(YES) |
| TOTALIZER ERROR | NO(YES) |
| WET STEAM ALARM | NO(YES) |
| OFF FLUID TABLE | NO(YES) |
| FLOW IN OVERRANGE | NO(YES) |
| INPUT1 OVERRANGE | NO(YES) |
| INPUT2 OVERRANGE | NO(YES) |
| FLOW LOOP BROKEN | NO(YES) |
| LOOP1 BROKEN | NO(YES) |
| LOOP2 BROKEN | NO(YES) |
| RTD 1 OPEN | NO(YES) |
| RTD 1 SHORT | NO(YES) |
| RTD 2 OPEN | NO(YES) |
| RTD 2 SHORT | NO(YES) |
| PULSE OUT OVERRUN | NO(YES) |
| Iout 1 OUT OF RANGE | NO(YES) |
| Iout 2 OUT OF RANGE | NO(YES) |
| RELAY 1 HIGH ALARM | NO(YES) |
| RELAY 1 LOW ALARM | NO(YES) |
| RELAY 2 HIGH ALARM | NO(YES) |
| RELAY 2 LOW ALARM | NO(YES) |
| RELAY 3 HIGH ALARM | NO(YES) |
| RELAY 3 LOW ALARM | NO(YES) |
| TRAP ERROR | NO(YES) |
| TRAP BLOWING | NO(YES) |
| INPUT 3 OVERRANGE | NO(YES) |
| INPUT 3 BROKEN | NO(YES) |
| 24VDC OUT ERROR | NO(YES) |
| PULSE IN ERROR | NO(YES) |
| INPUT 1 Vin ERROR | NO(YES) |
| INPUT 1 Iin ERROR | NO(YES) |
| INPUT 2 Iin ERROR | NO(YES) |
| INPUT 2 RTD ERROR | NO(YES) |
| INPUT 3 Iin ERROR | NO(YES) |
| INPUT 3 RTD ERROR | NO(YES) |
| PULSE OUT ERROR | NO(YES) |
| Iout 1 ERROR | NO(YES) |
| Iout 2 ERROR | NO(YES) |
| RELAY 1 ERROR | NO(YES) |
| RELAY 2 ERROR | NO(YES) |
| RS-232 ERROR | NO(YES) |
| A/D MALFUNCTION | NO(YES) |
| PROGRAM ERROR | NO(YES) |
| SETUP DATA LOST | NO(YES) |
| TIME CLOCK LOST | NO(YES) |
| DISPLAY MALFUNCTION | NO(YES) |
| RAM MALFUNCTION | NO(YES) |
| DATALOG LOST | NO(YES) |

**6.14
NETWORK
CARD**

# NETWORK CARD

| | |
|---|---|
| **PROTOCOL** | The flow computer can be connected via RS-485 interface to a personal computer and communicate via Modbus RTU protocol.<br><br>**Selection:**<br><br>MODBUS RTU<br><br>**Display:**     MODBUS RTU<br>       PROTOCOL |
| **DEVICE ID** | Enter the unique unit I.D. tag number for the flow computer if a number of flow computers are connected to the same interface.<br><br>**Selection:**<br><br>3 digit number: 1...247<br><br>**Display:**            1<br>       DEVICE ID |
| **BAUD RATE** | Enter the baud rate for serial communication between the flow computer and a personal computer.<br><br>**Selection:**<br><br>19200, 9600, 4800, 2400, 1200, 600, 300<br><br>**Display:**     9600<br>       BAUD RATE |
| **PARITY** | Select the desired parity. The setting selected here must agree with the parity setting for the computer.<br><br>**Selection:**<br><br>NONE, ODD, EVEN<br><br>**Display:**     NONE<br>       PARITY |

**6.15
SERVICE &
ANALYSIS**

# SERVICE & ANALYSIS

**EXAMINE AUDIT
TRAIL**

Two counters contain the number of times the calibration and/or configuration parameters have been changed. Changes in important calibration and configuration data are registered and displayed ("electronic stamping"). These counters advance automatically. These counters cannot be reset so that unauthorized changes can be identified.

**Example:**

CAL 015   CFG   076

**Display:**　　　CAL 015　　　CFG 076
　　　　　　　　EXAMINE AUDIT TRAIL

**ERROR LOG**

A list of errors that have occurred can be viewed and cleared.

**Selection:**

VIEW?  NO
VIEW?  YES

If "YES" is selected the error log can be viewed and errors individually cleared (if editing enabled with Service Code).

**Display:**　　　CLEAR?　　　NO
　　　　　　　　POWER FAILURE

**SOFTWARE
VERSION**

Display the software version of the flow computer. (Contact local agent for upgrade information)

**Example:**

02.00.14

**Display:**　　　　02.00.14
　　　　　　　　SOFTWARE VERSION

**HARDWARE
VERSION**

Display the hardware version of the flow computer. (Contact local agent for upgrade information)

**Example:**

01.00.01

**Display:**　　　　01.00.01
　　　　　　　　HARDWARE VERSION

# SERVICE & ANALYSIS

**PERFORM
CALIBRATION**

**NOTE:**
This menu item will only
appear if editing is en-
abled with Service Code.

This feature allows the calibration of the units inputs and outputs.

**CAUTION:**
The calibration should only be performed by qualified technicians.
The calibration procedure requires the use of precision Voltage &
Current sources, a frequency generator, a 100Ω resistor (± 0.1%),
an ammeter, an ohmmeter and a frequency counter. If calibration
fails, use the "Restore Factory Calibration" feature.

**Selection:**

⬆⬇ NO, YES

**Display:**  PERFORM?  YES
  CALIBRATION

---

**VOLTAGE INPUT
CALIBRATION**

Connect your voltage source to (+) Pin 2 and (-) Pin 4.

**LEARN
0.0 V
(Pin 2)**

Apply 0.0 Volts. Press enter to learn 0.0 Volts.

**Display:**  RESULT:  0.000 V
  LEARN 0.0 V PIN 2

**LEARN
10.0 V
(Pin 2)**

Apply 10.0 Volts. Press enter to learn 10.0 Volts.

**Display:**  RESULT:  10.000 V
  LEARN 10.0 V PIN 2

---

**CURRENT INPUT
CALIBRATION**

Connect your current source to (+) Pin 2 and (-) Pin 4.

**LEARN
0.0 mA
(Pin 2)**

Apply 0.0 mA. Press enter to learn 0.0 mA.

**Display:**  RESULT:  0.000 mA
  LEARN 0.0 mA PIN 2

**LEARN
20.0 mA
(Pin 2)**

Apply 20.0 mA. Press enter to learn 20.0 mA.

**Display:**  RESULT:  20.000 mA
  LEARN 20.0 mA PIN 2

---

Connect your current source to (+) Pin 3 and (-) Pin 4.

**LEARN
0.0 mA
(Pin 3)**

Apply 0.0 mA. Press enter to learn 0.0 mA.

**Display:**  RESULT:  0.000 mA
  LEARN 0.0 mA PIN 3

**LEARN
20.0 mA
(Pin 3)**

Apply 20.0 mA. Press enter to learn 20.0 mA.

**Display:**  RESULT:  20.000 mA
  LEARN 20.0 mA PIN 3

**6.15
SERVICE &
ANALYSIS**
(Continued)

## SERVICE & ANALYSIS

| | |
|---|---|
| **CURRENT INPUT CALIBRATION (continued)** | Connect your current source to (+) Pin 7 and (-) Pin 4. |
| **LEARN 0.0 mA (Pin 7)** | Apply 0.0 mA.  Press enter to learn 0.0 mA. |
| | **Display:**　　RESULT:　　　　0.000 mA<br>　　　　LEARN 0.0 mA PIN 7 |
| **LEARN 20.0 mA (Pin 7)** | Apply 20.0 mA.  Press enter to learn 20.0 mA. |
| | **Display:**　　RESULT:　　　　20.000 mA<br>　　　　LEARN 20.0 mA PIN 7 |

Connect your current source to (+) Pin 11 and (-) Pin 4.

**LEARN 0.0 mA (Pin 11)**　Apply 0.0 mA.  Press enter to learn 0.0 mA.

**Display:**　　RESULT:　　　　0.000 mA
　　　　LEARN 0.0 mA PIN 11

**LEARN 20.0 mA (Pin 11)**　Apply 20.0 mA.  Press enter to learn 20.0 mA.

**Display:**　　RESULT:　　　　20.000 mA
　　　　LEARN 20.0 mA PIN 11

**RTD INPUT CALIBRATION**　Connect a 100Ω resistor between Pins 6 & 7 and place a jumper wire between Pins 5 & 6.

**Temperature Input (Pins 5, 6 & 7)**　Press enter to learn RTD resistance on Pins 5, 6 & 7.

**Display:**　　RESULT:　　　　100.00 ohm
　　　　LEARN RTD PIN 5-6-7

Connect a 100Ω resistor between Pins 10 & 11 and place a jumper wire between Pins 9 & 10.

**Temperature 2 Input (Pins 9, 10 & 11)**　Press enter to learn RTD resistance on Pins 9, 10 & 11.

**Display:**　　RESULT:　　　　100.00 ohm
　　　　LEARN RTD PIN 9-10-11

**6.15
SERVICE &
ANALYSIS**
(Continued)

# SERVICE & ANALYSIS

**ANALOG OUTPUT 1
CALIBRATION
(Pins 14 & 16)**

Connect your Ammeter (current meter) to (+) Pin 14 and (-) Pin 16.

**ADJ
4 mA
(Pins 14 & 16)**

Observe the reading on the ammeter.  Using the numeric keys, enter the actual reading (in mA) and press enter.

**Display:**      ACTUAL?     4.025 mA
                ADJ 4mA PIN 14-16

**ADJ
20 mA
(Pins 14 & 16)**

Observe the reading on the ammeter.  Using the numeric keys, enter the actual reading (in mA) and press enter.

**Display:**      ACTUAL?    20.017 mA
                ADJ 20mA PIN 14-16

---

**ANALOG OUTPUT 2
CALIBRATION
(Pins 15 & 16)**

Connect your Ammeter (current meter) to (+) Pin 15 and (-) Pin 16.

**ADJ
4 mA
(Pins 15 & 16)**

Observe the reading on the ammeter.  Using the numeric keys, enter the actual reading (in mA) and press enter.

**Display:**      ACTUAL?     4.041 mA
                ADJ 4mA PIN 15-16

**ADJ
20 mA
(Pins 15 & 16)**

Observe the reading on the ammeter.  Using the numeric keys, enter the actual reading (in mA) and press enter.

**Display:**      ACTUAL?    20.006 mA
                ADJ 20mA PIN 15-16

---

**FREQUENCY OUTPUT
SIMULATION
(Pins 12 & 13)**

Connect your frequency meter to (+) Pin 12 and (-) Pin 13.  This feature is used to check the pulse output.  Calibration is not performed.

**Selection:**

OFF, 50 Hz, 10 Hz, 1.0 Hz, 0.1 Hz, 0.0 Hz

**Display:**              OFF
                SIMULATION FREQ.

**6.15
SERVICE &
ANALYSIS**
(Continued)

## SERVICE & ANALYSIS

| | |
|---|---|
| **RELAY TEST**<br><br>**RELAY 1<br>TEST<br>(Pins 17, 18 & 19)** | Using the ohmmeter, check continuity between pins (17 & 18) and 18 & 19 while turning ON & OFF Relay 1 using the up/down arrow keys. Press enter when test is completed.<br><br>**Display:**     RELAY 1:     OFF<br>           TEST RELAY 1 |
| **RELAY 2<br>TEST<br>(Pins 20, 21 & 22)** | Using the ohmmeter, check continuity between pins 20 & 21 and (21 & 22) while turning ON & OFF Relay 2 using the up/down arrow keys. Press enter when test is completed.<br><br>**Display:**     RELAY 2:     OFF<br>           TEST RELAY 2 |
| **RELAY 3<br>TEST<br>(Pins 19 & 20)** | Using the ohmmeter, check continuity between pins 19 & 20 while turning ON & OFF Relay 2 using the up/down arrow keys. Press enter when test is completed.<br><br>**Display:**     RELAY 3:     OFF<br>           TEST RELAY 3 |
| **PULSE INPUT TEST**<br><br>**INPUT<br>FREQUENCY<br>(Pins 2 & 4)** | Using the frequency generator, apply a frequency to (+) Pin 2 and (-) Pin 4. Compare the displayed frequency with the input frequency.<br><br>**Display:**         0.000 Hz<br>      INPUT FREQUENCY |
| **SAVE AS FACTORY<br>CALIBRATION** | The calibration procedure is complete. You may now choose to save this calibration as the Factory Calibration.<br><br>**Display:**         NO<br>     SAVE AS FACTORY CAL. |
| **RESTORE FACTORY<br>CALIBRATION** | If you are not satisfied with the calibration results you can restore the last saved Factory Calibration.<br><br>**Display:**         NO<br>     RESTOR FACT. CALIB. |
| **SET NEXT<br>CALIBRATION DATE** | This feature allows you to enter the next date you would like the unit to be calibrated. This is very useful when components must be periodically calibrated. This date is included on Print Maint. and Setup Reports.<br><br>**Display:**     10 DEC 1999<br>     NEXT CALIBRATION |
| **PRINT<br>MAINT. REPORT** | This feature allows you to transmit a maintenance report over the RS-232 port for printout. The report includes error messages and calibration information<br><br>**Display:**         NO<br>     PRINT MAINT. REPORT |

**6.15
SERVICE &
ANALYSIS**
(Continued)

# SERVICE & ANALYSIS

**PRINT SYSTEM SETUP**

This feature allows the units setup parameters to be printed to a connected printer.

**Display:**
```
                    NO
          PRINT SYSTEM SETUP
```

**SELF CHECK**

This feature starts the self-test of the flow computer. A test is internally conducted on the EEPROM, A/D Converter, Time/Date clock, Display and several other hardware circuits.

**Display:**
```
          RUN?          NO
             SELF CHECK
```

**SERVICE TEST**
(Not available with 3 Relay option)

**NOTE:**
This will only appear if editing is enabled with the Service Code.

The Service Test requires a special calibration apparatus that connects to the rear terminals of the unit.  This is used to determine whether the flow computer or the field wiring is faulty.  The calibration apparatus may be purchased from your local distributor.

**Display:**
```
          RUN?          NO
            SERVICE TEST
```

# 7. Principle Of Operation

**General
Operation**

## 7.1 General:

The FC-22 Flow Computer uses several internal calculations to compute the compensated flow based on specific data input. Several computations are performed to arrive at the uncompensated flow, temperature, pressure, density and viscosity. This information is then used to compute the Corrected Volume Flow, Mass Flow or Heat Flow.

**Square Law
Flowmeter
Considerations**

## 7.2 Square Law Flowmeter Considerations:

Head class flowmeters are supplied by the manufacturers with a 4-20 mA output span which is already in flow units. The FC-22 permits the user to enter this flowmeter information directly. However, closely associated with this information is the density that was assumed during flowmeter calibration. This information must also be input if the user is to obtain maximum accuracy.

It is assumed that the user has the printout from a standardized sizing program for the particular device he will be using. Such standardized printouts list all the necessary information which the user will then be prompted for.

Several specialized flow equations are listed that are not intended for the standard unit but to be offered to appropriate OEMs or as special order items. These are designated by a "†".

### Note concerning Fluid Information
The user will be prompted for Fluid Information during the setup of the instrument. SeeAppendix A for the properties of several common fluids.

**Flow Equations**

## 7.3 Flow Equations:

**7.3.1
Flow Input
Computation**

### Flow Input Computation:

*Linear*
Input Flow = [% input span • (flow FS - flow low scale)]+ flow low scale

*Square Law without External SQRT Extractor*
delta P = [(% input span) • ( flow FS - flow low scale)] + flow low scale

*Square Law with External SQRT Extractor*
delta P = [(% input span)$^2$ • ( flow FS - flow low scale)] + flow low scale

**NOTE:** For stacked differential pressure option, the appropriate input sensor signal is used in calculations at all times to maximize accuracy.

**7.3.2**
**Pressure**
**Computation**

**Pressure Input:**

*General Case*
Pf = [% input span • (Pres full scale - Pres low scale ] + Pres low scale

*Gauge Case*
Pf = Pf + Barometric

*Manual Case or In Event of Fault*
Pf = Pressure Default Value

**7.3.3**
**Temperature**
**Computation**

**Temperature  Computation:**

*General Case*
Tf  = [% input span • (Temp full scale - Temp low scale ] + Temp low scale

*RTD Case*
Tf =  f ( measured input resistance)

*Manual Case or In Event of Fault*
Tf = Temperature Default Value

*Delta Temp Case*
Delta Temp = T2 - T1      Flowmeter location = cold
Delta Temp = T1 - T2      Flowmeter location = hot

**7.3.4**
**Density/Viscosity**
**Computation**

**Density Computation:**

*Water Case*
density_water = density (Tf)

*Liquid Case*
density = reference density • ( 1 - Therm.Exp.Coef. •( Tf - $T_{ref}$))$^2$

*Steam Case*
density = 1/ specific volume(Tf, Pf)

*Gas Case*

$$\text{density} = \text{reference density} \bullet \frac{Pf}{P_{ref}} \bullet \frac{(T_{ref} + 273.15)}{(Tf + 273.15)} \bullet \frac{Z_{ref}}{Zf}$$

**NOTE:**    For Natural Gas:

$\dfrac{Z_{ref}}{Zf}$  is determined by NX-19 when this selection is supplied and selected.

**NOTE:**    Therm.Exp.Coef is (x 10$^{-6}$)

**7.3.4
Density/Viscosity
Computation**
(continued)

**Viscosity (cP) Computation:**

_Liquid Case_

$$\text{cP viscosity} = A \bullet \exp \frac{B}{(\text{Tf} + 459.67)}$$

_NOTE:_

$$\text{Viscosity cS} = \frac{\text{viscosity (in cP)}}{\left(\dfrac{\text{flowing density}}{\text{density of water @ 4°C}}\right)}$$

_Gas Case_

$$\text{cP viscosity} = A \bullet (\text{Tf} + 459.67)^B$$

_Steam Case_

$$\text{cP viscosity} = f(\text{Tf, Pf})$$

**7.3.5
Corrected
Volume Flow
Computation**

**Corrected Volume Flow Computation:**

_Liquid Case_
    std. volume flow = volume flow • ( 1 - Therm.Exp.Coef. •( Tf - T$_{ref}$))$^2$

_Gas Case_
    std.volume flow =    volume flow $\bullet \dfrac{\text{Pf}}{\text{P}_{ref}} \bullet \dfrac{(\text{T}_{ref} + 273.15)}{(\text{Tf} + 273.15)} \bullet \dfrac{\text{Z}_{ref}}{\text{Zf}}$

**NOTE:** For Natural Gas:

$\dfrac{Z_{ref}}{Z_f}$     is determined by NX-19 when this selection is supplied and selected.

**Natural Gas NX-19 Equation:** The NX-19 (1963) natural gas state equations are widely used in custody transfer applications. Over most normal measurement ranges, 500 to 5000 psia (3.5 to 10.4 MPa) and -10 to 100°F (-23 to 38°C), the NX-19 equation will compute the gas compressibility factor to within 0.2% of the values computed by the newer AGA-8 state equation.
The ranges over which the NX-19 equation applies are:
    Pressure $P_G$             To 5000 psig (10.34 MPa gauge)
    Temperature $T_f$        -40 to 240°F (-40 to 116°C)
    Specific Gravity $G$       0.554 to 1.0
    $CO_2$ and $N_2$              0 to 15%

Our Flow Computer uses the Specific Gravity method to first obtain the adjusted temperature and pressure before entering the state equation. This method calculates the adjusted pressure and temperature from the mole fractions of carbon dioxide and nitrogen as

$$P_{adj} = \frac{156.47\, P_G}{160.8 - 7.22\, G_g + 100 X_{C02} - 39.2 X_{N2}}\qquad \text{psig}$$

Where $X_{C02\ and}\ X_{N2}$ are the mole fractions of carbon dioxide and nitrogen, respectively. The adjusted temperature is defined by

$$T_{adj} = \frac{226.29\, (T_F + 460)}{99.15 + 211.9\, G_g - 100 X_{C02} - 168.1 X_{N2}}\qquad \text{°F}$$

**7.3.5**
**Corrected**
**Volume Flow**
**Computation**
(continued)

After calculating the adjusted pressure and temperature, the mixture's pressure and temperature *correlations parameters* are calculated by

$$P = \frac{P_{adj} + 14.7}{1000} \qquad\qquad T = \frac{T_{adj}}{500}$$

The compressibility factor is then calculated by first determining

$$m = 0.0330378\,T^{-2} - 0.0221323\,T^{-3} + 0.0161353\,T^{-5}$$
$$n = (0.265827\,T^{-2} + 0.0457697\,T^{-4} - 0.133185\,T^{-1})m^{-1}$$
$$B = \frac{3 - mn^2}{9mp^2}$$
$$b = \frac{9n - 2mn^3}{54mp^2} - \frac{E}{2mp^2}$$
$$D = [b + (b^2 + B^3)^{0.5}]^{1/3}$$

Where $E$ is a function of the pressure $p$ and temperature $T$ correlation parameters. The equations for $E$ are given in the following table for the designated regions. The following compressibility $Z_f$ is determined by

$$Z_f = \frac{1}{B/D - D + n/3p}$$

NX-19 Natural Gas Regions and $E$ Equations

| Ranges | | |
|---|---|---|
| $P$ | $T$ | $E$ |
| 0 to 2 | 1.09 to 1.40 | $E_1$ |
| 0 to 1.3 | 0.84 to 1.09 | $E_2$ |
| 1.3 to 2.0 | 0.88 to 1.09 | $E_3$ |
| 1.3 to 2.0 | 0.84 to 0.88 | $E_4$ |
| 2.0 to 5.0 | 0.84 to 0.88 | $E_5$ |
| 2.0 to 5.0 | 0.88 to 1.09 | $E_6$ |
| 2.0 to 5.0 | 1.09 to 1.32 | $E_7$ |
| 2.0 to 5.0 | 1.32 to 1.40 | $E_8$ |

$$T_a = T - 1.09 \qquad T_b = 1.09 - T$$
$$E_1 = 1 - 0.00075p^{2.3}\exp(-20T_a) - 0.0011\,T_a^{0.5}p^2(2.17 + 1.4\,T_a^{0.5} - p)^2$$
$$E_2 = 1 - 0.00075p^{2.3}[2 - \exp(-20T_b)] - 1.317\,T_b^4 p(1.69 - p^2)$$
$$E_3 = 1 - 0.00075p^{2.3}[2 - \exp(-20T_b)] + 0.455(200\,T_b^6 - 0.03249\,T_b$$
$$+ 2.0167\,T_b^2 - 18.028\,T_b^3 + 42.844\,T_b^4)(p - 1.3)[1.69(2)^{1.25} - p^2]$$
$$E_4 = 1 - 0.00075p^{2.3}[2 - \exp(-20T_b)] + 0.455(200\,T_b^6 - 0.03249\,T_b$$
$$+ 2.0167\,T_b^2 - 18.028\,T_b^3 + 42.844\,T_b^4)(p - 1.3)[1.69(2)^{1.25 + 80(0.88 - t)2} - p^2]$$
$$E_5 = E_4 - X \qquad E_6 = E_3 - X \qquad E_7 = E_1 - X \qquad E_8 = E_7 - X_1$$
$$X = A(T - 2) + A_1(p - 2)^2 + A_2(p - 2)^3 + A_3(p - 2)^4$$
$$X_1 = (p - 1.32)^2(p - 2)[3 - 1.483(p - 2) - 0.1(p - 2)^2 + 0.0833(p - 2)^3]$$
$$A = 1.7172 - 2.33123T - 1.56796T^2 + 3.47644T^3 - 1.28603T^4$$
$$A_1 = 0.016299 - 0.028094T - 0.48782T^2 - 0.78221T^3 + 0.27839T^4$$
$$A_2 = -0.35978 + 0.51419T + 0.165453T^2 - 0.52216T^3 + 0.19687T^4$$
$$A_3 = 0.075255 - 0.10573T - 0.058598T^2 + 0.14416T^3 - 0.054533T^4$$

When NX-19 is used for custody transfer applications, the base compressibility factor is calculated by:

$$Z_b = \left(1 + \frac{0.00132}{T^{3.25}}\right)^{-2}$$

**7.3.6**
**Mass Flow**
**Computation**

**Mass Flow Computations:**

mass flow = volume flow • density

**7.3.7**
**Comb. Heat Flow**
**Computation**

**Combustion Heat Flow Computations:**

combustion heat flow = mass flow • combustion heating value

**7.3.8
Heat Flow
Computation**

**Heat Flow Computation:**

*Steam Heat*
heat flow = mass flow  • total heat steam(Tf, Pf)

*Steam Net Heat*
heat flow = mass flow • [total heat steam(Tf, Pf) - heat saturated water(Pf)]

*Steam Delta Heat*
heat flow = mass flow • [total heat saturated steam (Pf) - heat water (Tf)]

**7.3.9
Sensible Heat
Flow
Computation**

**Sensible Heat Flow:**

*Special Case for Water*
heat flow = mass flow (Tf) • enthalpy ( Tf )

**7.3.10
Liquid Delta Heat
Computation**

**Liquid Delta Heat:**

*General Case*
heat flow = mass flow • specific heat • ( T2 - Tf )

*Water Case*
heat flow = mass flow(Tf) • [enthalpy (T2 ) - enthalpy (Tf)]

**7.3.11
Expansion Factor
Computation for
Square Law Flow-
meters**

**Expansion Factor Computation for Square Law Flowmeters:**
In the following Equations, delta P is assumed in ("$H_2O$), Pf is in PSIA, 27.7 is a PSIA to ("$H_2O$) units conversion.

*Liquid Case*
Y = 1.0

*Gas, Steam Case*

*Orifice Case*

$$Y = 1.0 - (0.41 + 0.35 \cdot B^4) \cdot \frac{\text{delta P}}{\text{isentropic exponent} \cdot Pf \cdot 27.7}$$

*Venturi, Flow Nozzle, Wedge Case:*

$$R = 1 - \frac{\Delta p}{27.7 \cdot p_f}$$

$$Y = \sqrt{\frac{(1 - \beta^4) \cdot \frac{\kappa}{\kappa - 1} \cdot R^{2/\kappa} \cdot (1 - R^{(\kappa-1)/\kappa})}{[(1 - (\beta^4 \cdot R^{2/\kappa})) \cdot (1 - R)]}}$$

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**7.3.11**
**Expansion Factor**
**Computation for**
**Square Law**
**Flowmeters**
(Continued)

*V-Cone Case*

NOTE: Y=1 for noncompressible  uids (e.g. water, oil etc.).

$$Y = 1 - (0.649 + 0.696\beta^4) \ \frac{P/27.7}{k \cdot P}$$

Note that $\Delta P$ and P can be in any units as long as they are the same.

*Verabar Case*

$$Y_v = 1 + \left(18093 - .4191(1-\beta)^2\right) \cdot \left(\frac{h_w}{27.73 \cdot P_{fa} \cdot \Gamma}\right)$$

Where:

$\beta$ = The sensor blockage = $\dfrac{4 \cdot P_w}{\pi \cdot D}$

$\pi$ = 3.14159
$D$ = Internal pipe diameter in inches.
$P_w$ = The sensor's probe width in inches.
  $P_w$ = 0.336" for a -05 sensor.
  $P_w$ = 0.614" for a -10 sensor.
  $P_w$ = 1.043" for a -15 sensor.

$h_w$ = Verabar differential pressure in inches of $H_2O$.

$P_{fa}$ = Absolute static pressure (high side of the Verabar) in psia.
$\Gamma = k$ = Isentropic exponent for a real gas or steam.

*Accelabar Case*

$$Y_a = 1 - Y_{a-coef} \cdot \left(\frac{h_w}{27.73 \cdot P_{fta} \cdot \Gamma}\right)$$

Where:
$Y_a$ = General Accelerator gas expansion factor (dimensionless)

$Y_{a-coef}$ = Accelabar gas expansion factor coefficient (dimensionless)

$h_w$ = Differential pressure (inches $H_2O$ @ 68°F)

$P_{fta}$ = Flowing Accelerator Throat Pressure (psia)

= Flowing throat pressure in psig + atmospheric pressure in psi
$\Gamma$ = Isentropic Exponent for a real gas or steam

| Accelabar Size | $Y_{a-coef}$ |
|---|---|
| 3" | 0.7432 |
| 4" | 0.6986 |
| 6" | 0.6865 |
| 8" | 0.6407 |
| 10" | 0.6095 |
| 12" | 0.5891 |

**7.3.12**
**Uncompensated**
**Flow Computation**

**Uncompensated Flow Computation:**

*Pulse, Linear Case*

$$\text{volume flow} = \frac{\text{input frequency} \bullet \text{Time Scaling Factor}}{\text{K-Factor} \cdot [1 - \text{Meter Exp.Coeff.} \cdot (T_f - T_{cal})]}$$

*Analog, Linear Case*

$$\text{volume flow} = \frac{\text{Measured Input Flow}}{[1 - \text{Meter Exp.Coeff.} \cdot (T_f - T_{cal})]}$$

*Square Law Case*

$$\text{volume flow} = \frac{\text{DP Factor}}{[1 - \text{Meter Exp.Coeff.} \cdot (T_f - T_{cal})]} \cdot Y \cdot \left[\frac{2 \bullet \text{delta P}}{\text{density}}\right]^{1/2}$$

*Square Law , Target Flowmeter Case*

$$\text{volume flow} = \text{input flow} \cdot \frac{\sqrt{\text{density cal.}}}{\sqrt{\text{density flowing}}}$$

*Pulse, Linearization Case*

$$\text{volume flow} = \frac{\text{input frequency} \bullet \text{Time Scaling Factor}}{\text{K-Factor(Hz)} \cdot [1 - \text{Meter Exp.Coeff.} \cdot (T_f - T_{cal})]}$$

*Analog, Linearization Case*

$$\text{volume flow} = \frac{\text{Input Flow} \bullet \text{Correction Factor (Input Flow )}}{[1 - \text{Meter Exp.Coeff.} \cdot (T_f - T_{cal})]}$$

*Square Law, Linearization  Case*

$$\text{volume flow} = \frac{\text{DP Factor(RN)}}{[1 - \text{Meter Exp.Coeff.} \cdot (T_f - T_{cal})]} \cdot Y \cdot \left[\frac{2 \bullet \text{delta P}}{\text{density}}\right]^{1/2}$$

*Pulse, UVC Case*

$$\text{volume flow} = \frac{\text{input frequency} \bullet \text{Time Scaling Factor}}{\text{K-Factor (Hz/cstks)} \cdot [1 - \text{Meter Exp.Coeff.} \cdot (T_f - T_{cal})]}$$

*Shunt Flow Bypass Flowmeter*

$$\text{volume flow} = \frac{\text{input frequency} \bullet 457 \bullet Epa \bullet Y_m}{\sqrt{\text{flowing density}} \cdot DC \cdot \text{bypass calibration favtor}}$$

*Gilflo Flowmeter*

$$\text{volume flow}_{\text{at flowing conditions}} = \text{input flow}_{\text{at design conditions}} \bullet \sqrt{\frac{\text{calibration density}}{\text{flowing density}}}$$

**NOTE:**    Therm.Exp.Coef is $10^{-6}$

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**7.3.13**
**ILVA Flow Meter**
**Equations**

*ILVA Flowmeter* - This meter type requires an initial linearization using the linearization table. In addition, the following specialized corrections are required.

For Gas/Steam Expansion (imperial)　　　**Y = 1 – (115.814 • (dp / p) • 0.0001)**

Where:　　　Y = gas expansion correction (NOTE: Y=1 for liquid)
dp = differential pressure - inches water gauge
p = upstream pressure - psia

For Reynolds Number (volumetric calculations for Gas/Steam)

$$Cre = (1 – (n / Qn)^{-1}$$
**to a maximum value of m**

Where:　　　Cre = Reynolds number correction (NOTE Cre = 1 for liquid)
Qn = nominal water volumetric flowrate (column 6)
m = (see table below)
n = (see table below)

| Meter Size | n | m |
|---|---|---|
| DN50 | 2.53 | 1.200 |
| DN80 | 0.64 | 1.125 |
| DN100 | 0.21 | 1.100 |
| DN150 | 0.13 | 1.067 |
| DN200 | 0.07 | 1.050 |
| DN250 | 0 | 1 |
| DN300 | 0 | 1 |

The final gas expansion and Reynolds number correction is:　　　**Qc = Qn • Y • Cre**

For Volumetric Calculations: (calculate the density corrected volumetric flowrate):
$$Qd = Qc • (Dn / Da)^{0.5}$$

Where:　　　Qd = density corrected volumetric flowrate
Qc = nominal water volumetric flowrate (column 6) corrected for Reynolds Number and gas expansion effects.
Da = actual flowing density of working fluid
Dn = nominal density of water at reference conditions

Once corrected for density a further correction is required to take into account the effect of temperature on the ILVA primary element.

Temperature Compensation

For Volumetric Calculations: Using the value of Qd derived above, the temperature corrected flowrate can be calculated:　　　**Qa = ((Ta - Tref) • 0.000189 • Qd) + Qd)**

Where:　　　Qa = actual volumetric flowrate
Qd = density corrected volumetric flowrate (from above)
Tref = reference temperature in °C (generally 20°C)
Ta = actual flowing temperature of working fluid (in °C)

It is possible to convert from a mass flowrate to a volumetric flowrate and vice versa using the following simple formula:　　　**Ma = Qn • Da**

Where:　　　Da = actual flowing density of working fluid

**7.4 Computation of the DP Factor**

It is assumed that the user has the printout from a standardized sizing program for the particular device he will be using. Such standardized printouts list all the necessary information which the user will then be prompted for by the instrument or diskette.

It is also important that the user select the flow equation to be used and  either select or enter the following items:

> Flowmeter Type
> The fluid type  or the fluid properties applicable to the fluid to be measured
> Beta, Meter Exp. Coeff., Inlet Pipe Bore
> Reference Conditions of temperature, pressure, Z and calibration temperature

The user is prompted for the following:

> mass flow or volume flow or corrected volume flow as indicated by the flow equation
> Differential Pressure
> Inlet Pressure
> Temperature
> Density
> Isentropic Exponent

The unit then computes the following results corresponding to the user entry conditions and appropriate methods:

> Y

Finally the DP Factor is computed as follows:

*Steam Case*

$$\text{DP Factor} = \frac{\text{mass flow} \cdot [1 - \text{Meter Exp.Coeff.} \cdot (Tf - T_{cal})]}{Y \cdot [2 \cdot \text{delta P} \cdot \text{density}]^{1/2}}$$

*Liquid Case*

$$\text{DP Factor} = \frac{\text{volume} \cdot [1 - \text{Meter Exp.Coeff.} \cdot (Tf - T_{cal})]}{\left[\dfrac{2 \cdot \text{delta P}}{\text{density}}\right]^{1/2}}$$

*Gas Case*

$$\text{DP Factor} = \frac{\text{Std.Vol.Flow} \cdot \text{ref density} \cdot [1 - \text{Meter Exp.Coeff.} \cdot (Tf - T_{cal})]}{Y \cdot [2 \cdot \text{delta P} \cdot \text{density}]^{1/2}}$$

**Application Hint:**
The user may reenter this DP Factor multiple times to assist him in assembling the table points of DP Factor and Reynold's Number necessary to construct a 16 point table for the meter run.

**NOTE:**  Meter Exp.Coef is ($\times 10^{-6}$)

## 8. RS-232 Serial Port

### 8.1 RS-232 Port Description:
The FC-22 has a general purpose RS-232 Port which may be used for any one of the following purposes:

Transaction Printing, Data Logging, Remote Metering by Modem (optional), Computer Communication Link, Configuration by Computer, Print System Setup, Print Calibration/ Malfunction History

### 8.2 Instrument Setup by PC's over Serial Port
A Diskette program is provided with the FC-22 that enables the user to rapidly configure the FC-22 using a Personal Computer. Included on the diskette are common instrument applications which may be used as a starting point for your application. This permits the user to have an excellent starting point and helps speed the user through the instrument setup.

### 8.3 Operation of Serial Communication Port with Printers
FC-22's RS-232 channel supports a number of operating modes. One of these modes is intended to support operation with a printer in metering applications requiring transaction printing, data logging and/or printing of calibration and maintenance reports.
For transaction printing, the user defines the items to be included in the printed document. The user can also select what initiates the transaction print generated as part of the setup of the instrument. The transaction document may be initiated via a front panel key depression.
In data logging, the user defines the items to be included in each data log as a print list. The user can also select when or how often he wishes a data log to be made. This is done during the setup of the instrument as either a time of day or as a time interval between logging.
The system setup and maintenance report list all the instrument setup parameters and usage for the current instrument configuration. In addition, the Audit trail information is presented as well as a status report listing any observed malfunctions which have not been corrected.
The user initiates the printing of this report at a designated point in the menu by pressing the print key on the front panel.

### 8.4 FC-22 RS-232 Port Pinout
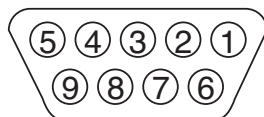
1 Handshake Line (cd in)
2 Transmit (tx)
3 Receive (rx)
4 Do Not Use
5 Ground
6 Do Not Use
7 RTS out
8 Do Not Use or Ground for Modem Power Option
9 Do Not Use or 8VDC Out for Modem Power Option
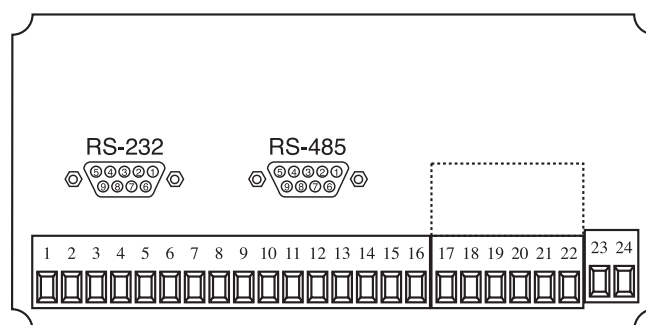
# 9. RS-485 Serial Port (optional)

## 9.1 RS-485 Port Description:

The FC-22 has a an optional general purpose RS-485 Port which may be used for any one of the following purposes:

Accessing Process Parameters

Rate, Temperatures, Pressures, Density, Time & Date, Setpoints, etc.

Accessing System Alarms

System, Process, Self Test, Service Test Errors

Accessing Totalizers

Heat, Mass, Corrected Volume, Volume Totalizers and Grand Totalizers

Executing Various Action Routines

Reset Alarms, Reset Totalizers, Print Transaction, Reset Error History,

## 9.2 General

The optional RS-485 card utilizes Modbus RTU protocol to access a variety of process parameters and totalizers.  In addition, action routines can be executed.  For further information, contact factory and request RS-485 Protocol manual.

## 9.3 Operation of Serial Communication Port with PC

The flow computer's RS-485 channel supports a number of Modbus RTU commands. Refer to port pinout (below) for wiring details.  Modbus RTU drivers are available from third party sources for a variety of Man Machine Interface software for IBM compatible PC's.

The user reads and writes information from/to the RS-485 using the Modbus RTU commands. The FC-22 then responds to these information and command requests.

Process variables and totalizers are read in register pairs in floating point format. Time and date are read as a series of integer register values. Alarms are individually read as coils. Action routines are initiated by writing to coils.

## 9.4 FC-22 RS-485 Port Pinout



1 Ground
2 Ground
3 Ground
4 TX/RX (+)
5 TX/RX (-)
6 Do Not Use
7 Terminating Resistor (180 Ω)
8 TX/RX (+)
9 TX/RX (-)
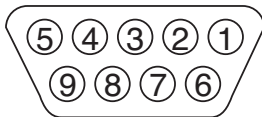
**NOTES:**
4 is internally connected to 8
5 is internally connected to 9

To terminate end of cable, connect pin 7 to either 4 or 8.

Request *FC-22 RS-485 Option with Modbus RTU Protocol* manual for complete details of RS-485
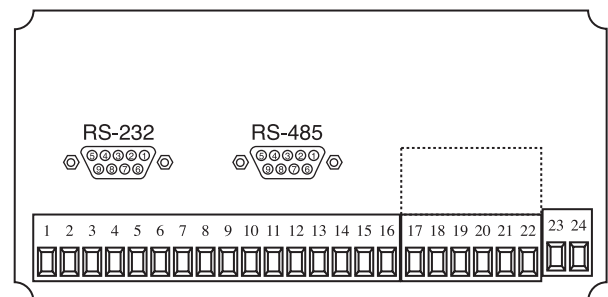
## 10. Flow Computer Setup Software

The FC-22 setup program provides for configuring, monitoring and controlling a FC-22 unit. Sample applications are stored in disk files. The setup program calls these *Templates*. You can store the setup from the program's memory to either the FC-22 (*Downloading* the file) or to a disk file (*Saving* the file) for later usage. Similarly you can load the setup in program memory from either a disk file (*Opening* a file) or from the FC-22 unit (Up*loading* a file). The program can monitor outputs from the unit while it is running.
The program can reset alarms and totalizers.
The peak demand may be reset when the option is supplied.
For assistance there are mini-helps at the bottom of each screen in the program. There is also context sensitive help available for each screen accessible by pressing the F1 key.

### 10.1 System Requirements:

IBM PC or compatible with 386 or higher class microprocessor
4 MB RAM
3 MB free disk space
VGA or higher color monitor at 640 x 480
Microsoft® Windows™ 3.1 or 3.11 or Windows 95/98™ or higher
Communication Port - RS-232
RS-232 Cable (customer supplied)

### 10.2 Cable and Wiring Requirements:

The serial communication port on your PC is either a 25 pin or 9 pin connector. No cabling is supplied with the setup software. A cable must be purchased separately or made by the user. It is recommended to purchase a serial cable which matches the available communication port on you PC and a 9 pin male connection for the FC-22 serial port.

### 10.3 Installation for Windows™ 3.1 or 3.11

The Setup Software includes an installation program which copies the software to your hard drive.
Insert Setup Disk 1 in a floppy drive.
In the Program Manager, click File, and then select Run.
> NOTE: For Windows 95™ Click the Start button, select Run and proceed as follows:

Type the floppy drive letter followed by a colon (:) and a backslash (\), and the word setup.
For Example:
> a:\setup

Follow the instructions on your screen.

### 10.4 Using the Flow Computer Setup Software

The setup software window consists of several menu "Tabs". Each tab is organized into groups containing various configuration and/or monitoring functions. To view the tab windows, simply click on the tab. The previous tab window will be hidden as the new tab window is brought to the foreground.

**Caution:** It is required that the FC-22 unit which is being configured be kept in the operating mode while using the setup diskette. If not, uncertainty exists as to what information will be retained when the session is concluded.

### 10.5 File Tab

The File Tab has three sections. Any of the options on this tab can also be accessed from

the File submenu.

The **Template Section** provides for opening and saving templates. The *Save* and *Save As* buttons provide the standard Windows functionality for dealing with files.  The Open button is used to open existing templates.

The *Open* option allows for creating custom  templates using the existing template in memory as the starting point. Assign a new name for this template. The template will be saved under this new name.

A typical scenario using the setup program would be the following:
- Open up a predefined template from the supplied list
- Choose 'Save As' to save this to a new file name
- Proceed to customize the template by making any changes that are needed
- Save the template to disk (if you want to reuse this template)
- Download the template to an attached unit.

The **Communications with FC-22 Section** allows the user to upload the setup from the unit or download the program's current template to the unit.

The **Print (report) Section** allows the user to:
1. Configure the current Windows printer through the Select Printer option.
2. Print a Maintenance Report through the PC's printer using the Print Maintenance  option.
3. Print the current setup through the PC's printer using Print Setup option.

## 10.6 Setup Tab

The Setup tab is where the majority of the FC-22 instrument setup modifications are done. The Setup tab is divided into five sections.

**System Section:**          Parameters, Display, Units
**Input Section:**          Flow, Fluid, Compensation Inputs
**Output Section:**          Pulse, Currents
**Relay Section:**          Relays
**Other Settings Section:**          Administration, Communication, Printing
 **NOTE:**  Many setup items are enabled or disabled depending on previous setup selections,  It is important to work your way through the above list in the order shown.  Be sure to verify your selections when you are through programming to insure that no settings were changed automatically.

**10.7 View Tab**

The View Tab screen allows for viewing selected group items on the PC in a similar format to that shown on the unit display. Data from the following groups can be viewed in the List of Values section:

Process Parameters (i.e. rate, temperature)
Totalizers (i.e. total, grand total)
Input Signals
Analog Output
Error Status
FC-22 Software Version Information

The setup software assumes the current setup has been uploaded from the flow computer into the PC. It is important that the setup program and the FC-22 unit are using the same setup information at all times or the data will be inconsistent. It is best to upload or download the setup before using this feature to synchronize the setups.

Error Log
Data from the error logger is viewed in a separate Error Log section on the screen.
To start the viewer, first check the boxes of items to view and then click the start button. The data will appear in the appropriate sections and will be continuously updated. The refresh rate is dependent on the number of items that are being viewed and the baud rate of the connection. Data in the List of Values section can be collapsed by clicking on the 'minus' sign in front of the group title. The data can be expanded by clicking on the 'plus' sign in front of the group title. If a group is collapsed and data in the group changes on refresh, the group will automatically expand. Data in the Error Log section does not expand or collapse. Changing the view items requires stopping the current viewing, checking the new selections and then restarting the viewer.
If communication errors occur while reading data from the FC-22 device, the word 'Error' will appear in place of the actual value. If the connection to the FC-22 is lost, the viewer will time out with a message saying the device is not responding.
The viewer will attempt to communicate with the FC-22 device matching the device ID set in the communications screen. If you are having trouble establishing communication, compare settings for the PC and the flow computer. Also verify the connections between the PC and flow computer.

**10.8 Misc. Tab**

This tab has three sections: Tools, Actions and Options.
The tools section contains various system administration activities such as creating/ modifying the initial sign-on screen or create print headers.

The Actions section is used to send commands to the FC-22 unit.
Reset Totalizers, Reset Alarms, Simulations, Self Check, Reset Peak Demand (if equipped)

The Options section has the following selections:
Language Translations, Network Card Configuration
Additional capabilities may be provided in the future.

# 11. Glossary of Terms

**Access Code**
A numeric password which is entered by a user attempting to gain entry to change setup parameters.

**AGA-3**
A empirical flow equation applicable to orifice and several other  square law flowmeters.

**AGA-5**
A gas flow equation for computing the combustion heat flow from measured volume flow, temperature and pressure as well as stored gas properties.

**AGA-7**
A gas flow equation for pulse producing, volumetric flowmeters which computes the equivalent flow at reference conditions from the measurements made at flowing line conditions.

**Assign Usage**
A menu selection during the setup of the instrument which selects the intended usage for the input/output.

**Barometric Pressure**
An entry of the average, local atmospheric pressure at the altitude or elevation of the installation. (typically 14.696 psia)

**Beta**
A important geometric ratio for a square law flowmeters.

**Calibration**
An order sequence of adjustments which must be performed in  order for the equipment to operate properly.

**Calibration Temperature**
The temperature at which a flow sensor was calibrated on a test fluid.

**Combustion Heat**
The energy released by a fluid fuel during combustion .

**Default**
A value to be assumed for manual inputs or in the event of a  failure in a input sensor.

**Display Damping**
An averaging filter constant used to smooth out display bounce.

**DP Factor**
A scaling constant for a square law flowmeter.

**Error Log**
A historical record which captures errors which have occurred.

**Flow Equation**
A recognized relationship between the process parameters for flow, temperature, pressure and density used in flow measurements.

**Galvanic Isolation**
Input and or output functions which do not share a conductive ground or common connection between them.

**Gas Cor. Vol Eq.**
An equation where the corrected volume  flow of gas at STP is computer from measured volume flow, temperature and pressure as well as stored gas properties.

**Gas Comb. Heat Eq.**
An equation where the combustion heat flow of gas is computer from measured volume flow, temperature and pressure as well as  stored gas properties.

**Gas Mass Eq.**
An equation where the mass flow of gas is computer from measured volume flow, temperature and pressure as well as stored gas properties.

**Flowing Z-Factor**
The mean Z-Factor under flowing conditions of temperature and pressure for a specific gas.

## 11. Glossary of Terms (Continued)

**Full Scale**
The value of the process variable at the full scale or maximum input signal.

**Inlet Pipe Bore**
The internal pipe diameter upstream of the flow measurement element.

**Isentropic Exponent**
A property of a gas or vapor utilized in orifice meter calculations.

**K-Factor**
The calibration constant for a pulse producing flowmeter expressed in pulses per unit volume

**Linear**
A flow measurement device where the output signal is proportional to flow.

**Linear 16 Pt.**
A mathematical approximation to a nonlinear device where by a correction factor or K-Factor table as a function of  input signal
is    utilized to eliminate flowmeter nonlinearity.

**Low Flow Cutoff**
The value of input signal below which flow rate may be assumed to be 0 and at which totalization will cease.

**Low Scale**
The value of the process variable at the zero input signal.

**Manual**
An entry value to be used as a fixed condition in a equation

**Meter Exp. Coef.**
A coefficient in an equation which may be used to correct for changes in flowmeter housing dimensioned  changes with
temperature.

**Mole %**
The % composition of an individual gas in a gas mixture.

**NX-19**
A series of equations used to compute the compressibility of natural gas as a function of specific gravity, temperature,
pressure and gas composition.

**Protocol**
An agreed upon method of information exchange.

**Print Initiate**
A user specified condition which must be satisfied for a transaction document to be printed.

**Pulse Type**
A menu  selectable equivalent pulse output stage.

**Pulse Value**
An output scaling factor defining the equivalent amount of flow total represented by 1 output pulse.

**Ref. Z-Factor**
The Z-Factor for a gas at reference conditions of temperature and pressure.

**Ref. Density**
The density of a fluid at reference conditions of temperature and pressure.

**Relay Function**
The assigned usage for a relay output.

**Relay Mode**
The user's desired operating mode for the relay. Examples: follow, latch, timed pulse, above setpoint, below setpoint

**Safe State**
The state of an instrument's outputs which will occur during a power down state. The state the instrument assumes when the
computations are paused.

## 11. Glossary of Terms (Continued)

**Scroll List**
The user's desired display list which can be presented on the two list display on Line 1 and/or L2 when the SCROLL key is depressed.

**Self Check**
A diagnostic sequence of steps a unit performs to verify it's operational readiness to perform it's intended function.

**Service Test**
A diagnostic sequence requiring specialized test apparatus to function to verify system readiness.

**Setpoint**
An alarm trip point.

**Simulation**
A special operating mode for an output feature which enables a service personnel to manually exercise the output during installation or trouble shooting operations.

**Square Law Flowmeters**
Types of measurement devices which measure differential pressure across a known geometry to make a flow measurement.

**SQR LAW (Square Law w/o SQRT)**
A square law flow measurement device equipped with a pressure transmitter with out a integral square root extractor.

**SQR LAW-LIN (Square Law w/ SQRT)**
A square law flow measurement device equipped with a pressure transmitter with integral square root extraction.

**SQR Law 16PT (Square Law 16pt)**
A mathematical approximation to a square law device where the discharge coefficient is represented as a table of DP Factor vs Reynold's Number.

**Steam Delta Heat**
A computation of the net heat of saturated steam equal to the total heat of steam minus the heat of water at the measured actual temperature.

**Steam Heat**
A computation of the total heat of steam.

**Steam Net Heat**
A computation of the net heat of steam equal to the total heat of steam minus the heat of water at the same saturated temperature.

**STP Reference**
The user's desired pressure and/or temperature to be considered as the reference condition in the computation of fluid properties or corrected volume conditions.

**TAG**
An alphanumeric designation for a particular instrument.

**Time Constant**
An averaging filter constant used to reduce bounce on the analog output. The high the number the slower the response, the greater filtering.

**UVC**
Universal Viscosity Curve is a representation of the calibration factor for a turbine flowmeter. It is expressed as a table of K-Factor as a function of Hz/CSTKS.

**Viscosity Coef**
A parameter in an equation which is used to estimate the viscosity as a function of temperature.
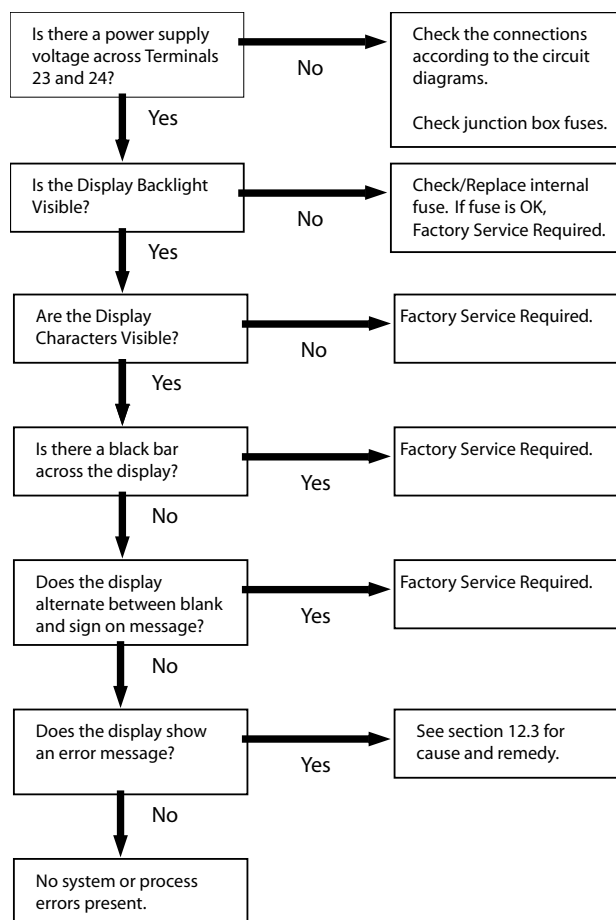
# 12. Diagnosis and Troubleshooting

## 12.1 Response of FC-22 on Error or Alarm:

Error indications which occur during operation are indicated alternately with the measured values.  The FC-22 Flow Computer has four types of error:

| TYPE OF ERROR | DESCRIPTION |
|---|---|
| System Alarms | Errors detected due to system failure |
| Sensor/Process Alarms | Errors detected due to sensor failure or process alarm conditions |
| Service Test Errors | Errors detected due to problems found during service test. (Service test can only be performed by qualified Factory service technicians because service code and special equipment are needed) |
| Self Test Errors | Errors detected during self test.  (Each time the unit is powered, it runs a self test) |

## 12.2 Diagnosis Flow Chart and Troubleshooting

All instruments undergo various stages of quality control during production.  The last of these stages is a complete calibration carried out on state-of-the-art calibration rigs.
A summary of possible causes is given below to help you identify faults.

Is there a power supply voltage across Terminals 23 and 24? → No → Check the connections according to the circuit diagrams. Check junction box fuses.

↓ Yes

Is the Display Backlight Visible? → No → Check/Replace internal fuse.  If fuse is OK, Factory Service Required.

↓ Yes

Are the Display Characters Visible? → No → Factory Service Required.

↓ Yes

Is there a black bar across the display? → Yes → Factory Service Required.

↓ No

Does the display alternate between blank and sign on message? → Yes → Factory Service Required.

↓ No

Does the display show an error message? → Yes → See section 12.3 for cause and remedy.

↓ No

No system or process errors present.

## 12.3 Error Messages:

**NOTE:** The 24 VDC output has a self resetting fuse.

| Error Message | Cause | Remedy |
| --- | --- | --- |
| POWER FAILURE | Power has been interrupted | Acknowledge Error Remedy not required |
| WATCHDOG TIMEOUT | Possible transient | Acknowledge Error Remedy not required |
| COMMUNICATION ERROR | Possible Improper wiring or usage Message Transmission failure. | Check wiring and communication settings / protocol |
| CALIBRATION ERROR | Operator Error | Repeat Calibration |
| PRINT BUFFER FULL | Print buffer full, Data may be lost | Check paper and printer connections |
| WET STEAM ALARM | Temperature or pressure input has gone below the saturated steam range of the internal steam tables | Check application, Insure that all sensors are working properly |
| OFF FLUID TABLE | Temperature or pressure input has gone below or exceeded the range of the internal steam tables | Check application, Insure that all sensors are working properly |
| FLOW IN OVERRANGE | Flow input has exceeded input range (if stacked, may be lo or hi transmitter) | Check sensor calibration |
| INPUT 1 OVERRANGE | Input 1 signal from sensor has exceeded input range | Check sensor calibration |
| INPUT 2 OVERRANGE | Input 2 signal from sensor has exceeded input range | Check sensor calibration |
| INPUT 3 OVERRANGE | Input 3 signal from sensor has exceeded input range | Check sensor calibration |
| FLOW LOOP BROKEN | Open circuit detected on flow input (if stacked, may be lo or hi transmitter) | Check wiring and sensor |
| LOOP 1 BROKEN | Open circuit detected on input 1 | Check wiring and sensor |
| LOOP 2 BROKEN | Open circuit detected on input 2 | Check wiring and sensor |
| LOOP 3 BROKEN | Open circuit detected on input 3 | Check wiring and sensor |
| RTD 1 OPEN | Open circuit detected on RTD 1 input | Check wiring and RTD |
| RTD 1 SHORT | Short circuit detected on RTD 1 input | Check wiring and RTD |

## 12.3 Error Messages: (Continued)

| Error Message | Cause | Remedy |
|---|---|---|
| **RTD 2 OPEN** | Open circuit detected on RTD 2 input | Check wiring and RTD |
| **RTD 2 SHORT** | Short circuit detected on RTD 2 input | Check wiring and RTD |
| **PULSE OUT OVERRUN** | Pulse output has exceeded the internal buffer | Adjust pulse value or pulse width |
| **Iout 1 OUT OF RANGE** | Current output 1 is below or above specified range | Adjust the "0"/ "Full Scale" values or increase/ lower flowrate |
| **Iout 2 OUT OF RANGE** | Current output 1 is below or above specified range | Adjust the "0"/ "Full Scale" values or increase/ lower flowrate |
| **TOTALIZER ERROR** | | |
| **RELAY 1 HI ALARM** | Relay 1 is active due to high alarm condition | Not required |
| **RELAY 1 LO ALARM** | Relay 1 is active due to low alarm condition | Not required |
| **RELAY 2 HI ALARM** | Relay 2 is active due to high alarm condition | Not required |
| **RELAY 2 LO ALARM** | Relay 2 is active due to low alarm condition | Not required |
| **RELAY 3 HI ALARM** | Relay 3 is active due to high alarm condition | Not required |
| **RELAY 3 LO ALARM** | Relay 3 is active due to low alarm condition | Not required |
| **24VDC OUT ERROR** | 24V output error detected during service test run | By Factory Service |
| **PULSE IN ERROR** | Pulse input error detected during service test run | By Factory Service |
| **INPUT 1 Vin ERROR** | Error detected on input 1 voltage input during service test run | By Factory Service |
| **INPUT 1 Iin ERROR** | Error detected on input 1 current input during service test run | By Factory Service |
| **INPUT 2 Iin/RTD ERROR** | Error detected on input 2 during service test run | By Factory Service |
| **INPUT 3 Iin/RTD ERROR** | Error detected on input 3 during service test run | By Factory Service |

| Error Message | Cause | Remedy |
|---|---|---|
| **PULSE OUT ERROR** | Pulse output error detected during service test run | By Factory Service |
| **Iout 1 ERROR** | Current output 1 error detected during service test run | By Factory Service |
| **Iout 2 ERROR** | Current output 2 error detected during service test run | By Factory Service |
| **RELAY 1 ERROR** | Relay 1 error detected during service test run | By Factory Service |
| **RELAY 2 ERROR** | Relay 2 error detected during service test run | By Factory Service |
| **RS-232 ERROR** | RS-232 error detected during service test run | By Factory Service |
| **A/D MALFUNCTION** | Error detected in A/D converter during self test | By Factory Service |
| **PROGRAM ERROR** | Error on access to the program memory | By Factory Service |
| **SETUP DATA LOST** | All or part of the EEPROM data for setup is damaged or has been overwritten | Re-Enter setup data, If problem persists, Factory service required |
| **TIME CLOCK LOST** | The real time clock data was lost during extended power outage | Re-Enter time and date |
| **DISPLAY MALFUNCTION** | A display malfunction has been detected. | By Factory Service |
| **RAM MALFUNCTION** | Part or all of the internal RAM is damaged | By Factory Service |
| **TRAP ERROR** | Steam trap malfunction | Service steam trap |
| **TRAP BLOWING** | Steam trap malfunction | Change error delay |
| **DATALOG LOST** | Contents of datalog were corrupt and lost | Clear datalog, Clear errors |

## Appendix A - Fluid Properties Table

## Fluid Properties Table

**LIQUID**

| FLUID | REF. DENSITY (lb./ft³) | REF. TEMP. (ºF) | COEFF. OF EXPANSION | COMBUSTION HEAT (Btu/lb) LIQUID $H_2O$ and $CO_2$ | SPECIFIC HEAT (Btu/lb °F) | LIQ.VISC. ANDREDE's EQUATION COEFF. "A" | VISCOSITY BY ANDREDE's EQUATION COEFF. "B" |
|---|---|---|---|---|---|---|---|
| AIR | 54.56 | -317.8 | 0.0016262 | 0 | 0.45 | 0.172 | 0 |
| AMMONIA | 42.63 | -28.2 | 0.0005704 | 0 | 1.05 | 0.00157 | 2228.25 |
| ARGON | 86.89 | -302.6 | 0.0014861 | 0 | 0.45 | 0.011291 | 511.34 |
| CO2 | 65.333 | -10.0 | 0.0012609 | 0 | 0.45 | 0.000001 | 5305.44 |
| METHANE | 26.48 | -258.7 | 0.0010523 | 23920 | 0.80 | 0.006819 | 526.08 |
| NATURAL GAS | 26.48 | -258.7 | 0.0010523 | 23920 | 0.80 | 0.006819 | 526.08 |
| NITROGEN | 50.44 | -320.4 | 0.0014917 | 0 | 0.55 | 0.006524 | 434.94 |
| OXYGEN | 71.21 | -297.4 | 0.0013458 | 0 | 0.41 | 0.019773 | 340.29 |
| PROPANE | 31.671 | 60 | 0.0007178 | 21690 | 0.6 | 0.009969 | 1267.35 |
| Nx-19 | 26.48 | -258.7 | 0.0010523 | 23920 | 0.80 | 0.006819 | 526.08 |
| GASOLINE | 46.8 | 60 | 0.0003703 | 20400 | 0.5 | 0.045617 | 1432.26 |
| KEROSENE | 51.79 | 60 | 0.0002681 | 18400 | 0.45 | 0.004378 | 3245.78 |
| No. 2 FUEL | 58.97 | 60 | 0.0000885 | 17970 | 0.42 | 0.000453 | 4946.15 |
| WATER | 62.37 | 60 | 0.0001015 | 0 | 1 | 0.001969 | 3315.61 |
| HYDROGEN | 4.41874 | -432.2 | 0.0007259 | 60620.5 | 2.336 | 0.003537 | 48.5432 |
| ETHYLENE | 34.085 | -127.5 | 0.00068257 | 22292 | 1 | 0.000238 | 26665.90 |
| HELIUM | 9.14157 | -452.1 | 0.00011477 | 0 | 1 | 0.0033 | 0 |

**GAS**

| FLUID | REF. DENSITY (lb./ft³) | REF. TEMP. (ºF) | REF. Z FACTOR (14.696 PSIA) | Z FACTOR AT 100 PSIA and 60°F | SPECIFIC HEAT (Btu/lb °F) | COMBUSTION HEAT (Btu/lb) LIQUID $H_2O$ and $CO_2$ | ISENTROPIC EXPONENT | VISCOSITY BY ANDREDE's EQUATION COEFF. "A" | VISCOSITY BY ANDREDE's EQUATION COEFF. "B" |
|---|---|---|---|---|---|---|---|---|---|
| AIR | 0.076 | 60 | 1 | 0.997 | 0.24 | 0 | 1.4 | 0.000138 | 0.775522 |
| AMMONIA | 0.045 | 60 | 1 | 0.955 | 0.52 | 0 | 1.31 | 0.000013 | 1.05951 |
| ARGON | 0.105 | 60 | 1 | 0.995 | 0.125 | 0 | 1.67 | 0.00021 | 0.750757 |
| CO2 | 0.116 | 60 | 1 | 0.954 | 0.21 | 0 | 1.32 | 0.000049 | 0.91136 |
| METHANE | 0.042 | 60 | 1 | 0.970 | 0.55 | 23920 | 1.31 | 0.000018 | 1.015892 |
| NAT. GAS | 0.0456 | 60 | 1 | 0.970 | 0.55 | 23920 | 1.31 | 0.000018 | 1.015892 |
| NITROGEN | 0.074 | 60 | 1 | 0.998 | 0.25 | 0 | 1.41 | 0.000202 | 0.7128734 |
| OXYGEN | 0.084 | 60 | 1 | 0.995 | 0.22 | 0 | 1.41 | 0.000169 | 0.761811 |
| PROPANE | 0.116 | 60 | 1 | 0.870 | 0.4 | 21690 | 1.14 | 0.00002 | 0.952092 |
| Nx-19 | 0.0456 | 60 | 1 | 0.97 | 0.55 | 23920 | 1.31 | 0.000018 | 1.015892 |
| HYDROGEN | 0.00532 | 60 | 1 | 1.0042 | 3.42 | 60620.5 | 1.405 | 0.000151 | 0.647667 |
| ETHYLENE | 0.074717 | 60 | 1 | 0.994 | 0.386 | 22292 | 1.244 | 0.0093 | 0 |
| HELIUM | 0.01055 | 60 | 1 | 1 | 1.25 | 0 | 1.630 | 0.000209 | 0.721975 |

## Appendix B - Setup Menus

**SETUP MENUS**
Operator Code Access

**START HERE**

**SYSTEM PARAMETER:** EZ SETUP · ACCESS CODE · FLOW EQUATION · ENTER DATE · ENTER TIME · DAYLIGHT SAVINGS · OPERATOR CODE · TAG # · ORDER CODE · SERIAL # · SENSOR SERIAL #

**DISPLAY:** SCROLL LIST · DISPLAY DAMPING · MAX. DEC. POINT · LANGUAGE · TOTAL ROLL OVER

**SYSTEM UNITS:** TIME BASE · HEAT FLOW UNIT · HEAT TOTAL UNIT · MASS FLOW UNIT · MASS TOTAL UNIT · VOLUME TOTAL UNIT · VOLUME FLOW UNIT · COR. VOL. TOTAL UNIT · COR. VOL. FLOW UNIT · DEFINITION bbl · TEMPERATURE UNIT · PRESSURE UNIT · DENSITY UNIT · SPEC. ENTHALPY UNIT · LENGTH UNIT

**FLUID DATA:** FLUID TYPE · REF. DENSITY · THERM. EXP. COEF. · COMBUSTION HEAT · SPECIFIC HEAT · FLOW Z-FACTOR · REF. Z-FACTOR · ISENTROPIC EXP. · MOLE % NITROGEN · MOLE % $CO_2$ · VISCOSITY COEF. A · VISCOSITY COEF. B

**FLOW INPUT:** FLOWMETER TYPE · SQUARE LAW FLOWMETER · ILVA SIZE · ACCELABAR SIZE · INPUT SIGNAL · LOW SCALE · FULL SCALE · LOW SCALE HIGH RANGE · FULL SCALE HIGH RANGE · SWITCH UP · SWITCH DOWN · LOW FLOW CUTOFF · CALIBRATION DENSITY · K-FACTOR · PIPE INNER DIAMETER · ENTER BETA

**COMPENSATION INPUT:** SELECT INPUT
- **1:** INPUT SIGNAL · LOW SCALE VALUE · FULL SCALE VALUE · DEFAULT VALUE · STP REFERENCE · CALIBRATION TEMP · LOW DELTA T CUTOFF · VIEW INPUT SIGNAL · TRAP ERROR DELAY · TRAP BLOWING DELAY
- **2:** INPUT SIGNAL · LOW SCALE VALUE · FULL SCALE VALUE · DEFAULT VALUE · STP REFERENCE · BAROMETRIC PRESS · VIEW INPUT SIGNAL

(branch) METER EXP. COEF · DP-FACTOR · LOW PASS FILTER · LINEARIZATION · FLOW METER LOCATION · BYPASS CAL. FACTORL · BYPASS EAM FACTOR
(branch) BYPASS DC FACTOR · BYPASS YM FACTOR · VIEW INPUT SIGNAL · VIEW HI RANGE SIGNAL

**PULSE OUTPUT:** ASSIGN PULSE OUTPUT · PULSE TYPE · PULSE VALUE · PULSE WIDTH · SIMULATION FREQ.

**CURRENT OUTPUT:** SELECT OUTPUT
- **1:** ASSIGN CURRENT OUT. · CURRENT RANGE · LOW SCALE VALUE · FULL SCALE VALUE · TIME CONSTANT · CURRENT OUT VALUE (DISPLAY) · SIMULATION CURRENT
- **2:** ASSIGN CURRENT OUT. · CURRENT RANGE · LOW SCALE VALUE · FULL SCALE VALUE · TIME CONSTANT · CURRENT OUT VALUE (DISPLAY) · SIMULATION CURRENT

**RELAYS:** SELECT RELAY 1, 2, 3 · RELAY FUNCTION · RELAY MODE · LIMIT SETPOINT · PULSE VALUE · PULSE WIDTH · HYSTERESIS · RELAY SIMULATION · RESET ALARM

**COMMUNUICATION:** RS232 USAGE · DEVICE ID · BAUD RATE · PARITY · HANDSHAKE · PRINT LIST · PRINT INITIATE · DATALOG ONLY · PRINT INTERVAL · PRINT TIME · DATALOG FORMAT · MODEM CONTROL · DEVICE MASTER · SEND INC TOT ONLY · INC ONLY SCALER · CLEAR DATALOG
(branch) MODEM AUTO ANSWER · CALL OUT NO · CALL OUT TIME · CALL ON ERROR · NUMBER OF REDIALS · HANGUP IF INACTIVE · ERROR MASK

**NETWORK CARD:** PROTOCOL · DEVICE ID · BAUD RATE · PARITY

**SERVICE & ANALYSIS:** EXAMINE AUDIT TRAIL · ERROR LOG · SOFTWARE VERSION (DISPLAY) · HARDWARE VERSION (DISPLAY) · PRINT SYSTEM SETUP · SELF CHECK

> These functions will only appear with appropriate settings in other functions.

## Appendix B- Setup Menus
(continued)

## SETUP MENUS
### Service Code Access

**START HERE**

**SYSTEM PARAMETER:** EZ SETUP · ACCESS CODE · FLOW EQUATION · ENTER DATE · ENTER TIME · DAYLIGHT SAVINGS · ENGINEERING CODE · SUPERVISOR CODE · OPERATOR CODE · TAG # · ORDER CODE · SERIAL # · SENSOR SERIAL#

**DISPLAY:** SCROLL LIST · DISPLAY DAMPING · MAX. DEC. POINT · LANGUAGE · TOTAL ROLL OVER

**SYSTEM UNITS:** TIME BASE · HEAT FLOW UNIT · HEAT TOTAL UNIT · MASS FLOW UNIT · MASS TOTAL UNIT · VOLUME FLOW UNIT · COR. VOL. FLOW UNIT · VOLUME TOTAL UNIT · COR. VOL. TOTAL UNIT · DEFINITION bbl · TEMPERATURE UNIT · PRESSURE UNIT · DENSITY UNIT · SPEC. ENTHALPY UNIT · LENGTH UNIT

**FLUID DATA:** FLUID TYPE · REF. DENSITY · THERM. EXP. COEF. · COMBUSTION HEAT · SPECIFIC HEAT · FLOW Z-FACTOR · REF Z-FACTOR · ISENTROPIC EXP. · MOLE % NITROGEN · MOLE % CO2 · VISCOSITY COEF. A · VISCOSITY COEF. B

**FLOW INPUT:** FLOWMETER TYPE · SQUARE LAW FLOWMETER · ILVA SIZE · ACCELABAR SIZE · INPUT SIGNAL · LOW SCALE · FULL SCALE · LOW SCALE HIGH RANGE · FULL SCALE HIGH RANGE · SWITCH UP · SWITCH DOWN · LOW FLOW CUTOFF · CALIBRATION DENSITY · K-FACTOR · PIPE INNER DIAMETER · ENTER BETA

(branch) METER EXP. COEF · DP-FACTOR · LINEARIZATION · FLOW METER LOCATION · LOW PASS FILTER · BYPASS CAL. FACTORL · BYPASS EAM FACTOR · BYPASS DC FACTOR · BYPASS YM FACTOR · VIEW INPUT SIGNAL · VIEW HI RANGE SIGNAL

**COMPENSATION INPUT:**
- SELECT INPUT 1: INPUT SIGNAL · LOW SCALE VALUE · FULL SCALE VALUE · DEFAULT VALUE · STP REFERENCE · CALIBRATION TEMP · VIEW INPUT SIGNAL · LOW DELTA T CUTOFF · TRAP ERROR DELAY · TRAP BLOWING DELAY
- SELECT INPUT 2: INPUT SIGNAL · LOW SCALE VALUE · FULL SCALE VALUE · DEFAULT VALUE · STP REFERENCE · BAROMETRIC PRESS · VIEW INPUT SIGNAL

**PULSE OUTPUT:** ASSIGN PULSE OUTPUT · PULSE TYPE · PULSE VALUE · PULSE WIDTH · SIMULATION FREQ.

**CURRENT OUTPUT:**
- SELECT OUTPUT 1: ASSIGN CURRENT OUT. · CURRENT RANGE · LOW SCALE VALUE · FULL SCALE VALUE · TIME CONSTANT · CURRENT OUT VALUE (DISPLAY) · SIMULATION CURRENT
- SELECT OUTPUT 2: ASSIGN CURRENT OUT. · CURRENT RANGE · LOW SCALE VALUE · FULL SCALE VALUE · TIME CONSTANT · CURRENT OUT VALUE (DISPLAY) · SIMULATION CURRENT

**RELAYS:** SELECT RELAY 1, 2, 3: RELAY FUNCTION · RELAY MODE · LIMIT SETPOINT · PULSE VALUE · PULSE WIDTH · HYSTERESIS · RELAY SIMULATION · RESET ALARM

**COMMUNICATION:** RS232 USAGE · DEVICE ID · BAUD RATE · PARITY · HANDSHAKE · PRINT LIST · PRINT INITIATE · DATALOG ONLY · PRINT INTERVAL · PRINT TIME · DATALOG FORMAT · MODEM CONTROL · DEVICE MASTER · SEND INC TOT ONLY · INC ONLY SCALER

**NETWORK CARD:** PROTOCOL · DEVICE ID · BAUD RATE · PARITY · MODEM AUTO ANSWER · CALL OUT NO · CALL OUT TIME · CALL ON ERROR · NUMBER OF REDIALS · HANGUP IF INACTIVE · ERROR MASK

**SERVICE & ANALYSIS:** EXAMINE AUDIT TRAIL · ERROR LOG · SOFTWARE VERSION (DISPLAY) · HARDWARE VERSION (DISPLAY) · CALIBRATION · RESTORE FACTORY CALIBRATION · NEXT CALIBRATION · PRINT MAINT. REPORT · PRINT SYSTEM SETUP · SELF CHECK · SERVICE TEST

These functions will only appear with appropriate settings in other functions.

**Appendix C- RS-485 Modbus Protocol**

# RS-485 & Modbus RTU Protocol

When the Flow Computer is equipped with the RS-485 communication option, the protocol it uses is the Modbus RTU protocol. This protocol defines a message structure that hosts and clients will recognize and use on the RS-485 network over which they communicate. It describes the process a master device (PC compatible) uses to request access to another device (Flow Computer), how it will respond to requests from the other devices, and how errors will be detected and reported. It establishes a common format for the layout and contents of message fields.

During communications on a Modbus RTU network, the protocol determines how each Flow Computer will know its device address, recognize a message addressed to it, determine the kind of action to be taken, and extract any data or other information contained in the message. If a reply is required, the Flow Computer will construct the reply message and send it using Modbus RTU protocol.

**RTU Mode**
The Flow Computer with RS-485 communications option supports the Modbus RTU (Remote Terminal Unit) mode only. The Modbus ASCII mode is not supported.  The main advantage of the RTU mode is that its greater character density allows better data throughput than ASCII for the same baud rate.  The Modbus RTU uses a Master-Slave Query-Response Cycle in which the Flow Computer is the slave device.

**Control Functions**
The Flow Computer with RS-485 communications option supports the following function codes:

| CODE | NAME | DESCRIPTION |
|---|---|---|
| 01 | Read Coil Status | Read a single coil |
| 03 | Read Holding Register | Read a range of holding registers |
| 05 | Force Single Coil | Forces a single coil (0x reference) to either ON or OFF |
| 06 | Preset Single Register | Presets a value into a single holding register (4x reference) |
| 15 | Force Multiple Coil | Forces each coil (0x reference) in a sequence of coils to either ON or OFF |
| 16 | Preset Multiple Registers | Presets values into a sequence of holding registers (4x reference) |

## Appendix C- RS-485 Modbus Protocol (continued)

**Flow Computer RS-485 Port Pinout** (recommended mating connector: DB-9M)
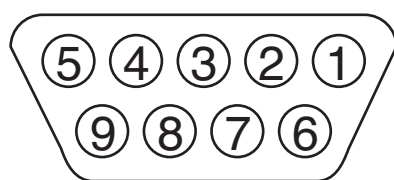
1 Ground
2 Ground
3 Ground
4 TX/RX (+)
5 TX/RX (-)
6 Do Not Use
7 Terminating Resistor (180 Ω)
8 TX/RX (+) (spare internally connected to 4)
9 TX/RX (-) (spare internally connected to 5)
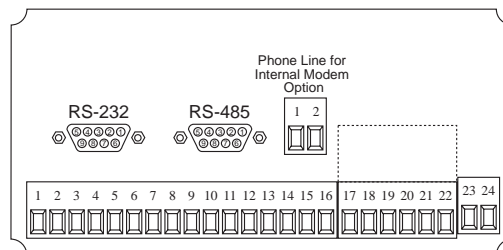
**Flow Computer RS-485 Port Pinout** (Terminal Block Option)

1 Common
2 TX/RX (+)
3 TX/RX (-)
4 Terminating Resistor (180Ω)
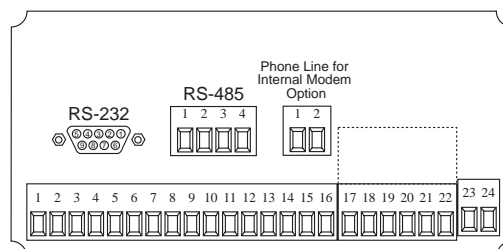
### Installation Overview
A two wire RS-485 may be multidropped up to 4000 ft. and up to 32 units may be chained together. A RS-485 to RS-232 interface adapter is required at the PC. An optically isolated type is recommended. Suitable wiring should be selected based on anticipated electrical interference.  Terminators should be used to help improve the quality of electronic signals sent over the RS-485 wires. The RS-485 chain should be terminated at the beginning (RS-485 adaptor) and at the last device in the RS-485 chain and nowhere else. On the Flow Computer this is accomplished by connecting a jumper from the terminal labeled *Terminating Resistor (180 Ω)* to the terminal labeled *TX/RX(+)*  at the RS-485 port. If lightning protection is required, a suitable surge protector should be used.

For additional information, refer to the technical requirements of EIA-485, interface adaptor user manual and the communication software user manual

### Flow Computer Communication Setup Menu
The setup menu allows Modbus RTU Protocol communications parameters of: Device ID, Baud Rate, and Parity to be selected to match the parameters of your RS-485 network. Each Flow Computer must have it's own Device ID and the same Baud Rate and Parity setting.

# Appendix C- RS-485 Modbus Protocol (continued)

## Terminal Layout for Wall Mount Option:

**NEMA 12, 13 Terminal Designations**

**NEMA 12, 13 Terminal Layout**

**RS-232**

| | |
|---|---|
| 1 | TX |
| 2 | RX |
| 3 | COM |
| 4 | BIAS |
| 5 | DCD |
| 6 | MP (+8 VDC) |

**RS-485**

| | |
|---|---|
| 1 | TX/RX(+) |
| 2 | Terminating Resistor (180 ohms) |
| 3 | TX/RX(−) |
| 4 | Common |

**Phone**

| | |
|---|---|
| 1 | TIP |
| 2 | RING |
| 3 | Not Used |
| 4 | Not Used |
| 5 | Not Used |
| 6 | Not Used |

**3 Relay Option**  **DC Power Option**

| | |
|---|---|
| 1 | DC OUTPUT |
| 2 | PULSE IN — Vin (+)* FLOW IN |
| 3 | - - - - - - - - - -  Iin (+) |
| 4 | COMMON |
| 5 | RTD EXCIT (+)  TEMPERATURE IN |
| 6 | RTD SENS (+) |
| 7 | RTD SENS (-)  Iin (+) |
| 8 | DC OUTPUT |
| 9 | RTD EXCIT (+)  PRESSURE (TEMP 2) IN |
| 10 | RTD SENS (+) |
| 11 | RTD SENS (-)  Iin (+) |
| 12 | PULSE OUTPUT (+) |
| 13 | PULSE OUTPUT (-) |
| 14 | ANALOG OUTPUT 1 (+) |
| 15 | ANALOG OUTPUT 2 (+) |
| 16 | ANALOG OUTPUT COMMON (-) |
| 17 | NO RLY1 |
| 18 | COM RLY1 |
| 19 | NC RLY1 |
| 20 | NC RLY2 |
| 21 | COM RLY2 |
| 22 | NO RLY2 |
| 23 | AC LINE  DC (+)  POWER IN |
| 24 | AC LINE  DC (-) |

Specify Power Input When Ordering.

```
RATE        147.43 GPM
TOTAL 267395.749 GAL
```

Keys: TOTAL 1, RATE 2, PRE 1 3, TEMP 4, PRINT 5, CLEAR, MENU, GRAND 6, SCROLL 7, PRE 2 8, DENS 9, TIME 0, HELP ., ENTER

RS-232 (1 2 3 4 5 6)  RS-485 (1 2 3 4)  Phone (1 2 3 4 5 6)

1 2 3 4 5 6 7  8 9 10 11 12 13 14 15 16  17 18 19 20 21 22  23 24

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**Appendix C- RS-485 Modbus Protocol** (continued)


# Register & Coil Usage

_**Register Usage**_ (each register is 2 bytes)  **NOTE:** The Float data type follows the IEEE format for a 32 bit float.

| FC-22 Data | Register | Data Type |
|---|---|---|
| Heat Flow | Reg 40001 & 40002 | Float |
| Mass Flow | Reg 40003 & 40004 | Float |
| STD Volume Flow | Reg 40005 & 40006 | Float |
| Volume Flow | Reg 40007 & 40008 | Float |
| Temperature 1 | Reg 40009 & 40010 | Float |
| Temperature 2 | Reg 40011 & 40012 | Float |
| Delta Temperature | Reg 40013 & 40014 | Float |
| Process Pressure | Reg 40015 & 40016 | Float |
| Diff. Pressure | Reg 40017 & 40018 | Float |
| Density | Reg 40019 & 40020 | Float |
| Specific Enthalpy | Reg 40021 & 40022 | Float |
| Heat Total | Reg 40023 & 40024 | Float |
| Mass Total | Reg 40025 & 40026 | Float |
| STDVolumeTotal | Reg 40027 & 40028 | Float |
| Volume Total | Reg 40029 & 40030 | Float |
| Heat Grand Total | Reg 40031 & 40032 | Float |
| Mass Grand Total | Reg 40033 & 40034 | Float |
| STDVolumeGrandTotal | Reg 40035 & 40036 | Float |
| Volume Grand Total | Reg 40037 & 40038 | Float |
| Alarm Point 1 | Reg 40039 & 40040 | Float |
| Alarm Point 2 | Reg 40041 & 40042 | Float |
| Alarm Point 3 | Reg 40043 & 40044 | Float |
| Year | Reg 40045 | Integer |
| Month | Reg 40046 | Integer |
| Day | Reg 40047 | Integer |
| Hours | Reg 40048 | Integer |
| Min | Reg 40049 | Integer |
| Sec | Reg 40050 | Integer |
| Peak Demand | Reg 40051 & 40052 | Float |
| Demand Last | Reg 40053 & 40054 | Float |
| Viscosity | Reg 40055 & 40056 | Float |
| Abs. Viscosity | Reg 40057 & 40058 | Float |
| Reserved | Reg 40059 & 40060 | Float |
| Power Lost Hour | Reg 40061 | Integer |
| Power Lost Min. | Reg 40062 | Integer |
| Reserved | Reg 40063 & 40064 | Float |
| Reserved | Reg 40065 & 40066 | Float |
| Reserved | Reg 40067 & 40068 | Float |
| Reserved | Reg 40069 & 40070 | Float |
| Reserved | Reg 40071 & 40072 | Float |
| Reserved | Reg 40073 & 40074 | Float |
| Reserved | Reg 40075 & 40076 | Float |
| Time base | Reg 40077 | Integer |
| Heat Flow Units | Reg 40078 | Integer |
| Mass Flow Units | Reg 40079 | Integer |
| STD Flow Units | Reg 40080 | Integer |
| Vol. Flow Units | Reg 40081 | Integer |
| Temperature Units | Reg 40082 | Integer |
| Pressure Units | Reg 40083 | Integer |
| Density Units | Reg 40084 | Integer |
| Heat Total Units | Reg 40085 | Integer |
| Mass Total Units | Reg 40086 | Integer |

## Appendix C- RS-485 Modbus Protocol (continued)

### *Register Usage* (each register is 2 bytes)

| FC-22 Data | Register | Data Type |
|---|---|---|
| STD Total Units | Reg 40087 | Integer |
| Vol. Total Units | Reg 40088 | Integer |
| Definition of Barrel | Reg 40089 | Integer |
| Specific Enthalpy Units | Reg 40090 | Integer |
| Length Units | Reg 40091 | Integer |
| Calibration trail | Reg 40092 | Integer |
| Configuration trail | Reg 40093 | Integer |
| Tag Number | Reg 40094 | Integer |
| Peak Year | Reg 40095 | Integer |
| Peak Month | Reg 40096 | Integer |
| Peak Day | Reg 40097 | Integer |
| Peak Hours | Reg 40098 | Integer |
| Peak Min | Reg 40099 | Integer |
| Unused | Reg 40100 | Integer |
| Unused | Reg 40101 & 40102 | Float |
| Unused | Reg 40103 & 40104 | Float |
| Unused | Reg 40105 & 40106 | Float |
| Unused | Reg 40107 & 40108 | Float |
| Unused | Reg 40109 & 40110 | Float |
| Unused | Reg 40111 & 40112 | Float |
| Unused | Reg 40113 & 40114 | Float |
| Unused | Reg 40115 & 40116 | Float |
| Unused | Reg 40117 & 40118 | Float |
| Unused | Reg 40119 & 40120 | Float |
| Unused | Reg 40121 & 40122 | Float |
| Unused | Reg 40123 & 40124 | Float |

### *COIL USAGE* (each coil is 1 bit)

| FC-22 Data | Coil | Data Type |
|---|---|---|
| System Alarm Power Failure | Coil 00001 | bit |
| System Alarm Watchdog | Coil 00002 | bit |
| System Alarm Communication Error | Coil 00003 | bit |
| System Alarm Calibration Error | Coil 00004 | bit |
| System Alarm Print Buffer Full | Coil 00005 | bit |
| System Alarm Totalizer Error | Coil 00006 | bit |
| Sensor/Process Alarm Wet Steam Alarm | Coil 00007 | bit |
| Sensor/Process Alarm Off Fluid Table | Coil 00008 | bit |
| Sensor/Process Alarm Flow In Over Range | Coil 00009 | bit |
| Sensor/Process Alarm Input 1 Over Range | Coil 00010 | bit |
| Sensor/Process Alarm Input 2 Over Range | Coil 00011 | bit |
| Sensor/Process Alarm Flow Loop Broken | Coil 00012 | bit |
| Sensor/Process Alarm Loop 1 Broken | Coil 00013 | bit |
| Sensor/Process Alarm Loop 2 Broken | Coil 00014 | bit |
| Sensor/Process Alarm RTD 1 Open | Coil 00015 | bit |
| Sensor/Process Alarm RTD 1 Short | Coil 00016 | bit |
| Sensor/Process Alarm RTD 2 Open | Coil 00017 | bit |
| Sensor/Process Alarm RTD 2 Short | Coil 00018 | bit |
| Sensor/Process Alarm Pulse Out Overrun | Coil 00019 | bit |
| Sensor/Process Alarm Iout 1 Out Of Range | Coil 00020 | bit |
| Sensor/Process Alarm Iout 2 Out Of Range | Coil 00021 | bit |
| Sensor/Process Alarm Relay 1 Hi Alarm | Coil 00022 | bit |

## COIL USAGE (each coil is 1 bit)

| FC-22 Data | Coil | Data Type |
|---|---|---|
| Sensor/Process Alarm Relay 1 Lo Alarm | Coil 00023 | bit |
| Sensor/Process Alarm Relay 2 Hi Alarm | Coil 00024 | bit |
| Sensor/Process Alarm Relay 2 Lo Alarm | Coil 00025 | bit |
| Sensor/Process Alarm Relay 3 Hi Alarm | Coil 00026 | bit |
| Sensor/Process Alarm Relay 3 Lo Alarm | Coil 00027 | bit |
| Service Test 24Vdc Out Error | Coil 00028 | bit |
| Service Test Pulse In Error | Coil 00029 | bit |
| Service Test Input 1 Vin Error | Coil 00030 | bit |
| Service Test Input 1 Iin Error | Coil 00031 | bit |
| Service Test Input 2 Iin Error | Coil 00032 | bit |
| Service Test Input 2 RTD Error | Coil 00033 | bit |
| Service Test Input 3 Iin Error | Coil 00034 | bit |
| Service Test Input 3 RTD Error | Coil 00035 | bit |
| Service Test Pulse Out Error | Coil 00036 | bit |
| Service Test Iout 1 Error | Coil 00037 | bit |
| Service Test Iout 2 Error | Coil 00038 | bit |
| Service Test Relay 1 Error | Coil 00039 | bit |
| Service Test Relay 2 Error | Coil 00040 | bit |
| Service Test RS-232 Error | Coil 00041 | bit |
| Self Test A/D Malfunction | Coil 00042 | bit |
| Self Test Program Error | Coil 00043 | bit |
| Self Test Setup Data Lost | Coil 00044 | bit |
| Self Test Time Clock Lost | Coil 00045 | bit |
| Self Test Display Malfunction | Coil 00046 | bit |
| Self Test Ram Malfunction | Coil 00047 | bit |
| Language Select | Coil 00048 | bit Write |
| Reset Totalizers | Coil 00049 | bit Write with Caution |
| Reset All Error Codes | Coil 00050 | bit Write |
| Reset Alarm 1 | Coil 00051 | bit Write |
| Reset Alarm 2 | Coil 00052 | bit Write |
| Reset Alarm 3 | Coil 00053 | bit Write |
| Print Transaction Document | Coil 00054 | bit Write |
| Reset Peak Demand | Coil 00055 | bit Write |
| Reset Accumulated Power Loss | Coil 00056 | bit Write |
| Aux. Status Input | Coil 00057 | bit |
| Reserved | Coil 00058 | bit |
| Reserved | Coil 00059 | bit |
| Reserved | Coil 00060 | bit |
| Reserved | Coil 00061 | bit |
| Reserved | Coil 00062 | bit |
| Flowmeter Location | Coil 00063 | bit |
| Unused | Coil 00064 | bit |

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2. Model and serial number of the product, and
3. Repair instructions and/or specific problems relative to the product.

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