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VOLUME 3

Firmware Revisions 23.74/27.74

Configuration and Advanced Operation

Omni 3000 / 6000 Flow Computer
User Manual

Gas Using Orifice/Turbine Meter

Effective June 2009

Omni®

Volume 3

CONFIGURATION AND ADVANCED OPERATION

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For Your Information

Measure the Difference!®

About Our Company

OMNI Flow Computers, Inc. is the world's leading manufacturer and supplier of panel-mount custody transfer flow computers and controllers. Our mission is to continue to achieve higher levels of customer and user satisfaction by applying the basic company values: our people, our products and productivity.

***OMNI Flow Computers** – Our products are currently being used world-wide at:*

- ✓ *Offshore oil and gas production facilities*
- ✓ *Crude oil, refined products, LPG, NGL and gas transmission lines*
- ✓ *Storage, truck, and marine loading/offloading terminals*
- ✓ *Refineries; petrochemical and cogeneration plants*

Our products have become the international flow computing standard. OMNI Flow Computers pursues a policy of product development and continuous improvement. As a result, our flow computers are considered the "brain" and "cash point" of liquid and gas flow metering systems.

Our staff is knowledgeable and professional. They represent the energy, intelligence and strength of our company, adding value to our products and services. With the customer and user in mind, we are committed to quality in everything we do, devoting our efforts to deliver workmanship of high caliber. Teamwork with uncompromising integrity is our lifestyle.

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Getting User Support

Technical and sales support is available world-wide through our corporate or authorized representative offices. If you require user support, please contact the location nearest you (see insert) or our corporate offices. Our staff and representatives will enthusiastically work with you to ensure the sound operation of your flow computer.

About the Flow Computer Applications

OMNI 6000 and OMNI 3000 Flow Computers are integral into the majority of liquid and gas flow measurement and control systems. The current firmware revisions of OMNI 6000/OMNI 3000 Flow Computers are:

- **23/27:** Orifice/Turbine Gas Flow Metering Systems (US/metric units)

About the User Manual

This manual applies to 23/27 firmware revisions of OMNI 6000 and OMNI 3000 Flow Computers. It is structured into 5 volumes and is the principal part of your flow computer documentation.

Target Audience

As a user's reference guide, this manual is intended for a sophisticated audience with knowledge of liquid and gas flow measurement technology. Different user levels of technical know-how are considered in this manual. You need not be an expert to operate the flow computer or use certain portions of this manual. However, some flow computer features require a certain degree of expertise and/or advanced knowledge of liquid and gas flow instrumentation and electronic measurement. In general, each volume is directed towards the following users:

- Volume 1. System Architecture and Installation
  - ♦ Installers
  - ♦ System/Project Managers
  - ♦ Engineers/Programmers
  - ♦ Advanced Operators
  - ♦ Operators
- Volume 2. Basic Operation
  - ♦ All Users
- Volume 3. Configuration and Advanced Operation
  - ♦ Engineers/Programmers
  - ♦ Advanced Operators
- Volume 4. Modbus™ Database Addresses and Index Numbers
  - ♦ Engineers/Programmers
  - ♦ Advanced Operators
- Volume 5. Technical Bulletins
  - ♦ Users with different levels of expertise.

Manual Structure

The User Manual comprises 5 volumes; each contained in separate binding for easy manipulation. You will find a detailed table of contents at the beginning of each volume.

The User Manual comprises 5 volumes; each contained in separate binding for easy manipulation. You will find a detailed table of contents at the beginning of each volume.

User Reference Documentation *– The User Manual is structured into five volumes. Volumes 1, 2, and 5 are generic to all flow computer application revisions. Volumes 3 and 4 are application specific. These have four versions each, published in separate documents; i.e., one per application revision per volume. You will receive the version that corresponds to your application revision.*

The volumes respective to each application revision are:

Revision 23/27: *Volume #s 3, 4*

Volume 1. System Architecture and Installation

Volume 1 is generic to all applications and considers both US and metric units. This volume describes:

* Basic hardware/software features
* Installation practices
* Calibration procedures
* Flow computer specifications

Volume 2. Basic Operation

This volume is application specific and is available in four separate versions (one for each application revision). It covers the essential and routine tasks and procedures that may be performed by the flow computer operator. Both US and metric units are considered.

General computer-related features are described, such as:

* Overview of keypad functions
* Adjusting the display
* Clearing and viewing alarms
* Computer totalizing
* Printing and customizing reports

The application-related topics may include:

* Batching operations
* Proving functions
* PID control functions
* Audit trail
* Other application specific functions

Depending on your application, some of these topics may not be included in your specific documentation. An index of display variables and corresponding key press sequences that are specific to your application are listed at the end of each version of this volume.

Volume 3. Configuration and Advanced Operation

Volume 3 is intended for the advanced user. It refers to application specific topics and is available in four separate versions (one for each application revision). This volume covers:

* Application overview
* Flow computer configuration data entry
* User-programmable functions
* Modbus™ Protocol implementation

Flow equations and algorithms

Volume 4. Modbus™ Database Addresses and Index Numbers

Volume 4 is intended for the system programmer (advanced user). It comprises a descriptive list of database point assignments in numerical order, within our firmware. This volume is application specific, for which there is one version per application revision.

Volume 5. Technical Bulletins

Manual Updates and Technical Bulletins *– Volume 5 of the User Manual is a compendium of Technical bulletins. You can view and print technical bulletins from our website:* ***http://www.omniflow.com***

Volume 5 includes technical bulletins that contain important complementary information about your flow computer hardware and software. Each bulletin covers a topic that may be generic to all applications or specific to a particular revision. They include product updates, theoretical descriptions, technical specifications, procedures, and other information of interest.

This is the most dynamic and current volume. Technical bulletins may be added to this volume after its publication.

Conventions Used in this Manual

Several typographical conventions have been established as standard reference to highlight information that may be important to the reader. These will allow you to quickly identify distinct types of information.

CONVENTION USED	DESCRIPTION
	The light bulb icon indicates a tip, suggestion, or concise information of interest. It is highly recommended that you read them.
Keys / Key press Sequences Example: **[Prog] [Batch] [Meter] [*n*]**	Keys on the flow computer keypad are denoted with brackets and bold face characters (e.g.: the 'up arrow' key is denoted as **[↑]**). The actual function of the key as it is labeled on the keypad is what appears between brackets. Key press sequences that are executed from the flow computer keypad are expressed in a series of keys separated by a space (as shown in the example).

Screen Displays
Example:
`Use Up/Down Arrows`
`To Adjust Contrast;`
`Left, Right Arrows`
`To Adjust Backlight`
	Sample screens that correspond to the flow computer display appear surrounded by a dark gray border with the text in bold face characters and mono-spaced font. The flow computer display is actually 4 lines by 20 characters. Screens that are more than 4 lines must be scrolled to reveal the text shown in the manual.

Headings Example: **2. Chapter Heading** **2.3. Section Heading** **2.3.1. Subsection Heading**	Sequential heading numbering is used to categorize topics within each volume of the User Manual. The highest heading level is a chapter, which is divided into sections, which are likewise subdivided into subsections. Among other benefits, this facilitates information organization and cross-referencing.
Figure Captions Example: **Figure. 2-3.** *Figure No. 3 of Chapter 2*	Figure captions are numbered in sequence as they appear in each chapter. The first number identifies the chapter, followed by the sequence number and title of the illustration.
Page Numbers Example: **2-8**	Page numbering restarts at the beginning of every chapter and technical bulletin. Page numbers are preceded by the chapter number followed by a hyphen. Technical bulletins only indicate the page number of that bulletin. Page numbers are located on the outside margin in the footer of each page.

Trademark References

The following are trademarks of OMNI Flow Computers, Inc.:

- OMNI 3000
- OMNI 6000
- OmniCom®

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OMNI Flow Computers, Inc., in conformance with its policy of product development and improvement, may make any necessary changes to this document without notice.

Warranty, Licenses and Product Registration

Important!

Product warranty and licenses for use of OMNI flow computer firmware and of OmniCom Configuration PC Software are included in the first pages of each Volume of this manual. We require that you read this information before using your OMNI flow computer and the supplied software and documentation.

If you have not done so already, please complete and return to us the product registration form included with your flow computer. We need this information for warranty purposes, to render you technical support and serve you in future upgrades. Registered users will also receive important updates and information about their flow computer and metering system.

Chapter 1

Overview of Firmware Revisions 23/27

Orifice / Turbine / Coriolis/ Ultrasonic Gas Flow Metering Systems

1.1. Number of Meter Runs - Type of Flowmeters

Minimum 1 run, maximum 4 runs – Typical gas orifice meter run shown.

1.2. Product Configuration

Parallel runs measuring the same product or independent runs with different products.

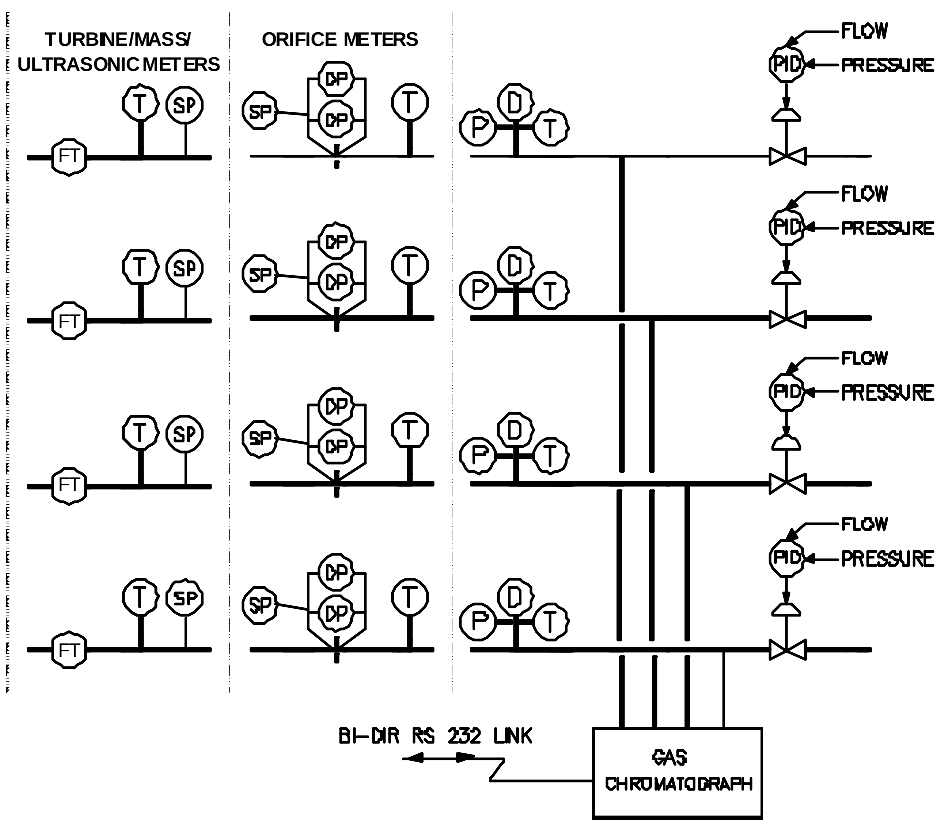

Figure. 1-1. Typical Gas Flow Metering Configuration Using Turbine / Coriolis/Ultrasonic and Orifice Flowmeters

1.3. Configurable Sensors per Meter Run

Meter turbines, differential pressures, Rosemount Multivariable DP, Honeywell Multivariable DP, Instroment Qsonic, V-Cone Flowmeter, FMC MPU1200, Equimeter AAT, Daniel Ultransonic, Coriolis Meter, FlowSic 600 Ultrasonic, meter temperature and pressure, meter density, density temperature and pressure.

1.4. Temperature, Pressure and Differential Pressure Transmitters

All transmitters can be 4-20mA, 1-5V or Honeywell DE digital protocol types. In addition temperature sensors can also be four wire DIN or American curve RTD probes connected directly.

1.5. Densitometers

Can be configured for any combination or mix of individual or shared densitometers of any type (analog specific gravity, analog density, digital Solartron pulse, digital Sarasota pulse or digital UGC pulse); the maximum number that can be connected is four.

1.6. Gas Chromatographs

Where applicable, analysis data can be obtained automatically via a serial communication port from a gas chromatograph. Standard protocols communicate with (1) Applied Automation™ analyzers, (2) Daniels™ Danalyzer, (3) other analyzers which communicate using Modbus™ protocol. It is now possible to read two independent Gas Chromatographs streams via the third serial port.

1.7. Station Capability

Meter runs may be combined or subtracted in any mode to provide station flow rates and totalizers. Can be used in 'Check /Pay' meter systems to monitor flows and alarm if deviations exceed a preset limit.

1.8. Gas Products - Information Stored / Product

Information for four different gases can be stored. Product setup information includes: name, type of gas, component analysis, relative density at reference conditions and calculation algorithm to be used when running the product.

1.9. Type of Gases Measured

Natural gas and other fluids covered by: AGA 3 1992; API 14.3; AGA 8 Reports 1994, 1992 and 1985; ASTM Steam; NIST Steam, Water, Argon, Nitrogen, Oxygen, paraHydrogen, and Ethylene using NIST 1048.

1.10. Totalizing and Batching

Gross (uncorrected) volume, Net (standard conditions) volume, Mass and Energy totalizers are provided for each meter run and defined station group. Separate totalizer sets provide, Cumulative (non resettable) Daily and Batch totalizers. The Batch totalizers can be used to provide either weekly, monthly or on demand totalizing information.

1.11. PID Control Functions

Four independent control loops are provided for control of a primary variable with either high or low override control by a secondary variable. Contact closure inputs are activated to provide a startup ramp function for each control loop if needed. Primary set point can be adjusted via an analog input, a keypad entry or communication link. Control loops are not dedicated and may be cascaded. Data is processed every 500 msec.

1.12. Master Meter Proving

Master Meter proving has been added. Meter I/O point #4 has to be setup as the Master Meter Input.

1.13. Time Weighted and Flow Weighted Averages

Either Flow weighted or time weighted averages for all input variables and correction factors based on daily flow or batch flow are standard. Because errors such as entering an incorrect orifice diameter, would cause large flow errors and errors in the flow weighted averages, time weighted averages are calculated for orifice metering runs. Averaging does not occur if the flow rate is zero. All variables associated with Turbine metering runs are flow weighted averaged. Gas chromatograph data is always time weighted.

1.14. User-Programmable Digital I/O

Each I/O point is individually configurable as either an input or output with variable 'delay On' and 'delay Off'. Pulse widths are adjustable when used as auxiliary totalizer outputs or sampler outputs.

1.15. User-Programmable Logic Functions

Sixty-four logic statements can be user programmed to control meter run switching and provide user auxiliary control functions.

1.16. User-Programmable Alarm Functions

Sixteen of the programmable logic statements described above can be used to contain custom text messages which can be displayed, logged and printed.

1.17. User-Programmable Variables

Sixty-four user variables can be programmed to manipulate data for display and printing or remote access via a communication port. Typical uses include, special units conversions, customer averaging algorithms for leak detection, special limit checking and control functions. The programmable variable statements can also be used to type cast data of one type to another (i.e., change a floating point variable to an integer type so that a PLC or DCS system can make use of it).

1.18. User Display Setups

The user may specify eight key press combinations which recall display screens. Each user display screen can show four variables each with a descriptive tag defined by the user.

1.19. User Report Templates

Using OmniCom the user can generate custom report templates or edit existing templates. These are uploaded into the flow computer. Custom templates for the snapshot, batch end, daily and prove reports can be defined.

1.20. Serial Communication Links

Up to six serial data links are available for communications with other devices such as printers, SCADA systems, PLC's and other OMNI Flow Computers. Ports communicate using a superset of the Modbus™ protocol (ASCII or RTU). Printer data is ASCII data.

Ethernet communications are also available. Up to two modules per system can be used.

1.21. Peer-to-Peer Communications

OMNI flow computers can be user configured to communicate with each other as equal peers. Groups of data variables can be exchanged or broadcast between other flow computers. Multiple flow computers can share resources such as a PLC.

1.22. Archive Data

Two types of data archiving are possible in the flow computer. (1) Formatted ASCII text using custom report templates, (2) Raw Data using archive records and files.

1.23. OmniCom® Windows Version Software Communications Package

OmniCom® Windows version software is provided with each flow computer, and allows the user to configure the computer on-line or off-line using a personal computer.

1.24. OmniView® Window Version Software Communications Package

A Man-Machine Interface package for the OMNI Flow Computer is also available as an option.

1.25. Detailed Daily Report

A Detailed Daily report has been added for the user to select. The computer stores 35 days configuration data of each meter run for this report. The data includes low flow cutoff, viscosity, isentropic expansion factor, pipe diameter at reference temperature, orifice diameter at reference temperature, density of air, base temperature, base pressure atmospheric pressure and the daily average of water content. See under 'Password Maintenance" for associated entry. To print the report Press 'Prog' 'Print' 'Enter and scroll down to the entry (which must be activated under the Password Menu screen) to display 'Meter # Detail Report and enter the meter number to print the report.

1.26. Maintenance Mode

Totalizer Maintenance Mode has been added to firmware 23.74.30 and 27.74.30.

For additional help see technical bulletin 52-0000-0010 (TB980701).

1.27. HART Protocol

Firmware version 23/27.75 can now accept HART enabled devices (Differental Pressure, Temperature or Pressure transmitters) communication. The user can now configure the HART enabled devices thru the use of a new I/O module which can be setup as a HT or HM module. See Technical Bulletin 52-0000-0019 (TB090003) for additional information.

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Chapter 2

Flow Computer Configuration

2.1. Introduction

Configuration data is stored in the computer's battery backed-up RAM memory which will retain its data for at least 1 to 2 months with no power applied. Configuration data can be entered using one of three methods:

1) Configure off-line using the OmniCom PC configuration program and then uploading all data at once.
2) Configure on-line using the OmniCom PC configuration program which uploads each change as it is entered.
3) Enter configuration data via the front panel keypad using the Program Mode.

Methods 1) and 2) require an IBM compatible PC running the OmniCom Configuration Software and are described in **Volume 5** and in OmniCom Help. Method 3) is described here.

2.2. Configuring with the Keypad in Program Mode

2.2.1. Entering the Program Mode

INFO: *Key presses are denoted in bold face between brackets; e.g.: the enter key appears in this manual as* ***[Enter].***

While in the Display Mode press the **[Prog]** key. The front panel Program LED above the key will glow green and the following selection menu will be displayed on the first three lines of the LCD display. The 4th line of the display is used to show the user key presses.

```
Press Keys to Select
Group Entry, or
Press "Prog" to Exit
```

2.2.2. Changing Data

Data can be accessed using a sequential list of menu prompts or in a random access manner by going directly to a specific group of entries.

2.2.3. Menu Selection Method

INFO: *Characters in '**[ ]**' refer to key presses.*

TIP: *It is best to use the menu selection method when programming an application for the first time as every possible option and variable will be prompted. Once a computer is in operation and you become familiar with the application you can decide to use the faster Random Access Method. To use the menu selection method, while in the Program Mode (program LED on) press **[Setup] [Enter]**. A Setup Menu similar to the one on the right will be displayed*

```
***  SETUP MENU  ***
Misc Configuration _
Time/Date Setup
Printer Setup
Analyser Setup
PID Control Setup
Grav/Density Setup
Temperature Setup
Pressure Setup
DP Inches of Water
Prover Setup
Station Setup
Meter Run Setup
Factor Setup
FluidData&Analysis
```

Use the **[↑]/[↓]** (up/down arrow) keys to move the cursor to the appropriate entry and press **[Enter]** to access a particular submenu. The first menu, 'Misc Configuration', should always be completed first as these entries specify the number and type of input and output devices connected to the flow computer; i.e., the menus following the 'Misc Configuration' menu do not ask for configuration data unless a transducer has been defined.

2.2.4. Random Access Method

In addition to the Setup Menu, the data is also presented in related groups such as Temperature, Pressure, Meter, etc. You press the group key of your choice to get to a data area. By specifying a meter run before or after a group you go directly to the data for that group and that group only.

Once a group is selected use the 'Up/Down' arrow keys to step to a specific data entry within the group. You can view data and, assuming a valid password has been entered, change its value as required. If an error is made, press **[Clear]**, re-enter the correct data and press **[Enter]** to enter the new value. The cursor will automatically step to the next data item in that group unless that would cause a total change of screen (i.e., you can always verify your entry). A list of data groups and associated key presses is listed later in this chapter.

Example:

Pressing **[Temp]** will allow you access to temperature data for all meter runs. Pressing **[Meter] [1] [Temp]** or **[Temp] [Meter] [1]** will allow access to only Meter Run #1 temperature data. For example, pressing **[Meter] [1] [Temp]** will display the following until the **[Enter]** key is pressed.

```
Press Keys to Select
Group Entry, or
Press "Prog" to Exit
Meter 1 Temp
```

Pressing the **[Enter]** key will display a screen similar to this:

```
TEMPERATURE #1 Deg.F
Low Limit       30.0
High Limit     125.0
Override        60.0
```

2.2.5. Passwords

INFO: *Most entry groups occupy multiple screens so be sure to use the **[↑]/[↓]** to scroll and see all data.*

Except when changing transducer high/low alarm limits, a password is usually asked for when changing the configuration data within the computer.

The flow computer has independent password protection of the following:

- Local Keypad Access / Modbus Port #1 (selectable)
- (Physical Serial Port #1)
- Modbus Port #2 - (Physical Serial Port #2)
- Modbus Port #3 - (Physical Serial Port #3)
- Modbus Port #4 - (Physical Serial Port #4)

Local Keypad Access

Three password levels are provided:

- Privileged Level: Allows complete access to all entries within the flow computer including keypad passwords 1, 1A and 2 below. The initial privileged password for each Modbus port is selected via this password level.
- Level 1: This level allows technician access to most entries within the flow computer with the exception of I/O Points assignments, programmable variables and Boolean statements and passwords other than 'Keypad Level 1'.
- Level 1A: This level allows technician access to the following entries only:
  - ♦ Meter Factors
  - ♦ K Factors
  - ♦ Densitometer Correction Factors (Pycnometer Factor)
- Level 2: Allows access to the operator type entries. These entries include:
  - ♦ Transducer Manual Overrides
  - ♦ Product Gravity Overrides
  - ♦ Prove Operations
  - ♦ Batching Operations

Changing Passwords at the Keypad

INFO: *Characters in '**[ ]**' refer to key presses.*

1) At the keypad press **[Prog] [Setup] [Enter]**.
2) With the cursor blinking on '**Misc Configuration**', press **[Enter]**.
3) With the cursor blinking on '**Password Maint?**', press **[Enter]**.
4) Enter the Privileged Level Password (up to 6 Characters) and press **[Enter]**.
5) The Level 1, 1A and Level 2 passwords can now be viewed and changed if required.
6) Scroll down to access each of the Modbus serial port 'Level A' passwords. These are labeled 'Serial 1' (if Modbus Protocol is selected), 'Serial 2', Serial 3', and 'Serial 4' corresponding to the physical port numbering for Modbus Ports 1, 2, 3 and 4.

INFO: *See Technical Bulletin 52-0000-0001 (**TB-960701)** in **Volume 5** for setting Level B and Level C passwords using OmniCom.*

NOTE: *Level B and Level C passwords for each Modbus port cannot be viewed or changed from the keypad*

INFO: *The Help System is not limited to just the Program Mode. Context sensitive help is available in all modes of operation*

2.3. Getting Help

Context sensitive help is available for most data entries. Help is summoned by pressing the **[Display/Enter]** key twice (**[Help]** key) with the cursor on the data field in question. Help screens are frequently more than 1 full screen so always use the **[↑]/[↓]** keys to scroll in case there is more. Press **[Prog]** or **[Enter]** once to exit the help system and return to your original screen.

2.4. Program Inhibit Switch

A 'Program Inhibit Switch' mounted behind the front panel prevents unauthorized changing of data when in the 'Inhibit' position. Most data can be viewed while the switch is in the program inhibit position, but any attempt to alter data will be ignored and cause 'PROGRAM LOCKOUT' to be displayed on the bottom line of the LCD display.

The inner enclosure of the flow computer can be locked or sealed within the outer enclosure blocking access to the 'Program Inhibit Switch'.

CAUTION! *These units have an integral latching mechanism which first must be disengaged by lifting the bezel upwards before withdrawing the unit from the case.*

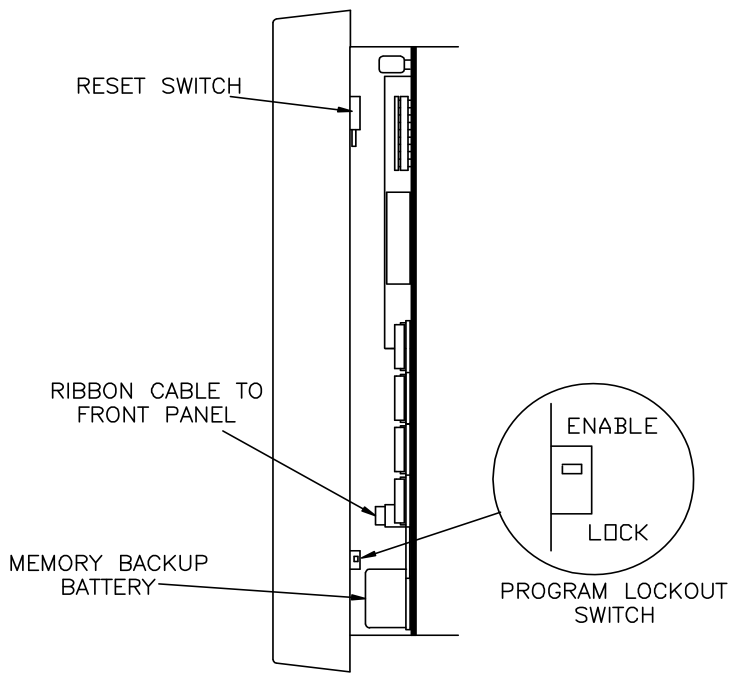


Figure. 2-1. Figure Showing Program Inhibit Switch

2.5. Configuring the Physical Inputs / Outputs

TIP: *It is best to use the Menu Selection Method (see **2.2.3**, this chapter) when programming an application for the first time as every possible option and variable will be prompted. Once a computer is in operation and you become familiar with the application you can decide to use the faster Random Access Method (see **2.2.4**, this chapter)*

INFO: *Characters in '**[ ]**' refer to key presses*

INFO: *The first menu, 'Misc Configuration', should always be completed first as these entries specify the number and type of input and output devices connected to the flow computer. You are advise to complete all entries under this menu before proceeding. Only transducers that have been assigned to physical I/O points will be available for further configuration (i.e., the menus following the 'Misc Configuration' menu do not ask for or accept configuration data unless a transducer has been defined). (See **2.5.2**, this chapter)*

The OMNI Flow Computer can accept many I/O modules and be configured to match just about any combination of measurement transmitters. Configuring the physical I/O means setting up the number of meter runs, what types of transducers are to be used and to which physical I/O points they are connected.

2.5.1. Miscellaneous I/O Configuration (Misc. Setup Menu)

The physical I/O configuration of the flow computer is changed by entering the '**Misc. Setup**' menu while the '**Select Group Entry**' screen is displayed (see **9.2.1.** "**Entering the Program Mode**"

```
Press Keys to Select
Group Entry, or
Press "Prog" to Exit
Setup
```

Press **[Setup]** then **[Enter]** and the following selection menu will be displayed:

```
***  SETUP MENU  ***
Misc Configuration _
Time/Date Setup
Station Setup
```

The cursor automatically appears at the 'Misc Configuration' option. Press **[Enter]** and the following selection menu will be displayed:

```
*** Misc. Setup ***
Password Maint?(Y)
Check Modules ?(Y)
Config Station?(Y)
Config Meter "n"
Config PID ? "n"
Config D/A Out"n"
Front Pnl Counters
Program Booleans ?
Program Variables?
User Display ? "n"
Config Digital"n"
Serial I/O "n"
Peer/Peer Comm(Y)?
Custom Packet "n"
Archive File "n"
```

2.5.2. Physical I/O Points not Available for Configuration

Configuration parameter groups are only prompted as needed. Meter runs and transducers which are not assigned to a physical I/O point will not be available for configuration. In these cases the following message will be displayed: If this message is displayed, check the I/O point assignment for the variable.

```
Variable Selected is
Not Assigned to a
Physical I/O Point
```

2.5.3. Password Maintenance Settings

Password maintenance settings can only be entered via the OMNI front panel keypad. Enter **[Y]** at '**Password Maint ?**' of the '**Misc Setup**' menu to open the following entries:

INFO: *Characters in '{ }' refer to password levels. Characters in '**[ ]**' refer to key presses.*

TIP: *Use the blank lines provided next to each configuration option to write down the corresponding settings you entered in the flow computer. Some of these entries may not appear on the display or in OmniCom. Depending on the various configuration settings of your specific metering system, only those configuration options which are applicable will be displayed*

{PL} Privileged ________________

Enter the privileged password to allow you to view and change all configuration data including other passwords.

{PL} Level 1 ________________

Enter the Level 1 password to allow entry of all configuration data except entries which determine the physical I/O personality of the computer.

{PL} Level 1A ________________

Enter the Level 1A password to allow entry of Meter factors, K Factors and Density Correction Factors only.

{PL} Level 2 ________________

Enter the Level 2 password which is required for operator type entries such as gravity overrides and meter factors.

{PL} Serial Port #1 Password ________________

Enter the Serial Port password. All data in the Modbus database except passwords can be read via the serial ports. These passwords allow writes to the Modbus database. Password protection can be disabled by entering a blank field as a password.

{PL} Lockout Switch Active? (Serial Port #1) ________________

Enter **[N]** for the lockout switch to be **inactive** for this serial port.

Enter **[Y]** for the lockout switch to be **active** for this serial port.

{PL} Serial Port #2 Password ________________

Enter the Serial Port #2 Password.

{PL} Lockout Switch Active? (Serial Port #2) ________________

{PL} Serial Port #3 Password ________________

{PL} Lockout Switch Active? (Serial Port #3) _______________

{PL} Serial Port #4 Password _______________

{PL} Lockout Switch Active? (Serial Port #4) _______________

{PL} Serial Port #5 Password _______________

{PL} Lockout Switch Active? (Serial Port #5) _______________

{PL} Serial Port #6 Password _______________

{PL} Lockout Switch Active? (Serial Port #6) _______________

2.5.4. Entries Requiring a Valid Privileged Password

The following entries display only when a Valid Privileged Password is entered:

{PL} Model Number (0=3000, 1=6000) _______________

This entry is used by the OmniCom configuration software to determine the maximum I/O capability of the computer.

{PL} Disable Download? _______________

Enter 'Y' to prevent OmniCom from downloading the configuration file to the OMNI Flow Computer.

{PL} Re-configure Archive _______________

Enter **[Y]** to re-configure archive records definition. Enter **[N]** when finished.

{PL} Archive Run (Y/N) _______________

Enter **[Y]** to start the archive running.

CAUTION! *If you change the number or type of installed I/O modules, you must perform the 'Check Modules' Function to inform the computer that you wish to use the new hardware configuration.*

{PL} Start Screen Default (Y/N) _______________

Enter **[Y/N]** for the computer to return to the last viewed display after a reset or power down Default is N. If using default, user must review historical alarm for any system fail codes.

{PL} Dual Pulse Comparison Delay Cycle 0-20 _______________

Maximum threshold and dual pulse delay cycle. Dual Pulse Comparison will be activated when the accumulated error counts exceed this number. For the delay cycle enter 0-20 as the number of 500ms cycle delays, differentiate between simultaneous noise with A=0 and a A failure

{PL} Activated Detailed Daily Report ? _______________

Enter Y to activate a Detailed Daily Report within the Flow Computer.

{PL} Reset All Totalizers? (Y/N) ______________

Entering Y will reset all current meter totalizers to 0.0. Once this has been done the user will see another display " All Totalizers now reset" and the user can now select the totalizers resolution # of digits, 0=9, 1=8. Next the user can select the decimal place resolution for the front panel by selecting the number of decimal places required for Gross, Net and Mass. The three electromechanical totalizers on the front of the computer cannot be zeroed.

{PL} Reset All RAM? (Y/N) ______________

Resetting all RAM will clear all configuration data, calibration data and totalizers. This means that all configuration data will have to be re-entered.

{PL} Input Calibrate Default? ______________

Entering a **[Y]** here will set all the analog input calibration constants used to scale zero and span settings to the default value. This will require you to re calibrate all the inputs. **You can also do this on a channel by channel basis by entering the input channel number**.

{PL} D/A Calibrate Default? ______________

Entering a **[Y]** here will set all the analog output calibration constants used to scale zero and span settings to the default value. This will require you to re-calibrate all the outputs. **You can also do this on a channel by channel basis by entering the output channel number**.

2.5.5. Module Settings

Enter **[Y]** at '**Check Modules?**' of the '**Misc Setup**' menu and a screen similar to the following will display:

```
MODULE S-WARE H-WARE
A-1       Y      Y
B-1       Y      Y
E-1       Y      Y
H-1       Y      Y
D-2       Y      Y
S-1       Y      Y
SE-1       Y      Y
Update S-Ware ?
```

{PL} Update S-Ware? (Y) ______________

A table is displayed showing all of the physically installed I/O modules verses the I/O modules recognized by the software (see display example above). You must answer the 'Update Software' question entering **[Y]** whenever you change the number or type of installed modules. The available I/O point numbers are allocated to each module at this time according to the type and number of each module (see **Chapter 2** for more information).

2.5.6. Meter Station I/O Assignments

INFO: *The number of process variable I/O points available depends on the number of combo modules installed (see* ***Chapter 2*** *in* ***Volume 1*** *for more information). Point numbers range from 01 through 24. Assign* ***[0]*** *to 'invalidate the assigning of a variable.*

I/O Type Mismatch: *The computer will not let you assign the same I/O point # to incompatible transducer types; i.e., an I/O point cannot be assigned as a temperature input for Meter Run #1 and a pressure input for Meter Run #2. If the 'I/O Type Mismatch' message is displayed, recheck the I/O.*

Shared Transducers: *Enter the same I/O point to share transducers between meter runs.*

Correcting a Mistake: *Enter an I/O point # of* ***[0]*** *to cancel an incorrectly entered I/O point #, then enter the correct number.*

Assigning I/O Point #99: *This indicates that the associated variable will be available for display and be used in all calculations, but will not be obtained via a live input. The variable value is usually downloaded into the flow computer database via a communication port or via a user variable statement.*

Enter **[Y]** at '**Config Station?**' of the '**Misc Setup**' menu to open the following entries:

{PL} Station Configured As: ________________

Station Totals and Flows Defined As: Define which meter runs will be included in the station flow rates and totalizers. Meter data can be added or subtracted.

Example: Entering **[1] [+] [2] [-] [3] [-] [4]** defines the station flows and totals as the result of Meter Runs #1 and #2 added together, subtracted by the flows of Meters #3 and #4.

Enter **[0]** for no station totalizers.

{PL} Reference Specific Gravity (SG) I/O Point # ________________

Enter the physical I/O point number used to input the gas specific gravity at reference conditions (Points 1-24) the live SG will be used in the AGA 8 equation. Enter **[0]** if no live SG is available.

SG Transducer Tag ________________

Enter the 8-character tag name used to identify this SG transducer on the LCD display.

SG Transducer Type ________________

Enter the SG transducer type: 1=4-20mA signal, 2=Solartron 3098 digital pulse.

{PL} Nitrogen (N_2) % I/O Point # ________________

Enter the physical I/O point number used to input this gas analysis variable (Points 1-24). The data from this input signal will be used in the AGA 8 equation of state. Enter **[0]** if this signal is not available to the flow computer.

N_2 % Transducer Tag ________________

Enter the 8-character tag name used to identify this transducer on the LCD display.

{PL} Carbon Dioxide (CO_2) % I/O Point # ________________

Enter the physical I/O point number used to input this gas analysis variable (Points 1-24). The data from this input signal will be used in the AGA 8 equation of state. Enter **[0]** if this signal is not available to the flow computer.

CO_2 % Transducer Tag ________________

Enter the 8-character tag name used to identify this transducer on the LCD display.

{PL} Gas Heating Value (HV) % I/O Point # _______________

Enter the physical I/O point number used to input this gas analysis variable (Points 1-24). The data from this input signal will be used in the AGA 8 equation of state and used to calculate energy flow. Enter **[0]** if this signal is not available to the flow computer.

Gas HV Transducer Tag _______________

Enter the 8-character tag name used to identify this transducer on the LCD display.

Auxiliary Input Assignment

{PL} Auxiliary Input #1 I/O Point # _______________

Enter the physical I/O point number to which this auxiliary input is connected. Auxiliary Inputs can be used to enter miscellaneous variables.

Auxiliary Input #1 Tag _______________

Enter the 8-character tag name used to identify this transducer on the LCD display.

Auxiliary Input Type _______________

Enter the Auxiliary Input Type:

0 = DIN RTD
1 = American RTD
2 = Honeywell Smart Transmitter or 4-20mA.

{PL} Auxiliary Input #2 I/O Point # _______________

Auxiliary Input #2 Tag _______________

Auxiliary Input Type _______________

{PL} Auxiliary Input #3 I/O Point # _______________

Auxiliary Input #3 Tag _______________

Auxiliary Input Type _______________

{PL} Auxiliary Input #4 I/O Point # _______________

Auxiliary Input #4 Tag _______________

Auxiliary Input Type _______________

2.5.7. Meter Run I/O Assignments

Config Meter Runs: *Physical I/O information for up to 4 meter runs can be entered. Transducers that are not assigned an I/O point will not be available for display or further configuration.*

INFO: *The number of process variable I/O points available depends on the number of combo modules installed (see **Chapter 2** in **Volume 1** for more information). Point numbers range from 01 through 24. Assign **[0]** to 'invalidate the assigning of a variable.*

I/O Type Mismatch: *The computer will not let you assign the same I/O point # to incompatible transducer types; i.e., an I/O point cannot be assigned as a temperature input for Meter Run #1 and a pressure input for Meter Run #2. If the 'I/O Type Mismatch' message is displayed, recheck the I/O.*

Shared Transducers: *Enter the same I/O point to share transducers between meter runs.*

Correcting a Mistake: *Enter an I/O point # of **[0]** to cancel an incorrectly entered I/O point #, then enter the correct number.*

Assigning I/O Point #99: *This indicates that the associated variable will be available for display and be used in all calculations, but will not be obtained via a live input. The variable value is usually downloaded into the flow computer database via a communication port or via a user variable statement.*

Enter **[1]**, **[2]**, **[3]** or **[4]** at '**Config Meter "n"**' of the '**Misc Setup**' menu to open the following entries:

{PL} Select Device Type ________________

Select flow measurement device type from 0=Orifice DP, 1=Turbine, 2=Rosemount MV DP, 3=Honeywell HV DP, 4=Instromet Qsonic, 5=V-Cone Flowmeter, 6=FMC MPU 1200, 7=Equimeter AAT, 8=Daniel Ultrasonic, 9=Coriolis Meter, 10=FlowSic 600 UFM

	Meter #1	Meter #2	Meter #3	Meter #4
{PL} Flowmeter I/O Point #	_______	_______	_______	_______

This entry applies only when turbine meters are selected in the entry above. Enter the number of the I/O point used to input the flow signal for each meter run. Flowmeter pulse inputs can only be assigned to the 3rd input channel of A, B and E combo modules, and 4th input channel of A and E combo modules.

Flowmeter Tag _______ _______ _______ _______

This entry applies only when turbine meters are selected in the entry above. Enter the 8-character tag name used to identify this flowmeter on the LCD display.

{PL} Dual Pulse Fidelity Check _______ _______ _______ _______

This entry applies only when turbine meters are selected in the entry above. Enter **[Y]** to enable 'Level A' pulse fidelity and security checking for this meter run (API MPMS Chapter 5, Section 5). This can only be achieved with a flowmeter device which is fitted with two pickoffs which produce pulse trains signals which are not coincident. The pulse trains must be connected to channels 3 and 4 of an 'E Type Combo Module'.

The OMNI will continuously compare both pulse trains and alarm any differences of phase or frequency between the pulse trains. Totalizing will be unaffected by a failure of either pulse train and simultaneous transients and noise pulses will be rejected with an 85 % certainty.

Enter **[N]** if pulse fidelity checking is not to be used.

	Meter #1	Meter #2	Meter #3	Meter #4

{PL} DP Low Range I/O Point # _______ _______ _______ _______

This entry applies only when orifice meters are selected in the entry above. Enter the I/O point used to input the signal from the low range differential pressure signal for this meter run. Duplicate I/O assignments can be made when a transducer is shared between meter runs. (e.g.: forward and reverse flow).

DP Low Range Tag _______ _______ _______ _______

This entry applies only when turbine meters are selected in the entry above. Enter the 8-character tag name used to identify this transmitter on the LCD display.

{PL} DP High Range I/O Point # _______ _______ _______ _______

This entry applies only when orifice meters are selected in the entry above. Enter the I/O point used to input the signal from the low range differential pressure (DP) signal for this meter run. Duplicate I/O assignments can be made when a transducer is shared between meter runs. (e.g.: forward and reverse flow).

Enter **[0]** if stacked DP transmitters are not used.

DP High Range Tag _______ _______ _______ _______

This entry applies only when turbine meters are selected in the entry above. Enter the 8-character tag name used to identify this transmitter on the LCD display.

{PL} Temperature I/O Point # _______ _______ _______ _______

Enter the I/O point number used to input the temperature signal for each meter run. Duplicate I/O assignments are allowed when a sensor is shared by more than one meter run.

Temperature Transmitter Tag _______ _______ _______ _______

Enter the 8-character tag name used to identify this temperature transducer on the LCD display.

Temp Transmitter Type _______ _______ _______ _______

Enter the Temperature Transmitter Type:

0 = DIN RTD probe (α=0.0385)
1 = American RTD probe (α=0.0392)
2 = Honeywell smart transmitter or linear 4-20mA output.

{PL} Pressure I/O Point # _______ _______ _______ _______

Enter the I/O point number used to input the pressure signal for each meter run. Duplicate I/O assignments are allowed when a sensor is shared by more than one meter run.

Pressure Transducer Tag _______ _______ _______ _______

Enter the 8-character tag name used to identify this pressure transducer on the LCD display.

{PL} Density I/O Point # ________ ________ ________ ________

Enter the I/O point number used to input the density signal for each meter run. Duplicate I/O assignments are allowed when a densitometer is shared by more than one meter run. Digital pulse densitometers can only be assigned I/O point numbers corresponding to the 4th input channel of a B type Combo Module or the 3rd and 4th input channels of an E/D combo module.

Density Transducer Tag ________ ________ ________ ________

Enter the 8-character tag name used to identify this density transducer on the LCD display.

Densitometer Type ________ ________ ________ ________

Enter the Densitometer Type:

1 = Not applicable
2 = 4-20 SG linear
3 = 4-20 Density linear (gr/cc)
4 = Solartron pulse
5 = Sarasota pulse
6 = UGC pulse.

{PL} Dens Temperature I/O Point # ________ ________ ________ ________

Enter the I/O point number used to input the signal applied to compensate for temperature effects at the densitometer for each meter run.

If the densitometer has no temperature sensor fitted, enter the same I/O point assignment as the meter run temperature sensor.

Dens Temp Transmitter Tag ________ ________ ________ ________

Enter the 8-character tag name used to identify this density temperature transducer on the LCD display.

Dens Temp Transmitter Type ________ ________ ________ ________

Enter the Densitometer Temperature Transmitter Type:

0 = DIN RTD probe (α=0.0385)
1 = American RTD probe (α=0.0392)
2 = Honeywell smart transmitter or linear 4-20mA output.

Meter #1 **Meter #2** **Meter #3** **Meter #4**

{PL} Dens Pressure I/O Point ________ ________ ________ ________

Enter the I/O point number used to input the signal applied to compensate for pressure effects at the densitometer for each meter run.

If the densitometer has no pressure sensor fitted, enter the same I/O point assignment as the meter run pressure sensor.

Dens Press Transducer Tag ________ ________ ________ ________

Enter the 8-character tag name used to identify this density pressure transducer on the LCD display.

2.5.8. PID Control I/O Assignments

Proportional Integral Derivative (PID): *For practical reasons we refer to PID Control Loops in this manual. However, your flow computer actually performs the Proportional Integral (PI) function and does not apply the derivative term. The addition of the derivative term would greatly complicate tuning of the control loop and besides is not normally applicable to the types of flow and pressure control used in pipelines.*

Valid Assignments: *Any integer or floating point variable within the database can be assigned to be the primary or secondary controlled variable (see **Volume 4** for a complete listing of database addresses and index numbers)*

Enter **[1]**, **[2]**, **[3]** or **[4]** at '**Config PID? "n"**' of the '**Misc Setup**' menu to open the following password Privileged Level **{PL}** entries:

	Loop #1	Loop #2	Loop #3	Loop #4
Assign Primary Variable	________	________	________	________

Enter the database index number of the primary variable in the PID loop.

Remarks ______________ ______________ ______________ ______________

Enter a remark in this 16-character field to identify the function of each variable assignment.

Primary Action (F/R) ________ ________ ________ ________

Enter **[F]** (forward action) if the value of the primary variable increases as the controller output % increases. Enter **[R]** (reverse action) if the value of the primary variable decreases as the controller output % increases.

Remote Setpoint I/O Point # ________ ________ ________ ________

Enter the I/O point number that the remote set point analog signal is connected to (01-24). Assign this point to **99** in cases where the set point will be downloaded via a communication port. Enter **[0]** if you will not be using a remote setpoint.

Assign Secondary Variable ________ ________ ________ ________

Enter the database index number of the secondary variable in the PID loop.

Remarks ______________ ______________ ______________ ______________

Enter a remark in this 16-character field to identify the function of each variable assignment.

Secondary Action (F/R) ________ ________ ________ ________

Enter **[F]** (forward action) if the value of the primary variable increases as the controller output % increases. Enter **[R]** (reverse action) if the value of the primary variable decreases as the controller output % increases.

	Loop #1	Loop #2	Loop #3	Loop #4
Error Select (L/H)	________	________	________	________

This entry determines the circumstances under which the primary or secondary variables are controlled. Enter **[L]** for low or **[H]** for high error select, according to the following modes:

MODE #1

Are both primary and secondary actions forward?

- yes → Enter **[L]** for Low Error Select
- no → Is secondary action forward?
  - yes → Enter **[L]** for Low Error Select
  - no → Enter **[H]** for High Error Select

MODE #2

Are both primary and secondary actions forward?

- yes → Enter **[H]** for High Error Select
- no → Is secondary action forward?
  - no → Enter **[L]** for Low Error Select

Mode #1: The controller will attempt to control the primary variable but will switch to controlling the secondary variable, should the controller be trying to drive the secondary variable ABOVE its setpoint. An example of this mode would be controlling flow rate (primary) while not exceeding a MAXIMUM delivery pressure (secondary).

Mode #2: The controller will attempt to control primary variable but will switch to controlling the secondary variable, should the controller be trying to drive the secondary variable BELOW its setpoint. An example of this mode would be controlling flow rate (primary) while not dropping below a MINIMUM pressure value (secondary).

	Loop #1	Loop #2	Loop #3	Loop #4
Startup Mode (L/M)	________	________	________	________

This entry determines how the computer handles a system reset such as a momentary loss of power. Enter **[L]** (Last) to cause the PID loop to stay in the operating mode it was last in before the system reset. Enter **[M]** (Manual) to cause the PID loop to startup with the PID loop in manual control mode and with the valve open % as it was before the system reset.

	Loop #1	Loop #2	Loop #3	Loop #4
PID Tag	________	________	________	________

Enter an 8-character tag name to identify the PID controller output signal on the LCD display.

2.5.9. Analog Output Assignments

Press **[*n*] [Enter]** at '**Config D/A Out "n"**' of the '**Misc Setup**' menu to open the following password Level 1 **{L1}** entries (n = D/A Output #):

	Assign	at 4mA	at 20mA
Analog Output #1	___________	___________	___________

Under '**Assign**', enter the database index number of the variable that will be assigned to the digital-to-analog output points.

Under '**at 4mA**' and '**at 20mA**', enter the required scaling parameters in engineering units at 4mA and 20mA (e.g.: For Meter #1 Net Flow Rate assign **7102**. Typical scaling might be 4mA=0.0 Bbls/hr and 20mA=1000.0 Bbls/hr).

Remark _______________

Enter a remark in this 16-character field which identifies and documents the function of each digital-to-analog output.

	Assign	at 4mA	at 20mA
Analog Output #2	___________	___________	___________
Remark	_______________		
Analog Output #3	___________	___________	___________
Remark	_______________		
Analog Output #4	___________	___________	___________
Remark	_______________		
Analog Output #5	___________	___________	___________
Remark	_______________		
Analog Output #6	___________	___________	___________
Remark	_______________		
Analog Output #7	___________	___________	___________
Remark	_______________		
Analog Output #8	___________	___________	___________
Remark	_______________		
Analog Output #9	___________	___________	___________
Remark	_______________		
Analog Output #10	___________	___________	___________
Remark	_______________		
Analog Output #11	___________	___________	___________
Remark	_______________		
Analog Output #12	___________	___________	___________
Remark	_______________		

NOTE: The number of Analog Outputs can be up to 18 outputs. This number of analog outputs can be achieved by using SV modules along with regular I/O Modules.

2.5.10. Front Panel Counter Settings

Enter **[Y]** at '**Front Pnl Counters**' of the '**Misc Setup**' menu to open the following password Level 1 **{L1}** entries:

	Counter A	Counter B	Counter C
Assign Front Panel Counter	____	____	____

Enter the database index number of the accumulator variable that will be output to this electromechanical counter.

The unit of measure is the same as that shown on the LCD for the totalizer (i.e., barrels, klbs, m^3, etc.) The maximum count rate is limited to 10 counts per second. Count rates higher than 10 pulses per second will cause the computer to remember how many counts did not get output and continue to output after the flow stops until all buffered counts are output.

Remark ____ ____ ____

Enter a remark in this 16-character field which identifies and documents the function of each front panel counter.

Pulses/Unit ____ ____ ____

Enter the number of pulses per unit (volume, mass, energy).

2.5.11. Programmable Boolean Statements

Program Booleans: *These 64 Boolean statements are evaluated every 100 msec starting at Point **1025** continuing through **1088**. Each statement can contain up to 3 Boolean variables, optionally preceded by the slash (/) denoting the **NOT** Function and separated by a valid Boolean operator.*

Operator	*Symbol*	*Operator*	*Symbol*	*Operator*	*Symbol*
NOT	/	*AND*	&	*OR*	+
EXOR	*	*EQUAL*	=	*IF*	)
GOTO	G	*MOVE*	:	*COMPARE*	%
INDIRECT	"	*RISING EDGE*	(	*FALLING EDGE*	(/
ONE SHOT	@				

E.g.: *1025 1002&/1003*

*Boolean **1025** is true when point **1002** is true **AND** point **1003** is **NOT** true*
NOTE: *Points **1002** and **1003** in this example reflect the status of Physical Digital I/O Points 2 and 3*

There are no limitations as to what Boolean points can be used in a statement.

Statements can contain the results from other statements

E.g.: *1026 /1025+1105*

*Boolean **1026** is true when Boolean **1025** is **NOT** true **OR** Point **1105** is true*

*Using the '**=**' operator, the result of a statement can initiate a command*

E.g.: *1027 1719=1026*

*Request a 'Snapshot Report' when Boolean **1026** is true*

Enter **[Y]** at '**Program Booleans ?**' of the '**Misc Setup**' menu to open the following password Privileged Level **{PL}** entries:

Boolean Point 10xx	**Equation or Statement**	**Comment or Remark**
25:	______________	______________
26:	______________	______________
27:	______________	______________
28:	______________	______________
29:	______________	______________
30:	______________	______________
31:	______________	______________
32:	______________	______________
33:	______________	______________
34:	______________	______________
35:	______________	______________
36:	______________	______________
37:	______________	______________
38:	______________	______________
39:	______________	______________
40:	______________	______________
41:	______________	______________
42:	______________	______________
43:	______________	______________
44:	______________	______________
45:	______________	______________
46:	______________	______________
47:	______________	______________
48:	______________	______________
49:	______________	______________
50:	______________	______________
51:	______________	______________
52:	______________	______________
53:	______________	______________
54:	______________	______________
55:	______________	______________

Boolean Point 10xx	Equation or Statement	Comment or Remark
56:		
57:		
58:		
59:		
60:		
61:		
62:		
63:		
64:		
65:		
66:		
67:		
68:		
69:		
70:		
71:		
72:		
73:		
74:		
75:		
76:		
77:		
78:		
79:		
80:		
81:		
82:		
83:		
84:		
85:		
86:		
87:		
88:		

2.5.12. Programmable Variable Statements

Program Booleans: *These 64 variable statements are evaluated every 500 msec starting at the statement that determines the value of Points **7025** through **7088**. Each statement can contain up to 3 variables or constants. Variables can be optionally preceded by the '**$**' symbol denoting the **ABSOLUTE** value of the variable is to be used. Constants are identified by placing a '**#**' symbol ahead of the number. These and other operators are.*

Operator	*Symbol*	*Operator*	*Symbol*	*Operator*	*Symbol*
ABSOLUTE	*$*	*ADD*	*+*	*MOVE*	*:*
CONSTANT	*#*	*SUBTRACT*	*-*	*COMPARE*	*%*
POWER	*&*	*EQUAL*	*=*	*INDIRECT*	*"*
MULTIPLY	***	*IF*	*)*	*RISING EDGE*	*(*
DIVIDE	*/*	*GOTO*	*G*	*FALLING EDGE*	*(/*
ONE SHOT	*@*	*RANGE CHECK*	*<*		

The order of precedence is: ABSOLUTE, POWER, MULTIPLY/DIVIDE, ADD/SUBTRACT. In cases where operators have the same precedence, statements are evaluated left to right.

E.g.: *The value of floating point variable **7035** is defined as**: 7035:7027&#0.5*7026.***

*The power operator is evaluated first (the value of Point **7035** is set equal to the square root of the number contained in Point **7027**) and the result is multiplied by the number stored in variable **7026**. Note that statements can contain the results of other statements. (See OmniCom Help for more information by pressing **[F1]** on your PC keyboard in the "Configure Variable Statement' menu.*

Enter **[Y]** at '**Program Variables?**' of the '**Misc Setup**' menu to open the following password Privileged Level **{PL}** entries:

Prog Variable 70xx	Equation or Statement	Comment or Remark
25:	______	______
26:	______	______
27:	______	______
28:	______	______
29:	______	______
30:	______	______
31:	______	______
32:	______	______
33:	______	______
34:	______	______
35:	______	______
36:	______	______
37:	______	______

Prog Variable 70xx	Equation or Statement	Comment or Remark
38:		
39:		
40:		
41:		
42:		
43:		
44:		
45:		
46:		
47:		
48:		
49:		
50:		
51:		
52:		
53:		
54:		
55:		
56:		
57:		
58:		
59:		
60:		
61:		
62:		
63:		
64:		
65:		
66:		
67:		
68:		
69:		
70:		
71:		
72:		

Prog Variable 70xx	Equation or Statement	Comment or Remark
73:	______________________	______________________
74:	______________________	______________________
75:	______________________	______________________
76:	______________________	______________________
77:	______________________	______________________
78:	______________________	______________________
79:	______________________	______________________
80:	______________________	______________________
81:	______________________	______________________
82:	______________________	______________________
83:	______________________	______________________
84:	______________________	______________________
85:	______________________	______________________
86:	______________________	______________________
87:	______________________	______________________
88:	______________________	______________________

TIP: *Use the blank lines provided next to each configuration option to write down the corresponding settings you enter in the flow computer.*

NOTE: *See **Volume 4** for detailed list of Booleans and Status Commands.*

Valid Numeric Variables - *These are any long integer or floating point number within the database (Points **5000-8999**), **including Boolean variables**. For the purpose of evaluation, Boolean variables have the value of 1.0 if they are True and 0.0 if they are False*

2.5.13. User Display Settings

Enter **1** through **8** for the selected user display at '**User Display? "n"**' of the '**Misc Setup**' menu to open the following password Level 1 **{L1}** entries:

User Display #1 Key Press Sequence [__] [__] [__] [__]

Using the keys marked **A** through **Z**, enter the sequence of key presses needed to recall the selected user display (see the side bar for details). A maximum of 4 keys are allowed. User key press sequences take priority over any existing resident key press sequences.

1st Variable Tag ______________

Enter an 8-character tag name used to identify the display variable on the LCD display.

1st Variable Index Number ______________

Enter the database index number of the variable that you want to appear on the LCD display. Each variable within the flow computer database is assigned an index number or address. Any Boolean integer or floating point variable within the database can be displayed.

1st Variable Decimal Point Position ______________

Enter the number of digits to the right of the decimal point for the variable. Valid entries are 0 through 7. The computer will display each variable using the display resolution that you have selected, except in cases where the number is too large or too small. In either case, the flow computer will adjust the decimal position or default to scientific display mode.

	Tag	Index #	Decimal Points
2nd Variable	______	______	______
3rd Variable	______	______	______
4th Variable	______	______	______

User Display #2 Key Press Sequence [__] [__] [__] [__]

	Tag	Index #	Decimal Points
1st Variable	______	______	______
2nd Variable	______	______	______
3rd Variable	______	______	______
4th Variable	______	______	______

User Display #3 Key Press Sequence [__] [__] [__] [__]

	Tag	Index #	Decimal Points
1st Variable	______	______	______
2nd Variable	______	______	______
3rd Variable	______	______	______
4th Variable	______	______	______

User Display #4 Key Press Sequence [__] [__] [__] [__]

	Tag	Index #	Decimal Points
1st Variable	______	______	______
2nd Variable	______	______	______
3rd Variable	______	______	______
4th Variable	______	______	______

User Display #5 Key Press Sequence [__] [__] [__] [__]

	Tag	Index #	Decimal Points
1st Variable	______	______	______
2nd Variable	______	______	______
3rd Variable	______	______	______
4th Variable	______	______	______

User Display #6 Key Press Sequence [__] [__] [__] [__]

	Tag	Index #	Decimal Points
1st Variable	______	______	______
2nd Variable	______	______	______
3rd Variable	______	______	______
4th Variable	______	______	______

User Display #7 Key Press Sequence [__] [__] [__] [__]

	Tag	Index #	Decimal Points
1st Variable	______	______	______
2nd Variable	______	______	______
3rd Variable	______	______	______
4th Variable	______	______	______

User Display #8 Key Press Sequence [__] [__] [__] [__]

	Tag	Index #	Decimal Points
1st Variable	______	______	______
2nd Variable	______	______	______
3rd Variable	______	______	______
4th Variable	______	______	______

2.5.14. Digital I/O Point Settings

TIP: *Use the blank lines provided next to each configuration option to write down the corresponding settings you enter in the flow computer.*

Some of these entries may not appear on the display or in OmniCom. Depending on the various configuration settings of your specific metering system, only those configuration options which are applicable will be displayed.

Config Digital "n": *Assign each physical I/O point to a Modbus address of a Boolean variable. There are no limitations as to what Boolean points can be assigned to physical I/O points. Enter* ***[0]*** *(zero) for Modbus control.*

Assigning as Pulse Outputs: *Meter and Station Accumulators may be output in the form of pulses*

Pulse Width: *Pulse width is measured using 10msec ticks; i.e., 100 = 1 second.*

Pulse per Unit: *Pulse per unit entry can be used to provide unit conversion (e.g.: entering 4.2 pulses per barrel will give 1 pulse every 10 gallons as there are 42 gallons in a barrel). The units of volume, mass and energy flow are the same as is displayed on the LCD.*

Assigning as Control Output: *Any internal alarm or Boolean can be output*

Digital I/O Point Settings (continued)

Enter **1** through **24** for the selected digital I/O Point at '**Config Digital "n"**' of the '**Misc Setup**' menu to open the following password Level 1 **{L1}** entries:

	Assign	Pulse Width	Pulse/Unit or	Delay On	Delay Off
Digital I/O #1	________	________	________	________	________
Remark	______________				
Digital I/O #2	________	________	________	________	________
Remark	______________				
Digital I/O #3	________	________	________	________	________
Remark	______________				
Digital I/O #4	________	________	________	________	________
Remark	______________				
Digital I/O #5	________	________	________	________	________
Remark	______________				
Digital I/O #6	________	________	________	________	________
Remark	______________				
Digital I/O #7	________	________	________	________	________
Remark	______________				
Digital I/O #8	________	________	________	________	________
Remark	______________				
Digital I/O #9	________	________	________	________	________
Remark	______________				
Digital I/O #10	________	________	________	________	________
Remark	______________				
Digital I/O #11	________	________	________	________	________
Remark	______________				
Digital I/O #12	________	________	________	________	________
Remark	______________				

Digital I/O Point Settings (continued)

Assign	Pulse Width	Pulse/Unit	or	Delay On	Delay Off
Digital I/O #13	________	________	________	________	________
Remark	______________				
Digital I/O #14	________	________	________	________	________
Remark	______________				
Digital I/O #15	________	________	________	________	________
Remark	______________				
Digital I/O #16	________	________	________	________	________
Remark	______________				
Digital I/O #17	________	________	________	________	________
Remark	______________				
Digital I/O #18	________	________	________	________	________
Remark	______________				
Digital I/O #19	________	________	________	________	________
Remark	______________				
Digital I/O #20	________	________	________	________	________
Remark	______________				
Digital I/O #21	________	________	________	________	________
Remark	______________				
Digital I/O #22	________	________	________	________	________
Remark	______________				
Digital I/O #23	________	________	________	________	________
Remark	______________				
Digital I/O #24	________	________	________	________	________
Remark	______________				

2.5.15. Serial Input / Output Settings

Baud Rates Available: *300, 600, 1200, 2400, 4800, 9600, 19200, 38400*

Data Bits: *7 or 8 - 7 for ASCII Modbus, 8 for RTU Modbus.*

Stop Bits: *0, 1 or 2.*

Parity Bit: *Odd, Even, None.*

Transmitter Carrier Key Delay: *Delays are approximate only. 0=msec, 1=50msec, 2=100msec, 3=150msec.*

Modbus Type: *Select the protocol type which matches the Modbus master device. If the master can support either ASCII or RTU, choose RTU protocol as it is approximately twice as efficient as the ASCII protocol. Serial Ports #3 and #4 have additional protocol options*

Modicon™ Compatible: *OmniCom will not operate if downloading configuration with this entry set to 'Y'*

Enter **[1]**, **[2]**, **[3], [4], [5] or [6]** at '**Serial I/O "n"**' of the '**Misc Setup**' menu to open the following entries:

{L1} Baud Rate………………………… (Computer Default Mode 9600)

{L1} Number of Stop Bits…………… (Computer Default Mode 1)

{L1} Number of Data Bits…………….. (Computer Default Mode 8)

{L1} Parity Bit (Even/Odd/None)……. (Computer Default Mode N)

{L1} Transmit Carrier Key Delay……. (Computer Default Mode 0)

Enter one of the following options:

0 = 0 msec delay	2 = 100 msec delay
1 = 50 msec delay	3 = 150 msec delay

You must enter **[0]** for Transmitter Carrier Key Delay for any port that will be used with a shared printer.

{L1} Serial Port Type………………….. (Computer Default Mode 0)

This entry corresponds to Serial Port #1 only. Enter one of the following options:

0 = Printer
1 = Modbus RTU

{L1} Modbus Protocol Type…………..(Computer Default Mode 2)

This entry does not apply to Serial Port #1. Enter the type of protocol to be used on this port:

0 = Modbus RTU
1 = Modbus ASCII
2 = Modbus RTU (modem).

Serial Port #4 has the following additional options:

3 = Allen Bradley Full Duplex
4 = Allen Bradley Half Duplex

Mixed protocols are not allowed on a communication link. All devices must use the same protocol type. The RTU protocol is preferred as it is twice the speed of the ASCII. Selecting 'Modbus RTU Modem' provides RTU protocol with relaxed timing which is usually needed when communicating via smart modems. These modems have been found to insert inter-character delays which cause a premature end of message to be detected by the flow computer.

IMPORTANT: You must select either 'Modbus RTU' or 'Modbus RTU Modem' protocol for the port that will be used to communicate with OmniCom PC configuration software.

{L1} Modbus ID………………………… (Computer Default Mode ID 1)

This entry does not apply to Serial Port #1 when a printer is selected as the port type. Enter the Modbus slave ID number that this serial port will respond to (1 through 247 acceptable). This entry will be disabled for Serial Port #1 if a printer is selected as the port type.

> ***Skip CRC/LCR Check:*** *If you have disabled the error checking on incoming messages, you must substitute dummy bytes in the message string. Outgoing messages will always include the error checking bytes*

{L1} Modicon Compatible (Y/N)………… (Computer Default Mode N)

Enter **[Y]** to configure these Modbus ports to be compatible with Modicon PLC equipment (e.g.: 984 series) and DCS systems (e.g.: Honeywell TDC3000 systems using the Advanced Process Manager APM-SI). This entry will be disabled for Serial Port #1 if a printer is selected as the port type.

In this mode the point number indexes requested and transmitted while using the Modbus RTU modes are actually one less than the index number documented in this manual. ASCII mode transmissions use the address documented in this manual. Data is counted in numbers of 16 bit registers rather than points. i.e., To request two 4 byte IEEE floating point variables, index numbers 7101 and 7102, would require the host to ask for 4 registers starting at index 7100. IEEE Floating Point data bytes are transmitted in swapped format:

Normal IEEE Float Format				Order Transmitted			
Byte #1	Byte #2	Byte #3	Byte #4	Byte #1	Byte #2	Byte #3	Byte #4
Biased Exponent	MS Mantissa	Mantissa	LS Mantissa	Mantissa	LS Mantissa	Biased Exponent	MS Mantissa

{L1} CRC Enabled………………………….. (Computer Default Mode Y)

Many protocols use either a CRC, LRC or BCC error check to ensure that data received is not corrupted. The flow computer can be configured to ignore the error checking on incoming messages. This allows software developers an easy means of debugging communications software. **Error checking should only be disabled temporarily when debugging the master slave communication link**. The computer expects dummy characters in place of the CRC, LRC or BCC.

Enter **[Y]** to perform error checking on incoming messages. For maximum data integrity always enter **[Y]** during normal running conditions. Enter **[N]** to disable error checking on incoming messages. This entry will be disabled for Serial Port #1 if a printer is selected as the port type.

{L1} Ethernet Module (SE)………………… (Computer Default Mode N)

If an Ethernet module is installed the following entries will display when this entry is set to Yes

{L1} Modbus ID

{L1} Modicon Compatible (Y/N)………………… (Computer Default Mode N)

{L1} IP Address

All devices on a network require a unique IP address. This is the IP address used for all network connections to the Modbus Mux. The IP address is entered in dotted decimal notation..

{L1} Netmask

IP addresses contain a Network Identifier (netid) a Subnet Identifier (subnetid) and a Host Identifier (hosted). The mask IP address is entered in dotted decimal notation.

{L1} Gateway

If a default gateway exists for accessing other subnets, it can be entered here. The Gateway is entered in dotted decimal notation.

Allows computer Alarm reports to be printed thru the ethernet module

2.5.16. Custom Modbus™ Data Packet Settings

INFO: *Packets defined are usually read-only and must always be retrieved as a packet. When Modicon 984 is selected these packet setup entries are used to define a logical array of variables which can be read or written in any grouping. The number of data points is always input in terms of OMNI "logical" elements; i.e., an IEEE floating point number comprises two 16-bit words but is considered one logical element*

Custom Modbus Data Packets are provided to reduce the number of polls needed to read multiple variables which may be in different areas of the database. Groups of data points of any type of data can be concatenated into one packet by entering each data group starting index numbers 001, 201 and 401. The number of data bytes in a custom packet in non-Modicon compatible mode cannot exceed 250 (RTU mode) or 500 (ASCII mode). When Modicon compatible is selected, the number of data bytes in a custom packet cannot exceed 400 (RTU mode) or 800 (ASCII mode).

Enter **[1]**, **[2], or [3]** to select a data packet at '**Custom Packet "n"**' of the '**Misc Setup**' menu to open the entries below. Under **Index #**, enter the database address or Modbus index number for each start data point of each group. Under **Points**, enter the number of consecutive data points to include in each data group.

Custom Modbus Data Packet #1 (Addressed at 001)

{L1} Index # | Points **Index # | Points** **Index # | Points** **Index # | Points**

#1_______|_____ #2_______|_____ #3_______|_____ #4_______|_____

#5_______|_____ #6_______|_____ #7_______|_____ #8_______|_____

#9_______|_____ #10_______|_____ #11_______|_____ #12_______|_____

#13_______|_____ #14_______|_____ #15_______|_____ #16_______|_____

#17_______|_____ #18_______|_____ #19_______|_____ #20_______|_____

Custom Modbus Data Packet #2 (Addressed at 201)

{L1} Index # | Points **Index # | Points** **Index # | Points** **Index # | Points**

#1_______|_____ #2_______|_____ #3_______|_____ #4_______|_____

#5_______|_____ #6_______|_____ #7_______|_____ #8_______|_____

Custom Modbus Data Packet #3 (Addressed at 401)

{L1} Index # | Points **Index # | Points** **Index # | Points** **Index # | Points**

#1_______|_____ #2_______|_____ #3_______|_____ #4_______|_____

#5_______|_____ #6_______|_____ #7_______|_____ #8_______|_____

#9_______|_____ #10_______|_____ #11_______|_____ #12_______|_____

#13_______|_____ #14_______|_____ #15_______|_____ #16_______|_____

#17_______|_____ #18_______|_____ #19_______|_____ #20_______|_____

2.5.17. Programmable Logic Controller Setup

Note: *See **Technical Bulletin 52-0000-0004 (TB-960702)** "**Communicating with Allen-Bradley™ Programmable Logic Controllers**" in **Volume 5** for information on the '**PLC Group "n"**' submenu.*

2.5.18. Archive File Setup

Note: *See **Technical Bulletin 52-0000-0002 (TB-960703)** "**Storing Archive Data within the Flow Computer**" in **Volume 5** for information on the '**Archive File "n"**' submenu.*

2.5.19. Peer-to-Peer Communications Settings

TIP: *For maximum efficiency, always start Modbus ID numbers from **1.***

Serial Port #2 of the flow computer can be configured to act as a simple Modbus slave port or as a peer-to-peer communication link. Using the peer-to-peer link allows multiple flow computers to be interconnected and share data.

Enter **[Y]** at '**Peer / Peer Comm (Y)?**' of the '**Misc Setup**' menu to open the following submenu:

{L1} Activate Redundancy Mode ________________

The active redundancy mode feature allows two flow computers to operate as a pair. Each flow computer receives the same process signals and performs the same calculations; i.e., in "redundancy". This mode is typically used in critical applications where failure of a flow computer cannot be tolerated.

Enter **[Y]** to allow both flow computers to manage the peer-to-peer link between them and automatically switch between being the master or slave computer. Important data such as meter factors and PID control settings can be continually exchanged between flow computers ensuring that at any time, should a failure occur to one, the other unit would be able to assume control of the PID and ticketing functions.

The redundancy mode requires that four digital I/O ports be cross-connected to sense watchdog failure modes using the following points 2714=Input master status, 2864=Output Master status, 2713 Input watchdog status, 2863 = Output of watchdog status. See Technical Bulletin 52-0000-0002 (**TB-980402).**

{L1} Next Master in Sequence ________________

Enter the slave number of the next flow computer in sequence in the peer-to-peer communication sequence to pass over control. After the flow computer completes all of its transactions it will attempt to pass over master control of the Modbus link to this Modbus ID. For maximum efficiency, always start Modbus ID definitions from 1.

Enter the Modbus ID of this flow computer if there are no other peers in sequence on the communication link.

Enter [0] to disable the peer-to-peer feature and use Serial Port #2 as a standard Modbus slave port.

{L1} Last Master in Sequence ID # ________________

Enter the slave number of the last OMNI (the highest Modbus ID number) in the peer-to-peer communication sequence. This is required for error recovery. Should this flow computer be unable to hand over control to the 'next master in sequence' (see previous entry), it will attempt to establish communications with a Modbus slave with a higher Modbus ID. It will keep trying until the ID number exceeds this entry. At that point the flow computer will start at Modbus ID #1.

Enter the Modbus ID of this flow computer if it is the only master on the link.

{L1} Retry Timer ________________

Should any slave device fail to respond to a communication request, the master device will retry to establish communications several times. Enter the number of 50 millisecond ticks that the flow computer should wait for a response from the slave device. To ensure fast recovery from communication failures set this entry to as low a number as possible. Enter **[3]** for peer-to-peer links involving only OMNI flow computers. Other Modbus devices may require more time to respond.

INFO: *The OMNI Flow Computer determines what Modbus function code and what data type is involved by the Modbus index number of the data within the OMNI's database. The **Source Index** determines the data type for a 'write'. The **Destination Index** determines the data type for a 'read'. Function codes used are: 01=Read Multiple Booleans, 15=Write Multiple Booleans, 03=Read Multiple Variables, 16=Write Multiple Variables*

Transaction #1

{L1} Target Slave ID # ________________

Each transfer of data is called a transaction. Enter the Modbus ID # of the other slave involved in the transaction. Modbus ID '**0**' can be used to broadcast write to all Modbus slave devices connected to the peer-to-peer link. Other valid IDs range from 1-247.

{L1} Read/Write? ________________

Enter **[R]** if data will be read from the slave. Enter **[W]** if data will be written to the slave.

{L1} Source Index # ________________

Enter the database index number or address of the Modbus point where the data is to be obtained, corresponding to the first data point of the transaction. This is the slave's database index number when the transaction is a 'read', and the master's database index number when the transaction is a 'write'. Refer to **Volume 4** for a list of available database addresses or index numbers.

{L1} Number of Points ________________

Enter the number of contiguous points to transfer. Each transaction can transfer multiple data points that can be any valid data type recognized by the OMNI. The maximum number of points that can be transferred depends on the type of data:

- IEEE floats (4bytes each) → 63 max
- 32-bit Integers (4 bytes each) → 63 max
- 16-bit integers (2 bytes each) → 127 max
- Packed coils or status (8 to a byte) → 2040 max.

The OMNI automatically knows what Modbus function to use and what data types are involved by the Modbus index number of the data within the flow computer database. The destination index number determines the data type when the transaction is a 'read'. The source index number determines the data type when the transaction is a 'write'.

{L1} Destination Index # ________________

Enter the database index number or address of where the data is to be stored (destination index or address). If the transaction is a 'read', this will be the index number within the master OMNI's database. If the transaction is a 'write', this will be the register number within the remote slave's database.

Transaction #2

Target Slave ID # ________________

Read/Write? ________________

Source Index # ________________

Number of Points ________________

Destination Index # ________________

Transaction #3

Target Slave ID # ________________

Read/Write? ________________

Source Index # ________________

Number of Points ________________

Destination Index # ________________

Transaction #4

Target Slave ID# ________________

Read/Write ? ________________

Source Index # ________________

Number of Points ________________

Destination Index # ________________

Transaction #5

- Target Slave ID # ____________
- Read/Write? ____________
- Source Index # ____________
- Number of Points ____________
- Destination Index # ____________

Transaction #6

- Target Slave ID # ____________
- Read/Write? ____________
- Source Index # ____________
- Number of Points ____________
- Destination Index # ____________

Transaction #7

- Target Slave ID # ____________
- Read/Write? ____________
- Source Index # ____________
- Number of Points ____________
- Destination Index # ____________

Transaction #8

- Target Slave ID # ____________
- Read/Write? ____________
- Source Index # ____________
- Number of Points ____________
- Destination Index # ____________

Transaction #9

- Target Slave ID # ____________
- Read/Write? ____________
- Source Index # ____________
- Number of Points ____________
- Destination Index # ____________

Transaction #10

- Target Slave ID # ____________
- Read/Write? ____________
- Source Index # ____________
- Number of Points ____________
- Destination Index # ____________

Transaction #11

Target Slave ID # ________________

Read/Write? ________________

Source Index # ________________

Number of Points ________________

Destination Index # ________________

Transaction #12

Target Slave ID # ________________

Read/Write? ________________

Source Index # ________________

Number of Points ________________

Destination Index # ________________

Transaction #13

Target Slave ID # ________________

Read/Write? ________________

Source Index # ________________

Number of Points ________________

Destination Index # ________________

Transaction #14

Target Slave ID # ________________

Read/Write? ________________

Source Index # ________________

Number of Points ________________

Destination Index # ________________

Transaction #15

Target Slave ID # ________________

Read/Write? ________________

Source Index # ________________

Number of Points ________________

Destination Index # ________________

Transaction #16

Target Slave ID # ________________

Read/Write? ________________

Source Index # ________________

Number of Points ________________

Destination Index # ________________

2.5.20. Custom Modbus™ Data Packet Settings

INFO: *Packets defined are usually read-only and must always be retrieved as a packet. When Modicon 984 is selected these packet setup entries are used to define a logical array of variables which can be read or written in any grouping.*

The number of data points is always input in terms of OMNI “logical” elements; i.e., an IEEE floating point number comprises two 16-bit words but is considered one logical element

Custom Modbus Data Packets are provided to reduce the number of polls needed to read multiple variables which may be in different areas of the database. Groups of data points of any type of data can be concatenated into one packet by entering each data group starting index numbers 001, 201 and 401. The number of data bytes in a custom packet in non-Modicon compatible mode cannot exceed 250 (RTU mode) or 500 (ASCII mode). When Modicon compatible is selected, the number of data bytes in a custom packet cannot exceed 400 (RTU mode) or 800 (ASCII mode).

Enter **[1]**, **[2], or [3]** to select a data packet at ‘**Custom Packet “n”**’ of the ‘**Misc Setup**’ menu to open the entries below. Under **Index #**, enter the database address or Modbus index number for each start data point of each group. Under **Points**, enter the number of consecutive data points to include in each data group.

Custom Modbus Data Packet #1 (Addressed at 001)

{L1} Index #	**Points**	**Index #**	**Points**	**Index #**	**Points**	**Index #**	**Points**
#1________	______	#2________	______	#3________	______	#4________	______
#5________	______	#6________	______	#7________	______	#8________	______
#9________	______	#10________	______	#11________	______	#12________	______
#13________	______	#14________	______	#15________	______	#16________	______
#17________	______	#18________	______	#19________	______	#20________	______

Custom Modbus Data Packet #2 (Addressed at 201)

{L1} Index #	**Points**	**Index #**	**Points**	**Index #**	**Points**	**Index #**	**Points**
#1________	______	#2________	______	#3________	______	#4________	______
#5________	______	#6________	______	#7________	______	#8________	______

Custom Modbus Data Packet #3 (Addressed at 401)

{L1} Index #	**Points**	**Index #**	**Points**	**Index #**	**Points**	**Index #**	**Points**
#1________	______	#2________	______	#3________	______	#4________	______
#5________	______	#6________	______	#7________	______	#8________	______
#9________	______	#10________	______	#11________	______	#12________	______
#13________	______	#14________	______	#15________	______	#16________	______
#17________	______	#18________	______	#19________	______	#20________	______

2.5.21. Archive File Setup

Flow Computer Configuration via the Menu Selection Method: *It is best to use this method when programming an application for the first time as every possible option and variable will be prompted. Once a computer is in operation and you become familiar with the application you can decide to use the faster Random Access Method described below. Once you have finished entering data in a setup submenu, press the* ***[Prog]*** *key to return to the '****Select Group Entry****' screen. Proceed as described in this manual for each setup option.*

Time and Date Setup via the Random Access Method: *Setup entries require that you be in the Program Mode. In the Display Mode press the* ***[Prog]*** *key. The Program LED will glow green and the '****Select Group Entry****' screen will appear. Then press* ***[Time] [Enter]*** *and use* ***[↑] / [↓]*** *keys to scroll.*

NOTE: *See Technical Bulletin 52-0000-0002 (TB-960703) "Storing Archive Data within the Flow Computer" in Volume 5 for information on the 'Archive File "n"' submenu. Setting Up the Time and Date.*

2.6. Setting Up The Time and Date

2.6.1. Accessing the Time/Date Setup Submenu

Applying the Menu Selection Method, in the '**Select Group Entry**' screen (Program Mode) press **[Setup] [Enter]** and a menu similar to the following will be displayed:

```
***  SETUP MENU  ***
Misc Configuration
Time/Date Setup    _
Printer Setup
```

Use the **[↑]/[↓]** (up/down arrow) keys to move the cursor to '**Time/Date Setup**' and press **[Enter]** to access the submenu.

2.6.2. Time and Date Settings

{L1} OMNI Time ____:____:____

Enter Current Time using the correct method 'hh:mm:ss'. To change only the hour, minutes or seconds, move cursor to the respective position and enter the new setting.

{L1} OMNI Date ____/____/____

Enter Current Date using the correct method 'mm/dd/yy' or 'dd/mm/yy'. To change only the month, day or year, move cursor to the respective position and enter the new setting.

{L1} Select Date Format Type ____________

Select date format required by entering **[Y]** or **[N]**:

Y = month/day/year
N = day/month/year

2.7. Configuring Printers

***Printer Setup via the Random Access Method:** Setup entries require that you be in the Program Mode. In the Display Mode press the **[Prog]** key. The Program LED will glow green and the '**Select Group Entry**' screen will appear. Then press **[Print] [Setup] [Enter]** and use **[↑] / [↓]** keys to scroll.*

2.7.1. Accessing the Printer Setup Submenu

Applying the Menu Selection Method, in the '**Select Group Entry**' screen (Program Mode) press **[Setup] [Enter]** and a menu similar to the following will be displayed:

```
***  SETUP MENU  ***
Misc Configuration
Time/Date Setup
Printer Setup     _
```

Use the **[↑]/[↓]** (up/down arrow) keys to move the cursor to '**Printer Setup**' and press **[Enter]** to access the submenu.

2.7.2. Printer Settings

{L1} Computer ID ________________

Appears on all reports. Enter up to 8 alphanumeric characters to identify the flow computer.

{L1} Print Interval in Minutes ________________

Enter the number of minutes between each interval report. Entering **[0]** will disable interval reports. The maximum allowed is 1440 minutes which will provide one interval report per 24-hour period.

{L1} Print Interval Start Time ______:______

Enter the start time from which the interval report timer is based (e.g.: Entering '01:00' with a Print Interval of 120 minutes will provide an interval report every odd hour only).

{L1} Daily Report Time ______:______

Enter the hour at which the daily report will print at the beginning of the contract day (e.g.: 07:00).

{L1} Disable Daily Report? ________________

Enter **[Y]** to disable the Daily Report (default is '**N**'). This simply blocks the report from printing. Data will still be sent to the historical buffers (last 8) and archive if archive is setup.

{L1} Disable Detail Report? ________________

Enter **[Y]** to disable the Detail Report (default is '**N**'). This simply blocks the report from printing. Data will still be sent to the historical buffers (last 8) and archive if archive is setup.

{L1} Daylight Savings Time Start ______/______/______

Enter the Day/Month/Year that daylight savings time begins.
Users requesting not to use Daylight Savings Time must enter 00/00/00 via the front panel only.

{L1} Daylight Savings Time End ______/______/______

Enter the Day/Month/Year that daylight savings time ends.
Users requesting not to use Daylight Savings Time must enter 00/00/00 via the front panel only.

{L1} Clear Daily Totals at Batch End? ________________

Enter **[N]** to provide 24 hour totals of all flow through the flowmeter regardless of what product is run. Select **[Y]** to clear the totalizers at the end of each batch. This would mean that the daily totalizers would not necessarily represent 24 hours of flow but the amount of flow since the last batch end or the daily report.

{L1} Automatic Hourly Batch Select? _______________

Enter **[Y]** to automatically cause a batch end every hour on the hour. If customized reports are selected a batch end report will be printed. If default reports are selected no batch end report will be printed.

{L1} Automatic Weekly Batch Select? _______________

Enter a number 1 through 7 to automatically print a batch end report in addition to a daily report on a specific day of the week (0=No batch end, 1=Monday, 2=Tuesday, etc.).

{L1} Automatic Monthly Batch Select? _______________

Enter a number 1 through 31 to automatically print a batch end report in place of a daily report on a specific day of the month (0=No batch end).

{L1} Print Priority _______________

Enter **[0]** when the computer is connected to a dedicated printer. If several computers are sharing a common printer, one computer must be designated as the master and must be assigned the number 1. The remaining computers must each be assigned a different Print Priority number between 2 and 12.

{L1} Number of Nulls _______________

For slow printers without an input buffer, a number of null characters can be sent after each carriage return or line feed. A number between 0-255 will be accepted. Set this to '0' if your printer supports hardware handshaking and you have connected pin 20 of the printer connector to terminal 6 of the flow computer (see **Chapter 3**).

{L1} Use Default Snapshot Report? _______________

Entering **[Y]** instructs the flow computer to use the default Snapshot report format.

***Common Printer Control Codes: Epson, IBM & Compatible**: _Condensed Mode= 0F, Cancel Condensed=12. **OKI Data Models**: __Condensed Mode= 1D, Cancel Condensed=1E. **HP Laser Jet II & Compatible:** Condensed= 1B266B3253, Cancel Cond= 1B266B3053.*

{L1} Use Default Batch Report? _______________

Entering **[Y]** instructs the flow computer to use the default Batch report format.

{L1} Use Default Daily Report? _______________

Entering **[Y]** instructs the flow computer to use the default Daily report format.

{L1} Use Default Prove Report? _______________

Entering **[Y]** instructs the flow computer to use the default Prove report format.

{L1} Condensed Print Mode Control String _______________

Certain default report templates exceed 80 columns when the computer is configured for 4 meter runs and a station. Enter the hexadecimal character string which will put the printer into the condensed print mode. Data must be in sets of 2 characters (i.e., 05 not 5). A maximum of 5 control characters are allowed.

{L1} Cancel Condensed Print Mode Control String _______________

Uncondensed Print Mode. Enter the hexadecimal character string which when sent to the printer will cancel the condensed print mode. Data must be in sets of 2 characters (i.e., 05 not 5). A maximum of 5 control characters are allowed.

{L1} Company Name ____

____

Two lines of the display allow entry of the Company Name. On each line enter a maximum of 19 characters and press **[Enter]**. Both lines are concatenated and appear on all reports.

{L1} Location ____

____

Two lines of the display allow entry of the station location Name. On each line enter a maximum of 19 characters and press **[Enter]**. Both lines are concatenated and appear on all reports.

2.8. Configuring Gas Chromatograph (GC) Analyzers

Analyzer Setup via the Random Access Method: *Setup entries require that you be in the Program Mode. In the Display Mode press the* ***[Prog]*** *key. The Program LED will glow green and the '****Select Group Entry****' screen will appear. Then press* ***[Analysis] [Enter]*** *or* ***[Analysis] [Setup] [Enter]*** *and use* ***[↑] / [↓]*** *keys to scroll.*

2.8.1. Accessing the Analyzer Setup Submenu

Applying the Menu Selection Method, in the '**Select Group Entry**' screen (Program Mode) press **[Setup] [Enter]** and a menu similar to the following will be displayed:

```
***  SETUP MENU  ***
Time/Date Setup
Printer Setup
Analyser Setup     _
```

Use the **[↑]/[↓]** (up/down arrow) keys to move the cursor to '**Analyzer Setup**' and press **[Enter]** to access the submenu.

2.8.2. Analyzer Settings

GC Analyzer No. ________________

Enter the identifying number of the Applied Automation or Daniels Danalyzer gas chromatograph. This is the serial communication ID number of the analyzer.

GC Analyzer 2 No. ________________

Enter the identifying number of the second Gas Chromatograph.

GC Analyzer Type ________________

Enter the gas analyzer type: 0=Applied Automation, 1=Danalyzer. The OMNI flow computer can communicate and retrieve analysis data from either an Applied Automation or a Daniels Danalyzer chromatograph. In both cases the flow computer uses the 3rd serial port for communications. When talking to an Applied Automation, the flow computer uses the AA proprietary HCI-A protocol interface. When talking to a Danalyzer, Modbus ASCII or RTU is used.

Results Interval (Seconds) ________________

Enter the maximum number of seconds that the flow computer should wait for results from either type of gas chromatograph. When operating with an Applied Automation analyzer, the flow computer will request results from the chromatograph if it is not in the 'listen only' mode. The 'GC Alarm' bit will be set if no results are received after this request.

Danalyzer Type (0=USA, 1=ISO) ________________

If USA version is selected, Modbus point 7054 of Danalyzer will be read as Actual BTU, otherwise will be read as WOBBE index.

Danalyzer Heating Value (0=Actual BTU, 1=Dry Superior) ________________

Select the register for the flwo computer to read to acquire the heating value from the Danalyzer. The choices are Actual BTU (7054) and Dry Superior (7033). (available with firmware version 27.75.01 and up).

Listen Only Mode

Enter **[Y]** to set the flow computer to the 'Listen Only' mode. Enter **[N]** to disable this mode. In many cases, more than one flow computer will be connected to a single gas analyzer. Only one flow computer is allowed to act as a host device and request data from the analyzer. All of the remaining computers must 'listen' to the result data 'only'.

GC Fail Code

The selections are: 0=Always use GC #1, 1=Always use the last good analysis from the GC, 2=Use override on GC#1 Failure, 3= GC #1 Fail to GC#2, 4= Always Use GC #2

A failure may be due to a fatal error flagged by the GC indicating that the composition data may not be reliable. Fatal errors usually are caused by some type of hardware problem at the GC. EPROM error, D/A converter error, etc. A breakdown of communications between the flow computer and the GC will also cause a GC failure error.

Gas Chromatograph Component Numbers

Danalyzer C6+ Settings: *Danalyzer instruments (as of May 1994) group all components C6 through C8 as a C6+ group. Four different groupings of C6+ can be provided. These groups are numbered 108, 109, 110 and 111 in the Danalyzer documentation. For the OMNI to work correctly the Danalyzer must be setup with the C6+ analysis value as the first component in its component table. The OMNI will automatically determine the correct values of C6, C7 and C8 from the component code selected at the Danalyzer. Because of this, there should be no component number 1 in the OMNI setup.*

Each gas chromatograph can be unique in the total number of components it can recognize and the order than they are presented. For the following settings, enter the component number position for each of the components listed below. Enter **[0]** for any unused components.

Mol % Deviation ______________

Enter the maximum deviation % of the gas component. If the unnormalized total is outside the limit the GC will fail to fail code.

Methane (CH_4) ________________

Nitrogen (N_2) ________________

Carbon Dioxide (CO_2) ________________

Ethane (C_2H_6) ________________

Propane (C_3H_8) ________________

Water (H_2O) ________________

Hydrogen Sulfide (H_2S) ________________

Hydrogen (H_2) ________________

Carbon Monoxide (CO) ________________

Oxygen (O_2) ________________

i-Butane (iC_4H_{10}) ________________

n-Butane (nC_4H_{10}) ________________

i-Pentane (iC_5H_{12}) ________________

n-Pentane (n C_5H_{12}) ________________

n-Hexane (C_6H_{14}) ________________

n-Heptane (C_7H_{16}) ________________

n-Octane (C_8H_{16}) ________________

n-Nonane ________________

n-Decane ________________

Helium (He) ________________

Argon (Ar) ________________

Heating Value (SV) ________________

Specific Gravity (SG) ________________

C6 Distribution % ________________

C7 Distribution % ________________

C8 Distribution % ________________

C9 Distribution % ________________

C10 Distribution % ________________

C6+ Total % ________________

2.9. Configuring Premium Billing Threshold Levels (Revision 23.74/ 75 US Customary Units Only)

Premium Billing Threshold Level Setup via the Random Access Method: *Premium Billing settings only apply to Firmware Revision 23.74+ (US customary units) and can only be accessed via the Random Access Method.*

*Setup entries require that you be in the Program Mode. In the Display Mode press the **[Prog]** key. The Program LED will glow green and the '**Select Group Entry**' screen will appear. Then press **[Net] [Setup] [Enter]** or **[Setup] [Net] [Enter]***

2.9.1. Accessing Premium Billing Settings

Premium Billing settings can only be accessed via the Random Access Method. Valid key press sequences in the Program Mode are **[Net] [Setup] [Enter]** or **[Setup] [Net] [Enter]**.

2.9.2. Premium Billing Threshold Settings

Flow which occurs below Level 1 threshold will be accumulated in the 'Base Level' totalizer. Flow occurring between the Level 1 and the Level 2 threshold will accumulate in the 'Level 1' totalizer. Flow occurring between the Level 2 and the Level 3 threshold will accumulate in the 'Level 2' totalizer. Flow occurring above the Level 3 threshold will accumulated in the 'Level 3' totalizer.

The 'Special Billing' threshold acts just like a fourth premium level when it is set to be greater in value than the Level 3 threshold but overrides any other premium threshold that is set greater than the Special Billing threshold.

Premium totalizers are stored for each meter run and the station for the last 10 days (see database points **6n01-6n61** in Chapter 2 of Volume 4).

For the following settings, enter the premium billing flow threshold levels in thousand standard cubic feet (MSCF)/hour.

	Station	Meter #1	Meter #2	Meter #3	Meter #4
Premium Level 1	________	________	________	________	________
Premium Level 2	________	________	________	________	________
Premium Level 3	________	________	________	________	________
Special Billing	________	________	________	________	________

2.10. Configuring PID Control Outputs

PID Control Output Setup via the Random Access Method: *Setup entries require that you be in the Program Mode. In the Display Mode press the* ***[Prog]*** *key. The Program LED will glow green and the '****Select Group Entry****' screen will appear. Then press* ***[Control] [n] [Enter]*** *(n = PID Control Loop # 1, 2, 3 or 4). Use* ***[↑] / [↓]*** *keys to scroll.*

2.10.1. Accessing the PID Control Setup Submenu

Applying the Menu Selection Method, in the '**Select Group Entry**' screen (Program Mode) press **[Setup] [Enter]** and a menu similar to the following will be displayed:

```
***  SETUP MENU  ***
Printer Setup
Analyser Setup
PID Control Setup  _
```

Use the **[↑]/[↓]** (up/down arrow) keys to move the cursor to '**PID Control Setup**' and press **[Enter]** to access the submenu.

2.10.2. PID Control Output Settings

	Loop #1	Loop #2	Loop #3	Loop #4

Operating Mode

Manual Valve Open (Y/N) ________ ________ ________ ________

Enter **[Y]** to adjust the valve open % and adjust using the **[↑]/[↓]** keys. Enter **[N]** to change to AUTO mode.

Local Setpoint (Y/N) ________ ________ ________ ________

Enter **[Y]** to use a local set point and adjust using the **[↑]/[↓]** keys. Enter **[N]** for 'Remote' set point mode.

Secondary Setpoint Value ________ ________ ________ ________

Enter the value in engineering units for the set point of the secondary variable. The primary variable will be the controlled variable until the secondary variable reaches this set point. The secondary variable will not be allowed to drop below or rise above this set point, depending on the "Error Select" entry in the 'Config PID' menu.

Tuning Adjustments

{L1} Primary Gain Factor ________ ________ ________ ________

Enter a value between 0.01 to 99.99 for the Primary Gain Factor (Gain=1/Proportional Band).

{L1} Primary Integral Factor ________ ________ ________ ________

Enter a value between 0.0 and 40.00 for the Primary Integral Factor (Repeats/Min=1/Integral Factor ⇨ the reciprocal of the reset period).

{L1} Secondary Gain Factor ________ ________ ________ ________

Enter a value between 0.01 to 99.99 for the Secondary Gain Factor (Gain=1/Proportional Band).

The actual controller gain factor used when controlling the secondary variable is the product of this entry and the 'Primary Gain Factor'. Tune the primary control variable first and then use this entry to adjust for stable control of the secondary variable.

{L1} Secondary Integral Factor _______ _______ _______ _______

Enter a value between 0 and 40.00 for the Secondary Integral Factor (Repeats/Min=1/Integral Factor ⇨ the reciprocal of the reset period).

PID Startup, Stop and Shutdown Ramp Command Points: *These have been added to eliminate the need to manipulate the PID permissives directly. Using these command points greatly simplifies operation of the PID ramping functions. (See database points* ***1727-1730****,* ***1788-1791****,* ***1792-1795*** *respectively.)*

Loop #1 **Loop #2** **Loop #3** **Loop #4**

{L1} Deadband % _______ _______ _______ _______

Enter the dead band percent range. PID Control will only compensate for setpoint deviations out of this range. The control output will not change as long as the process input and the setpoint error (deviation) is within this dead band percentage limit range.

{L1} Startup Ramp % _______ _______ _______ _______

Enter the maximum percentage to which the valve movement is limited per 500 msec at start-up. The control output is clamped at 0% until the 1st PID Permissive (PID #1-#4 ⇨ database points **1722-1725**) is set true. The control output % is then allowed to increase at the start-up ramp rate.

{L1} Shutdown Ramp % _______ _______ _______ _______

Enter the maximum percentage to which the valve movement is limited per 500 msec at shutdown. When the 1st PID Permissive is lost, the control output will ramp-down towards 0% at the shutdown ramp rate.

During the ramp-down phase, a 2nd PID Permissive (PID #1-#4 ⇨ database points **1752-1755**) is used to provide a “ramp hold” function. If this 2nd permissive is true, 100 msec before entering the ramp-down phase, the control output % will ramp-down and be held at the minimum ramp-down limit % (see the following entry) until it goes false. The control output will then immediately go to 0%.

{L1} Minimum Ramp to % _______ _______ _______ _______

Enter the minimum percentage that the control output will be allowed to ramp down to. In many cases, it is important to deliver a precise amount of product. This requires that the control output be ramped to some minimum % and held there until the required delivery is complete. The control output is then immediately set to 0%.

Primary Controlled (Remote Setpoint) Variable

{L1} Low Limit _______ _______ _______ _______

Enter the engineering unit value below which the primary setpoint variable is not allowed to drop while in the remote setpoint mode.

{L1} High Limit _______ _______ _______ _______

Enter the engineering unit value above which the primary setpoint variable is not allowed to rise while in the remote setpoint mode.

Secondary Controlled (Setpoint) Variable

{L1} Zero Value _______ _______ _______ _______

If a secondary controlled variable is used, enter the value in engineering units of the variable which will represent zero.

{L1} Full Scale Value _______ _______ _______ _______

Enter the value in engineering units of the secondary variable at controller full scale, which is usually 2 times the normal operating setpoint setting.

2.11. Configuring Meter Specific Gravity / Density

2.11.1. Accessing the Gravity/Density Setup Submenu

Applying the Menu Selection Method, in the '**Select Group Entry**' screen (Program Mode) press **[Setup] [Enter]** and a menu similar to the following will be displayed:

```
***  SETUP MENU  ***
Analyser Setup
PID Control Setup
Grav/Density Setup _
```

Use the **[↑]/[↓]** (up/down arrow) keys to move the cursor to '**Grav/Density Setup**' and press **[Enter]** to access the submenu.

2.11.2. Meter Specific Gravity / Density Settings

Meter Specific Gravity/Density Setup via the Random Access Method: *Setup entries require that you be in the Program Mode. In the Display Mode press the* ***[Prog]*** *key. The Program LED will glow green and the '****Select Group Entry****' screen will appear. Then enter the key press sequence that corresponds to the options you want to configure.* ***Specific Gravity****: To access these settings, press* ***[S.G.] [Enter]*** *or* ***[S.G.] [Meter] [n] [Enter]*** *or* ***[Meter] [n] [S.G./API] [Enter]. Density:*** *_To access these settings, press* ***[Density] [Enter]*** *or* ***[Density] [Meter] [n] [Enter]*** *or* ***[Meter] [n] [Density] [Enter]. Digital Densitometers:*** *To access these settings, press* ***[Factor] [Density] [Meter] [n] [Enter]*** *or* ***[Density] [Factor] [Meter] [n] [Enter].*** *("n" represents the meter run # 1, 2, 3 or 4).* ***NOTE:*** *Digital densitometers can only be configured via the Random Access Method.*

INFO: *Densitometer constants are usually on a calibration certificate supplied by the densitometer manufacturer. Usually they are based on SI or metric units. For US customary applications you must ensure that the constants entered are based on gr/cc, °F and PSIG. Constants are always displayed using scientific notation; e.g.: K_0=-1.490205E+00 (gr/cc). To enter K_0, press* ***[Clear]*** *and press* ***[-1.490205] [Alpha Shift] [E] [+00] [Enter].***

Specific Gravity / Density Data

	Station	Meter #1	Meter #2	Meter #3	Meter #4
Low Alarm Limit	_________	_________	_________	_________	_________
High Alarm Limit	_________	_________	_________	_________	_________
{L2} Override Value	_________	_________	_________	_________	_________

Low Alarm Limit: Enter the gravity/density below which the gravitometer/densitometer low alarm activates.

High Alarm Limit: Enter the gravity/density above which the gravitometer/densitometer high alarm activates.

{L2} Override Value: Enter the gravity/density value that is substituted for the live transducer value, depending on the override code. An '*' displayed along side of the value indicates that the override value is substituted. Each product setup can specify a gravity override to be used when ever that product is run. The override gravity in the product setup area overrides any transducer override.

{L2} Override Code _________ _________ _________ _________ _________

Enter the Override Code strategy:

0 = Never use override code
1 = Always use override code
2 = Use override code on transmitter failure
3 = On transmitter failures use last hour's average
4 = On transmitter failure use station transducer value
5 = On transmitter failure use absolute value of override SG/API of the running product.

{L1} Value at 4 mA _________ _________ _________ _________ _________

These entries apply if an analog gravitometer or densitometer is specified during the '**Config Meter Run**' in '**Misc. Setup**'. Engineering units that the transmitter outputs at 4mA or 1volt, or LRV of Honeywell Smart Transmitters.

{L1} Value at 20 mA _________ _________ _________ _________ _________

These entries apply if an analog gravitometer or densitometer is specified during the '**Config Meter Run**' in '**Misc. Setup**'. Engineering units that the transmitter outputs at 20mA or 5 Volts, or URV of Honeywell Smart Transmitters.

	Station	Meter #1	Meter #2	Meter #3	Meter #4
{L1A} Factor A	_________	_________	_________	_________	_________

This entry applies if an analog (4-20mA density linear) or a digital densitometer is specified during the '**Config Meter Run**' in '**Misc. Setup**'. It is not available when using specific gravity gravitometers. Enter the Pycnometer Density correction factor (Limit: 0.8 to 1.2). (Usually very close to 1.0000).

Digital Densitometer Factors

The following additional entries are required if a digital densitometer is specified during the '**Config Meter Run**' in the '**Misc. Setup**' menu. There are three selections which refer to digital densitometers: 4 = Solartron, 5 = Sarasota, 6 = UGC. ({L1} Password Level required.)

Solartron	**Station**	**Meter #1**	**Meter #2**	**Meter #3**	**Meter #4**
K_0					
K_1					
K_2					
K_{18}					
K_{19}					
K_3					
K_4					
K_5					

Sarasota	**Station**	**Meter #1**	**Meter #2**	**Meter #3**	**Meter #4**
D_0					
T_0					
T_{coef}					
T_{cal}					
P_{coef}					
P_{cal}					

UGC	**Station**	**Meter #1**	**Meter #2**	**Meter #3**	**Meter #4**
K_0					
K_1					
K_2					
T_C					
K_{t1}					
K_{t2}					
K_{t3}					
P_c					
K_{p1}					
K_{p2}					
K_{p3}					

2.12. Configuring Meter Temperature

Meter Temperature Setup via the Random Access Method: *Setup entries require that you be in the Program Mode. In the Display Mode press the **[Prog]** key. The Program LED will glow green and the '**Select Group Entry**' screen will appear. Then press **[Temp] [Enter]**, or **[Temp] [Meter] [n] [Enter]** or **[Meter] [n] [Temp] [Enter]** (n = Meter Run # 1, 2, 3 or 4). Use **[↑] / [↓]** keys to scroll.*

** **NOTE:** Not Valid when a RTD Probe is specified*

2.12.1. Accessing the Temperature Setup Submenu

Applying the Menu Selection Method, in the '**Select Group Entry**' screen (Program Mode) press **[Setup] [Enter]** and a menu similar to the following will be displayed:

```
***  SETUP MENU  ***
PID Control Setup
Grav/Density Setup
Temperature Setup  _
```

Use the **[↑]/[↓]** (up/down arrow) keys to move the cursor to '**Temperature Setup**' and press **[Enter]** to access the submenu.

2.12.2. Station and Meter Run Temperature Settings

	Station	Meter #1	Meter #2	Meter #3	Meter #4
Low Alarm Limit	________	________	________	________	________

Enter the temperature below which the flowmeter low alarm activates. Transducer values approximately 5% below this entry fail to low.

	Station	Meter #1	Meter #2	Meter #3	Meter #4
High Alarm Limit	________	________	________	________	________

Enter the temperature above which the flowmeter high alarm activates. Transducer values approximately 5% above this entry fail to high.

	Station	Meter #1	Meter #2	Meter #3	Meter #4
{L2} Override	________	________	________	________	________

Enter the temperature value that is substituted for the live transducer value, depending on the override code. An '*' displayed along side of the value indicates that the override value is substituted.

	Station	Meter #1	Meter #2	Meter #3	Meter #4
{L2} Override Code	________	________	________	________	________

Enter the Override Code strategy:

0 = Never use override code
1 = Always use override code
2 = Use override code on transmitter failure
3 = On transmitter failures use last hour's average

	Station	Meter #1	Meter #2	Meter #3	Meter #4
{L1} at 4mA*	________	________	________	________	________

Enter the temperature engineering units that the transmitter outputs at 4mA or 1volt, or lower range limit (LRV) of Honeywell Smart Transmitters.

	Station	Meter #1	Meter #2	Meter #3	Meter #4
{L1} at 20mA*	________	________	________	________	________

Enter the temperature engineering units that the transmitter outputs at 20mA or 5 Volts, or upper range limit (URV) of Honeywell Smart Transmitters.

	Station	Meter #1	Meter #2	Meter #3	Meter #4
{L1} Damping Code	________	________	________	________	________

This entry only applies to Honeywell digital transmitters connected to an H Type combo module. The process variable (i.e., temperature) is filtered by the transmitter before being sent to the flow computer. The time constant used depends on this entry.

For Temperature Transmitters, enter the selected Damping Code:

0 = 0 seconds
1 = 0.3 seconds
2 = 0.7 seconds
3 = 1.5 seconds
4 = 3.1 seconds
5 = 6.3 seconds
6 = 12.7 seconds
7 = 25.5 seconds
8 = 51.5 seconds
9 = 102.5 seconds

2.12.3. Station and Meter Run Density Temperature Settings

Meter Density Temperature Setup via the Random Access Method: *To access these settings, in the Program Mode press **[Density] [Temp] [Enter].***

INFO: *The Density Temperature sensor is used to compensate for temperature expansion effects which effect the periodic time of oscillation of the densitometer. It is also used when desired to calculate the density of the liquid to reference temperature using API 2540; Table 23, 23A or 23B*

** **NOTE:** Not Valid when a RTD Probe is specified*

	Station	Meter #1	Meter #2	Meter #3	Meter #4
Low Alarm Limit	________	________	________	________	________

Enter the temperature below which the densitometer low alarm activates. Transducer values approximately 5% below this entry activate the transducer fail low alarm.

High Alarm Limit ________ ________ ________ ________ ________

Enter the temperature above which the densitometer high alarm activates. Transducer values approximately 10% above this entry activate the transducer fail high alarm.

{L2} Override ________ ________ ________ ________ ________

Enter the temperature value that is substituted for the live transducer value, depending on the override code. An '*' displayed along side of the value indicates that the override value is substituted.

{L2} Override Code ________ ________ ________ ________ ________

Enter the Override Code strategy:

0 = Never use override code
1 = Always use override code
2 = Use override code on transmitter failure
3 = On transmitter failures use last hour's average

{L1} at 4mA* ________ ________ ________ ________ ________

Enter the temperature engineering units that the transducer outputs at 4mA or 1volt, or lower range limit (LRV) of Honeywell Smart Transmitters.

{L1} at 20mA* ________ ________ ________ ________ ________

Enter the temperature engineering units that the transducer outputs at 20mA or 5volts, or upper range limit (URV) of Honeywell Smart Transmitters.

{L1} Damping Code_________ _________ _________ _________ _________

This entry only applies to Honeywell digital transmitters connected to an H Type combo module. The process variable (i.e., temperature) is filtered by the transmitter before being sent to the flow computer. The time constant used depends on this entry.

For Temperature Transmitters, enter the selected Damping Code:

0 = 0 seconds
1 = 0.3 seconds
2 = 0.7 seconds
3 = 1.5 seconds
4 = 3.1 seconds
5 = 6.3 seconds
6 = 12.7 seconds
7 = 25.5 seconds
8 = 51.5 seconds
9 = 102.5 seconds

2.13. Configuring Meter Pressure

Meter Pressure Setup via the Random Access Method: *Setup entries require that you be in the Program Mode. In the Display Mode press the* ***[Prog]*** *key. The Program LED will glow green and the '****Select Group Entry****' screen will appear. Then press* ***[Press] [Enter]****, or* ***[Press] [Meter] [n] [Enter]*** *or* ***[Meter] [n] [Press] [Enter]*** *(n = Meter Run # 1, 2, 3 or 4). Use* ***[↑] / [↓]*** *keys to scroll.*

2.13.1. Accessing the Pressure Setup Submenu

Applying the Menu Selection Method, in the '**Select Group Entry**' screen (Program Mode) press **[Setup] [Enter]** and a menu similar to the following will be displayed:

```
***  SETUP MENU  ***
Grav/Density Setup
Temperature Setup
Pressure Setup    _
```

Use the **[↑]/[↓]** (up/down arrow) keys to move the cursor to '**Pressure Setup**' and press **[Enter]** to access the submenu.

2.13.2. Station and Meter Run Pressure Settings

	Station	Meter #1	Meter #2	Meter #3	Meter #4

Low Alarm Limit _________ _________ _________ _________ _________

Enter the pressure below which the flowmeter low alarm activates. Transducer values approximately 5% below this entry fail to low.

High Alarm Limit _________ _________ _________ _________ _________

Enter the pressure above which the flowmeter high alarm activates. Transducer values approximately 10% above this entry fail to high.

{L2} Override _________ _________ _________ _________ _________

Enter the pressure value that is substituted for the live transducer value, depending on the override code. An '*' displayed along side of the value indicates that the override value is substituted.

{L2} Override Code_________ _________ _________ _________ _________

Enter the Override Code strategy:

0 = Never use override code
1 = Always use override code
2 = Use override code on transmitter failure
3 = On transmitter failures use last hour's average

{L1} at 4mA* _________ _________ _________ _________ _________

Enter the pressure engineering units that the transmitter outputs at 4mA or 1volt, or lower range limit (LRV) of Honeywell Smart Transmitters.

{L1} at 20mA* _________ _________ _________ _________ _________

Enter the pressure engineering units that the transmitter outputs at 20mA or 5volts, or upper range limit (URV) of Honeywell Smart Transmitters.

	Station	Meter #1	Meter #2	Meter #3	Meter #4
{L1} Damping Code	_________	_________	_________	_________	_________

This entry only applies to Honeywell digital transmitters connected to an H Type combo module. The process variable (i.e., pressure) is filtered by the transmitter before being sent to the flow computer. The time constant used depends on this entry.

For Pressure Transmitters, enter the selected Damping Code:

0 = 0 seconds	5 = 2 seconds
1 = 0.16 seconds	6 = 4 seconds
2 = 0.32 seconds	7 = 8 seconds
3 = 0.48 seconds	8 = 16 seconds
4 = 1 seconds	9 = 32 seconds

2.13.3. Station and Meter Run Density Pressure Settings

Meter Density Pressure Setup via the Random Access Method: *To access these settings, in the Program Mode press **[Density] [Press] [Enter]**.*

INFO: *The Density Pressure sensor is used to compensate for pressure effects which effect the periodic time of oscillation of the densitometer. It is also used when desired to calculate the density of the liquid at the densitometer to equilibrium pressure using API 2540 MPMS 11.2.1 or 11.2.2.*

** **NOTE:** Not Valid when a RTD Probe is specified*

	Station	Meter #1	Meter #2	Meter #3	Meter #4
Low Alarm Limit	_________	_________	_________	_________	_________

Enter the pressure below which the densitometer low alarm activates. Transducer values approximately 5% below this entry activate the transducer fail low alarm.

High Alarm Limit _________ _________ _________ _________ _________

Enter the pressure above which the densitometer high alarm activates. Transducer values approximately 10% above this entry activate the transducer fail high alarm.

{L2} Override _________ _________ _________ _________ _________

Enter the pressure value that is substituted for the live transducer value, depending on the override code. An '*' displayed along side of the value indicates that the override value is substituted.

{L2} Override Code _________ _________ _________ _________ _________

Enter the Override Code strategy:

0 = Never use override code
1 = Always use override code
2 = Use override code on transmitter failure
3 = On transmitter failures use last hour's average

{L1} at 4mA* _________ _________ _________ _________ _________

Enter the pressure engineering units that the transducer outputs at 4mA or 1volt, or lower range limit (LRV) of Honeywell Smart Transmitters.

{L1} at 20mA* _________ _________ _________ _________ _________

Enter the pressure engineering units that the transducer outputs at 20mA or 5volts, or upper range limit (URV) of Honeywell Smart Transmitters.

{L1} Damping Code_________ _________ _________ _________ _________

This entry only applies to Honeywell digital transmitters connected to an H Type combo module. The process variable (i.e., pressure) is filtered by the transmitter before being sent to the flow computer. The time constant used depends on this entry.

For Pressure Transmitters, enter the selected Damping Code:

0 = 0 seconds	5 = 2 seconds
1 = 0.16 seconds	6 = 4 seconds
2 = 0.32 seconds	7 = 8 seconds
3 = 0.48 seconds	8 = 16 seconds
4 = 1 seconds	9 = 32 seconds

2.14. Configuring Differential Pressure

2.14.1. Accessing the Differential Pressure Setup Submenu

Meter Differential Pressure Setup via the Random Access Method: *Setup entries require that you be in the Program Mode. In the Display Mode press the* ***[Prog]*** *key. The Program LED will glow green and the '****Select Group Entry****' screen will appear. Then press* ***[D.P.] [Enter]****, or* ***[D.P.] [Meter] [n] [Enter]*** *or* ***[Meter] [n] [D.P.] [Enter]*** *(n = Meter Run # 1, 2, 3 or 4). Use* ***[↑] / [↓]*** *keys to scroll.*

NOTE: *Differential pressure is expressed as "inches of water" (US units) and either kPa or mBar (metric units), depending upon setting made in the 'Factor Setup' menu.*

Applying the Menu Selection Method, in the '**Select Group Entry**' screen (Program Mode) press **[Setup] [Enter]** and a menu similar to the following will be displayed:

```
***  SETUP MENU  ***
Temperature Setup
Pressure Setup
DP Inches of Water _
```

Use the **[↑]/[↓]** (up/down arrow) keys to move the cursor to '**DP Inches of Water**' and press **[Enter]** to access the submenu.

2.14.2. Station and Meter Differential Pressure Settings

	Station	Meter #1	Meter #2	Meter #3	Meter #4
Low Alarm Limit	________	________	________	________	________

Enter the flowing differential pressure below which the orifice flowmeter low alarm digital point activates.

High Alarm Limit ________ ________ ________ ________ ________

Enter the flowing differential pressure above which the orifice flowmeter high alarm digital point activates.

{L2} Override Value ________ ________ ________ ________ ________

Enter the pressure value that is substituted for the live transducer value, depending on the override code. An '*' displayed along side of the value indicates that the override value is substituted.

{L2} Override Code ________ ________ ________ ________ ________

Enter the Override Code strategy:

0 = Never use override code
1 = Always use override code
2 = Use override code on transmitter failure
3 = On transmitter failures use last hour's average

{L1} Low DP at 4mA ________ ________ ________ ________ ________

Enter the pressure engineering units that the low range DP transmitter outputs at 4mA or 1volt, or LRV of Honeywell Smart Transmitters.

{L1} Low DP at 20mA_________ _________ _________ _________ _________

Enter the pressure engineering units that the low range DP transmitter outputs at 20mA or 5 Volts, or URV of Honeywell Smart Transmitters.

Station	Meter #1	Meter #2	Meter #3	Meter #4

{L1} Damping Code_________ _________ _________ _________ _________

This entry only applies to Honeywell digital transmitters connected to an H Type combo module. The process variable (I.e., pressure) is filtered by the transmitter before being sent to the flow computer. The time constant used depends on this entry.

For Differential Pressure/Pressure Transmitters, enter the selected Damping Code:

0 = 0 seconds	5 = 2 seconds
1 = 0.16 seconds	6 = 4 seconds
2 = 0.32 seconds	7 = 8 seconds
3 = 0.48 seconds	8 = 16 seconds
4 = 1 seconds	9 = 32 seconds

{L1} Hi DP at 4mA _________ _________ _________ _________ _________

Enter the pressure engineering units that the high range DP transmitter outputs at 4mA or 1volt, or LRV of Honeywell Smart Transmitters.

{L1} Hi DP at 20mA_________ _________ _________ _________ _________

Enter the pressure engineering units that the high range DP transmitter outputs at 20mA or 5 Volts, or URV of Honeywell Smart Transmitters.

{L1} Damping Code_________ _________ _________ _________ _________

This entry only applies to Honeywell digital transmitters connected to an H Type combo module. The process variable (I.e., pressure) is filtered by the transmitter before being sent to the flow computer. The time constant used depends on this entry.

For Differential Pressure/Pressure Transmitters, enter the selected Damping Code:

0 = 0 seconds	5 = 2 seconds
1 = 0.16 seconds	6 = 4 seconds
2 = 0.32 seconds	7 = 8 seconds
3 = 0.48 seconds	8 = 16 seconds
4 = 1 seconds	9 = 32 seconds

High DP Select % _________ _________ _________ _________ _________

The flow computer will automatically switch over to the signal from the high range DP transmitter when the signal from the low range transmitter exceeds this percent of its range. The switch over will not occur if the high range transmitter has failed or is not installed.

Low DP Select % _________ _________ _________ _________ _________

The flow computer will automatically switch over to the signal from the low range DP transmitter when the signal from the high range transmitter falls below this percent of its range. The switch over will not occur if the high range transmitter has failed or is not installed.

2.15. Configuring the Meter Station

Meter Station Setup via the Random Access Method: *Setup entries require that you be in the Program Mode. In the Display Mode press the **[Prog]** key. The Program LED will glow green and '**Select Group Entry**' screen will appear. Then press **[Meter] [Enter]** and use **[↑] / [↓]** keys to scroll.*

Meter Station Run Switching Flow Rate Thresholds: *The OMNI flow computer has 3 Boolean flags which are set or reset depending on the station flow rate: Run Switching Flag #1 at Modbus database point **1824,** Run Switching Flag #2 at Modbus database point **1825,** Run Switching Flag #3 at Modbus database point **1826.** Each of these flags has a low threshold and high threshold flow rate. Each flag is set when the station flow rate exceeds the corresponding high threshold value. These flags reset when the station flow rate falls below the respective low threshold limit. See **Chapter 3** for more information on how to include these flags in Boolean statements to automatically switch meter runs depending on flow rates*

2.15.1. Accessing the Station Setup Submenu

Applying the Menu Selection Method, in the '**Select Group Entry**' screen (Program Mode) press **[Setup] [Enter]** and a menu similar to the following will be displayed:

```
***  SETUP MENU  ***
Pressure Setup
DP Inches of Water
Station Setup      _
```

Use the **[↑]/[↓]** (up/down arrow) keys to move the cursor to '**Station Setup**' and press **[Enter]** to access the submenu.

2.15.2. Meter Station Settings

{L1} Station ID ________________

Enter 8 alphanumeric characters maximum. This string variable usually appears in user custom reports (Modbus database point **4815**).

High/Low Limits Units Selection (0=Mass, 1=Net) ________________

Select the units for the high and low alarm limit. The choices are Mass or Net Volume. (Available with firmware 27.75.01 and up).

Flow Low Alarm Limit ________________

Enter the flow rate below which the Station Low Flow Alarm activates (Modbus database point **1810**). Flow rates 5% below this value activate the Low Low Alarm (Modbus database point **1809**).

Flow High Alarm Limit ________________

Enter the flow rate above which the Station High Flow Alarm activates (Modbus database point **1811**). Flow rates 5% above this value activate the High High Alarm (Modbus database point **1812**).

{L1} Gross Flowrate Full Scale ________________

Enter the gross flow rate at full-scale for the meter station. Sixteen-bit integer variables representing station gross and net flow rate are included in the database at **3802** and **3804**. These variables are scaled using this entry and stored as percentage of full scale with a resolution of 0.1% (i.e., 0 to 999 = 0% to 99.9%)

{L1} Mass Flowrate Full Scale _______________

Enter the mass flow rate at full-scale for the meter station. A 16-bit integer variable representing station mass flow rate is included in the database at **3806**. This variable is scaled using this entry and stored as percentage of full scale with a resolution of 0.1% (i.e., 0 to 1000 = 0% to 100.0%)

Run Switch Operating Mode _______________

In multi-meter run systems the flow computer can be configured to automatically open and close meter run block valves depending upon orifice differential pressure. Enter **[Y]** to select 'Automatic' mode if you have a multi-run system and wish to have the flow computer control the MOV block valves. Enter **[N]** to select 'Manual' mode if you wish to operate the valves via the keypad of the flow computer manually or via a Modbus link. Ignore this entry if you do not have MOVs which are controlled by the flow computer.

Run Switch Delay Timer _______________

Enter the amount of time in seconds that you want the flow computer to allow for each meter run block valve to open and flow rate to be established. If after this amount of time differential reassure or flow rate has not been detected, the meter run block valve will be given the 'close' command and the meter run alarmed as being out of service. The flow computer will not attempt to open a meter run which is out of service until it is placed back in service, either via the flow computer keypad or via a Modbus command.

Run Switch Threshold Low Differential Pressure % _______________

A meter run will be closed when the differential pressure across the orifice falls below this threshold percentage of its maximum range. Orifice runs are closed starting from the highest meter run number to the lowest. The last meter run is always left open but may be closed via manual command.

Run Switch Threshold High Differential Pressure % _______________

A meter run will be opened when the differential pressure across the orifice of the last run opened exceeds this percentage of its maximum range. Meter runs are opened in order from lowest to highest skipping any meter runs which may not be in service. Runs placed back in service will automatically be utilized when the flow computer 'wraps around' (i.e., opens the highest numbered meter run and then starts looking for any runs that may have be out of service previously).

Gas Analysis Variables

Gas Analysis Variables: *Press* ***[Prog], [Meter], [Enter]*** *at the front keypad to access the following gas analysis variables: Reference Specific Gravity (Ref SG), Nitrogen (N2) %, Carbon Dioxide (CO2) %, Heating Value (HV).*

** **NOTE:** Not Valid when a RTD Probe is specified*

	Ref. SG	N_2 %	CO_2 %	HV
Low Alarm Limit	_______	_______	_______	_______

Enter the gas analysis variable value to be used as the low alarm point. The low alarm will activate when the input variable falls below this value.

High Alarm Limit _______ _______ _______ _______

Enter the gas analysis variable value to be used as the high alarm point. The high alarm will activate when the input variable goes above this value.

{L2} Override Value _______ _______ _______ _______

Enter the engineering value that is substituted for the live transducer value, depending on the override code. An '*' displayed along side of the value indicates that the override value is substituted.

{L2} Override Code ________ ________ ________ ________

Enter the Override Code strategy:

0 = Never use override code
1 = Always use override code
2 = Use override code on transmitter failure
3 = On transmitter failures use last hour's average

{L1} Value at 4mA* ________ ________ ________ ________

Enter the engineering units that the transducer outputs at 4mA or 1volt. This entry does not apply for reference specific gravity when Solartron 3098 gravitometer is selected as the reference SG transducer type.

{L1} Value at 20mA* ________ ________ ________ ________

Enter the engineering units that the transducer outputs at 20mA or 5volt. This entry does not apply for reference specific gravity when Solartron 3098 gravitometer is selected as the reference SG transducer type.

{L1} NX19 Analysis ______________

Selecting NX19 Analysis will require the user to enter the GC components Mole % for Nitrogen (N2) and Carbon Dioxide (CO2)

Gas Analysis Variable & Auxiliary Input Setup via the Random Access Method: *Setup entries require that you be in the Program Mode. In the Display Mode press the **[Prog]** key. The Program LED will glow green and '**Select Group Entry**' screen will appear. Then press **[Analysis] [Input] [Enter]** or **[Analysis] [Input] [n] [Enter]** (n = Auxiliary Input # 1, 2, 3 or 4). Use **[↑] / [↓]** keys to scroll.*

** **NOTE:** Not Valid when a RTD Probe is specified*

Time Reference of Gas 'X' ______________

This entry applies only if Solartron 3098 gravitometer is selected as the reference specific gravity transducer type. Enter the periodic times (in microseconds) recorded when measuring the two sample gases 'X' and 'Y' used to determine the calibration constants K_0 and K_2 for the Solartron 3098 specific gravity transducer.

Specific Gravity of Reference Gas 'Y' ______________

This entry applies only if Solartron 3098 gravitometer is selected as the reference specific gravity transducer type. Enter the reference specific gravity of 'Reference Gas X or Y'. Sample gases 'X' and 'Y' are used to determine the calibration constants K_0 and K_2 for the Solartron 3098 specific gravity transducer.

Time Reference of Gas 'Y' ______________

This entry applies only if Solartron 3098 gravitometer is selected as the reference specific gravity transducer type. Enter the periodic times (in microseconds) recorded when measuring the two sample gases 'X' and 'Y' used to determine the calibration constants K_0 and K_2 for the Solartron 3098 specific gravity transducer.

Auxiliary Inputs

	Input #1	Input #2	Input #3	Input#4
Low Limit	________	________	________	________
High Limit	________	________	________	________
{L2} Override	________	________	________	________

Low Limit

Enter the auxiliary input signal value below which the Low Alarm activates.

High Limit

Enter the auxiliary input signal value above which the High Alarm activates.

{L2} Override

Enter the value (in engineering units) which will be substituted for the transducer value depending, on the override code selected. An '*****' displayed along side of the value indicates that the override value is substituted.

{L2} Override Code ________ ________ ________ ________

Enter the Override Code strategy:

0 = Never use override code
1 = Always use override code
2 = Use override code on transmitter failure
3 = On transmitter failures use last hour's average

{L1} at 4mA* ________ ________ ________ ________

Enter the value (in engineering units) that produces a transmitter output of 4mA or 1vol, or LRV of Honeywell Smart Transmitters t.

{L1} at 20mA* ________ ________ ________ ________

Enter the value (in engineering units) that produces a transmitter output of 20mA or 5 Volts, or URV of Honeywell Smart Transmitters.

Specific Gravity of Reference Gas 'X' ________________

This entry applies only if Solartron 3098 gravitometer is selected as the reference specific gravity transducer type. Enter the reference specific gravity of 'Reference Gas X or Y'. Sample gases 'X' and 'Y' are used to determine the calibration constants K_0 and K_2 for the Solartron 3098 specific gravity transducer.

{L1} Damping Code ________ ________ ________ ________

This entry only applies to Honeywell digital transmitters connected to an H Type combo module. The process variable (I.e., temperature/pressure) is filtered by the transmitter before being sent to the flow computer. The time constant used depends on this entry.

For Pressure Transmitters, enter the selected Damping Code:

0 = 0 seconds	5 = 2 seconds
1 = 0.16 seconds	6 = 4 seconds
2 = 0.32 seconds	7 = 8 seconds
3 = 0.48 seconds	8 = 16 seconds
4 = 1 seconds	9 = 32 seconds

For Temperature Transmitters, enter the selected Damping Code:

0 = 0 seconds	5 = 6.3 seconds
1 = 0.3 seconds	6 = 12.7 seconds
2 = 0.7 seconds	7 = 25.5 seconds
3 = 1.5 seconds	8 = 51.5 seconds
4 = 3.1 seconds	9 = 102.5 seconds

2.16. Configuring Meter Runs

Meter Run Setup via the Random Access Method: *Setup entries require that you be in the Program Mode. In the Display Mode press the* ***[Prog]*** *key. The Program LED will glow green and the '****Select Group Entry****' screen will appear. Then press* ***[Meter] [n] [Enter]*** *(n = Meter Run # 1, 2, 3 or 4). Use* ***[↑] / [↓]*** *keys to scroll.*

Alternate Access to Meter Run Settings from Meter Station Setup: *After entering the Meter Station Settings, without exiting, press the* ***[↓]*** *key and you will scroll down through each Meter Run setup entry.*

2.16.1. Accessing the Meter Run Setup Submenu

Applying the Menu Selection Method, in the '**Select Group Entry**' screen (Program Mode) press **[Setup] [Enter]** and a menu similar to the following will be displayed:

```
***  SETUP MENU  ***
DP Inches of Water
Station Setup
Meter Run Setup   _
```

Use the **[↑]/[↓]** (up/down arrow) keys to move the cursor to '**Meter Run Setup**' and press **[Enter]** to access the submenu.

2.16.2. Meter Run Settings

	Meter #1	Meter #2	Meter #3	Meter #4
Meter ID	______	______	______	______

Enter the ID of the flowmeter (up to 8 alphanumeric characters) for each meter run. This ID usually appears on reports.

Product # Analysis Selected ______ ______ ______ ______

Enter the product number for the analysis data to be used for each meter run. The flow computer is capable of processing up to four meter streams each with independent fluids and or analysis data. Product and analysis data can be common to any number of metering runs. Valid product numbers are 1-4.

High/Low Limits Unit Selection (0=Mass, 1=Net) ______

Select the units for the high and low alarm limits. The choices are Mass or Net Volume. (Available with firmware 27.75.01 and up)

Flow Low Limit ______ ______ ______ ______

Enter the flow rate for each meter run below which the Flow Low Alarm (database point **1n21**) activates. Flow rates 5% below this value will activate the Low Low Alarm (Modbus database point **1809**).

Flow High Limit ______ ______ ______ ______

Enter the flow rate for each meter run above which the Flow High Alarm (database point **1n22**) activates. Flow rates 5% below this value will activate the High High Alarm (Modbus database point **1812**).

	Meter #1	Meter #2	Meter #3	Meter #4

Gross Flow at Full Scale ________ ________ ________ ________

Enter the gross flow rate at full-scale for each meter run. Sixteen-bit integer variables representing meter run gross and net flow rate are included in the database at **3n42** and **3n40** respectively. These variables are scaled using this entry and stored as percentage of full scale with a resolution of 0.1% (i.e., 0 to 1000 = 0% to 100.0%)

Mass Flow at Full Scale ________ ________ ________ ________

Enter the mass flow rate at full-scale for each meter run. A 16-bit integer variable representing meter run mass flow rate is included in the database at **3n44**. This variable is scaled using this entry and stored as percentage of full scale with a resolution of 0.1% (i.e., 0 to 1000 = 0% to 100.0%)

Additional Entries when Turbine Meter Type Selected

The following entries apply when a turbine meter is selected in the '**Config Meter "n"**' submenu of the '**Misc Configuration**' menu. Unless otherwise indicated, the password level for these settings is {L1}.

Active Frequency Threshold ________ ________ ________ ________

Enter the Active Frequency Threshold for each meter run. Flow meter pulse frequencies equal or greater than this threshold will cause the Meter Active Flag (**1n05**) to be set.

By using any Boolean statement you can use this flag bit to enable and disable totalizing by controlling the Disable Meter Run Flags (Modbus database points **1736**, **1737**, **1738** & **1739**).

Example: 1030:1736=/1105 ⇨ Turn off Meter #1 flow if not greater than Active Frequency.

Error Check Threshold ________ ________ ________ ________

This entry will display only when 'Dual Pulse' is selected under 'Config Meter Runs' (Misc Setup). It applies only when a 'E' combo module is fitted and 'Pulse Fidelity Checking' is enabled.

Enter the Pulse Fidelity Error Check Threshold (in Hz) for each meter run. To eliminate bogus alarms and error count accumulations, the dual pulse error checking functions are disabled until the sum of both pulse trains exceeds the pulses per seconds entered for this setting.

Example: Entering 50 for this threshold means that the dual pulse error checking will be disabled until both A and B channels of the flowmeter pick-offs are providing 25 pulses per second each.

Max Error Counts/Batch ________ ________ ________ ________

This entry will display only when 'Dual Pulse' is selected under 'Config Meter Runs' (Misc Configuration). It applies only when a 'E' combo module is fitted and 'Pulse Fidelity Checking' is enabled.

Enter the maximum number of error pulses allowed in one transaction for each meter run. The alarm points are:

- ❑ 1n48 A/B Comparator Error Detected
- ❑ 1n49 A Channel Failed
- ❑ 1n50 B Channel Failed
- ❑ 1n51 A and B Channels not equal

The dual pulse A/B Comparator Error Alarm (**1n48**) is activated when the accumulated error counts between the flowmeter channels exceeds this count threshold. Accumulated error counts are cleared for every batch.

	Meter #1	Meter #2	Meter #3	Meter #4
{L1A} K Factor #1				

This entry applies for simple flow-based linearization of K Factor. Enter the K Factors for each meter run. In this case, up to 12 K Factors and the associated flowmeter pulse frequencies are entered per meter run to define the K Factor Curve. The flow computer will continuously monitor the flowmeter pulse frequency and calculate gross flow based on and interpolated K Factor derived from the entered data points. Use only K Factor #1 in cases where flowmeter linearizing is not required. The K Factors associated with the lowest or highest frequency point will be used in cases where the flowmeter frequency is outside of the entered values.

	Meter #1	Meter #2	Meter #3	Meter #4
Frequency Point 1				

Enter the flowmeter pulse frequency associated with the corresponding K Factor. The frequency points must be entered lowest to highest (Hz).

	Meter #1	Meter #2	Meter #3	Meter #4
{L1A} K Factor #2				
Frequency Point 2				
{L1A} K Factor #3				
Frequency Point 3				
{L1A} K Factor #4				
Frequency Point 4				
{L1A} K Factor #5				
Frequency Point 5				
{L1A} K Factor #6				
Frequency Point 6				
{L1A} K Factor #7				
Frequency Point 7				
{L1A} K Factor #8				
Frequency Point 8				
{L1A} K Factor #9				
Frequency Point 9				
{L1A} K Factor #10				
Frequency Point 10				
{L1A} K Factor #11				
Frequency Point 11				
{L1A} K Factor #12				
Frequency Point 12				

Meter #1 **Meter #2** **Meter #3** **Meter #4**

Meter Factor _________ _________ _________ _________

Enter the meter factor for the turbine flowmeter. The meter factor is a multiplier close to 1.0000 included to correct for small changes in flow meter characteristics. Net and mass flows are dependent on this number. Meter factors are determined by proving the flowmeter against some known standard volume or standard rate.

Meter Model _________ _________ _________ _________

Enter the model number of the flowmeter (up to 8 alphanumeric characters). This entry usually appears on the prove report.

Meter Size _________ _________ _________ _________

Enter the size of the flowmeter (up to 8 alphanumeric characters). This entry usually appears on the prove report.

Serial Number _________ _________ _________ _________

Enter the serial number of the flowmeter (up to 8 alphanumeric characters). This entry usually appears on the prove report.

Transducer Density Select ? _________ _________ _________ _________

Enter **[Y]** if you have a densitometer transducer measuring flowing density on this metering run and you wish to use this density value to calculate mass and volume flow rate. Enter **[N]** to cause the flow computer to use the appropriate equation of state.

Additional Entries when Orifice Meter Type Selected

The following entries apply when an orifice meter is selected in the '**Config Meter "n"**' submenu of the '**Misc Configuration**' menu. Unless otherwise indicated, the password level for these settings is {L1}.

Low Flow Cutoff _________ _________ _________ _________

Differential pressure signals lower than the value entered here will not be totalized. Differential pressure is expressed as 'inches of water' for U.S. units applications and 'kPa' or 'mBar' for metric units applications.

Orifice/Venturi Throat Diameter _________ _________ _________ _________

Enter the diameter (inches or mm) of the orifice bore at the orifice plate reference temperature. The actual diameter of the orifice bore is calculated continuously based on the flowing temperature of the fluid.

Orifice/Venturi Ref. Temperature _________ _________ _________ _________

Enter the temperature (°F for US units or °C for metric units) that corresponds to the temperature of the orifice plate when the bore was measured.

Orifice/Venturi Expansion Coef. _________ _________ _________ _________

Enter the expansion coefficient for the type of material of the orifice plate (see table below). The orifice bore diameter will expand and contract depending upon the temperature and thermal expansion coefficient for the type of plate material. The orifice equations require the linear coefficient of expansion.

	US Customary Units	Metric Units
Mild Steel Plate	-100 to 300 °F = 6.20 x e^{-6}	-73.3 to 148.9 °C = 1.12 x e^{-5}
304/316 Stainless Steel	-100 to 300 °F = 9.25 x e^{-6}	-73.3 to 148.9 °C = 1.67 x e^{-5}
Monel	-7 to 154 °F = 7.95 x e^{-6}	-21.6 to 67.8 °C = 1.43 x e^{-5}

	Meter #1	Meter #2	Meter #3	Meter #4

Pipe Measured Diameter ________ ________ ________ ________

Enter the diameter of the meter tube pipe (inches or mm) at the reference temperature. The actual diameter of the meter tube used in the equations is calculated continuously based on the flowing temperature of the fluid.

Pipe Reference Temperature ________ ________ ________ ________

Enter the temperature (°F for US units or °C for metric units) that corresponds to the temperature of the metering tube when the orifice diameter was measured.

Pipe Expansion Coefficient ________ ________ ________ ________

Enter the expansion coefficient for the type of material of the pipe. The meter tube diameter will expand and contract depending upon the temperature and thermal expansion coefficient for the type of pipe material. The orifice equations require the linear coefficient of expansion.

	US Customary Units	Metric Units
Mild Steel Plate	-100 to 300 °F = 6.20 x e^{-6}	-73.3 to 148.9 °C = 1.12 x e^{-5}
304/316 Stainless Steel	-100 to 300 °F = 9.25 x e^{-6}	-73.3 to 148.9 °C = 1.67 x e^{-5}
Monel	-7 to 154 °F = 7.95 x e^{-6}	-21.6 to 67.8 °C = 1.43 x e^{-5}

Use Downstream Pressure? ________ ________ ________ ________

Static pressure of the flowing fluid can be obtained from either the upstream or downstream pressure tap. Enter **[Y]** if downstream pressure is used. Enter **[N]** if upstream pressure is used.

Disable Isentropic Temp Correct. ________ ________ ________ ________

Enter **[Y]** (for 'Yes') to disable the downstream-to-upstream temperature correction calculation which assumes that an 'isentropic expansion' occurs after the orifice plate. The default for this entry is 'Yes' as AGA-3/API 14.3 do NOT mandate the use of this correction. This entry should always be **[Y]** when the temperature of the fluid is measured upstream of the orifice. At high differential pressures across the orifice, a significant cooling of the fluid can take place as it decompresses, if temperature is measured downstream of the orifice you may choose to ignore this effect by entering **[Y]** or correct for this effect by entering **[N]** (for 'No'). The flow computer corrects the downstream temperature to the equivalent upstream*am temperature.

Type of Differential Pressure Taps ________ ________ ________ ________

Enter the Flange or Pipe Tap:

0 = Orifice corner
1 = Orifice pipe
2 = Orifice flange
3 = Orifice D & D/2
4 = ASME flow nozzle
5 = Venturi (C=0.084)
6 = Venturi (C=0.995)

The flow computer must be informed as to where the differential pressure taps are located on the orifice metering tube.

Transducer Density Select ? ________ ________ ________ ________

Enter **[Y]** if you have a densitometer transducer measuring flowing density on this metering run and you wish to use this density value to calculate mass and volume flow rate.

Enter **[N]** to cause the flow computer to use the appropriate equation of state.

ISO 5167 Selection (Rev 2774) ________ ________ ________ ________

Heating Value and ISO5167 selection both use this help menu. For Heating Value select 0=AGA5, 1=GPA2172-96, 2=ISO6976-95. For ISO5167 enter 0=ISO5167 1991(E), 1=ISO5167 1998(E), 2=ISO5167 2003(E).

2.17. Configuring Miscellaneous Factors

Factor Setup via the Random Access Method: *Setup entries require that you be in the Program Mode. In the Display Mode press the* ***[Prog]*** *key. The Program LED will glow green and the '****Select Group Entry****' screen will appear. Then press* ***[[Factor] [Enter]****, or* ***[Factor] [Meter] [n] [Enter]****, or* ***[Meter] [n] [Factor]****(n = Meter Run # 1, 2, 3, or 4). Use* ***[↑] / [↓]*** *keys to scroll.*

2.17.1. Accessing the Factor Setup Submenu

Applying the Menu Selection Method, in the '**Select Group Entry**' screen (Program Mode) press **[Setup] [Enter]** and a menu similar to the following will be displayed:

```
***  SETUP MENU  ***
Station Setup
Meter Run Setup
Factor Setup      _
```

Use the **[↑]/[↓]** (up/down arrow) keys to move the cursor to '**Factor Setup**' and press **[Enter]** to access the submenu.

2.17.2. Factor Settings

{L1} Kg/m^3 to Lb/ft^3 ________________

This entry applies to Revision 23 (US units) only. Enter the multiplier needed to convert the Solartron densitometer readings from Kg/m^3 to Lb/ft^3 (default = 0.062428).

{L1} Atmospheric Pressure ________________

Enter the Atmospheric Pressure in PSIa (US units) or absolute metric units (KPaa or mBara). This is used to convert flowing (gauge) pressure readings in PSIg to PSIa (absolute pressure units) for US units, and for the metric version to absolute units (KPaa or mBara), in conformance with pressure (metric) units selected. Absolute pressure is required for the equations of state.

{L1} Ft^3 to Gallon Factor ________________

This entry applies to Revision 23 (US units) only. Enter the number of gallons in a cubic foot (default = 7.480556).

{L1} Base Pressure ________________

Enter the contract base pressure in PSIa (US units) or absolute metric units (KPAa or mBara), in conformance with pressure (metric) units selected. This is required by the AGA 8 density equation.

{L1} Base Temperature ________________

Enter the contract base temperature in °F (US units) or °C (metric units). This is used by the AGA 8 density equation.

{L1} Density of Air ________________

This entry is needed only for natural gas measurement where AGA 8 will **NOT** be used to calculate 'density at base conditions' (see '**Specific Gravity**' entry in the '**Fluid Data & Analysis**' menu. Entering **[0]** forces the flow computer to use AGA 8 to calculate density at base conditions. Net flow is calculated by dividing mass flow rate by density at base conditions.

{L1} Flow Average Factor _______________

This entry applies only to turbine meters. The flow averaging factor is the number of calculation cycles used to smooth the displayed flow rate. A number 1-99 will be accepted. (A calculation cycle is 500msec).

Alarm Deadband % _______________

Nuisance alarms can occur when input variables spend any amount of time near the high or low alarm set points. These nuisance alarms can swamp the alarm log with useless alarms leaving no room for real alarms. This entry sets a percentage limit based on the 'high alarm' entry. A variable must return within the high/low alarm limits by more than this amount before the alarm is cleared.

Example: High limit is 100°F, Low limit is 20°F, and Alarm deadband is set to 2%. A transducer input which exceeded 100°F will set the 'high alarm'. The transducer signal must drop 2 percent below the high alarm setpoint (98°F) before the alarm will clear.

{L1} Roll All Totalizers _______________

This entry is read-only and can only be changed at the keypad of the flow computer. Totalizers within the computer can be rolled at 8 or 9 significant digits.

Totalizer Decimal Place Resolution

The following are read-only entries that cannot be changed via OmniCom. To change totalizer resolution you must first 'Clear All Totals' in the 'Password Maintenance' menu from the front panel keypad of the flow computer. You will then be given the opportunity to set the totalizing resolution. Valid decimal place settings are: XX; X.X; X.XX; and X.XXX.

Gross (Uncorrected) Totalizer Decimal Places _______________

Enter the number of decimal places for gross totalizer resolution.

Net (Corrected) Totalizer Decimal Places _______________

Enter the number of decimal places for net totalizer resolution.

Mass Totalizer Decimal Places _______________

Enter the number of decimal places for mass totalizer resolution.

Energy Totalizer Decimal Places _______________

Enter the number of decimal places for energy totalizer resolution.

More Factors and System Constants

Flow Weighted Average ? _______________

Two averaging methods are available: flow weighted and time weighted. These methods do not modify the averaged variable if there is no flow taking place. Gas Chromatograph data is always time weighted. Enter **[Y]** to calculated averages weighted by mass flow increment. Enter **[N]** to calculate averages weighted by time period.

Select Pressure Units _______________

This entry applies to Revision 27 (metric units) only, and is a global selection for all pressure variables within the flow computer (1Bar=100KPa, 1kg/cm^2=98.0665KPa). Display resolution is: XX.XKPa, X.XXXBar, or X.XXXKg/cm^2. Enter the pressure units you want to use: 0=KPa; 1=Bar; 2=Kg/m^2.

Select Differential Pressure Units _______________

This entry applies to Revision 27 (metric units) only, and is a global entry which applies to all DP variables within the flow computer (1KPA=10mBar. Display resolution is: x.xxKPa or x.xmBar. Enter the DP units you want to use: 0=KPa; 1=mBar.

2.18. Configuring Fluid Data and Analysis of Products

Product Setup via the Random Access Method: *Setup entries require that you be in the Program Mode. In the Display Mode press the **[Prog]** key. The Program LED will glow green and the '**Select Group Entry**' screen will appear. Then press **[Product] [Enter]** or **[Product] [n] [Enter]** (n = Product # 1 through 16). Use **[↑] / [↓]** keys to scroll.*

2.18.1. Accessing the Fluid Data & Analysis Setup Submenu

Applying the Menu Selection Method, in the '**Select Group Entry**' screen (Program Mode) press **[Setup] [Enter]** and a menu similar to the following will be displayed:

```
***  SETUP MENU  ***
Meter Run Setup
Factor Setup
FluidData&Analysis _
```

Use the **[↑]/[↓]** (up/down arrow) keys to move the cursor to '**Fluid Data & Analysis**' and press **[Enter]** to access the submenu.

2.18.2. General Fluid Data & Analysis (Product) Settings

Fluid data and analysis for up to four different gas products can be stored. Gas product setup data includes: name, type of gas, component analysis, relative density at reference conditions, and calculation algorithms to be used when running the product

	Prod. #1	Prod. #2	Prod. #3	Prod. #4
{L1} Fluid Name	________	________	________	________

Enter the name of the product (up to 8 alphanumeric characters). Appears on reports.

{L1} Fluid Type	________	________	________	________

Enter the type of fluid product:

0 = None.

1 = Natural Gas (AGA 8 1992 Equation of State).

2 = Steam (ASTM).

3 = Steam (NIST).

4 = Water (Keenan & Keys).

5 = Argon (NIST 1048).

6 = Nitrogen (NIST 1048).

7 = Oxygen (NIST 1048).

8 = Hydrogen (NIST 1048).

9 = Ethylene(NIST 1048).

10 =Ethylene (IUPAC).

11= NIST14.

GC Analyzer Stream Number ________ ________ ________ ________

In many cases a gas chromatograph or gas analyzer will be shared between several meter runs or flow streams. When data is transmitted to the flow computer the analyzer will identify which flow stream the analysis data pertains to. Enter the number of the flow stream that this meter run should match before using the analysis data.

Reg Lb/FT³ (Reference Density) ________ ________ ________ ________

Enter the amount of water that the gas contains in Lbs/MMCF.

Use Calculate Viscosity ________ ________ ________ ________

Enter a Y to allow the flow computer to calculate the viscosity. Enter an N to enable the viscosity data to be entered.

Use Isentropic Y/N ________ ________ ________ ________

Enter a Y to allow the flow computer to calculate the isentropic exponent. Enter an N to enable the isentropic exponent to be entered.

Heating Value BTUSCF (Stream) ________ ________ ________ ________

Enter a minus (negative) override value if you want the flow computer to calculate a heating value to calculate energy totals.

{L1} Reference Density ________ ________ ________ ________

This entry is not required when AGA8 is selected. Reference density is required to calculate standard volume. Enter the density of the gas or water in Lb/FT^3 (US units) or Kg/m^3 (metric units) at standard temperature and pressure.

Add Neo C5 to Density Calculation ________ ________ ________ ________

Add Neo C5 to Heating Value Calculation

________ ________ ________ ________

Prod. #1 **Prod. #2** **Prod. #3** **Prod. #4**

{L1} Flowing Fluid Viscosity ________ ________ ________ ________

Enter the absolute viscosity of the gas at flowing conditions in centipoise units. For NIST 1048 products only, enter '**-999**' to have the flow computer calculate the viscosity using the equation of state.

{L1} Isentropic Exponent ________ ________ ________ ________

Enter the Isentropic Exponent dimensionless factor for this product at flowing conditions. For NIST 1048 fluids only, enter '**-999**' to have the flow computer calculate it for you using the equation of state.

{L1} Heating Value (HV) ________ ________ ________ ________

Enter a minus (negative) override value if you want the flow computer to calculated a heating value to calculate energy totals. Heating value is calculated using AGA-5, GPA 2172 or ISO 6976 for natural gas. NIST algorithms are used for steam and other gases. HV is expressed in BTU/SCF (US units) or MJ/Nm3 (metric units). Enter a positive override value to be used in place of the calculated value in systems where a gas chromatograph (GC) is not available. In systems which use a GC this override is also the fall back value should the GC fail. The GC HV if available will always be used unless it is assigned the component number '0' in the 'Analysis Setup' menu. Energy can also be calculated using the live 4-20mA value obtained from a BTU analyzer. In this case the analyzer value overwrites this entry in the #1 product area only.

{L1} LBS/MMCF
Water Content ________ ________ ________ ________

This entry applies to Revision 23(US units) only. Enter the amount of water that the gas contains in Lbs/MMCF. It is used to calculate the correction factor FWV. Due to the resolution of FWV(X.XXXX) water contents of 7 Lbs/MMCF and less produce FWV factors of 1.0000. Factor FWV corrects the net volume and therefore energy for water content. Enter zero if a GC is providing water content in the compositional analysis.

2.18.3. Additional Settings for Natural Gas Product

INFO: *AGA 8 can also be used for many other gas mixtures, including carbon dioxide.*

	Prod. #1	Prod. #2	Prod. #3	Prod. #4
Density Method	________	________	________	________

Enter the AGA 8 calculation method for characterization of the natural gas mixture (see selections below). You must select a 'detailed method' if you will be connected to a gas chromatograph analyzer.

0 = Disable AGA 8 Calculations.

1 = 1994 - Detailed Analysis. (AGA10 is available when 1994 Density Method #1 selected)

2 = 1994 - HV / SG / CO_2.

3 = 1994 - SG / N_2 / CO_2.

4 = 1992 - Detailed Analysis.

5 = 1992 - HV / SG / CO_2.

6 = 1992 - SG / N_2 / CO_2.

7 = 1985 - Detailed Analysis.

8 = 1985 - HV / SG / CO_2.

9 = 1985 - HV / SG / N_2 / CO_2.

10 =1985 - SG / N_2 / CO_2.

11 =1985 - HV / N_2 / CO_2.

12 =1985 - SG / CO_2 / C_1.

17 =Redlich-Kwong.

19 =Ideal Gas Calculation

Enable AGA10 Y/N	________	________	________	________

AGA10 Variables will be calculated if the Density method selected as AGA8 1994 Detail method and AGA10 is enabled by selecting Yes as shown above. AGA10 variables, Velocity of Sound, Cp, Cv. Cp/Cv, Isentropic Exponent, dZ/dT, Molecular weight and Cmp will be calculated and can be viewed on the computer front panel display with the key press 'Temp' 'Factor' 'Meter' 'N' Enter.

Heating Value Method Select	________	________	________	________

Enter the method used to calculate the heating value of the gas: 0=AGA-5, 1=GPA 2172-96, 2=ISO 6976-95. The energy flow of the gas may or may NOT be calculated using the method selected, depending upon the manual override value for the entered HV.

	Prod. #1	Prod. #2	Prod. #3	Prod. #4
Specific Gravity	________	________	________	________

Enter a minus (negative) number to instruct the flow computer to calculate 'density at reference conditions' using the AGA 8 equation of state (detailed methods only). Net volumes are calculated by dividing mass flow by 'density at reference conditions'. Otherwise enter a positive override value of specific gravity at reference conditions that will be used together with the 'density of air' entry to calculate 'density at reference conditions'. On product #1 only this value is overwritten if SG is to be obtained from Solartron 3098 gravitometer. In cases where a chromatograph is used, this entry serves as the GC failure override. The GC value of SG if available will also be used unless the component number for SG is set to '0' in the 'Analysis Setup' menu.

Entries for AGA 8 1994/1992 Methods

The following entries apply to AGA 8 1992 and 1994 calculation methods, and represent component mole percentage overrides. Enter the mole percentages of each component of the gas stream. These percentages are used to calculate the flowing density and heating value if the application does not have a gas chromatograph (GC) analyzer or the GC fails. This data may be overwritten by data received from the GC. All entries apply for the detailed analysis method.

	Component # - Mole % Override	Prod. #1	Prod. #2	Prod. #3	Prod. #4
	01 - % Methane (CH_4)	______	______	______	______
#	02 - % Nitrogen (N_2)	______	______	______	______
*#	03 - % Carbon Dioxide (CO_2)	______	______	______	______
	04 - % Ethane (C_2H_6)	______	______	______	______
	05 - % Propane (C_3H_8)	______	______	______	______
	06 - % Water (H_2O)	______	______	______	______
	07 - % Hydrogen Sulfide (H_2S)	______	______	______	______
	08 - % Hydrogen (H_2)	______	______	______	______
	09 - % Carbon Monoxide (CO)	______	______	______	______
	10 - % Oxygen (O_2)	______	______	______	______
	11 - % i-Butane (iC_4H_{10})	______	______	______	______
	12 - % n-Butane (nC_4H_{10})	______	______	______	______
	13 - % i-Pentane (iC_5H_{12})	______	______	______	______
	14 - % n-Pentane (nC_5H_{12})	______	______	______	______
	22 - % Neo Pentane ($neoC_5H_{12}$)	______	______	______	______
	15 - % n-Hexane (C_6H_{14})	______	______	______	______
	16 - % n-Heptane (C_7H_{16})	______	______	______	______
	17 - % n-Octane (C_8H_{16})	______	______	______	______
	18 - % n-Nonane	______	______	______	______
	19 - % n-Decane	______	______	______	______
	20 - % Helium (He)	______	______	______	______
	21 - % Argon (Ar)	______	______	______	______
	Total %	______	______	______	______

Entries for AGA 8 1985 Methods

***NOTES:** These entries apply to the following AGA 8 1985 methods when selected:*

** AGA 8 1985 HV/SG/CO_2*

 # AGA 8 1985 HV/SG/N_2/CO_2 & SG/N_2/CO_2 & HV/N_2/CO_2

^ AGA 8 1985 SG/CO_2/C_1

***INFO:** AGA 8 can also be used for many other gas mixtures, including carbon dioxide*

The following entries apply to AGA 8 1985 calculation methods, and represent component mole percentage overrides. Enter the mole percentages of each component of the gas stream. These percentages are used to calculate the flowing density and heating value if the application does not have a gas chromatograph (GC) analyzer or the GC fails. This data may be overwritten by data received from the GC. All entries apply for the detailed analysis method.

	Component # - Mole % Override	Prod. #1	Prod. #2	Prod. #3	Prod. #4
#^	**01 - % Nitrogen (N_2)**	_______	_______	_______	_______
*#^	**02 - % Carbon Dioxide (CO_2)**	_______	_______	_______	_______
	03 - % Hydrogen Sulfide (H_2S)	_______	_______	_______	_______
	04 - % Water (H_2O))	_______	_______	_______	_______
	05 - % Helium (He)	_______	_______	_______	_______
^	**06 - % Methane (CH_4)**	_______	_______	_______	_______
	07 - % Ethane (C_2H_6	_______	_______	_______	_______
	08 - % Propane (C_3H_8)	_______	_______	_______	_______
	09 - % i-Butane (iC_4H_{10})	_______	_______	_______	_______
	10 - % n-Butane (nC_4H_{10})	_______	_______	_______	_______
	11 - % i-Pentane (iC_5H_{12})	_______	_______	_______	_______
	12 - % n-Pentane (nC_5H_{12})	_______	_______	_______	_______
	21 - % Neo-Pentane ($neoC_5H_{12}$)	_______	_______	_______	_______
	13 - % n-Hexane (C_6H_{14})	_______	_______	_______	_______
	14 - % n-Heptane (C_7H_{16})	_______	_______	_______	_______
	15 - % n-Octane (C_8H_{16})	_______	_______	_______	_______
	16 - % n-Nonane	_______	_______	_______	_______
	17 - % n-Decane	_______	_______	_______	_______
	18 - % Oxygen (O_2)	_______	_______	_______	_______
	19 - % Carbon Monoxide (CO)	_______	_______	_______	_______
	20 - % Hydrogen (H_2)	_______	_______	_______	_______
	Total %	_______	_______	_______	_______

	Prod. #1	Prod. #2	Prod. #3	Prod. #4
Enable AGA10 Y/N	_______	_______	_______	_______

AGA10 Variables will be calculated if the Density method selected as AGA8 1994 Detail method and AGA10 is enabled by selecting Yes as shown above. AGA10 variables, Velocity of Sound, Cp, Cv. Cp/Cv, Isentropic Exponent, dZ/dT, Molecular weight and Cmp will be calculated and can be viewed on the computer front panel display with the key press 'Temp' 'Factor' 'Meter' 'N' Enter.

2.19. Configuring Prover

Prover Setup via the Random Access Method: *Setup entries require that you be in the Program Mode. In the Display Mode press the **[Prog]** key. The Program LED will glow green and the '**Select Group Entry**' screen will appear. Then press **[Prove] [Setup] [Enter]** and use **[↑] / [↓]** keys to scroll.*

2.19.1. Accessing the Prover Setup Submenu

Applying the Menu Selection Method, in the '**Select Group Entry**' screen (Program Mode) press **[Setup] [Enter]** and a menu similar to the following will be displayed:

```
***  SETUP MENU  ***
Pressure Setup
DP Inches of Water
Prover Setup      _
```

Use the **[↑]/[↓]** (up/down arrow) keys to move the cursor to '**Prover Setup**' and press **[Enter]** to access the submenu.

2.19.2. Prover Settings

{L2} Enable Prove Y/N ________________

Enter a Y to enable the prover data to be entered. Computer default is N. NOTE: If archiving RAM has be setup to run this selection will not be allow to be run. To run a prove Archiving must be disabled.

{L2} Number of Runs to Average ________________

Enter the number of consecutive runs required to be considered a complete prove sequence. This number must be between 2 and 10.

{L2} Maximum Number of Runs ________________

Enter the maximum number of runs that will be attempted to achieve a complete prove sequence. This number must be between 2 and 99.

{L2} Master Meter Prover Type Comparison ________________

Enter 0 or 1 to select the Master Meter Proving Comparison. 0=Mass Volume, 1=Net Volume..

{L1} Prover Volume ________________

The Master Meter Method, enter the minimum volume that must flow through the master meter (Meter #4) for each prove run.

{L2} Inactivity Timer ________________

Enter the time in seconds before the prove is aborted due to prover inactivity. Master Meter Method, allow enough time for the amount of flow to pass through the master meter at the lowest expected flow rate.

{L2} Stability Check Sample Time ________________

Enter the Stability Check Sample Time in seconds, used to calculate the rate of change of temperature and flow rate at the prover or master meter. The prove sequence will not start until the temperature and flow rate are stable.

{L2} Sample Time Temperature Change (ΔTemp) ________________

Enter the temperature change allowed during the stability sample time (see previous entry). The change in temperature per sample period must be less than this value for the temperature to be considered stable enough to start a prove.

{L2} Sample Time Flow Rate Change (∆Flow) ________________

Enter the change in flow rate allowed during the stability sample time (see previous two entries). The change in flow rate per sample period must be less than this value before the flow rate is considered to be stable enough to start a prove.

{L2} Prover-to-Meter Temperature Deviation Range ________________

Enter the prover-to-meter temperature range (°C or °F) allowable after the temperature and flow rate have stabilized. The temperature at the meter and the prover must be within this limit or the prove sequence attempt will be aborted.

{L2} Run Repeatability Maximum Deviation % ________________

Enter the maximum allowable percentage deviation between run counts or run meter factors (depending on selection of previous entry). The deviation is calculated by comparing the high/low meter counts or meter factors based on their low point, as follows:

Deviation = 100 (High - Low) / Low Point

This deviation is always calculated using the meter factor when the Master Meter Method of proving is selected.

{L2} Meter Factor Deviation Percent ________________

The prove meter factor (just calculated) is compared against the current meter factor and must be within this percentage range to be accepted as a valid meter factor.

{L2} Automatic Meter Factor Implementation? ________________

Enter **[Y]** to automatically implement the new meter factor and store in the appropriate product file. Enter **[N]** to select not to automatically implement the meter factor determined from the prove.

{L2} Archive All Prove Reports (Y/N) ________________

Chapter 3

User-Programmable Functions

3.1. Introduction

The computer performs many functions, displays and prints large amounts of data, but there are always some application-specific control functions, calculations or displays that cannot be anticipated.

The OMNI Flow Computer incorporates several programmable features that enable the user to easily customize the computer to fit a specific application.

- User-programmable Boolean Flags and Statements
- User-programmable Variables and Statements
- User-configurable Display Screens
- User-customized Report Templates

The first three Items are explained here. The last item requires the use of the OmniCom PC configuration software that comes with the flow computer.

3.2. User-Programmable Boolean Flags and Statements

3.2.1. What is a Boolean?

A Boolean point is simply a single bit register within the computer (sometimes called a flag) which has only two states, On or Off (True or False, 1 or 0). These Boolean flags or points are controlled and/or monitored by the flow computer and represent alarms, commands and status points. Each Boolean point is given an identifying number within the data base of the computer allowing the state (On or Off) to be monitored or modified by assigning that Boolean point to a physical digital I/O point or accessing it via a communication port. A maximum of 24 physical digital I/O points are available for monitoring limit switches, status signals or controlling relays or lamps.

*INFO: The 4-digit 'point' numbers referred to in this chapter are Modbus index numbers used to identify each variable (Boolean or other) within the Modbus database. A complete listing and descriptions of database points is included in **Volume 4**.*

Boolean points are numbered as follows:

1001 through 1024	Physical Digital I/O Points 1 through 24
1025 through 1088	Programmable Boolean Points (64 total)
1089 through 1099	Programmable Pulse outputs (11 total)
1100 through 1199	Meter Run #1 Boolean Points (Alarms, Status etc.)
1200 through 1299	Meter Run #2 Boolean Points (Alarms, Status etc.)
1300 through 1399	Meter Run #3 Boolean Points (Alarms, Status etc.)
1400 through 1499	Meter Run #4 Boolean Points (Alarms, Status etc.)
1500 through 1699	Scratchpad Storage for Results of Boolean Statements
1700 through 1799	Command or Status Inputs
1800 through 1899	Station Boolean Flags (Alarms, Status etc.)
2100 through 2199	Meter Run #1 Totalizer Roll-over Flags
2200 through 2299	Meter Run #2 Totalizer Roll-over Flags
2300 through 2399	Meter Run #3 Totalizer Roll-over Flags
2400 through 2499	Meter Run #4 Totalizer Roll-over Flags
2600 through 2623	Miscellaneous Station Boolean Points (Alarms, Status etc.)
2700 through 2759	Miscellaneous Boolean Command and Status Points
2800 through 2876	Station Totalizer Roll-over Flags
2877 through 2899	More Miscellaneous Boolean Command and Status Points

Physical Digital I/O Points (1001 → 1024)

Each of the physical digital I/O points is assigned to a valid Boolean point number as detailed above. Points 1700 through 1799 are command inputs which are described later, all other point assignments indicate that the I/O point is to be set up as an output point. Output points which are dedicated as flow accumulator outputs can be set up for pulse widths ranging from 10 msec to 100 sec in 10 msec increments. All other output point assignments have associated 'time ON delay' and 'time OFF delay' timers which are adjustable from 0.0 to 1000 sec in 100 msec increments.

Programmable Boolean Points (1025 → 1088)

There are 64 user flags or Boolean points are available and are controlled by 64 Boolean statements or equations. These are provided to perform sequencing and control functions. Each statement or equation is evaluated every 100 msec. starting at point 1025 and ending at point 1088. The results of these Boolean statements can then assigned to physical digital I/O points. There are no restrictions as to what Boolean points can be used in a Boolean statement including the results of other Boolean statements or the status of physical I/O points.

Programmable Accumulator Points (1089 → 1099)

There are 11 Programmable points that are used with Variable Points 7089 through 7099 for programming pulse outputs for Digital I/O or Front Panel Counters.

One-Shot Boolean Points (1501 → 1649)

The 149 Boolean flags located between 1501 and 1650 are used to store temporary data that has been received via the Modbus link or put there by a Boolean statement. These Boolean variables can be sent to a digital output or used in the Boolean statements described above.

Scratch Pad Boolean Points (1650 → 1699)

The 50 Boolean flags located between 1650 and 1699 can be use as momentary commands. When set true they remain on for two seconds.

3.2.2. Sign (+, -) of Analog or Calculated Variables (5001 → 8999)

The sign of analog or calculated variables can also be used in a Boolean statements by simply specifying the point number. The Boolean value of the variable is 'true ' if it is positive and 'false' if it has a negative value.

3.2.3. Boolean Statements and Functions

TIP: *Leave plenty of empty statements between programmed ones. This will allow you to modify the execution order of your program if you need to later.*

INFO: *Use the Exclusive OR function '*' to compare 2 points. The result of an Exclusive OR of 2 points is true only if both points are different states*

Each Boolean statement consists of up to 3 variables optionally preceded by the Boolean '**NOT**' function and separated by one of the Boolean functions '**AND**', '**OR**', 'Exclusive **OR**' or '**EQUAL**'. The following symbols are used to represent the functions:

Function	Symbol
NOT	/
AND	&
OR	+
EX OR	*
EQUAL	=
IF	)
GOTO	G
MOVE RANGE	:
INDIRECT	"
COMPARE	%
TIMER FUNCTION	,
RISING EDGE	(
FALLING EDGE	(/
ONE SHOT	@

The '=' function allows a statement to be used to change the state of the Boolean point on the left of the equal sign (usually a command point). Evaluation precedence is left to right.

The “,” (Timer Function) you can delay activating or deactivating a Boolean point in increments of 100mS ticks to avoid momentary alarms or to allow time for status flags to remain on for extended periods so they can be detected via Modbus reads. This operator works in the same manner as the “Delay On” and “Delay Off” settings when configuring a digital output.

To program the Boolean points proceed as follows:

From the Display Mode press **[Prog] [Setup] [Enter] [Enter]** and the following menu will be displayed:

```
*** Misc. Setup ***
Password Maint?(Y)
Check Modules ?(Y)
Config Station?(Y)
Config Meter "n"
Config PID ? "n"
Config D/A Out "n"
Front Pnl Counters
Program Booleans ? _
Program Variables ?
User Display ? "n"
```

Scroll down to '**Set Boolean? (Y)**' and enter **[Y]**. Assuming that no Booleans are as yet programmed, the display shows:

```
Boolean Point #10xx
25:  _
Rmk
26:
```

Note that the cursor is on the line labeled 25: At this point enter the Boolean equation that will cause Boolean point 1025 to be ON (True) / OFF (False).

INFO: *Points 1005 and 1006 reflect the current status of physical I/O Points 05 and 06 which could be inputs connected to the outside world or outputs controlling relays, etc.*

For example, to turn Boolean 1025 ON whenever Boolean 1005 is OFF, **OR** whenever 1006 is ON, enter **[/1005+1006]** (note the use of the '/' to indicate the '**NOT**' function).

```
Boolean Point #10XX
25: /1005+1006
Rmk
26: _
```

Boolean 1025 could then be used in the statement following which defines Boolean 1026. For example, by including Boolean 1205 which indicates that Meter #2 is active and flowing (see following page), Boolean 1026 will be ON whenever 'Meter 2 is active and flowing' **AND** (1005 is **NOT** ON **OR** 1006 is ON).

```
Boolean Point #10xx
25: /1005+1006
Rmk
26: 1205&1025
```

Use the 'Up/Down' arrow keys to scroll though all 64 programmable Boolean points.

Remember that the Boolean statements are evaluated in order starting from 1025 proceeding to 1088. For maximum speed always ensure that statements used in other statements are evaluated ahead of time by placing them in the correct order.

Example 1: Meter Failure Alarm for Two-Meter Run Application

Object: Using signals from 'flow sensing switches' inserted into the pipeline, provide an alarm output which activates whenever the signals from the flow switches and flow meter signals differ, also provide a snapshot report by setting command point 1719.

How the hardware is configured:

Physical I/O points 02 and 03 are setup as inputs by assigning them to 1700 (see the Command and Status Booleans on a later page). They are connected to flow sensing switches on meter runs 1 and 2 respectively. The switches activate with flow.

Physical I/O point 04 is connected to a 'meter fail alarm bell'. The output is assigned to Programmable Boolean 1027. A 'delay ON' of 5 seconds is selected to eliminate spurious alarms which would occur during startup and shutdown. A 'delay OFF' of 5 seconds is selected to ensure that the alarm bell remains on for at least 5 seconds.

The Booleans are programmed as follows:

INFO: *Booleans 1025, 1026 and 1027 are only used as an example here. Any unused programmable Booleans can be used for this function.*

Notes: *Boolean Point 1025 is true (Meter 1 failed) whenever 'Meter 1 Active' (Point 1105) differs from 'Flow Detected' Flow Switch 1 (Point 02).*

Boolean Point 1026 is true (Meter 2 failed) whenever 'Meter 2 Active' (Point 1205) differs from 'Flow Detected' Flow Switch 2 (Point 03).

Boolean Point 1027 is true (Meter 1 OR 2 failed) whenever point 1025 OR 0126 are true. The Boolean Command Bit 1719 is set when Boolean Point 1027 is true.

True if Meter #1 fails.

True if Meter #2 fails.

Request snapshot if either meter fails.

```
BOOLEAN POINT #10xx
25: 1105*1002
26: 1205*1003
27: 1719=1025+1026
28:
```

Example 2: Automatic Run Switching for 4-Meter Run Application

Object: To improve metering accuracy by automatically selecting the correct flow meter run to be active in a multi run application. Small turbines need to be protected from over-speeding while for best accuracy larger turbines should be valved off when the flow drops below their minimum rate. In the example shown, except when switching from one flow meter to the other, only one flow meter run is active at one time. This is one example only. The number of runs open for a given application at any flow rate obviously depends on the size of the flow meters used.

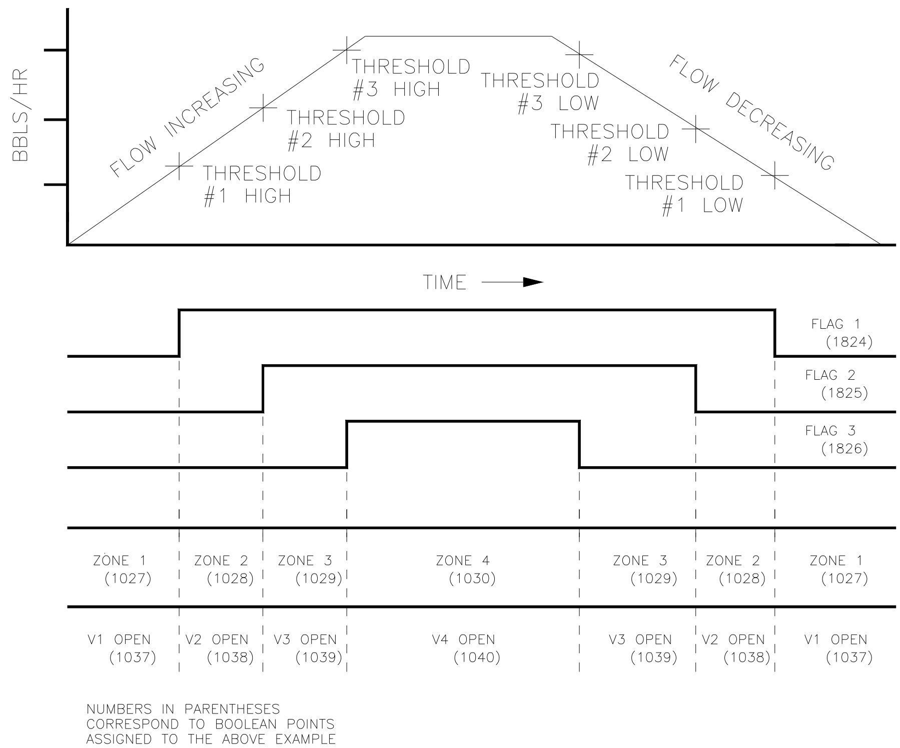


Figure. 3-1. Figure Showing Automatic Four-Meter Flow Zone Thresholds

Switching is based on the station flow gross flow rate which is compared to preset switching thresholds entered by the user (See '**Meter Station Settings**' in **Chapter 2**). Threshold Flags 1, 2 and 3 are set and reset according to the actual station flow rate.

The first task is to identify the 4 zones and assign programmable Boolean points to them. This allows us to include them in further Boolean statements.

Zone 1 = **NOT** Flag 1 **AND NOT** Flag 2 **AND NOT** Flag 3

Zone 2 = Flag 1 **AND NOT** Flag 2 **AND NOT** Flag 3

Zone 3 = Flag 1 **AND** Flag 2 **AND NOT** Flag3

Zone 4 = Flag 1 **AND** Flag 2 **AND** Flag 3

As each statement can have only 3 terms in it we must pre-process some part of the equations. The term '**NOT** Flag 2 **AND NOT** Flag 3' appears in Zone 1 and 2 equations.

Now we assign valid point numbers to our statements and rewrite them the way they will be input.

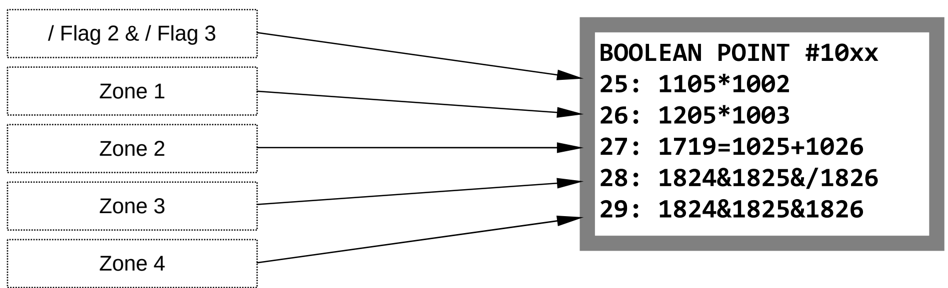
First one term needs to be pre-processed to simplify:

1025 = **NOT** Flag 2 **AND NOT** Flag 3	25: /1825&/1826

Next the flow Zones are defined:

Zone 1 = **NOT** Flag 1 **AND NOT** Flag 2 **AND NOT** Flag 3	26: /1824&1025
Zone 2 = Flag 1 **AND NOT** Flag 2 **AND NOT** Flag 3	27: 1824&1025
Zone 3 = Flag 1 **AND** Flag 2 **AND NOT** Flag 3	28: 1824&1825&/1826
Zone 4 = Flag 1 **AND** Flag 2 **AND** Flag 3	29: 1824&1825&1826

The program thus far looks like:



In our example each meter run valve (V1, V2, V3 and V4) fails closed, energizes to open. A limit switch mounted on each valve indicates the fully open position (SW1, SW2, SW3 and SW4).

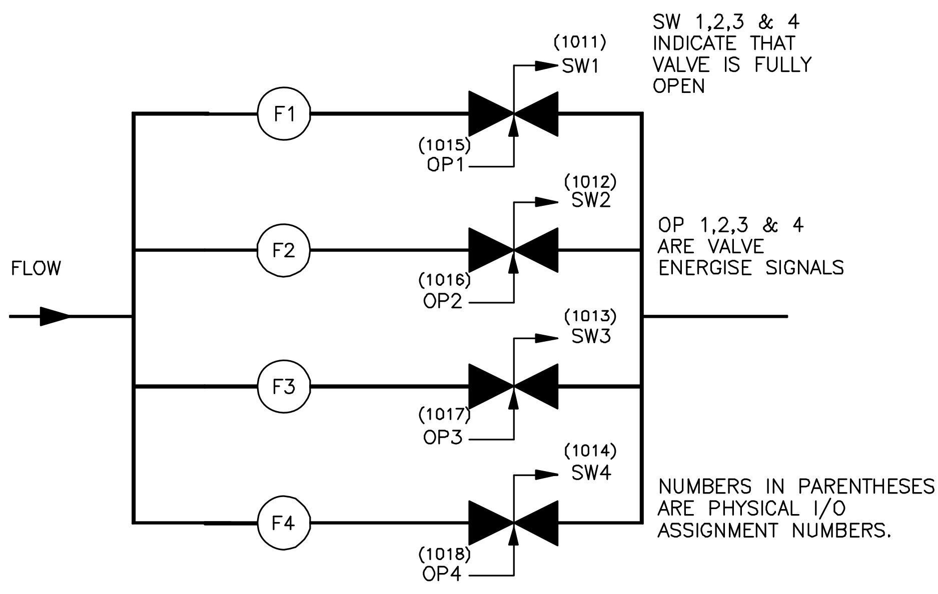


Figure. 3-2. Figure Showing Four-Meter Run Valve Switching

3.2.4. How the Digital I/O Assignments are Configured

We will use Physical I/O Points 11, 12, 13 and 14 to connect to valve limit switches SW1, SW2, SW3 and SW4 respectively. The switches activate when the appropriate valve is fully open. The points are designated as inputs by assigning them to the dummy input Boolean Point 1700 (see the Command and Status Booleans on a later page). Their data base point numbers are simply their I/O point number preceded by 10 (e.g.: I/O Point 11 = 1011).

Physical I/O points 15, 16, 17 and 18 are wired so as to open the meter run valves V1, V2, V3 and V4. They will be assigned to the Boolean Flags 32 (Point 1032) through 35 (Point 1035) which represent the required state of V1 through V4 as explained below.

The Boolean equations are as follows:

V1 = (**NOT** SW2 **AND NOT** SW3 **AND NOT** SW4) **OR** Zone 1

Valve #1 is opened when the flow is in Zone 1 and will remain open until at least 1 of the other 3 valves is fully open.

Valves V2, V3 and V4 are programmed in a similar fashion.

V2 = (**NOT** SW1 **AND NOT** SW3 **AND NOT** SW4) **OR** Zone 2

V3 = (**NOT** SW1 **AND NOT** SW2 **AND NOT** SW4) **OR** Zone 3

V4 = (**NOT** SW1 **AND NOT** SW2 **AND NOT** SW3) **OR** Zone 4

To simplify we pre-process the common terms. The term '**NOT** SW3 **AND NOT** SW4' is used to determine V1 and V2. The term '**NOT** SW1 **AND NOT** SW2' is used to determine V3 and V4.

Assigning the next valid point numbers to our statements and re-write them the way they will be input.

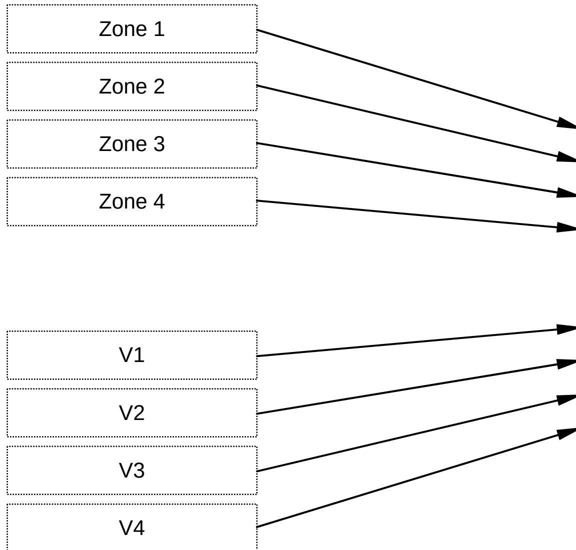
1030 = **NOT** SW3 **AND NOT** SW4	30: /1013&/1014
1031 = **NOT** SW1 **AND NOT** SW2	31: /1011&/1012

The final Equations to determine the state of V1, V2, V3 and V4 are as follows:

V1= **NOT** SW2 **AND** (**NOT** SW3 **AND NOT** SW4) **OR** Zone 1	32: /1012&1030+1026
V2 =**NOT** SW1 **AND** (**NOT** SW3 **AND NOT** SW4) **OR** Zone 2	33: /1011&1030+1027
V3= (**NOT** SW1 **AND NOT** SW2) **AND NOT** SW4 **OR** Zone 3	34: 1031&/1014+1028
V4 =(**NOT** SW1 **AND NOT** SW2) **AND NOT** SW3 **OR** Zone 4	35: 1031&/1013+1029

The computer evaluates each expression from left to right, so the order of the variables in the above statements is critical. The logic requires that the **OR** variable comes last.

The final program consists of 11 statements:



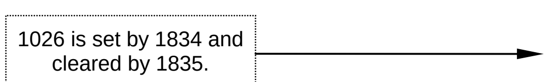

```
BOOLEAN POINT #10xx
25: /1825&/1826
26: /1824&1025
27: 1824&1025
28: 1824&1825&/1826
29: 1824&1825&1826
30: /1013&/1014
31: /1011&/1012
32: /1012&1030+1026
33: /1011&1030+1027
34: 1031&/1014+1028
35: 1031&/1013+1029
```

The only thing left to do now is assign Booleans 1032, 1033, 1034 and 1035 to the appropriate digital I/O points which control V1, V2, V3 and V4. Here is a summary of all of the digital I/O as assigned:

PHYSICAL I/O POINT	ASSIGNED TO BOOLEAN	WIRED TO	SYMBOL
11	1700	Valve 1 Fully Open Switch	SW1
12	1700	Valve 2 Fully Open Switch	SW2
13	1700	Valve 3 Fully Open Switch	SW3
14	1700	Valve 4 Fully Open Switch	SW4
15	1032	Valve 1 Actuator	V1
16	1033	Valve 2 Actuator	V2
17	1034	Valve 3 Actuator	V3
18	1035	Valve 4 Actuator	V4

Any pulse signal can be latched by using a small program similar to the following:

INFO: *A list of Modbus database addresses and index numbers is included in* ***Volume 4*** *of the OMNI User Manual.*




```
BOOLEAN POINT #10xx
25: /1834&/1026
26: /1835&/1025
27:
```

3.3. User Programmable Variables and Statements

There are 64 user-programmable floating point variables within the flow computer numbered 7025 through 7088. The value stored in each of these variables depends on an associated equation or statement. These statements are evaluated every 500 msec and the resultant variable values can be displayed on the LCD display, printed on a report, output to a D-A output, or accessed via one of the communication ports. Typical uses for the variables and statements include providing measurement units conversions, special averaging functions, limit checking and comparisons.

3.3.1. Variable Statements and Mathematical Operators Allowed

TIP: *The order of precedence is: ABSOLUTE, POWER, MULTIPLY & DIVIDE, ADD & SUBTRACT. Where operators have the same precedence the order is left to right.*

TIP – *RH = Right Hand Variable. LH = Left Hand Variable.*

Each statement can contain up to 3 variables or constants. The following symbols are used to represent the functions:

Operator	Symbol	Description
ADD	**+**	Add the two variables or constants
SUBTRACT	**-**	Subtract the RH variable or constant from LH
MULTIPLY	*****	Multiply the two variables or constants
DIVIDE	**/**	Divide the two variables or constants
CONSTANT	**#**	The number following is interpreted as a constant
POWER	**&**	Raise the LH variable to the power of the RH
ABSOLUTE	**$**	Use the abs. unsigned value of variable following
EQUAL	**=**	Make the variable on left equal to the expression on the right.
IF STATEMENT	**)**	The Logical Value of the variable to the left of the) operator is true, evaluate the rest of the statement.
GOTO STATEMENT	**G**	Go to a different variable
MOVE RANGE	**:**	Move statement or result to another variable.
EXACT COMPARE	**%**	Compare a value with or equal to
TOTALIZE	**,**	Used to create custom totalizers where Remainders need to be carried into the custom totalizer in the next calculation cycle.
INDIRECT REFERENCE	**;**	Use the contents of the point following to Determine the address of the target data base point.
WRITE ASCII STRING	**“**	Write the ASCII string data contained between the quotes to the address to the left of the = sign
RISING EDGE	**(**	Rising Edge operator e.g. (7501
FALLING EDGE	**(/**	Falling Edge operator e.g. (/7501
ONE SHOT	**@**	One Shot operator e.g. @7501
RANGE CHECKING	**<**	Range checking operator e.g. 7025:#60<7105<#75.5. 7026:7106<#150

To program the user variables proceed as follows: From the Display Mode press **[Prog] [Setup] [Enter] [Enter]** and the following menu will be displayed:

```
*** Misc.  Setup ***
Password Maint?(Y)
Check Modules ?(Y)
Config Station?(Y)
Config Meter "n"
Config PID ? "n"
Config D/A Out"n"
Front Pnl Counters
Program Booleans ?
Program Variables? _
```

Scroll down to '**Program Variables ? (Y)**' and enter **[Y]**. Assuming that no variables are as yet programmed, the display shows:

```
PROG. VARIABLE #70xx
25:   _
26:
27:
```

Note that the cursor is on the line labeled 25:. At this point enter the variable equation that will calculate the value of variable 7025.

<u>Example 1</u>:

To provide a variable (7025) which represents Meter Run #1 gross flow rate in 'MCF per day' in place of the usual MCF per hour, multiply the 'MCF per hour' variable (7101) by the constant 24.

bbls/hr x 24 = bbls/day

bbls/hr x 0.7 = gal/min

```
PROG. VARIABLE #70xx
25: 7101*#24
26: 7101*#.7_
27:
```

<u>Example 2:</u>

To provide a variable that represents 'gallons per minute' (7026) we can convert the 'barrels per hour' variable (7101) to gallons by multiplying by 0.7 (0.7 = 42/60 which is the number of gallons in a barrel / divided by the number of minutes in an hour).

bbls/hr x 24 = bbls/day

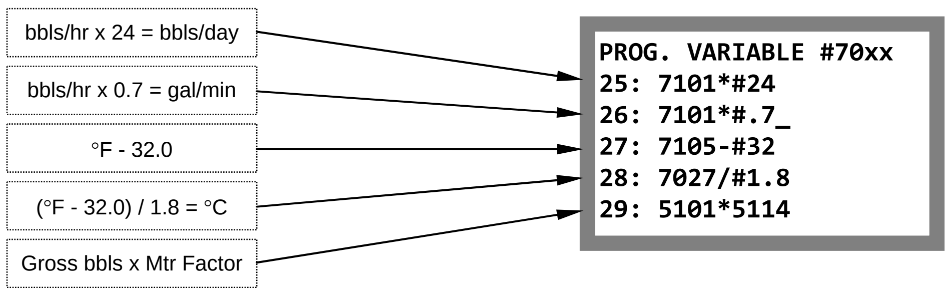
```
PROG. VARIABLE #70xx
25: 7101*#24
26:
27:
```

Example 3:

To provide a variable (7028) that represents meter run #1 temperature in 'degrees Celsius' we subtract 32 from the 'degrees Fahrenheit' variable (7105) and divide the result (7027) by 1.8.

Example 4:

Gross barrels within the flow computer are simply flow meter counts divided by the flow meter 'K-Factor' (pulses per barrel); i.e., gross barrels are not meter factored. To provide a variable (7029) which represents Meter Run #1 gross meter factored barrels, multiply the batch gross barrel totalizer (5101) by the batch flow weighted average meter factor (5114).

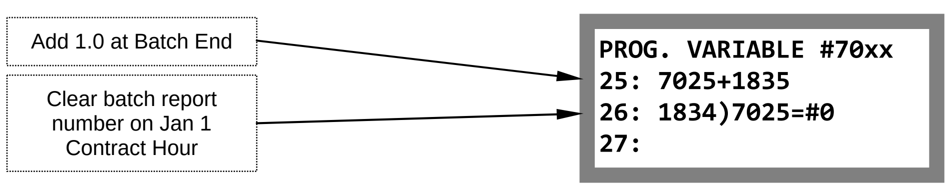


3.3.2. Using Boolean Variables in Variable Statements

Boolean points used in a programmable variable statement are assigned the value 1.0 when the Boolean value is TRUE and 0.0 when the Boolean value is FALSE. By multiplying by a Boolean the user can set a variable to 0.0 when the Boolean point has a value FALSE.

Example:

Provide a variable (7025) which functions as a 'Report Number'. The report number which will appear on each 'batch end report' must increment automatically after each batch and reset to zero at the contract day start hour on January 1 of each year.



Boolean 1835 is true one calculation cycle at the end of a batch. Boolean point 1834 is equal to 1.0 for one calculation cycle on the contract day start hour on January 1. If statement 1834 is true we reset counter 7025.

3.3.3. Entering Values Directly into the User Variables

In some cases it may be necessary to enter data directly into a user variable (not the expression, just the variable). For example, to preset the 'Report Number' Variable 7025 in the example above we proceed as follows. While in the Display Mode press **[Prog] [Input] [Enter]**, the following will display:

Current value (can be changed by the user).

Expression for this variable (cannot be changed from this entry).

```
USER VARIABLE #7025
Value          1234
7025+1835
```

3.3.4. Using the Variable Expression as a Prompt

Entering plain text into the expression associated with the variable causes the computer no problems. It ignores the text and leaves the variable unchanged.

For example:

```
USER VARIABLE 7025
Value ?       .00018
Enter Lbs to SCF ?
```

3.3.5. Password Level Needed to Change the Value of a User Variable

The first four variables, 7025, 7026, 7027 and 7028 require ‘Level 2’ password. The remaining variables require ‘Level 1’.

3.3.6. Using Variables in Boolean Expressions

NOTE: *See the beginning of this chapter on how to program a Boolean expression if necessary.*

In some cases it is also necessary to trigger some type of an event based on the value of a calculated variable. Boolean variables used in the Boolean expressions and described in the previous text can have only one of two values, ON or OFF (TRUE or FALSE). How can the floating point numbers described in this chapter be used in a Boolean expression? Simply using the fact that a variable can be either positive (TRUE) or negative (FALSE). Any variable or floating point can be used in a Boolean expression.

<u>Example</u>:

Provide an alarm and snapshot report which will occur when the absolute difference in net flow rate between Meter Runs #1 and #2 exceeds 10 bbls/hr, but only when Meter Run #1 flow rate is greater than 1000 bbls/hr.

Result can be positive or negative.

Absolute flow difference minus 10.

Positive if flow rate is greater than 1000.

```
PROG. VARIABLE #70xx
30: 7102-7202
31: $7030-#10
32: 7102-#1000
```

Variable 7031 will be positive (TRUE) if Meter Runs #1 and #2 flow rates differ by more than 10 bbls/hr. Variable 7032 will be positive (TRUE) when Meter Run #1 flow rate exceeds 1000 bbls/hr .

User variables 7031 and 7032 shown above must both be positive for the alarm to be set. In addition, we will require that the condition must exist for 5 minutes to minimize spurious alarms. The alarm will be activated by Physical I/O Point #02 and we will use Boolean statements 1025 and 1026.

Enter the following Boolean statements (1025 and 1026 used as example only):

True when both are positive.

Snapshot report when alarm active.

```
BOOLEAN POINT #10xx
25: 7031&7032
26: 1719=1002
27:
```

To complete the example we assign Digital I/O Point #02 (Point # 1002) to 1025 and select a 'delay on' of 3000 to provide a 5 minute delay on activate (3000 ticks = 3000 x 100 msec = 300 seconds). Set the ‘delay off’ to 0.

3.4. User Configurable Display Screens

INFO: *The computer checks for the user display key presses first so you may override an existing display screen by selecting the same key press sequence.*

The user can specify up to eight display screen setups. Each display screen can be programmed to show four variables, each with a descriptive tag. Any variable within the data base can be selected for display.

Steps needed to configure a display screen are:

1) Specify a sequence of up to four key presses that will be used to recall the display. Key presses are identified by the A through Z character on each key. For each variable (four maximum):
2) Specify the eight character string to be used to identify the variable. Any valid characters on the keypad can be used.
3) Specify the database index or point number.
4) Specify the display resolution of the variable (i.e., how many digits to the right of the decimal point).

Should the number exceed the display capacity, the decimal will be automatically shifted right to counter the overflow. The computer will shift to scientific display mode if the integer part of the number exceeds +/- 9,999,999.

To configure the user display screens proceed as follows:

From the Display Mode press **[Prog] [Setup] [Enter] [Enter]** and the following menu will be displayed:

```
*** Misc.  Setup ***
Password Maint?(Y)
Check Modules ?(Y)
Config Station?(Y)
Config Meter "n"
Config PID ? "n"
Config D/A Out"n"
Front Pnl Counters
Program Booleans ?
Program Variables?
User Display ? "n" _
```

Scroll down to '**User Display? "n"**' and enter 1 through 8 to specify which screen you wish to configure.

The screen for Display #1 shows:

```
USER DISPLAY #1
Key Press    _
Var #1 Tag
Var #1 Index
Var #1 Dec.
Var #2 Tag
Var #2 Index
Var #2 Dec.
Var #3 Tag
Var #3 Index
Var #3 Dec.
Var #4 Tag
Var #4 Index
Var #4 Dec.
```

Use the 'UP/DOWN' arrows to scroll through the screen. For 'Key Press' enter the key press sequence (up to 4 keys) that will be used to recall this display. The keys are identified by the letters A through Z.

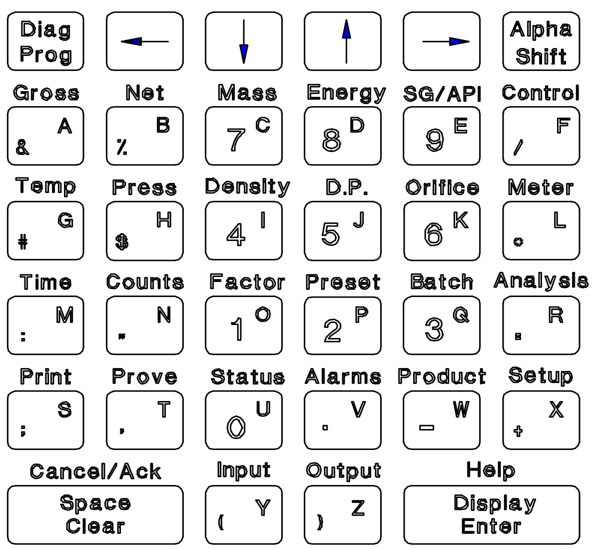


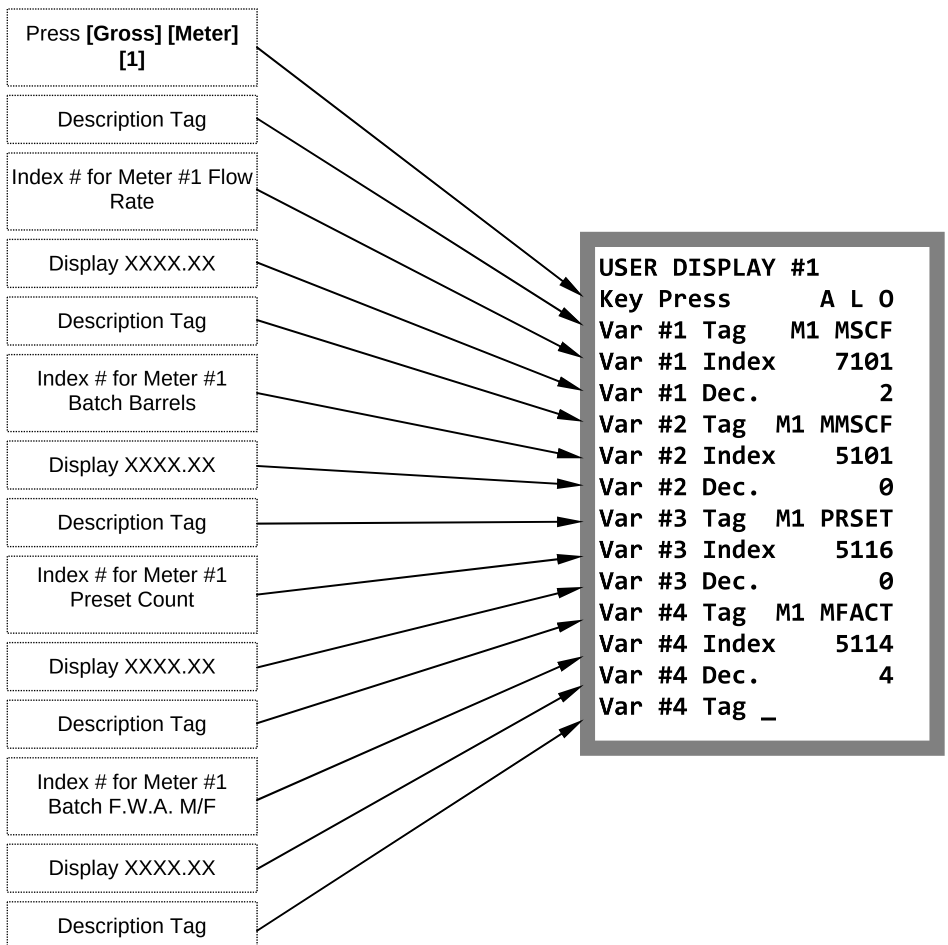
Figure. 3-3. Keypad Layout - A through Z Keys

<u>Example</u>:

You wish to recall '**User Display #1**' by pressing **[Gross] [Meter] [1]**, select the key sequence **[A] [L] [O]** as shown below.

```
USER DISPLAY #1
Key Press A L O
Var #1 Tag
Var #1 Index
Var #1 Dec.
```

Continue configuring User Display #1 by entering the description tag, index number and decimal position required for each variable.



In the preceding example, User Display #1 is used to display Meter Run #1:

Variable #1	Flow rate in MSCF per Hour
Variable #2	Accumulated Batch MSCF
Variable #3	Meter Factor for the Batch
Variable #4	Not Used

The screen is recalled by pressing **[Gross] [Meter] [1] [Enter]** and displays:

```
USER DISPLAY # 1
M1 MSCF      1234.56
M1 MMSCF   123456789
M1 MFACT      1.0000
```

Chapter 4

Flow Equations and Algorithms for U.S. Customary Units (Revision 23.74/75)

4.1. Flow Rate for Gas Differential Pressure Devices (Orifice, Nozzle and Venturi)

Flow Rate Units: *For practical reasons, the OMNI flow computer displays calculated flow rates in thousands of units per hour, in comparison to the standards (AGA and API). Therefore, the flow equations must be divided by 1000.*

The practical flow equations expressed in this section are based on the following standards:

- American Gas Association Report N$^{\underline{O}}$ 3: *Orifice Metering of Natural Gas and other Related Hydrocarbon Fluids, Part 3: Natural Gas Applications* (AGA 3)
- American Gas Association Report N$^{\underline{O}}$ 5: *Fuel Gas Energy Metering* (AGA 5)
- American Gas Association Report N$^{\underline{O}}$ 8: *Compressibility Factors of Natural Gas and Other Related Hydrocarbon Gases* (AGA 8)
- American Petroleum Institute: *Manual of Petroleum Measurement Standards, Chapter 14: Natural Gas Fluids Measurement; Section 3: Concentric, Square-Edged Orifice Meters; Part 1: General Equations and Uncertainty Guidelines* (API MPMS 14.3.1)
- American Society of Mechanical Engineers: *Measurement of Fluid Flow in Pipes Using Orifice, Nozzle, and Venturi* (ASME MFC-3M)

4.1.1. Mass Flow Rate at Flowing Conditions 'Q_m' (Klbm/hr)

$$\mathrm{Q_m} = (\mathrm{C} \times \mathrm{EV} \times \mathrm{Y} \times \pi/4 \times \mathrm{d2} \times \sqrt{2 \times \Delta P \times Pf}\,) \times 3600 \div 1000$$

4.1.2. Volumetric Gross Flow Rate at Flowing Conditions 'Q_v' (MCF/hr)

$$\mathrm{Q_v} = \frac{\mathrm{Q_m}}{\rho_f}$$

4.1.3. Volumetric Net Flow Rate at Base Conditions 'Q_b' (MSCF/hr)

$$Q_b = \frac{Q_m}{\rho_b}$$

4.1.4. Energy Flow Rate at Base Conditions 'Q_e' (MMBTU/hr)

$$Q_e = \left(Q_b \times HV \right) / 1000$$

4.1.5. Nomenclature

The following symbols are used in the flow rate equations. Some of these require further elaboration or calculation, which can be found in the indicated standards.

Q_m = mass flow rate at flowing (actual) conditions for gas differential pressure flowmeters, in thousands of pounds mass per hour (Klbm/hr)

Q_v = volume (gross) flow rate at flowing (actual) conditions for gas differential pressure flowmeters, in thousands of cubic feet per hour (MCF/hr)

Q_b = volume (net) flow rate at base (standard/reference) conditions for gas differential pressure flowmeters, in thousands of standard cubic feet per hour (MSCF/hr)

Q_e = energy flow rate at base (standard/reference) conditions for gas differential pressure flowmeters, in millions of British thermal units per hour (MMBTU/hr)

C = coefficient of discharge (dimensionless —see **4.1.8** this chapter)

E_v = velocity of approach factor (dimensionless —see **4.1.7** this chapter)

Y = fluid expansion factor referenced to upstream static pressure (dimensionless —see **4.1.9** this chapter)

d = orifice plate bore or nozzle/Venturi throat diameter at flowing temperature, in inches (see **4.1.6** this chapter)

ρ_f = fluid density at upstream flowing conditions (actual temperature and pressure), in pounds mass per cubic foot (lbm/CF)

ΔP = differential pressure, in inches of water at 60°F, which is the static pressure difference measured between the upstream and downstream flange tap holes or in the throat taps.

ρ_b = fluid density at base conditions (standard/reference temperature and pressure), in pounds mass per cubic foot (lbm/CF)

HV = volumetric heating value at reference conditions, in British thermal units per standard cubic foot (BTU/SCF)

4.1.6. Diameters and Diameter Correlations

The various orifice meter flow equations require calculating the diameters of the orifice plate bore or of the nozzle/Venturi throat, the meter tube (internally), and the beta ratio. These calculated diameters are also used to calculate the pipe Reynolds number, which is used in calculating discharge coefficients.

Orifice Plate Bore or Nozzle / Venturi Throat Diameter 'd' (inches)

The calculated diameter (in inches) of the orifice plate bore or of the throat of the nozzle or Venturi tube at flowing temperature is used in the flow equations to calculate flow rates and the orifice Reynolds number. It is the internal diameter of the orifice plate measuring aperture (bore) or throat computed at flowing temperature, and is defined as follows:

$$d = \mathrm{d_r}\left[1 + \alpha_1\left(\mathrm{T_f} - \mathrm{T_{r_1}}\right)\right]$$

Where:

- d = orifice plate bore or nozzle/Venturi throat diameter at flowing temperature, in inches
- d_r = reference orifice plate bore or nozzle/Venturi throat diameter at reference temperature, in inches
- α_1 = linear coefficient of thermal expansion of the orifice plate or nozzle/Venturi throat material, in/in·°F
- T_f = temperature of the fluid at flowing conditions, in °F
- T_{r1} = reference temperature for the orifice plate bore or nozzle/Venturi throat diameter, in °F

Upstream Meter Tube (Pipe) Internal Diameter 'D' (inches)

The calculated upstream internal meter tube diameter (in inches) at flowing temperature is used in the flow equations to calculate the diameter ratio and the pipe Reynolds number. It is the inside diameter of the upstream section of the meter tube computed at flowing temperature, and is defined as follows:

$$D = \mathrm{D_r}\left[1 + \alpha_2\left(\mathrm{T_f} - \mathrm{T_{r_2}}\right)\right]$$

Where:

- D = upstream internal meter tube diameter or upstream diameter of classical Venturi tube at flowing temperature, in inches
- D_r = reference meter tube internal diameter at reference temperature, in inches
- α_2 = linear coefficient of thermal expansion of the meter tube material, in in/in·°F
- T_f = temperature of the fluid at flowing conditions, in °F
- T_{r_2} = reference temperature for the meter tube internal diameter, in °F

Diameter (Beta) Ratio ‘β’

Dimensionless Values: *Both the diameter (beta) ratio and pipe Reynolds number are dimensionless; however, consistent units must be used.*

The diameter ratio (or beta ratio) is defined as the calculated orifice plate bore or nozzle/Venturi throat diameter divided by the calculated meter tube internal diameter:

$$\beta = {}^{d}\!/\!_{D}$$

Where:

d = orifice plate bore or nozzle/Venturi throat diameter at flowing temperature, in inches

D = upstream meter tube (pipe) internal diameter at flowing temperature, in inches

Pipe Reynolds Number ‘R_D’ and ‘R_d’

The pipe Reynolds number is used in the equation for calculating the coefficient of discharge for differential pressure flowmeters. It is a correlating parameter used to represent the change in the orifice plate, nozzle or Venturi tube coefficient of discharge with reference to either the meter tube diameter (R_D) or the bore (throat) diameter (R_d), and the fluid mass flow rate (its velocity through the orifice), the fluid density, and the fluid viscosity.

Pipe Reynolds Number Referenced to the Meter Tube Diameter ‘R_D’

The following equation applies to orifice, nozzle and Venturi differential pressure flow metering devices, except for pipe-tapped orifice flowmeters.

$$R_D = \frac{48\, q_m}{\pi\, \mu\, D}$$

Where:

R_D = pipe Reynolds number referenced to the upstream internal meter tube diameter or upstream diameter of a classical Venturi tube

q_m = mass flow rate at flowing (actual) conditions for differential pressure flowmeters, in lbm/sec

π = universal constant
= 3.14159

μ = absolute (dynamic) viscosity of fluid at flowing conditions, in lbm/ft·sec

D = upstream internal meter tube diameter or upstream diameter of a classical Venturi tube at flowing temperature, in inches

Pipe Reynolds Number Referenced to the Bore or Throat Diameter 'R_d'

The following equation applies only to pipe-tapped orifice meters.

$$R_d = \frac{48\,q_m}{\pi\,\mu\,d}$$

Where:

R_d = pipe Reynolds number referenced to the orifice plate bore or nozzle/Venturi throat diameter

q_m = mass flow rate at flowing (actual) conditions for differential pressure flowmeters, lbm/sec

π = universal constant
= 3.14159

μ = absolute (dynamic) viscosity of fluid at flowing conditions, in lbm/ft·sec

d = orifice plate bore or nozzle/Venturi throat diameter at flowing temperature, in inches

4.1.7. Velocity of Approach Factor 'E_v'

Dimensionless Values: *The calculated velocity of approach factor is dimensionless; however, consistent units must be used.*

The velocity of approach factor is used in the differential pressure flowmeter equations to calculate the flow rate. It relates the velocity of the flowing fluid in the flowmeter approach section (upstream meter tube) to the fluid velocity in the orifice plate, nozzle or Venturi tube. The velocity of approach factor is defined by the following expression:

$$E_v = \frac{1}{\sqrt{1 - \beta^4}}$$

Where:

E_v = velocity of approach factor

β = diameter (beta) ratio (see **4.1.6** this chapter)

4.1.8. Discharge Coefficients 'C_d'

Dimensionless Values: *The calculated coefficient of discharge is dimensionless; however, consistent units must be used.*

The equations for the coefficient of discharge (Cd) have been determined from test data and correlated as a function of the diameter ratio (β), the meter tube diameter (D), and the pipe Reynolds number (R_D). It is used in the flow rate equations.

Coefficient of Discharge for Orifice Flowmeters

With Flange Taps (RG Equation) '$C_d(FT)$'

The Reader-Harris/Gallager (RG) equation for concentric, square-edged, flange-tapped orifice flowmeter coefficient of discharge [$C_d(FT)$] is a function of the orifice geometry and of a specified pipe Reynolds number, and is defined as follows:

$$C_d(FT) = \left\{ \begin{array}{l} C_i(FT) + 0.000511 \left(\dfrac{10^6 \beta}{R_D} \right)^{0.7} \\ + \left[0.0210 + 0.0049 \left(\dfrac{19000 \beta}{R_D} \right)^{0.8} \right] \times \beta^4 \left(\dfrac{10^6}{R_D} \right)^{0.35} \end{array} \right\}$$

Where:

$C_d(FT)$ = coefficient of discharge at a specified pipe Reynolds number for flange-tapped orifice flowmeters

$C_i(FT)$ = coefficient of discharge at an infinite pipe Reynolds number for flange-tapped orifice flowmeters

= $C_i(CT)$ + *Tap Term*

Where:

$C_i(CT)$ = coefficient of discharge at an infinite pipe Reynolds number for corner-tapped orifice flowmeters

$$= \left\{ \begin{array}{l} 0.5961 + 0.0291 \beta^2 - 0.2290 \beta^8 \\ + 0.003 (1 - \beta) \left[\max \left(2.8 - D, 0.0 \right) \right] \end{array} \right\}$$

Tap Term = *Upstrm* + *Dnstrm*

$$Upstrm = \left\{ \begin{array}{l} \left[0.0433 + 0.0712 e^{-8.5 L_1} - 0.1145 e^{-6.0 L_1} \right] \\ \times \left[1 - 0.23 \left(\dfrac{19000 \beta}{R_D} \right)^{0.8} \right] \times \left(\dfrac{\beta^4}{1 - \beta^4} \right) \end{array} \right\}$$

$$Dnstrm = \left\{ \begin{array}{l} -0.0116 \left[\left(\dfrac{2 L_2}{1 - \beta} \right) - 0.52 \left(\dfrac{2 L_2}{1 - \beta} \right)^{1.3} \right] \\ \times \beta^{1.1} \left[1 - 0.14 \left(\dfrac{19000 \beta}{R_D} \right)^{0.8} \right] \end{array} \right\}$$

Where:

e	=	Napierian constant = 2.71828
L_1	=	dimensionless correction for upstream tap location
	=	1/D
	=	L_2
L_2	=	dimensionless correction for downstream tap location

D = upstream internal meter tube diameter or upstream diameter of a classical Venturi tube at flowing temperature, in inches (see **4.1.6** this chapter)

β = diameter (beta) ratio (see **4.1.6** this chapter)

R_D = pipe Reynolds number referenced to the upstream internal meter tube diameter (see **4.1.6** this chapter)

With Corner Taps 'C_d(CT)'

$$C_d(CT) = 0.5959 + 0.0312\,\beta^{2.1} - 0.184\,\beta^{8} + 91.71\,\beta^{2.5}\left(R_D\right)^{-0.75}$$

Where:

$C_d(CT)$ = coefficient of discharge at a specified pipe Reynolds number for orifice flowmeters with corner taps

β = diameter (beta) ratio (see **4.1.6** this chapter)

R_D = pipe Reynolds number referenced to the upstream internal meter tube diameter (see **4.1.6** this chapter)

With D and D/2 Taps 'C_d(DT)'

$$C_d(DT) = \left\{ \begin{array}{l} 0.5959 + 0.0312\,\beta^{2.1} - 0.184\,\beta^{8} + 0.039\,\beta^{4}\left(1-\beta^{4}\right)^{-1} \\ -0.01584\,\beta^{3} + 91.71\,\beta^{2.5}\left(R_D\right)^{-0.75} \end{array} \right\}$$

Where:

$C_d(DT)$ = coefficient of discharge at a specified pipe Reynolds number for orifice flowmeters with D and D/2 taps

β = diameter (beta) ratio (see **4.1.6** this chapter)

R_D = pipe Reynolds number referenced to the upstream internal meter tube diameter (see **4.1.6** this chapter)

With Pipe Taps ‘C_d(PT)’

$$C_d(PT) = C_i(PT)\left[1+\left(\frac{d\left[830-5000\beta+9000\beta^2-4200\beta^3\left(75+\frac{875}{D}\right)\right]}{R_d}\right)\right]$$

Where:

C_d(PT) = coefficient of discharge at a specified pipe Reynolds number for orifice flowmeters with pipe taps

C_i(PT) = coefficient of discharge at an infinite pipe Reynolds number for orifice flowmeters with pipe taps

$$= \frac{C_e(PT)}{1+\left(\frac{15\,d\left[830-5000\beta+9000\beta^2-4200\beta^3\left(75+\frac{875}{D}\right)\right]}{d\left(10^6\right)}\right)}$$

Where:

C_e(PT) = coefficient of discharge for orifice flowmeters with pipe taps when the pipe Reynolds number ‘R_d’ is equal to [$d(10^6)/15$]

$$= \left\{\begin{array}{l} 0.5925+\frac{0.0182}{D}+\left(0.44-\frac{0.06}{D}\right)\beta^2 \\ +\left(0.935+\frac{0.225}{D}\right)\beta^5 \quad +1.35\,\beta^{14} \\ +\left(\frac{1.43}{D^{0.5}}\right)\times\left(0.25-\beta\right)^{5/2} \end{array}\right\}$$

D = upstream internal meter tube diameter or upstream diameter of a classical Venturi tube at flowing temperature, in inches (see **4.1.6** this chapter)

d = orifice plate bore diameter at flowing temperature, in inches (see **4.1.6** this chapter)

β = diameter (beta) ratio (see **4.1.6** this chapter)

R_d = pipe Reynolds number referenced to the diameter of the orifice plate bore (see **4.1.6** this chapter)

Coefficient of Discharge for ASME Flow Nozzles 'C_d(FN)'

Dimensionless Values: *The calculated coefficient of discharge is dimensionless; however, consistent units must be used.*

$$C_d(FN) = 0.9975 - 0.00653\left(\frac{10^6 \beta}{R_D}\right)^{0.5}$$

Where:

C_d(FN) = coefficient of discharge at a specified pipe Reynolds number for ASME flow nozzles

β = diameter (beta) ratio (see **4.1.6** this chapter)

R_d = pipe Reynolds number referenced to the diameter of the orifice plate bore (see **4.1.6** this chapter)

Coefficient of Discharge for Classical Venturi Tubes

With Rough Cast / Fabricated Convergent Section '$C_d(VT_{R/F})$'

$$C_d(VT_{R/F}) = 0.984$$

When:

$$4 \text{ inches} \leq D \leq 48 \text{ inches}$$

$$0.3 \leq \beta \leq 0.75$$

$$2 \times 10^5 \leq R_D \leq 6 \times 10^6$$

Where:

$C_d(VT_{R/F})$ = discharge coefficient for classical Venturi tube with a rough cast or fabricated convergent section

β = diameter (beta) ratio (see **4.1.6** this chapter)

R_D = pipe Reynolds number (see **4.1.6** this chapter)

With Machined Convergent Section '$C_d(VT_M)$'

$$C_d(VT_M) = 0.995$$

When:

$$2 \text{ inches} \leq D \leq 10 \text{ inches}$$

$$0.3 \leq \beta \leq 0.75$$

$$2 \times 10^5 \leq R_D \leq 2 \times 10^6$$

Where:

$C_d(VT_M)$ = discharge coefficient for a classical Venturi tube with a machined convergent section

β = diameter (beta) ratio (see **4.1.6** this chapter)

R_D = pipe Reynolds number (see **4.1.6** this chapter)

4.1.9. Fluid Expansion Factor Referenced to Upstream Pressure 'Y_1'

Expansion Factor Referenced to Upstream Pressure 'Y_1': *The flow rate equations for differential pressure flow metering devices always require using the expansion factor referenced to upstream pressure (Y_1), even when the static pressure is measured at downstream taps.*

Dimensionless Values: *The calculated fluid expansion factor is dimensionless; however, consistent units must be used.*

The fluid expansion factor (Y) is used to take into account the compressibility of the fluid in calculation the flow rate. This coefficient is determined from correlating the diameter ratio (β), the differential pressure (ΔP), the flowing isentropic exponent (κ), and the absolute static pressure (P) at upstream (Y_1) conditions. This factor is used in the mass flow rate equation for differential pressure metering devices and can be calculated using the following expressions:

Upstream Expansion Factor for Orifice Plates

With Flange / Corner / D & D/2 Taps

$$Y_1 = 1 - \left(0.41 + 0.35\,\beta^4\right)\frac{x_1}{\kappa}$$

Where:

Y_1 = fluid expansion factor based on the absolute static pressure at the upstream tap

β = diameter (beta) ratio (see **4.1.6** this chapter)

$\frac{x_1}{\kappa}$ = upstream acoustic ratio

x_1 = ratio of differential pressure to absolute static pressure measured at the upstream tap

<u>When static pressure is measured at upstream flange tap holes</u>:

$$x_1 = \frac{\Delta P}{N_3 P_{f_1}}$$

<u>When static pressure is measured at downstream flange tap holes</u>:

$$x_1 = \frac{\Delta P}{N_3 P_{f_2} + \Delta P}$$

Where:

ΔP = orifice differential pressure, in inches of water at 60°F

N_3 = unit conversion factor
= 27.707

P_{f1} = absolute static pressure at the upstream tap

P_{f2} = absolute static pressure at the downstream tap

κ = isentropic exponent

With Pipe Taps

$$Y_1 = 1 - \left[0.333 + 1.145 \left(\beta^2 + 0.7\,\beta^5 + 12\,\beta^{13} \right) \right] \frac{x_1}{\kappa}$$

Where:

Y_1 = fluid expansion factor based on the absolute static pressure at the upstream tap

β = diameter (beta) ratio (see **4.1.6** this chapter)

$\frac{x_1}{\kappa}$ = upstream acoustic ratio

x_1 = ratio of differential pressure to absolute static pressure measured at the upstream tap

$$x_1 = \frac{\Delta P}{N_3 P_{f_1}}$$

Where:

ΔP = orifice differential pressure, in inches of water at 60°F

N_3 = unit conversion factor
= 27.707

P_{f1} = absolute static pressure at the upstream tap

κ = isentropic exponent

Upstream Expansion Factor for ASME Flow Nozzles and Classical Venturi Tubes

$$Y_1 = \sqrt{ \left(\frac{\kappa\, \tau^{2/\kappa}}{\kappa - 1} \right) \times \left(\frac{1 - \beta^4}{1 - \beta^4\, \tau^{2/\kappa}} \right) \times \left(\frac{1 - \tau^{(\kappa-1)/\kappa}}{1 - \tau} \right) }$$

Where:

Y_1 = fluid expansion factor at upstream (pressure) conditions

κ = isentropic exponent

τ = pressure ratio

$= \frac{P_2}{P_1}$

Where:

P_1 = absolute upstream static pressure of the fluid

P_2 = absolute downstream static pressure of the fluid

β = diameter (beta) ratio (see **4.1.6** this chapter)

4.2. Flow Rate for Gas Turbine Flowmeters

4.2.1. Volumetric Gross Flow Rate at Flowing Conditions ‘Q_V’ (MCF/hr)

$$Q_V = \frac{\text{Pulses / sec}}{K_F} \times 3600$$

4.2.2. Mass Flow Rate at Flowing Conditions ‘Q_m’ (Klbm/hr)

$$Q_m = Q_V \times \rho_f \times M_F$$

4.2.3. Volumetric Net Flow Rate at Base Conditions ‘Q_b’ (MSCF/hr)

$$Q_b = Q_V \times \frac{\rho_f}{\rho_b} \times M_F$$

4.2.4. Energy Flow Rate at Base Conditions ‘Q_e’ (MMBTU/hr)

$$Q_e = {(Q_b \times HV)}\big/{1000}$$

4.2.5. Nomenclature

Q_V = volumetric gross flow rate at flowing conditions for gas turbine flowmeters, in thousands of cubic feet per hour (MCF/hr)

Q_m = mass flow rate at flowing conditions for gas turbine flowmeters, in thousands of pounds mass per hour (Klb/hr)

Q_b = volumetric net flow rate at base conditions for gas turbine flowmeters, in thousands of standard cubic feet per hour (MSCF/hr)

Q_e = energy flow rate at base (standard/reference) conditions for gas turbine flowmeters, in millions of British thermal units per standard cubic foot (MMBTU/SCF)

Pulses = number of pulses emitted from the flowmeter pulse train per second.

ρ_f = fluid density at flowing conditions (actual temperature and pressure), in pounds mass per cubic foot (lbm/CF)

ρ_b = reference density at base conditions (standard/reference temperature and pressure), in pounds mass per cubic foot (lbm/CF)

K_F = K factor, in pulses per thousand cubic feet (Pulses/MCF)

M_F = meter factor (dimensionless)

HV = volumetric heating value at reference conditions, in British thermal units per standard cubic foot (BTU/SCF)

4.3. Flow Rate for Gas Coriolis Flowmeters

As the Coriolis Meter uses its density value internally to convert mass to actual volume pulses you should not configure the Coriolis Meter for volume pulses, i.e the mass measurement is accurate but the density and therefore the actual volume may not accurate. OMNI therefore assumes that it is receiving mass pulses from the Coriolis meter. See Omnicom Help F1 under meter configuration.

Therefore calculations are preformed every 500ms in the flow computer and are as described in AGA11. They are as follows:

Qm *KLb/Hr* = Coriolis mass pulses per second x 3600 / (K-Factor *(pulses per lb)* x 1000)

Qf *MCF/Hr* = Qm x 1000 / DENf

Qb *MSCF/Hr* = Qm x 1000 / DENb

Qe = (Qb x HV) / 1000

where

Qm = Mass flowrate *(KLb/Hr)*

Qf = Volume flowrate at actual conditions *(MCF/Hr)* also referred to as Gross volume flowrate in the flow computer.

Q*b* = Volume flowrate at base conditions (*MSCF/Hr)* also referred to as Net volume flowrate in the flow computer.

Qe = Energy *(MMBTU/Hr)*

DENf = Density of the gas at flowing conditions *(lb/ft3)* calculated using AGA-8, or measured by a suitable gas densitometer *(Note: AGA-11 states that it is not permissible to use the density measured by the Coriolis meter).*

DENb = Density of the gas at base conditions *(lb/ft3)* calculated using AGA-8, or by RD x DENair.

RD = Relative density of the gas at base conditions obtained from either a manual input or a gas chromatograph.

DENair = Density of air at base conditions *(lb/ft3)*

HV = Volumetric heating value at base conditions (*BTU/SCF*) calculated using ISO 6976, AGA-5, GPA 2172, or obtained from a gas chromatograph or manual input.

4.4. Densities and Other Properties of Gas

4.4.1. AGA Report Nº 8: Compressibility for Natural Gas and Other Related Hydrocarbon Gases

AGA Report Nº 8 Documentation References - *Detailed information on computations performed in conformance to the different editions of this standard can be found in the following AGA Report Nº 8 versions:*

Second Edition, July 1994: *2nd Printing, Catalog Nº XQ9212*

Second Edition, November 1992: *Catalog Nº XQ9212*

December 1985: *Catalog Nº XQ1285*

OMNI flow computer firmware has been programmed in conformance with the December 1985, November 1992, and July 1994 editions of the American Gas Association Report Nº 8 (AGA 8). This standard provides computation methodology for compressibility and super compressibility factors and densities of natural gas and other hydrocarbon gases.

Of the three editions, the July 1994 edition is considered the most reliable, accurate and complete. However, due to contract requirements or other conditions, some users may want to apply an earlier AGA 8 version.

The December 1985 edition of AGA 8 incorporates improvements to the accuracy of computations compressibility and super compressibility factors beyond the capabilities of AGA's "Manual for the Determination of Super compressibility Factors for Natural Gas" (December 1962; Catalog Nº L00304). Other improvements included in this version were the expansion in the ranges of gas composition, temperature and pressure, and applications to gas thermodynamic properties.

A very significant improvement to this standard is apparent in the AGA 8 November 1992 edition. Major changes incorporate more precise computations of compressibility factors and densities of natural gas and related hydrocarbon gases, calculation uncertainty estimations and upgraded FORTRAN computer program listings. Other improvements include enhanced equations of state, more accurate calculations for rich gases based on new velocity of sound data, revised correlation methodology.

The current AGA 8 manual was updated in July 1994 for the purpose of correcting typographical errors found in the previous edition, improving the computer programs, and achieving consistency with GPA 2172-94 and the 1992 edition of AGA Report Nº 3, Part 3.

For reference purposes and as a comparison and contrast exposition of these AGA 8 editions, the following is a brief presentation of some aspects applied by the OMNI flow computer, which include:

- Types of Gases
  - Mole Percent Ranges of Gas Mixture Characteristics
  - Natural Gas Compound Identification Codes
- Methods for Gas Mixture Characterization
  - AGA 8 1994/1992 Methods
  - AGA 8 1985 Methods
  - AGA 8 Used to Calculate Density
  - AGA 3 Used to Calculate Mass (Flowrate)

Types of Gases

The AGA 8 report is intended for natural gases and other related hydrocarbons gases. OMNI flow computer programs include calculations and other information from the three latest editions of the AGA Report Nº 8 at the time of firmware release. The following table lists the type of gases, the corresponding identification codes assigned to each gas type in the computer program, and the mole % range of gas mixture characteristics contained in OMNI firmware that have been taken from AGA 8 1994, 1992 and 1985 editions.

 # NOTE: *The normal range is considered to be zero for these compounds, as follows:*

AGA 8 1994*: oxygen & argón*

AGA 8 1992: *hydrogen, carbon monoxide, oxygen & argon*

Comparative Table of Natural Gas Types, Identification Codes and Mole Percent Ranges
(AGA Report Nº 8 Editions Applicable to OMNI Flow Computers)

Type of Gas Mixture	1994 / 1992 ID Code	1994 / 1992 Mole % Range Normal	1994 / 1992 Mole % Range Expanded	1985 ID Code	1985 Mole % Range
Methane	1	45.0 to 100.0	0 to 100.0	6	50.0 to 100.0
Nitrogen	2	0 to 50.0	0 to 100.0	1	0 to 50.0
Carbon Dioxide	3	0 to 30.0	0 to 100.0	2	0 to 50.0
Ethane	4	0 to 10.0	0 to 100.0	7	0 to 20.0
Propane	5	0 to 4.0	0 to 12.0	8	0 to 5.0
Water Vapor	6	0 to 0.5	0 to Dew Point	4	0 to 1.0
Hydrogen Sulfide	7	0 to 0.02	0 to 100.0	3	0 to 1.0
Hydrogen	8	0 to 10.0 / #	0 to 100.0	20	0 to 1.0
Carbon Monoxide	9	0 to 3.0 / #	0 to 3.0	19	0 to 1.0
Oxygen	10	#	0 to 21.0	18	0 to 1.0
Iso-Butane	11	0 to 1.0 (Total Butanes)	0 to 6.0 (Total Butanes)	10	0 to 3.0 (Butanes)
Normal Butane	12			9	
Iso-Pentane	13	0 to 0.3 (Total Pentanes)	0 to 4.0 (Total Pentanes)	12	0 to 2.0 (Pentanes)
Normal Pentane	14			11	
Normal Hexane	15	0 to 0.2 (Hexane Plus Heavier Hydrocarbons)	0 to Dew Point (Hexane Plus Heavier Hydrocarbons)	13	0 to 1.0 (Hexane Plus Heavier Hydrocarbons)
Normal Heptane	16			14	
Normal Octane	17			15	
Normal Nonane	18			16	
Normal Decane	19			17	
Helium	20	0 to 0.2	0 to 3.0	5	0 to 1.0
Argon	21	#	0 to 1.0	N/A	0 to 1.0

Methods for Gas Mixture Characterization

AGA REPORT N^{O} 8 - 1994/1992 EDITIONS:

Three methods of characterization of a gas mixture from the AGA 8 1994/1992 editions are available for use on the OMNI Flow Computers: the Detailed Method and the Gross Characterization Methods (#1 & #2).

The Detailed Characterization Method

The gas phase pressure-temperature-density behavior of natural gas mixtures is accurately described by the detailed characterization method, for a wide range of conditions. This behavior can also be accurately described for the pure components methane, ethane, carbon dioxide, nitrogen and hydrogen and binary mixtures of these components. A low density correlation was developed for propane and heavier hydrocarbons, and binary mixtures of these components with methane, ethane, nitrogen and carbon dioxide. The uncertainty of compressibility factors and density calculations for natural gases from production separators, which can contain mole percentages of hexanes plus heavier hydrocarbons greater than 1%, is reduced by this method. Correlations were developed to reduce the calculation uncertainty of the following:

- Natural gases containing hydrogen sulfide (sour gas): correlations of the density behavior of pure hydrogen sulfide and binary mixtures of hydrogen sulfide with methane, ethane, nitrogen and carbon
- Natural gases containing water vapor (wet gas): second virial correlations for water and binary mixtures of water with methane, ethane, nitrogen and carbon dioxide

Gross Characterization Methods

The following table identifies the nominal ranges of gas characteristics for which these methods are used:

**** NOTE:*** *Reference conditions: Combustion at 60°F, 14.73 psia: Density at 60°F. 14.73 psia*

***** NOTE:*** *Reference conditions: Combustion at 25°C, 0.101325 MPa: Density at 0°C, 0.101325 MPa*

RANGE	QUANTITY
Relative Density	0.56 to 0.87
Gross Heating Value *	477 to 1150 Btu/scf
Gross Heating Value **	18.7 to 45.1 MJ/m3
Mole % Methane	45.2 to 98.3
Mole % Nitrogen	0.3 to 53.6
Mole % Carbon Dioxide	0.04 to 28.94
Mole % Ethane	0.24 to 9.53
Mole % Propane	0.02 to 3.57
Mole % Butanes	0.01 to 1.08
Mole % Pentanes	0.002 to 0.279
Mole % Hexanes Plus	0.0005 to 0.1004
Mole % Helium	0 to 0.158

Method #1: Utilizes the volumetric gross heating value (HV), relative density, mole fraction CO_2.

Method #2: **U**tilizes Relative Density, mole fraction N_2, mole fraction CO_2.

AGA REPORT N^{O} 8 - 1985 EDITION:

Six methods of characterization of a gas mixture from the AGA 8 1985 edition are available for use on the OMNI Flow Computers: the primary method and five alternate methods.

Primary Characterization Method

The primary method is the most accurate method in this AGA 8 version for characterization of natural gas, for computations using the equation of state for compressibility factor. This method consists of a complete compositional analysis (the mole fractions of all components) of a natural gas mixture.

Alternate Characterization Methods

An alternate characterization method is used when a complete compositional analysis for a natural gas is not available. One of the five alternate methods can be used to estimate the mole fractions of methane and other important hydrocarbons in the natural gas, as well as diluents other than carbon dioxide and nitrogen. These characterization methods do not include water vapor or hydrogen components.

Various combinations of the following quantities are utilized:

- Real Gas Relative Density (Specific Gravity) (G), at 60°F and 14.73 psia
- Real Gas Gross Heating Value per Unit Volume (HV), at 60°F and 14.73 psia (BTU/ft^3)
- Mole Fraction of Carbon Dioxide [x(CO_2)]
- Mole Fraction of Nitrogen [x(N_2)]
- Mole Fraction of Methane [x(CH_4)]

These alternate methods yield estimates of the mole fraction of the following:

- Methane
- Ethane
- Propane
- Normal Butane
- Iso-Butane
- Total Pentanes
- Total Hexanes plus Heavier Hydrocarbon Gases
- Total Diluents other than Nitrogen and Carbon Dioxide

The five alternate characterization methods are:

(1) The Gravity, Carbon Dioxide, Nitrogen Method
(2) The Gravity, Heating Value, Carbon Dioxide, Nitrogen Method
(3) The Gravity, Heating Value, Carbon Dioxide Method
(4) The Heating Value, Carbon Dioxide, Nitrogen Method
(5) The Gravity, Methane, Carbon Dioxide, Nitrogen Method

4.4.2. ASME 1967 Steam Equation 'υ_r'

The OMNI flow computer applies the ASME 1967 steam equation. This equation is a closed-form solution (non-iterative), developed using reduced properties; pressure (P_r) and temperature parameters (T_r), to define the reduced volume (υ_r) of steam.

4.4.3. Water Density

Acknowledgement: *The implementation of the Keenan & Keyes steam tables was based on the work of Don Kyle of Kyle Engineering, Inc*

Water density calculations performed by the OMNI flow computer are derived from the fundamental equation which expresses the characteristic function 'ψ', known as the Helmholtz free energy, in terms of the independent variables density (ρ) and temperature (T). This fundamental equation from which water density is derived has been obtained from: Joseph H. Keenan, Frederick G. Keyes, et al., *Steam Tables: Thermodynamic Properties of Water Including Vapor, Liquid and Solid Phases* (John Wiley & Sons, 1969), page 134.

4.4.4. NBS Density (lb/CF), Viscosity Isentropic Exponent, Sound Velocity, and Enthalpy

The NBS Technical Note 1048 (Issued July 1982) is used to calculate density (lb/ft^3), absolute viscosity (C.P.) isentropic exponent, sound velocity, and enthalpy (BTU/lb) for the following gases:

- Argon
- Nitrogen
- Oxygen
- Hydrogen
- Ethylene

4.4.5. Density and Relative Density (Specific Gravity) Calculated from Digital Densitometer and Gravitometer Output Frequency

Density and Specific Gravity Values Determined from Densitometer and Gravitometer Frequency Signals: *The equations used to determine the density and specific gravity via gas density and specific gravity transducers are provided by the respective manufacturers.*

The calculations expressed in this section are performed by the OMNI to determine the density from frequency signals received from the following third party densitometers and gravitometers:

- Sarasota™ / Peek™
- UGC™
- Solartron™

Sarasota Density (lb/CF)

Sarasota density is calculated using the frequency signal produced by a Sarasota densitometer, and applying temperature and pressure corrections as shown below:

$$D_c = DCF \times \left[\frac{2D_0\left(t - t_0\right)}{t_0}\right] \times \left[\frac{1 + K\left(t - t_0\right)}{2x\, t_0}\right]$$

Where:

Dc = corrected density

DCF = Density correction factor

**** NOTE:*** *D_0' must be expressed in pounds per cubic foot (lb/CF).*

D_0 = calibration constant, in mass/volume*

t = densitometer oscillation period in microseconds (µsec)

t_0 = calibration constant, in microseconds

t_0' = T_{coef} x (T_f - T_{cal}) + P_{coef} x (P_f - P_{cal}) + t_0

K = spool calibration constant

T_f = flowing temperature, in °F

T_{coef} = temperature coefficient, in µsec/°F

P_f = flowing pressure, in psig

P_{coef} = pressure coefficient, in µsec/psig

P_{cal} = calibration pressure, in psig

UGC Density (lb/CF)

Density and Specific Gravity Values Determined from Densitometer and Gravitometer Frequency Signals - *The equations used to determine the density and specific gravity via gas density and specific gravity transducers are provided by the respective manufacturers.*

UGC density is calculated using the frequency signal produced by a UGC densitometer, and applying temperature and pressure corrections as shown below:

<u>UNCORRECTED DENSITY</u>:

$$D = K_0 + (K_1 \times t) + (K_2 \times t^2)$$

Where:

D = uncorrected density, in lb/CF

$\left.\begin{matrix} K_0 \\ K_1 \\ K_2 \end{matrix}\right\}$ = calibration constants of density probe, entered via the keypad

t = densitometer oscillation time period, in microseconds (μsec)

<u>CORRECTED DENSITY</u>:

$$D_c = DCF \times \left\{ \begin{matrix} \left[\left(K_{P_3} D^2 + K_{P_2} D + K_{P_1}\right) \times \left(P_f - P_c\right)\right] \\ + \left[\left(K_{t_3} D^2 + K_{t_2} D + K_{t_1}\right) \times \left(T_f - T_c\right)\right] + D \end{matrix} \right\}$$

Where:

D_c = corrected density, in lb/CF

DCF = density correction factor

D = uncorrected density, in lb/CF

$\left.\begin{matrix} K_{P_1} \\ K_{P_2} \\ K_{P_3} \end{matrix}\right\}$ = pressure constants

P_f = flowing pressure, in psig

P_c = calibration pressure, in psig

$\left.\begin{matrix} K_{t_1} \\ K_{t_2} \\ K_{t_3} \end{matrix}\right\}$ = temperature constants

T_f = flowing temperature, in °F

T_c = calibration temperature, in °F

Solartron™ Density (kg/m³)

Info: *For Solartron gas density transducers, it is **NOT** necessary to convert the calibration sheet from metric to US customary units. OMNI will display the density in LB/FT³.*

Solartron™ density is calculated using the frequency signal produced by a Solartron frequency densitometer, and applying temperature and pressure corrections as detailed below.

UNCORRECTED DENSITY:

$$D = K_0 + (K_1 \times t) + (K_2 \times t^2)$$

Where:

D = uncorrected density, in kg/m³

$\left.\begin{matrix} K_0 \\ K_1 \\ K_2 \end{matrix}\right\}$ = calibration constants supplied by Solartron, in kg/m³ and °C

t = densitometer oscillation time period, in microseconds (μsec)

TEMPERATURE CORRECTED DENSITY:

$$D_T = D \times \left[1 + K_{18}\left(T_F - 20\right)\right] + \left[K_{19}\left(T_F - 20\right)\right]$$

Where:

D_T = temperature corrected density, in kg/m³

D = uncompensated density, in kg/m³

$\left.\begin{matrix} K_{18} \\ K_{19} \end{matrix}\right\}$ = calibration constants supplied by Solartron

T_F = Temperature in °C

ACTUAL DENSITY:

$$D_a = D_T \times \left[1 + \frac{K_3}{(D_T + K_4)} \times \left(K_5 - \frac{G}{(T_F + 273)}\right)\right]$$

Where:

D_a = actual density, in kg/m³

D_T = temperature compensated density, in kg/m³

$\left.\begin{matrix} K_3 \\ K_4 \\ K_5 \end{matrix}\right\}$ = calibration constants supplied by Solartron

$G = \dfrac{\text{Gas Specific Gravity}}{\text{Ratio of Specific Heats}}$

T_F = Temperature in °C

Solartron™ NT 3098 Gravitometer: Relative Density (Specific Gravity)/Output Frequency Relationship

Density and Specific Gravity Values Determined from Densitometer and Gravitometer Frequency Signals: *The equations used to determine the density and specific gravity via gas density and specific gravity transducers are provided by the respective manufacturers*.

The relationship between the gravitometer output frequency and the specific gravity is given by the following:

$$G = K_0 + K_2 T^2$$

Where:

G = specific gravity of a gas determined from the transducer frequency signal

T = periodic time of the sample gas specific gravity at stable temperature and at the selected reference chamber pressure, in microseconds (μsec)

$$= \sqrt{\frac{G - K_0}{K_2}}$$

K_0 = calibration constant

$$= G_Y - K_2 T_Y^2$$

K_2 = calibration constant

$$= \frac{G_X - G_Y}{T_X^2 - T_Y^2}$$

G_X = specific gravity of calibration (sample) gas 'X'

G_Y = specific gravity of calibration (sample) gas 'Y'

T_X = periodic time of a known calibration (sample) gas of 'X' specific gravity under stable operating conditions, in μsec

T_Y = periodic time of a known calibration (sample) gas of 'Y' specific gravity under stable operating conditions, in μsec

Chapter 5

Flow Equations and Algorithms for S.I. (Metric) Units (Revision 27.74/75)

5.1. Flow Rate for Gas Differential Pressure Devices (Orifice, Nozzle and Venturi)

Flow Rate Units: *For practical reasons. the OMNI flow computer displays calculated flow rates in thousands of units per hour, in comparison to the standards (ISO). Therefore, the flow equations must be either divided or multiplied by 1000.*

The practical flow equations expressed below are based on the International Standard ISO 5167-1 (Method is selectable): *Measurement of Fluid Flow by Means of Pressure Differential Devices, Part 1: Orifice Plates, Nozzles and Venturi Tubes Inserted in Circular Cross-section Conduits Running Full.*

5.1.1. Mass Flow Rate at Flowing Conditions 'Q_m' (Tonnes/hr)

$$Q_m = \frac{K_1 \times \dfrac{C}{\sqrt{1 - \beta^4}} \times \varepsilon \times d^2 \times \sqrt{\Delta P \times \rho_f}}{1000}$$

Where:

$$\frac{1}{\sqrt{1 - \beta^4}} = \text{velocity of approach factor} = \text{Ev}$$

Therefore also:

$$Q_m = \left(K_1 \times C \times E_v \times \varepsilon \times d^2 \times \sqrt{\Delta P \times \rho_f} \right) \Big/ 1000$$

5.1.2. Volumetric Gross Flow Rate at Flowing Conditions 'Q_v' (m^3/hr)

$$Q_v = \frac{Q_m}{\rho_f} \times 1000$$

5.1.3. Volumetric Net Flow Rate at Base Conditions 'Q_b' (m^3/hr)

$$Q_b = \frac{Q_m}{\rho_b}$$

5.1.4. Energy Flow Rate at Base Conditions 'Q_e' (GJ/hr)

$$Q_e = (Q_b \times HV) / 1000$$

5.1.5. Nomenclature

The following symbols are used in the flow rate equations. Some of these require further elaboration or calculation, which can be found on the following pages in this chapter and in the indicated standards.

Q_m = mass flow rate at flowing (actual) conditions for differential pressure flowmeters, in Tonnes per hour (Tonnes/hr)

Q_v = volume (gross) flow rate at flowing (actual) conditions for differential pressure flowmeters, in cubic meters per hour (m^3/hr)

Q_b = volume (net) flow rate at base (standard/reference) conditions for differential pressure flowmeters, in cubic meters per hour (m^3/hr)

Q_e = energy flow rate at base (standard/reference) conditions for differential pressure flowmeters, in gigajoule per hour (GJ/hr)

K_1 = factor of combined numerical constants and unit conversions

$$= \frac{\pi}{4} \times \sqrt{2 \times 3600}$$

C = coefficient of discharge (dimensionless —see **5.1.7** this chapter)

β = diameter (beta) ratio (dimensionless —see **5.1.6** this chapter)

E_v = velocity of approach factor (dimensionless) = $1 / \sqrt{1 - \beta^4}$

ε = fluid expansion factor (dimensionless —see **5.1.8** this chapter)

d = orifice plate bore (throat) diameter at flowing temperature conditions, in meters (see **5.1.6** this chapter)

ΔP = differential pressure, in Pascals (Pa), which is the static pressure difference measured between the upstream and downstream tap holes (or in the throat of a Venturi tube).

ρ_f = fluid density at flowing conditions (actual temperature and pressure), in kilograms per cubic meter (kg/m^3)

ρ_b = fluid density at base conditions (standard/reference temperature and pressure), in kilograms per cubic meter (kg/m^3)

HV = volumetric heating value at reference conditions, in MJ/M^3

5.1.6. Diameters and Diameter Correlations

The various flow equations require calculating the diameters of the orifice plate bore or nozzle/Venturi throat, the meter tube or pipe (internally), and the diameter (beta) ratio. These calculated diameters are also used to calculate the pipe Reynolds number, which is used in calculating discharge coefficients.

Orifice Plate Bore or Nozzle / Venturi Throat Diameter 'd' (mm)

The calculated diameter (in millimeters) of the orifice plate bore or of the throat of the nozzle or Venturi tube at flowing temperature is used in the flow equations to calculate flow rates and the orifice Reynolds number. It is the internal diameter of the orifice plate measuring aperture (bore), or the throat of the nozzle or the Venturi tube, computed at flowing temperature. It is defined as follows:

$$d = \mathrm{d_r}\left[1 + \alpha_1\left(\mathrm{T}_f - \mathrm{T_{r1}}\right)\right]$$

Where:

- d = orifice plate bore (or nozzle/Venturi throat) diameter at flowing temperature, in mm
- d_r = reference orifice plate bore diameter or throat at reference temperature, in mm
- α_1 = linear coefficient of thermal expansion of the orifice plate or nozzle/Venturi throat material, in mm/mm·°C
- T_f = temperature of the fluid at flowing conditions, in °C
- T_{r_1} = reference temperature for the orifice plate bore or nozzle/Venturi throat diameter, in °C

Meter Tube (Pipe) Internal Diameter 'D' (mm)

The calculated internal diameter of the meter tube (in millimeters) at flowing temperature is used in the flow equations to calculate the diameter ratio and the pipe Reynolds number. It is the inside diameter of the upstream section of the meter tube computed at flowing temperature, and is defined as:

$$D = \mathrm{D_r}\left[1 + \alpha_2\left(\mathrm{T_f} - \mathrm{T_{r2}}\right)\right]$$

Where:

- D = meter tube internal diameter at flowing temperature, in mm
- D_r = reference meter tube internal diameter at reference temperature, in mm
- α_2 = linear coefficient of thermal expansion of the meter tube material, in mm/mm·°C
- T_f = temperature of the fluid at flowing conditions, in °C
- T_{r_2} = reference temperature for the meter tube internal diameter, in °C

Diameter (Beta) Ratio ‘β’

Dimensionless Values: *Both the diameter (beta) ratio and the pipe Reynolds number are dimensionless; however, consistent units must be used.*

The diameter ratio (or beta ratio) is defined as the calculated orifice plate bore diameter divided by the calculated meter tube internal diameter:

$$\beta = d/D$$

Where:

d = orifice plate bore diameter at flowing temperature, in mm

D = meter tube internal diameter at flowing temperature, in mm

Pipe Reynolds Number ‘R_D’

The pipe Reynolds number is used in the equation for calculating the coefficient of discharge for differential pressure flowmeters. It is a correlating parameter used to represent the change in the device’s coefficient of discharge with reference to the meter tube diameter, the fluid mass flow rate (its inertia or velocity through the device), the fluid density, and the fluid viscosity, It is a parameter that expresses the ratio between the inertia and viscous forces, and is calculated using the following equation:

$$R_D = \frac{4\,q_m}{\pi \times \mu \times D}$$

Where:

R_D = pipe Reynolds number

q_m = mass flow rate at flowing (actual) conditions, in kg/sec

π = universal constant
= 3.14159

μ = absolute (dynamic) viscosity of fluid at flowing conditions, in Pascals·second

D = meter tube internal diameter at flowing temperature, in meters

5.1.7. Coefficient of Discharge 'C'

INFO: *The coefficient of discharge, as defined for and incompressible fluid flow, relates the actual flow rate (at flowing conditions) to the theoretical (reference) flow rate through a device. Calibration of standard primary devices by means of incompressible fluids (liquids) shows that the discharge coefficient is dependent only on the pipe Reynolds number (R_D) for a given primary device in a given installation. The numerical value of the coefficient of discharge (C) is the same for different installation whenever such installations are geometrically similar and the flows are characterized by identical pipe Reynolds numbers. (ISO 5167-1: 1991; page 3.)*

NOTE: *For pipelines with: D $\leq$ 58.62mm and L_1 $\geq$ 0.4333 use 0. 039 = $\beta^4(1-\beta^4)^{-1}$ in the discharge coefficient equation for orifice plates*

Dimensionless Values: *The discharge coefficient is dimensionless; however, consistent units must be used*

The equations for the coefficient of discharge (C) have been determined from test data and correlated as a function of the diameter ratio (β), the pipe diameter (D), and the pipe Reynolds number (R_D). It is used in the flow rate equations and is defined by the following equations:

Coefficient of Discharge for Orifice Plates 'C(OP)'

The discharge coefficient for orifice plates is given by the Stolz equation:

$$C(OP) = 0.5959 + 0.0312\,\beta^{2.1} - 0.184\,\beta^{8} + 0.0029\,\beta^{2.5}\left(\frac{10^6}{R_D}\right)^{0.75}$$
$$+ 0.09\,L_1\,\beta^4\left(1-\beta^4\right)^{-1} - 0.0337\,L_2^{'}\,\beta^3$$

Where:

C(OP) = discharge coefficient for orifice plate

β = diameter (beta) ratio (see **5.1.6** this chapter)

R_D = pipe Reynolds number (see **5.1.6** this chapter)

L_1 = relative upstream pressure tapping spacing
= l_1/D

Where:

- l_1 = distance of the upstream tapping from the upstream orifice plate face
- D = pipe diameter

L'_2 = relative downstream pressure tapping spacing
= l'_2/D

Where:

- l'_2 = distance of the downstream tapping from the downstream orifice plate face
- D = pipe diameter

<u>FOR CORNER TAPPINGS</u>:

$L_1 \;=\; L'_2 \;=\; 0$

<u>FOR D AND D/2 TAPPINGS</u>:

$L_1 \;=\; 1$

$L'_2 \;=\; 0.47$

<u>FOR FLANGE TAPPINGS</u>:

$$L_1 \;=\; L'_2 = \frac{25.4}{D}$$

Coefficient of Discharge for ISA 1932 Nozzles 'C(IN)'

$$C(IN) = 0.99 - 0.2262\,\beta^{4.1} - \left(0.00175\,\beta^{2} - 0.0033\,\beta^{4.15}\right)\left(\frac{10^{6}}{R_D}\right)^{1.15}$$

Where:

C(IN)	=	discharge coefficient for ISA 1932 nozzle
β	=	diameter (beta) ratio (see **5.1.6** this chapter)
R_D	=	pipe Reynolds number (see **5.1.6** this chapter)

Coefficient of Discharge for Long Radius Nozzles 'C(LN)'

$$C(LN) = 0.9965 - 0.00653\,\beta^{0.5}\left(\frac{10^{6}}{R_D}\right)^{0.5}$$

Where:

C(LN)	=	discharge coefficient for long radius nozzle
β	=	diameter (beta) ratio (see **5.1.6** this chapter)
R_D	=	pipe Reynolds number (see **5.1.6** this chapter)

Coefficient of Discharge for Classical Venturi Tubes

Venturi Tube with an Rough Cast / Fabricated Convergent Section 'C($VT_{R/F}$)'

$$C(VT_{R/F}) \;=\; 0.984$$

When:

$$100\text{ mm} \le D \le 800\text{ mm}$$

$$0.3 \le \beta \le 0.75$$

$$2 \times 10^{5} \le R_D \le 2 \times 10^{6}$$

Where:

$C(VT_{R/F})$ = discharge coefficient for classical Venturi tube with an "as cast" convergent section

β = diameter (beta) ratio (see **5.1.6** this chapter)

R_D = pipe Reynolds number (see **5.1.6** this chapter)

Venturi Tube with a Machined Convergent Section '$C(VT_M)$'

$$C(VT_M) = 0.995$$

When:

$$50 \text{ mm} \le D \le 250 \text{ mm}$$

$$0.4 \le \beta \le 0.75$$

$$2 \times 10^5 \le R_D \le 1 \times 10^6$$

Where:

$C(VT_M)$ = discharge coefficient for a classical Venturi tube with a machined convergent section

β = diameter (beta) ratio (see **5.1.6** this chapter)

R_D = pipe Reynolds number (see **5.1.6** this chapter)

Venturi Tube with a Rough-welded Sheet-iron Convergent Section '$C(VT_{RS})$'

$$C(VT_{RS}) = 0.985$$

When:

$$200 \text{ mm} \le D \le 1200 \text{ mm}$$

$$0.4 \le \beta \le 0.7$$

$$2 \times 10^5 \le R_D \le 2 \times 10^6$$

Where:

$C(VT_{RS})$ = discharge coefficient for a classical Venturi tube with a rough-welded sheet-iron convergent section

β = diameter (beta) ratio (see **5.1.6** this chapter)

R_D = pipe Reynolds number (see **5.1.6** this chapter)

Coefficient of Discharge for Venturi Nozzles 'C(VN)'

$$C(VN) = 0.9858 - 0.196\,\beta^{4.5}$$

Where:

C = discharge coefficient for Venturi nozzle

β = diameter (beta) ratio (see **5.1.6** this chapter)

5.1.8. Fluid Expansion Factor 'ε'

Dimensionless Values: *The fluid expansion factor is dimensionless; however, consistent units must be used.*

The fluid expansion factor (ε) is used to take into account the compressibility of the fluid in calculation the flow rate. This coefficient is determined from correlating the diameter ratio (β), the differential pressure (ΔP), the flowing isentropic exponent (κ), and the absolute static pressure (P) at upstream (ε_1) or downstream (ε_2) conditions. In addition to these variables, the pressure ratio is also correlated for fluids flowing through nozzle type and Venturi type devices.

Expansion Factor at Upstream Conditions 'ε_1'

The fluid expansion factor at upstream (pressure) conditions is given by the following expressions:

Orifice Plates

$$\varepsilon_1 = 1 - \left(0.41 + 0.35\beta^4\right)\frac{\Delta P}{\kappa \, P_1}$$

Where:

ε_1 = fluid expansion factor at upstream (pressure) conditions

β = diameter (beta) ratio

ΔP = differential pressure

P_1 = absolute upstream static pressure of the fluid

κ = isentropic exponent

Nozzles, Long Radius Nozzles, Venturi Tubes and Venturi Nozzles

$$\varepsilon_1 = \sqrt{\left(\frac{\kappa\,\tau^{2/\kappa}}{\kappa - 1}\right) \times \left(\frac{1 - \beta^4}{1 - \beta^4\,\tau^{2/\kappa}}\right) \times \left(\frac{1 - \tau^{(\kappa-1)/\kappa}}{1 - \tau}\right)}$$

Where:

ε_1 = fluid expansion factor at upstream (pressure) conditions

κ = isentropic exponent

τ = pressure ratio

$= \dfrac{P_2}{P_1}$

P_1 = absolute upstream static pressure of the fluid

P_2 = absolute downstream static pressure of the fluid

β = diameter (beta) ratio

Expansion Factor at Downstream Conditions 'ε_2'

The fluid expansion factor at downstream (pressure) conditions for differential pressure flow metering devices is given by the following expressions:

$$\varepsilon_2 = \varepsilon_1 \times \sqrt{1 + \frac{\Delta P}{P_2}}$$

Where:

ε_1 = fluid expansion factor at upstream (pressure) conditions

ε_2 = fluid expansion factor at downstream (pressure) conditions

ΔP = differential pressure

P_2 = absolute downstream static pressure of the fluid

5.2. Flow Rate for Gas Helical Turbine Flowmeters

5.2.1. Volumetric Gross Flow Rate at Flowing Conditions 'Q_V' (m^3/hr)

$$Q_V = \frac{\text{Pulses / sec}}{K_F} \times 3600$$

5.2.2. Mass Flow Rate at Flowing Conditions 'Q_m' (Tonnes/hr)

$$Q_m = \left(Q_V \times \rho_f \times M_F \right) / 1000$$

5.2.3. Volumetric Net Flow Rate at Base Conditions 'Q_b' (m^3/hr)

$$Q_b = Q_V \times \frac{\rho_f}{\rho_b} \times M_F$$

5.2.4. Energy Flow Rate at Base Conditions 'Q_e' (GJ/hr)

$$Q_e = \left(Qb \times HV \right) / 1000$$

5.2.5. Nomenclature

Q_V = volumetric gross flow rate at flowing conditions for gas turbine flowmeters, in cubic meters per hour (m^3/hr)

Q_m = mass flow rate at flowing conditions for gas turbine flowmeters, in Tonnes per hour (Tonnes/hr)

Q_b = volumetric net flow rate at base conditions for gas turbine flowmeters, in cubic meters per hour (m^3/hr)

Q_e = energy flow rate at base (standard/reference) conditions for gas turbine flowmeters, in gigajoule per hour (GJ/hr)

Pulses = number of pulses emitted from the flowmeter pulse train per second

ρ_f = fluid density at flowing conditions (actual temperature and pressure), in kilograms per cubic meter (Kg/m^3)

ρ_b = reference density at base conditions (standard/reference temperature and pressure), in kilograms per cubic meter (Kg/m^3)

K_F = K factor, in pulses per cubic meter (pulses/m^3)

M_F = meter factor (dimensionless)

HV = volumetric heating value at reference conditions, in megajoule per standard cubic meter (MJ/m^3)

5.3. Flow Rate for Gas Coriolis Flowmeters

As the Coriolis Meter uses its density value internally to convert mass to actual volume pulses you also cannot configure the Coriolis Meter for volume pulses, i.e the mass measurement is accurate but the density and therefore the actual volume may not be accurate. Omni therefore assumes that it is receiving mass pulses from the Coriolis meter. See Omnicom Help F1 under meter configuration.

Therefore calculations are preformed every 500ms in the flow computer and are as described in AGA11. They are as follows:

Qm *Tonne/Hr* = Coriolis mass pulses per second x 3600 / (K-Factor *(pulses per kg)* x 1000)

Qf *m3/Hr* = Qm x 1000 / DENf

Qb *m3/Hr* = Qm x 1000 / DENb

Qe = (Qb x HV) / 1000

where

Qm = Mass flowrate *(tonne/Hr)*

Qf = Volume flowrate at actual conditions *(m3/Hr)* also referred to as Gross volume flowrate in the flow computer.

Q*b* = Volume flowrate at base conditions (*m3/Hr)* also referred to as Net volume flowrate in the flow computer.

Qe = Energy *(GJ/Hr)*

DENf = Density of the gas at flowing conditions *(kg/m3)* calculated using AGA-8, or measured by a suitable gas densitometer *(Note: AGA-11 states that it is not permissible to use the density measured by the Coriolis meter).*

DENb = Density of the gas at base conditions *(kg/m3)* calculated using AGA-8, ISO6976, or by RD x DENair.

RD = Relative density of the gas at base conditions obtained from either a manual input or a gas chromatograph.

DENair = Density of air at base conditions *(kg/m3)*

HV = Volumetric heating value at base conditions (*MJ/m3*) calculated using ISO 6976, AGA-5, GPA 2172, or obtained from a gas chromatograph or manual input.

5.4. Densities and Other Properties of Gas

5.4.1. AGA Report N$^{\underline{O}}$ 8: Compressibility for Natural Gas and Other Related Hydrocarbon Gases

AGA Report N$^{\underline{O}}$ 8 Documentation References - *Detailed information on computations performed in conformance to the different editions of this standard can be found in the following AGA Report N$^{\underline{O}}$ 8 versions:*

Second Edition, July 1994: *2nd Printing, Catalog N$^{\underline{O}}$ XQ9212*

Second Edition, November 1992: *Catalog N$^{\underline{O}}$ XQ9212*

December 1985: *Catalog N$^{\underline{O}}$ XQ1285*

OMNI flow computer firmware has been programmed in conformance with the December 1985, November 1992, and July 1994 editions of the American Gas Association Report N$^{\underline{O}}$ 8 (AGA 8). This standard provides computation methodology for compressibility and super compressibility factors and densities of natural gas and other hydrocarbon gases.

Of the three editions, the July 1994 edition is considered the most reliable, accurate and complete. However, due to contract requirements or other conditions, some users may want to apply an earlier AGA 8 version.

The December 1985 edition of AGA 8 incorporates improvements to the accuracy of computations compressibility and super compressibility factors beyond the capabilities of AGA's "Manual for the Determination of Super compressibility Factors for Natural Gas" (December 1962; Catalog N$^{\underline{O}}$ L00304). Other improvements included in this version were the expansion in the ranges of gas composition, temperature and pressure, and applications to gas thermodynamic properties.

A very significant improvement to this standard is apparent in the AGA 8 November 1992 edition. Major changes incorporate more precise computations of compressibility factors and densities of natural gas and related hydrocarbon gases, calculation uncertainty estimations and upgraded FORTRAN computer program listings. Other improvements include enhanced equations of state, more accurate calculations for rich gases based on new velocity of sound data, revised correlation methodology.

The current AGA 8 manual was updated in July 1994 for the purpose of correcting typographical errors found in the previous edition, improving the computer programs, and achieving consistency with GPA 2172-94 and the 1992 edition of AGA Report N$^{\underline{O}}$ 3, Part 3.

For reference purposes and as a comparison and contrast exposition of these AGA 8 editions, the following is a brief presentation of some aspects applied by the OMNI flow computer, which include:

- Types of Gases
  - ♦ Mole Percent Ranges of Gas Mixture Characteristics
  - ♦ Natural Gas Compound Identification Codes
- Methods for Gas Mixture Characterization
  - ♦ AGA 8 1994/1992 Methods
  - ♦ AGA 8 1985 Methods
  - ♦ AGA10 Method available when AGA8 1994 Detailed Method is selected.

Types of Gases

The AGA 8 report is intended for natural gases and other related hydrocarbons gases. OMNI flow computer programs include calculations and other information from the three latest editions of the AGA Report Nº 8 at the time of firmware release. The following table lists the type of gases, the corresponding identification codes assigned to each gas type in the computer program, and the mole % range of gas mixture characteristics contained in OMNI firmware that have been taken from AGA 8 1994, 1992 and 1985 editions.

 # NOTE: *The normal range is considered to be zero for these compounds, as follows:*

AGA 8 1994*: oxygen & argon*

AGA 8 1992: *hydrogen, carbon monoxide, oxygen & argon*

Comparative Table of Natural Gas Types, Identification Codes and Mole Percent Ranges
(AGA Report Nº 8 Editions Applicable to OMNI Flow Computers)

Type of Gas Mixture	1994 / 1992			1985	
	ID Code	Mole % Range: Normal	Mole % Range: Expanded	ID Code	Mole % Range
Methane	1	45.0 to 100.0	0 to 100.0	6	50.0 to 100.0
Nitrogen	2	0 to 50.0	0 to 100.0	1	0 to 50.0
Carbon Dioxide	3	0 to 30.0	0 to 100.0	2	0 to 50.0
Ethane	4	0 to 10.0	0 to 100.0	7	0 to 20.0
Propane	5	0 to 4.0	0 to 12.0	8	0 to 5.0
Water Vapor	6	0 to 0.5	0 to Dew Point	4	0 to 1.0
Hydrogen Sulfide	7	0 to 0.02	0 to 100.0	3	0 to 1.0
Hydrogen	8	0 to 10.0 / #	0 to 100.0	20	0 to 1.0
Carbon Monoxide	9	0 to 3.0 / #	0 to 3.0	19	0 to 1.0
Oxygen	10	#	0 to 21.0	18	0 to 1.0
Iso-Butane	11	0 to 1.0 (Total Butanes)	0 to 6.0 (Total Butanes)	10	0 to 3.0 (Butanes)
Normal Butane	12			9	
Iso-Pentane	13	0 to 0.3 (Total Pentanes)	0 to 4.0 (Total Pentanes)	12	0 to 2.0 (Pentanes)
Normal Pentane	14			11	
Normal Hexane	15	0 to 0.2 (Hexane Plus Heavier Hydrocarbons)	0 to Dew Point (Hexane Plus Heavier Hydrocarbons)	13	0 to 1.0 (Hexane Plus Heavier Hydrocarbons)
Normal Heptane	16			14	
Normal Octane	17			15	
Normal Nonane	18			16	
Normal Decane	19			17	
Helium	20	0 to 0.2	0 to 3.0	5	0 to 1.0
Argon	21	#	0 to 1.0	N/A	0 to 1.0

Methods for Gas Mixture Characterization

<u>AGA REPORT N^{O} 8 - 1994/1992 EDITIONS</u>:

Three methods of characterization of a gas mixture from the AGA 8 1994/1992 editions are available for use on the OMNI Flow Computers: the Detailed Method and the Gross Characterization Methods (#1 & #2).

The Detailed Characterization Method

The gas phase pressure-temperature-density behavior of natural gas mixtures is accurately described by the detailed characterization method, for a wide range of conditions. This behavior can also be accurately described for the pure components methane, ethane, carbon dioxide, nitrogen and hydrogen and binary mixtures of these components. A low density correlation was developed for propane and heavier hydrocarbons, and binary mixtures of these components with methane, ethane, nitrogen and carbon dioxide. The uncertainty of compressibility factors and density calculations for natural gases from production separators, which can contain mole percentages of hexanes plus heavier hydrocarbons greater than 1%, is reduced by this method. Correlations were developed to reduce the calculation uncertainty of the following:

- <u>Natural gases containing hydrogen sulfide (sour gas)</u>: correlations of the density behavior of pure hydrogen sulfide and binary mixtures of hydrogen sulfide with methane, ethane, nitrogen and carbon
- <u>Natural gases containing water vapor (wet gas)</u>: second virial correlations for water and binary mixtures of water with methane, ethane, nitrogen and carbon dioxide

Gross Characterization Methods

The following table identifies the nominal ranges of gas characteristics for which these methods are used:

**** NOTE:** Reference conditions: Combustion at 60°F, 14.73 psia: Density at 60°F. 14.73 psia*

***** NOTE:** Reference conditions: Combustion at 25°C, 0.101325 MPa: Density at 0°C, 0.101325 MPa*

RANGE	QUANTITY
Relative Density	0.56 to 0.87
Gross Heating Value *	477 to 1150 Btu/scf
Gross Heating Value **	18.7 to 45.1 MJ/m3
Mole % Methane	45.2 to 98.3
Mole % Nitrogen	0.3 to 53.6
Mole % Carbon Dioxide	0.04 to 28.94
Mole % Ethane	0.24 to 9.53
Mole % Propane	0.02 to 3.57
Mole % Butanes	0.01 to 1.08
Mole % Pentanes	0.002 to 0.279
Mole % Hexanes Plus	0.0005 to 0.1004
Mole % Helium	0 to 0.158

<u>Method #1</u>: Utilizes the volumetric gross heating value (HV), relative density, mole fraction CO_2.

<u>Method #2</u>: **U**tilizes Relative Density, mole fraction N_2, mole fraction CO_2.

AGA Report N^{O} 8 - 1985 Edition:

Six methods of characterization of a gas mixture from the AGA 8 1985 edition are available for use on the OMNI Flow Computers: the primary method and five alternate methods.

Primary Characterization Method

The primary method is the most accurate method in this AGA 8 version for characterization of natural gas, for computations using the equation of state for compressibility factor. This method consists of a complete compositional analysis (the mole fractions of all components) of a natural gas mixture.

Alternate Characterization Methods

An alternate characterization method is used when a complete compositional analysis for a natural gas is not available. One of the five alternate methods can be used to estimate the mole fractions of methane and other important hydrocarbons in the natural gas, as well as diluents other than carbon dioxide and nitrogen. These characterization methods do not include water vapor or hydrogen components.

Various combinations of the following quantities are utilized:

- Real Gas Relative Density (Specific Gravity) (G), at 60°F and 14.73 psia
- Real Gas Gross Heating Value per Unit Volume (HV), at 60°F and 14.73 psia (BTU/ft^3)
- Mole Fraction of Carbon Dioxide [$x(CO_2)$]
- Mole Fraction of Nitrogen [$x(N_2)$]
- Mole Fraction of Methane [$x(CH_4)$]

These alternate methods yield estimates of the mole fraction of the following:

- Methane
- Ethane
- Propane
- Normal Butane
- Iso-Butane
- Total Pentanes
- Total Hexanes plus Heavier Hydrocarbon Gases
- Total Diluents other than Nitrogen and Carbon Dioxide

The five alternate characterization methods are:

(1) The Gravity, Carbon Dioxide, Nitrogen Method
(2) The Gravity, Heating Value, Carbon Dioxide, Nitrogen Method
(3) The Gravity, Heating Value, Carbon Dioxide Method
(4) The Heating Value, Carbon Dioxide, Nitrogen Method
(5) The Gravity, Methane, Carbon Dioxide, Nitrogen Method

5.4.2. ASME 1967 Steam Equation 'υ_r'

The OMNI flow computer applies the ASME 1967 steam equation. This equation is a closed-form solution (non-iterative), developed using reduced properties; pressure (P_r) and temperature parameters (T_r), to define the reduced volume (υ_r) of steam.

5.4.3. Water Density

Acknowledgement - *The implementation of the Keenan & Keyes steam tables was based on the work of Don Kyle of Kyle Engineering, Inc.*

Water density calculations performed by the OMNI flow computer are derived from the fundamental equation which expresses the characteristic function 'ψ', known as the Helmholtz free energy, in terms of the independent variables density (ρ) and temperature (T). This fundamental equation from which water density is derived has been obtained from: Joseph H. Keenan, Frederick G. Keyes, et al., *Steam Tables: Thermodynamic Properties of Water Including Vapor, Liquid and Solid Phases* (John Wiley & Sons, 1969), page 134.

5.4.4. NBS Density, Viscosity Isentropic Exponent, Sound Velocity, and Enthalpy

The NBS Technical Note 1048 (Issued July 1982) is used to calculate density (lb/ft^3), absolute viscosity isentropic exponent, sound velocity, and enthalpy for the following gases:

- Argon
- Nitrogen
- Oxygen
- Hydrogen
- Ethylene

5.4.5. Density and Relative Density (Specific Gravity) Calculated from Digital Densitometer and Gravitometer Output Frequency

Density and Specific Gravity Values Determined from Densitometer and Gravitometer Frequency Signals: *The equations used to determine the density and specific gravity via gas density and specific gravity transducers are provided by the respective manufacturers.*

The calculations expressed in this section are performed by the OMNI to determine the density from frequency signals received from the following third party densitometers and gravitometers:

- Sarasota™
- UGC™
- Solartron™

Sarasota Density 'kg/m³'

Sarasota density is calculated using the frequency signal produced by a Sarasota densitometer, and applying temperature and pressure corrections as shown below:

$$D_c = DCF \times \left[\frac{2D_0^{'}\left(t - t_0^{'}\right)}{t_0^{'}} \right] \times \left[\frac{1 + K\left(t - t_0^{'}\right)}{2x\, t_0^{'}} \right]$$

Where:

Dc	=	corrected density
DCF	=	Density correction factor
D_0	=	calibration constant, in mass/volume*

**** NOTE:*** *D_0' must be expressed in kilograms per cubic meter (kg/m³).*

t	=	densitometer oscillation period in microseconds (μsec)
t_0	=	calibration constant, in microseconds
t_0'	=	T_{coef} x (T_f - T_{cal}) + P_{coef} x (P_f - P_{cal}) + t_0
K	=	spool calibration constant
T_f	=	flowing temperature, in °C
T_{coef}	=	temperature coefficient, in μsec/°C
P_f	=	flowing pressure, in kPa
P_{coef}	=	pressure coefficient, in μsec/kPa
P_{cal}	=	calibration pressure, in kPa

UGC Density 'kg/m^3'

UGC density is calculated using the frequency signal produced by a UGC densitometer, and applying temperature and pressure corrections as shown below:

UNCORRECTED DENSITY:

$$D = K_0 + (K_1 \times t) + (K_2 \times t^2)$$

Where:

D = uncorrected density, in kg/m^3

$\left.\begin{array}{l} K_0 \\ K_1 \\ K_2 \end{array}\right\}$ = calibration constants of density probe, entered via the keypad

t = densitometer oscillation time period, in microseconds (μsec)

CORRECTED DENSITY:

$$D_c = DCF \times \left\{ \begin{array}{l} \left[\left(K_{P_3} D^2 + K_{P_2} D + K_{P_1}\right) \times \left(P_f - P_c\right)\right] \\ + \left[\left(K_{t_3} D^2 + K_{t_2} D + K_{t_1}\right) \times \left(T_f - T_c\right)\right] + D \end{array} \right\}$$

Where:

D_c = corrected density, in kg/m^3

DCF = density correction factor

D = uncorrected density, kg/m^3

$\left.\begin{array}{l} K_{P_1} \\ K_{P_2} \\ K_{P_3} \end{array}\right\}$ = pressure constants

P_f = flowing pressure, in kPa

P_c = calibration pressure, in kPa

$\left.\begin{array}{l} K_{t_1} \\ K_{t_2} \\ K_{t_3} \end{array}\right\}$ = temperature constants

T_f = flowing temperature, in °C

T_c = calibration temperature, in °C

Solartron™ Density 'kg/m³'

*INFO: For Solartron gas density transducers, it is **NOT** necessary to convert the calibration sheet from metric to US customary units.*

Solartron™ density is calculated using the frequency signal produced by a Solartron frequency densitometer, and applying temperature and pressure corrections as detailed below.

UNCORRECTED DENSITY:

$$D = K_0 + (K_1 \times t) + (K_2 \times t^2)$$

Where:

D = uncorrected density, in kg/m³

$\left.\begin{matrix} K_0 \\ K_1 \\ K_2 \end{matrix}\right\}$ = calibration constants supplied by Solartron, in kg/m³ and °C

t = densitometer oscillation time period, in microseconds (μsec)

TEMPERATURE CORRECTED DENSITY:

$$D_T = D \times [1 + K_{18}(T_F - 20)] + [K_{19}(T_F - 20)]$$

Where:

D_T = temperature corrected density, in kg/m³

D = uncompensated density, in kg/m³

$\left.\begin{matrix} K_{18} \\ K_{19} \end{matrix}\right\}$ = calibration constants supplied by Solartron

T_F = Temperature in °C

ACTUAL DENSITY:

$$D_a = D_T \times \left[1 + \frac{K_3}{(D_T + K_4)} \times \left(K_5 - \frac{G}{(T_F + 273)} \right) \right]$$

Where:

D_a = actual density, in kg/m³

D_T = temperature compensated density, in kg/m³

$\left.\begin{matrix} K_3 \\ K_4 \\ K_5 \end{matrix}\right\}$ = calibration constants supplied by Solartron

$G = \dfrac{\text{Gas Specific Gravity}}{\text{Ratio of Specific Heats}}$

T_F = Temperature in °C

Solartron™ NT 3098 Gravitometer: Relative Density (Specific Gravity)/Output Frequency Relationship

Density and Specific Gravity Values Determined from Densitometer and Gravitometer Frequency Signals: *The equations used to determine the density and specific gravity via gas density and specific gravity transducers are provided by the respective manufacturers.*

The relationship between the gravitometer output frequency and the specific gravity is given by the following:

$$G = K_0 + K_2 T^2$$

Where:

G = specific gravity of a gas determined from the transducer frequency signal

T = periodic time of the sample gas specific gravity at stable temperature and at the selected reference chamber pressure, in microseconds (μsec)

$$= \sqrt{\frac{G - K_0}{K_2}}$$

K_0 = calibration constant

$$= G_Y - K_2 T_Y^2$$

K_2 = calibration constant

$$= \frac{G_X - G_Y}{Tx^2 - Ty^2}$$

G_X = specific gravity of calibration (sample) gas 'X'

G_Y = specific gravity of calibration (sample) gas 'Y'

T_X = periodic time of a known calibration (sample) gas of 'X' specific gravity under stable operating conditions, in μsec

T_Y = periodic time of a known calibration (sample) gas of 'Y' specific gravity under stable operating conditions, in μsec

5.4.6. NX19 Analysis (1980 Edition)

$$Fpv = \frac{[(B/D - D + n/(3\pi)]^{0.5}}{1 + (0.00132 / \tau^{3.25})}$$

Where:

$$B = \frac{(3 - m * n^2)}{(9 * m * \pi^2)}$$

$$m = 0.0330378*(\tau)^{-2} - 0.0221323*(\tau)^{-3} + 0.0161353*(\tau)^{-5}$$

$$n = \frac{0.265827*(\tau)^{-2} + 0.0457697*(\tau)^{-4} - 0.133185*(\tau)^{-1}}{m}$$

π = $(P_{adj} + 14.7) / 1000$

τ = $(t_{adj} + 460) / 500$

$P_{adj} = P * F_P$

$T_{adj} = [(t + 460) * F_T] - 460$

P = gauge pressure, psig

$F_P = 156.47 / (160.8 - 7.22*G + K_P)$

Where:

Kp = Mc – 0.392*Mn

G = Specific Gravity of flowing gas

Mc = mol percent carbon dioxide

Mn = mol percent nitrogen

T = flowing temperature, ^oF

$F_t = 226.29 / (99.15 + 211.9*G - K_t)$

Where:

K_t = Mc + 1.681 * Mn

$D = [b + (b^2 + B^3)^{0.5}]^{1/3}$

$$b = \frac{9*n - 2*m*n^3}{54*m*\pi^3} - \frac{E}{2*m*\pi^2}$$

The following equations used for developing E values based on the respective ranges of applicability for pressure and temperature:

$E_1 = 1 - 0.00075*(\pi)^{2.3} * e^{-20(\tau-1.09)}$
$- 0.0011*(\tau-1.09)^{0.5} * (\pi)^2 * [2.17 + 1.4*(\tau-1.09)^{0.5} - \pi]^2$
Pressure Range : π, 0 to 2, or P, 0 to 2000 psia
Temperature Range: τ, 1.09 to 1.4, or t, 85°F to 240°F

$E_2 = 1 - 0.00075*(\pi)^{2.3} * [2 - e^{-20(1.09-\tau)}]$
$- 1.317*(1.09-\tau)^4 * \pi * (1.69 - \pi^2)$
Pressure Range : π, 0 to 1.3, or P, 0 to 1300 psia
Temperature Range: τ, 0.84 to 1.09, or t, -40°F to 85°F

$E_3 = 1 - 0.00075*(\pi)^{2.3} * [2 - e^{-20(1.09-\tau)}] + 0.455*[200*(1.09-\tau)^6$
$- 0.03249*(1.09-\tau) + 2.0167*(1.09-\tau)^2 - 18.028*(1.09-\tau)^3$
$+ 42.844*(1.09-\tau)^4]*(\pi - 1.3) * [1.69 * (2)^{1.25} - \pi^2]$
Pressure Range : π, 1.3 to 2.0, or P, 1300 to 2000 psia
Temperature Range: τ, 0.88 to 1.09, or t, -20°F to 85°F

$E_4 = 1 - 0.00075*(\pi)^{2.3} * [2 - e^{-20(1.09-\tau)}] + 0.455*[200*(1.09-\tau)^6$
$- 0.03249*(1.09-\tau) + 2.0167*(1.09-\tau)^2 - 18.028*(1.09-\tau)^3$
$+ 42.844*(1.09-\tau)^4]*(\pi - 1.3) * [1.69 * (2)^{1.25+80*(0.88-\tau)2} - \pi^2]$
Pressure Range : π, 1.3 to 2.0, or P, 1300 to 2000 psia
Temperature Range: τ, 0.84 to 0.88, or t, -40 °F to –20 °F

$E_{5a} = E_4 - Y$
Pressure Range : π, 2.0 to 5.0, or P, 2000 to 5000 psia
Temperature Range: τ, 0.84 to 0.88, or t, -40 °F to –20 °F

$E_{5b} = E_3 - Y$
Pressure Range : π, 2.0 to 5.0, or P, 2000 to 5000 psia
Temperature Range: τ, 0.88 to 1.09, or t, -20 °F to 85 °F

$E_{5c} = E_1 - Y$
Pressure Range : π, 2.0 to 5.0, or P, 2000 to 5000 psia
Temperature Range: τ, 1.09 to 1.32, or t, 85 °F to 200 °F

$E_6 = E_{5c} - U$

Pressure Range : π, 2.0 to 5.0, or P, 2000 to 5000 psia

Temperature Range: τ, 1.32 to 1.4, or t, 200 °F to 240 °F

$$Y = A*(\pi - 2) + A_1*(\pi - 2)^2 + A_2*(\pi - 2)^3 + A_3*(\pi - 2)^4$$

Where:

$$A = 1.71720 - 2.33123*(\tau) - 1.56796*(\tau)^2 + 3.47644*(\tau)^3 - 1.28603*(\tau)^4$$

$$A_1 = 0.016299 - 0.028094*(\tau) + 0.48782*(\tau)^2 - 0.728221*(\tau)^3 + 0.27839*(\tau)^4$$

$$A_2 = -0.35978 + 0.51419*(\tau) + 0.16453*(\tau)^2 - 0.52216*(\tau)^3 + 0.19687*(\tau)^4$$

$$A_3 = 0.075255 - 0.10573*(\tau) - 0.058598*(\tau)^2 + 0.14416*(\tau)^3 - 0.054533*(\tau)^4$$

$$U = (\tau - 1.32)^2 * (\pi - 2) * [3 - 1.488 * (\pi - 2) \quad 0.10 *(\pi - 2)^2 + 0.0833 * (\pi - 2)^3]$$