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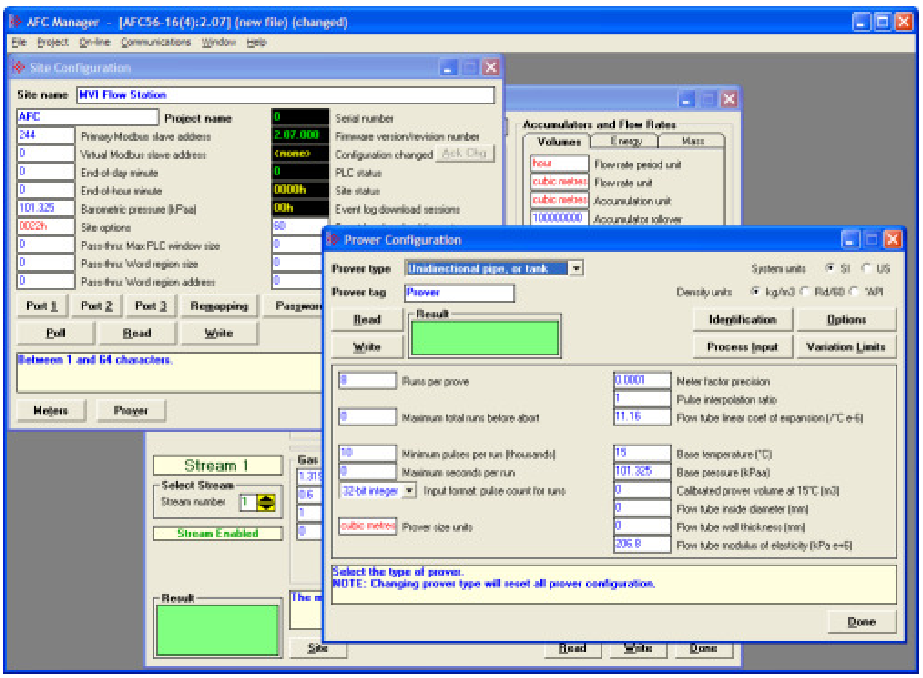

AFC Manager

Configuration Tool

Liquid and Gas Flow Computer

March 2, 2011

USER MANUAL

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AFC Manager User Manual

March 2, 2011

ProSoft Technology® Product Documentation

In an effort to conserve paper, ProSoft Technology no longer includes printed manuals with our product shipments. User Manuals, Datasheets, Sample Ladder Files, and Configuration Files are provided on the enclosed CD-ROM, and are available at no charge from our web site: www.prosoft-technology.com

Contents

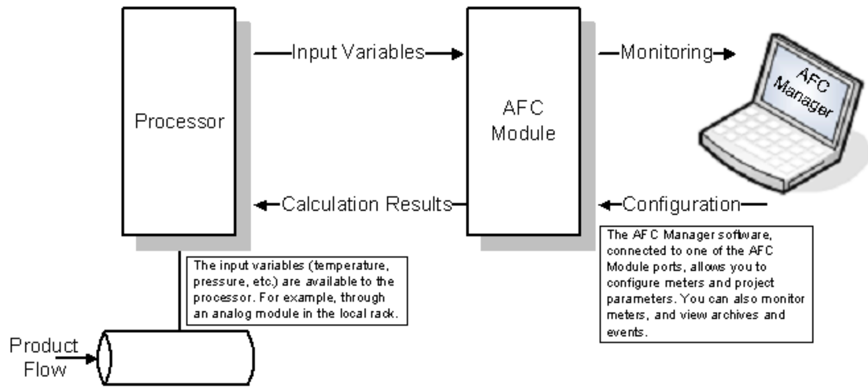
1 Introduction

In This Chapter

The AFC Manager is a software application (computer program) for Microsoft Windows that allows you to perform the following tasks with your AFC module:

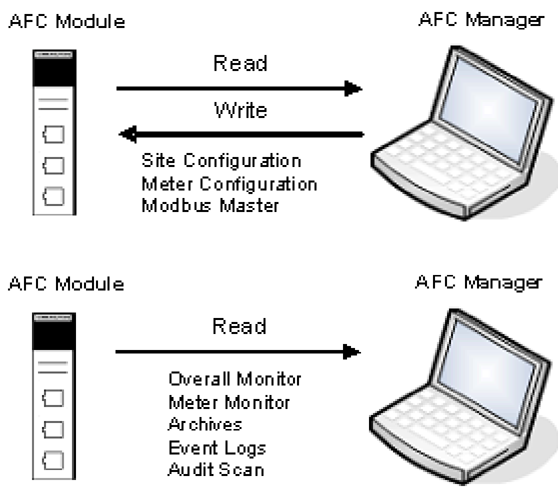
- Configure project parameters (site configuration)
- Configure the port communication parameters
- Remap registers from the primary slave to the virtual slave. Modbus master interface allows easy access to primary and virtual database.
- Configure meter channels
- Enable and disable the meter channels
- Set the module passwords
- Keep track of configuration changes
- Monitor the meter operation
- Perform an audit scan
- Configure the archives
- Monitor the archives
- Monitor the events

The following illustration shows a typical AFC Manager Software project:



You can configure each meter in the local computer (saving the configuration as a .AFC file) and then download the file to the module. Later, you can adjust specific meter configuration parameters without downloading the entire project; this is accomplished using the Write button in the Meter Configuration dialog box.

You can also transfer the current configuration from the module to the local computer by uploading the current configuration.



1.1 Update Notice

If your module measures liquids, please read this notice before upgrading from version 2.04 (or earlier) to 2.05 (or later).

For compliance with new measurement standards, the AFC version 2.05 has introduced several new liquid product groups. In particular, the two non-refined liquid product groups of version 2.04, which covered the entire density range of crudes and NGLs, have each been split into two separate product groups, one for the higher density range of crudes and the other for the lower density range of NGLs. If your module has meter channels configured for either "Crude, NGL" or "Oil-water emulsion", you should decide **before upgrading the firmware** the new product group (light or heavy) to which each such channel should be assigned. This assignment will be performed during the upgrade process and will preserve all other configuration and historical records including accumulator values and archives, in contrast to changing a product group after the upgrade which resets the meter configuration and erases all historical records. Meter channels configured for "Gas" or "Refined products" are not affected.

AFC Manager exhibits the same behavior when converting a project between versions 2.04 (or earlier) and 2.05 (or later).

The criterion for assigning the new product group depends on the density units and the Default Reference Density, as described in the following tables:

Density Units = kg/m3

Version 2.04 Product Group	Default Reference Density	Version 2.05 Product Group
Crude, NGL	= 0 OR ≥ 610.0	Crude oils, JP4
Crude, NGL	> 0 AND < 610.0	NGLs, LPGs
Oil Water Emulsion	= 0 OR ≥ 610.0	Oil-water emulsion (Crd)
Oil Water Emulsion	> 0 AND < 610.0	Oil-water emulsion (NGL)

Density Units = Rd/60

Version 2.04 Product Group	Default Reference Density	Version 2.05 Product Group
Crude, NGL	= 0 OR ≥ 0.6100	Crude oils, JP4
Crude, NGL	> 0 AND < 0.6100	NGLs, LPGs
Oil Water Emulsion	= 0 OR ≥ 0.6100	Oil-water emulsion (Crd)
Oil Water Emulsion	> 0 AND < 0.6100	Oil-water emulsion (NGL)

Due to roundoff error of numeric conversions, a Relative Density very close to the cutoff value of 0.6100 may cause the module to assign the new product group opposite to the one that was intended. Before upgrading, change the Default Reference Density to a number significantly different from 0.6100, such as 0.6110 (to target Crude) or 0.6090 (to target NGLs). You may change it back to the correct value after the upgrade.

Density Units = API Gravity

Version 2.04 Product Group	Default Reference Density	Version 2.05 Product Group
Crude, NGL	= 0 OR ≤ 100.0	Crude oils, JP4
Crude, NGL	> 0 AND > 100.0	NGLs, LPGs
Oil Water Emulsion	= 0 OR ≤ 100.0	Oil-water emulsion (Crd)
Oil Water Emulsion	> 0 AND > 100.0	Oil-water emulsion (NGL)

1.2 Quick Start

In this section, you will use these basic steps to configure the module using AFC Manager:

Step 1: Install the AFC Manager Software (page 16)

Step 2: Install the Module (Refer to the AFC User Manual for your module)

Step 3: Connect the AFC Module to the AFC Manager (page 19)

Step 4: Start a New AFC project (page 23)

Step 5: Configure the Project Parameters (page 29)

Step 6: Configure Each Meter (page 55)

Step 7: Save the Module Configuration to the Local Computer (page 131)

Step 8: Download the Module Configuration to the Module (page 132)

Step 9: Verify Correct Operation (page 28)

1.3 Install AFC Manager

The AFC Manager application is included on the CD-ROM shipped with your module. Before you can use the application, you must install it on your computer.

1.3.1 System Requirements

The following system requirements are the recommended minimum specifications to successfully install and run AFC Manager:

- Microsoft Windows compatible PC
- Windows 2000 with Service Pack 2 or higher, or Windows XP Professional with Service Pack 2 or higher, or Windows 2003/Vista/7
- 300 mHz Pentium processor (or equivalent)
- 128 megabytes of RAM
- 20 megabytes of free disk space
- Available serial port (COM port) or USB to Serial adapter cable with necessary drivers, required for communication between AFC Manager software and the AFC module.
- DB9 adapter cable (included with module), required for connection between PC serial port and AFC module (PTQ-AFC module does not require an adapter).

To install the AFC Manager application:

1 Insert the ProSoft Solutions CD in your CD-ROM drive. On most computers, a menu screen will open automatically. If you do not see a menu within a few seconds, follow these steps:

   a Click the Start button, and then choose Run.
   b In the Run dialog box, click the Browse button.
   c In the Browse dialog box, click "My Computer". In the list of drives, choose the CD-ROM drive where you inserted the ProSoft Solutions CD.
   d Select the file **prosoft.exe**, and then click Open.
   e On the Run dialog box, click OK.

2 On the CD-ROM menu, click Documentation and Tools. This action opens a Windows Explorer dialog box.
3 Open the Utilities folder, and then open the AFCManager folder.
4 Double-click the file Setup.exe. If you are prompted to restart your computer so that files can be updated, close all open applications, and then click OK. When your computer has finished restarting, begin again at Step 1.
5 Click OK or Yes to dismiss any confirmation dialog boxes.
6 It may take a few seconds for the installation wizard to start. Click OK on the AFC Manager Setup dialog box to begin installing AFC Manager.
7 Follow the instructions on the installation wizard to install the program with its default location and settings.
8 When the installation finishes, you may be prompted to restart your computer if certain files were in use during installation. The updated files will be installed during the restart process.

1.3.2 Upgrading from a Previous Version of AFC Manager

This version of the AFC Manager User Manual discusses AFC Manager version 2.07, which supports AFC module firmware versions 2.07 and earlier.

To upgrade from an earlier version of AFC Manager

1 Uninstall all previous versions of AFC Manager from your PC, using the **Settings/Control Panel/Add and Remove Programs** applet. Answer "Yes to all" when prompted to remove shared components.

2 Download the latest version of AFC Manager from www.prosoft-technology.com. Navigate to **Support** / **Downloads**, and then choose your AFC Module. From the download page, select AFC Manager. When the download is complete, choose "Open", and then run Setup.exe.

Note: Some parts of the user interface, particularly the Meter Configuration dialog box, have changed from versions of AFC Manager prior to 2.05. These changes were necessary for the multiple stream support added in firmware version 2.05, and primarily involve a more logical arrangement of items on the meter configuration screen. These changes do not affect the functionality of the program, and all previous firmware versions are supported. For firmware upgrades, please contact ProSoft Technical Support.

1.4 Install the Module in the Rack

If you have not already installed and configured your processor and power supply, please do so before installing the AFC module. Refer to the processor documentation for installation instructions.

Warning: You must follow all safety instructions when installing this or any other electronic devices. Failure to follow safety procedures could result in damage to hardware or data, or even serious injury or death to personnel. Refer to the documentation for each device you plan to connect to verify that suitable safety procedures are in place before installing or servicing the device.

After you have checked the placement of the jumpers, insert the AFC module into the rack. Use the same technique recommended by the processor manufacturer to remove and install AFC modules.

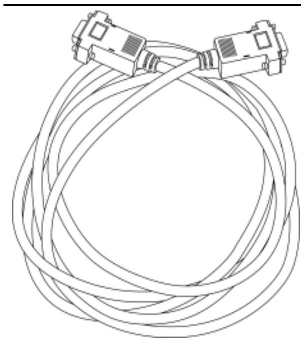
Warning: When you insert or remove the module while backplane power is on, an electrical arc can occur. This could cause an explosion in hazardous location installations. Verify that power is removed or the area is non-hazardous before proceeding. Repeated electrical arcing causes excessive wear to contacts on both the module and its mating connector. Worn contacts may create electrical resistance that can affect module operation.
Note: If you insert the module improperly, the system may stop working, or may behave unpredictably.

After you have installed the AFC module in the rack with the processor, you should then download the sample program to the processor.

1 Connect a null modem cable from the serial port on your computer to the serial port on the processor.
2 Start the configuration tool for your processor (RS Logix for MVI-AFC modules; Concept, Unity or ProWorx for PTQ-AFC) and establish communication with the processor.
3 Open the sample program in the configuration tool. Adjust the slot number and processor type, if necessary, to match the physical configuration of the processor and the position of the AFC module in the rack.
4 Download the program to the processor. The sample program is located on the CD-ROM in the box with your module. Refer to the User Manual for your module for specific instructions on downloading the sample program.

1.5 Connect the AFC Module to the AFC Manager

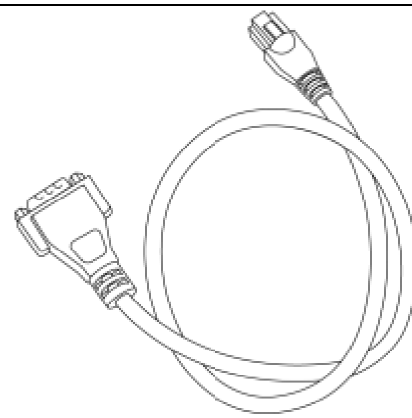
You will need the correct cables to connect the AFC module to the computer running AFC Manager. The null-modem cable as well as any required adapter cables are included in the box with the module.



Null-modem Cable

Included with all AFC modules

Connects directly to PTQ-AFC module configuration/debug port, all other AFC modules require an adapter cable (RJ45/DB9 adapter or 8 pin mini DIN/DB9 adapter, supplied with module as needed).



RJ45/DB-9 adapter

Included with MVI46, 56, 69 and 71 AFC modules

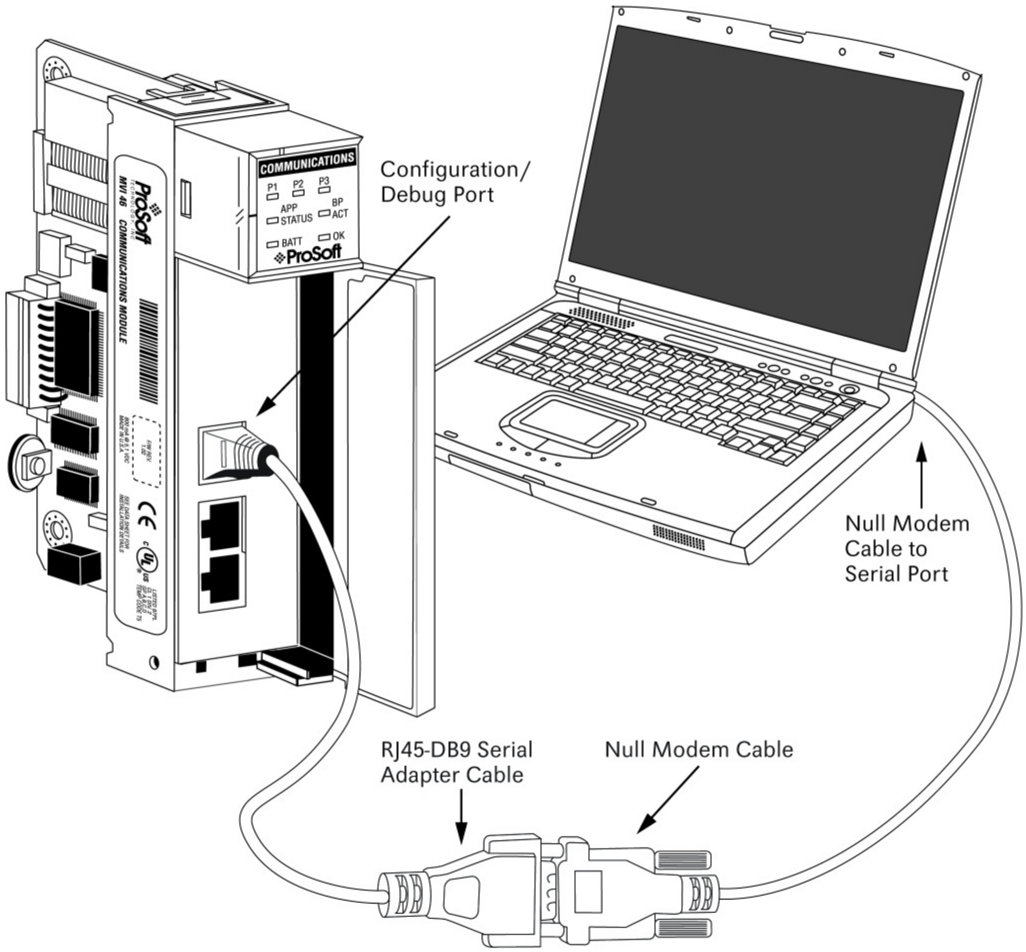
Connects Null-modem Cable to MVI46, 56, 69 and 71 AFC module configuration-debug port.

1 Connect the DB-9 adapter to the CFG (configuration/debug) port of the AFC module (refer to the port labels on the front of the module to find the correct port).

Note: The PTQ-AFC module connects directly to the null modem cable and does not require an adapter.

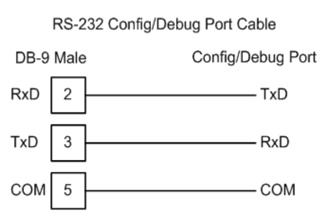
2 Connect the null-modem cable to the DB-9 adapter cable on the module, and to an available serial port on your computer.

Note: Some desktop and notebook computers are not equipped with a serial port. In this case, you may require a USB to Serial adapter cable, with drivers. Not all USB to Serial adapters will work correctly with this application. If you encounter problems, please contact ProSoft Technical Support for recommendations.

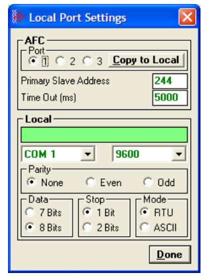


Note: The illustration above shows an MVI46-AFC. The connection process is similar for all MVI-AFC and PTQ-AFC models.

The null-modem cable that is supplied with the module uses the following cabling scheme:



3 Start AFC Manager, and then select the port settings at: **Communications** / **Local Port Settings**. The default communication settings are shown in the following illustration.



4 The AFC Manager will establish communication with the module. Open the Project menu and then select Site Configuration to open the Site Configuration dialog box.

5 On the Site Configuration dialog box, click the Read button. You should see the word "Success" in the Result area of the dialog box.

1.5.1 Troubleshooting AFC Manager Connection Problems

If AFC Manager has trouble making a connection to the AFC's Primary Slave:

1 Check your cabling. You must connect a null-modem cable between the COM port on your PC and the serial port on the module.

2 Connect to the module's Configuration/Debug port if possible. If you try to connect to another of the module's ports, the AFC's configuration may have the Primary Slave hidden at that port. At the Configuration/Debug port the Primary Slave is always visible.

3 Double-check your communications settings via **Communications** / **Local Port Settings.** You must set up your COM port to match the settings of the AFC's port. By default the AFC sets up its Configuration/Debug port as: Slave address 244, 9600 baud, no parity, 8 data bits, 1 stop bit, RTU mode; so use those settings unless the AFC's default configuration has been changed. Be sure that you are selecting the correct COM port on your PC, especially if you are using a USB serial adapter as those adapters may be assigned to different COM ports at different times.

4 Ensure that the COM port on your PC is not in use by another application, such as HyperTerminal. If the port is held by another application, then AFC Manager will not be able to use it.

1.6 Starting AFC Manager

To start AFC Manager:

1. Click the **START** button, and then choose **PROGRAMS**.
2. In the Programs menu, choose ProSoft Technology.
3. In the ProSoft Technology menu, choose AFC Manager.

1.7 Using AFC Manager

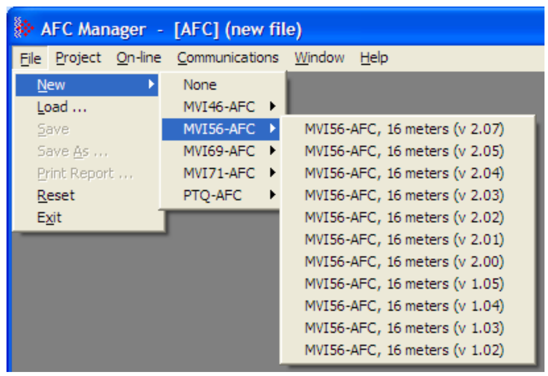
The AFC module is configured with configuration files that you create using AFC Manager. A configuration file is called a Project.

1.7.1 Starting a New Project

To start a new project:

1 Start **AFC MANAGER**, and then open the *File* Menu.

2 On the *File* Menu, choose **NEW**, and then select your module and firmware version number.

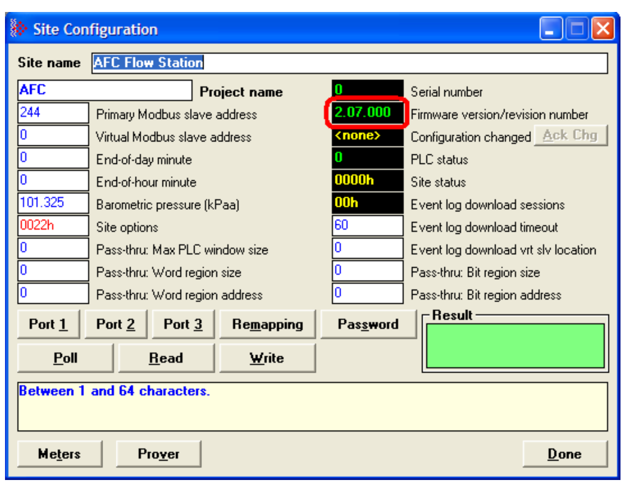


The version number refers to the firmware version of your module. If you do not know the firmware version number, follow these steps:

a) Open the *Project* menu.

b) Choose **SITE CONFIGURATION**. This action opens the *Site Configuration dialog box (page 30).*

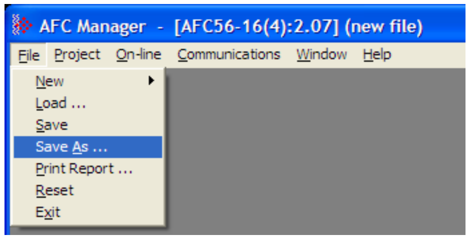
c) Click the **READ** button (page 53). The firmware version is listed below the serial number, in the upper right part of the dialog box.



Important: You must be connected to the module and "online" to read data from the module.

3 Follow the steps in the remainder of this User Guide to configure your module and your AFC device.

4 Before closing the program, open the *File* menu and choose **SAVE AS**, to save your project so you can open it again later.



1.7.2 Loading an Existing project

You can open and edit a project you have previously saved. Do this if you have started, but not completed, the configuration of your project, or if you need to modify the settings for a project that has already been downloaded to the module.

To load an existing project:

1 Start **AFC MANAGER**, and then open the *File* menu.

2 On the *File* menu, choose **LOAD**. This action opens a dialog box that shows a list of AFC Manager project files (AFC files) in the current folder.

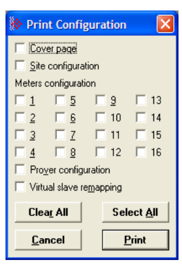
3 Choose the project to load, and then click **OPEN**.

1.7.3 Printing the Configuration Report

You can print a report of your configuration for future reference, or for archival purposes.

To print the configuration report:

1 Open the *File* menu, and then select **PRINT REPORT**. This action opens the *Print Configuration* dialog box.



2 On the *Print Configuration* dialog box, select (check) the items to include in the printed report.

3 Click **PRINT** to send the report to your default printer.

Note: The size of the report depends on items you choose to include, and may require 75 pages or more. Consider this before printing.

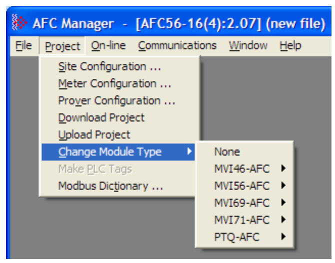
1.7.4 Converting a Project

You can convert an existing project (configuration file) to use it with a different module or firmware version. Do this if:

- You want to reuse an application created for a different AFC module, for example a project that was created for a PTQ-AFC that you want to use for an MVI69-AFC.
- You apply a firmware upgrade to a module.

To convert a project:

1 Open the *File* menu, and then choose **OPEN**.
2 Open the project (configuration file) to convert.
3 Open the *Project* menu, and then choose **CHANGE MODULE TYPE**.



4 Choose the module type and firmware version from the menu.
5 Save your project.

Note: AFC Manager will save your updated configuration file with the same name as the file you loaded. If you need to keep your original configuration, change the file name of your updated configuration before saving.

1.7.5 Resetting Configuration Parameters

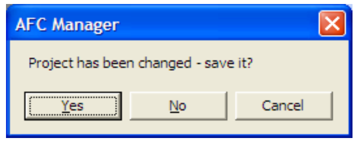
If you have modified your project (configuration file), or if you have loaded a configuration file from disk, but you want to start a new project, you can reset the configuration parameters back to their defaults without having to close and reopen the AFC Manager.

To reset configuration parameters

1 Close any dialog boxes that are open.
2 Save the configuration file you were working on, if you would like to load it again later.
3 On the *File* menu, choose **RESET**.

Note: This procedure has the same effect as choosing **File / New / None**.

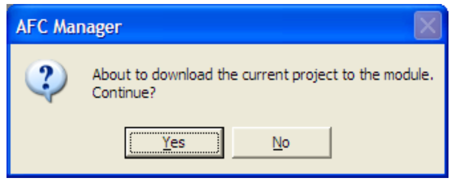
If you have made changes to the configuration that have not yet been saved, a confirmation dialog box will open.



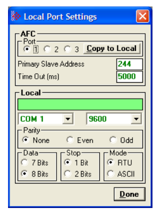
Answer Yes to save your changes, or No to discard your changes and begin working on a new configuration. Click Cancel to abandon the attempted action that caused this message.

1.7.6 Downloading the Project to the Module

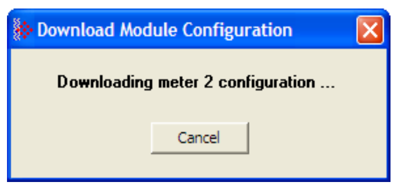
1 Click **PROJECT / DOWNLOAD PROJECT.**



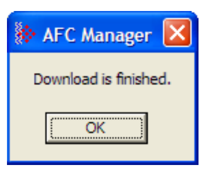
2 This action opens the Local Port Settings window. Enter the port parameters to use, and then click **DONE.**



3 During the download operation, the following progress window is displayed:



4 When the file transfer is complete, the following window is displayed:



Note: The virtual slave remapping data (page 214) is not downloaded during the procedure because it requires a separate download operation.
Troubleshooting Tip: If the AFC Manager displays an "Illegal Data Value" message, it typically indicates an invalid meter type or product group configuration. The module does not accept a configuration file that attempts to change a meter type or product group for a meter that is currently enabled. Disable all meters, change the meter types and product groups, and then enable the meters again.

1.7.7 Verifying Correct Operation

When all of the configuration steps have been completed, the module should be ready to perform measurement calculations. To verify that the module is configured correctly, follow these steps:

1 Enable all meters that will be used, as any meter will only perform calculations if it is enabled. Any meter can be enabled either with ladder logic (AFC Manager modules), function blocks (PTQ modules) or with AFC Manager.

2 Make sure that the wallclock is running, and that it has valid date and time information. After power-up, the wallclock will be stopped, therefore the module will not perform any time-scheduled operations, such as writing period-end archives, and will not timestamp records written to the event log until it receives a wallclock command from the ladder logic.

The sample ladder logic programs the wallclock update command upon detecting "power-up" status from the AFC. The date/time information used is the same as the processor, therefore you should use the configuration tool for your processor to verify that the processor has valid date/time data. If the processor wallclock is not valid (for example if the year = 1900), the module will not accept the command. You may easily determine if the wallclock is running by performing two consecutive read operations in the Meter Monitor (page 139).

3 Make sure that the meter does not have any alarms. A meter alarm may affect flow calculation. Look at the Meter Monitor dialog box for alarms.

4 Make sure that the input parameters transferred from the processor are correct. You can look at these values in the Meter Monitor dialog box.

5 When using a pulse meter, make sure that the pulse input rollover parameter in Meter Configuration matches the actual input rollover value used in the high speed counter module.

2 Site Configuration

In This Chapter

The first task in setting up a Project is to configure the overall settings for the site. The Site Configuration dialog box is where you assign the settings that apply to the entire project.

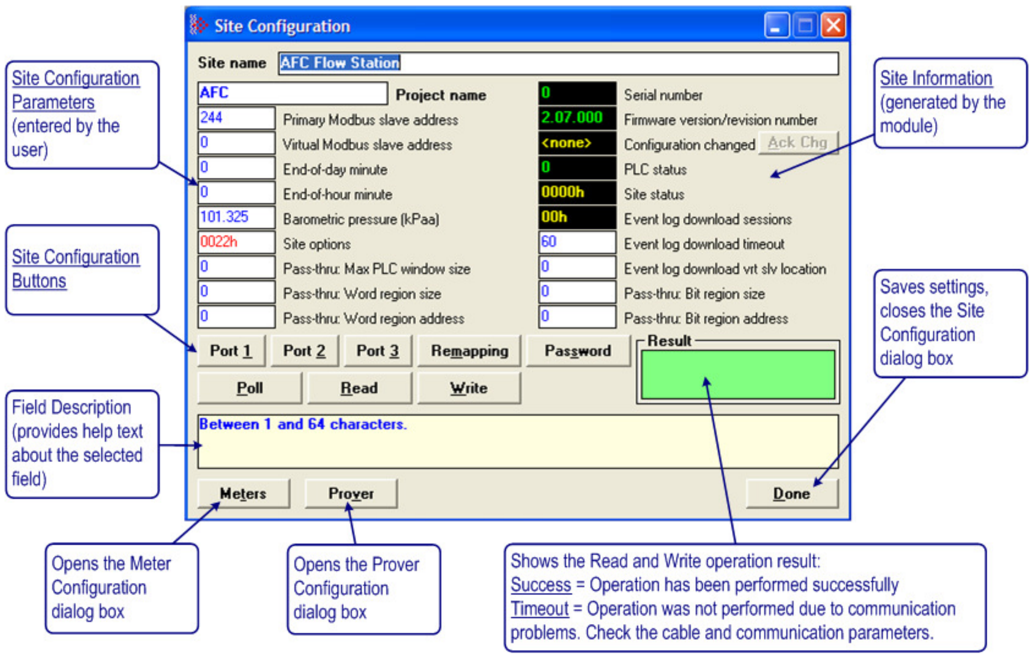
- Project name
- Modbus slave addresses
- Memory allocation
- Port configuration and mapping
- Site options and status.

To begin configuring a site

1. Start AFC Manager.
2. On the File menu, choose New, and then select the module type, number of meters, and firmware version.
3. On the Project menu, choose Site Configuration. This action opens the Site Configuration dialog box.
4. Choose the settings to apply to the site.
5. When you are finished, click Done, and then open the File menu and choose Save As to save your project.

2.1 Site Configuration Dialog Box

The Site Configuration dialog box opens when you open the Project menu in AFC Manager, and then choose Site Configuration. Use this dialog box to define the settings that apply to the Project as a whole.



2.2 Site Information

This section of the Site Configuration dialog box contains a detailed explanation about the values that are generated by the module on the Site Configuration dialog box. These values can only be read from the module to the local computer.

2.2.1 Serial Number

This section of the Site Configuration dialog box shows the module serial number (hardware). AFC Manager must be connected and "online" to the module to display this value.

2.2.2 Firmware Version Number

This section of the Site Configuration dialog box shows the current module firmware version. For example, 2.07.000. The firmware version number corresponds with the module type and firmware version you selected from the File menu.

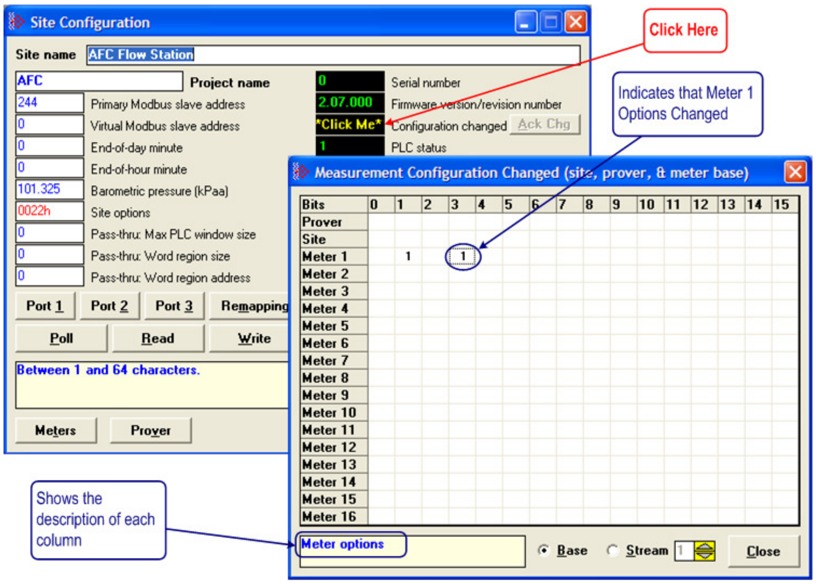
2.2.3 Configuration Changed

This value is set when any bit in the "measurement configuration changed" registers is set.

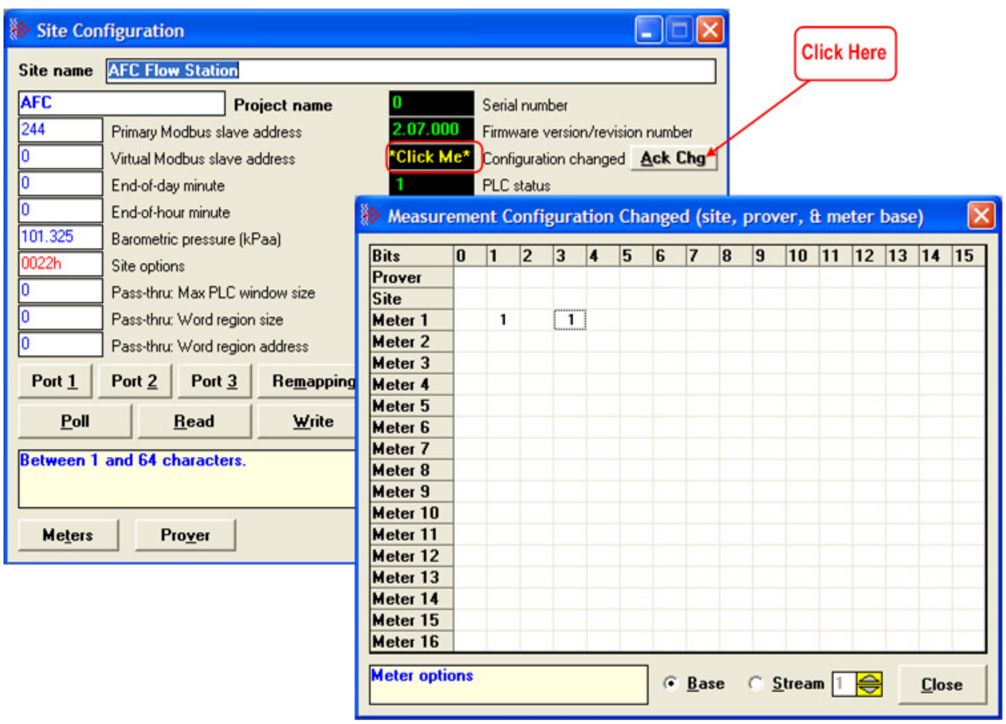
Measurement Configuration Changed dialog box

This dialog box opens when you click the Measurement Configuration Changed field on the Site Configuration dialog box.

The Measurement Configuration Changed dialog box contains detailed information about changes to the meter configuration. These changes are related to the "sealable parameters" that actually affect the module calculation. When a sealable parameter is changed, a new event is generated.



After you have verified the Measurement Configuration Changes, click the Ack Chg button on the Site Configuration dialog box to clear the bits in order to keep track of future changes.



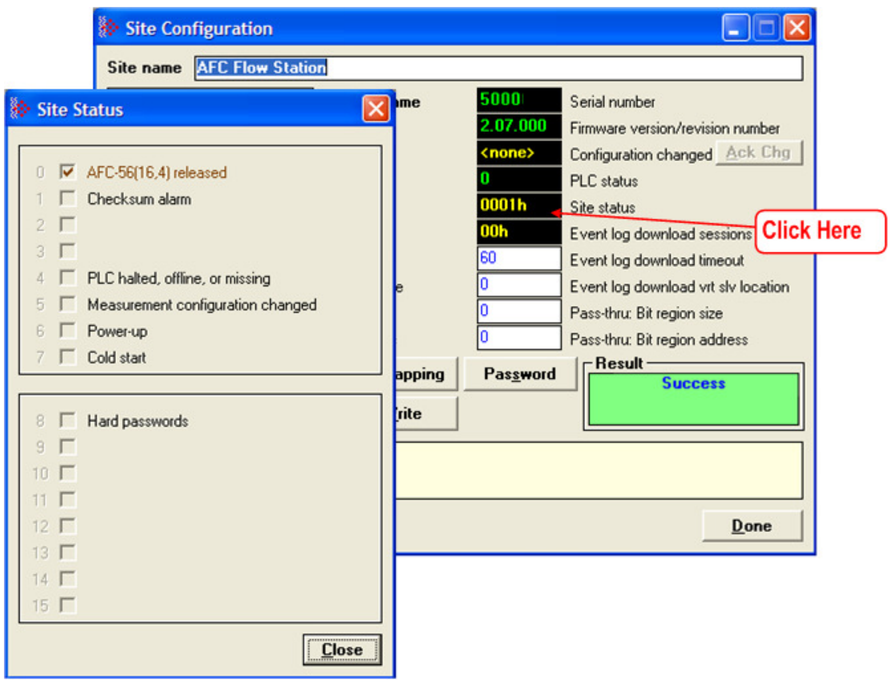
2.2.4 PLC Status

This section of the Site Configuration dialog box shows the current processor status. The possible values are:

- 0 = processor on-line
- 1 = processor off-line

2.2.5 Site Status

The Site Status dialog box opens when you click the Site Status field on the Site Configuration dialog box.



The Site Status dialog box provides information about the module's current status.

<u>*AFC Released*</u>

Latched when both **Cold Start** bit and **PLC Offline** bit first become clear simultaneously, remaining so until any subsequent cold start. While this bit remains clear, events are not logged, allowing an initial configuration to be fully completed without filling up the event log.

Checksum Alarm

A checksum alarm indicates a checksum verification failure during power-up. Non-volatile information is kept in battery-backed RAM. It is partitioned into several blocks, each of which contains a checksum, and when the information is changed the checksum is updated also. During power-up, the checksum is verified, and upon failure the alarm bit is latched and the checksum corrected. Refer to Checksum Alarms (page 217) to verify the source of the alarm, and then clear it.

The alarm bit remains latched, even through subsequent power cycles, until it is explicitly cleared from outside.

PLC Halted, Offline or Missing

Set while backplane communication is faulty, which typically occurs when the PLC is switched to program mode. While set, measurement does not occur. Upon resumption of backplane communication, the module compensates for the downtime by computing an accumulator increment in a manner that depends on the meter type.

For differential (orifice) meters, and meters configured for flow rate or pulse frequency integration, the first measurement scan acquires a scan period equal to the period of downtime as computed from the system timer, hence periods of PLC downtime shorter than the rollover period of the system timer causes no loss of product. For linear (pulse count) meters, the first measurement scan acquires a pulse increment equal to the difference between the PLC-supplied pulse count of the current scan, and that of the last scan before communication loss, hence periods of PLC downtime shorter than the rollover period of the counter module cause no loss of product.

Measurement Configuration Changed

Set when any bit in the measurement configuration changed registers is set.

Power-up

Set upon power-up, and cleared when the wallclock has been set.

Cold start

Upon power-up, the module's non-volatile memory is checked for validity, confirming that certain known values are present in their proper locations. If the contents of the memory are invalid, the memory is initialized with a default configuration and the bit is set. The bit remains set, even through subsequent power cycles, until at least one meter is enabled at which time the bit is cleared.

If the module contains the BBRAM daughter card (supported on firmware versions 2.00.000 or newer), the cold start status is easily identified when both LEDs (OK and ERR) are illuminated.

Hard Passwords

Enables secure password-controlled access to the AFC. Passwords are stored in the AFC by writing them to the password registers 9 and 19, but in hard-password mode reading those registers always returns zero. Read and/or write access to the AFC is granted by writing a candidate password to the password-test register (register 18) and the access granted is determined by reading back that register and examining its contents. The access is granted to the port over which the request was made; other ports remain unaffected. If the port remains idle with no Modbus activity for two minutes, then the granted access is removed and can be regained only by writing a new password to the test register.

2.3 Site Configuration Parameters

The following topics describe the Site Configuration parameters you will enter.

2.3.1 Site Name

Identifies the site (1 to 64 characters). Default is "AFC Flow Station".

2.3.2 Project Name

The Project Name allows an external application such as AFC Manager to synchronize its database with the database resident in the module. Default is "AFC".

2.3.3 Primary & Virtual Modbus Slave Configuration

The configuration, process, and historical data for the site and all meters are stored in the Primary Modbus Slave (approximately 130,000 registers). In order to optimize the polling of data, the AFC module has a second Modbus slave; the Virtual Modbus Slave. These two Modbus slaves have distinct Modbus addresses that are configured in the Site Configuration dialog box.

Primary Modbus Slave Address

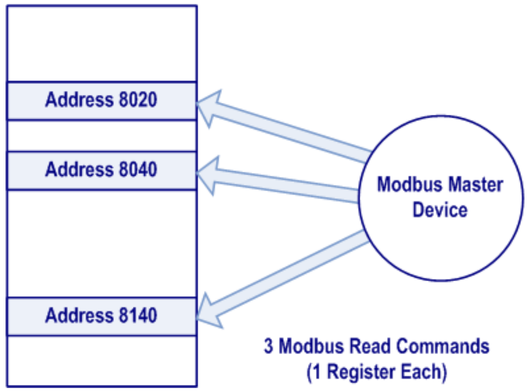
The primary Modbus slave address identifies the Primary Slave when another Modbus device is polling it. You can use the AFC Manager Modbus Interface to read and write Modbus registers from the Primary Modbus Slave. Except for the Modbus Master interface, every time the AFC Manager communicates with the module, it uses the Primary Modbus Slave. Valid address values are 1 to 247. The default address is 244.

Virtual Modbus Slave Address

The Virtual Modbus slave address identifies the Virtual Slave when another Modbus device is polling it. You can also use the AFC Manager Modbus Master Interface to read/write Modbus registers using the Virtual Modbus Slave. Any value greater than zero will activate the Virtual Modbus Slave and the module will use the remapping table to assign data to the correct memory locations. Valid address values are 0 (zero) to 247. A value of zero disables the Virtual Modbus Slave.

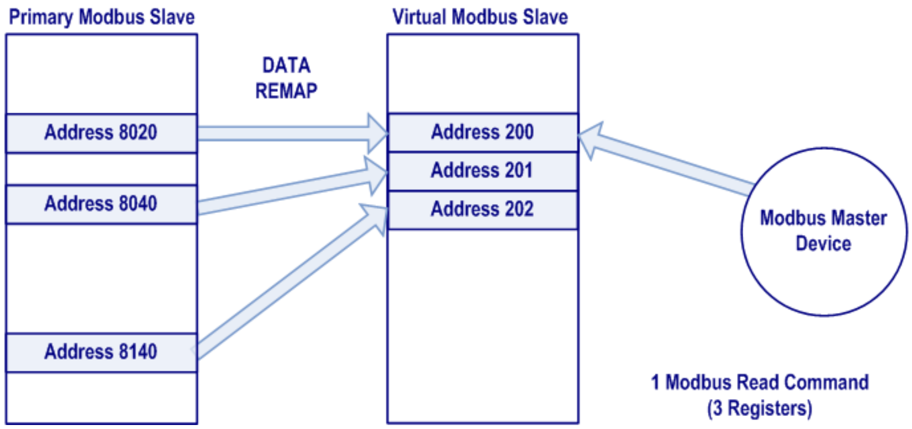
The following illustration shows the benefits of using the Virtual Modbus Slave when polling data from the module:

Data Polling Without Virtual Modbus Slave



For this application, the master reads three MODBUS registers: 8020, 8040 and 8140. As these registers are not contiguous, the master uses three Modbus commands to poll all the registers.

Data Polling With Virtual Modbus Slave

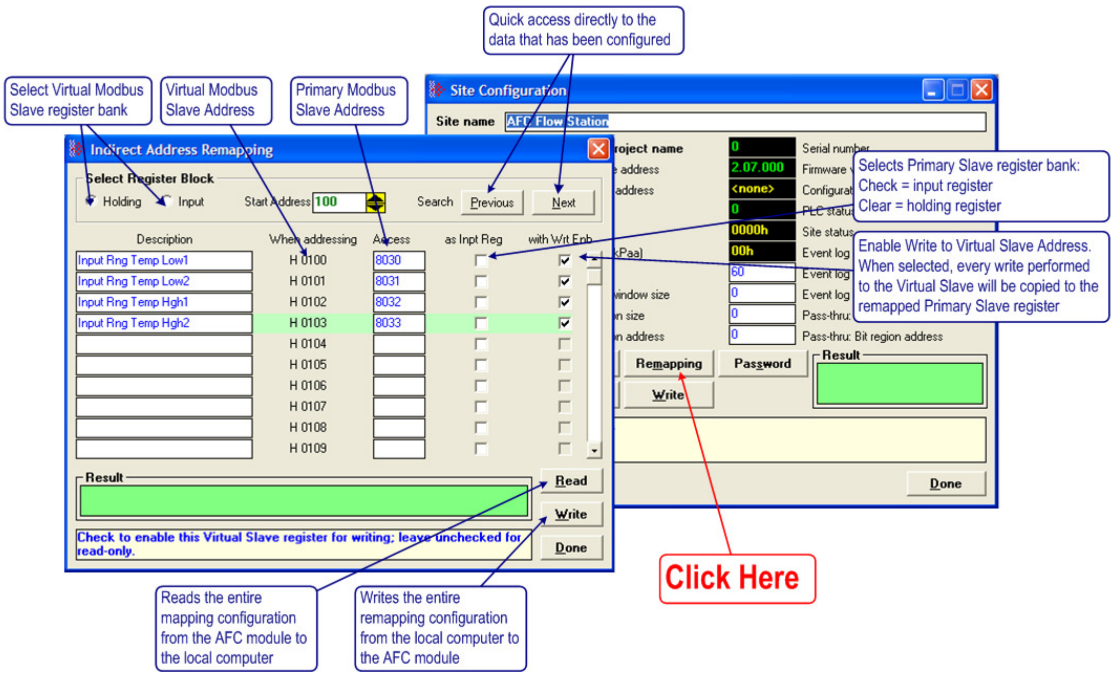


When the registers are remapped into a contiguous group in the Virtual Slave, the master can use a single Modbus command to poll the registers. This results in better system performance, because the number of commands is reduced.

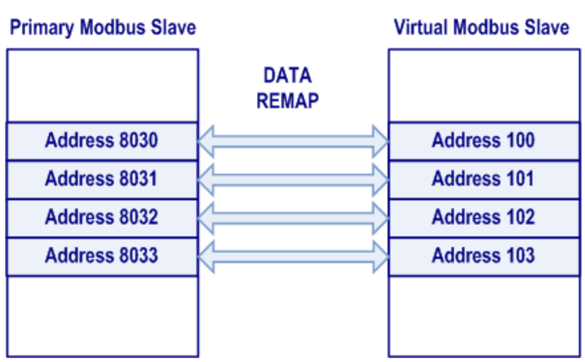
Note: You must configure a virtual Modbus address value greater than zero to enable the virtual slave.

Indirect Address Remapping dialog box

To configure the data remapping between the two slaves, click the Remapping button. This action opens the Indirect Address Remapping dialog box.



The values in the illustration above would configure the following indirect addressing remapping:



Because all registers in the example had the write enable bit set, all data copied to the Virtual Slave would also be written to the remapped Primary Slave. If a Modbus device writes a value to address 100 in the Virtual Slave, that value would also be written to address 8030 in the Primary Slave. If it reads the current value on the Virtual Slave address 102, it would be the same value in Primary Slave address 8032.

Important: Virtual Slave addresses must be equal to or greater than 100.

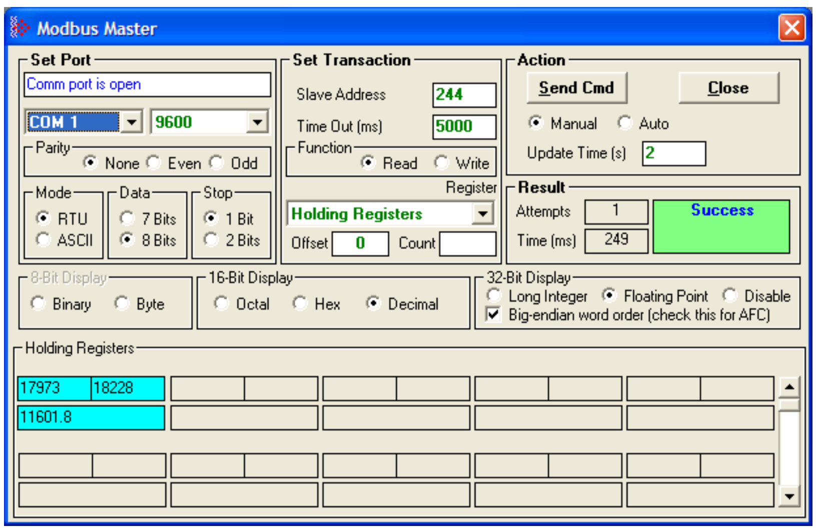
When the configuration procedure is complete, click the Write button to transfer the entire remapping configuration to the module. This process may take a few minutes. While the transfer is taking place, the Result field (green rectangle) shows the message "Writing indirect address definition block xx of yy", where xx = 1 to 249 and yy may be as large as 249. When the transfer is complete, the result field displays "Success".

To read the current remapping configuration from the module to the local computer, click the Read button. This process may take a few minutes.

Important: The Download Configuration does not transfer the remapping configuration. Use the steps described in this topic to transfer the remapping configuration to the module.
Tip: Use the Modbus Dictionary dialog box (page 209) to view Modbus addresses in the module.

Accessing the Data

The AFC Manager provides an easy way to read and write data from both slaves through the Modbus Master Interface.



Modbus Communication

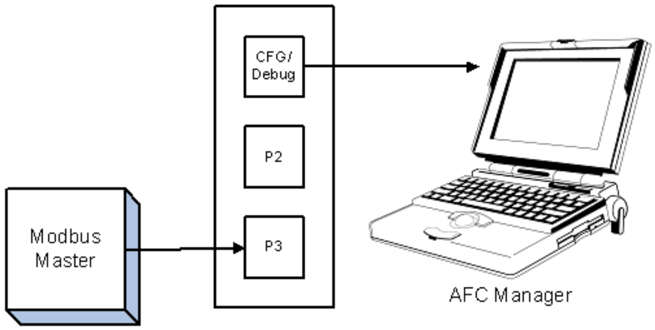
A remote Modbus Master device can be connected to any one of the communication ports for data polling. The module accepts the following Modbus command functions according to the Modbus protocol specification:

Modbus Function Code	Description
3	Read Holding Registers
4	Read Input Registers
6	Preset (Write) Single Register
16	Preset (Write) Multiple Registers

Ports 2 and 3 support RS-232, RS-422, or RS-485 communications. The Configuration/Debug port (Port 1) supports RS-232 only.

Refer to Cable Connections for wiring instructions.

The Modbus Master command can be sent to either the Primary or Virtual Modbus Slaves in the module. Each slave has individual Modbus addresses that you can configure (**Project** / **Site Configuration**). The Primary Slave address is configured as 244 by default.



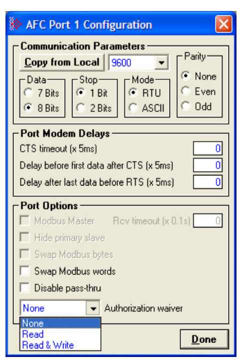
Communication Parameters

The module supports the following communication parameters for each communication port:

Parameter	**Values**
Baud Rate	300, 600, 1200, 2400, 4800, 9600 or 19200
Data Bits	7 or 8
Stop Bits	1 or 2 Bits
Mode	RTU or ASCII
Parity	None, Even or Odd

Note: Do not configure a port for both RTU mode and 7 data bits as this combination is not supported by the Modbus protocol.

You must configure the communication parameters for each communication port using the AFC Manager software (Site Configuration):



Port Options

The following options can be configured:

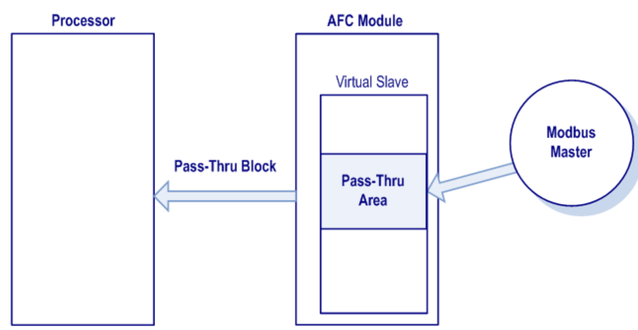
Port Options	Description
Hide Primary Slave	Protects the Primary Slave from any read or write operation from a remote master. Only the virtual slave is visible on this port.
Swap Modbus Bytes	Swap the Modbus bytes transferred through this port (Not implemented)
Swap Modbus Words	Swap the Modbus words transferred through this port. This parameter is only applicable to those data points that hold 32-bit quantities (long integers, floats, totalizers),
Disable Pass-Thru	Disables the pass-thru feature on this port
Modbus Master	Enables the Modbus Master for the port (Port 3 only)
Authorization waiver	Each port can be individually configured to waive the authorization requirement. This feature allows each port to have a different access level.

Not all options are available on every port:

- Port 1 is restricted, so that AFC Manager can always communicate with the Primary Slave using this port.
- Modbus Master option is available only on Port 3.

<u>Modbus Pass-Through</u>

The Modbus pass-through feature allows you to configure a Modbus pass-through region in the Virtual Slave (**Project** / **Site Configuration**). After the module receives a holding register write command (Modbus functions 6 or 16) or a bit write command (Modbus functions 5 or 15) to this region, it will generate a pass-through block to be sent to the processor containing the Modbus command data. You may define a word pass-through region (for Modbus functions 6 and 16) and a bit pass-through region (for Modbus functions 5 and 15).



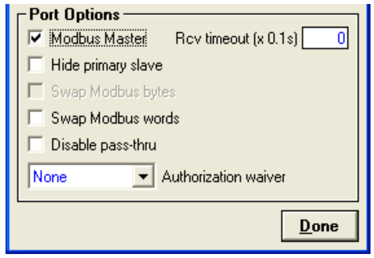
Important: You must enable the virtual slave by configuring a Modbus address greater than 0 (**Project / Site Configuration**).

You can control which communication ports will support the pass-through (**Project** / **Site Configuration** / **Port X button**).

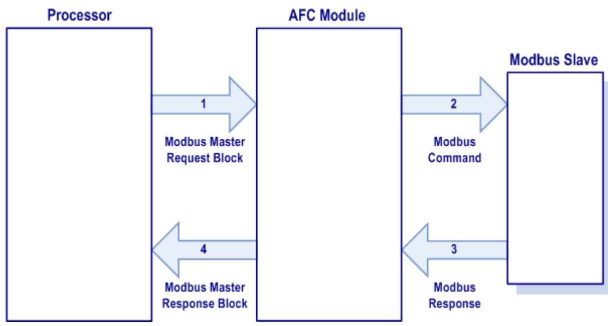
This feature requires ladder logic to read the pass-through block from the module to the processor. Refer to the Ladder Logic section for more information about the pass-through feature.

Modbus Master

Port 3 can be configured for Modbus Master operation (**Project** / **Site Configuration** / **Port 3**).



The Modbus Master command is generated from the processor using ladder logic (Modbus master block). After the Modbus Master transaction is completed the module is ready to receive another Modbus Master request from the ladder logic:



The following Modbus functions are supported for Modbus Master operation:

Modbus Function Code	Description
1	Read Coil Status
2	Read Input Status
3	Read Holding Registers
4	Read Input Registers
15	Force (Write) Multiple Coils
16	Preset (Write) Multiple Registers

The module offers considerable flexibility for Modbus Master operation, allowing the ladder logic to select one of the following data types:

- Bit (packed 16 to a word)
- Word (16-bit register)
- Long (32-bit items as register pairs)
- Long Remote (32-bit items as single registers)

Note: Long data type implements each data unit as one pair of 16-bit registers (words). Each register contains two bytes. Long remote data type implements each data unit as one 32-bit register. Each register contains four bytes. The proper choice depends on the remote slave's Modbus implementation.

Example

The following table shows how the data types are implemented if a **write** function is selected and the item count is configured with a value of 10 (decimal):

Data Type	Register Type	Modbus Function	Number of Coils	Number of Bytes	Number of Registers	Number of words (16-bits) transferred
Bit	Coil	15	10	2	-	1
Word	Holding	16	-	20	10	10
Long	Holding	16	-	40	20	20
Long Remote	Holding	16	-	40	10	20

Note: The number of coils, bytes, and registers are part of the Modbus request (functions 15 and 16) according to the Modbus specification.

The following table shows how the data types are implemented if a **read** function is selected and the item count is configured with a value of 10 (decimal):

Data Type	Register Type	Modbus Function	Number of Registers
Bit	Coil	1	10
Bit	Input	2	10
Word	Holding	3	10
Word	Input	4	10
Long	Holding	3	20
Long	Input	4	20
Long Remote	Holding	3	10
Long Remote	Input	4	10

Note: The number of registers is part of the Modbus request according to the Modbus specification.

Refer to the ladder logic section for your module for more information about the Modbus Master block.

2.3.4 End-of-Day Minute

This parameter sets the minute of the day when the daily archives are created. The default value of 0 (zero) creates the daily archive at midnight. Valid values are between 0 and 1439.

2.3.5 End-of-Hour Minute

This parameter sets the minute of the hour when the hourly archives are created. The default value of 0 (zero) creates hourly archives at the top of each hour. Valid values are between 0 and 59.

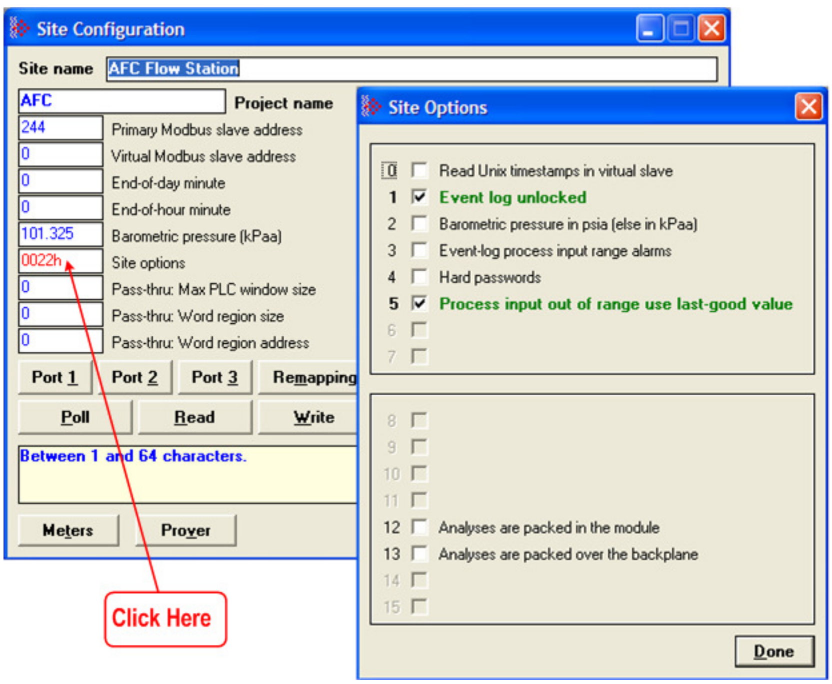
2.3.6 Barometric Pressure

This parameter sets the barometric pressure used on the module calculations. The module expects each meter's pressure input to be in gauge units. Because some calculations require the pressure of the fluid to be in absolute units, the module adds barometric pressure to the gauge pressure in order to obtain the absolute pressure.

The calculation assumes that all meters measured by a single AFC are located at the same site and have the same barometric pressure.

2.3.7 Site Options

The Site Options dialog box opens when you click the Site Options field in the Site Configuration dialog box.



<u>*Read UNIX Timestamps in Virtual Slave*</u>

When this option is set, and timestamps are remapped from the Primary to the Virtual Slave, their values will be expressed in UNIX format (the number of seconds since 1970). Timestamps viewed in the primary slave are always bit-field encoded.

Event Log Unlocked

The event log buffer can store up to 1999 events. When all record positions (1 through 1999) contain events that have not yet been downloaded, the log is full. In this case, the handling of a new event depends on the value of the "Event log unlocked" site option:

- If the option is set, then the log-full condition is ignored and the new event overwrites the oldest one. As the overwritten event was never downloaded, it is permanently lost.
- If the option is clear, the event log is locked, and the new event is rejected if possible or otherwise ignored. In this case, controllable events (changes to sealable parameters), are not allowed to occur. Such parameters remain unchanged retaining their current values, and a Modbus command that attempts such a change receives an "illegal data" exception response. Uncontrollable events, such as power-up, are not recorded. The log must be downloaded in order to unlock it for further events.

Barometric Pressure in psia (else in kPaa)

If set, the barometric pressure will be expressed in psia units, otherwise it will use kPaa.

Event-Log Process Input Range Alarms

This option determines how the event log should process input range alarms. If set, the process input out of range alarms are logged as events. Depending on the configuration and the stability of the site (meter transmitters), enabling this option may cause rapid fill up of event log and meter archives. If cleared, process input out of range alarms are not event-logged (However, archives still record cumutively all alarms that occur during the archive period).

Hard Passwords

Enables secure password-controlled access to the AFC. Passwords are stored in the AFC by writing them to the password registers 9 and 19, but in hard-password mode reading those registers always returns zero. Read and/or write access to the AFC is granted by writing a candidate password to the password-test register (register 18) and the access granted is determined by reading back that register and examining its contents. The access is granted to the port over which the request was made; other ports remain unaffected. If the port remains idle with no Modbus activity for two minutes, then the granted access is removed and can be regained only by writing a new password to the test register.

Process input out of range use last-good value

If set, then an out-of-range process input value is substituted by the latest detected in-range value. If clear, then the "default" value configured for the process input is substituted.

Analyses are packed in the module

If set, then molar concentrations of individual components are "packed" towards the front of the analysis for each stream of each meter by omitting the zeroes corresponding to components that are not selected in the component map for the meter. If clear, then molar concentrations of individual components appear always in the same locations regardless of whether the corresponding components are selected.

Changing this setting causes all stored analyses to be restructured consistently so that no analysis information is lost, and may require corresponding changes to polling systems such as SCADA. Default setting is "packed" to be consistent with earlier versions of the AFC, but this default will change in a future version.

Analyses are packed over the backplane

If set, then molar concentrations of individual components are "packed" towards the front of an analysis received over the backplane by omitting the zeroes corresponding to components that are not selected in the component map for the meter. If clear, then molar concentrations of individual components appear always in the same locations regardless of whether the corresponding components are selected.

Changing this setting may require corresponding changes to PLC programs that deliver the analyses. Default setting is "packed" to be consistent with earlier versions of the AFC, but this default will change in a future version.

This option is present only for MVI56-AFC and MVI69-AFC. For other platforms, where the option is not present, analyses transferred over the backplane are always "unpacked".

2.3.8 Pass-thru Configuration

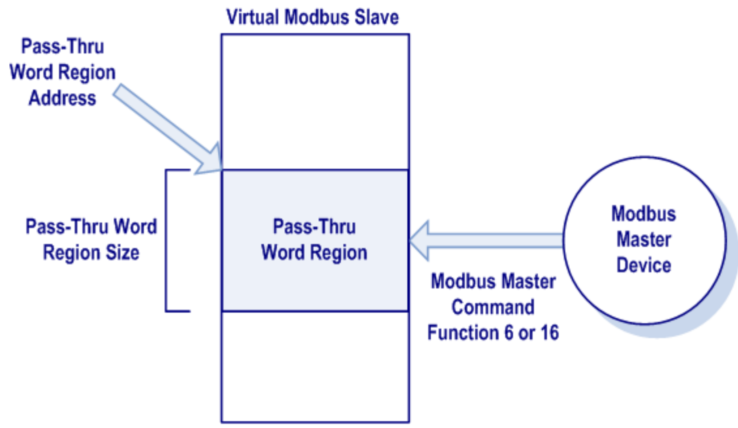
The module supports the Modbus Pass-Thru feature for write commands. When the pass-thru region in the virtual slave is properly configured, all Modbus write commands pointing inside that area will be handled by ladder logic using the Modbus Pass-Thru function block. Refer to the module's user manual for specific information on the pass-through backplane functionality.

Pass-Thru: Max PLC Window Size

Defines the maximum pass-thru window size (expressed as 16-bit words) in the Virtual Modbus Slave. The maximum allowed value for this point depends on the platform. Refer to the user manual for your module for specific configuration information.

Pass-Thru: Word Region Address & Pass-Thru: Word Region Size

These two parameters define the Pass-Thru Word Region located in the Virtual Modbus Slave. The region starts at the address configured by the word region address parameter and its range is defined by the Pass-Thru Word Region Size parameter:

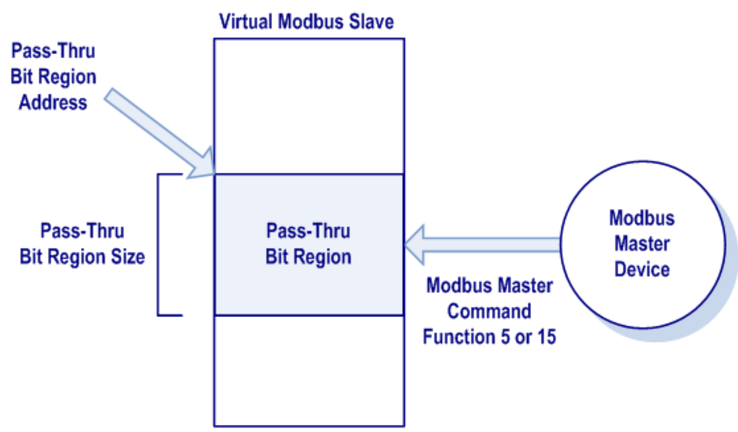


The first 100 words in the Virtual Slave are reserved. Therefore, the pass-thru region address value must begin no lower than word 100.

By configuring a Pass-Thru Word Region Address of 20,000 or greater, you may avoid any reduction of the remappable address space of the Virtual Slave.

Pass-Thru: Bit Region Address & Pass-Thru: Bit Region Size

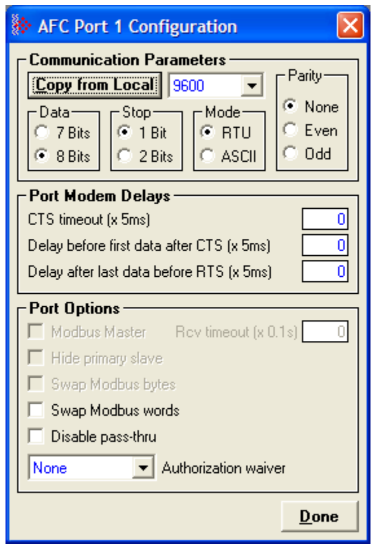
These two parameters define the Pass-Thru Bit Region located in the Virtual Modbus Slave. The region starts at the address configured by the Bit Region Address parameter and its range is defined by the Pass-Thru Bit Region Size parameter:



2.4 Site Configuration Buttons

2.4.1 Port 1, Port 2 and Port 3 Configuration

The Port Configuration dialog box opens when you click one of the port configuration buttons (Port 1, Port 2, and Port 3) on the Site Configuration dialog box. Use this dialog box to configure the communication parameters and Modbus access for each module port:



The Communication Parameters configure each port's communication settings. The default communication port configuration is 9600 baud rate, 8 data bits, 1 stop bit, RTU mode and no parity. Use these settings the first time you use AFC Manager on the port connected to the local PC.

The Port Modbus Options field configures the Modbus communication to a Modbus device.

<u>Port Configuration Notes</u>

The module has three Modbus ports, however Port 1 is intended mainly for configuration, and is only suitable for Modbus communication in the following circumstances.

- The top port (Configuration/Debug Port) is unbuffered, therefore it should not be used for other Modbus operations, such as SCADA.
- The Configuration/Debug Port is RS232 only, while Ports 2 and 3 support RS232, RS422 and RS485. Unless a device can only communicate using an RS232 port, use one of the other ports.
- Although you can set a maximum baud rate on the Configuration/Debug Port of 19200, this setting is not recommended for general use. Performance will be most satisfactory if you set the Configuration/Debug Port to 9600 baud or lower.

Modbus Master (Port 3 Only)

When checked, allows Port 3 to act as a Modbus Master device, sending Modbus master commands from ladder logic.

Hide Primary Slave

When checked, protects the Primary Modbus Slave from any read or write command from a Modbus master device. In this case, you could also remap the register from the Primary Slave to the Virtual Slave protecting each register from write commands (refer to the Primary & Virtual Modbus Slaves Configuration section).

Swap Modbus Bytes

If checked, the bytes transferred by a Modbus master device will be swapped.

Swap Modbus Words

If checked, the words transferred by a Modbus master device will be swapped. This setting only applies to double-register data items (floating point and long integer).

Disable Pass-Thru

Disables the pass-thru feature for this port.

Port Authorization Parameters

Each port can be individually configured to waive the authorization requirement. This feature allows each port to have a different access level as shown in the following table.

Port Waiver Configuration	Read Operation: Requires Authorization?	Write Operation: Requires Authorization?
None	Yes	Yes
Read Only	No	Yes
Read-Write	No	No

Note 1: The waiver is effective for both hard and soft passwords.
Note 2: The backplane (Modbus Gateway) always has a "read-write" waiver so that the processor has full unrestricted access regardless of any passwords or hard/soft configuration.

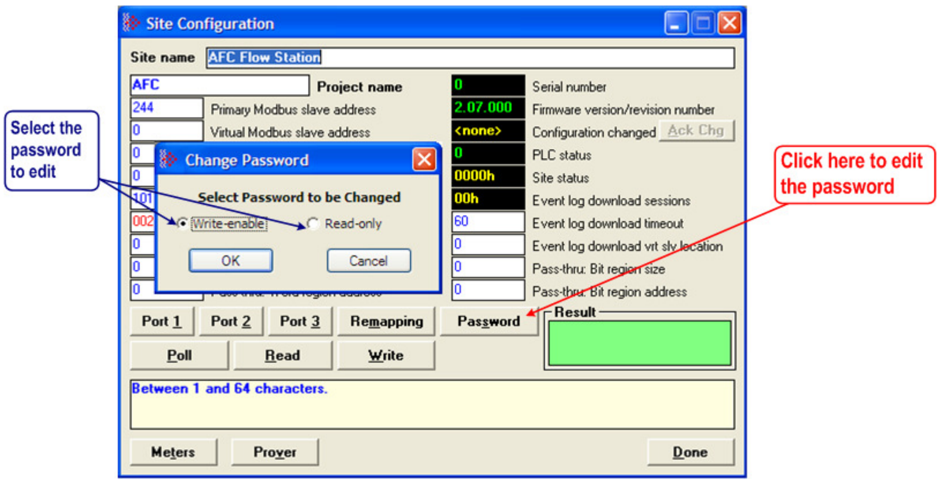
2.4.2 Remapping Button

Refer to the Primary & Virtual Modbus Slaves Configuration section.

2.4.3 Security (Passwords)

The passwords are intended for interrogation by application software in order to verify an operator's authorization to make configuration changes and to view measurement results. The passwords are resident in the module so that different operators using different copies of the application software must use the same password. Passwords cannot be retrieved in "Hard Password" mode. The password protection is not used by default.

Passwords can be numbers between -32768 and 32767. For example, 1234. A password of 0 (zero) is interpreted as "No password present".



The module supports two passwords: Write-Enable and Read-Only. Each password is enabled when you write a non-zero value to the corresponding register.

Password	Holding Register Address	Description
Write-Enable	9	Protects the module from write operations from the AFC Manager
Read-Only	19	Protects the module from read or write operations from the AFC Manager

The following table shows how the passwords affect the AFC Manager operation depending on the values that you configure:

Protection Level	Read-Only Password	Write-Enable Password	Read Operation: Requires Authorization?	Write Operation: Requires Authorization?
No protection	Zero	Zero	No	No
Write Protection	Zero	Non-zero	No	Yes (Use Write-Enable password)
Read and Write Protection	Non-zero	Zero	Yes (Use Read-Only password)	Yes (Use Read Only password)
Read and Write Protection	Non-zero	Non-zero	Yes (Use Read-Only or Write-Enable password)	Yes (Use Write-Enable password)

Each port can be assigned to different password protection levels. Refer to the Port Configuration Section for more information about this topic.

Hard Password

The hard password feature offers further protection against unauthorized access to the module.

If the Hard Password option is cleared, these registers can be read either from an external Modbus device, from the processor or using the Modbus Master interface in the AFC Manager. This operation mode is called "Soft Password" mode. It is then the responsibility of a compatible application (such as AFC Manager) to verify the password given by the operator against those fetched from the module in order to determine the access granted.

If the Hard Password option is selected, a read of a password register will return zero regardless of the password's actual value. In this case, read or write access is obtained by writing a candidate password to the Password Test register (register 18), the module itself verifies the password, and the access granted is determined by reading back that same register 18 (called the Accessed Port and Authorization register when read) and examining its contents. The access is granted to the port over which the request was made; other ports remain unaffected. If the port remains idle with no Modbus activity for two minutes, then the granted access is removed and can be regained only by writing a new password to the test register. For highest security, you can explicitly revoke your own password-obtained authorization before it times out by writing zero to the Password Test register.

Access granted by password, whether Soft or Hard, is to the module as a whole, including the password registers themselves. That is, in order to change a stored Hard password you must first obtain write access to the module by giving the correct Write-Enable password. However, some registers are exempt from authorization. There are a very few registers that are exempt from write authorization and are always writable; the Password Test register 18 is one such for the obvious reason. Similarly, some registers are exempt from read authorization and are always readable; they include most of the first 20 holding registers, including the Firmware Product and Group codes in registers 0 and 1 (so an application like AFC Manager can learn whether it is talking to an AFC without being trapped in a catch-22), the Site Status in register 6 (so the application can learn whether the password mode is Soft or Hard and verify the operator's password entry using the proper method), and the Accessed Port and Authorization register 18 (so the application can learn whether access was granted in Hard-password mode even if the wrong read password was entered).

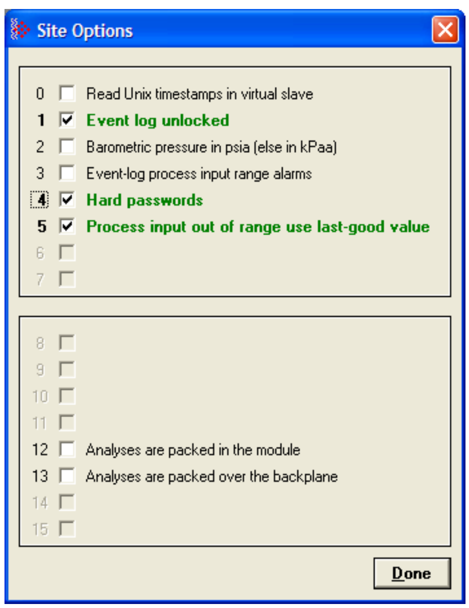
The Accessed Port and Authorization register is a bit-mapped word defined as follows:

Bits	Description
0 to 3	The number of the accessing port (0 for Modbus Gateway)
4	Read Authorization Waived
5	Write Authorization Waived
6	Read Access Granted
7	Write Access Granted
8 to 15	Reserved

A waived authorization means that password entry is not required for this action even if a non-zero password has been configured. Authorization waivers are configured separately for each port, so, for example, a SCADA system connected to port 2 can be allowed to read measurement results without having to supply a password while an operator connecting AFC Manager to port 1 still must enter the correct password. The backplane is always given both waivers, so the PLC never has to supply a password.

<u>To set a hard password in AFC Manager:</u>

1 Open the Site Configuration Dialog box
2 Click in the Site Options field. This action opens the Site Options dialog box
3 Select (check) option 4, Hard Passwords



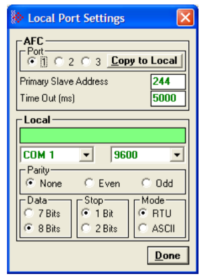
When this option is selected, any authorization granted using Hard Passwords times out after two minutes of inactivity, and the user will be required to re-enter the password to continue.

2.4.4 Poll Button

The function of the poll button is to update the display of site status (the black-background boxes in the upper right quadrant of Site Configuration).

Local Port Settings Dialog Box

This dialog box opens when you click the Read, Write or Poll buttons on the Site Configuration dialog box.



Adjust the communication settings if necessary, and then click Done to confirm your port settings and perform the requested task.

2.4.5 Read Button

The read button reads the current site configuration from the module to the local PC. Look at the result area (green rectangle) on the Site Configuration dialog box for the status of the read operation. When a "Success" indication shows in the result area, it indicates that the site configuration has been successfully read to the local PC.

2.4.6 Write Button

After you have completed the site configuration in the local PC AFC Manager software, click the Write button to transfer the configuration to the module. When the Result area shows "Success", the site configuration has been successfully written to the module.

Click the Read button to read the current module site configuration. The configuration should match the last write operation data.

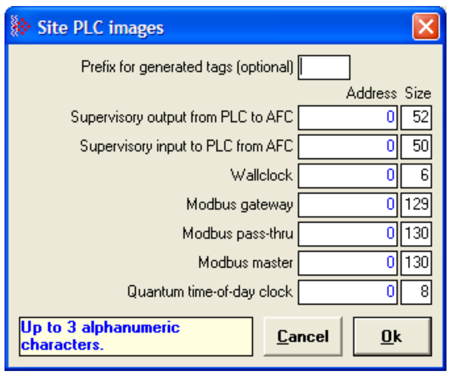
If the result area shows "Time out", verify the serial port communication parameters and the communication cable (null modem).

2.4.7 PLC Image Button

This button is only visible when the module type is PTQ-AFC. Refer to the PTQ-AFC User Manual for detailed information about the Site PLC Images.

The PLC Image button opens the Site PLC Images dialog box, which shows the locations in the PLC of image files.

- Prefix for generated tags - This optional Prefix of up to 3 characters will be prepended to all tag names generated by the Make PLC Tags menu function, in order to avoid collision with tag names that are already defined in the PLC program.
- Address 0 = not defined (file will not be scanned)
- Else address must be between 400001 and 465535.



2.4.8 Ack Chg Button

Refer to the Measurement Configuration Changed section.

2.4.9 Meters Button

This button opens the Meter Configuration dialog box (page 55).

2.4.10 Done Button

This button stores your settings temporarily and closes the Site Configuration dialog box. Note that you must also save your project before closing AFC Manager, otherwise your configuration will be discarded.

3 Meter Configuration

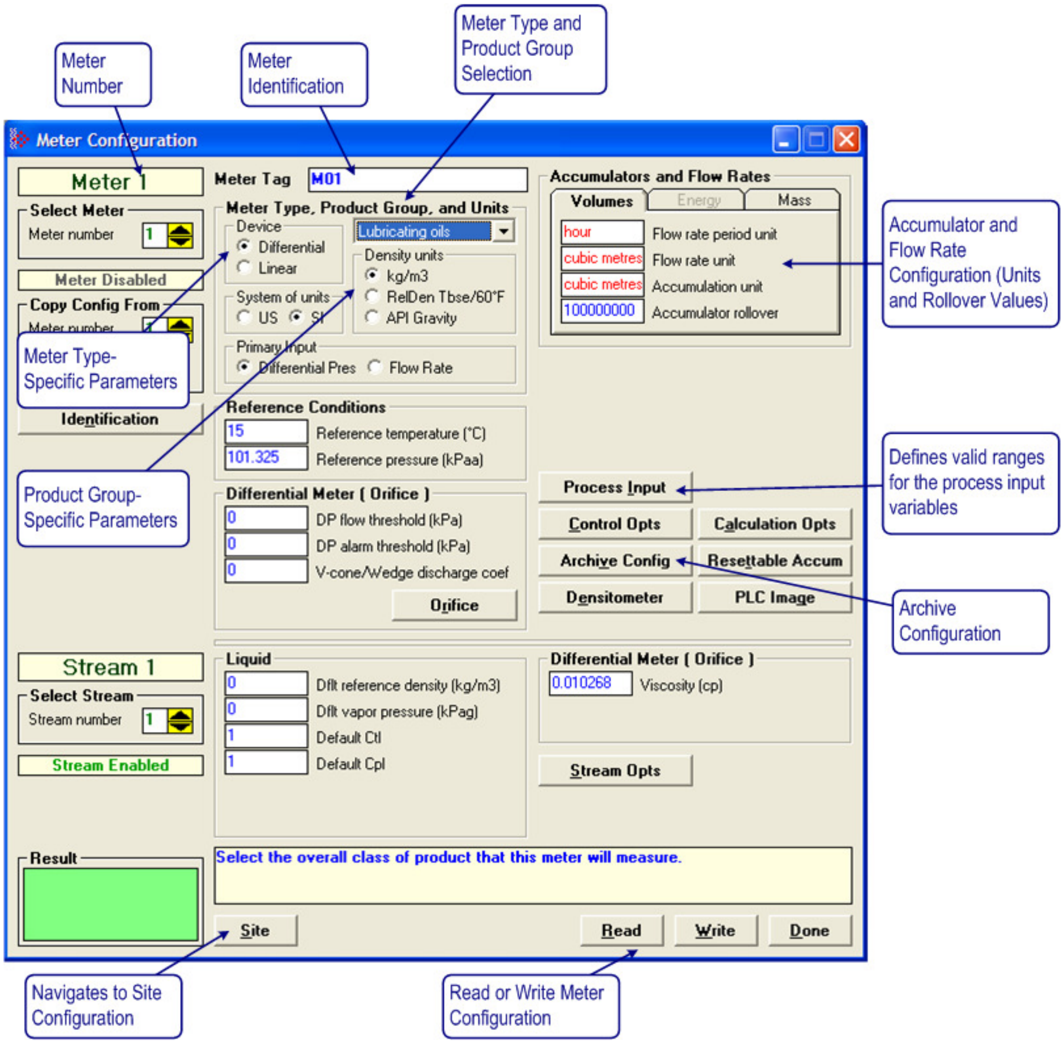
In This Chapter

After you have completed the Site Configuration tasks, the next step is to configure the Meters that will be associated with the module. The Meter Configuration dialog box is where you assign the settings for each meter.

To configure a meter

1 Start AFC Manager.
2 On the File menu, choose Load, and then open the project file.
3 On the Project menu, choose Meter Configuration. This action opens the Meter Configuration dialog box.
4 Choose the meter to be configured in the Select Meter panel.

5 To quickly set up a meter to be similar to another, you can use the Copy Config From panel.



Note: The items on this dialog box change according to the Meter Type and Product Group you select.

3.1 Meter Type and Product Group Configuration

Use the Meter Type and Product Group parameters to configure the type of meter and product to use for the calculation.

Specify the meter type (differential or linear) and the product group (gas, crude or refined liquids, or oil-water emulsion). Depending on the meter type and product group you select, additional settings may be visible.

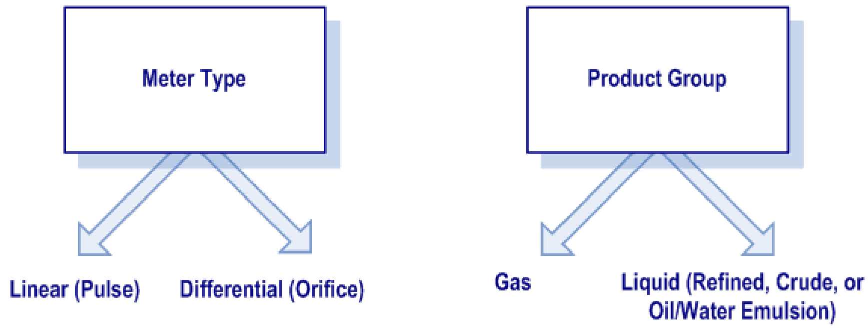
Each meter channel can be assigned as a linear meter (*pulse meter*) input or as a differential meter *(orifice meter*) input for flow measurement using either SI or US units.

Each meter channel can be configured for gas or liquid (*crude* or *refined*) product. The Product Group selects the API/AGA Standards to be used in calculating flow rates/increments.

Product Group	Standard
Gas	AGA8 and either AGA3 or AGA7
Liquid	API MPMS Chapter 11
Crude oils, JP4 ▪ Use for crude oils that are relatively water-free (less than 5%), and for jet fuel JP4.	"A" tables 23/24/53/54
NGLs, LPGs ▪ Use for propane, butane, NGLs (natural gas liquids), LPG (Liquefied Petroleum Gas, e.g. propane)	"E" tables 23/24/53/54
Refined Products (xJP4) ▪ Use for gasolines, jet fuels (except JP4), and fuel oils	"B" tables 23/24/53/54.
Lubricating Oils	"D" tables 23/24/53/54.
Special Applications ▪ For this product group the coefficient of thermal expansion is configured directly rather than being computed from density.	"C" tables 23/24/53/54.
Oil-Water Emulsions (Crd) ▪ Use for crude that might have a high concentration of water (more than 5%) for which the API Chapter 20.1 is applicable). Firmware version 2.03.000 or later is required to support this option.	"A" tables 23/24/53/54
Oil-Water Emulsions (NGL) ▪ Use for NGL/LPG that might have a high concentration of water (more than 5%) for which the API Chapter 20.1 is applicable). Firmware version 2.03.000 or later is required to support this option.	"E" tables 23/24/53/54

The following table provides a brief overview of the standards used according to the Meter Type and Product Group:

Meter Type	Product Group	Standards
Differential	Gas	AGA8, AGA3
Differential	Liquid	API MPMS ch 11, AGA3
Linear	Gas	AGA8, AGA7
Linear	Liquid	API MPMS ch 11, MPMS ch12.2



Note: The meter channel must disabled in order to change its meter type and product group.

3.1.1 MPMS Chapter 11 Tables

Tables x3 calculate density at reference conditions from density measured at flowing conditions. Tables x4 calculate the CTL (temperature correction) factor. Tables 2x perform their calculations using US units (°F, psi, relative density 60/60), and tables 5x perform the calculations using SI units (°C, kPa, kg/m3).

The meter configuration dialog box will automatically display the correct configuration parameters for the meter type you selected.

Refer to Meter Type Specific Parameters and Product Group Specific Parameters (page 87) for more information.

3.1.2 Device = Differential or Linear

For Pulse Meters, select the Linear option. For Orifice meters, select the Differential option.

- When Differential is selected, the module will use the AGA 3 standards to perform the flow calculation.
- When Linear Meter (for Pulse meters) is selected, the module will use the AGA 7 report (for gases) to perform the flow calculation.

The meter configuration dialog box will automatically display the correct configuration parameters for the meter type you selected.

3.1.3 Product Group = Gas, Refined Product, Crude/NGL/LPG or Oil-Water Emulsion

The Product Group selects the API/AGA Standards to be used in calculating flow rates/increments.

- For "Gas", the calculation uses AGA8 and either AGA3 or AGA7 Standards.
- For liquids, the calculation uses the API MPMS Chapter 11 Standards.
  - "Crude, JP4" uses the "A" tables.
  - "NGLs, LPGs" uses the "E" tables (GPA TP-27). Choose this for lighter products such as propane, butane and natural gas liquids.
  - "Refined Products (xJP4)" uses the "B" tables. Choose this for gasolines, fuel oils and jet fuels (except JP4).
  - "Lubricating Oils" uses the "D" tables.
  - "Special Applications" uses the "C" tables. This selection requires explicit configuration of the coefficient of thermal expansion, and should be chosen when the other tables, which calculate that coefficient from density, are deemed to be unacceptable according to experimental results or contract.
  - "Oil-Wtr Emulsions (Crd)" is the same as "Crude, JP4", except that it also uses MPMS Ch 20.1 section 1.9.5 to calculate net clean oil. Choose "Oil-Water Emulsion" for crude oil that is emulsified with large amounts of water.
  - "Oil-Wtr Emulsions (NGL)" is the same as "NGLs, LPGs", except that it also uses MPMS Ch 20.1 section 1.9.5 to calculate net clean oil. Choose "Oil-Water Emulsion" for lighter products that are emulsified with large amounts of water.

3.1.4 Units = US or SI

Selects the units used in the flow measurement calculations (US or SI).

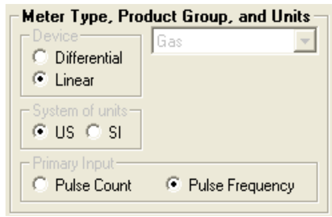
3.1.5 Primary Input

You can select the primary input for volume calculation. The available options depend on the configured meter type.

Meter Type	Options
Differential	Differential Pressure or Flow Rate
Linear	Pulse Count or Pulse Frequency

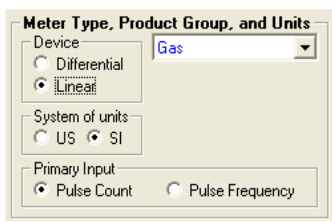
3.1.6 Changing the Meter Type, Product Group, or Unit

In order to perform a meter type and product group selection, the meter must be disabled temporarily, otherwise the fields would be locked for changes as shown below:



A meter can be enabled or disabled using ladder logic, however it is also possible to perform the same task using the AFC Manager. The following steps show this procedure:

1 **Read the Current Configuration from the Module.** Click the Read button at the Meter Configuration dialog box to update the dialog box information.
2 **Disable the Meter.** Click the **Control Opts** button, and clear the Meter Enable checkbox.
3 **Write the Configuration to the Module.** Click the Write button at the Meter Configuration dialog box. When the result area shows that the operation has completed successfully it means that the meter should be now disabled. At this time, the Meter Type and Product Group Selection parameters should be enabled:

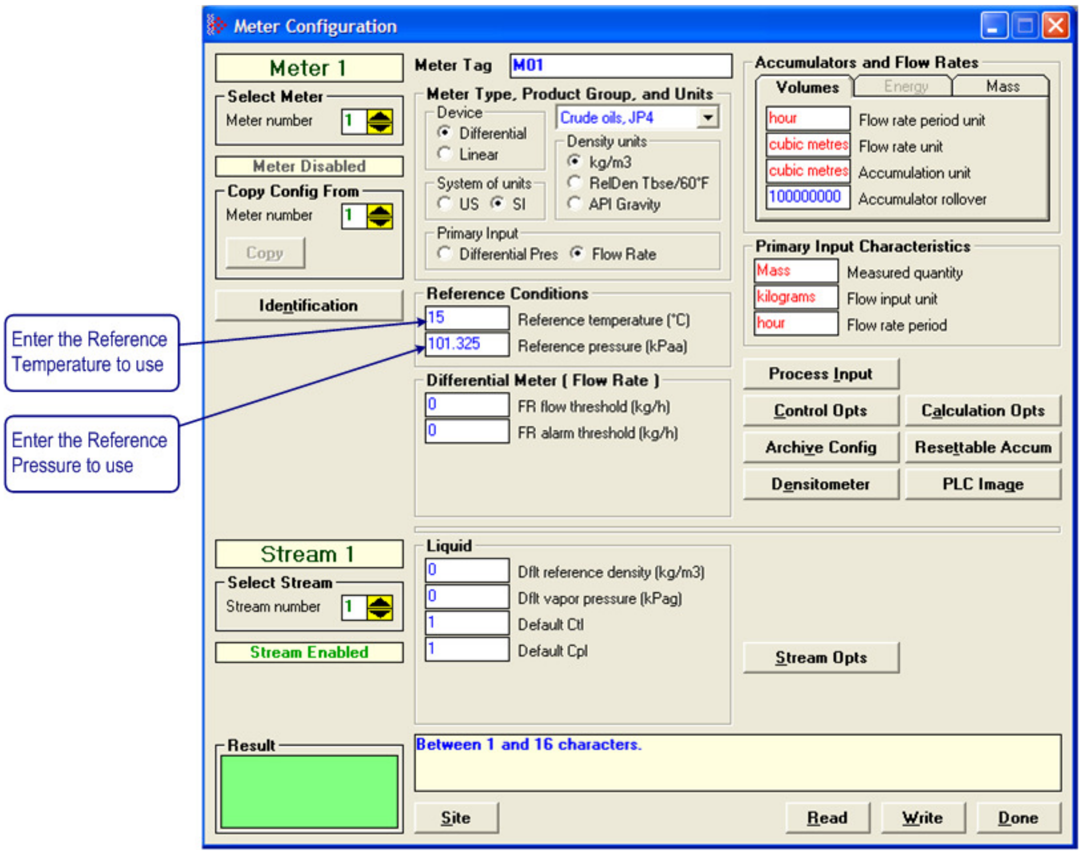


4 **Enter the New Configuration.** Select the meter type, product group, and units.
5 **Write the Configuration to the Module.** Click the Write button on the Meter Configuration dialog box.
6 **Enable the Meter.** Click the **Control Opts** button, and select the Meter Enable checkbox. Click the Write button on the Meter Configuration dialog box to write the configuration to the module.

Important: If the meter is enabled, it is not allowed to download a configuration from the local computer to the module when the meter type or product group does not match the current meter configuration at the module. An "Illegal Data Value" warning will be generated at every configuration download attempt.
The only parameters that require the meter to be disabled for changing are Meter Type, Product Group, Units, and Primary Input. All other parameters can be changed at any time.

3.2 Reference Conditions

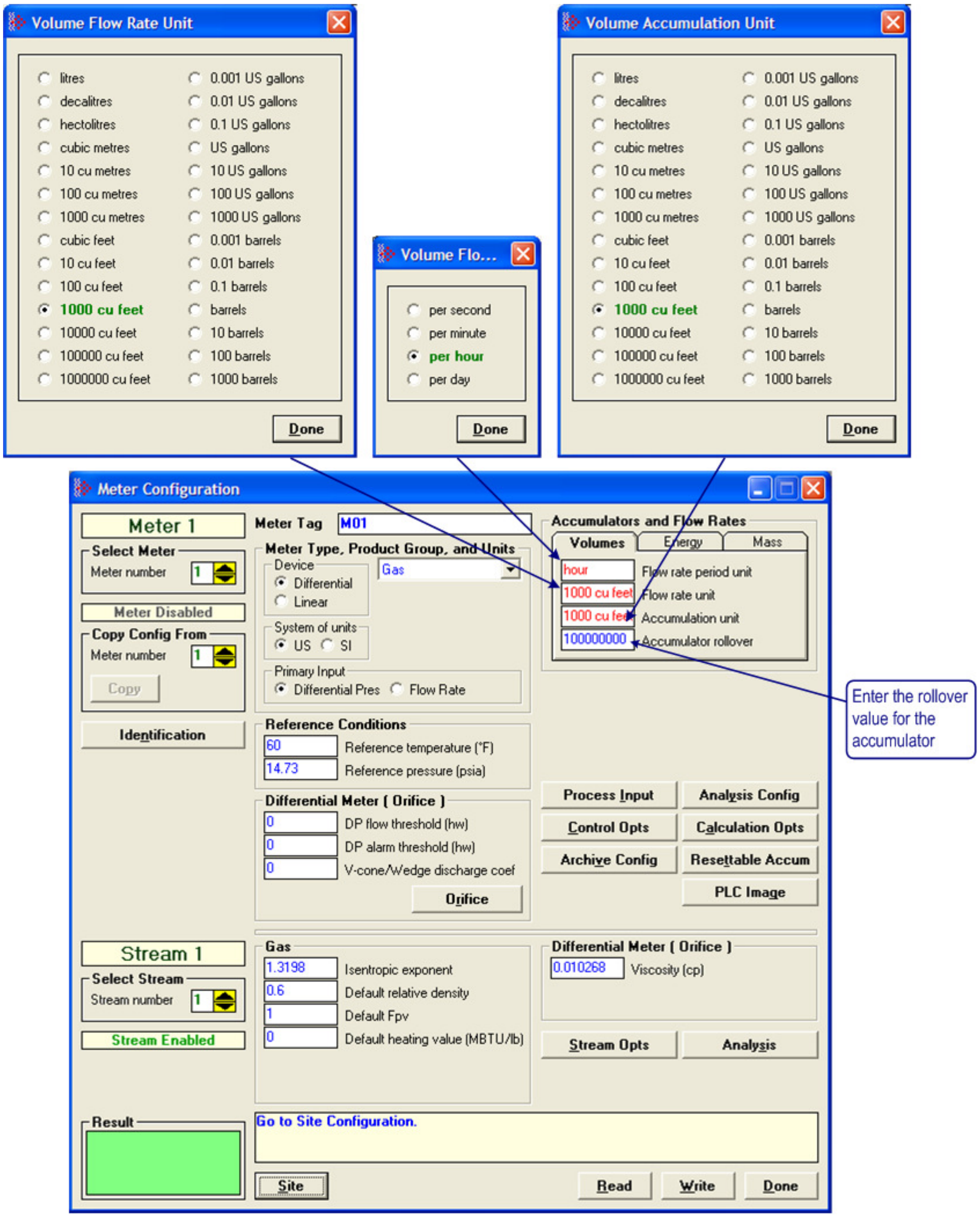
Measurements of gas and liquids are calculated based on their characteristics at a specific temperature and atmospheric pressure. Specify the reference conditions in this area. The default values are 15°C/101.325 kPaa (SI) and 60°F/14.696psia (US), which are the standard API base conditions. If configured reference conditions are different from API base, then for liquids the API calculations are done twice as necessary to correct from flowing conditions to API base and then de-correct from API base to your selected reference, while for gases the calculations are direct.



3.3 Accumulators and Flow Rates

Use these parameters to configure the flow rate units, accumulator units, and the accumulator rollover values for Volume, Energy, and Mass.

The AFC Manager automatically displays the possible unit values to be selected as shown in the following illustration.

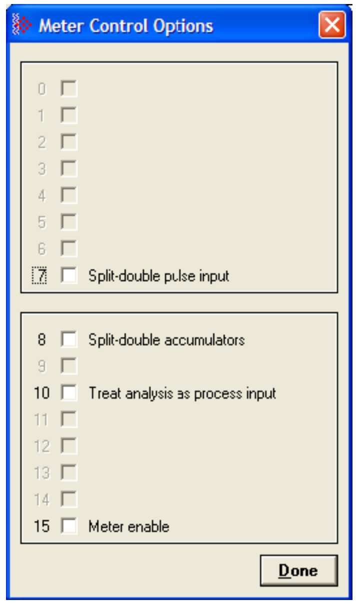


3.3.1 Accumulator Rollovers

An accumulator rollover value is the value at which the accumulator is reset to zero, and is 1 greater than the highest value that the accumulator may hold. For example, a value of 1000000 (6 zeros) specifies a 6-digit accumulator, which rolls over to 0 from 999999. Any unsigned 32-bit value may be given. A value of zero indicates a free-running accumulator, which rolls over to 0 from 655359999 (split: refer to Control Opts button) or 4294967295 (32-bit). For a split accumulator, a value greater than 655360000 is deemed to be 655360000, that is, free-running. The rollover value for a free-running 24-bit accumulator is 16777216.

3.4 Meter Control Options Dialog Box

Click the Control Opts button to configure certain meter-specific parameters.



3.4.1 Split-double pulse input

If set, the input from the pulse counter module is deemed to arrive as a split-double value, in which the actual value is (MSW * 10,000 + LSW).

If clear, the pulse input is interpreted as a full 32-bit integer.

3.4.2 Split-double Accumulator

If this option is clear, the accumulator totalizers are treated as unsigned 32-bit binary numbers, with any carry out of the low-order 16 bits being added into the high-order 16 bits.

If this option is set, then the totalizers are "split", with the low order half rolling over from 9999 to 0000 at which time the high-order half is incremented. A 32-bit value is more suited to computation and has a greater range than a split value, whereas a split value is easier to read when it is represented as a pair of 16-bit numbers, as in a PLC data file.

3.4.3 Treat analysis as process input

When this option is selected, the module will treat the analysis as a process input, which means that the module will not generate events when the molar concentrations change.

If an analysis is manually entered, for example, once per month after receiving the results from a sample sent to a lab, then it makes sense to treat it as a "sealable parameter", logging the change to the event log. This arrangement would be appropriate for metering gas flowing from a well, whose composition would be expected to change only very slowly over time, if at all. In this case you would keep this option cleared.

On the other hand, an intermediate gas stream in an industrial process may undergo dramatic changes in composition over a short time. The analysis of such streams may be kept up to date by repeatedly sampling it with a Gas Chromatograph and sending the results to the AFC as they arrive, possibly as often as every 15 seconds. Logging analysis changes to the event log would drown out other events. It is appropriate in such cases to treat the analysis as process input like temperature or pressure, as that is indeed what it is. In this case you would keep this option checked.

3.4.4 Meter Enabled

When this option is selected, the meter will begin processing calculations. You must disable the meter by unchecking this box before you can change the meter type or product group. You should also disable any meter that is not being used, to allow for best possible module performance. After enabling or disabling the meter, click Done, and then click the Write button in the Meter Configuration area. To retrieve the status of a meter, click the Read button in the Meter Configuration area.

Note: The meter can also be enabled or disabled from ladder logic (refer to the module's User Manual).

Enable a Meter

1 Select (check) the Meter enable check box
2 Click the Meter Options Done button
3 Click on **Meter Configuration** / **Write** button.

Disable a Meter

1 Clear the Meter enable check box
2 Click the Meter Options Done button
3 Click on **Meter Configuration** / **Write** button.

Read the Current Status

1 Click on **Meter Configuration** / **Read** button.
2 Click on **Meter Configuration** / **Control Opts** button
3 If the check box is cleared, the meter is disabled, otherwise the meter is enabled.

Note: The meter can also be enabled or disabled from ladder logic (refer to the module's User Manual)

3.5 Archive Configuration

To configure archives for a meter, click the Archive Config button in the Meter Configuration dialog box. This action opens the Archive Configuration dialog box.

Firmware versions 2.01 and newer allow you to configure the calculation values that will be located in each archive. The default archive configuration depends on the meter type and the product groups.

Note: If the Archive Config button is not visible on the Meter Configuration dialog box, you are configuring a module with firmware earlier than version 2.01. Contact ProSoft Technical Support to update the firmware on your module if your project requires this functionality.

3.5.1 Archive Overview

An archive is a set of data that records relevant process values that occurred during a certain period of time (per meter channel). The archives are automatically generated by the module and no further action is required. The process values can include:

- Net flow rate (average)
- Total accumulator
- Temperature (average)
- Alarms occurred during the period

The process values will depend on the meter type and product group as listed later in this section.

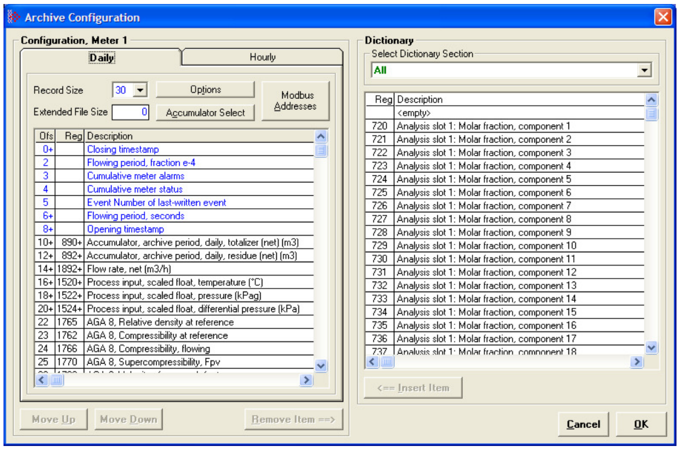
Each archive contains two values that exhibits the period of time about that archive:

- opening timestamp = starting date and time for archive
- closing timestamp = ending date and time for archive

The example described in this chapter is of the default archive configuration as is present for a newly allocated meter. Version 2.01 of the firmware and AFC Manager allows the default configuration to be changed. Refer to Editing the Archive Structure.

3.5.2 Archive Configuration Dialog Box

This dialog box opens when you click the Archive Config button on the Meter Configuration dialog box. Each meter has its own archive, which you can configure.



Daily and Hourly tabs: The Daily and Hourly tabs list the data elements that will be collected.

Record Size: The default configuration uses a 30 word record for each daily or hourly archive. Use the Record Size dropdown list to choose a different record size.

The module reserves a total of 1060 words for daily archives and 1440 words for hourly archives. Therefore, the total number of archives per meter run will depend on the configured number of words per archive as follows:

Number of words per archive	Number of daily archives	Number of hourly archives
10	106 daily archives	144 hourly archives
20	53 daily archives	72 hourly archives
30	35 daily archives	48 hourly archives
40	26 daily archives	36 hourly archives

Extended File Size: This feature is only available for firmware versions 2.02.001 and newer, as it requires the Compact Flash to be installed in the module. It should be used for projects that demand extra archives. You may define up to 1440 *extended* daily archives and 1440 *extended* hourly archives. The maximum number of extended archives does not depend on the number of words per archive.

Options: Opens the Archive Options dialog box.

Accumulator Select: Opens the Accumulator Select dialog box, where you can select the quantity to be accumulated in the *archive period accumulator* result.

Move Up and Move Down: Use these buttons to change the order of selected points in the list of elements to archive. Be aware that items occupying two words will be shifted by two word positions, so that they are always located at an even offset.

Addresses: Use this button to open the Archive Modbus Addresses window for the selected archive file, which you can use to learn how to retrieve specific archive records from the module, including the Modbus addresses where they reside.

Remove Item: Use this button to remove the selected point from the list of elements to archive.

Dictionary: The Dictionary dropdown list acts as a filter for the types of points to archive. The filtered results are listed in the right pane of the Archive Configuration dialog box. The default filter is "All". The other selections in the dropdown list depend on the Meter Type and Product Group you selected on the Meter Configuration dialog box.

Insert Item: Use this button to insert the selected point in the list of points to archive.

Archive Data Format

There are 3 columns associated with each archive data:

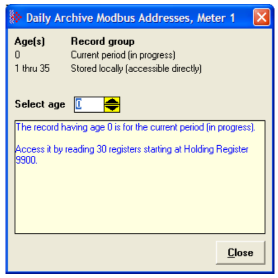
Column	Description
Ofs	Shows the offset location of the data in each archive. The maximum offset value will depend on the *Record Size* value you configured. If the value has a "+" (for example "0+") it means that the data occupies 2 words of data.
Reg	Shows the Primary Modbus Slave Address of the source data. This is a meter-relative address. For example: a Reg value of 890+ for meter 1 would be equivalent to Modbus addresses 8890 and 8891.
Description	Data Description.

The archive header is common for all meter types and product groups and cannot be edited. The archive header uses up to 10 words and is displayed with a blue text:

Ofs	Reg	Description
0+		Closing timestamp
2		Flowing period, fraction e-4
3		Cumulative meter alarms
4		Cumulative meter status
5		Event Number of last-written event
6+		Flowing period, seconds
8+		Opening timestamp

3.5.3 Archive Modbus Addresses dialog box

This dialog box opens when you click the Addresses button on the Archive Configuration dialog box. Use it to learn how to retrieve specific archive records.



Select the age of the archive to be retrieved.

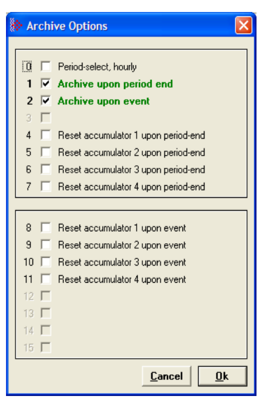
- Archive 0 is the current period (in progress).
- Archives 1 through 35 are recent records stored locally (for daily archives).
- Archives 1 through 48 are recent records stored locally (for hourly archives).
- Older archives are stored on Compact Flash, and are retrieved by copying them into a window in the Modbus table.
- The number of records stored locally depends on both the file selected (daily or hourly) and on the record size (numbers shown are for 30-word records).

The help text in this dialog box describes the procedure to fetch the contents of the archive you select.

3.5.4 Archive Options Dialog Box

This dialog box opens when you click the Options button on the Archive Configuration dialog box. On this dialog box, you can:

- Configure when the archives will be generated (upon period end and/or upon event)
- Specify when the resettable accumulators will be reset (upon period end and/or upon event)

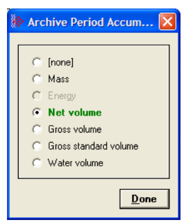


The following table explains each option

Parameter	Description
Period-select, hourly	This option should be clear for Daily Archive and set for Hourly Archive
Archive upon period end	If this option is set, the module will generate a new archive when the configured hourly or daily period ends.
Archive upon event	If this option is set, the module will generate a new archive every time an event occurs (for example: change the orifice diameter value)
Reset Accumulator X upon period-end	If this option is set, the Resettable Accumulator X will be reset once the archive period ends. Note: This is the actual meter accumulator value that is displayed in the Meter Monitor dialog box.
Reset Accumulator X upon event	If this option is set, the Resettable Accumulator X will be reset every time an event occurs. Note: This is the actual meter accumulator value that is displayed in the Meter Monitor dialog box.

3.5.5 Archive Period Accumulation Dialog Box

This dialog box opens when you click the Accumulator Select button on the Archive Configuration dialog box.



Select the quantity to be accumulated in the *archive period accumulator* result. The following types are available, according to the meter type and product group.

- None
- Mass
- Energy
- Net Volume
- Gross Volume
- Gross Standard Volume
- Water Volume.

3.6 Differential Meter Configuration

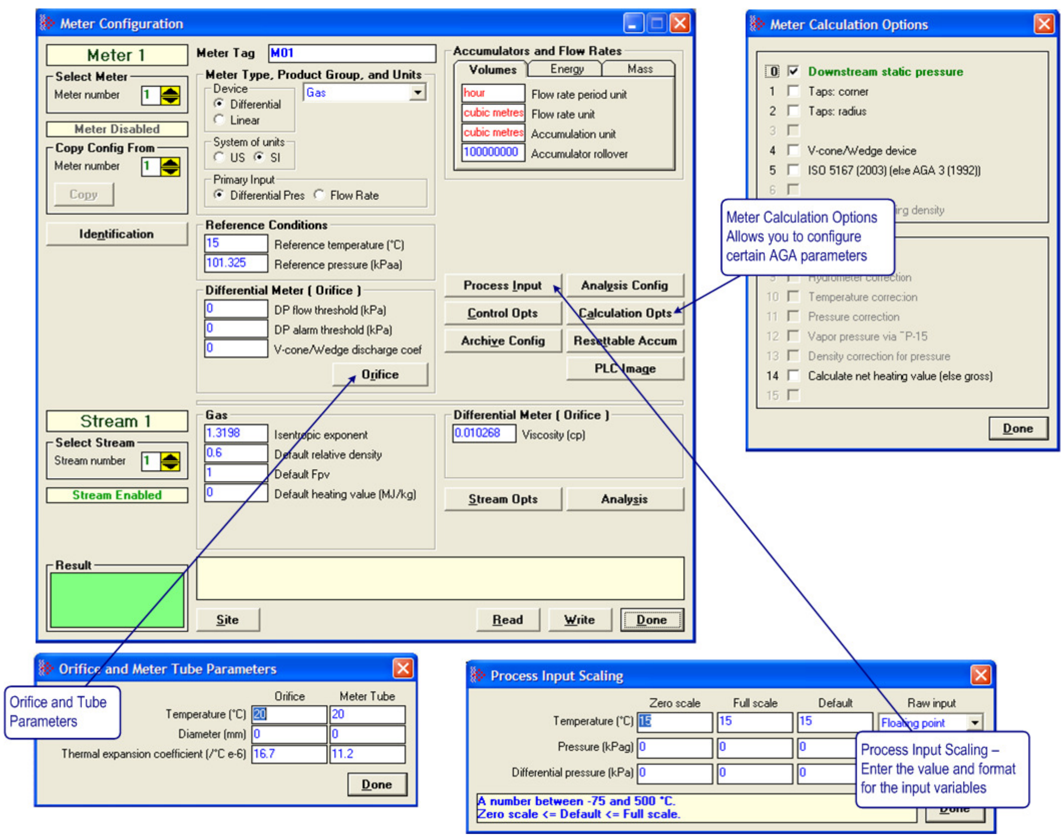
The Differential Meter parameters are displayed after you select Differential Meter in the Process Input area of the Meter Configuration dialog box.

Differential pressure configures the module to use the differential pressure value transferred through the backplane as the primary input for volume calculation. This is the normal setting for most projects.

Flow rate configures the module to use the flow rate value transferred through the backplane for volume calculation. In this situation, the flow rate value should be transferred through the backplane instead of the differential pressure. This means that the flow rate will use the same backplane location that the differential pressure would use.

3.6.1 Differential Meter, Differential Pressure (Orifice Meters)

After configuring the meter as a Differential meter (AGA 3), you might configure the following parameters:



DP Flow Threshold

If at any time the differential pressure input value is less than the DP Flow Threshold parameter, the module will treat the differential pressure as zero (no flow).

DP Alarm Threshold

If at any time the differential pressure input value is less than the DP Alarm Threshold parameter, the module will flag a Differential Pressure Low alarm. Note that this alarm is different from the one the module would flag if the differential pressure would be out of range (Input Out of Range: Differential pressure).

V-Cone Discharge Coefficient

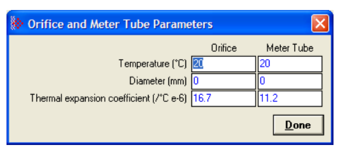
For an Orifice meter, AGA3 dictates the calculation of the "Coefficient of Discharge", a multiplicative factor used in calculating the flow rate. For a V-cone meter, there is no corresponding calculation, so the Coefficient of Discharge must be entered from the manufacturer’s data sheet. The "V-Cone Discharge Coefficient" has no meaning unless the "V-Cone Device" option is selected (see Calculation Options button).

Viscosity

Enter the viscosity value to be used in the calculation. The default value is 0.010268.

3.6.2 Orifice and Meter Tube Parameters dialog box

This dialog box opens when you click the Orifice button on the Meter Configuration dialog box.



Temperature

The temperatures at which the diameter measurements are made. Default value for each is 20ºC (68ºF).

Diameter

Each measured diameter should be positive, and orifice plate diameter should be less than meter tube diameter. Default values are zero, which will cause a measurement alarm. For a V-Cone device, enter the cone diameter instead of the orifice diameter.

Thermal Expansion Coefficient

For each, coefficient of thermal expansion ("alpha") is of the order of 10e-6 /º; the actual value is multiplied by 1000000 for display and the entered value is divided by 1000000 for storage and Modbus transmission.

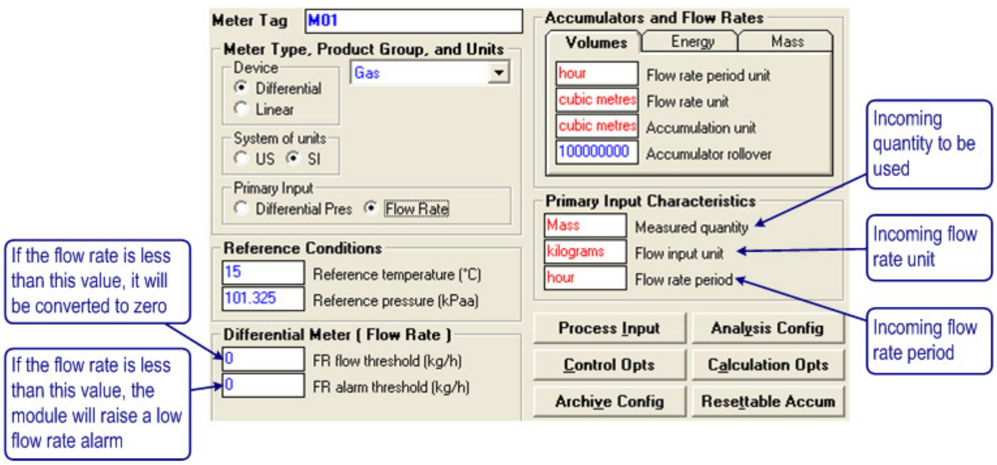
Values for typical materials are:

Material	Value
304/316 SS	16.7e-6 /ºC, 9.2e-6 /ºF
Monel	14.3e-6 /ºC, 7.9e-6 /ºF
carbon steel	11.2e-6 /ºC, 6.2e-6 /ºF

Default values are 304/316 SS for orifice plate and carbon steel for meter tube.

3.6.3 Differential Pressure, Flow Rate Integration

Select Flow Rate as the primary input to configure the following parameters:



Choose Primary Input Characteristics according to the incoming flow rate delivered over the backplane.

FR Flow Threshold

If at any time the flow rate input value is less than the FR Flow Threshold parameter, the module will treat the flow rate as zero (no flow).

FR Alarm Threshold

If at any time the flow rate input value is less than the FR Alarm Threshold parameter, the module will flag a Flow Rate Low alarm. Note that this alarm is different from the one the module would flag if the flow rate would be out of range (Input Out of Range: Flow Rate).

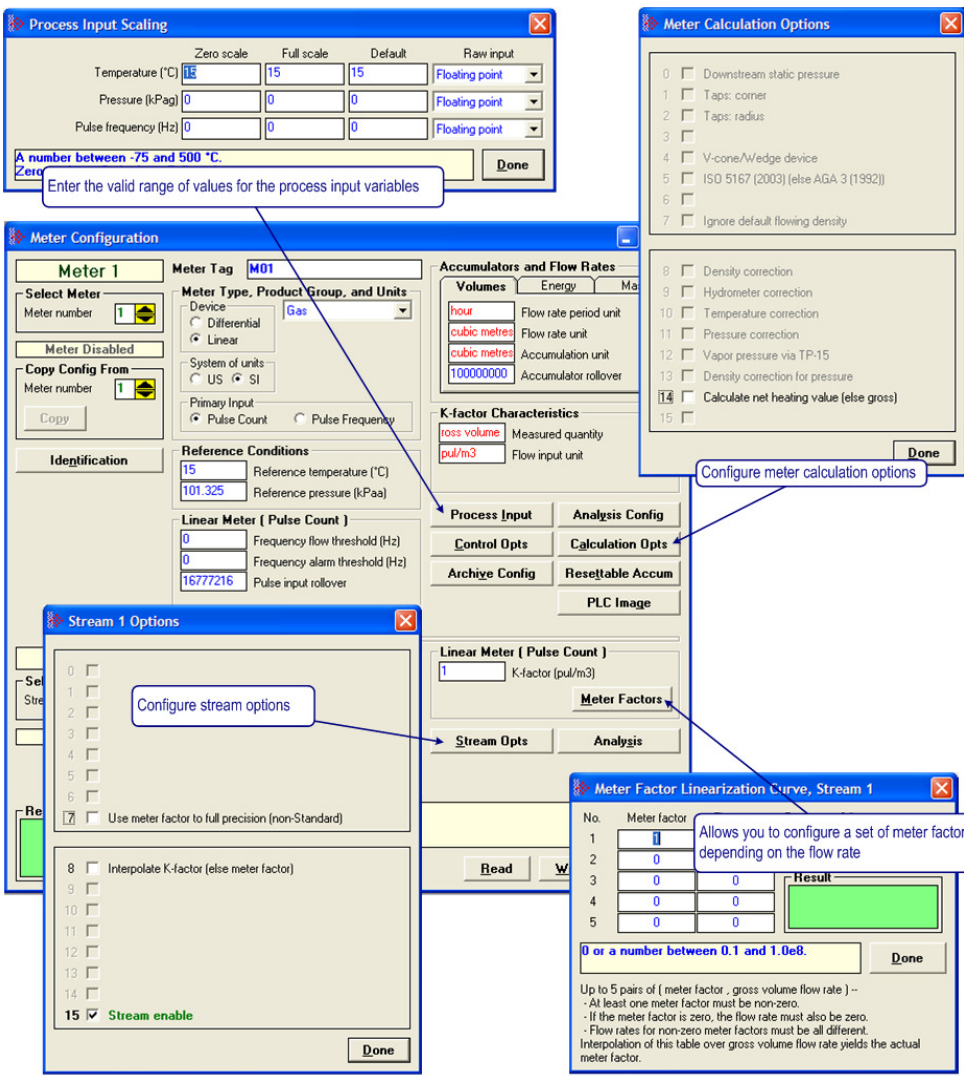
3.7 Linear Meter Configuration

The Linear Meter parameters are displayed after you select the Linear Meter.

Primary Input "Pulse Count" configures the meter to accept both pulse count and pulse frequency transferred over the backplane, and to calculate flow accumulations from the pulse count and flow rates from the pulse frequency.

Primary Input "Pulse Frequency" configures the meter to accept only pulse frequency input (pulse count is ignored), and to calculate both rates and accumulations from the frequency.

After configuring the Primary Input type for Pulse Count or Pulse Frequency, you will configure the following parameters:



3.7.1 Linear Meter (Pulse Count)

This area is visible when the meter type is set to Linear, and the Primary Input is set to Pulse Count. Enter the K-factor and pulse input rollover values for this meter. Click the Meter Factors button to enter values for Meter Factor at up to five different Flow Rates for this meter.

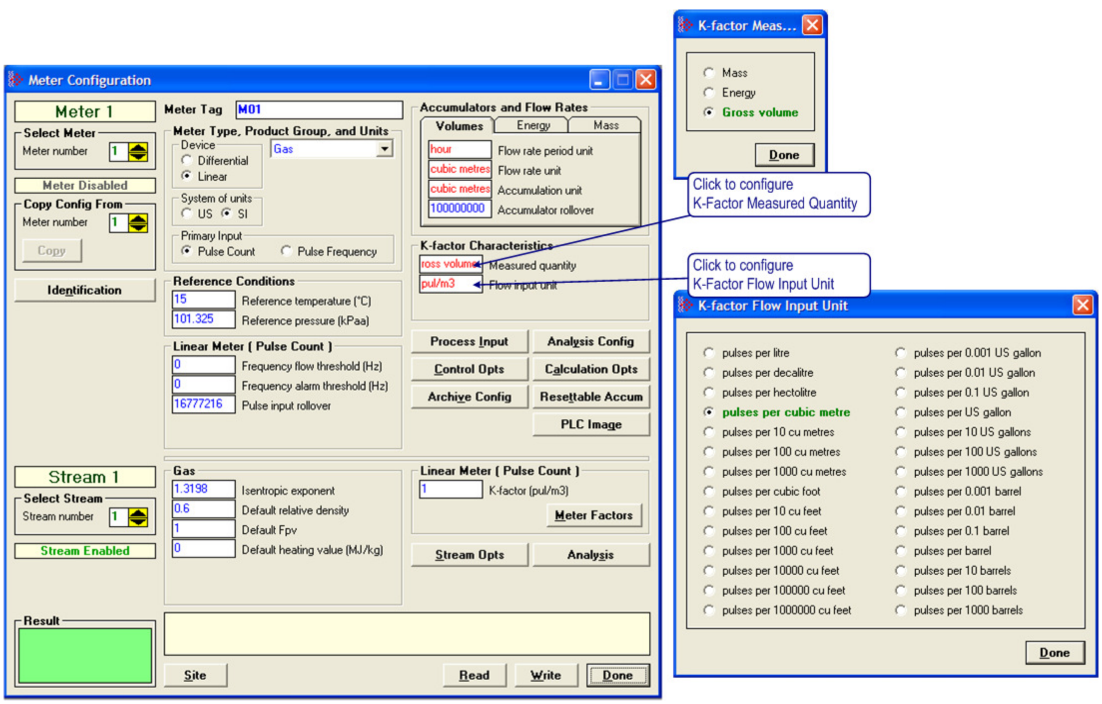
3.7.2 Linear Meter (Pulse Frequency)

This area is visible when the meter type is set to Linear, and the Primary Input is set to Pulse Frequency. Enter the K-factor, Frequency flow threshold and Frequency alarm threshold values. Click the Meter Factors button to enter values for Meter Factor at up to five different Flow Rates for this meter.

3.7.3 K-factor Characteristics

This area is visible when the meter type is Linear. Click the Measured quantity and Flow input unit fields to choose the quantity type and flow input unit for this meter.

The K-Factor itself is entered as a stream parameter; see below.



The K-factor units available for selection will depend on the selected measured quantity.

3.7.4 K-Factor

For a linear (pulse) meter:

```
gross volume = (pulses/K-factor) x meter factor
```

The K-factor is a factor that converts raw pulse count (from the Pulse Meter) to a volume and is expressed as "pulses per unit volume", such as "1000 pulses per gallon" or "3578.224 pulses per cubic meter". This number, found on the manufacturer's data sheet for the meter, is determined at the factory for the specific unit before shipping. So, dividing "pulses" by "pulses per gallon" gives you "gallons". API calls the value "pulses / K-factor" as "indicated volume".

3.7.5 Pulse Input Rollover (Pulse Count meters)

When the meter is selected as a Pulse Meter, one of the input variables transferred from the programmable logic controller will be the Pulse Count value which is the number of pulses transferred from the Pulse Meter or the High Speed Counter Module. This parameter sets the value at which the pulse count will rollover to zero. It is essential that this value match the actual pulse rollover used in the field by the pulse meter or counter module, otherwise the flow calculation will generate unexpected values. Enter this value as (maximum value)+1.

3.7.6 Frequency Flow Threshold (Hz)

This is the threshold value for the pulse frequency. If the received value is less than the configured threshold it will be deemed to be zero.

3.7.7 Frequency Alarm Threshold (Hz)

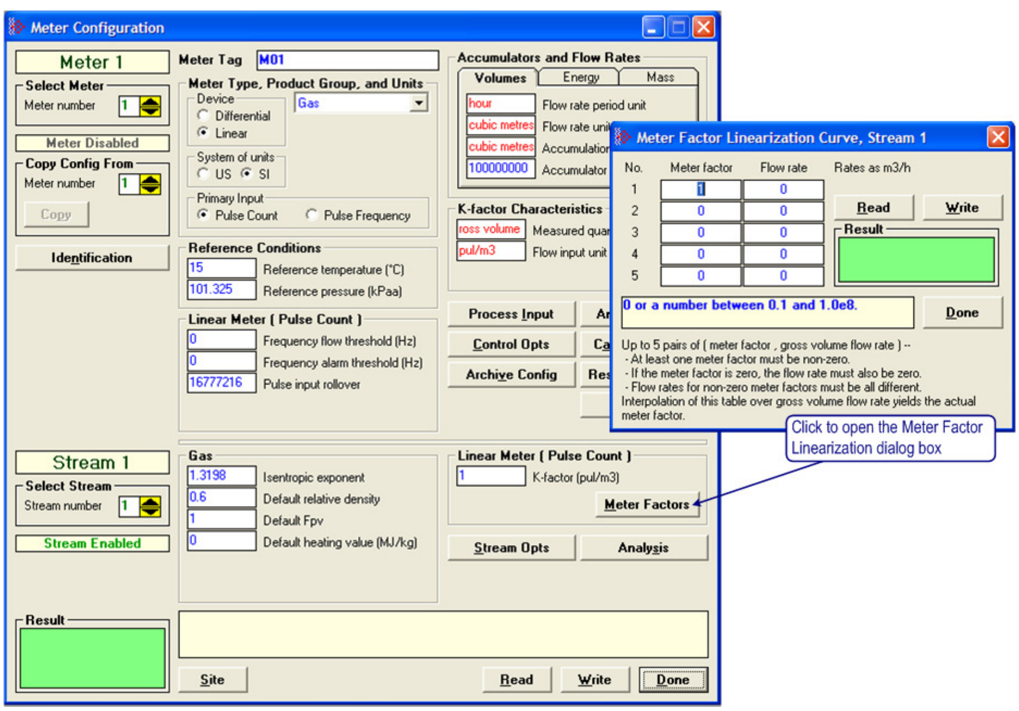
If the received pulse frequency is less than this value the "Pulse Frequency Low" alarm will be raised.

3.8 Meter Factor Linearization

Meters are mechanical instruments, so eventually they wear out. Over time, the actual measured volume (the "gross volume") will tend to drift from the nominal measured volume (the "indicated volume"). The factor that corrects "indicated" to "gross" is called the "meter factor", and is a number very close to 1. The procedure that is performed periodically to determine a (new) meter factor is called "proving". A pulse type meter is "proved" periodically to ensure that the meter performs as expected over a period of time.

A prover passes a known volume of product through the meter and compares the volume indicated by the meter against the fixed volume of the prover (measured with a high degree of precision). If the meter indicates the measured volume to be exactly the same as the known prover volume, the Meter Correction Factor is said to be equal to 1.00000 (*Meter Factor = Prover Volume/Metered Volume*).

Because meters are mechanical instruments, their behavior may differ depending on the rate of flow through the meter. That is, the meter factor may depend on the flow rate at which the measurement is performed. The AFC accommodates this by allowing you to enter up to 5 factor-flowrate pairs (the "Meter Factor Linearization" table); the AFC determines the meter factor to be used by linear interpolation on this table from flow rate at operating conditions (Since flow rate depends on the meter factor according to API, but meter factor depends on flow rate according to the linearization table, the AFC performs a second iteration of the interpolation in order to obtain an accurate meter factor).

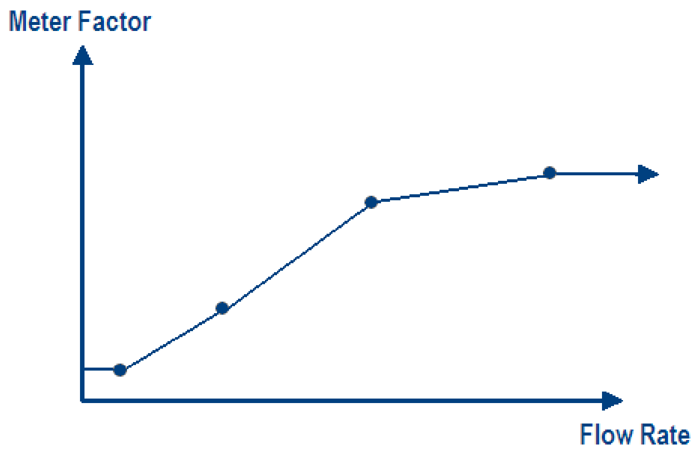


Click the Meter Factor Curve **Read** button to transfer the current Meter Factor Linearization configuration from the AFC module to the local PC

When the Meter Factor Linearization configuration is concluded, click the Meter Factor Curve **Write** button to transfer it to the AFC module

The module will use the values you entered in the Meter Factor Linearization dialog box and interpolate the values so it can use a specific meter factor depending on the current flow rate.

For example, if you enter four points (flow rate, meter factor) the module would interpolate the points as shown below:



In order for the module to accept the values you entered, the following conditions are required:

- All values are non-negative (≥ 0.0).
- At least one meter factor is non-zero.
- If a meter factor is zero, the corresponding flow rate is also zero.
- The flow rates corresponding to non-zero meter factors are all different.

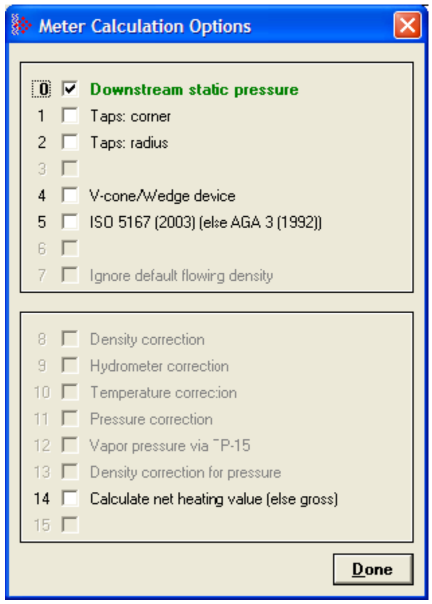
You do not need to enter factor-flowrate pairs in any particular order, or even enter them all as a contiguous group, but you may enter each factor-flowrate pair into any of the five table entries and the AFC will sort it all out.

If you do not want to enter meter factor linearization data, leave the first element as 1. This will set the meter factor as 1 for all flow rates.

3.9 Meter Calculation Options

The Meter Calculation Options dialog box opens when you click the **Calculation Opts** button. Use this dialog box to choose the required calculation parameters:

Note: Options that are not applicable to the meter type are not enabled and cannot be selected.



3.9.1 Downstream Static Pressure

The static pressure of the gas stream may be measured either upstream of the meter (before the differential pressure drop), or downstream of the meter (after the pressure drop). Both AGA3 and AGA8 require the upstream static pressure for their calculations, where:

```
upstream pressure = downstream pressure + differential pressure
```

If the pressure is measured from a downstream tap (typical), this parameter must be checked.

3.9.2 Taps: Corner & Taps: Radius

These options select the minor adjustments to the AGA3 calculations that depend on the precise geometry of the pressure taps.

There are 4 different kinds of taps; pipe, flange, corner, and radius. Pipe taps are obsolete; addressed in the 1985 AGA3, but absent in the 1992 version. Flange taps are used in the vast majority of orifice meter installations and are used as default for the module calculation. When using corner or radius taps, it is required that the corresponding option be selected.

3.9.3 V-Cone / Wedge Device

A differential meter is one that measures flow rate rather than flow increment. It does so by measuring a pressure drop ("differential pressure") across a constriction in the flow tube and calculating the mass flow from the DP, the geometry of the constriction, the temperature, and so on, and a well-known flow equation.

One type of constriction is the "orifice", which blocks the flow around the periphery of the tube forcing the fluid to flow through a narrower aperture in the middle. The AGA3 standard specifies the calculations for this method of metering, including the calculation of the orifice "discharge coefficient".

Another type of constriction is the "V-cone", which blocks the flow in the center of the tube, forcing the fluid to flow around the blockage through the periphery of the tube; where the orifice blocks, the V-cone does not, and where the V-cone blocks, the orifice does not. Much of the AGA3 standard still applies (in particular, the well-known flow equation), except that there is no longer a calculation of the V-cone "discharge coefficient" which must then be entered into the AFC as a separate data point (refer to the previous discharge coefficient discussion).

A wedge meter is a device that constricts the flow towards one side of the flow tube. Here, also, a separate entry of the discharge coefficient must be made.

3.9.4 ISO 5167 (2003) (else AGA 3 (1992))

Available for firmware versions 2.04.000 or later. If cleared, the module will use the AGA3 standard for flow calculation. If checked, the module will use the ISO 5167 (2003) standard for flow calculation.

3.9.5 Ignore Default Flowing Density

For liquid measurement with an input of density at flowing conditions, if the density (either input over the backplane or output from a densitometer calculation) is out of range, the default is substituted, just as is done for the other process inputs of temperature and pressure. In some cases this might not be suitable, especially when the temperature of the fluid may vary, thus making it difficult to settle on an appropriate default value for density at flowing conditions. This option tells the AFC to ignore the flowing density default value, and to instead use the Default Standard Density while at the same time skipping any density correction that might be configured (For liquid meters, the density at flowing conditions is combined with the temperature to calculate a density at standard conditions used in all further calculations).

3.9.6 Density Correction, Hydrometer Correction, Temperature Correction & Pressure Correction

You should consider these options to select or unselect MPMS Chapter 11 calculations for liquid measurement, depending on the requirements of the project.

For example, if flowing density is manually entered directly from the reading of a glass hydrometer containing a sample of the fluid, the Hydrometer Correction for the expansion of the glass due to temperature would be required. On the other hand, if the meter already provides a temperature-corrected pulse train, it would be an error to perform Temperature Correction a second time.

3.9.7 Vapor Pressure Via TP-15 ("Technical Paper #15")

API specifies that the pressure correction factor (CPL), which corrects the measured volume for the effect of pressure, must correct to "standard pressure or equilibrium pressure, whichever is higher".

In US units, "standard" pressure (for liquids) is 14.696 psia (one atmosphere at sea level) and "standard" temperature is 60°F. This works well for liquids such as gasoline and crudes, but lighter products (such as propane) are gaseous at these conditions.

The "equilibrium" pressure of the API standard is the pressure at which the liquid fluid and its vapor are in equilibrium. This is also called the "vapor pressure". GPA's TP-15 ("Technical Paper #15") is a correlation for calculating the equilibrium (vapor) pressure for typical hydrocarbon fluids (for example, propane) from density and temperature.

3.9.8 Density Correction for Pressure

This option, effective only when option "Density Correction" is selected, enables the effect of pressure to be included in the density correction calculation.

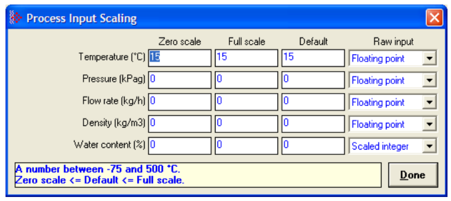
When cleared, only the effect of temperature is considered.

3.9.9 Calculate Net Heating Value (else gross)

This option selects whether the produced water is in vapor (net) or liquid (gross) state.

3.10 Process Input Scaling

Click the Process Input button to configure the valid input ranges. If an input data is not within the configured range, the AFC will flag an alarm on the Meter Monitor dialog box (refer to Meter Monitor section) and the alarm bit for the meter will be set.



The entries available on this dialog box depend on the selected product group, device, and primary input:

Product Group	Input Variables
Gas	Temperature, Pressure, Flow Rate, Differential Pressure, Pulse Frequency
Liquid	Temperature, Pressure, Flow Rate, Differential Pressure, Pulse Frequency, Density, Water Content

3.10.1 Zero Scale

This value is the minimum valid value for the input variable.

3.10.2 Full Scale

This value is the maximum valid value for the input variable.

3.10.3 Default

This parameter is used by the module as the input value when the input variable is out of range and site option "Process input out of range use last-good value" is clear. In this situation, the module will flag the alarm and use the default value instead of the value transferred by the module.

3.10.4 Raw Input

This parameter configures how the module will interpret the input variable within the given range. The possible selections are floating point, scaled integer, and 4 to 20 mA. The default is floating point, in which the raw input from the processor is a floating point value already converted to engineering units.

For scaled integer input, the module will expect the following data formats:

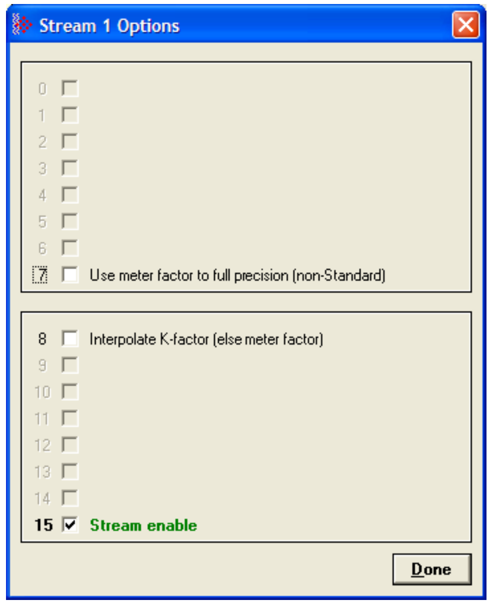
Scaled Integer		
Variable	**Format**	**Example**
Temperature	Two decimal places implied	A value of 1342 would be equivalent to 13.42ºC
Pressure	Zero decimal places implied for the SI units (kPa) and one decimal place implied for the U.S. units (psi).	A value of 200 would be equivalent to 200 kPag
Differential Pressure	Two decimal places implied for inches of H_2O and three places for kPa	A value of 35142 would be equivalent to 35.142 kPa
Flow Rate	Zero decimal places implied; for desired precision, choose an appropriate input flow rate unit	A value of 6672, with input flow rate units configured as gal/hr, would be equivalent to 6672 gal/hr
Pulse Frequency	Zero decimal places implied	A value of 2276 would be equivalent to 2276 Hz
Density (kg/m^3)	One implied decimal place	A value of 5137 would be equivalent to 513.7 kg/m3
Density (Relative Density)	Four implied decimal places	A value of 10023 would be equivalent to 1.0023 60ºF/60ºF.
Density (API)	Two implied decimal places	A value of 8045 would be equivalent to 80.45 °API.

For 4 to 20 mA input, the value received from the processor is the raw unscaled A/D count obtained from the analog input card. The module scales the raw count to engineering units using the configured values for zero scale and full scale assuming the following ranges:

4 to 20 mA A/D counts			
Processor	**Module**	**Zero scale (4 mA)**	**Full scale (20 mA)**
SLC	MVI46-AFC	3277	16384
ControlLogix	MVI56-AFC	13107	65535
CompactLogix	MVI69-AFC	6241	31206
PLC	MVI71-AFC	819	4095
Quantum	PTQ-AFC	4000	20000

In the Meter Monitor dialog box, the raw value is shown in the "Last Raw" column and the converted values are shown in the "Scaled Avg" column.

3.11 Stream Options



Meters often are used for measurement of different products at different times. The reasons for doing so include cost and convenience (a pipeline may carry gasoline one day and fuel oil the next) and accounting (a plant may receive product from several different suppliers who must be fairly paid). Available for firmware versions 2.05 and later, the Multiple Stream feature of the AFC allows such a meter to be modeled with up to four different product streams, each of which has its own set of product-specific configuration parameters and accumulators.

A meter always has exactly one active stream, which corresponds to the particular product that flows though the meter at that moment. The active stream may be switched to any enabled stream via a meter signal; enabling a stream allows it to become active and disabling it prevents it from becoming active, and the currently active stream may not be disabled. As the physical switching of a product stream through a meter is almost always accompanied by additional actions such as the swinging of valves it is expected that the stream-switching signal will be issued by the processor, hence to reduce the likelihood of unfortunate errors the AFC Manager provides no specific method for issuing that signal. Issuing a stream-switch signal, however, is like issuing any other signal, which is by latching a bit in one of the AFC's Modbus registers, hence in exceptional circumstances it can be issued from anywhere, such as by a SCADA system connected to one of the Modbus ports or by the AFC Manager itself via the Modbus Master window.

Parameters whose values may depend on the properties of the product being measured are configured for each stream separately. Such parameters include both those that describe the product directly (e.g. density, viscosity, analysis) and those that describe indirect effects of the product (e.g. meter factor). Measurement calculations always use the parameters for the active stream.

The output of each stream consists of a complete set of accumulators laid out like those of the meter itself. Computed increments are accumulated simultaneously in both the meter accumulators and those of the active stream, so that each meter accumulator is always the sum of the corresponding accumulators for all four streams (modulo the rollover value).

3.11.1 Use meter factor to full precision (non-Standard)

If "Use meter factor to full precision" is clear, the Meter Factor is rounded to five decimal places (four decimal places for firmware versions 2.04 and earlier) before being used to calculate gross volume (gross = pulses / KF * MF). If the option is set, the MF is used as is without rounding. The API standard requires the meter factor to be rounded.

3.11.2 Interpolate K-factor

This option bit swaps the roles of K-factor and meter factor, so that when this option is selected, the "K-factor" entry becomes "Meter factor" and the "Meter Factor Linearization" table becomes "K-factor Linearization".

The calculations described up to this point are those recommended by API and performed by the vast majority of users of linear meters. Some users, however, may prefer to keep the meter factor at exactly 1.0000 and periodically adjust the K-factor with a meter prove; and then the K-factor may depend on the flow rate.

3.11.3 Stream Enable

Select (check) to enable the current stream. Unselect (uncheck) to disable the current stream. A disabled stream cannot be made active. When downloading the configuration to the module, this option is silently forced for the active stream.

3.12 Product Group Specific Parameters

After the meter type has been selected, and its specific parameters are set, it is time to configure the Product Group considered for the meter and its specific parameters.

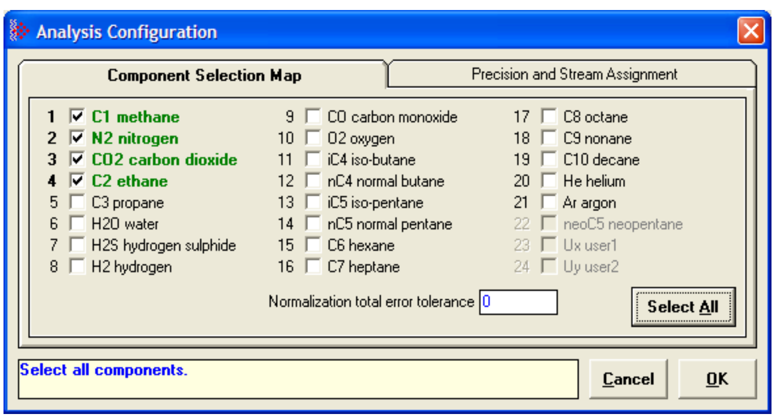
The Product Group selects the measurement Standards to be used in calculating flow rates and accumulations. Select "Gas" to use AGA8 and either AGA3 or AGA7 Standards. Select a liquid group to use the MPMS Chapter 11 Standards. For more detail on measurement standards, see the Measurement Standards subsection of the Reference chapter in this manual.

The following sections group products into two categories, Gas and Liquid, grouping all the liquid products together. The reason for this approach is because the configuration interfaces for all the liquid products are very similar while that for gas is significantly different.

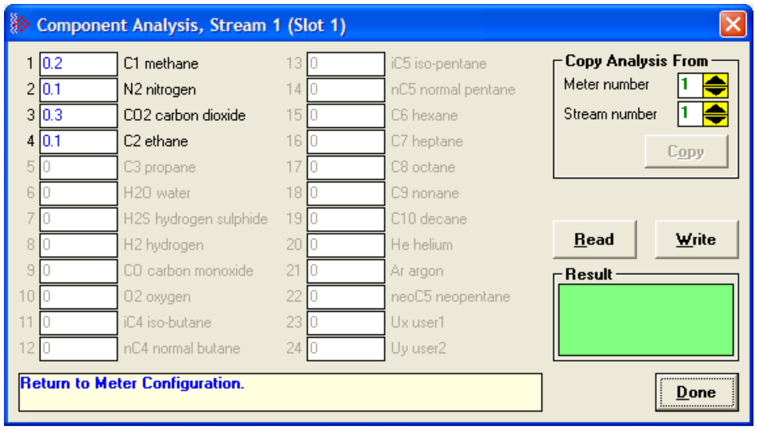
3.12.1 Gas Product Overview

The gas compressibility calculations are based on molar analysis concentrations of up to 21 components, using the Detail Characterization Method of AGA8 (1992). The module automatically generates alarms if the sum of the molar concentrations is not 100%

Configure the analysis settings using the AFC Manager (**Meter Configuration** / **Analysis Config**) as follows. This window allows the selection of the components(Component Selection Map) and analysis precision (Precision and Stream Assignment – version 2.06.000 or higher). The sample ladder logic assumes that all components are selected so check all components at the Component Selection Map window.



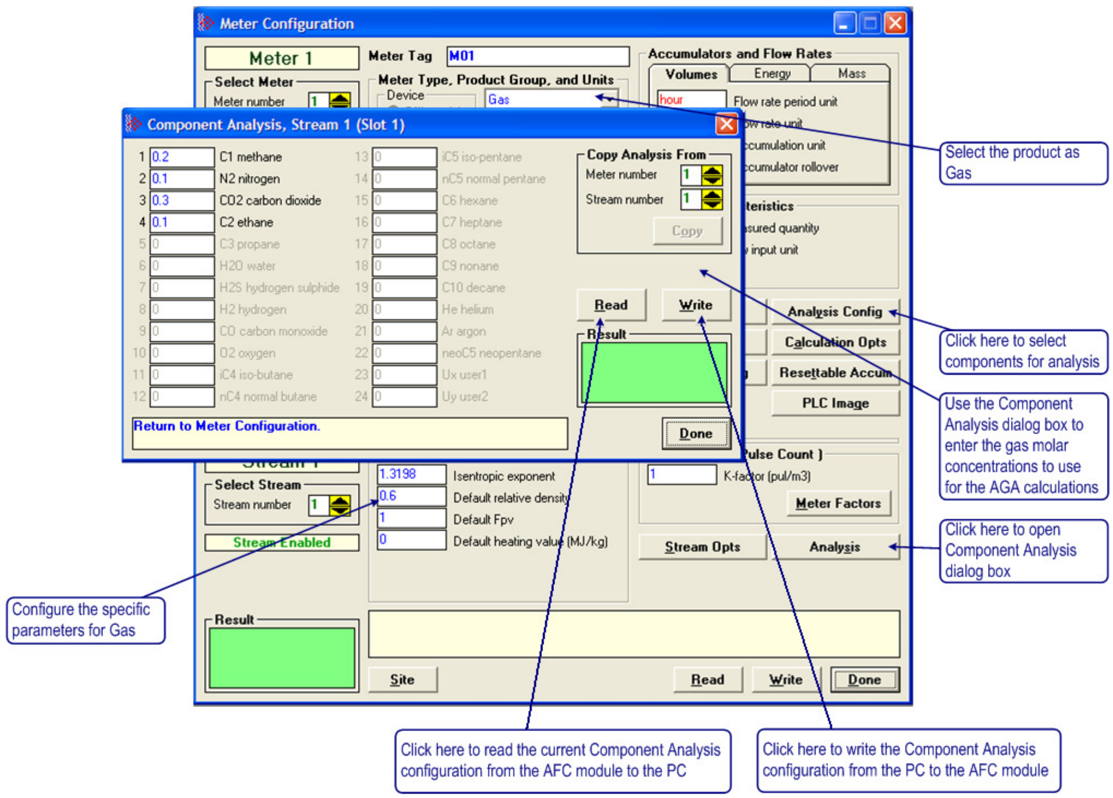
Enter the gas analysis concentrations by clicking the Analysis button.You can also update the concentrations through the backplane as will be later shown at this User Manual.



The module records events every time a molar concentration value changes. For applications that involve gas chromatograph devices, this feature might not be desirable because it is expected that the values should frequently change. You can disable this feature using AFC Manager (**Meter Configuration** / **Control Options** / **Treat Analysis as Process Input**).

3.12.2 Gas Specific Parameters and Component Analysis (Molar Analysis) Configuration

When gas is selected as the product group, the following parameters must be configured:



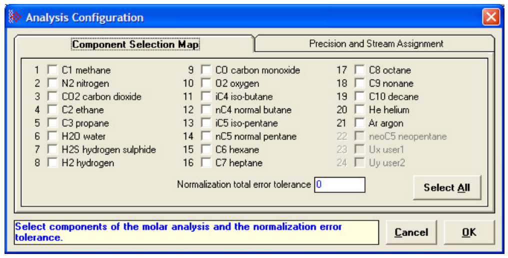
The following parameters are required for the calculations.

Parameters	**Low Limit**	**High Limit**	**Default**
Isentropic Exponent	1.01	5.0	1.3198
Default Relative Density (Specific Gravity)	0.04	5.0	0.6
Default Fpv	0.5	2.0	1
Reference Temperature	0℃ (32℉)	25℃ (77℉)	15℃ (60℉)
Reference Pressure	50kPaa (7.3 psia)	110kPaa (16 psia)	101.325kPaa (14.73 psia)

Component Analysis (Molar Analysis) Dialog Box

Click Read to retrieve the Molar Analysis settings from the module, or click Write to send the Molar Analysis settings from the PC to the module. A dialog box will open to confirm your local port settings.

To enter gas molar concentrations, click the Analysis Config button on the Meter Configuration dialog box and select the Component Selection tab. This area of the Meter Configuration dialog box is visible when the product type is Gas.

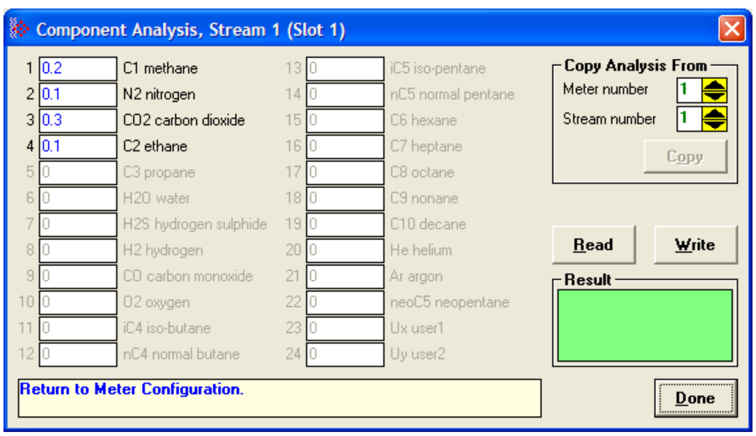


Select (check) the components to be analyzed, enter the Normalization total error tolerance value, and then click Done.

Note: the sample ladder logic assumes that all components are selected so it is suggested to check all components for compatibility with the sample ladder logic.

Next, enter the molar concentration for each component. Click the Analysis button to open the Component Analysis dialog box.

Because the module uses the Detail Characterization Method, you must enter a complete molar analysis for the gas.



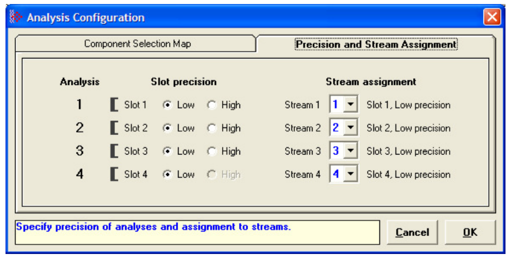
Enter the molar concentration for each component (up to 4 fractional digits).

For example, when you enter:

```
C1 Molar Fraction = 0.8
```

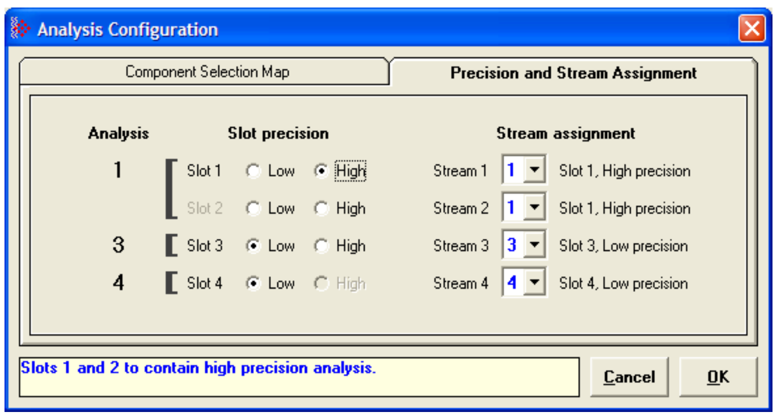
It means that the methane (C1) component has a molar concentration of 80%.

Precision and Stream Analysis



For module firmware versions 2.06 and newer, you can specify the association of each stream to specific slots, where each slot has enough space for 24 words. This configuration option allows you to use high precision calculations for the specified slots.

To use high precision calculations, change the Analysis slot precision value from Low to High, as shown in the following illustration. Notice that AFC Manager automatically reserves two slots (48 words) identified as Slot 1 (the first slot). Streams 1 and 2 are using high precision analysis (sharing the same analysis data), while Streams 3 and 4 are using low precision.



The sample program for your AFC module allows you to view and update the high precision molar analysis. Refer to the Ladder Logic (Sample Program) chapter of the manual for your AFC module for more information.

Normalization Error Tolerance

Analyses are often obtained from an on-line gas chromatograph, which device should provide output consisting of a collection of numbers between 0 and 100 all adding up to exactly 100%. Real devices, however, usually produce a total slightly different from 100%, and sometimes may provide individual concentrations that go negative (for example, -1.08%) or super-positive (for example, 101.3%). When properly calibrated, most Gas Chromatographs produce individual concentrations that lie between 0 and 100% and a total that is very close to (but not always identical to) 100%.

The "Normalization Error Tolerance" is the amount by which an analysis total may differ from 10,000 (= 100%) without raising the "Analysis Total Not Normalized" alarm. It is intended to allow for deviation from the strict 100% total that arises either from the normal variation of the output from a properly calibrated Gas Chromatograph or from roundoff error when converting concentrations to the 4-digit integers required by the AFC.

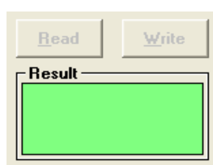
If the concentration total differs from 100% by more than the tolerance, the module raises the alarm.

In all cases, whether or not the alarm is raised, the module normalizes the analysis to 100% before continuing with the calculation.

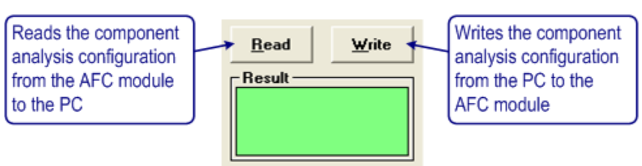
Transferring the Analysis

In order to transfer the Molar Analysis data between the local PC and the module, it is essential that the component selection in the local PC and the module match.

If the Molar Analysis Write and Read buttons are currently disabled, it indicates that the AFC Manager does not acknowledge that the current module meter configuration and the local PC component selection files are equal. In this case, the buttons are disabled, as shown in the following illustration.



In order to enable the Read and Write buttons, the component selection on the local PC and on the module must be the same. In order to accomplish this, you can perform a Read (Meter Configuration), then change your analysis and then Write it. After both component selections are identical, the Read/Write molar analysis buttons should be enabled:



After the molar analysis buttons are enabled, you can transfer the analysis between the module and the local PC.

The Result area contains the transfer process result:

Message	Description
Success	Transfer was successfully completed
Time out	Transfer was not completed. Verify the cables and the port communication parameters
Illegal Data Value	The values entered are not acceptable. Make sure the values have a valid format.

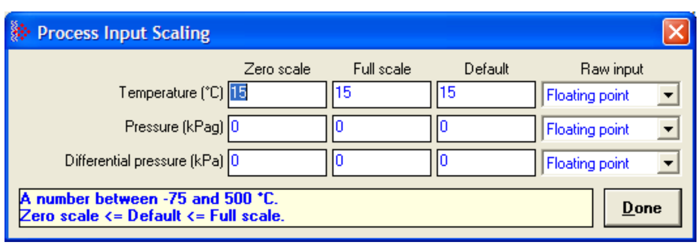
For applications involving chromatograph devices, the ladder logic can dynamically update the molar analysis data to the module. Refer to the Ladder Logic section of the user manual for your platform for more information about this subject.

Important: If the molar concentration values for your project are available from a gas chromatograph, it is possible to update these values dynamically from the programmable logic controller to the module using the Molar Analysis function block (requires ladder logic). In this case, the values entered in the AFC Manager Software will be overwritten by the function block values but you still need to select the components and enter the normalization error tolerance using the AFC Manager Software. Refer to the User Manual for your platform for more information about the Molar Analysis function block.

Process Input Scaling (Gas)

This parameter configures how the module will interpret the input variable within the given range. The possible values are floating point, scaled integer, and 4 to 20mA.

Click the Process Input button to configure the valid input ranges. If an input data is not within the configured range, AFC Manager will flag an alarm on the Meter Monitor dialog box and the alarm bit for the meter will be set.



The process input variables available for gas products depend on the meter type (differential or linear), and the primary input type.

For scaled integer process input scaling, the module requires the following data formats:

Scaled Integer		
Variable	**Format**	**Example**
Temperature	Two decimal places implied	A value of 1342 would be equivalent to 13.42°C
Pressure	No decimal places implied for the SI units (kPa) and one decimal place implied for the U.S. units (psi).	A value of 200 would be equivalent to 200 kPa
Differential Pressure	Two decimal places implied for inches of H_2O and three places for kPa	A value of 35142 would be equivalent to 35.142 kPa
Flow rate	No decimal places implied for the SI units or US units. To obtain desired precision, choose appropriate Primary Input Characteristics	A value of 102 would be equivalent to 102 lb/hr

3.12.3 Liquid Product Overview

The module supports applications involving crude or refined oil such as crude oil, oil/water emulsion, propane, butane, NGLs, LPGs, gasoline, jet fuels and lubricating oils.

When measuring liquids with density correction, density at flowing conditions is required. This value may be provided directly as a process input, or the module can calculate a density from the frequency provided by a densitometer device.

Density Units

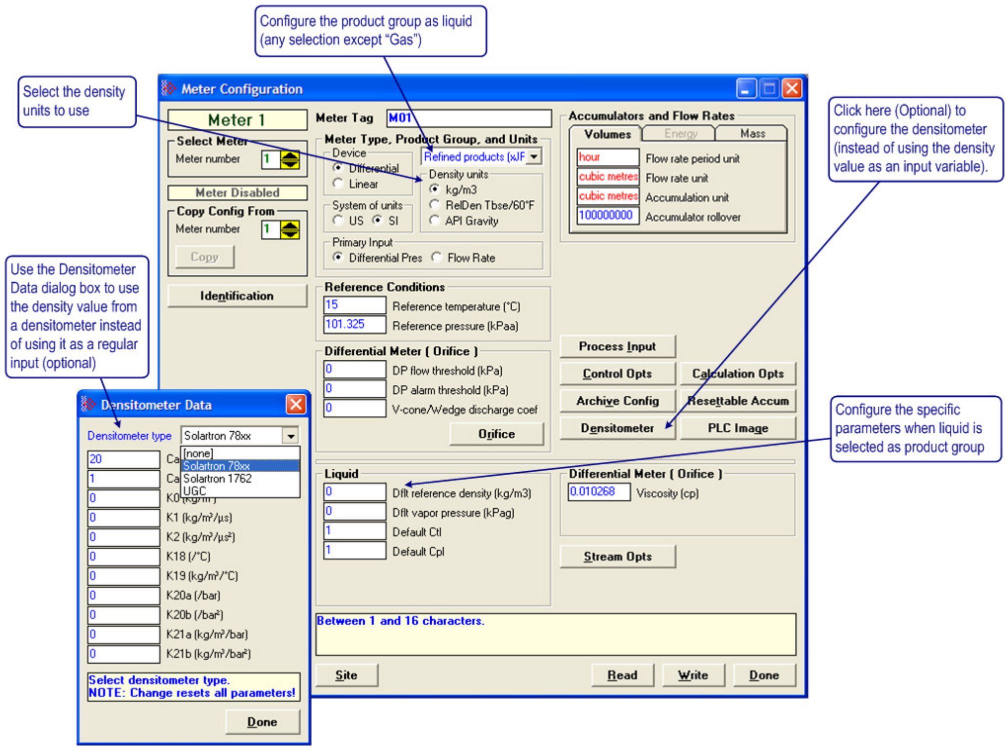
The liquid density units can be expressed as:

- Density is in kg/m^3
- Relative density 60ºF/60ºF
- API gravity

For NGL and crude oil measurement applications, the optional automatic calculation of Net Oil Volume and mass based on the Sediment and Water (S&W) percent input is supported. Only provide the S&W percent value in the specified controller register. The module puts the gross standard, net oil and water accumulations in separate accumulators.

3.12.4 Liquid Specific Parameters and Densitometer Configuration

When liquid is selected as the product group, the following parameters must be configured:



This area is visible when the product group is set to a liquid group. Enter the values for Default Reference Density, Vapor Pressure, Default Ctl and Default Cpl. The following parameters are required for the calculations.

Parameters	Low Limit	High Limit	Default
Dflt Reference Density	0 kg/m^3 0 Rd60 -60.75°API	2000 kg/m^3 2.0 Rd60 320°API	0
Default Vapor Pressure	0	100,000 kPa (14,000 psi)	0
Default Ctl	0.5	2.0	1
Default Cpl	0.5	2.0	1

Tip: To see the limits and defaults for each parameter, view the blue text in the "Note" box when you click in the entry text box.

For firmware version 2.03 and later, if you select an "Emulsion" group, the following parameters can be configured:

Parameters	Low Limit	High Limit	Default
Water density at 60°F	900.0	1200.0	999.016
Shrinkage Factor	0 (total loss)	1 (no loss)	1

These parameters are covered by the standard specification API MPMS ch 20.1, First Edition, September 2003.

For firmware versions 2.05 and later, if you select "Special Applications" for the product group, the following parameter must be configured: "Thermal expansion coefficient".

Temperature Correction

If this option is selected, the module will calculate the temperature correction factor (CTL) as determined by the API standard. If this option is cleared, the module will not calculate the temperature correction factor. Instead, it will use the CTL value configured through the Default CTL parameter (meter configuration).

Default CTL

This value is used if the "Temperature Correction" option is unselected (Meter Calculation Options) or if the module cannot calculate the CTL factor. If the calculation fails, the module will set the Temperature Correction Alarm.

Pressure Correction

If this option is selected, the module will calculate the pressure correction factor (CPL) as determined by the API standard. If this option is cleared, the module will not calculate the pressure correction factor. Instead, it will use the CPL value configured through the Default CPL parameter (meter configuration).

Default CPL

This value is used if the "Pressure Correction" option is unselected (Meter Calculation Options) or if the module cannot calculate the CPL factor. If the calculation fails, the module will set the Pressure Correction Alarm.

Default Reference Density

This value is used if the flowing density transferred over the backplane is out of range (alarmed) and "Ignore Default Flowing Density" is selected on the Meter Calculation Options dialog box, or if the density correction calculation fails (also alarmed).

Default Vapor Pressure

If the vapor pressure via TP-15 option is not selected on the Meter Calculation Options dialog box, or the vapor pressure calculation results in error, this value is used as the vapor pressure.

Density Calculation

This section provides detailed explanations about the density correction logic used by the AFC module. It also explains the terminology that is implemented by the module.

Terminology

Conditions (Temperature & Pressure)

- Reference Conditions

  A fixed Temperature and a fixed Pressure at which a fluid's volume accumulation and volume flow rates are to be recorded. Also known as "Base" or "Standard" Conditions. Derives from sales contracts between parties that mandate transfer of fluids in volume units, such as "100,000 gallons of gasoline at 60°F and 1 atmosphere pressure". Typical Reference Conditions are:

  - 60°F and 14.696 psia (US)
  - 15°C and 101.325 kPa (Canada, Europe)
  - 20°C and 101.325 kPa (Latin America)

- Flowing Conditions

  The fluid's T&P in effect at the point the initial measurement is performed (DP measurement (differential meter), pulse counting (linear meter)). Almost always different from Reference Conditions, hence volume correction calculations are required, hence the flow computer.

Densities

- Flowing Density

  Density at Flowing Conditions. Calculations are applied to this to arrive at a Reference Density (next). In the AFC, "Flowing Density" is a process input (over the backplane from the Processor), though if the **Calculation Options** / **Density Correction** configuration is cleared, its value is deemed to be at Reference Conditions regardless of process Temperature and Pressure.

- Reference Density

  Density at Reference Conditions. Also known as "Standard Density". This is a core parameter to the calculation of Volume Correction Factors (VCFs): CTL depends on Reference Density and Temperature; CPL depends on Reference Density, Temperature and Pressure.
  The AFC's "Reference Density" is at user-specified Reference Conditions (User Base), while the Reference Density required for VCF calculations is at API-specified Reference Conditions (API Base); the AFC's calculations account for any difference between User Base and API Base. For MPMS Ch 11.1 (2004), API Reference Conditions are always 60°F and 14.696 psia.

- Corrected Density

  Reference Density resulting from a calculation with inputs of Flowing Density, Temperature, and Pressure. It is the output of a calculation, as opposed to Default Reference Density which is a manual input. In some circumstances, the Corrected Density (output) is merely a copy of the Default Reference Density (input). In the AFC, it is the Corrected Density, not the Default Reference Density, that is used in subsequent VCF calculations.

Defaults

A "Default" value is one that is substituted for another when that other value is either unavailable or erroneous. In effect, it is a choice of last resort. For liquid measurement, the AFC provides two distinct Default Densities, "Default Flowing Density" and "Default Reference Density", both of which are manually entered as part of the meter configuration.

Calculations

The AFC calculates Corrected Density from process inputs (including Flowing Density) under control of its meter configuration that includes Process Input Scaling and two Calculation Options:

- "Ignore Default Flowing Density" (bit 7)
- "Density Correction" (bit 8)

substituting one or both of the Default Densities under certain conditions.

The logic is:

1 Flowing Density process input is marked "Unspecified" (we have not yet determined whether the process input is at Flowing or Reference Conditions).

2 Flowing Density process input is scaled, and if out of range it is substituted by:

a) Default Flowing Density, if "Ignore Default Flowing Density" option is clear, or

b) Default Reference Density, if "Ignore Default Flowing Density" option is set, and in this case the input is marked "Reference".

3 If "Density Correction" option is clear, then the input is marked "Reference", meaning that the process input over the backplane is at Reference Conditions regardless of its "Flowing" designation.

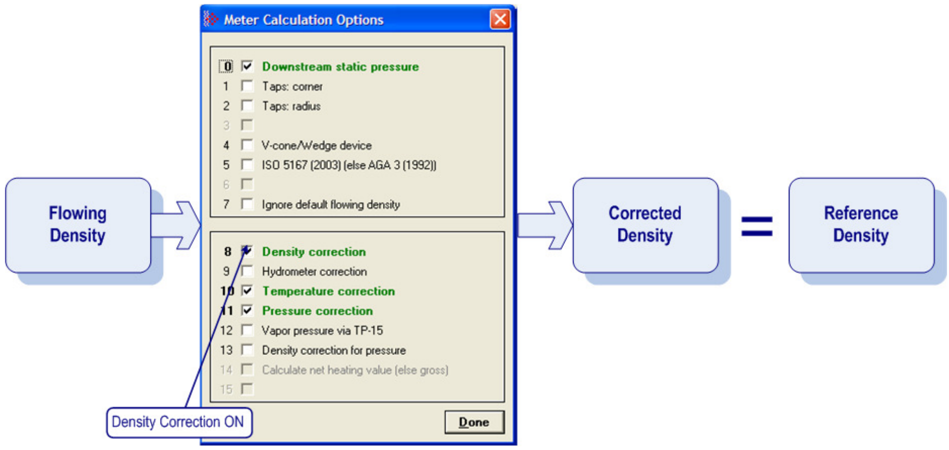
4 If the input is marked "Reference", then Corrected Density acquires this value.

5 If the input is still marked "Unspecified", it is assumed to be "Flowing", and the API density correction calculation is performed, which takes the Flowing Density as input, together with the (already scaled) Temperature and Pressure process inputs. Successful calculation yields Corrected Density as output; an error during the calculation, for example exceeding an API range limit, causes substitution of Default Reference Density for the Corrected Density output.

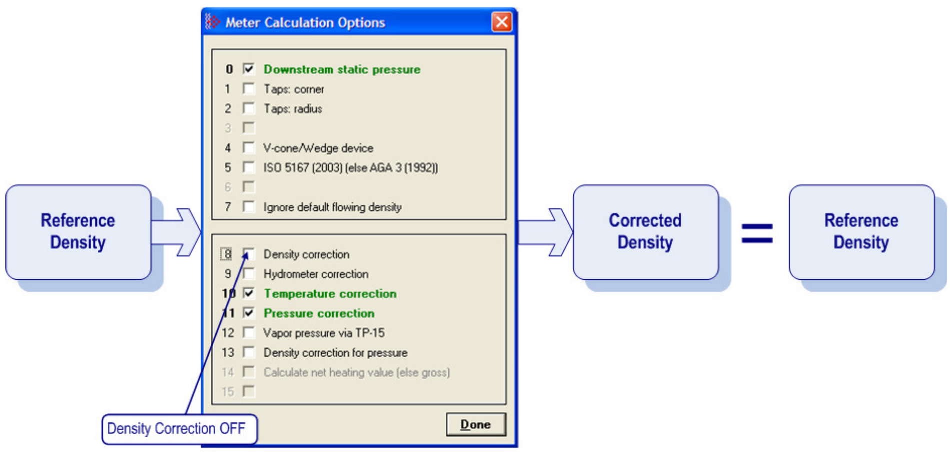
6 This Corrected Density is used for all subsequent VCF calculations.

The following diagram shows two possible density applications.

If input density is at flowing conditions:



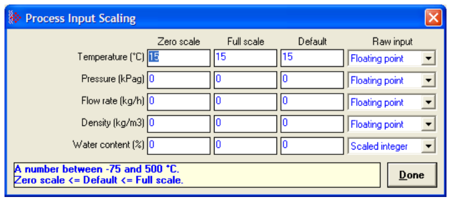
If input density is at reference conditions (already corrected)



Process Input Scaling (Liquid)

This parameter configures how the module will interpret the input variable within the given range. The possible values are floating point, scaled integer, and 4 to 20mA.

Click the Process Input button to configure the valid input ranges. If an input data is not within the configured range, AFC Manager will flag an alarm on the Meter Monitor dialog box and the alarm bit for the meter will be set.



The process input variables available for liquid products depend on the meter type (differential or linear), and the primary input type.

For scaled integer process input scaling, the module requires the following data formats:

Scaled Integer

Variable	**Format**	**Example**
Temperature	Two implied decimal places	A value of 1342 would be equivalent to 13.42°C
Pressure	No decimal places implied for the SI units (kPa) and one decimal place implied for the US units (psi).	A value of 200 would be equivalent to 200 kPa
Differential Pressure	Two decimal places implied for inches of H_2O and three places for kPa	A value of 35142 would be equivalent to 35.142 kPa
Pulse Frequency (Hz)	No decimal places	A value of 200 would be equivalent to 200 Hz
Density (kg/m3)	One implied decimal place	A value of 5137 would be equivalent to 513.7 kg/m3
Density (Relative Density)	Four implied decimal places	A value of 10023 would be equivalent to 1.0023 60°F/60°F.
Density (API)	Two implied decimal places	A value of 8045 would be equivalent to 80.45 °API.
Flow rate	No decimal places implied for the SI units or US units. To obtain desired precision, choose appropriate Primary Input Characteristics	A value of 102 would be equivalent to 102 lb/hr.
Water Content	Two implied decimal places	A value of 105 is interpreted as 1.05%.

3.13 Densitometer Configuration

When measuring liquids with density correction, density at flowing conditions is required. This value may be either provided directly as a process input, or the AFC may calculate it from the frequency output of a densitometer.

<u>To use a densitometer</u>

The module can calculate a density from the frequency provided by a densitometer device. Follow the steps below to use a densitometer.

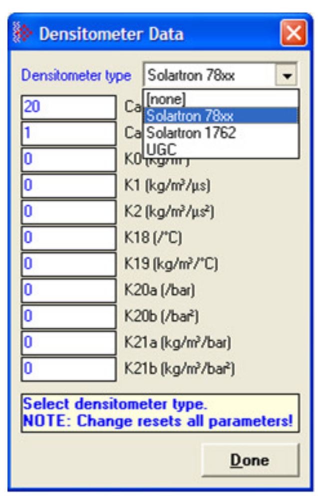
1 Click the Densitometer button to select the densitometer type.
2 Configure it, entering all configuration parameters directly from the calibration data sheet supplied by the densitometer manufacturer.
3 In the Density entry of Process Input Scaling, select Raw Input as 4 to 20 mA.
4 Supply the frequency output from the densitometer in Hz as a floating-point value in the "Flowing density" process-input location over the backplane (refer to the Backplane Interface section for your platform in the AFC User Manual for the correct location).

The AFC then calculates a flowing density value, which is then validated by the range check mandated by the "Density" values of "Process Input Scaling" of the meter configuration. The "Raw Input" sub-selection does not determine the format of the frequency input, however - the frequency is always input as floating-point.

Note: If you use the Densitometer feature, select the Density Process Input Scaling Raw Input for 4 to 20 mA and transmit the densitometer frequency over the backplane as a floating-point value.

3.13.1 Densitometer Data Dialog Box

This dialog box opens when you click the Densitometer button on the Meter Configuration dialog box. Choose the densitometer to use from the list of supported devices, and then fill in the calibration values from the calibration sheet of your densitometer.



3.14 Copying a Configuration From a Meter

For projects where more than one meter uses the same or similar configurations, you can copy the configuration from one meter to another.

To copy a meter configuration:

1 In the Select Meter panel of the Meter Configuration dialog box, select the number of the destination meter (the meter that has not yet been configured).
2 In the Copy Config From panel of the Meter Configuration dialog box, select the number of the source meter (the meter that has already been configured).
3 To copy the meter configuration and meter analysis, click Copy.

This action copies the entire meter configuration except:

- the Meter Tag
- the PLC Image assignments (PTQ-AFC only)

which retain their existing values.

You may then edit the copied configuration for any differences specific to the meter.

4 Meter Proving

In This Chapter

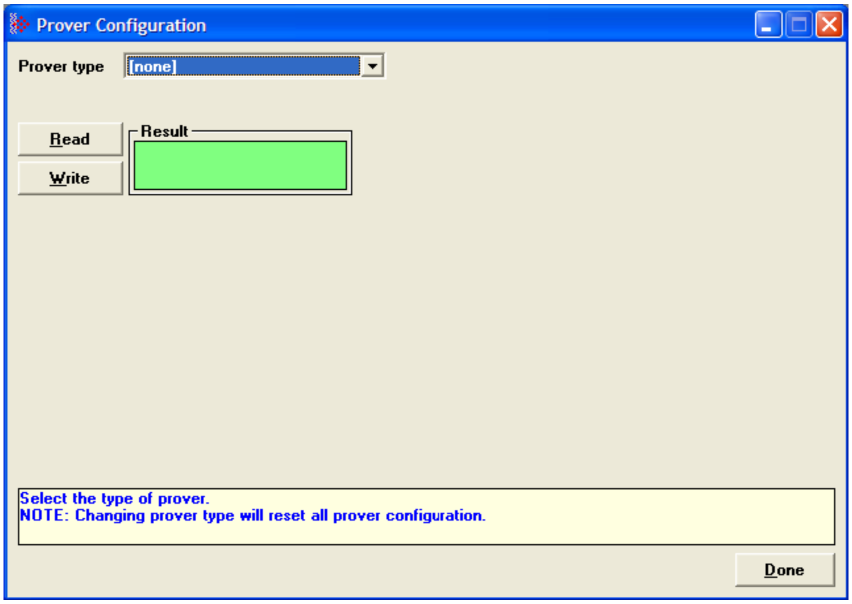
Note: Currently, this function is only available on the MVI56 and MVI69 – AFC modules. For all other platforms continue to use AFC Manager 2.05 or earlier.

As meters continue to be used over time, the meter's measurement accuracy deteriorates. Many things can cause the flow sensor bearings to wear down beyond specified limits so that meters are measuring lower volume levels causing producers to pump more oil than the consumer is buying. Meter Provers have a "Known Traceable Volume" which allows using actual flowing and operating conditions to establish a meter correction factor to restore measurement accuracy.

There are 4 types of provers. This chapter will give a basic overview for each type, its options, and configuration.

- The Unidirectional Pipe Prover
- The Bidirectional Pipe Prover
- The Compact Prover
- The Master Meter

4.1 Prover Configuration



Prover type is a parameter that identifies the basic type of the prover. It's values are:

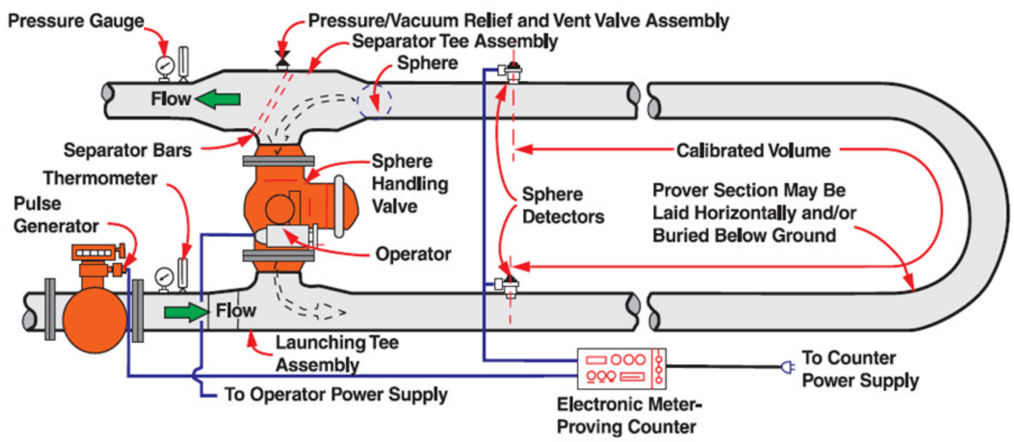
- **NO PROVER CONFIGURED**
- **UNIDIRECTIONAL PIPE PROVER** (You may also choose this selection for an atmospheric tank prover.)
- **BIDIRECTIONAL PIPE PROVER**
- **COMPACT (SHORT, SMALL VOLUME) PROVER**
- **MASTER METER**

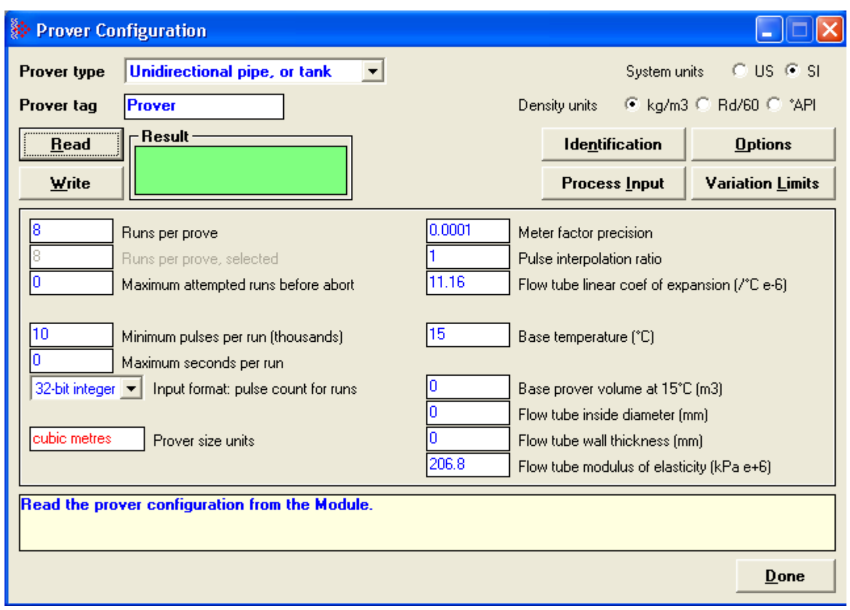
4.1.1 Prover Type

Prover characteristics and configurations will vary based on the type of prover and options you select. The following topics describe each type of prover.

Unidirectional Pipe Prover

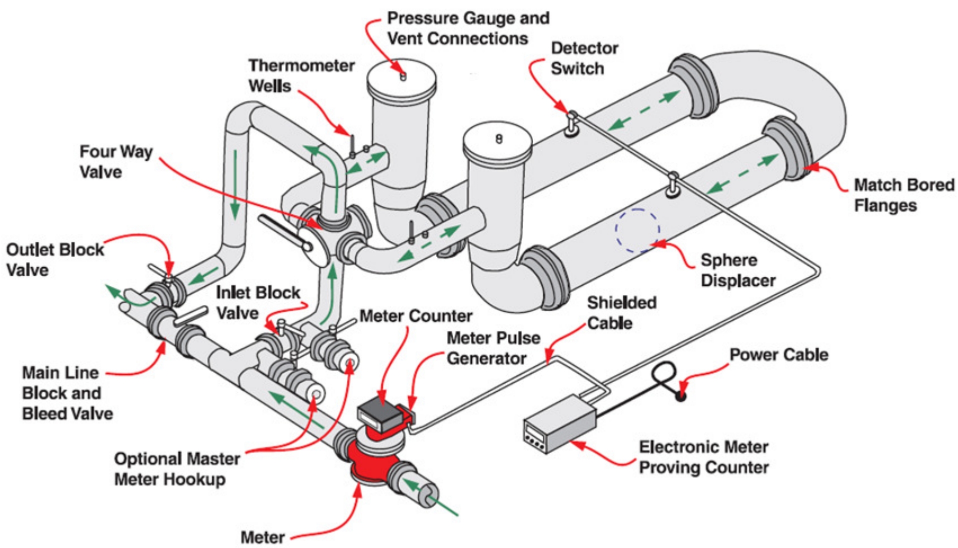
This is a long pipe, with a ball or piston that fills the pipe and moves with the fluid flow. At each end of the pipe is a switch that is tripped when the ball passes it. A proving run counts the pulses occurring between the switch trips. A run is prepared by positioning the ball in a *cul-de-sac* upstream of the first switch, ready to be injected into the stream. At the end of the run, the ball is extracted from the stream and returned via another path to the upstream end. In order to calculate a meter factor with sufficient precision, the prover volume must be large enough to count sufficient pulses. Therefore, unidirectional provers can be quite large.

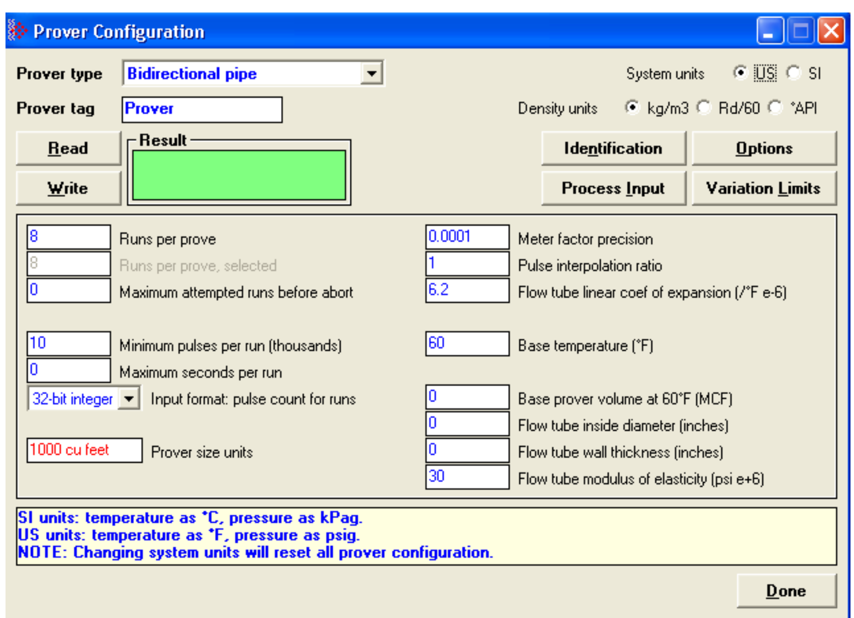




Bidirectional Pipe Prover

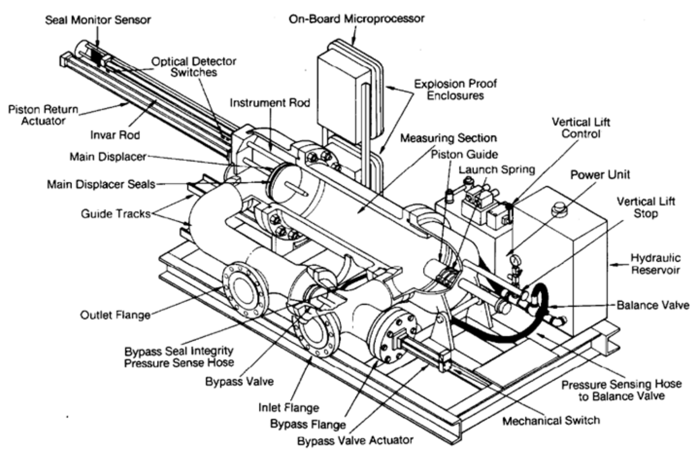
This is similar to a unidirectional prover, except that use is made of the *deadhead* transfer of the ball back to its starting point. Instead of returning the ball via a separate path, valves are swung to reverse the direction of flow in the prover and the ball is returned along its original path to trip the switches a second time in the opposite order. The first pass of the ball is called the *forward leg* and the second is called the *backward* or *return leg*. The pulse count for the run is then the sum of the counts for the two legs. Because the run's pulse count arises from two passes between the switches, a bidirectional prover need be only half the volume of its unidirectional counterpart and can be correspondingly smaller.

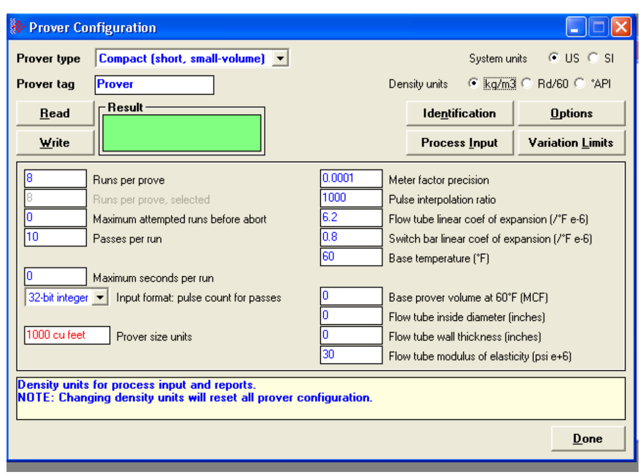




Compact (short, small volume) Prover

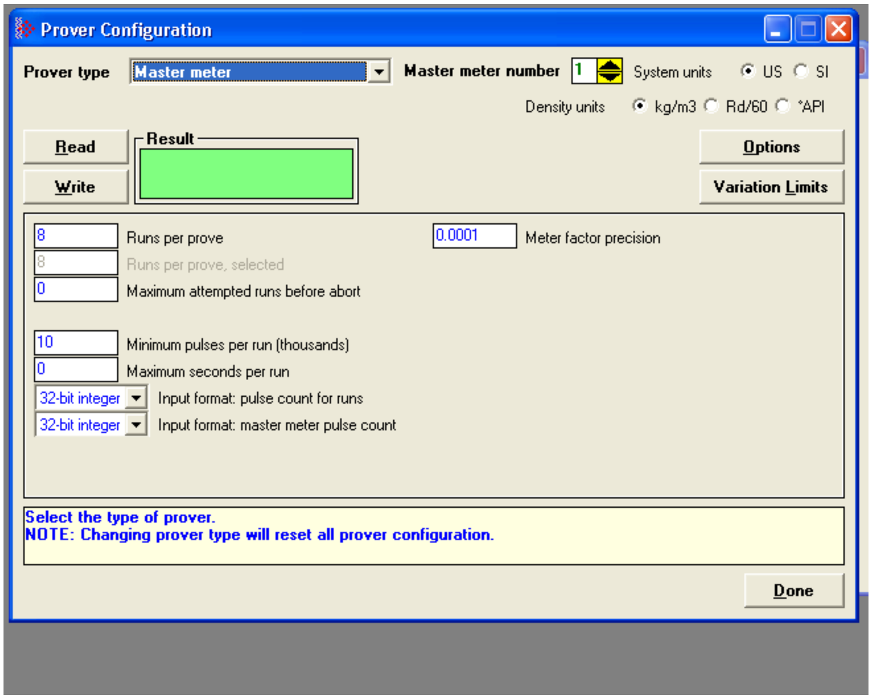
A compact prover, or small volume prover (SVP), has a short barrel or tube with a piston that travels the length of the tube. The piston has a valve that is opened to allow it to return to its starting point without stopping the flow in the tube. Most SVPs do not mount the switches to be tripped inside the tube. They mount the switches externally on a bar that moves with the piston outside the tube and the switches trip when they move past a fixed point. Each forth and back passage is called a *pass*. SVPs can be much less expensive than LVPs, so they are often preferred. Due to their small size they can collect at most a few hundred pulses during a pass. The number of pulses in a single pass is a number too small for calculating a meter factor with sufficient precision. The technique of double chronometry is then used to determine a fractional pulse count of sufficient precision. Even though a single pass in a SVP with double chronometry can yield a pulse count similar in precision to that from a single run of a LVP, it is often the practice to accumulate several passes into a single run so that the pulses totalized for all passes of the run yield a number large enough for calculating the required meter factor with sufficiently high precision.





Master Meter

This proving technique proves a meter by comparing its behavior to that of another *master* meter whose behavior is deemed to be accurate. A master meter itself must be proved to a high precision by using a conventional prover.



4.1.2 Prover Options

There are several options affecting the handling and representation of data, as well as affecting the relevance and availability of some configuration items. Not all options are available for all prover types. If an option does not apply to a particular prover type, it cannot be selected. For a description of each option listed below see the corresponding Modbus dictionary address in parenthesis below.

- Dual transmitters, temperature (65011.0)
- Dual transmitters, pressure (65011.1)
- Input meter density (65011.2)
- Return leg pulse count is round –trip count (65011.4)
- Prover is double-walled (65011.5)
- External switch bar (65011.6)
- Calculation method: Average Meter Factor (else Average Data) (65011.8)

4.1.3 Run Counts

Runs per prove (65012)

The total number of completed runs that constitute a single prove. This value must be at least 2 and must not exceed 8. If *Maximum attempted runs before abort* (register 65014) is non-zero, this value must not exceed that value.

Runs per prove, selected

The total number of completed runs to be selected for contribution to the prove calculations. This value must be at least 2 and not exceed *Runs per prove,* (register 65012). This value is automatically updated when you edit the *Runs per prove* field.

Maximum attempted runs before abort (65014)

The total number of runs to be attempted before abandoning a prove as incomplete, which permits an automatic proving sequence to automatically terminate itself under exceptionally variable conditions. If this value is zero, no limit is imposed. Otherwise, the value must be at least as large as *Runs per prove,* (register 65012) and must not exceed 65535.

4.1.4 Run Input Setup

Minimum pulses per run (thousands) (65016)

The minimum number of pulses required for a run to be considered for contribution to the prove, represented in thousands. This value must lie between 10 (representing 10,000 pulses) and 1000 (representing 1,000,000 pulses). Runs counting 10,000 pulses or more have sufficient precision to enable calculation of 4-digit meter factors. For all prover types except compact SVPs, the AFC rejects any LVP run that does not meet this condition. Since SVPs can deliver fractional pulse counts that provide sufficient precision with only a small number of pulses, the AFC does not impose this limitation on prover calculation using SVPs.

Maximum seconds per run (65017)

This parameter is a timeout for the duration of a run. A timer is started when the run is started, and if the timer value equals or exceeds this value before the run is completed, then the AFC automatically cancels the run. This allows an automatic prove to recover from conditions that put the AFC and the proving hardware out of step, such as a missed switch signal. This value must lie between 0 and 10000, where zero means that no timeout is imposed.

Input format: line meter pulse count (65020)

This parameter is a code that specifies the format in which pulse counts for the line meter are delivered to the AFC at the ends of runs or passes. These values are:

Value	Format	Description
0	None	No pulse counts are delivered. Used only when no prover is configured
1	32-bit	Pulse counts are delivered as 32-bit (double) integers
2	Split-double	Pulse counts are delivered as split-double values, in which the actual value is (MSW * 10,000 + LSW)
3	Floating point	Pulse counts are delivered as IEEE 32-bit floating point values

When a prover is configured, the default setting is 1 (32-bit), except for compact provers, for which it is 3 (floating point).

Input format: master meter pulse count (65021)

This parameter is a code that specifies the format in which pulse counts for the master meter are delivered to the AFC at the ends of runs or passes. These values are:

Value	Format	Description
0	None	No pulse counts are delivered. Used when the prover is not a master meter.
1	32-bit	Pulse counts are delivered as 32-bit (double) integers.
2	Split-double	Pulse counts are delivered as split-double values, in which the actual value is (MSW * 10,000 + LSW).
3	Floating point	Pulse counts are delivered as IEEE 32-bit floating point values.

When a master meter is configured, the default setting is 1 (32-bit). This parameter is meaningful only when using master meter provers.

4.1.5 Prover Characteristics

Prover Characteristics will vary based on the type of prover and options you select. The following topics describe each field and its operating range.

Prover size units (65018.L)

This parameter sets the units in which the prover's base volume is represented. This parameter is not meaningful for master meter provers.

Meter factor precision (65028+)

This parameter is a number between 0.00000001 and 0.0001. The default setting is 0.0001

Pulse interpolation ratio (65030+)

Meter-proving pulse counts delivered to the AFC may be fractional, such as when double chronometry is used with a SVP. This value is the number of delivered counts that constitute a single actual pulse, so that the actual pulse count is determined by dividing the delivered count by this. The default value is 1000.0 for compact provers and 1.0 for other types. This parameter is meaningful only for non-master meter provers.

Flow tube linear coefficient of thermal expansion (65032+)

Holds the coefficient of thermal expansion of the prover barrel material, meaningful only for non-master-meter provers. Here are some typical materials and their expansion coefficients.

- Stainless steel 304 or 316 9.3e-6/°F 16.7e-6/°C
- Monel 7.9e-6/°F 14.3e-6/°C
- Carbon steel 6.2e-6/°F 11.2e-6/°C
- Invar .8e-6/°F 1.4e-6/°C

The default value is that of carbon steel, 6.2e-6/°F 11.2e-6/°C.

Switch bar linear coefficient of thermal expansion (65034+)

Holds the coefficient of thermal expansion of the external switch bar material, meaningful only for non-master-meter provers with option *External switch bar* (register 65011 bit 6) set. Here are some typical materials and their expansion coefficients.

- Stainless steel 304 or 316 9.3e-6/°F 16.7e-6/°C
- Monel 7.9e-6/°F 14.3e-6/°C
- Carbon steel 6.2e-6/°F 11.2e-6/°C
- Invar .8e-6/°F 1.4e-6/°C

The default value is that of invar .8e-6/°F 1.4e-6/°C.

Base prover volume (65036+)

Holds the base volume of the prover barrel as determined by the water-draw method, in the units specified by *Prover size units* (register 65018.L). This parameter is meaningful only for non-master meter provers.

The accepted standards mandate that the base volume of a bidirectional prover be that registered by a round trip of the displacer.

Flow tube inside diameter (mm) (65038+)

This parameter is the measured inside diameter of the prover barrel at standard (base) conditions and is meaningful only for non-master meter provers with the option *Prover is double-walled* (register 65011 bit 5) clear.

Flow tube wall thickness (mm) (65040+)

This parameter is the measured thickness of the prover barrel wall, and is meaningful only for non-master meter provers with the option *Prover is double-walled* (register 65011 bit 5) clear.

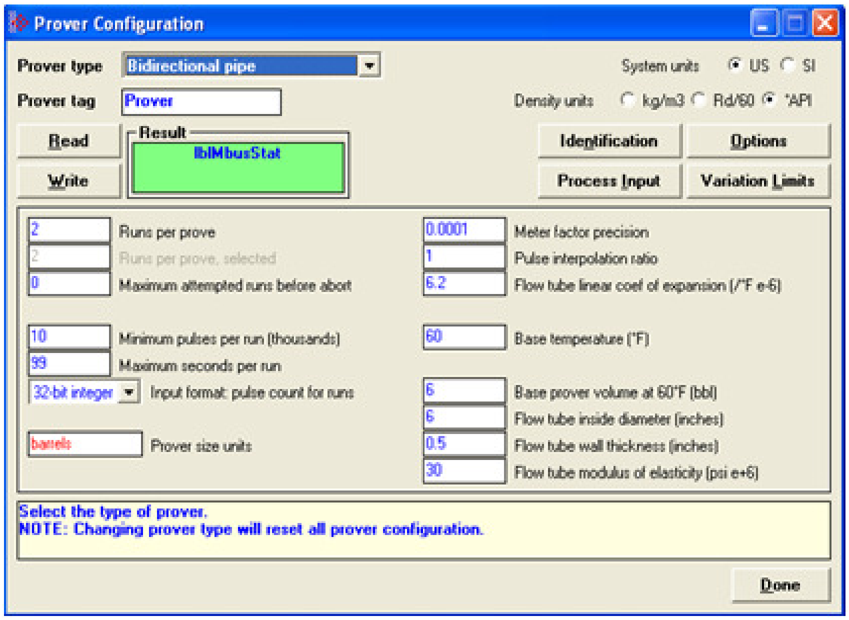
Flow tube modulus of elasticity (65042+)

This parameter is the prover barrel material modulus of elasticity, and is meaningful only for non-master meter provers with the option *Prover is double-walled* (register 65011 bit 5) clear. The default value is that of carbon steel, 206.8e+6 kPa.

4.2 Setting up the AFC module for Meter Proving

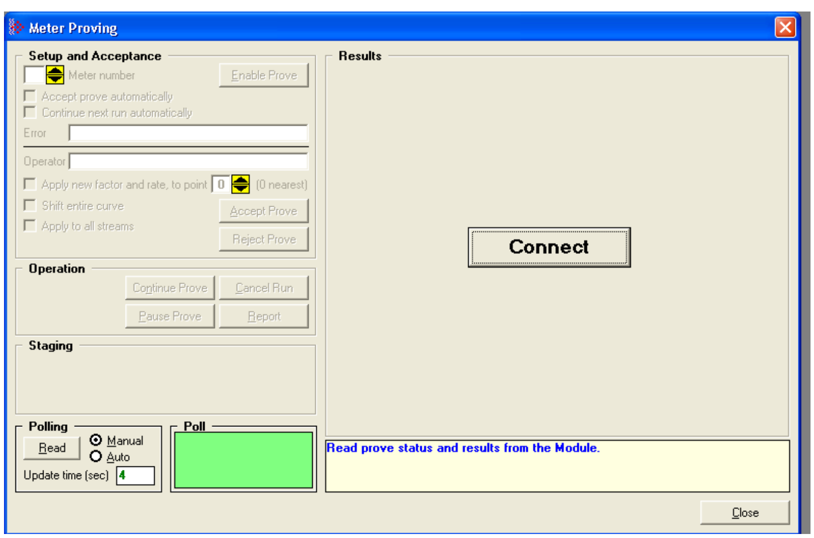
First, configure the parameters in the *Prover Configuration* dialog box. A Bidirectional Pipe Prover is shown in this example.

Note: Changing prover type will reset all prover configuration

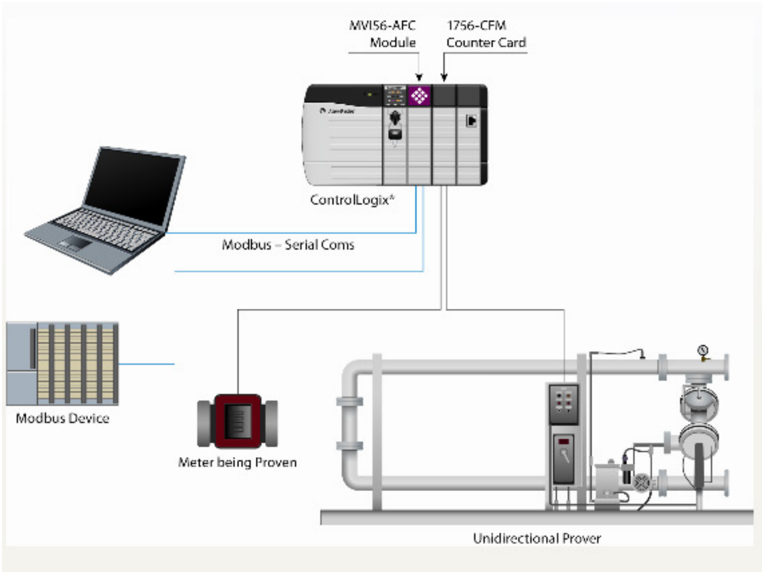


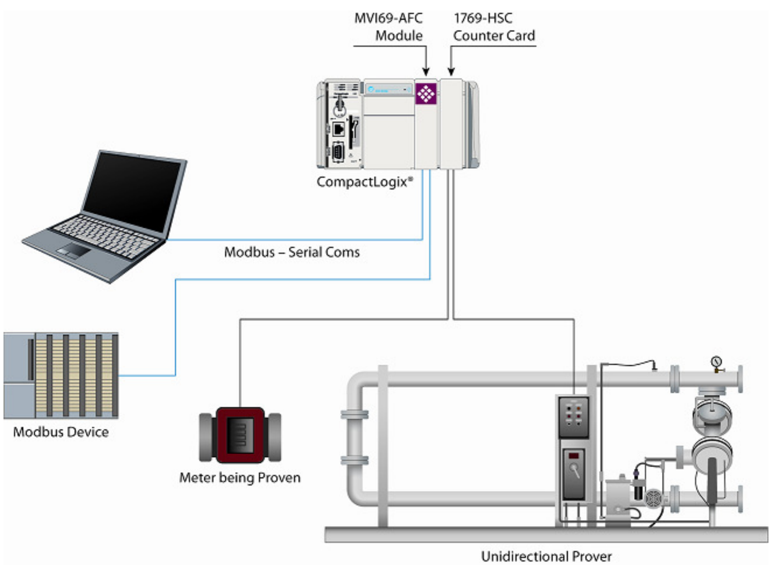
Meter Proving dialog box

This window is used to connect to the module to manage the prove and/or monitor prove status and results from the Modbus database.



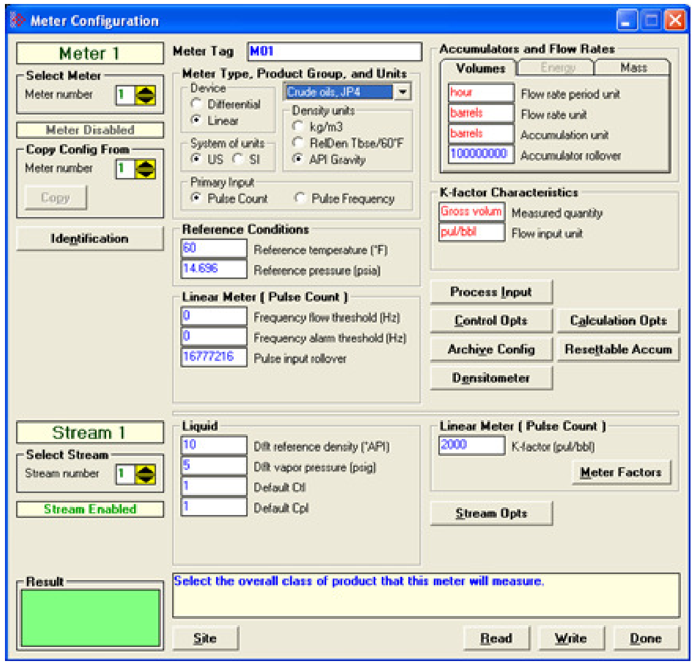
This is a typical configuration for a meter proving setup. Your application may vary from the example shown.



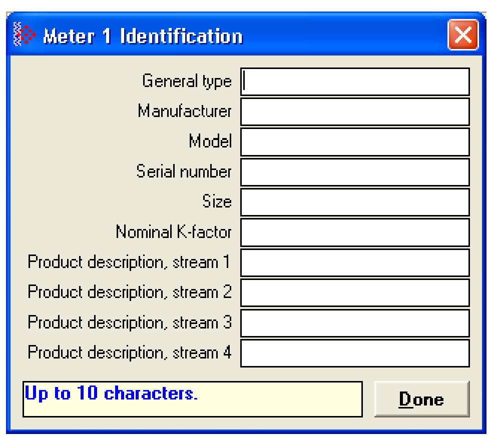


4.2.1 Initial Requirements

In its current version, the AFC supports proving of only liquid products, measured with linear devices that use pulse counts as the primary input variable, where each pulse represents a specific liquid volume.



In the *Meter Configuration* dialog box above, Meter 1 is used in this example as the meter selected to be proved. It can be proved using any one of the four provers that the AFC supports. These provers are described in the *Prover Configuration* section. There is an Identification button which opens an editable options window, shown below. Text entered here appears on the proving report.



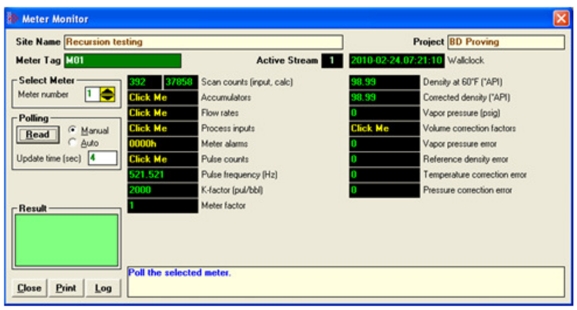
4.2.2 Meter Proving Alarms

These alarms are transient and any one might exist only for a single scan, so they might be missed when viewing this register directly. However, alarms are also accumulated into the results database, so alarms that have occurred during any run may be viewed by inspecting that database.

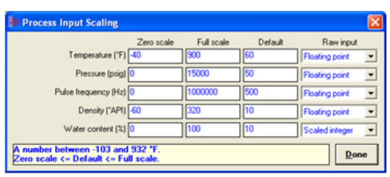
To Check for Alarms

1. Activate *Meter Monitor* dialog box
2. Select **METER** to be proved
3. Click on the **[READ]** button

> **Note**: Verify that the meter is not generating any alarms. Meter proving cannot proceed while any alarm is displayed.



This is accomplished by providing **PROCESS PARAMETER** values that are within the range of the *Process Input Scaling* Dialog box.



There are two sources of *alarms:*

1. From the meter, which occur whether or not a prove is in progress. These are illustrated above.
2. From the prove, and there are 2 kinds:
   a) Variation Limit Alarms
   b) Prove Calculation Alarms

> **Note**: Any alarm will always make a run not able to be selected.

Variation Limit Alarms

These alarms are due to variation outside the configured limits:

Bit/Byte	Description	Modbus Dictionary Address
01	Prover inlet temperature	65050
02	Prover outlet temperature	65052
03	Prover inlet-outlet temperature	65054
04	Prover temperature	65056
05	Prover-meter temperature	65058
06	Switch bar temperature	65060
07	Meter pressure	65062
08	Prover inlet pressure	65064
09	Prover outlet pressure	65066
10	Prover inlet-outlet pressure	65068
11	Prover pressure	65070
12	Prover-meter pressure	65072
13	Meter density	65074
14	Prover density	65076
15	Prover-meter density	65078
16	Water content	65080
17	Meter flow rate	65082
18	Prover flow rate	65084
19	Pulses over runs	65086
20	Pulses over passes	65088
21	Not enough pulses in run	N/A
22-31	[Reserved]	N/A

Prove Calculation Alarms

These alarms arise from prove calculations (e.g. outside API limits):

Bit/Byte	Description
00	[Reserved]
01	CTS prover
02	CPS prover
03	[Reserved]
04	High water
05	CTW
06	CPW
07	Density correction
08	CTL prover
09	CPL prover
10	CSW prover
11	Vapor pressure prover
12	CTL meter
13	CPL meter
14	CSW meter
15	Vapor pressure meter
16	Repeatability
17	Change in factor
18-22	[Reserved]
23	Divide by zero
24-31	[Reserved]

4.2.3 Prover Operation (How to do a Prove)

You must first configure a prover, and configure the channel of a Configurable Flow Meter (CFM) or High Speed Counter (HSC) module for proving.

Note: CFM modules are available for the 1756 platform from Rockwell Automation, and the Quantum platform via Spectrum. Any HSC card will work for the other modules, but if you use an HSC, you will need extra ladder logic in the PLC to complete the prove.

Once the parameters for the proving session have been configured, (pipe diameter, water-draw volume, wall thickness, tolerances and limits on the variation of temperature, flow rate, and other process variables), and the prove setup has been completed, the entire proving session can be completely automated within the PLC ladder logic.

Steps for proving a meter

- **a** Enter the prover parameters and variation limits (configuration)
- **b** Enter the number of the meter to be proved (setup)
- **c** Set the *enable prove* signal bit. This function verifies that the selected meter is provable (a liquid pulse meter), and clears the proving results for a new proving session.
- **d** Enable the counter card channel for proving, and launch the ball. When the first switch is tripped, set the *run start* signal bit. During the run, continuously copy the prover temperature, pressure, density, etc, to the AFC, so that it may monitor their variation and accumulate them for final averaging. For the same purpose, the AFC module itself retrieves meter process variables directly from the meter input from the PLC without PLC intervention.
- **e** When the second switch is tripped, copy the final pulse count from the counter card channel to the proper location and set the *run stop* signal bit This function computes results for the completed run (averages of process variables, variation limit alarms, etc.), and also computes results for the entire prove over all completed runs (averages of run averages, variation limit alarms, API calculations and calculation alarms, final meter factor and change in meter factor, and number of completed runs). Upon a *run start* or *accept prove* signal, any bad runs are deleted from the prove before continuing with with the remainder of the signaled function.
- **f** When a sufficient number of runs have been completed , set either the *accept prove* or the *reject prove* signal, which function marks the data in the prover results accordingly.

Missed Switch

It is possible that the tripping of the second switch to end a run is not seen by the PLC (due to a broken wire or poorly lubricated switch), leaving the AFC and the physical prover in inconsistent states. You may recover from this condition with the *Run Cancel* signal, which clears any active run and resets the AFC to be ready to start a new run. Data from any bad run will also be deleted by the *Run Cancel*.

Proving Controls

These bits supply parameter information to the *Enable prove* and *Accept prove* signals (register 65308 bits 1 and 2 respectively). Control bits 0 through 7 parameterize the *Enable* and bits 8 through 15 parameterize the *Accept*. Controls are latched into the results database upon receipt of a signal. Changes thereafter have no effect on the state of these control bits.

Proving Signals

A prover signal instructs the AFC to immediately perform a particular function once. A signal bit is latched by the process issuing the signal (for example, the PLC) and is unlatched by the AFC when the function has been performed. Prover signals are completely cleared at the start of the next proving scan. Modbus transactions to read the status of these signal bits may, therefore, show uncleared bits for functions that have already been completed but for which the signal bits have not yet been cleared

Prover Sequencing

This parameter reports the state of the proving hardware, making it available to the prove-management software for display of prove status and possible control of the prove. The prove-management feature of AFC Manager uses it only for display. This value usually comes from the proving hardware integrated into the PLC platform, therefore it is normally supplied by the PLC.

Prover Phase

These bits report the state of the run as known by the proving hardware. These values are chosen specifically for compatibility with several kinds of proving hardware, so that the work necessary for the PLC to translate hardware register values into these values required by the AFC is minimized and in many cases can be reduced to a simple mask-and-copy. There are 8 values ranging from 0-7. These values are:

Value	Name	Description
0	Prover not selected (not ready)	This is the normal value when no proving run is in progress.
1	Prover active, not yet counting	The counter card has been initialized for a proving run, but the ball or piston has not yet passed the first switch. Counting of the pulses for the run has not yet begun.
2	Prover active, past first switch and counting	The ball or piston has passed the first switch but not yet passed the second switch, and the run counter is counting pulses. For bidirectional provers, this is the forward leg.
3	Prover active, past second switch	This state is for bidirectional provers only. The ball or piston has passed the second switch of the forward leg, the run counter has been stopped, and the intermediate count for the forward leg is available. During this state the proving hardware should be swinging valves to reverse the stream's direction of flow through the prover, preparing it for the return leg.
4	Prover active, past first switch return leg	This state is for bidirectional provers only. The ball or piston has passed the first switch on the return leg but not yet passed the second switch, and the run counter is counting pulses.
5	Run Complete	The ball or piston has passed the second switch (for bidirectional provers, the second switch of the return leg), the run counter has been stopped, and the count for the run is available. For a bidirectional prover, this count may be either the count for only the return leg or the count for the entire run; use prover option "Return leg pulse count is round-trip count" (register 65011 bit 4) to specify which.
6	Prover not selected (not ready)	Some kinds of proving hardware report this value for a counting mode unrelated to proving. The AFC treats this value the same as value 0.
7	Prover not selected (not ready)	Some kinds of proving hardware report this value for a counting mode unrelated to proving. The AFC treats this value the same as value 0.

Prover Position: Ready for Launch

The prover's ball or piston is ready for launching into the stream. For a bidirectional prover, this is the launch of the forward leg.

Prover Position: Ready for Return

For bidirectional provers only, the prover's ball or piston is ready for launching into the stream for the return leg.

Prover Position: Valve Sealed Behind Ball

The prover's ball or piston has been launched into the stream and the sealing valve has been closed behind it. For a bidirectional prover, this is the start of the forward leg.

Prover Position: Valve Sealed Behind Ball, Return Leg

For bidirectional provers only, the prover's ball or piston has been launched into the stream for the return leg and the sealing valve has been closed behind it.

Prover Temperature

Absolute

This value is the process input temperature of the prover (traditional or master meter) in units relative to absolute zero, and is required for some calculations. This value is meaningful only while a prove is active.

Conventional

This value is the process input temperature of the prover (traditional or master meter) in conventional units. For a traditional prover with dual transmitters, this is the average of the two inputs. This value is meaningful only while a prove is active.

Prover Pressure

Absolute

This value is the process input pressure of the prover (traditional or master meter) in absolute units. This value is calculated as (gauge pressure) + (barometric pressure). This value is meaningful only while a prove is active.

Gauge

This value is the process input pressure of the prover (traditional or master meter) in gauge units. For a traditional prover with dual transmitters, this is the average of the two inputs. This value is meaningful only while a prove is active.

Prove-enable Error Code

This code reports the result of the most recent attempt to enable a prove. If the code is zero, the prove was successfully enabled; a non-zero code reports the reason for failure. The values are:

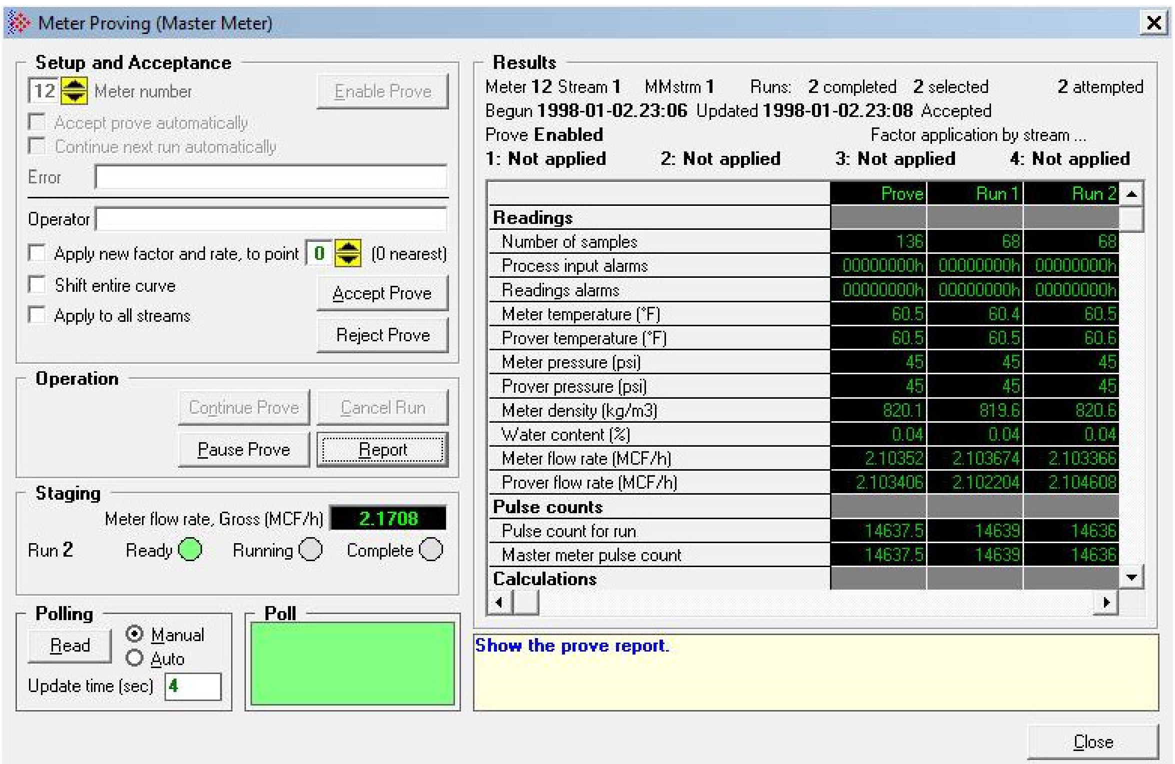
Value	Name	Description
0	The new prove has been enabled	The new prove has been enabled
21	*Requested meter number*	The *Requested meter number* (register 65300) is out of range, or, for a master meter prover, is the same as that of the master meter (an attempt to self-prove the master meter)
22	Line meter not liquid pulse	At the present time, the meter to be proved may only be a liquid pulse meter.
23	Incompatible measurement standard	At the present time, the configuration of both the prover and the line meter to be proved must specify the same system of measurement units (US, SI) and the same liquid density units selection (kg/m3, Rd/60, °API).
24	Unimplemented product group	Because of the nature of the proving calculations at the present time, not all product groups are provable. Meters configured for these product groups are provable: ▪ Liquid (crude oils and JP4) ▪ Liquid (refined products: gasolines, jet fuels, fuel oils, except JP4) ▪ Liquid (NGLs and LPGs) ▪ Liquid (lubricating oils) ▪ Liquid (special applications) Meters configured for these product groups are not provable: ▪ Gas ▪ Liquid (oil-water emulsion of crudes) ▪ Liquid (oil-water emulsion of NGLs)
25	Unimplemented measured quantity	At the present time, only pulse meters whose pulse train represents gross volume can be proved.
28	Line meter in calibration	The meter to be proved has at least one process input in calibration mode. Ensure that all process inputs are *live* before attempting to prove the meter.
29	Line meter not enabled	The meter to be proved is not enabled.
32	Master meter not liquid pulse	At the present time, a master meter prover must be a liquid pulse meter.
33	Master meter incompatible configuration	For a master meter prover, both the line meter and the master meter must be compatibly configured, including identical settings of: ▪ System of measurement units (US, SI) ▪ Liquid density units (kg/m3, Rd/60, °API) ▪ Product group ▪ Measured quantity (gross volume pulses) ▪ Reference conditions (base temperature and pressure) ▪ API calculation options (selection of density, temperature, and pressure corrections) ▪ For product group 8, *Special applications*, the coefficient of thermal expansion *Alpha*

38	Master meter in calibration	The master meter has at least one process input in calibration mode. Ensure that all process inputs are *live* before attempting to use the master meter for proving.
39	Master meter not enabled	The master meter is not enabled.
51	Invalid prover parameter	For a traditional (non-master-meter) prover, the base prover volume (register 65036) must be greater than zero, and, if the prover is single-walled, the inside diameter, wall thickness, and modulus of elasticity (registers 65038, 65040, and 65042) must all be greater than zero.
52	Invalid prover controls	Some undefined bits in the *at-enable* controls (register 65306 bits 0 through 7) have been set.

4.3 Meter Proving Reports

Clicking on the **REPORT** button generates a report with such information as:

- Manufacturer
- Model Number
- Serial Number
- Material Type
- Prover Tag
- Results of the prove will appear in this report, along with the static data entered in the text window during setup. For more information, see Initial Requirements (page 115).



The *Meter Proving* window above shows the system during a prove using a Master Meter. Notice the differences in the example of the information that is available before and after connecting to the module.

4.4 Protected Meter Proving Data in the AFC's Input Register Bank

The data concerned with Meter Proving is maintained in the Input Register Bank, (Modbus 3xxxxx read-only Input Register Addresses), protected from change from outside. There are two areas:

a Latest Prove Results (3x63400 to 3x63709)
b Meter Previous Prove Summary (3x61600 to 3x62399, 50 registers per meter)

These two areas are described in better detail in the following two topics.

4.4.1 Latest Prove Results

This area contains complete details of the latest prove that has been enabled, including

- Prove setup
- Prover and proved-meter configuration summary
- Prove state
- Prove-level calculations
- Run-level input and calculations for each run of the prove

This area supplies almost all the information presented on the proving report (the remaining info comes from the proved meter's Previous Prove Summary; see next). The contents of this area persist until a new prove is enabled, so a proving report may be regenerated at any time after the prove has been completed and before the next one is started. There is only one such area for all meters on the AFC module; therefore enabling a new prove for any meter resets the Prove Results from the last completed prove, regardless of which meters were involved.

The Latest Prove Results is a block of 1310 registers, starting at input register 62400 and proceeding through register 63709. The table below explains these sub-areas.

Name	Module Memory Address	Description
Prove Status	62400 to 62409	Occupies 10 registers
Prove Setup	62410 to 62553	Occupies 140 registers and protects meter configuration and prove setup information for use by proving calculations and report generation; this information remains unchanged from the moment of enable, regardless of how the original source information might be altered during or after the prove
Prove Acceptance	62554 to 62575	Occupies 22 registers and records timestamps associated with the prove, accumulator totalizer values, and details of the disposition of the new meter factor upon acceptance of the prove.
Prover Configuration	62576 to 62655	Occupies 80 registers and has the same purpose as Prove Setup, to protect the prover configuration against subsequent changes so that proving can proceed under reliably constant parameters, and so that the proving report can be generated and regenerated according to the original conditions of the prove.
Prove Only Calculations	62656 to 62665	Occupies 10 registers and contains a few calculated values that are applicable only for the prove as a whole.
Reading and Calculations for Prove	62666 to 62781	Occupies 116 registers and the "readings" part contains the averages of the corresponding readings for all runs of the prove. The "calculations" part contains calculations performed upon the prove-level readings if calculation method "average data" was chosen.
Reading and Calculations for Runs	62782 to 63709	Occupies 166 registers for each of up to 8 runs of the prove. The layout of each block of 116 registers is identical to that of the Readings and Calculations for Prove block. The "readings" part contains the weighted averages or snapshots of all process input and counter card input for the duration of the run. The "calculations" part contains calculations performed upon the run-level readings if calculation method "average meter factor" was chosen.

The Latest Prove Results area has a fixed layout so that any point can always be found at the same location regardless of setup, and with a collection of points intended to be sufficient for a variety of setups. Consequently, many points will be irrelevant for a given combination of prover configuration, meter configuration, and prove setup. Those irrelevant points will have zero values in the Results area and can be ignored. AFC Manager's Meter Proving window does not show irrelevant points.

4.4.2 Meter Previous Prove Summary

This area contains summary data for the previous prove of each of the AFC's meter runs. Each time a new prove is enabled and before the Prove Results area is reset, summary prove information for the meter previously proved (if any) is copied to the meter's Previous Prove Summary block, overwriting the old information. This area supplies a small amount of the information presented in the proving report.

The Previous Prove Summary block for each meter occupies 50 registers. Meter #1's block begins at input register 61600, so that Meter #2's block is at 61650, and so on; registers 61600 to 62399 are allocated to the Previous Prove Summary blocks for up to 16 meter runs.

5 Saving the project

In This Chapter

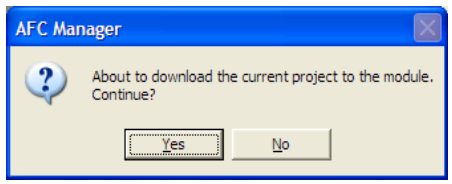
After you have finished working on your project, you should save your configuration so that you can open the project file later if you need to make changes.

To save your project, click the Done button to close any dialog boxes that are open, and then open the File menu and choose Save As to save your project.

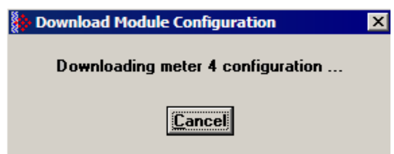
5.1 Configuration Download

A configuration download operation transfers the complete configuration (Meters & Site Configuration) from the local PC to the module. So, instead of writing each meter configuration to the module you can configure all meters at the local PC and then perform a configuration download operation.

After you click "**Project** / **Download Project**", you will be prompted to confirm the action.



After you confirm the download operation, the AFC Manager displays a download progress message:



Note: An "Illegal Data Value" warning indicates that the module has rejected one of the parameters. This error typically occurs when you try to download a meter configuration that has a different meter type, product group, units, density unit or primary input type than the configuration currently stored on the module. You cannot change a meter type when the meter is currently enabled. Disable the meter, perform the change, and then proceed with the download operation.

Another possible cause is that the event buffer is full and the module could be configured to lock any further events. To see the current number of events stored in the event buffer, click **On-Line / Event Log** and then click the Read button. If the "number of events not yet downloaded" is 1999, it indicates that the event log is full.

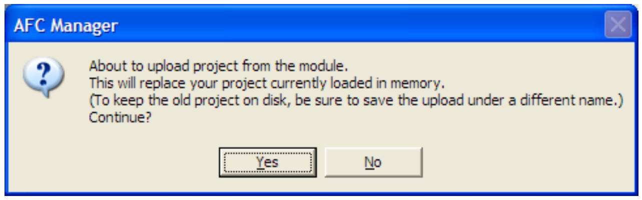
Finally, if "Event log unlocked" is unchecked on the Site Configuration dialog box, the module will not accept any further changes to configuration. Delete all events from the module event buffer, and then select (check) the "Event Log Unlocked" option so that the module can overwrite the oldest event from the buffer when the buffer is full.

Important: The download operation does not transfer the remapping configuration. The only way to transfer it to the module is by following the steps described in the Site Configuration section.

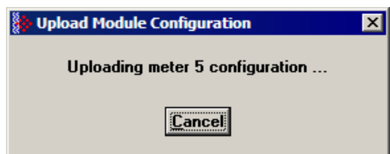
5.2 Configuration Upload

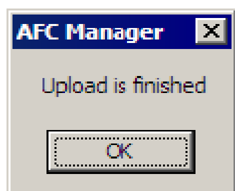
A configuration file upload transfers the complete configuration (Meters & Site Configuration) from the module to the local PC.

After you click "**Project** / **Upload Project**" you will be prompted to confirm the action.



After you confirm the upload operation, the AFC Manager indicates that the upload is in progress:



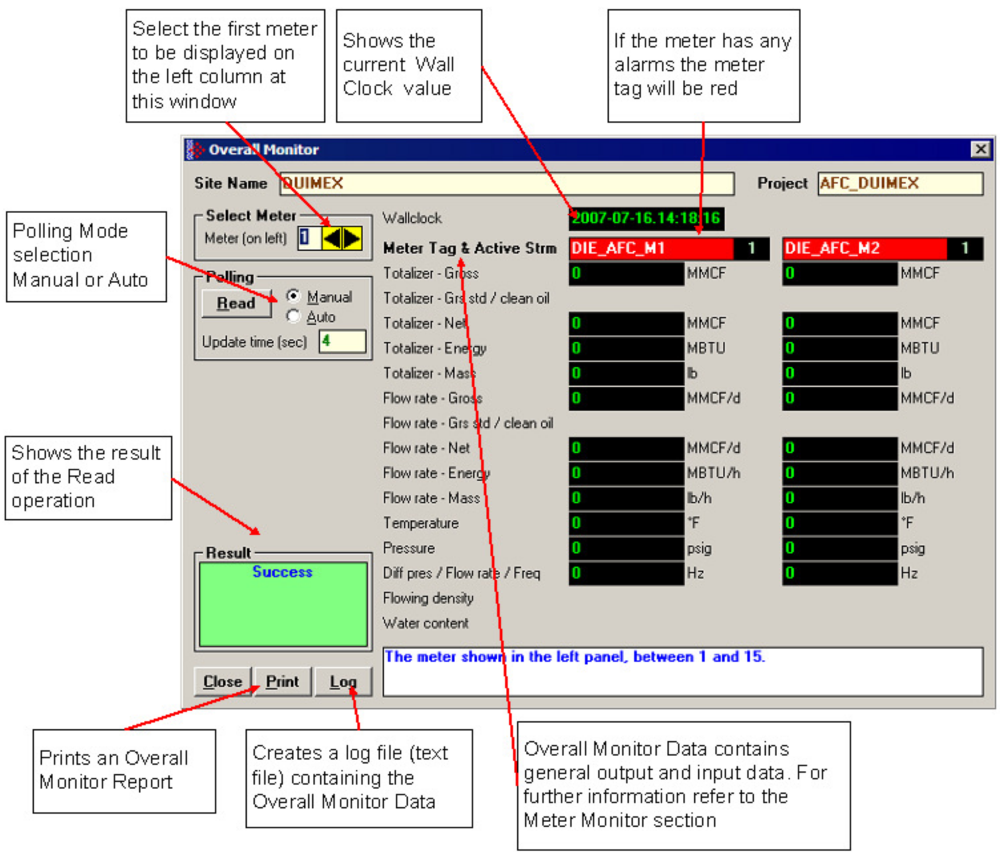


Important: The upload operation does not transfer the remapping configuration. The only way to transfer it from the module is by following the steps described in the Site Configuration section.

6 Overall Monitor

In This Chapter

The Overall Monitor provides a summary overview of all meters with less detail than the Meter Monitor. Use the Overall Monitor to get a summary of all meters. Use the Meter Monitor for more information about a specific meter.



To read data from the module

1 **Select the Meter Number I**n the Select Meter panel, enter the meter number that will be displayed on the left. The dialog box shows two meters at once, so the consecutive meter will be displayed on the right.
2 **Select the Polling Mode** The Polling Mode determines how frequently the data will be updated from the module.
   - **Manual:** the data will be read once.
   - **Auto:** the data will be updated periodically. Enter the number of seconds between each update operation in the Update Time (sec) field.
3 **Click the Read Button** After selecting the Polling Mode, click the Read Button to read the current meter data from the module.
4 Look at the Result Area for the read operation status.

Status	Description
Transmitted	The read operation has commenced
Success	The read operation has completed
Timeout	The operation was not completed due to communication problems. Check the cable and communication parameters. It is essential that the communication parameters in the local PC are the same as the current module meter configuration.

If the read operation has been successfully completed, but the output data calculated by the module does not seem to update correctly, follow these steps:

- Perform two consecutive Read operations to check if the Wall Clock is currently running. **If the Wall Clock is not running, the module may not correctly perform some time-scheduled operations.** The Wall Clock is set by the ladder logic (Wall Clock function). It should be set at least at every rack power up. Look at the ladder logic if the Wall Clock is not updating.
- Check to see if the meter has an alarm. If the Meter Tag background is red, it indicates that the meter has at least one alarm. The alarm typically indicates that an input is invalid or that there is some configuration error that would potentially affect the flow calculations. Refer to the Meter Monitor section in order to find out which alarm is currently set.
- Check to see if the meter is currently enabled. If the meter is disabled, the module will not perform the flow calculation for that meter. If you are currently on line to a disabled meter, the meter tag will be black. Refer to the Meter Configuration for more information about enabling and disabling a meter.
- Look at the process input variable (ex: temperature, pressure, and so on). Check to see if the variables values displayed on the Overall Monitor dialog box match the actual values transmitted by the processor. If the values do not match, look at the ladder logic in order to verify if the data is being transmitted correctly. Refer to the module's user manual for more information about the Process Variable function.

6.1 Create the File Report (Log File)

Click the Log Button to create a Log File that contains the last data read from the module. The following shows an example log file where only meter 1 is enabled:

```
AFC-56(16) Metering Data                                  Date: 16-09-2002 11:53:51
 Site Name: MVI Flow Station
 Project: AFC


 Meter 1:
Tag                                                      M01
Gross accum: totalizer (x f3)                            1290
Net accum: totalizer (x f3)                              214197
Mass accum: totalizer (x lb)                             12173
Gross flow rate (x f3/h)                                 564.0053
Net flow rate (x f3/h)                                   42568.86
Mass flow rate (x lb/h)                                  1954.654
Temperature (°F)                                         15
Pressure (psig)                                          1000
Differential pressure (hw)                               22
Alarms                                                   0200h

 Meter 2:
Tag                                                      M02
This meter channel is not enabled or used.

 Meter 3:
Tag                                                      M03
This meter channel is not enabled or used.

 Meter 4:
Tag                                                      M04
This meter channel is not enabled or used.

 Meter 5:
Tag                                                      M05
This meter channel is not enabled or used.

 Meter 6:
Tag                                                      M06
This meter channel is not enabled or used.

 Meter 7:
Tag                                                      M07
This meter channel is not enabled or used.

 Meter 8:
Tag                                                      M08
This meter channel is not enabled or used.

 Meter 9:
Tag                                                      M09
This meter channel is not enabled or used.

 Meter 10:
Tag                                                      M10
```

```
This meter channel is not enabled or used.

 Meter 11:
Tag                                               M11
This meter channel is not enabled or used.

 Meter 12:
Tag                                               M12
This meter channel is not enabled or used.

 Meter 13:
Tag                                               M13
This meter channel is not enabled or used.

 Meter 14:
Tag                                               M14
This meter channel is not enabled or used.

 Meter 15:
Tag                                               M15
This meter channel is not enabled or used.

 Meter 16:
Tag                                               M16
This meter channel is not enabled or used.
```

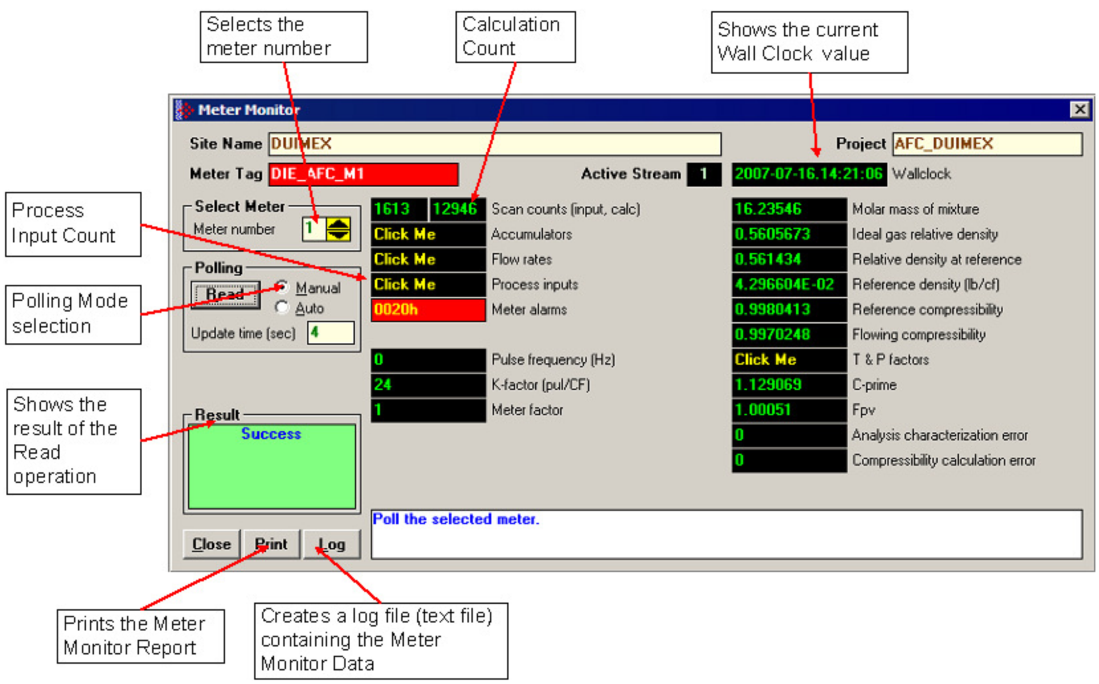
7 Meter Monitor

In This Chapter

Use the Meter Monitor to monitor each meter run by reading the results calculated by the module, the current input values, and any meter alarms.

Note: For more information about the meaning of specific values calculated by the module, we suggest that you refer to applicable measurement standards. It is beyond the scope of this document to discuss flow measurement theory.

Click on *Monitor / Meter Monitor* in order to open the Meter Monitor dialog box:



To read data from the module

1 **Select the Meter Number** In the Select Meter panel, enter the meter number that will be displayed.
2 **Select the Polling Mode** The Polling Mode determines how frequently the data will be updated from the module.
   - **Manual:** The data will be read once.
   - **Auto:** The data will be updated periodically. Enter the number of seconds between each update operation in the Update Time (sec).
3 **Click the Read Button** After selecting the Polling Mode, Click the Read Button to read the current meter data from the module.
4 **Look at the Result Area** Look at the Result Area for the read operation status.

Status	**Description**
Transmitted	The read operation has commenced.
Success	The read operation has completed
Timeout	The operation was not completed due to communication problems. Check the cable and communication parameters. It is essential that communication parameters on the local PC are the same as the current module meter configuration.

If the read operation has been successfully completed, but the output data calculated by the module does not seem to update correctly, follow these steps:

- Perform two consecutive Read operations to determine if the Wall Clock is currently running. **If the Wall Clock is not running, the module may not correctly perform some time-scheduled operations.** The Wall Clock is set by the ladder logic (Wall Clock function) and should be set at least at every rack power up. Look at the ladder logic if the Wall Clock is not updating.
- Determine if the meter has an alarm. If the Meter Tag background is red, it indicates that the meter has at least one alarm. The alarm typically indicates that an input is invalid, or that that there is some configuration error that would potentially affect the calculations. Refer to Alarm Monitor (page 147) to determine which alarm is currently set.
- Determine if the meter is currently enabled. If you are online to a disabled meter, the meter tag is black. If the meter is disabled, the module will not perform the calculation for that meter. Refer to Meter Configuration for more information about enabling and disabling a meter.
- Look at the process input variable (ex: temperature, pressure, and so on). Verify that the variable values displayed on the Process Inputs subwindow (subsection Input Data Monitor in this chapter) match the actual values transmitted by the processor. If the values do not match, look at the ladder logic in order to verify that the data is being transmitted correctly. Refer to the module's user manual for more information about the Process Variable function.

7.1 Print the Report

Click the Print button on any type of report to send a copy to your default printer. The following example shows a typical report.

```
AFC-56(16) Metering Data                              Date: 16-09-2002 12:04:04
    Site Name: MVI Flow Station
    Project: AFC
    ___________________________________________________________________________

    Meter 1:
   Tag                                                M01
   Gross accum: totalizer (x f3)                      1383
   Gross accum: residue (x f3)                        0.3344682
   Net accum: totalizer (x f3)                        221451
   Net accum: residue (x f3)                          7.455254E-02
   Mass accum: totalizer (x lb)                       12537
   Mass accum: residue (x lb)                         0.6372076
   Gross flow rate (x f3/h)                           483.1948
   Net flow rate (x f3/h)                             40248
   Mass flow rate (x lb/h)                            2280.571
   Temperature input (Floating point)                 15
   Temperature (°F)                                   15
   Pressure input (Floating point)                    1000
   Pressure (psig)                                    1000
   Differential Pressure input (Floating point)       22
   Differential pressure (hw)                         22
   Pressure extension                                 149.4683
   Velocity of approach factor Ev                     1.032773
   Expansion factor Y                                 0.9997441
   Discharge coefficient Cd                           0.6042569
   Orifice characterization error                     0
   Molar mass of mixture                              21.42973
   Ideal gas relative density                         0.7399113
   Relative density (60°F/60°F)                       0.7404104
   Reference density (kg/m3)                          5.666295E-02
   Flowing density (kg/m3)                            4.719774
   Fpv                                                1.050526
   Reference compressibility                          0.9989105
   Flowing compressibility                            0.9051347
   Composition factor                                 0.2728558
   Analysis characterization error                    0
   AGA8 calculation error                             0
   Alarms (details below)                             0000h

   Alarm Bits
   bit  0  Temperature input out of range               -
   bit  1  Pressure input out of range                  -
   bit  2  Diff. pressure input out of range            -
   bit  3  Flowing density input out of range           -
   bit  4  Water content input out of range             -
   bit  5  Diff. pressure low                           -
   bit  8  Orifice characterization error               -
   bit  9  Analysis total zero                          -
   bit 10  Analysis total not normalized                -
   bit 11  AGA8 calculation error                       -
   bit 12  API calculation error, density correction    -
```

```
bit 13  API calculation error, Ctl                -
bit 14  API calculation error, vapor pressure     -
bit 15  API calculation error, Cpl                -
```

7.2 Accumulator Monitor

The accumulators display the total fluid quantities accumulated since the last time they rolled over or were reset.

The AFC calculates accumulations (and flow rates) for several different "measured quantities", depending on the Product Group. These are:

Quantity	Products	Description
Gross Volume	All	Volume at operating conditions (includes water content of liquids)
Net Volume	All	Volume corrected to reference (base) conditions (water content of liquids removed)
Mass	All	Mass (water content of liquids removed)
Energy	Gas	Energy content (heating value)
Gross Standard Volume	Non-emulsion liquids	Volume corrected to reference (base) conditions with water content included
Gross Clean Oil	Emulsion liquids	Volume at operating conditions with water content removed
Water	Liquids	Volume of the water content corrected to reference (base) conditions

The AFC first calculates one of these quantities, the "primary" quantity, from process input depending on the meter type, then derives the other quantities by applying an appropriate combination of factors such as Temperature and Pressure Correction Factors, Density, characteristic Energy Content, and Water Content process input. These "primary" quantities are:

Meter Type	Primary Quantity
Differential Pressure	Mass
Differential Flow Rate	Configured Primary Input Measured Quantity
Linear	Configured K-factor Measured Quantity

The accumulators are expressed as the Totalizer and Residue parts. In this way, it is possible to accumulate a wide range of increments, up to a very large rollover of the integral part, while keeping a high precision of fractional part with an approximately constant and small roundoff error.

The totalizer stores the integral part of an accumulator as a 32-bit (or split) integer.

The residue is the fractional part (always less than 1.0) expressed as a 32-bit IEEE floating point. The residue is obtained using the following formula:

```
Residue = Total Accumulator – Totalizer
```

This technique ensures that the fractional part always has precision of between 7 and 8 decimal digits, and the round-off error of accumulation is always of the order of 2**(-24) of a totalizer unit, regardless of how large the totalizer itself is.

There are two types of accumulators: non-resettable and resettable accumulators.

7.2.1 Non-Resettable Accumulator

A non-resettable accumulator is only reset when the accumulator rollover value you configured (refer to the Meter Configuration section) is reached.

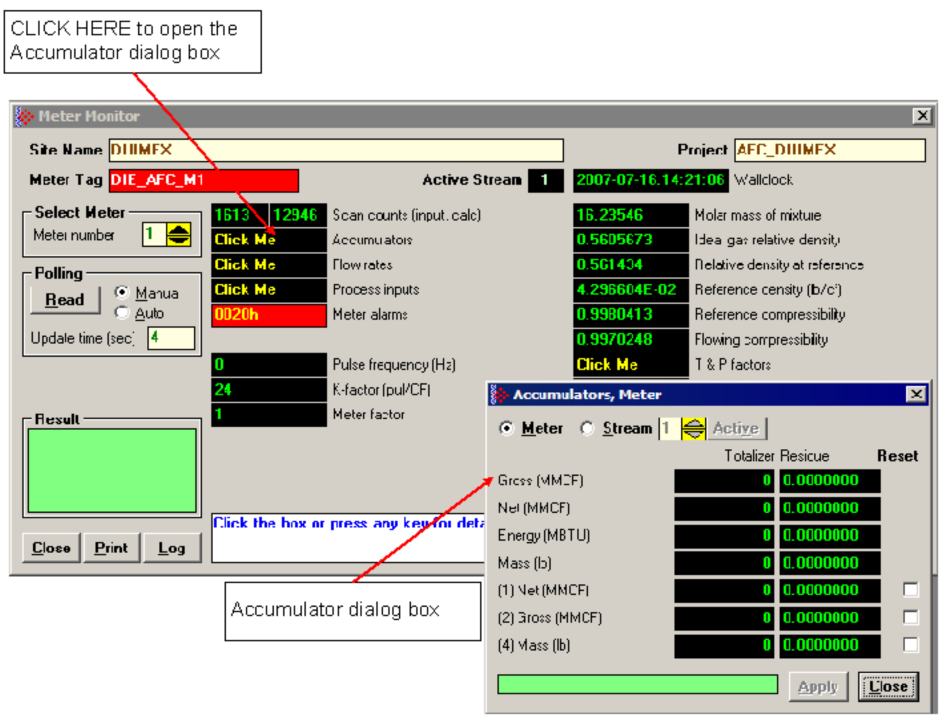
7.2.2 Resettable Accumulator

A Resettable Accumulator is reset automatically when the accumulator rollover value you configured (refer to the Meter Configuration section) is reached.

A Resettable Accumulator value may also be reset when the archive period end is reached. In this case the archive will be created and the resettable accumulator will be reset.

A resettable accumulator may also be reset by explicit signal, which may be issued by the PLC or SCADA, or by you manually.

To reset an accumulator manually, select the checkbox next to the accumulator to be reset, and then click Apply.

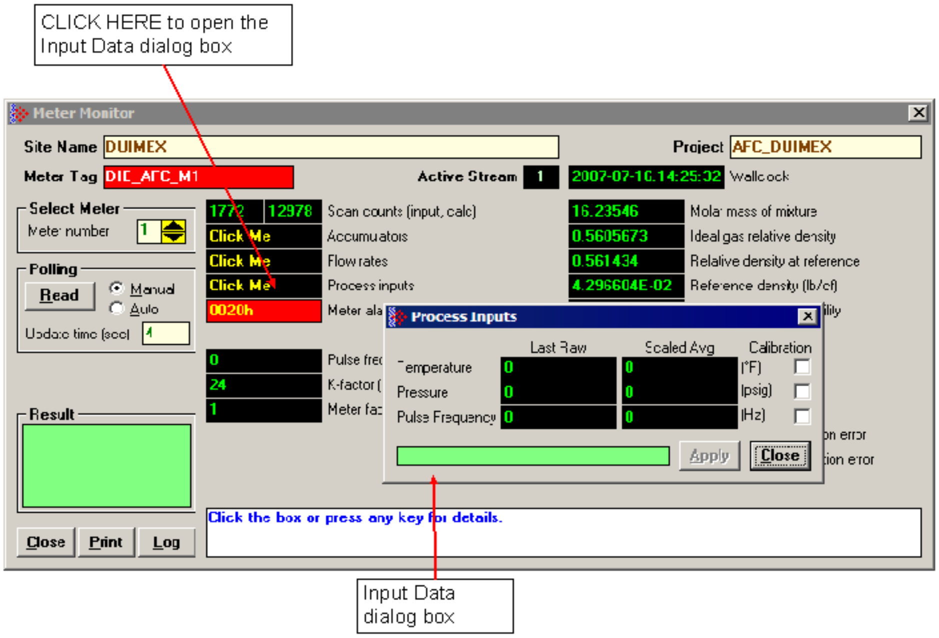


7.3 Flow Rate Monitor

You can monitor the flow rate values at any time. The flow rate units will be the ones you selected in the Meter Configuration dialog box.

7.4 Input Data Monitor

The processor constantly updates the input data values. You can verify these values as shown below:



Using these data is particularly important when troubleshooting the meter run, since you can verify if the values transferred from the processor are correctly being received at the module.

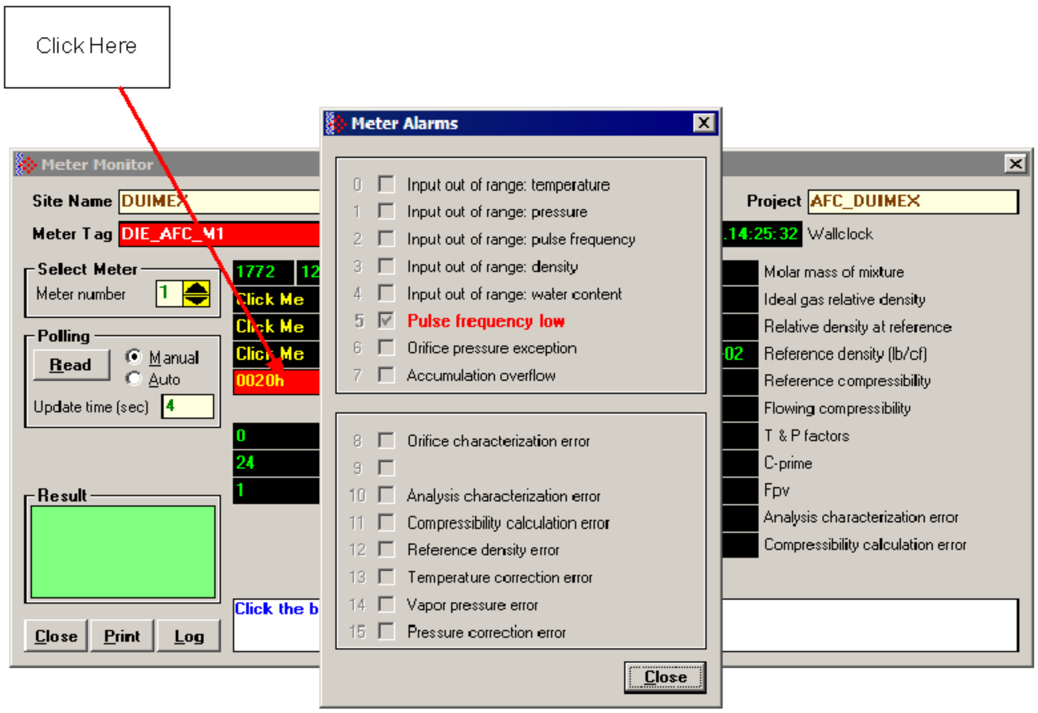
7.4.1 Calibration

The "Calibration" checkboxes force the AFC to "freeze" the input value for further calculations, until Calibration Mode is removed, at which time the AFC resumes taking the live value as the value of the input. Its purpose is to allow calibration of transmitters without shutting down or having to adjust measurement. During calibration, the transmitter's output may undergo significant changes that do not accurately reflect the value of the input. Calibration Mode makes the AFC ignore such changes, which assumes instead that the input value is constant throughout the period of calibration, holding the value of the input as it was at calibration start.

To switch an input into or out of Calibration Mode, toggle the checkbox and click Apply.

7.5 Alarm Monitor

If the module is generating unexpected data, you should verify if the meter has any alarms. Some alarms may be caused by an issue that could potentially affect the calculation results. Each archive also keeps track of the alarms that have occurred during the period (refer to the Archive section). The Meter Monitor dialog box allows you to monitor the meter alarms.



The above image shows the Meter Alarms bitmap, which gives you a quick overview of active alarms. Associated with many of these bits are Alarm Code registers which supply specific reasons for the alarms, most of which appear in the lower right corner of the main Meter Monitor window. For complete information, including which Code registers are associated with which alarm bits, use the Modbus Dictionary feature of AFC Manager.

The possible alarms are listed in the following table. Of the Alarm Codes listed, the values that can actually appear depend on both the selected Product Group and the firmware version.

Alarm Message	Description	Solution
Accumulation Overflow	The module ignores an accumulator increment of less than zero or greater than 1.000.000.000 occurring in a single meter scan.	Check your meter configuration to verify if your project is generating reasonable values.
Analysis Total Not Normalized (v ≤ 2.04)	Absolute difference between analysis total and 1.0000 (100%) is greater than the error tolerance	Make sure that the sum of all molar concentrations is within the error tolerance of 1.0000 (100%).

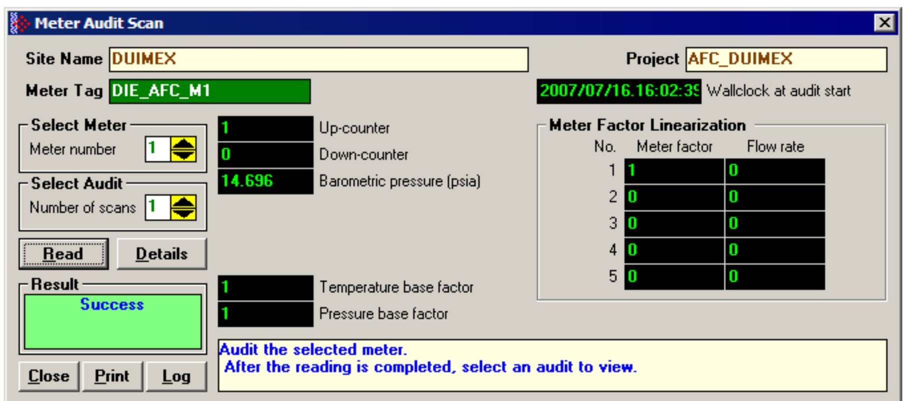
Alarm Message	Description	Solution
Analysis Total Zero ($v \leq 2.04$)	The molar concentration sum is zero.	Make sure that the sum of all molar concentrations is within the error tolerance of 1.0000 (100%).
Analysis Characterization error ($v \geq 2.05$)	Absolute difference between analysis total and 1.0000 (100%) is greater than the error tolerance, OR the molar concentration sum is zero.	Make sure that the sum of all molar concentrations is within the error tolerance of 1.0000 (100%). Alarm Code values: 0 = No alarm 1 = Analysis total not normalized 2 = Analysis total zero
Compressibility calculation error	The compressibility calculation resulted in error based on the input values and configuration parameters used.	Check the input values and meter configuration parameters. Alarm Code values: 0 = No alarm 1 = Density exceeded reasonable maximum (warning only) 2 = Pressure maximum found 3 = Non-convergence of procedure "braket" 4 = Non-convergence of procedure "ddetail"
Differential Pressure Low	The differential pressure value transferred to the module is below the DP Alarm Threshold parameter configured in the Meter Configuration.	Check the input differential pressure value transferred to the module. If the value is correct, change the DP Alarm Threshold parameter for your project.
Flow Rate Low	The flow rate value transferred to the module is below the FR Alarm Threshold parameter configured in the Meter Configuration.	Check the input flow rate value transferred to the module. If the value is correct, change the FR Alarm Threshold parameter for your project.
Pulse Frequency Low	The pulse frequency value transferred to the module is below the Frequency Alarm Threshold parameter configured in the Meter Configuration.	Check the input pulse frequency value transferred to the module. If the value is correct, change the Frequency Alarm Threshold parameter for your project.
High Water error	Set if input water content is greater than 99% (less than 1% oil). For this condition, the emulsion is deemed to be all water. Both volume and mass fractions are set to zero. The module does not perform any density correction calculation, so the "default standard density" value is assumed. This alarm is applied for emulsion liquids only.	Check that the value of process input "Water %" is reasonable Alarm Code values: 0 = No alarm 1 = Emulsion is more than 99% water
Input Out of Range	The input value is not within the range specified in the meter configuration window. Applies to temperature, pressure, differential pressure, flowing density, water content, pulse frequency ($v \geq 2.05$).	Check that the input variable's ranges (**Meter Configuration** / **Process Input** button) and the process input itself have reasonable values.

Alarm Message	Description	Solution
Orifice Characterization error	The orifice parameters (**Meter Configuration** / **Orifice** button) are invalid.	Check the orifice and meter parameters. The following conditions should be true: ▪ Orifice diameter > 0 ▪ Tube diameter > 0 ▪ Orifice diameter < Tube diameter The beta ratio between the orifice and tube diameters should follow the AGA Standard. Alarm Code values: ▪ 0 = No alarm ▪ 1 = Orifice diameter non-positive ▪ 2 = Orifice not narrower than pipe ▪ 3 = Beta ratio less than 0.10 (adjusted by tolerance) ▪ 4 = Beta ratio greater than 0.75 (adjusted by tolerance) ▪ 5 = Pipe diameter less than 2.0 inches (adjusted by tolerance) ▪ 6 = Orifice diameter less than 0.45 inches (adjusted by tolerance) The "tolerance", fixed by the AFC firmware, allows the AGA limits to be exceeded by up to 75% towards the physical limit. For example, while AGA restricts pipe diameter to 2.0 inches or greater, the AFC allows it to be as small as 0.5 inch.
Orifice Pressure Exception	Configuration and process input for an Orifice Meter are such that the effective downstream pressure is less than vacuum. For calculation, upstream pressure is raised by the amount necessary to raise absolute downstream pressure to zero.	Check the process inputs for Gauge Pressure and Differential Pressure, and the configured Barometric Pressure and Static Pressure Tap Location. Also check any performed vapor pressure calculations to ensure that all are reasonable.
Pressure correction error	The pressure correction calculation resulted in an error according to the standard.	Alarm Code values: 0 = No alarm 1 = Density outside range of API Chapter 11.2 2 = Temperature above near critical limit 3 = Temperature outside range of API Chapter 11.2.1 4 = Temperature outside range of API Chapter 11.2.2 5 = Non-convergence of Cpl-density iteration

Alarm Message	**Description**	**Solution**
Reference density error	The density correction calculation resulted in an error according to the standard.	Alarm Code values:: 0 = No alarm 1 = Low density (NGLs), input outside API range 2 = High density (crudes & refined), input outside API range 3 = Non-convergence 4 = Zero VCF 5 = Temperature above critical point 6 = Input density outside reference fluid adjusted range 7 = Corrected density out of range 8 = Standard density input outside API range 9 = Alpha input outside API range Also check the input values and calculation parameters for your project.
Temperature Correction error	The temperature correction calculation OR the water temperature correction calculation resulted in an error according to the standard.	Alarm Code values: 0 = No alarm 1 = Low density (NGLs), input outside API range 2 = High density (crudes & refined), input outside API range 5 = Temperature above critical point 9 = Alpha input outside API range Also see the Alarm Code for Water Temperature Correction error.
Vapor pressure error	The vapor pressure calculation resulted in an error according to the standard.	Alarm Code values: 0 = No alarm 1 = Expected vapor pressure above range of TP-15 (stream's "Default Vapor Pressure" is substituted) 2 = Vapor pressure > measured static absolute pressure (vapor pressure assumed to equal static pressure) 3 = Both 1 and 2
Water Temperature error (Alarm Code only)	The water temperature correction calculation resulted in an error according to the standard. This Alarm Code sets the "Temperature Correction error" alarm bit.	Alarm Code values: 0 = No alarm 1 = Temperature < 0°C (32°F) or > 138°C (280°F)

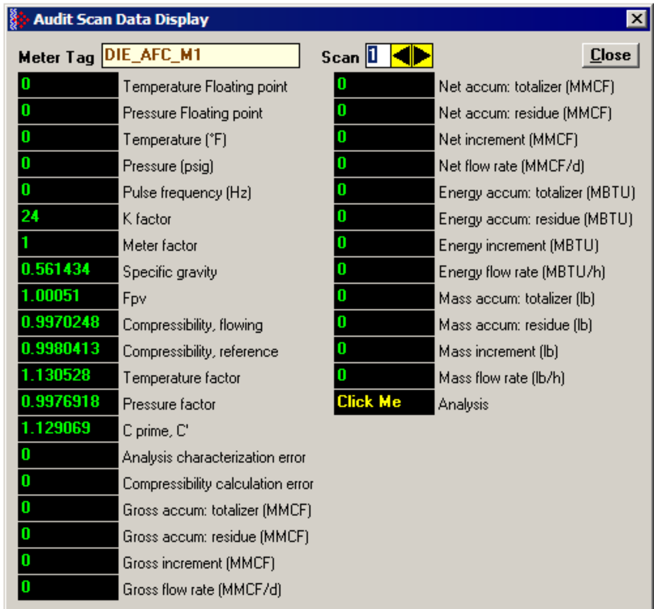
8 Audit Scan

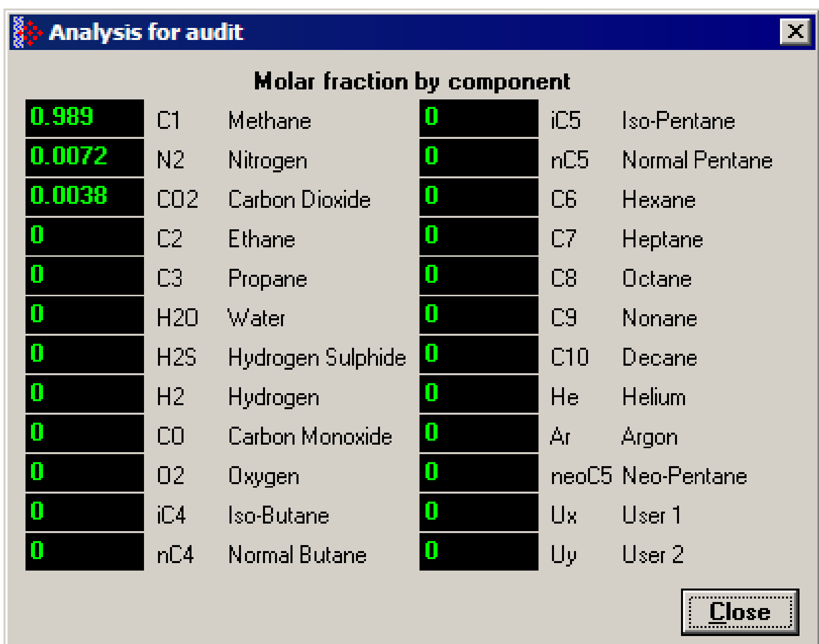
An Audit Scan captures a "snapshot" of input values, intermediate calculated values, and output results for each of a short series of calculation scans for a single meter. This allows an auditor to rigorously verify the calculations performed by the AFC on live in-service production meters. The module supports eight consecutive audit scans at a time.



1. Select the Meter Number for the audit
2. Select the number of scans for the audit
3. Click the Read Button to begin the audit
4. Look at the operation result. Success = audit has been successfully completed

5 When the Audit Scan is complete, click the Details Button to view the calculation and the input variables.





The following shows an example of an audit scan file report generated by the AFC Manager for 2 scans:

```
AFC-56(16) Audit                                  Date: 16-09-2002 16:18:07
  Site Name: MVI Flow Station
  Project: AFC
```

Meter 1:		
Tag		M01
Wallclock		0000/00/00.00:00:00
Barometric pressurekPaa		101,325
Viscosity		0,010268
Orifice/pipe geometric parameters		
	Orifice plate	Meter tube
Temperature	68	68
Diameter	1	2
Coefficient	9,25E-06	0,0000062

Scan	1
Temperature (Floating point)	15
Pressure (Floating point)	1000
Dif. pressure (Floating point)	22
Temperature (°F)	15
Pressure (psig)	1000
Dif. pressure (hw)	22
Scan period (second)	0,48
Specific gravity	0,7404104
Fpv	0
Compressibility flowing	0,9051347
Compressibility reference	0,9989105
Diameter at T tube	1,999343
Diameter at T orifice	0,9995098
Velocity of approach factor ev	1,032773
Pressure extension xt	149,4683
Coefficient of discharge cd	0,6042569
Expansion factor y	0,9997441
Composition factor	0,2728558
Mass flow Qh	2280,571
Orifice characterization error	0
Analysis characterization error	0
AGA8 calculation error	0
Gross accu. - totalizer (x f3)	3408
Gross accu. - residue (x f3)	0,2047686
Gross increment (x f3)	6,442598E-02
Gross flow rate (x f3/h)	483,1948
Net accu. - totalizer (x f3)	390113
Net accu. - residue (x f3)	0,8464546
Net increment (x f3)	5,3664
Net flow rate (x f3/h)	40248
Mass accu. - totalizer (x lb)	22094
Mass accu. - residue (x lb)	0,5677222
Mass increment (x lb)	0,3040761
Mass flow rate (x lb/h)	2280,571
Analysis components	
C1 methane	0,55
N2 nitrogen	0,45
CO2 carbon dioxide	0
C2 ethane	0
C3 propane	0
H2O water	0
H2S hydrogen sulphide	0
H2 hydrogen	0
CO carbon monoxide	0

```
  O2 oxygen                                         0
  iC4 iso-butane                                    0
  nC4 normal butane                                 0
  iC5 iso-pentane                                   0
  nC5 normal pentane                                0
  C6 hexane                                         0
  C7 heptane                                        0
  C8 octane                                         0
  C9 nonane                                         0
  C10 decane                                        0
  He helium                                         0
  Ar argon                                          0
  neoC5 neopentane                                  0
  Ux user1                                          0
  Uy user2                                          0


AFC-56(16) Audit                                   Date: 16-09-2002 16:18:08
Site Name: MVI Flow Station
Project: AFC
______________________________________________________________________
Meter 1:
  Tag                                               M01
  Wallclock                                         0000/00/00.00:00:00
  Barometric pressurekPaa                           101,325
  Viscosity                                         0,010268
  Orifice/pipe geometric parameters
                    Orifice plate                   Meter tube
  Temperature       68                              68
  Diameter          1                               2
  Coefficient       9,25E-06                        0,0000062
______________________________________________________________________
  Scan                                              2
  Temperature (Floating point)                      15
  Pressure (Floating point)                         1000
  Dif. pressure (Floating point)                    22
  Temperature (°F)                                  15
  Pressure (psig)                                   1000
  Dif. pressure (hw)                                22
  Scan period (second)                              0,495
  Specific gravity                                  0,7404104
  Fpv                                               0
  Compressibility flowing                           0,9051347
  Compressibility reference                         0,9989105
  Diameter at T tube                                1,999343
  Diameter at T orifice                             0,9995098
  Velocity of approach factor ev                    1,032773
  Pressure extension xt                             149,4683
  Coefficient of discharge cd                       0,6042569
  Expansion factor y                                0,9997441
  Composition factor                                0,2728558
  Mass flow Qh                                      2280,571
  Orifice characterization error                    0
  Analysis characterization error                   0
  AGA8 calculation error                            0
```

```
    Gross accu.- totalizer (x f3)                 3408
    Gross accu. - residue (x f3)                  0,2712079
    Gross increment (x f3)                        6,643929E-02
    Gross flow rate (x f3/h)                      483,1948
    Net accu. - totalizer (x f3)                  390119
    Net accu. - residue (x f3)                    0,3805552
    Net increment (x f3)                          5,534101
    Net flow rate (x f3/h)                        40248
    Mass accu. - totalizer (x lb)                 22094
    Mass accu. - residue (x lb)                   0,8813007
    Mass increment (x lb)                         0,3135785
    Mass flow rate (x lb/h)                       2280,571
  Analysis components
    C1 methane                                    0
    N2 nitrogen                                   0
    CO2 carbon dioxide                            0
    C2 ethane                                     0
    C3 propane                                    0
    H2O water                                     0
    H2S hydrogen sulphide                         0
    H2 hydrogen                                   0
    CO carbon monoxide                            0
    O2 oxygen                                     0
    iC4 iso-butane                                0
    nC4 normal butane                             0
    iC5 iso-pentane                               0
    nC5 normal pentane                            0
    C6 hexane                                     0
    C7 heptane                                    0
    C8 octane                                     0
    C9 nonane                                     0
    C10 decane                                    0
    He helium                                     0
    Ar argon                                      0
    neoC5 neopentane                              0
    Ux user1                                      0
    Uy user2                                      0
```

9 Archive Monitor

In This Chapter

The Archive Monitor dialog box opens when you open the Monitor menu, and then choose Archive.

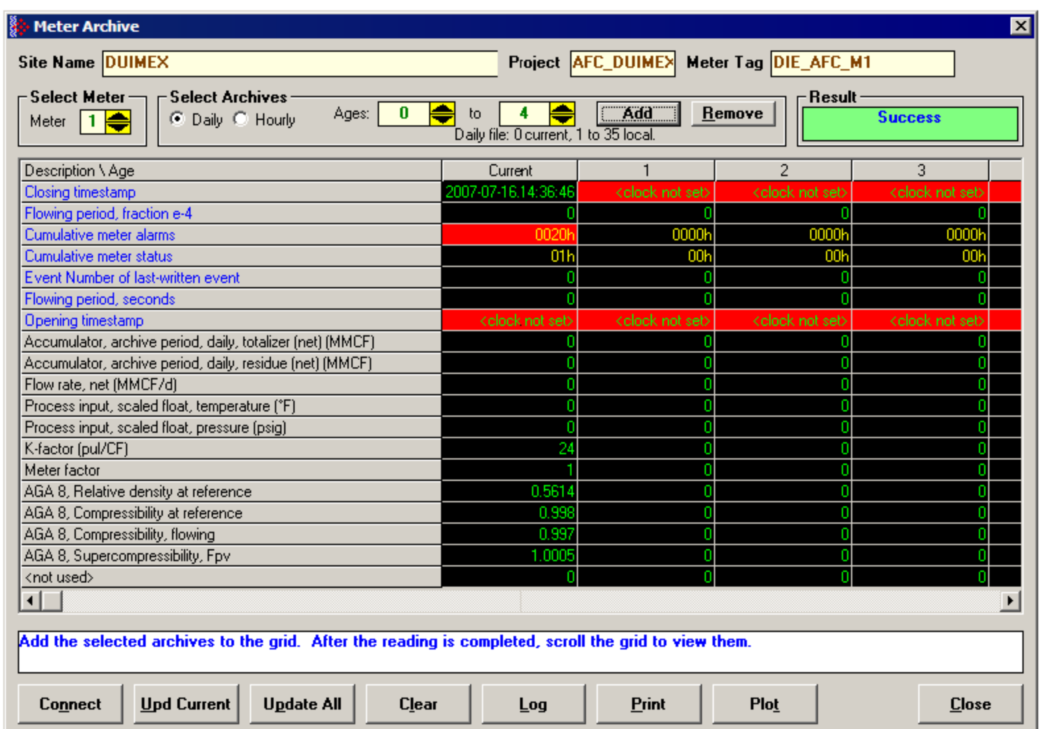
The module can archive data for each meter channel. The archives are periodically generated according to the period end defined in the Site Configuration.

There are hourly archives (48 archives) and daily archives (35 archives).

For example the daily archives will be stored as:

- Archive 0 = current archive
- Archive 1 = Archive created yesterday
- Archive 2 = Archive created 2 days ago
- Archive 3 = Archive created 3 days ago

And so on.



Control	Description
Select Meter	Select the meter number
Select Archives	Select the archive type
Ages	Select the first archive to be added or removed
To	Select the last archive to be added or removed
Add	Add the selected archives to the grid, fetching as necessary
Remove	Remove the selected archives from the grid
Connect	Connect to the module, if necessary
Upd Current	Update the current archive
Update All	Update all archives in the grid
Clear	Clear the grid
Log	Create a log file containing the archived data
Print	Print the archives to the local printer
Plot	Display a plot of two datum points from archives in the grid

The following shows an example of an archive report generated by the AFC Manager:

```
AFC-56(16) Daily Archive                              Date: 16-09-2002 16:26:41
    Site Name: MVI Flow Station
    Project: AFC
    ___________________________________________________________________________

    Meter 1:
   Tag                                                 M01
   Archive                                             0

   Closing timestamp of archive                        2002-04-27.23:59:08
   Opening timestamp of archive                        2002-04-27.00:00:02
   Status bitmap (details below)                       00h
   Alarms bitmap (details below)                       0000h
   Flowing period                                      86346
   Event counter                                       53
   Net accumulator (x f3)                              604
   Net accumulator residue (x f3)                      0,6703186
   Net flow rate (x f3/h)                              40247,93
   Temperature (°F)                                    14,99997
   Pressure (psig)                                     999,9995
   Differential pressure (hw)                          21,99997
   Relative density (60°F/60°F)                        0,7404
   Reference compressibility                           0,9989
   Flowing compressibility                             0,9051
   Fpv                                                 1,0505
   Velocity of approach factor Ev                      1,0328
   Expansion factor Y                                  0,9997
   Discharge coefficient                               0,6043

   Alarm Bits
   bit  0  Temperature input out of range                -
   bit  1  Pressure input out of range                   -
   bit  2  Diff. pressure input out of range             -
   bit  3  Flowing density input out of range            -
```

```
bit  4  Water content input out of range          -
bit  5  Diff. pressure low                        -
bit  8  Orifice characterization error            -
bit  9  Analysis total zero                       -
bit  10  Analysis total not normalized            -
bit  11  AGA8 calculation error                   -
bit  12  API calculation error, density correctio -
bit  13  API calculation error, Ctl               -
bit  14  API calculation error, vapor pressure    -
bit  15  API calculation error, Cpl               -

Status Bits
bit  11  Meter was enabled                        -
bit  12  Backplane communication fault            -
bit  13  Measurement configuration changed        -
bit  14  Power up                                 -
bit  15  Cold start                               -
```

```
 AFC-56(16) Daily Archive                         Date: 16-09-2002 16:26:41
 Site Name: MVI Flow Station
 Project: AFC
 ___________________________________________________________________________

 Meter 1:
Tag                                             M01
Archive                                         1

Closing timestamp of archive                    2002-04-27.00:00:02
Opening timestamp of archive                    2002-04-26.23:59:42
Status bitmap (details below)                   00h
Alarms bitmap (details below)                   0000h
Flowing period                                  20
Event counter                                   53
Net accumulator (x f3)                          234
Net accumulator residue (x f3)                  0,1092186
Net flow rate (x f3/h)                          40248,01
Temperature (°F)                                15
Pressure (psig)                                 1000
Differential pressure (hw)                      22
Relative density (60°F/60°F)                    0,7404
Reference compressibility                       0,9989
Flowing compressibility                         0,9051
Fpv                                             1,0505
Velocity of approach factor Ev                  1,0328
Expansion factor Y                              0,9997
Discharge coefficient                           0,6043

Alarm Bits
bit  0  Temperature input out of range            -
bit  1  Pressure input out of range               -
bit  2  Diff. pressure input out of range         -
bit  3  Flowing density input out of range        -
bit  4  Water content input out of range          -
bit  5  Diff. pressure low                        -
```

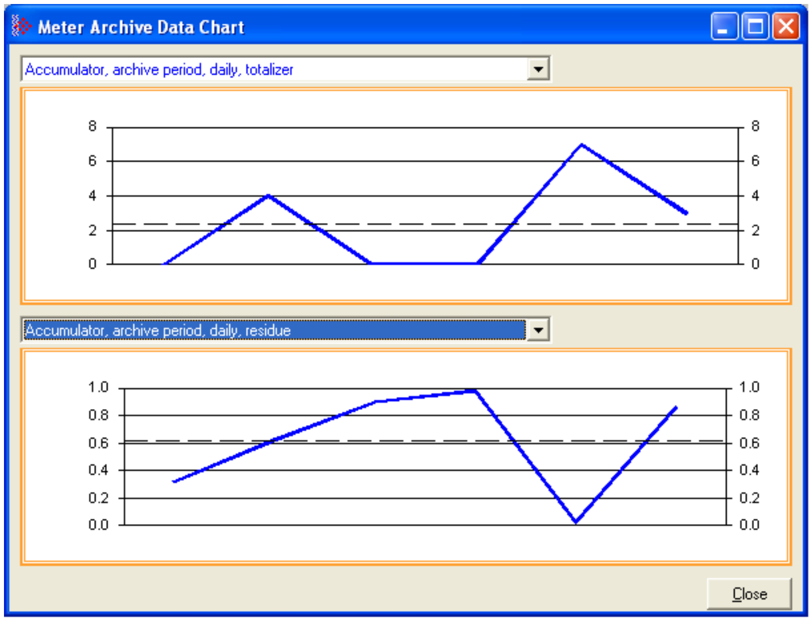
```
bit  8  Orifice characterization error           -
bit  9  Analysis total zero                      -
bit  10  Analysis total not normalized           -
bit  11  AGA8 calculation error                  -
bit  12  API calculation error, density correctio  -
bit  13  API calculation error, Ctl              -
bit  14  API calculation error, vapor pressure   -
bit  15  API calculation error, Cpl              -

Status Bits
bit  11  Meter was enabled                       -
bit  12  Backplane communication fault           -
bit  13  Measurement configuration changed       -
bit  14  Power up                                -
bit  15  Cold start                              -


 AFC-56(16) Daily Archive                          Date: 16-09-2002 16:26:44
 Site Name: MVI Flow Station
 Project: AFC
 ___________________________________________________________________________

 Meter 1:
Tag                                              M01
Archive                                          2

Closing timestamp of archive                     2002-04-26.23:59:42
Opening timestamp of archive                     2002-04-26.06:16:34
Status bitmap (details below)                    60h
Alarms bitmap (details below)                    0000h
Flowing period                                   1019877652
Event counter                                    53
Net accumulator (x f3)                           174811
Net accumulator residue (x f3)                   0,9399567
Net flow rate (x f3/h)                           40247,88
Temperature (°F)                                 15,00736
Pressure (psig)                                  1000,416
Differential pressure (hw)                       22,00479
Relative density (60°F/60°F)                     0,7404
Reference compressibility                        0,9989
Flowing compressibility                          0,9053
Fpv                                              1,0506
Velocity of approach factor Ev                   1,0331
Expansion factor Y                               1,0001
Discharge coefficient                            0,6045

Alarm Bits
bit  0  Temperature input out of range           -
bit  1  Pressure input out of range              -
bit  2  Diff. pressure input out of range        -
bit  3  Flowing density input out of range       -
bit  4  Water content input out of range         -
bit  5  Diff. pressure low                       -
bit  8  Orifice characterization error           -
bit  9  Analysis total zero                      -
```

```
bit  10  Analysis total not normalized          -
bit  11  AGA8 calculation error                 -
bit  12  API calculation error, density correctio  -
bit  13  API calculation error, Ctl             -
bit  14  API calculation error, vapor pressure  -
bit  15  API calculation error, Cpl             -

Status Bits
bit  11  Meter was enabled                      -
bit  12  Backplane communication fault          -
bit  13  Measurement configuration changed      yes
bit  14  Power up                               yes
bit  15  Cold start                             -


 AFC-56(16) Daily Archive                       Date: 16-09-2002 16:26:51
 Site Name: MVI Flow Station
 Project: AFC
 ________________________________________________________________________

 Meter 1:
Tag                                            M01
Archive                                        3

Closing timestamp of archive                   2002-04-26.06:16:34
Opening timestamp of archive                   2002-04-26.06:14:08
Status bitmap (details below)                  20h
Alarms bitmap (details below)                  0000h
Flowing period                                 146
Event counter                                  50
Net accumulator (x f3)                         1633
Net accumulator residue (x f3)                 6,271362E-02
Net flow rate (x f3/h)                         40248,02
Temperature (°F)                               14,99999
Pressure (psig)                                1000,002
Differential pressure (hw)                     22,00003
Relative density (60°F/60°F)                   0,7404
Reference compressibility                      0,9989
Flowing compressibility                        0,9051
Fpv                                            1,0505
Velocity of approach factor Ev                 1,0328
Expansion factor Y                             0,9997
Discharge coefficient                          0,6043

Alarm Bits
bit  0  Temperature input out of range           -
bit  1  Pressure input out of range              -
bit  2  Diff. pressure input out of range        -
bit  3  Flowing density input out of range       -
bit  4  Water content input out of range         -
bit  5  Diff. pressure low                       -
bit  8  Orifice characterization error           -
bit  9  Analysis total zero                      -
bit  10  Analysis total not normalized           -
bit  11  AGA8 calculation error                  -
```

```
bit  12  API calculation error, density correctio  -
bit  13  API calculation error, Ctl                -
bit  14  API calculation error, vapor pressure     -
bit  15  API calculation error, Cpl                -

Status Bits
bit  11  Meter was enabled                         -
bit  12  Backplane communication fault             -
bit  13  Measurement configuration changed         yes
bit  14  Power up                                  -
bit  15  Cold start                                -
```

9.1 Meter Archive Data Chart Dialog Box

This dialog box opens when you click the Plot button on the Meter Archive dialog box. This dialog box shows a graphical plot of the data you select from the dropdown lists, and allows you to trend the different quantities simultaneously.



10 Events

In This Chapter

10.1 The Event Log

An "event" is any occurrence that may affect the manner in which, or whether, measurement is performed. Events include, for example:

- Any change to a sealable parameter.
- Power-up (product may have been lost during the power-down period).
- A change in PLC operating mode (programming changes may alter measurement).
- A download of the event log (for audit trail purposes).

The Event Log occupies a block of 16000 Input registers in the Modbus table starting at address 40000 and proceeding through address 55999. It consists of a 5-register "header" at address 40000 followed by 1999 8-register "event" records starting at address 40008. As they are Input registers (read with Modbus function code 4), no part of the Event Log can be written from outside the module, but it is maintained exclusively by the AFC firmware.

As events occur they are recorded in the Log, which acts as a circular file. Each new event record overwrites the oldest one, hence the log stores up to 1999 of the most recent events. As each record is written the values in the header are updated to reflect the new status of the log.

Auditors may require the Log to be "downloaded" from time to time; events are read from the module and stored in a more permanent database, and the events so copied and archived are marked in the module as "downloaded".

If all record positions contain events that have not yet been downloaded, the log is full. In this case, the handling of a new event depends on the value of the "Event log unlocked" site option:

- If the option is set, then the log-full condition is ignored and the new event overwrites the oldest one. Since the overwritten event was never downloaded, it is permanently lost.
- If the option is clear, then the Event Log is "locked", and the new event is rejected if possible and otherwise ignored. Controllable events, that is, changes to sealable parameters, are not allowed to occur; such datum points remain unchanged retaining their current values and a Modbus command that attempts such a change receives an "illegal data" exception response. Uncontrollable events, such as PLC mode change, are simply not recorded. The Log must be downloaded in order to unlock it for further events.

10.2 Event Log Structures

The Event Log header contains housekeeping information for maintaining the Log. Its layout is:

Address	Description
40000	Number of records maximum (== 1999)
40001	Next new record position (0 thru maximum-1)
40002	Next new event number (0 thru 65535, wrapping to 0)
40003	Oldest event number on file
40004	Oldest event number on file not yet downloaded
40005-40007	[reserved]

Each event record is an 8-register quantity laid out as four 32-bit items (big-endian):

Registers	Contents
0 to 1	Event Id Tag (page 168)
2 to 3	Timestamp of event In our standard "packed bit-field" format.
4 to 5	Old item value For a Datum Point event, format depends on the "datum type" field of the Event Id Tag.
6 to 7	New item value For a Datum Point event, format depends on the "datum type" field of the Event Id Tag.

Each value is right-justified in its field and sign-extended or padded with zeros (0) if necessary, according to the source data type.

10.3 Event Id Tag

This 32-bit field has the following structure:

<table>
<tr><th>Bits</th><th>N</th><th>Meaning</th></tr>
<tr><td>31</td><td>1</td><td>0 Special, 1 Datum Point (e.g. sealable parameter)
If this bit is clear, then bits 19-00 contain a value from the Special event tag list below; if the bit is set, then bits 19-00 have the interpretation given here.</td></tr>
<tr><td>30</td><td>1</td><td>PLC offline; timestamp may not be accurate
This bit may also be set for a Special event.</td></tr>
<tr><td>29</td><td>1</td><td>[reserved]</td></tr>
<tr><td>28 to 24</td><td>5</td><td>Meter number, or 0 for Site
This field may also be set for a Special event.</td></tr>
<tr><td>23 to 20</td><td>4</td><td>[Meter] Stream number or 0; [Site] 0
This field may also be set for a Special event.</td></tr>
<tr><td>19 to 16</td><td>4</td><td>Data type:
<table>
<tr><th>Value</th><th>Mnemonic</th><th>Format</th></tr>
<tr><td>0</td><td>Ubyt</td><td>Unsigned byte</td></tr>
<tr><td>1</td><td>Usht</td><td>Unsigned short integer</td></tr>
<tr><td>2</td><td></td><td>[reserved]</td></tr>
<tr><td>3</td><td>Ulng</td><td>Unsigned long integer</td></tr>
<tr><td>4</td><td>Sbyt</td><td>Signed byte</td></tr>
<tr><td>5</td><td>Ssht</td><td>Signed short integer</td></tr>
<tr><td>6</td><td></td><td>[reserved]</td></tr>
<tr><td>7</td><td>Slng</td><td>Signed long integer</td></tr>
<tr><td>8</td><td>Bbyt</td><td>Bitmap (up to 8 bits)</td></tr>
<tr><td>9</td><td>Bsht</td><td>Bitmap (up to 16 bits)</td></tr>
<tr><td>10</td><td>Bm24</td><td>Bitmap (up to 24 bits)</td></tr>
<tr><td>11</td><td>Blng</td><td>Bitmap (up to 32 bits)</td></tr>
<tr><td>12</td><td>Bool</td><td>Boolean (value 0 or 1)</td></tr>
<tr><td>13</td><td>DiBy</td><td>Dibyte (both high and low)</td></tr>
<tr><td>14</td><td>B448</td><td>Bitfield nybble/nybble/byte</td></tr>
<tr><td>15</td><td>Flot</td><td>Floating point</td></tr>
</table></td></tr>
<tr><td>15 to 12</td><td>4</td><td>[reserved]</td></tr>
<tr><td>11 to 08</td><td>4</td><td>Group code
This value is one of the "measurement configuration changed" bit numbers.</td></tr>
<tr><td>07 to 04</td><td>4</td><td>Subgroup code
This value is the ordinal number (starting at 0) of the subgroup of parameters in the specified group.</td></tr>
<tr><td>03 to 00</td><td>4</td><td>Subgroup item code
Since a parameter subgroup may contain more than one item, this value identifies the particular item; items are numbered from 0.</td></tr>
</table>

10.4 Event-triggered Archives and Accumulator Resets

Each archive file (two for each meter) contains an Archive Options bitmap whose configuration specifies the actions to be scheduled (write archive and/or reset resettable accumulator(s)) when an event occurs (daily or hourly period-end, or most loggable events). Archives and/or resets are scheduled only for enabled meters (with one important clarification; see "Rkv" notes (page 201)). The actions to be taken upon period-end and those to be taken upon loggable events are configured separately.

Several archive/reset-triggering events can occur simultaneously. In such cases the archive or reset occurs only once (an archive is written only when archivable data has been accumulated for at least one meter scan; additional resets of already-reset accumulators have no effect).

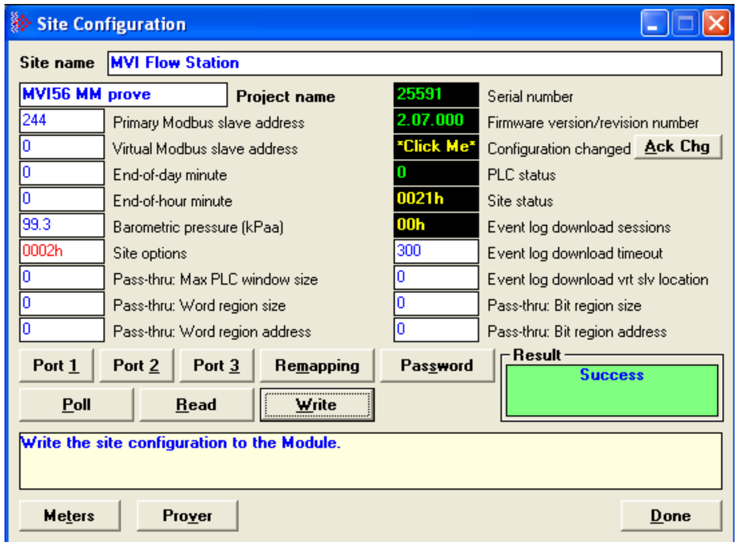
Scheduled accumulator resets are performed at the top of the meter scan. This permits their final values to be inspected/fetched/archived while the AFC rotates its scan among the other meters.

Scheduled archives are written at the top of the meter scan, at its bottom, or between successive scans, depending on the nature of the triggering event. Archives written at the top of the scan are written before any accumulator resets.

10.5 Downloading the Event Log in Firmware Version 2.07 and Later

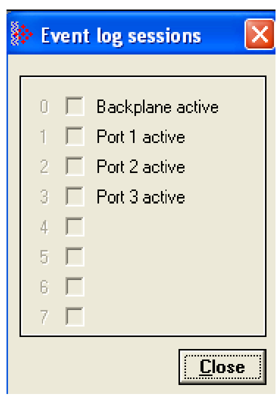
The following is an example of the Event Log Download.

In the *Site Configuration* window, the *Event log download timeout* has been changed from the default of 60 seconds, to 300 seconds (5 minutes).



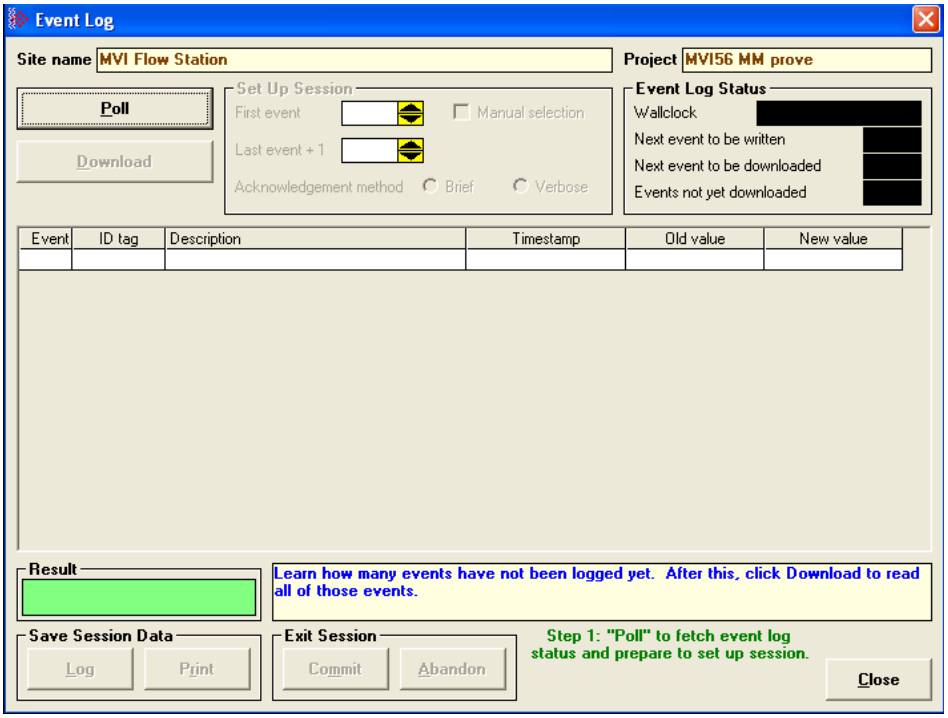
In the *Site Configuration* window above there are no active download sessions. This is indicated by the value of zero in *Event log download sessions field.*

Click the box to show the *Event log sessions* window.

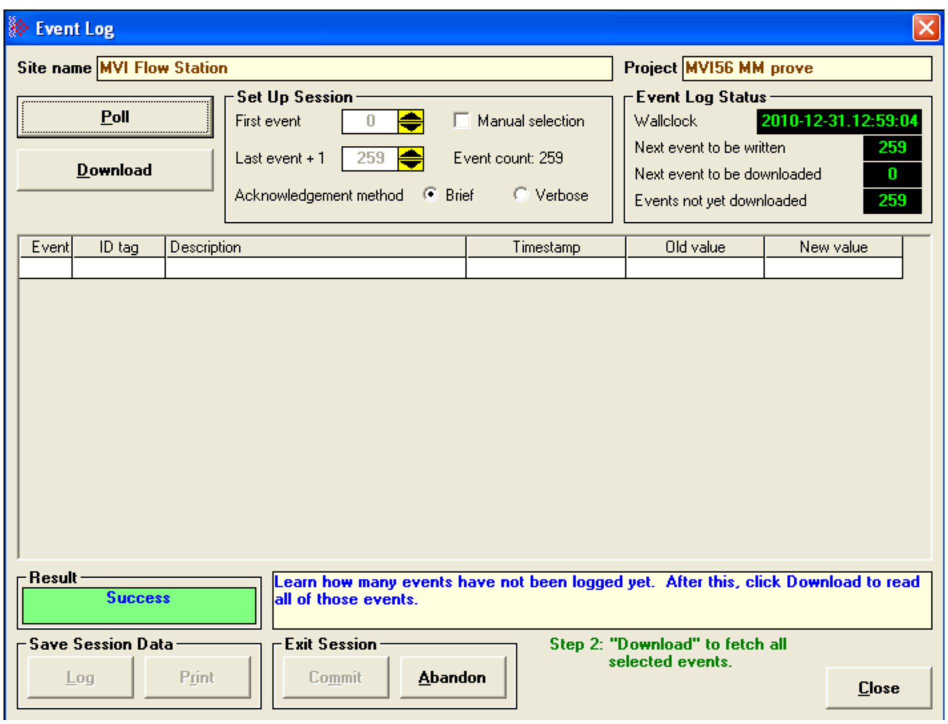


After opening the *Event log sessions* window from the **ON-LINE/EVENT LOG** menu; you will see instructions in green in the lower right area of the window.

Click **POLL** to fetch status and to prepare the session:

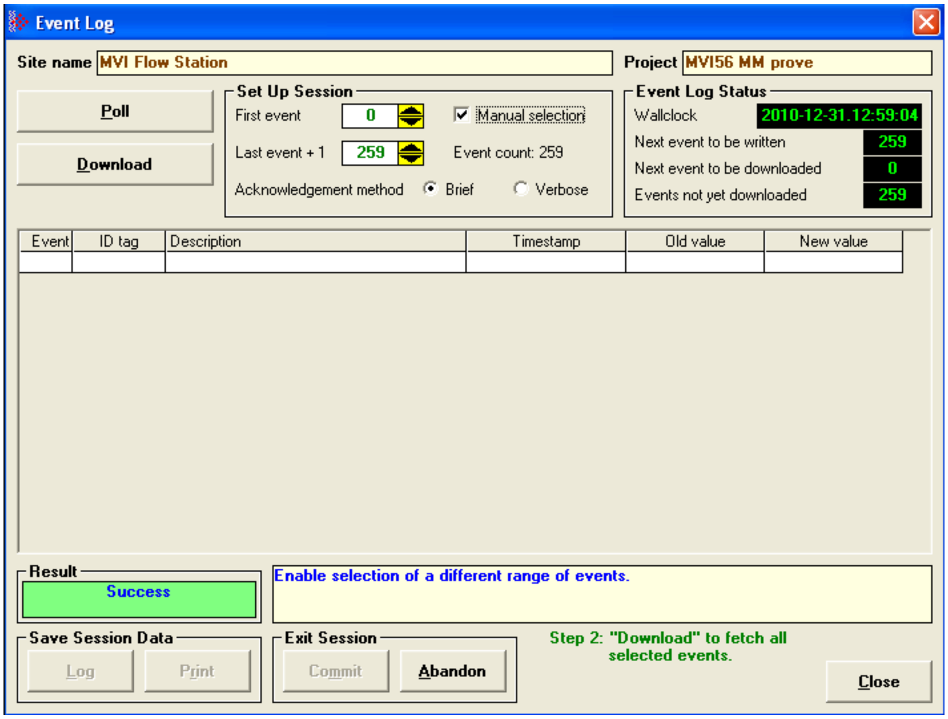


After polling, you are prompted to download:



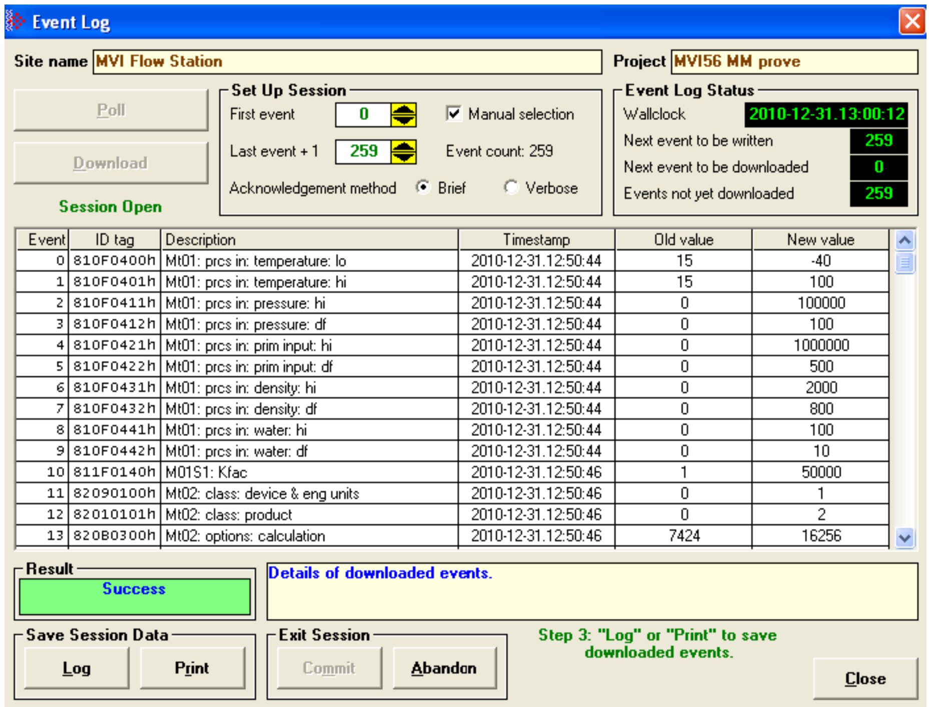
Before downloading you may want to modify the parameters of your download. Reasons for modification include such things as a need to re-fetch recent events that were already downloaded and committed in a previous session, or to limit the amount of download.

To change the download parameters, check the box **MANUAL SELECTION** in the *Event Log* window, and make any desired changes.

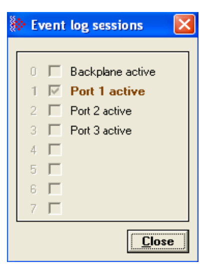


After the parameters are set to the chosen values click **DOWNLOAD**.

The requested events are fetched and displayed in the scrollable grid. The events displayed in this screenshot are of changes to configuration (*sealable parameters*):

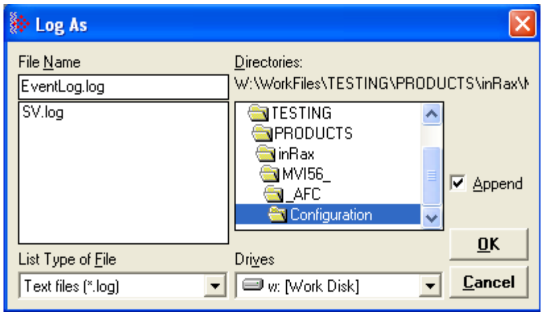


The *Download* action opens an *Event log sessions* window, which will be closed only when either (a) it is *Commit*ted, or (b) it is *Abandon*ed, or (c) it times out due to no activity. this can be seen by viewing again the *Event log download sessions* information from *Site Configuration* window (you will have to re-*Poll* the site information to see the update):

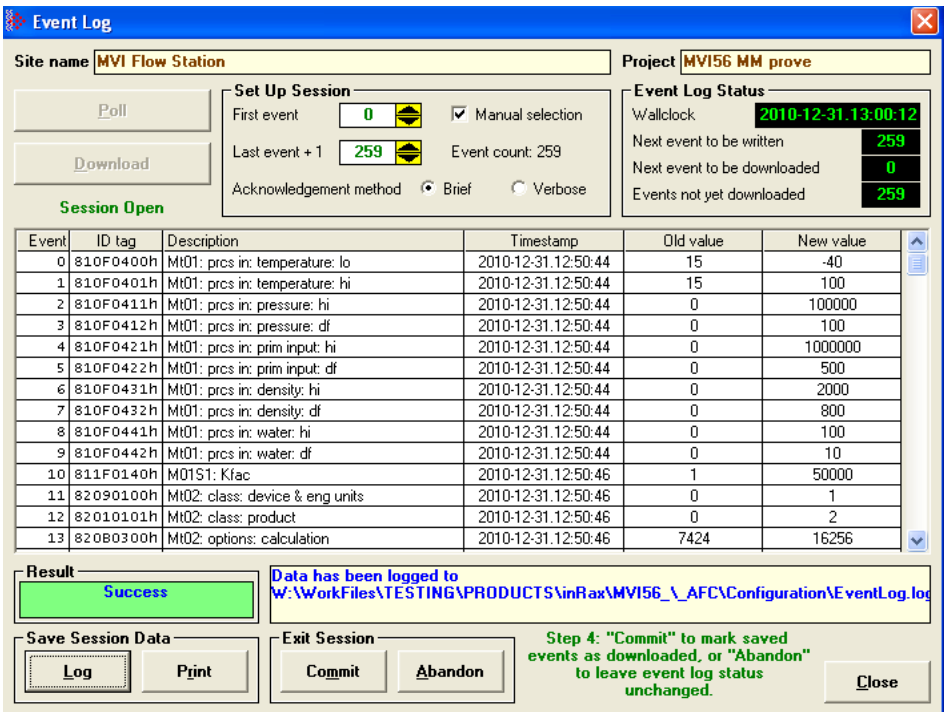


*Commit*ting a download tells the AFC module to *purge* the downloaded events, that is, to move its download pointer past the downloaded events and allow those events to be overwritten. Event log management standards mandate that downloaded events must be saved to more permanent storage before they can be purged from the module. In the earlier screenshot you can see that the **COMMIT** button is grayed out because the saving action has not yet been accomplished. AFC Manager considers the events to have been saved when they have been either logged to a file or printed.

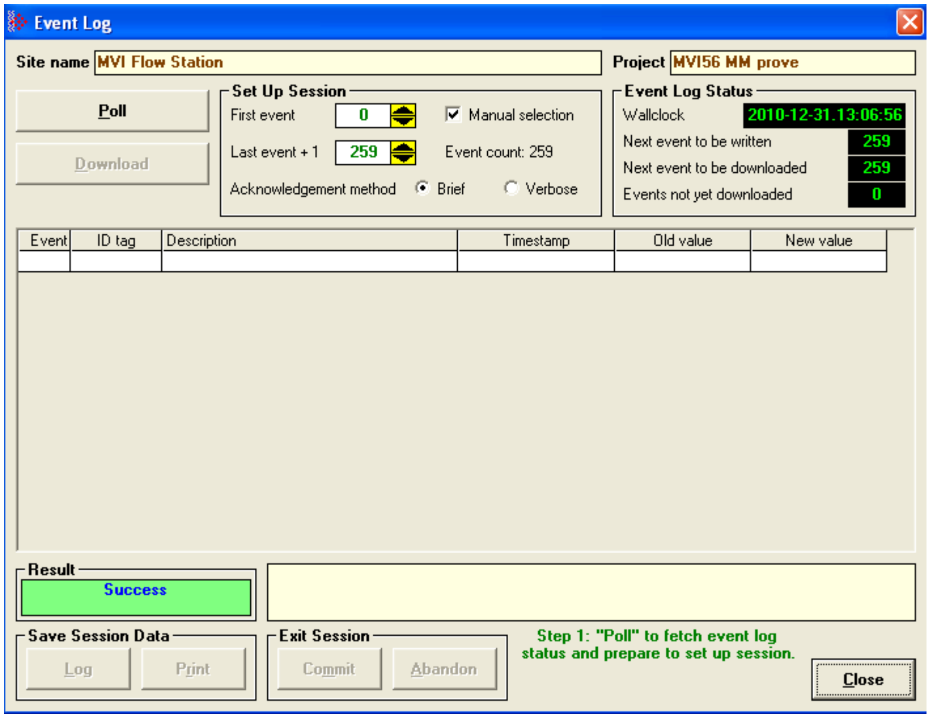
Click the **LOG** button and save the downloaded events to a text file of type ".log":



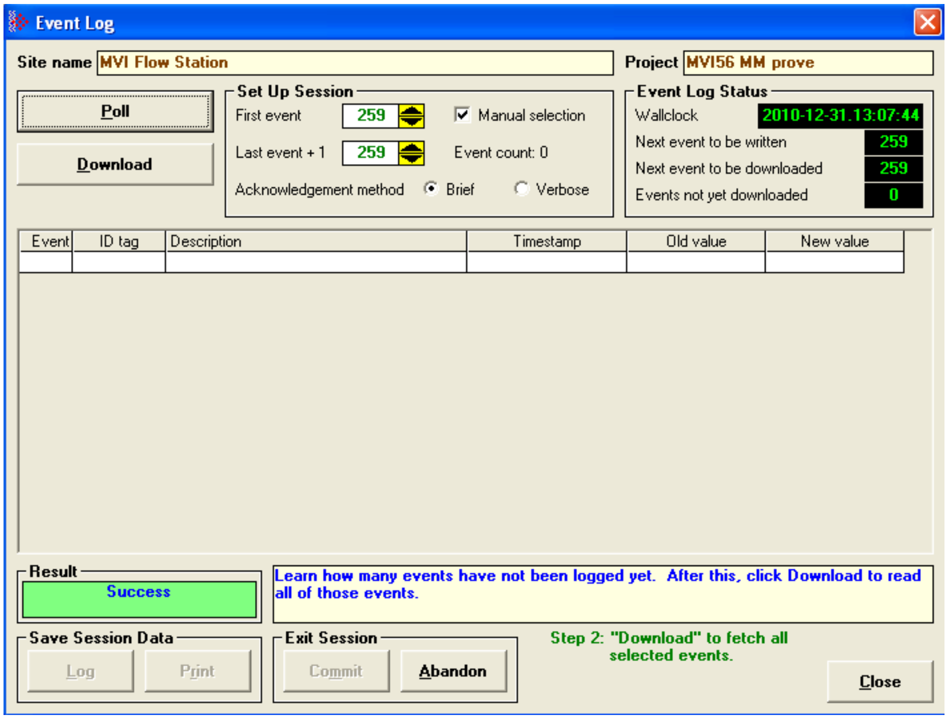
The **COMMIT** button is now enabled.



Click **COMMIT**, and the AFC then moves its download pointer (*Next event to be downloaded* in the *Event Log Status* panel):



To download again, click **POLL.** This will prompt you to start the next download starting from the new download pointer (*First event* in the *Set Up Session* panel). Once downloading all outstanding events is completed, there will be no more events to be downloaded as shown here by a 0 in the *Events not yet downloaded* field



For AFC firmware versions prior to 2.07, *Event Log Download* uses this same interface, but because the new firmware implementation is not present some features are not available or behave slightly differently. However, the same basic sequence of *poll, download*, and *commit/abandon* is the same.

10.5.1 Basic Principles of Implementation

A properly committed log-download session has three phases:

<u>*Phases*</u>

Setup Phase

This phase opens the session by a single Modbus transaction to the AFC that specifies the first event to be downloaded in the session. This event may be identified explicitly by event number, or it may be conveniently identified as the earliest event not yet previously downloaded.

Download Phase

This phase transfers event data during an open session by a sequence of zero or more fetch-and-acknowledge (F&A) cycles. A first Modbus transaction reads a short block of consecutive chronologically-ordered events from the AFC, and a second transaction writes sufficient data to inform the AFC that the events just read have been received without error; this pair of Modbus transactions constitutes a single F&A cycle. The starting event of the first F&A cycle is the event identified in the Setup phase. Each successful F&A cycle causes the subsequent cycle, if any, to begin with the earliest event not included in the previous cycle. The block of data read from the AFC includes, besides the events themselves, information that identifies the first event in the block, the number of events in the block, and the number of not-yet-downloaded events that remain in the AFC following those in the block. A failed F&A cycle does not cause the starting event to change, so it may be repeated as many times as is necessary to accomplish success. All F&A Modbus transactions access a block of registers beginning at the same address.

Completion Phase

This phase closes the session by a single Modbus transaction that updates the download point in the event log header with the earliest non-downloaded event and posts the Download event.

Dynamic Context

In order for the AFC to manage the log-download session, it maintains a "dynamic context" for the session, which includes in particular the number of the earliest event to be retrieved by the next F&A cycle. The dynamic context exists only while the session is open; the Setup phase opens the session and creates the context, and the Completion phase closes the session and discards the context. The dynamic context must not persist (the session remain open) indefinitely. Therefore, in case that a session is abandoned before completion, or otherwise fails due to problems such as loss of communication, a timeout is implemented that automatically abandons the session (closes it without completion) after a short period of inactivity; all Modbus transactions for the session must occur at a rate faster than this timeout for the session to be completed successfully.

One dynamic context is maintained for each port, permitting multiple hosts to perform download sessions simultaneously; see Section 8 for more on this. The backplane is deemed to be "port #0", so that a session may also be performed by the PLC via the Modbus Gateway feature.

To ensure maximum possible security, strict constraints are placed on the sequencing, addressing, and lengths of all Modbus transactions for the session. Violation of these constraints causes the offending transaction, depending on its nature, to be either rejected with a Modbus exception code or accepted but ignored; in no case does an offending transaction cause change of state in the AFC.

10.5.2 Data Elements

Modbus Points

Point in Modbus Table	Mandatory or Optional	Value	Description
slave selection	Mandatory	P	Primary Slave
		V	Virtual Slave
register bank	Mandatory	h	holding registers
		i	input registers
register address	Mandatory	nnnnn or, +nnn	A register address has the form "nnnnn" which is the 5-digit offset (0-based) of the register in the selected bank; a register address may also have the form "+nnn" where "nnn" is the 3-digit offset (0-based) of the register in a block of registers which block is located more globally by accompanying text.
byte selection	Optional	L	low-order byte
		H	high-order byte
bit number	Optional	/nn	Bit number, if present, is "/nn" where "nn" is the number of the bit in the 16-bit register or 8-bit byte, with bits numbered from 0 at the low-order end of the register or byte.

- "Ph00146" identifies the 16-bit register at offset 146 in the Primary Slave's holding register bank.
- "Ph00006H/01" identifies bit 1 of the high-order byte of Primary Slave holding register 6; this byte is already allocated in the AFC as the Site Extended Status byte. This bit can be alternately addressed as "Ph00006/09", but the AFC internally treats the two bytes as distinct.
- "Ph00200/05" identifies bit 5 of Primary Slave holding register 200; this bit is an as-yet unallocated bit in the Site Signals register.
- "LDW+000" identifies the first of a block of registers in the Primary Slave holding register bank and optionally in the Virtual Slave holding register bank, which block's absolute location is determined according to accompanying text.

Primary Slave Elements

These elements comprise configuration and status items required for the implementation, as well as the Log-Download Window (LDW) itself. If a host must access only the Virtual Slave for a log-download session, these points can be mapped to the Virtual Slave using the existing mapping functionality. As accesses to the LDW are severely restricted (every Modbus transaction to the LDW must be addressed to offset 0 of the LDW), a shortcut mapping is available that maps the entire LDW with a single data point.

Log-Download Window (LDW) Allocation

This is a block of 116 registers beginning at Primary Slave holding register 65400 and having a predefined layout. See Section 6 for the layout of this window. See Section 4 for how this window, when mapped to the Virtual Slave, is coordinated with other components of the Virtual Slave.

Site Configuration Items

1 Event Log Download Session Timeout Configuration word at Ph00146. This timeout is in seconds, which must be at least 5 and may not exceed 300 (5 minutes). Default value is 60 (1 minute).

2 Virtual Slave LDW Location Configuration word at Ph00147. This is the address in the Virtual Slave's holding register bank of the first register of the LDW. This value need not be limited to the 9900-register range of the mappable Virtual Slave but may be located anywhere in the Virtual Slave's address space from register 100 up to 65420 (which address places the last register of the LDW, at offset 115, at Virtual Slave register 65535). If this value is 0, the LDW is not available in the Virtual Slave (a conventionally mapped LDW is not visible).

Status

Event Log Download Active Session Map

Byte at Ph00007H (same word as Ph00007L, "PLC Offline Code").

This byte, previously unallocated, is a bitmap of the ports that currently have event-log download sessions active. Bits are numbered by the 1-based port number (where "Port #0" is the backplane), so that, for example, if a session is active on Port #2, the middle of the three front-panel ports, bit 2 of Ph00007H is set. The relevant bit is set when a download session is opened by the Setup phase, and is cleared when the session is committed by the Completion phase or when it is abandoned by timeout or explicit command. This byte Ph00007H is already available in the premapped portion of the Virtual Slave at Vh00007H.

10.5.3 Virtual Slave Precedence Relations

Addressing conflicts (collisions) can arise among three distinct regions of the Virtual Slave holding register bank. These regions are:

- The defined range of 9900 registers to which Primary Slave registers may be mapped.
- The word region of the pass-thru configuration, significant for Modbus write commands only.
- The LDW, specified in this document, when mapped to the Virtual Slave via Ph00147.

An addressing collision arises when the address of a holding register falls within more than one region. The AFC resolves such collisions as follows:

Each address is deemed to fall into one of (i) the pass-thru word region, (ii) the LDW, or (iii) the 9900-register defined range, whichever occurs first.

All Virtual Slave registers addressed by a single Modbus transaction must reside in the same region; no region-spanning is permitted. A region-spanning transaction is rejected with Modbus exception code 2, Illegal Address.

10.5.4 Security and Optimization

Two features are available that can improve security and throughput of a log-download session. These are:

1 **Session ID** - This is a value between 0 and 255 that is chosen by the host at the opening of the session and must be used in all transactions of the session. While a session is open, transactions that do not supply the correct Session ID are rejected. The AFC never displays the ID of the open session, so only the initiating host knows its value.

2 **Collapsed Acknowledgement** - This allows the Acknowledgement transaction of one F&A cycle to be embedded in the Fetch transaction of the next, reducing by almost half the number of transactions required for the session.

Use of either of these features, excepting only the use of Session ID 0, requires non-standard tweaking of the Modbus command packets of Fetch transactions, hence applications that cannot perform such tweaking are limited to the use of Session ID 0 and the non-Collapsed acknowledgement methods.

All session transactions except Fetch are Modbus writes; in those, the Session ID is included as an element of the written data. Fetch transactions are Modbus reads, which contain no data in their command packets; in those, the Session ID and (if used) the Collapsed Acknowledgement are encoded in the high-order 9 bits of the "number of registers" field, so that:

Bits 0 thru 6 contain the true "number of registers", which 7 bits are, for holding register access, sufficient to carry any value that is valid according to the standard Modbus protocol.

Bit 7 is used for the Collapsed Acknowledgement.

Bits 8 thru 15 contain the Session ID.

The tweaking of the Modbus read command packet is performed before calculation of the CRC or LRC. See Sections 6 and 7 for more detail.

All Modbus transactions of a log-download session, whether read or write, address offset 0 of the LDW, either to its Primary Slave location of 65400 or to its Virtual Slave mapped location configured by Ph00147, hence validation of Session ID, and recognition of tweaked Modbus command packets, are performed only for commands that address that location. Any attempt to address any other offset into the LDW is rejected with a Modbus exception code.

10.5.5 The Log-Download Window (LDW)

The LDW, located at Primary Slave holding register 65400 and optionally mapped to the Virtual Slave by register Ph00147 consists of a header of 4 registers followed by up to fourteen 8-register event records. Accordingly, the size of the block may be as large as (4+14*8) registers, that is, 116. The block is returned as the data in the Fetch transaction of a F&A cycle. Certain subsets of the block may be read or written at other times.

Layout

The header has this layout:

1 LDW+000: Function and Session ID

When written, this register is interpreted as two bytes, where:

The low-order byte contains a function code:

0: Acknowledge Fetch

1: Open Session

2: Commit Session

3: Abandon Session

All other function codes are rejected with Modbus exception 3, "Illegal Data".

The high-order byte contains the Session ID. This ID is specified by the host upon opening the session and it must be matched by all subsequent accesses during the session.

When read, this register is always zero.

LDW+001: Starting Event Number

This value is initialized to the number of the event selected by the Setup phase. After every successful F&A cycle, it is advanced by the number of events fetched by that cycle.

LDW+002: Number of Events This Block

This is the number of events returned by the Fetch transaction of a F&A cycle. It never exceeds the number of events that can fit inside the size of the data block requested, but it may be smaller, such as when fewer events are available than the number requested. In the latter case, the extra unreturned event records are all zero.

LDW+003: Number of Non-Downloaded Events After This Block

This is the number of events remaining in the log that have not yet been downloaded, not counting the events in the current Fetch.

10.5.6 Modbus Transaction Sequencing and Constraints

This section describes the details of the Modbus transactions that manage a log-download session, including full specifications of transaction contents and the conditions under which they are permitted. Also considered is smooth recovery from failed transactions, as might happen over an intermittently failing communication link; the general principle is that an otherwise valid transaction may be repeated as many times as is necessary to ensure success.

Setup Phase

This phase, which opens a download session, may be accomplished in one of two ways:

The Detailed Method

Issue a Modbus write of two registers to offset 0 of the LDW, specifying function *Open Session* (1) and the desired Session ID followed by the number of the desired starting event.

The Quick Method

Issue a Modbus write of a single register to offset 0 of the LDW, specifying function *Open Session* (1) and the desired Session ID. This is equivalent to the Detailed method in which the starting event is copied from the download pointer in the event log header.

The dynamic context for the session includes two event numbers: one is the *Session Download Pointer* (SDP), which is the number of the first event to be retrieved by the next F&A cycle, and the other is the *File Download Pointer* (FDP), which is the number of the earliest event on file that has not yet been downloaded. The Setup phase specifies, explicitly or implicitly, the SDP, and initializes the FDP from the download pointer in the event log header, so the SDP and FDP need not be the same number.

Download Phase

This phase performs the actual retrieval of logged events as a sequence of F&A cycles. All transactions must place the Session ID into the first register of data (writes), or into the "number of registers" field of the Modbus command packet (reads), as described in Section 5.

Fetch Transaction

Issue a Modbus holding-register read (function 3) addressed to offset 0 of the LDW and with length calculated as (4+n*8), where *n* is the number of events to be read and must lie between 0 and 14 inclusive; any other length constitutes an error. Note that a read of 0 events is permitted, so that the LDW header can be inspected without changing the session's dynamic context; however, such a fetch must still be acknowledged in the manner described next. The response is a block of the requested length formatted as described in Section 6, whose second register at offset 1 is the current value of the SDP.

Acknowledge Transaction

There are four methods of acknowledgement, three of which may be used at any time, and a session need not use any one consistently, even when repeating an acknowledgement that has apparently failed:

1 **Collapsed method -** This method embeds the acknowledgement of the previous Fetch transaction into the next Fetch transaction, as described in Section 5.A Collapsed Acknowledgement bit value of 1 acknowledges the previous Fetch; a 0, if the previous Fetch has not been explicitly acknowledged by one of the other methods, elicits a repeat of the previous block of events. The Collapsed Acknowledgement bit of the first Fetch of a session must be 0.

2 **Brief method -** Issue a Modbus write of a single register to offset 0 of the LDW, specifying function "Acknowledge Fetch" (0) with the correct Session ID. Use this method to conserve bandwidth when use of the Collapsed method is not possible.

3 **Verbose method -** Issue a Modbus write of (4+n*8) registers to offset 0 of the LDW, that echoes the complete data block read by the Fetch transaction except for insertion of the correct Session ID. The AFC verifies that all register values, except those at offsets 0 and 3 of the LDW header, are the same as were transmitted. Use this method for greater confidence of acknowledgement when bandwidth is less of a concern.

4 **Implicit method -** The final Fetch transaction of a session can be implicitly acknowledged by the Completion phase (7.3, next). Because of the potential for undetected data corruption with the LRC of ASCII mode, only the Verbose method is recommended for an ASCII-mode Modbus channel.

A successful F&A cycle adjusts the session's dynamic context as follows:

A The SDP is advanced by the number of events returned by the fetch transaction.

B If at any time the SDP reaches the FDP, the FDP becomes "locked" to the SDP, thereafter tracking the SDP so that it keeps the same value, until the end of the session.

This ensures that any update of the download pointer in the event log header during Completion (7.3, next) is done only when it is guaranteed that all newly downloaded events have been retrieved by the host.

Completion Phase

This phase commits a session by determining a final FDP for the event log header, closing the session, and discarding the dynamic context. If the value of the final FDP differs from its original value in the event log header, then the header is updated with the new value and, provided that Site Option "Event Log Locked" is set, the Download event is written. If the FDP has not changed, no Download event is written, so the download state of the log remains unchanged. The session is then closed and its dynamic context discarded. The final FDP is determined by one of two methods:

1 **Implicit Completion:** Issue a Modbus write of a single register to offset 0 of the LDW, specifying function "Commit Session" (2) with the correct Session ID. This method takes the final FDP from the dynamic context at the moment of completion.
2 **Explicit Completion:** Issue a Modbus write of two registers to offset 0 of the LDW, the same as Implicit Completion but passing in the second register the desired final FDP as an explicit value. If at any time during the session the FDP of the dynamic context reached this value, this value becomes the final FDP for the session completion, in preference to that of the dynamic context. If the explicit FDP was not reached, this phase is equivalent to session abandonment (next). An Explicit Completion never marks more events as "downloaded" than an Implicit Completion.

A Completion of either method can implicitly acknowledge the final Fetch transaction.

Abandonment

This action explicitly abandons a session by closing it and discarding the dynamic context, without updating the log header or writing a Download event. In this case, therefore, adjustment of the log's download state implied by a changed FDP is not performed. It is equivalent to waiting for the session timeout to occur except that its effect is immediate. Issue a Modbus write of a single register to offset 0 of the LDW, specifying function "Abandon Session" (3) with the correct Session ID.

<u>*Error Recovery*</u>

During a session, the AFC maintains sufficient context information to accept not only the next expected Modbus transaction of the sequence but also a repeat of the previous one, except for the *Commit Session* and *Abandon Session* actions (see below). This is to permit simple repetition of a transaction that has succeeded from the point of view of the AFC but has failed from that of the host, which would occur when the Modbus response transmitted by the AFC is not received by the host. (If the host uses Collapsed Acknowledgement, it must take care to set the acknowledgement bit correctly in a repeated Fetch.) Other than in such a case, any Modbus transaction that does not comply strictly with the conditions and sequencing described above is rejected with a Modbus exception code (typically code 2, Illegal Address, if not addressing LDW offset 0, otherwise code 3, Illegal Data).

Because both the *Commit Session* and the *Abandon Session* actions close the session, there is afterwards no session context to allow recognition of a repeated *Commit* or *Abandon*. In this case, a repeated *Commit* elicits a Modbus exception of 3, *Illegal Data*, and a repeated *Abandon* is accepted without error regardless of its Session ID.

<u>*Session Timeout*</u>

All transactions of a session must succeed frequently enough so that the duration between successful transactions does not exceed the session timeout. Each successful transaction restarts the timeout. If the timeout expires, the session is automatically abandoned. Other Modbus activity, unrelated to the log-download session, is not considered, and its only effect upon the timeout would be delays of session transactions imposed by bandwidth usage.

10.5.7 Access by Multiple Hosts

The functionality specified in this document can permit complete event-log retrieval by multiple hosts, provided that these conditions are satisfied:

1 As the session's dynamic context is local to the accessed port, multiple hosts may perform sessions simultaneously provided that they access separate ports. The Session ID is part of the dynamic context, so separate-port sessions may use the same Session ID without ambiguity.

2 For multiple hosts that access the same port (using Modbus Master arbitration or a similar scheme), all must perform their sessions at times sufficiently separated so that one host does not interfere by disturbing the dynamic context of another host's session in an unpredictable manner. The Session ID can provide significant protection against inadvertent infringement of this condition.

3 One host must be the Active host, performing the Completion phase that updates the AFC's event log state (download pointer). All other hosts must be Passive, failing to Complete their sessions but instead Abandoning them. If this condition is disregarded, so that multiple Active hosts perform simultaneous sessions each ending with the Completion phase, the AFC's Event Log, which is global, manages any updating of the download pointer and posting of the Download event in a globally consistent manner, but each host cannot be sure that the Download event written upon Completion, if any, is exactly what it expected.

4 Each host must, in one way or another, have access to its own long-term download context, which is the number of the earliest event not yet downloaded by that host. All Passive hosts must maintain this context locally. The Active host may let the AFC maintain its long-term context, using the download pointer in the event log header for this purpose; in such a case the same host must always be the Active one. If, however, each host regardless of role maintains its own long-term context, the role of Active host may be passed around among hosts.

5 All hosts must perform download sessions sufficiently often so that events are not lost by being overwritten by newer ones before those events have been downloaded by that host.

10.5.8 Other Considerations

Expired Events

If the starting event number is sufficiently small relative to the events on file (in particular, if it is 1999 or more before the number of the next event to be recorded), then that event is no longer on file and has already been overwritten. In this case, the event returned by a Fetch is all zero. This is not an issue for the Active host, especially when the event log is configured to be *locked*, as the Active host is interested only in non-downloaded events and those always remain on file with a *locked* log. But for Passive hosts, and when the event log is configured as *unlocked*, download sessions must be performed frequently enough so that the requested events still remain on file. Because event numbers wrap from 65535 to 0, and because events that have not yet been written do not in fact exist and have never existed, an event number that is numerically equal to or greater than the number of the next event to be recorded is deemed to be the number of an event from the previous wrap cycle.

Persistence

A log-download session does not survive a reset of the module (e.g. power cycle).

10.6 Period-end Events

A "period-end" event is detected by the wallclock. There are two such:

a) "End-of-hour" occurs when the minute of the hour steps into the "End-of-hour minute" of Site Configuration.
b) "End-of-day" occurs when the minute of the day steps into the "End-of-day minute" of Site Configuration.

A wallclock change that skips forward over an end-of-period minute will cause that period-end to be missed, and a change that skips backward over that minute will cause that period-end to be repeated, so wallclock adjustments should be performed at times well-removed from either end-of-period minute.

Though a period-end event is not recorded in the event log, it does cause archives and resets to be scheduled for all enabled meters according to their configured "period-end" Archive Options. Archives and resets scheduled by period-end are delayed in their action until at least one meter scan has occurred after the event (the archive data accumulation that takes place at the end of the meter scan also records the latest timestamp, so the written archive then reflects the fact that the period-end has occurred).

10.7 Loggable Events

The tables below give full details of all events that are recorded in the Event Log.

For the Special events (page 191), columns are:

Tag	Numeric value that identifies the event.
Rkv	Effect on archives and accumulator resets (see next).
Description	Lists: The event name, identifying its triggering condition. Contents and meaning of the old and new value fields. Relevant additional information.

For the Data Point (page 193, page 192, page 196) events, columns are:

Group	Group code.
Sbgp	Subgroup code.
Item	Item code.
Dtyp	Datum type code (mnemonic).
Rkv	Effect on archives and accumulator resets (see next).
Datum point	The corresponding writable Modbus point.

In these tables, the "Rkv" columns specify how archives and accumulator resets are scheduled upon occurrence of the corresponding loggable events.

Column values are:

Value	Meaning
*	Upon this event archives and resets are scheduled according to the configured "event" Archive Options, provided that the applicable meter(s) is(are) enabled. Applicable meters depend upon the event class: (a) Special (non-meter-specific) and Site Datum Point events: All meters. (b) Meter events (including meter-specific Specials): The addressed meter. (c) Stream events: The addressed meter, provided that the addressed stream is active. Scheduled archives are always written before completing any change to data or module state implied by the event; this ensures that the data contributing to an archive is limited to that which was available before the event.
-	This event has no effect on archives and resets.
(n)	Upon this event archives and resets are scheduled as for "*", modified by the conditions and actions given in "Note (n)" in "Rkv" notes (page 201).

10.8 Special Events

Tag	Rkv	Description
0	-	Never Used Value: Always 0. Notes: This entry in the Event Log has never been written. The number of such entries starts at 1999 upon cold start and decreases as events are written until none remain, after which oldest events are overwritten with new ones.
1	-	Event Log Download Value: Number of last-downloaded event. Notes: Triggered by a purge of the Event Log, which marks older events as available to be overwritten by new ones.
2	-	Cold Start Value: Always 0. Notes: This event is obsolete and is never written.
3	(1)	Power-Up Value: "Old" value is the last-saved wallclock from the previous session; "new" value is always 0 (clock not yet set). Notes: The last event written upon restart of the application and before entering the meter scan. This event may be preceded by Checksum Alarm and/or PLC Mode Change events.
4	-	PLC Mode Change Value: PLC mode (0 on line, 1 off line). Notes: Logs changes to PLC connectivity as reported by the backplane procedures. Typically caused by switching the PLC between "run" and "program" modes.
5	-	Checksum Alarm Value: Checksum alarm word (datum type "Bsht"). Notes: Logs changes to the checksum alarm bitmaps. Includes site/meter identification (bits 28-24). Upon power-up: Written automatically upon power up when a checksum failure is detected. In this case the event is written even if the bitmap does not change, such as when an affected bit is already set from a previous failure that was never cleared. Upon Modbus write to the bitmap: Records changes to the bitmap only, typically when clearing bits, though setting bits is also permitted.
6	(2)	Wallclock Change Value: Wallclock (packed bitfields). Notes: Triggered when the wallclock is set for the first time, or when it is reset to a value that differs from its current value by five minutes or more. These two cases can be distinguished by the "old value" in the event entry: for the initial setting this value is zero ("clock not set").
7	*	Stream Select Value: Stream number. Notes: Triggered by a "select active stream" meter signal. Includes meter identification (bits 28-24).

10.9 Site Data Point Events

Group	Sbgp	Item	DTyp	Rkv	Data point
0	0	0	Bsht	(3)	Site options
1					Site parameter value
	0	0	Flot	*	Barometric pressure
8	n	0	Usht	-	Arbitrary event-logged value "n" ("n" = 0 thru 9)
15					PLC image address (Quantum platform only)
	0	0	Usht	*	Supervisory, get
	1	0	Usht	*	Supervisory, put
	2	0	Usht	*	Wallclock, get & put
	3	0	Usht	*	Modbus gateway, get & put
	4	0	Usht	*	Modbus pass-thru, put
	5	0	Usht	*	Modbus master, get & put

10.10 Meter Data Point Events

Group	Sbgp	Item	DTyp	Rkv	Data point
0	0				Process input calibration
		0	Flot	*	Temperature
		1	Flot	*	Pressure
		2	Flot	*	Primary input
		3	Flot	*	Flowing density
		4	Flot	*	Water content
0	1				Process input alarm
		0	Flot	-	Temperature range
		1	Flot	-	Pressure range
		2	Flot	-	Primary input range
		3	Flot	-	Flowing density range
		4	Flot	-	Water content range
1	0				Meter classification
		0	Bsht	*	Meter device and engineering units
		1	Usht	*	Product group
2					Reference conditions
	0	0	Flot	*	Temperature
	1	0	Flot	*	Pressure
3					Meter options
	0	0	Blng	*	Calculation options
	1	0	Blng	(4)	Control options
4					Input scaling
	0				Temperature
		0	Flot	*	Range low end
		1	Flot	*	Range high end
		2	Flot	*	Default
		3	Sbyt	*	Module id code
	1				Pressure
		0	Flot	*	Range low end
		1	Flot	*	Range high end
		2	Flot	*	Default
		3	Sbyt	*	Module id code
	2				Primary input
		0	Flot	*	Range low end
		1	Flot	*	Range high end
		2	Flot	*	Default
		3	Sbyt	*	Module id code
	3				Flowing density
		0	Flot	*	Range low end

Group	Sbgp	Item	DTyp	Rkv	Data point
		1	Flot	*	Range high end
		2	Flot	*	Default
		3	Sbyt	*	Module id code
	4				Water content
		0	Flot	*	Range low end
		1	Flot	*	Range high end
		2	Flot	*	Default
		3	Sbyt	*	Module id code
5	0	0	Bm24	*	Analysis component selection map
6	0	0	Ulng	*	Pulse input rollover
7			Units		
	0	0	B448	*	Primary input (period, quantity, units)
	1	0	Ubyt	*	Mass flow rate period
	2	0	Ubyt	*	Mass flow rate units
	3	0	Ubyt	*	Mass accumulator units
	4	0	Ubyt	*	Energy flow rate period
	5	0	Ubyt	*	Energy flow rate units
	6	0	Ubyt	*	Energy accumulator units
	7	0	Ubyt	*	Volume flow rates period
	8	0	Ubyt	*	Volume flow rates units
	9	0	Ubyt	*	Volume accumulators units
8					Accumulator rollovers
	0	0	Ulng	*	Mass
	1	0	Ulng	*	Energy
	2	0	Ulng	*	Volumes
9					Meter parameter value
	0	0	Flot	*	Orifice plate measurement temperature
	1	0	Flot	*	Orifice plate measured diameter
	2	0	Flot	*	Orifice plate coefficient of thermal expansion
	3	0	Flot	*	Meter tube measurement temperature
	4	0	Flot	*	Meter tube measured diameter
	5	0	Flot	*	Meter tube coefficient of thermal expansion
	6	0	Flot	*	Primary input flow threshold
	7	0	Flot	*	Primary input alarm threshold
	8	0	Flot	*	V-cone/Wedge coefficient of discharge
10					[reserved]
11	0				Densitometer
		0	Usht	*	Densitometer type
		1	Flot	*	Calibration temperature
		2	Flot	*	Calibration pressure

Group	Sbgp	Item	DTyp	Rkv	Data point
		3	Flot	*	Calibration constant K0
		4	Flot	*	Calibration constant K1
		5	Flot	*	Calibration constant K2
		6	Flot	*	Calibration constant 6
		7	Flot	*	Calibration constant 7
		8	Flot	*	Calibration constant 8
		9	Flot	*	Calibration constant 9
		10	Flot	*	Calibration constant 10
		11	Flot	*	Calibration constant 11
		12	Flot	*	Calibration constant 12
		13	Flot	*	Calibration constant 13
		14	Flot	*	Calibration constant 14
		15			PLC image address (Quantum platform only)
	0	0	Usht	*	Meter process input &c, get
	1	0	Usht	*	Meter results, put
	2	0	Usht	*	Meter archive fetch, put

10.11 Stream Data Point Events

Group	Sbgp	Item	DTyp	Rkv	Data point
0	0	0	Bsht	*	Stream options
1					Stream parameter value
	0	0	Flot	*	Default relative density (gas) at reference
	1	0	Flot	*	Viscosity
	2	0	Flot	*	Isentropic exponent
	3	0	Flot	*	Default Fpv
	4	0	Flot	*	K/meter factor
	5	0	Flot	*	Default energy content
	6	0	Flot	*	Default reference density (liquid)
	7	0	Flot	*	Default vapor pressure
	8	0	Flot	*	Water density at API reference
	9	0	Flot	*	Default Ctl
	10	0	Flot	*	Default Cpl
	11	0	Flot	*	Shrinkage factor
	12	0	Flot	*	Precalculated alpha
2	0				Meter factor curve
		0	Flot	*	Datum point 1, meter factor
		1	Flot	*	Datum point 1, flow rate
		2	Flot	*	Datum point 2, meter factor
		3	Flot	*	Datum point 2, flow rate
		4	Flot	*	Datum point 3, meter factor
		5	Flot	*	Datum point 3, flow rate
		6	Flot	*	Datum point 4, meter factor
		7	Flot	*	Datum point 4, flow rate
		8	Flot	*	Datum point 5, meter factor
		9	Flot	*	Datum point 5, flow rate
3	0				Analysis mole fraction
					** Because the item code extends into the subgroup field, this can be the only subgroup of group 3 ! (Pending any future reformat of the Event Id Tag)
		0	Usht	(5)	Component 1, scaled molar fraction
		1	Usht	(5)	Component 2, scaled molar fraction
		2	Usht	(5)	Component 3, scaled molar fraction
		3	Usht	(5)	Component 4, scaled molar fraction
		4	Usht	(5)	Component 5, scaled molar fraction
		5	Usht	(5)	Component 6, scaled molar fraction
		6	Usht	(5)	Component 7, scaled molar fraction
		7	Usht	(5)	Component 8, scaled molar fraction
		8	Usht	(5)	Component 9, scaled molar fraction
		9	Usht	(5)	Component 10, scaled molar fraction

Group	Sbgp	Item	DTyp	Rkv	Data point
		10	Usht	(5)	Component 11, scaled molar fraction
		11	Usht	(5)	Component 12, scaled molar fraction
		12	Usht	(5)	Component 13, scaled molar fraction
		13	Usht	(5)	Component 14, scaled molar fraction
		14	Usht	(5)	Component 15, scaled molar fraction
		15	Usht	(5)	Component 16, scaled molar fraction
		16	Usht	(5)	Component 17, scaled molar fraction
		17	Usht	(5)	Component 18, scaled molar fraction
		18	Usht	(5)	Component 19, scaled molar fraction
		19	Usht	(5)	Component 20, scaled molar fraction
		20	Usht	(5)	Component 21, scaled molar fraction
		21	Usht	(5)	Component 22, scaled molar fraction
		22	Usht	(5)	Component 23, scaled molar fraction
		23	Usht	(5)	Component 24, scaled molar fraction

10.12 Prover Data Point Events

Group	Sbgp	Item	DTyp	Rkv	Data point
0	0				Process input calibration ** not implemented
		0	Flot	-	(Inlet) temperature
		1	Flot	-	Outlet temperature
		2	Flot	-	Switch bar temperature
		3	Flot	-	(Inlet) pressure
		4	Flot	-	Outlet pressure
0	1				Process input alarm ** not implemented
		0	Flot	-	(Inlet) temperature range
		1	Flot	-	Outlet temperature range
		2	Flot	-	Switch bar temperature range
		3	Flot	-	(Inlet) pressure range
		4	Flot	-	Outlet pressure range
1	0				Prover classification
		0	Diby	-	Prover type, master meter number
		1	Diby	-	Measurement system, density selection
2	0	0	Bsht	-	Prover options
3	0				Prover run counts
		0	Usht	-	Runs per prove, total
		1	Usht	-	Runs per prove, selected
		2	Usht	-	Max total runs before abort
		3	Usht	-	Passes per run (short prover)
		4	Usht	-	Min pulses per run * 1000
		5	Usht	-	Max seconds per run
4					Prover input format codes
	0	0	Usht	-	Pulse count for run/pass
	1	0	Usht	-	Master meter pulse count
5					Prover reference conditions
	0	0	Flot	*	Temperature
	1	0	Flot	*	Pressure
6					Prover parameter value
	0	0	Flot	-	Meter factor precision
	1	0	Flot	-	Pulse interpolation ratio
	2	0	Flot	-	Flow tube linear thermal expansion coefficient
	3	0	Flot	-	Switch bar linear thermal expansion coefficient
	4	0	Flot	-	Calibrated prover volume
	5	0	Flot	-	Flow tube inside diameter
	6	0	Flot	-	Flow tube wall thickness
	7	0	Flot	-	Flow tube modulus of elasticity
7	0				Prover variation limits

Group	Sbgp	Item	DTyp	Rkv	Data point
		0	Flot	-	Meter temperature
		1	Flot	-	Prover inlet temperature
		2	Flot	-	Prover outlet temperature
		3	Flot	-	Prover inlet-outlet temperature
		4	Flot	-	Prover temperature
		5	Flot	-	Prover-Meter temperature
		6	Flot	-	Switch bar temperature
		7	Flot	-	Meter pressure
		8	Flot	-	Prover inlet pressure
		9	Flot	-	Prover outlet pressure
		10	Flot	-	Prover inlet-outlet pressure
		11	Flot	-	Prover pressure
		12	Flot	-	Prover-meter pressure
		13	Flot	-	Density
		14	Flot	-	Water content
		15	Flot	-	Meter flow rate
		16	Flot	-	Prover flow rate
		17	Flot	-	Pulses over runs
		18	Flot	-	Pulses over passes
		19	Flot	-	Repeatability
		20	Flot	-	Change in factor
8					Prover process input scaling
	0				(Inlet) temperature
		0	Flot	*	Range low end
		1	Flot	*	Range high end
		2	Flot	*	Default
		3	Sbyt	*	Module ID code
	1				Outlet temperature
		0	Flot	*	Range low end
		1	Flot	*	Range high end
		2	Flot	*	Default
		3	Sbyt	*	Module ID codes
	2				Switch bar temperature
		0	Flot	*	Range low end
		1	Flot	*	Range high end
		2	Flot	*	Default
		3	Sbyt	*	Module ID codes
	3				(Inlet) pressure
		0	Flot	*	Range low end
		1	Flot	*	Range high end

Group	Sbgp	Item	DTyp	Rkv	Data point
		2	Flot	*	Default
		3	Sbyt	*	Module ID codes
	4				Outlet pressure
		0	Flot	*	Range low end
		1	Flot	*	Range high end
		2	Flot	*	Default
		3	Sbyt	*	Module ID codes
15					PLC image address (Quantum/Unity platform only)
	0	0	Usht	-	Prover, get
	1	0	Usht	-	Prover, put

10.13 "Rkv" Notes

1 Archives (only, not resets) are forced regardless of configuration, capturing any unarchived data from the previous session.

2 Archives and resets are scheduled (immediately, without a "period-end" delay) only for the initial setting of the wallclock; a "five-minute" event causes no scheduling. This ensures capture of any flow that has occurred prior to the initial clock-set.

3 Event occurs only when one or more of the following bits are changed:

- Bit 2, "Barometric pressure units"
- Bit 5, "Process input out of range use last good"
- Bit 12, "Analysis is packed in module"
- Bit 13, "Analysis is packed over backplane" (1756 and 1769 platforms only)

4 A change to Meter Control Options bit 15, "Meter enable", imposes these adjustments to the normally-scheduled archives/resets:

- Upon meter enable, cancel any scheduled archives (no data yet to be archived), but leave in place any scheduled resets.
- Upon meter disable, cancel any resets (for inspection and so on.; reset will be rescheduled upon subsequent enable), and force archiving of both files regardless of configuration (so that a disabled meter never has any pending unarchived data).

5 Events occur only if Meter Control Options bit 10, "Treat analysis as process input", is clear.

10.14 Downloading the Event Log in Firmware Version 2.05 and Earlier

For auditing purposes, each event has a "number" assigned sequentially, starting at 0 for the first event written and increasing up through 65535 then wrapping to 0 again.

An event record properly includes its event number along with the information listed in the preceding sections. To conserve space, and to make transmittal more efficient, the event number is not stored as part of the event record. Instead, the Event Log header contains sufficient information to calculate for any event its event number from the position of its record in the Log and vice versa.

The following procedures use these terms:

Term	Meaning
my_record	Known record position. Input to procedures (A) and (C)
event_number	Desired event number. Output from procedure (A).
Modbus_address	Desired Modbus address. Output from procedure (C).
my_event	Known event number. Input to procedure (B).
record_position	Desired record position. Output from procedure (B).
number_of_records	Maximum number of records. Contents of register 40000. In this version of the AFC "number_of_records" is 1999; however, to be compatible with future versions that may store a different number of events, an application should use the value from the header instead of a constant 1999.
next_record	Next new record position. Contents of register 40001.
next_event	Next new event number. Contents of register 40002.
oldest_event	Oldest event number on file. Contents of register 40003.
oldest_not_downloaded	Oldest event number not yet downloaded. Contents of register 40004.
events_on_file	Total number of events on file. Calculated. This value starts at 0 upon cold start, then, as events are logged, it rises to a maximum of "number_of_records" and stays there.
downloadable_event	Event number of event being downloaded. Calculated.
event_age	The age of the event in question. Calculated. The next event to be written (which of course is not yet on file) has age 0; the newest event already on file has age 1, the next older event has age 2, and so on up to age "number_of_records".

Also in these procedures:

a) The expression "AND 0x0000FFFF" means "take the low-order 16 bits of the result, discarding all other higher-order bits"; it is equivalent to "(non-negative) remainder upon dividing by 65536" (A traditionally negative remainder that would result from dividing a negative dividend by 65536 must be made positive by subtracting its absolute value from 65536)
b) The operator ":=" means "assignment"; that is, "assign" the expression on the right to the object on the left by calculating the value of the expression on the right and making the object on the left assume that value. The operator "==" means "is equal to".
c) Words in all caps and the other arithmetic operators have their expected meanings.
d) Text enclosed in brackets ("[ ]") are comments only.

Procedure (A): Calculate event number from record position.

1 Calculate number of events on file.

```
events_on_file := ( next_event - oldest_event ) AND 0x0000FFFF
```

2 Determine whether desired record is on file.

```
IF ( my_record < 0 OR my_record ≥ events_on_file ) THEN
    [record is not on file]
    EXIT this procedure
```

3 Calculate age of desired record.

```
event_age := ( next_record - my_record )
IF ( event_age ≤ 0 ) THEN
    event_age := event_age + number_of_records
```

4 Calculate event number of desired record.

```
event_number := ( next_event - event_age ) AND 0x0000FFFF
```

Procedure (B): Calculate record position from event number.

1 Calculate number of events on file.

```
events_on_file := ( next_event - oldest_event ) AND 0x0000FFFF
```

2 Calculate age of desired event.

```
event_age := ( next_event - my_event ) AND 0x0000FFFF
```

3 Determine whether desired event is on file.

```
IF ( event_age == 0 OR event_age > events_on_file ) THEN
    [event is not on file]
    EXIT this procedure
```

4 Calculate record position of desired event.

```
record_position := ( next_position - event_age )
IF ( record_position < 0 ) THEN
    record_position := record_position + number_of_records
```

Procedure (C): Calculate Modbus address of record from record position.

1 Calculate number of events on file.

```
events_on_file := ( next_event - oldest_event ) AND 0x0000FFFF
```

2 Determine whether desired record is on file.

```
IF ( my_record < 0 OR my_record ≥ events_on_file ) THEN
    [record is not on file]
    EXIT this procedure
```

3 Calculate Modbus address.

```
Modbus_address := ( my_record * 8 ) + 40008
```

Procedure (D): Download all events not yet downloaded.

The downloading application should download the entire Log, starting at the oldest event not yet downloaded and extending through all newer events.

1 Fetch event number of oldest event not yet downloaded.

```
downloadable_event := oldest_not_downloaded
```

2 Determine whether any more events remain to be downloaded.

```
IF ( downloadable_event == next_event ) THEN
    [all events have been downloaded]
    EXIT this procedure
```

3 Download this event.

a) Calculate record number.

```
my_event := downloadable_event
record_position := { via Procedure (B) }
```

b) Calculate Modbus address.

```
my_record := record_position
Modbus_address := { via Procedure (C) }
```

c) Download the event with Modbus.

```
Set Modbus Function Code := 4, Read Input Registers
Set Modbus Number of Registers := 8
Set Modbus Register Address := Modbus_address
Execute
Copy the returned data to permanent storage
```

4 Step to next event and loop.

```
downloadable_event := ( downloadable_event + 1 ) AND 0x0000FFFF
GOTO step 2.
```

When the download is complete, and the downloaded events have been logged to disk, the AFC should be told of this fact by issuing the "download complete" Site Signal. This signal updates the header to show that all records have been downloaded, unlocking the Log for further events, and (if "Event log unlocked" is clear) posts a "download" event. A download may be performed at any time; it is not necessary to wait for the log-full condition in order to download.

An application that downloads the event log should explicitly include the event number in any copy of the event that it stores in its own database.

11 Modbus Master

The Modbus Master dialog box opens when you open the Communications menu and then select Modbus Master. The Modbus Master allows you to read or write the registers in the Primary or Virtual Modbus Interface Slaves.

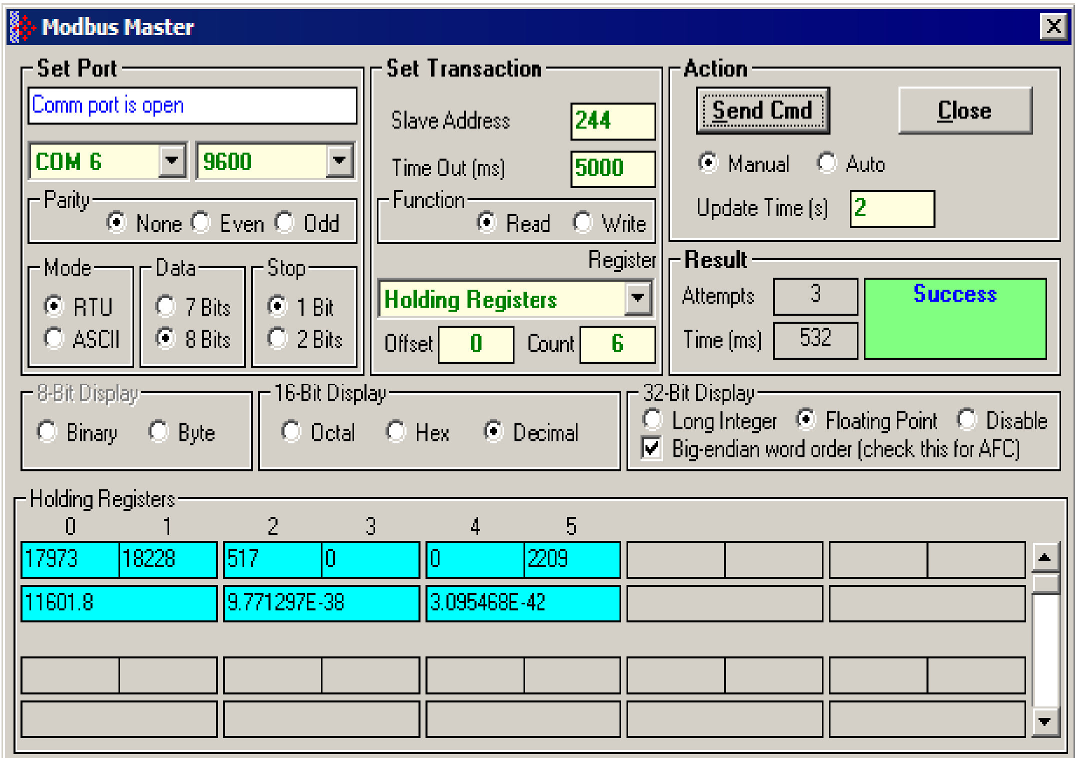
In order to access the Primary Slave, refer to the Modbus Dictionary dialog box (page 209), which contains the Primary Modbus Slave addressing. To access the registers defined in the Virtual Modbus Slave, remember that you must first re-map the registers from the Primary Modbus Slave. The Virtual Modbus Slave will only be active when its address is greater than 0. Refer to Site Configuration (page 29) for more information on configuring these options.

The following example describes the basic procedure to use the Modbus Master feature:

1 Configure the communication parameters.
2 Set the Primary or Virtual Modbus Slave Address configured in the Site Configuration section (>0).
3 Set the Time Out value. If the module does not respond within this period, it will time out.
4 Select the function type.
   - Read = reads from the module.
   - Write = writes to the module.

5 Select the register type: Holding Register or Input Register.
6 Enter the offset address in the Primary or Virtual Slave.
7 Enter the number of registers to transfer.
8 Choose the display format.
9 If writing, enter into the data panel the values that you want to write.
10 Click Send Cmd to execute the read or write operation.
11 If reading, the values read from the module are displayed in the data panel of the dialog box.

This example shows Holding Registers 0 (zero) and 1 containing the values 17973 and 18228 respectively; these values are fixed for the module type, and in this case the module has identified itself as a four stream, sixteen meter MVI56-AFC. Because the 32 bit Display parameter is configured as Floating Point, the 32-bit display shows the value in floating point format.



12 Modbus Database

In This Chapter

The module supports two individual Modbus slaves (Primary and Virtual) to optimize the polling of data from the remote SCADA system, or from the processor (through the backplane). Refer to the Modbus Dictionary dialog box in AFC Manager for information about Modbus addressing.

12.1 AFC Modbus Address Space

Addressable Modbus registers are divided into four banks as shown in the following table.

MODBUS Address Space Allocation: Total Modbus Registers: 131,072			
Primary Slave Banks (131072 registers)		**Virtual Slave Banks (20,000 registers)**	
Holding Registers	**Input Registers**	**Holding Registers**	**Input Registers**
From: 0	From: 0	From: 0	From: 0
To: 65535	To: 65535	To: 9999	To: 9999

The first 100 registers of the virtual slave (registers 0 through 99) are predefined to map to the first 100 registers of the primary slave. This mapping cannot be changed. Also, the Virtual Slave Input Registers can be accessed as Virtual Slave Holding Registers by adding 10000 to the Modbus register address; for example, Input Register 2386 is the same as Holding Register 12386.

12.1.1 Modbus Register Addressing

The original Modbus protocol specification partitions externally accessible registers into several blocks. These blocks include:

12.1.2 Input Registers

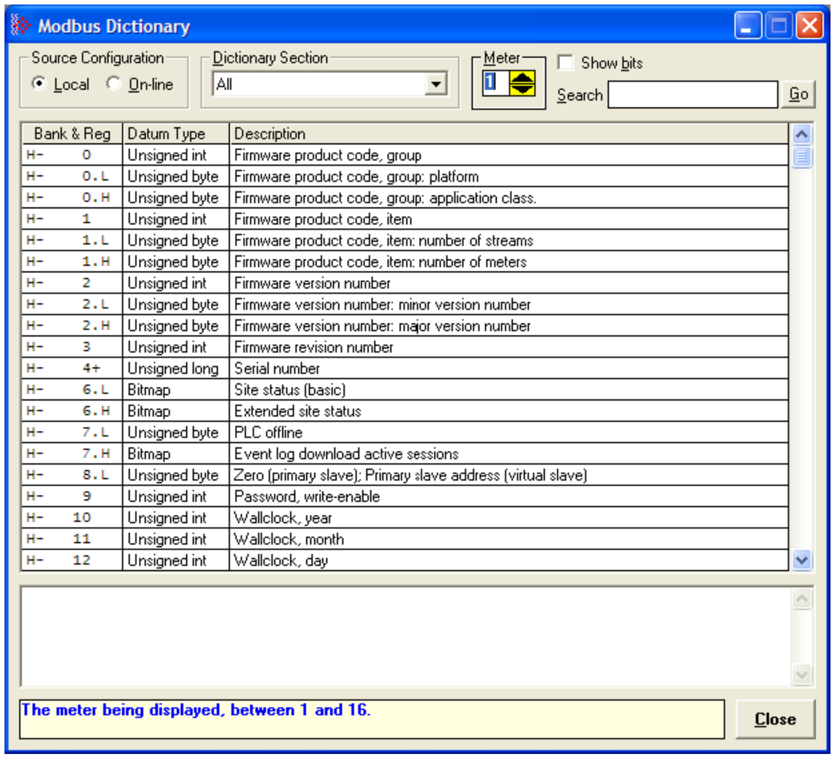
Intended for read-only values, these 16-bit integer registers are accessible via Modbus function 4 (Read Input Registers). The AFC module stores the archives and events as Input Registers.

12.1.3 Holding Registers

Intended for writable values such as setpoints, these 16-bit integer registers are accessible via Modbus function codes 3 (Read Holding Registers), 16 (Write Multiple Registers), and 6 (Write Single Register).

12.2 MODBUS Dictionary Dialog Box (MODBUS Map)

This dialog box opens when you open the Project menu and choose Modbus Dictionary. This dialog box shows a map of registers, addresses and data types for the Modbus database (holding register area only).



The information in this dialog box is "read-only", meaning that you cannot edit values here. To configure data remapping, refer to Primary & Virtual Modbus Slave Configuration (page 36).

Source Configuration selector: Select Local for current Modbus database configuration in AFC Manager. Select Online for current Modbus database configuration in the AFC module. The module must be connected to the PC and communicating with AFC Manager in order to view online configuration.

Note: The interpretation of specific Modbus addresses is determined by meter configuration. The configuration stored in the PC may be different from the one stored in the module.

Dictionary Section selector: Use the categories on this list to filter your view of the Modbus dictionary to locate specific sections of the database quickly. The following views are available:

- All (shows all registers)
- Site Identification (shows basic configuration information including firmware revision, serial number, and wallclock)
- Site Configuration (shows primary and virtual Modbus slave addresses, port parameters, project and site name, and configuration changed status)
- Site Operational (shows scan count, meter alarm status, and audit status)
- Meter Configuration (shows meter configuration details for the selected meter)
- Stream Configuration (shows stream options and calculation reference values)
- Stream Component Analysis (shows analysis molar fractions for each measured component)
- Meter Accumulators (shows gross and net values for non-resettable and resettable accumulators)
- Meter Calculations (shows meter calculation results)
- Meter Archive Status (shows current archive status for calculations).

Meter selector: Use the Up and Down arrows in the Meter selector to view settings for each configured meter.

Show bits check box: Select this check box to view individual bit values for bitmap registers such as Site Status and Meter Alarms.

Search window: You can search for specific text within the Description column. Type the search text in this window, then click the Search button or press **[Enter]**.

Search button: Use the Search button to select the next instance of the search text within the Description column.

Reg column: This column lists each Modbus register offset within the Modbus database (holding register area).

Datum Type column: This column lists the type of data stored in each register within the Modbus database, for example integer, byte, or bitmap.

Description column: This column describes the data stored in each register within the Modbus database.

Description window: If you select (highlight) a register, this window provides additional information about the selected register.

Help window: This window provides brief help information about the currently selected control (radio button, dropdown list, check box, edit window).

Close button: Use this button to close the dialog box.

12.2.1 Primary Slave

The Primary Slave contains the main AFC database that consists of 131,072 Modbus registers. The Site and Meter configuration, as well as all live process data and ongoing calculations are kept in the Primary Slave address space. This address space is divided equally between the Input Register Bank (65,536 registers) and the Holding Register Bank (65,536).

The register addressing is shown in the Modbus Dictionary dialog box in AFC Manager.

Modbus Address References

In these documents (the AFC Manager User's Guide and the User's Guide for your platform) you will occasionally see Modbus address references like *Ph00018* or *Mh00162.* The first two characters of such references indicate how to convert the following number into an absolute Modbus address in the module.

This table shows the possible values for the first identification character:

Address Translation ID	Description
P	Absolute Modbus address, Primary Slave
M	Meter-relative Modbus address, Primary Slave
V	Absolute Modbus address, Virtual Slave

This table shows the possible values for the second identification character:

Register Bank ID	Description
h	Holding register
i	Input register

Modbus Address Examples

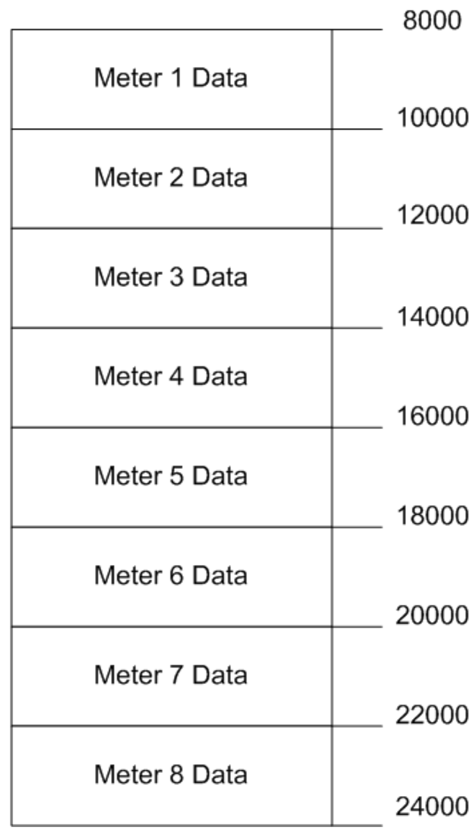
Ph02000 = holding register located at address 2000 in the primary slave

Pi02000 = input register located at address 2000 in the primary slave

Mh00100 = Meter-relative holding register located at offset 100 in the block of the primary slave that contains the data for the meter

Meter-relative Data

Meter-relative data starts at absolute holding register address 8000 and occupies 2000 words of data for each meter channel.



The meter-relative addresses are offsets within each meter data area. The correct absolute address is calculated by the following formula (assumes meters are numbered starting with 1):

```
(absolute address) = (2000 * (meter number-1)) + 8000 + (meter relative
address)
```

In the Modbus Dictionary dialog box, addresses listed for the selected meter are absolute addresses, so you should subtract the appropriate multiple of 8000 to calculate the meter-relative address.

Example: Find the orifice diameter address for the first 5 meter channels.

The meter 1 orifice diameter registers are located at the holding register address 8162 and 8163 as follows:

8160	8161	Float	Parameter: orifice plate: measurement temperature
8162	8163	Float	Parameter: orifice plate: measured diameter
8164	8165	Float	Parameter: orifice plate: coef of thermal expansion
8166	8167	Float	Parameter: meter tube: measurement temperature
8168	8169	Float	Parameter: meter tube: measured diameter
8170	8171	Float	Parameter: meter tube: coef of thermal expansion
8172	8173	Float	Parameter: differential pressure flow threshold

The meter-relative addresses are Mh00162 and Mh00163

The addresses for meters 1 to 5 are listed on the following table.

Meter	Registers
1	8162 and 8163
2	10162 and 10163
3	12162 and 12163
4	14162 and 14163
5	16162 and 16163

Scratchpad

The Primary Modbus Slave contains a scratchpad area that can be used to store any data required by each application. This area is "empty" by default and contains 6000 words of data starting at holding register 2000 in the Primary Modbus Slave.

Virtual Slave

The module also provides a Virtual Address Space of 20,000 Modbus registers. This address space is divided equally between the Input Register Bank (10,000 registers) and the Holding Register Bank Holding Register Bank (10,000). This is where you can create a virtual re-map by cross-referencing any of the 130,072 Primary Slave Modbus registers to the 20,000 Modbus registers in the Virtual Slave Banks, thereby making it easy for a SCADA Master to poll only the necessary Modbus addresses in contiguous blocks. The virtual slave can also be used for data polling from the processor through the backplane.

Modbus access to the Virtual Modbus Slave is disabled by default since its Modbus address is originally set as 0. To use the Virtual Modbus Slave, you must initially configure a Modbus address greater than zero in order to enable it. Refer to Site Configuration (page 29) for more information about enabling the Virtual Slave and using the remapping feature. The PLC may always access the Virtual Slave, whether or not it has a non-zero slave address and thus is available via Modbus.

A download operation will not transfer the Virtual Slave Remapping configuration. You must click on the **Write** button on the **Indirect Address Remapping** dialog box to transfer the data.

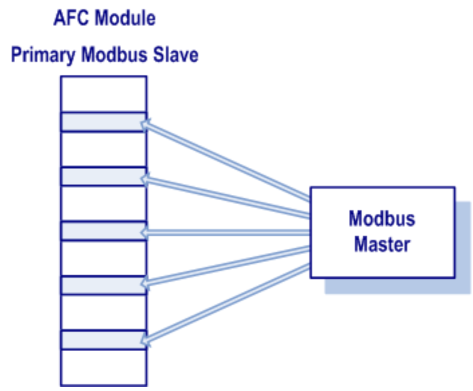
Note: The first 100 registers in the Virtual Slave Holding Register Bank have been pre-assigned and cannot be remapped. They map directly to the first 100 holding registers of the Primary Slave.

Virtual Slave Example Application

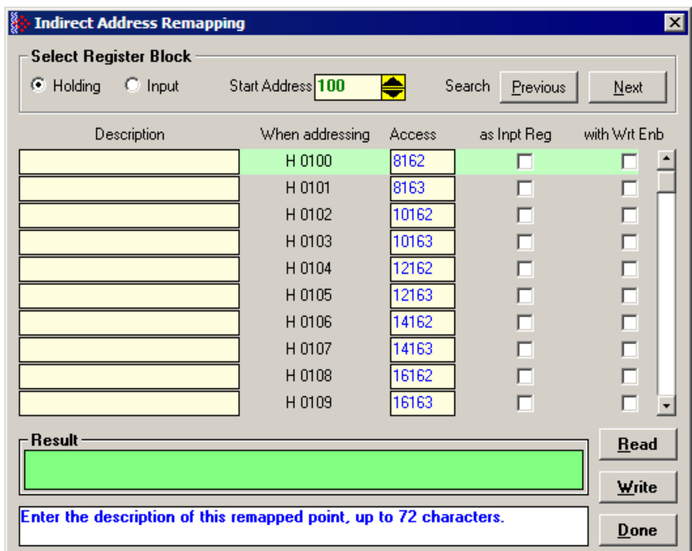
Assume that an application requires a remote Modbus Master to poll the orifice diameters for the first 5 channels. Continuing the previous example, the holding register addresses are listed again the following table.

Meter	Registers
1	8162 and 8163
2	10162 and 10163
3	12162 and 12163
4	14162 and 14163
5	16162 and 16163

Because these addresses are not contiguous, the Modbus Master would have to use five commands to poll all the data directly from the Primary Modbus Slave as follows:



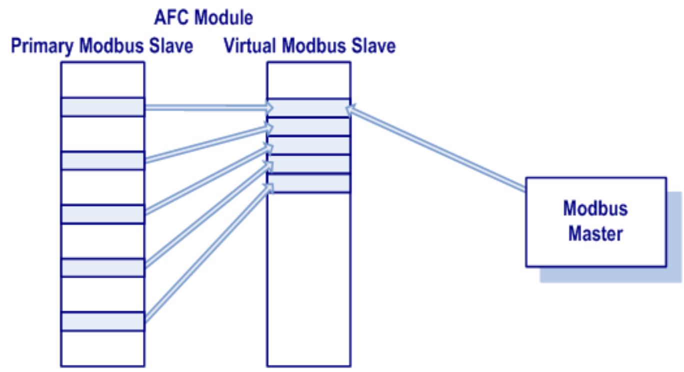
However, using the Virtual Modbus Slave optimizes the polling of data because the registers can be remapped in any order using the AFC Manager (Site Configuration window). The following illustration shows how the orifice diameter registers could be remapped to the Virtual Slave starting at address Vh00100:



The following table shows how the addresses would be remapped between both slaves:

Primary Modbus Slave Addresses	Virtual Modbus Slave Addresses
8162 and 8163	100 and 101
10162 and 10163	102 and 103
12162 and 12163	104 and 105
14162 and 14163	106 and 107
16162 and 16163	108 and 109

Therefore, instead of sending five Modbus commands (2 words each) to the Primary Modbus Slave, the Modbus Master device can now send one single Modbus command (10 words) to the Virtual Modbus Slave in order to poll the same data from the module:



This example demonstrates the benefits of using the Virtual Slave instead of accessing the data directly from the Primary Modbus Slave. The same procedure can be used when polling data from the processor (through the backplane) because the Modbus Gateway block also requires the data to be listed in a contiguous order.

13 Checksum Alarms

Occasionally, the module may flag a checksum alarm condition after a power cycle.

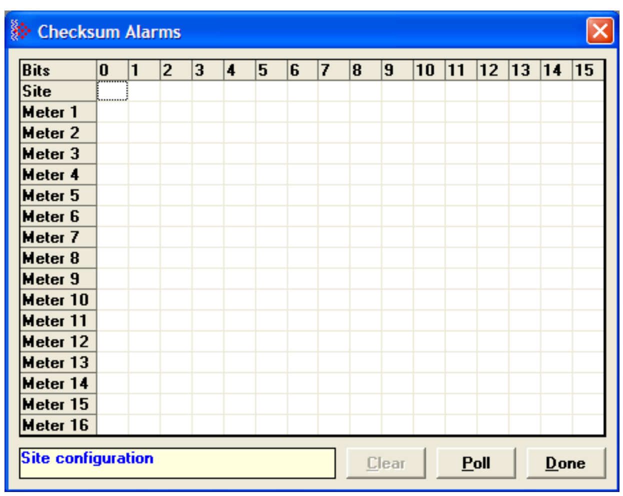
A checksum alarm indicates a checksum verification failure during power-up. Non-volatile information is kept in battery-backed RAM. It is partitioned into several blocks, each of which contains a checksum, and when the information is changed the checksum is updated also. During power-up, the checksum is verified, and upon failure the alarm bit is latched and the checksum corrected.

The alarm bit remains latched, even through subsequent power cycles, until it is explicitly cleared from an external source such as the AFC Manager.

When this event occurs, the module will recalculate the checksum after the power cycle and restore the original value.

The module informs you that a checksum alarm has occurred by blinking the green LED on the module.

If a checksum alarm occurs, you should verify the associated data. Use the Checksum Alarm dialog box to identify which part of the data is related to the alarm. After you verify that the data is OK, click the Clear button to clear the alarm.



14 Reference

In This Chapter

14.1 General Specifications

- Process I/O: analog inputs (pressure, temperature, differential pressure density) from analog modules and pulse inputs from pulse/frequency input modules in rack
- Number of meter channels: 8 or 16 meters: differential (AGA3 or ISO5167) or linear (AGA7) Gas; (MPMS Ch 12.2) Liquid.

MVI46-AFC	MVI56-AFC	MVI69-AFC	MVI71-AFC	PTQ-AFC
8 Meters	16 Meters	8 Meters	8 Meters	16 Meters

Calculation Methods

- AGA3 (1992)
- AGA7
- AGA8 (1992) Detail Characterization Method
- API MPMS Ch 21.1, 21.2
- API Tables (API MPMS Ch 11.1) 23/53 and 24/54 for Hydrocarbon Liquids
- GPA TP-25 for Hydrocarbon Liquids (Tables 23E/24E)
- API MPMS Ch 11.2
- GPA TP-15 for Vapor Pressure Correlation
- Energy (heating value) for gases according to AGA 8 Appendix C-4
- API MPMS Ch 20.1
- ISO 5167

Supports energy measurement for gas applications

Meter I/O Scan Time: Less than one second for all channels.

Product Measurement: Hydrocarbon gases and liquids including refined products

Process I/O Calibration Mode: Allows the calibration of transmitters without interfering with the process update for the module or impacting measurement.

Data Archiving

- Hourly for 2 days for each meter run (48 records per channel)
- Daily for 35 days

Note: The number of archives depends on the archive size you have configured. The default values for a 30 word archive are 48 hourly archives and 35 daily archives.

- Extended Archive feature supports up to 1440 daily archives and 1440 hourly archives stored on Compact Flash
- Each record consists of nearly 20 process and other variables. All archived data is available in the onboard Modbus memory map.
- User may configure when archives are generated
- User may configure archive content (from pre-defined list)
- Archives can be exported to an Excel spreadsheet or printed to a local printer.

Other Features

- Event Log with 1999-event buffer and timestamp.
- Virtual Slave with 20,000 re-mappable Modbus registers for contiguous SCADA polling.
- Password protection

14.1.1 On-line Communication & Configuration

The module is designed for online configuration via the configuration port. A user-friendly Windows 95/98/2000/NT/XP-based Module Configuration and Reporting/Monitoring Manager allows easy access to all configuration data for editing and saving on your computer.

Project configurations may be uploaded, downloaded, and saved to disk under user-selectable filenames. The module takes just minutes to configure using the MS Windows-based AFC Manager.

14.1.2 Reports

- **Event Log Report:** All security-sensitive configuration data (for example, orifice diameter) is date and time stamped and mapped to the local Modbus memory map. This data can be imported into any spreadsheet program and saved to disk or printed to a local printer.
- **Hourly and Daily Archive Reports:** Mapped to local Modbus memory. This data can be imported into any spreadsheet program and saved to disk, or printed as hard copy.
- **System Configuration:** May be transferred to or from the module. The configuration file can also be printed for hard reference or archiving.
- **Audit Scan:** A report can be saved to disk or printed to the local printer.

14.1.3 Modbus Interface

The two Modbus Slave ports allow the unit to be used as a SCADA interface and to broaden access to the AFC module's data table.

- Ports 2 and 3 support RS-232, RS-422 and RS-485 modes
- Supports baud rates of up to 19200 baud
- All ports may be configured for RTU or ASCII Modbus mode.
- All Modbus Slave ports provide access to all configuration and measurement data mapped to the Modbus table.
- Module contains two internal slaves (Primary and Virtual)
- Over 130,000 Modbus registers of the Primary Slave table may be re-mapped to up to 20,000 Modbus registers of the Virtual Slave for contiguous polling from a SCADA master.
- Port 3 can be configured as a Modbus master node
- Supports Modbus functions 3, 4, 5, 6, 15, and 16 as a slave (5 and 15 only on pass-thru operation)
- Supports Modbus functions 1, 2, 3, 4, 15, and 16 as a master
- Scratch Pad Modbus block of 6000 words for transfer of arbitrary data between the processor and the SCADA host via the module.

14.1.4 Configurable Options

Configurable options include:

- Gas analysis concentrations for up to 21 components
- Accumulator Rollover
- Reference temperature and pressure for both gases and liquids
- Orifice and pipe diameters, selection of type of taps, and tap locations, and so on.
- Meter K Factor and Meter Factors with 5-point linearization curve
- Temperature, Pressure, and Density Correction for liquids
- Local Atmospheric (barometric) pressure
- Default process and operating parameters such as DP Threshold for flow cutoff, and so on.
- Metric or US units
- User-selectable units for totalizers and flow rates on a per channel basis
- Resettable and non-resettable totalizers for every meter channel.

14.1.5 Supported Meters

The following meter types have been used with the AFC Manager module. Because of the broad range of meters available in today's market, refer to the meter's specifications and the contents of this manual to evaluate the use of the AFC modules (even if the meter is listed here). If you have questions, please contact ProSoft Technology Technical Support Group.

Meter Type	Configured As (Differential or Linear)
Turbine	Linear
Orifice	Differential
V-Cone	Differential. You must configure the meter as V-Cone type in the AFC Manager (**Meter Configuration** / **Calculation Options**)
Wedge	Differential. Refer to Wedge Meter Applications (page 230) for information about using the wedge meters.
Vortex	Linear or Differential
Ultrasonic	Linear or Differential
Coriolis	Linear or Differential

Note: For Vortex, Ultrasonic or Coriolis meters, the selection depends on the output generated by the meter.
If the meter provides a pulse train representing the volume increment, the AFC meter should be configured as Linear with Primary Input selected as Pulse Count.
If the meter provides the instantaneous flow rate, then the AFC meter should be configured as Differential with Primary Input selected as Flow Rate.
Note: The module does not support applications to measure water, because the implemented standards are applicable to hydrocarbon fluids only.

14.1.6 Hardware Specifications

These modules are designed by ProSoft Technology and incorporate licensed technology from Schneider Electric (Modbus technology) and from (backplane technology).

	MVI46-AFC	MVI56-AFC	MVI69-AFC	MVI71-AFC	PTQ-AFC
Current Loads	800mA @ 5.1 VDC (from backplane)	800mA @ 5.1 VDC (from backplane)	800 mA @ 5V (from backplane) Power supply distance rating of 2	800 mA @ 5.1 VDC (from backplane)	800 mA @ 5V (from backplane)
Operating Temperature	0 to 60°C 32 to 140°F	0 to 60°C 32 to 140°F	0 to 60°C 32 to 140°F	0 to 60°C 32 to 140°F	0 to 60°C 32 to 140° F
Storage Temperature	-40 to 85°C -40 to 185°F	-40 to 85°C -40 to 185°F	-40 to 85°C -40 to 185°F	-40 to 85°C -40 to 185°F	-40 to 85°C -40 to 185°F
Relative Humidity	5% to 95% (non-condensing)	5% to 95% (non-condensing)	5% to 95% (non-condensing)	5 to 95 % (non-condensing)	5 to 95 % (non-condensing)
Modbus Port Connector	Three RJ45 connectors (RJ45 to DB-9 cable shipped with unit) supporting RS-232, RS-422, RS-485 interfaces	Three RJ45 connectors (RJ45 to DB-9 cable shipped with unit) supporting RS-232, RS-422, RS-485 interfaces	Two RJ45 connectors (RJ45 to DB-9 cable shipped with unit (supporting RS-232, RS-422 and RS-485 interfaces (RJ45 to DB-9 cables shipped with unit.	Three RJ45 connectors (RJ45 to DB-9 cable shipped with unit), two of which support RS-232, RS-422, and RS-485 interfaces.	Three DB-9M connectors, two of which support RS-232, RS-422, and RS-485 interfaces.

14.2 Measurement Standards

The module supports the following hydrocarbon (gases and liquids) measurement standards currently employed in the oil and gas measurement industry:

American Petroleum Institute (API) Manual of Petroleum Measurement Standards (MPMS)	
a.	Density Correction to Reference Temperature Chapter 11.1.53, 11.1.23 Equations, Tables 53, 23 - Generalized Crude Oils, Refined Products, Lubricating Oils, Special Applications
b.	Correction of Volume to Reference Temperature and Thermal Expansion: Ctl. Chapter 11.1.54, 11.1.24 Equations, Tables 54, 24 - Generalized Crude Oils, Refined Products, Lubricating Oils, Special Applications
c.	Compressibility Factors for Hydrocarbons: Cpl. Chapter 11.2.1/Chapter 11.2.2 (Chapter 11.2.1M and 11.2.2M for SI units.
d.	Orifice Metering of NGLs & Crude Oils Chapter 14.3 (AGA3)
e.	Calculation of Liquid Petroleum Quantities Measured by Turbine or Displacement Meters Chapter 12.2
f.	Allocation Measurement Chapter 20.1 (high-water-content calculations used for emulsions)
g.	Flow Measurement Using Electronic Metering Systems Chapter 21.1, 21.2
h.	Proving reports (firmware version 2.07 and later // Chapter 12.3

American Gas Association (AGA)	
a.	Orifice Metering of Natural Gas & Other Hydrocarbon Fluids AGA Report No. 3 (1992) (MPMS Ch 14.3)
b.	Compressibility Factors of Natural Gas and Other Related Hydrocarbon Gases AGA Report No. 8 (1992) - Detail Characterization Method

International Standards Organization (ISO)	
a.	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Part 2: Orifice plates ISO 5167-2 (2003)

Gas Processors Association (GPA)	
a.	Temperature Correction for the Volume of Light Hydrocarbons - TP-25
b.	A Simplified Vapor Pressure Completion for Commercial NGLs GPA Document TP-15

14.2.1 Basic Metering According to Meter type

Orifice (Include V-cone): Uses AGA3 1992 / ISO 5167.

A V-cone meter is like an orifice meter, except that the V-cone is an obstruction in the center of the pipe while an orifice is an aperture. V-cone calculation differs from orifice calculation in the following respects:

1 The orifice Beta ratio is actually the square root of the ratio of aperture cross-section to pipe cross-section hence for the V-cone it is calculated differently from the two diameters.

2 The V-cone Coefficient of Discharge is entered as configuration and not calculated. Expansion Factor (Y) is calculated differently.

Output of the calculation is mass flow rate, which is divided by density to get volume and then integrated over time for accumulation.

Pulse: Both Gas and Liquid

Gross Volume is (pulses) / (K-factor) * (meter factor), according to API MPMS Ch 12 sec 2 1981 and 1995. Output of the standard calculation is volume flow increment, which is then multiplied by density to get mass increment. Flow rate is calculated in parallel to flow increment by applying to (pulse frequency) process input the same calculation as is applied to (pulses); this technique is employed instead of flow increment differentiation because the pulse frequency available from the counter card in the processor is not subject to variations of timing caused by scheduling delays in processor backplane transfer and in the firmware of the module, thus yielding a smoother flow rate.

Correction Factors According to Product Phase

Gas

Compressibility is calculated according to the Detail Characterization Method of AGA8 (1992). Gas density is a byproduct of this calculation. Essential input for this calculation is molar analysis. The compressibility Z is a factor in the gas equation PV=ZNRT, which is the rule by which gas volumes are corrected to reference conditions.

Liquid

Temperature and pressure correction factors are calculated according to API MPMS Ch 11 and applied according to the rules given in MPMS Ch 12. Essential input for this calculation is Liquid Density (page 94) at either standard or flowing conditions.

Gas Pulse Measurement

The standard applied is AGA7, which is merely a combination of the gross volume calculation (page 225) and the gas law (PV=ZNRT) which includes compressibility. It also specifies calculation of some intermediate factors, which are now idiosyncratic and vestigial, having been imported from an earlier AGA3 (1985 and before) which used the "factor" method to calculate gas flow and which has been superseded by the completely overhauled 1990/1992 AGA3.

Water Content of Liquids

The handling of water content in crude and NGL products depends upon whether an "emulsion" Product Group is chosen.

For emulsions, water content is removed from the mixture according to the calculations of API MPMS Chapter 20.1 before calculating and applying correction factors. In this case the volumetric quantity intermediate between "Gross" and "Net" is "Gross Clean Oil", which is the hydrocarbon component of the mixture at flowing conditions. This method is recommended for mixtures containing more than 5% water.

For non-emulsions, water content is removed from the mixture according to the rules of API MPMS Chapter 12.2 after calculating and applying correction factors. In this case the volumetric quantity intermediate between "Gross" and "Net" is "Gross Standard", which is the entire mixture including its water content corrected to standard conditions under the assumption that it is pure hydrocarbon. Because the presence of water skews the correction calculations, this method should be used only when the water content is very low.

Non-Standard Reference Conditions

For both liquids and gases, the AFC permits a range of reference conditions for volume measurement which may vary from the API/AGA standard of 15°C/101.325kPaa (SI) or 60°F/14.696psia (US) (US pressure base for gases is 14.73psia). The allowed ranges for SI units are temperature between 0°C and 25°C and pressure between 50kPaa and 110kPaa, with the allowed ranges for US units approximately equivalent.

For gases, this flexibility of reference conditions is handled automatically by the implementation of the AGA 8 (1992) standard for compressibility Z together with the "real" gas law PV=ZNRT.

For liquids, correction factors for non-standard reference conditions are calculated differently depending on the firmware version. For version 2.05 and later, correction factors and corrected density are calculated according to the 2004 edition of API MPMS Chapter 11.1, except for the "NGL" product groups for which the CTL and density calculations of GPA TP-27 are extended with the CPL calculations of (old) MPMS Chapter 11.2 in a manner analogous to that of the 2004 Chapter 11.1. For version 2.04 and earlier, correction factors and corrected density are calculated as described in the following paragraphs, using the calculations of the 1980 edition of MPMS Chapter 11.1. In all cases, the density input to the calculations is the density at standard API base conditions.

Temperature Correction Factor, CTL

First, the "standard" factor, CTL(Flowing / ApiBase), is calculated, except that the final rounding step is not performed. Then, CTL(UserBase / ApiBase) is calculated, also unrounded. The CTL(Flowing / UserBase) is then calculated as (CTL(Flowing / ApiBase) / CTL(UserBase / ApiBase)), to which result is applied the final rounding step of the standard CTL calculation.

Pressure Correction Factor, CPL

The CPL(Flowing / UserBase) is calculated according to the method given in MPMS Ch 12.2 1995. In order to correct "density at reference" to User Base conditions, and also when iteratively calculating corrected density for the effect of elevated pressure, the CPL(Flowing / ApiBase) (unrounded) is also calculated according to the same method.

Density Correction

The density at API Base is determined according to relevant standards, which density is used as input to the CTL and CPL calculations. The density at User Base is determined by multiplying den(ApiBase) by the term (CTL(UserBase / ApiBase) * CPL(Flowing / ApiBase) / CPL(Flowing / UserBase)), all unrounded factors; this density is reported only and is not used in any calculations. When density correction is not selected, or an alarm causes a default to be assumed, any default "density at reference conditions" is deemed to be at User Base, and is also corrected to API Base for input to the CTL and CPL calculations.

Archiving and Event Log

a) Accumulation and data recording for gas-phase archives conform to the requirements of API MPMS Ch 21 sec 1, 1993. Liquid-phase archives conform to API MPMS Ch 21 sec 2.
b) Event-logging conforms to the requirements given in the Industry Canada Weights and Measures Board Draft Specification "Metrological Audit Trails" of 1995-03-01

14.2.2 Liquid Correction Factor Details

For firmware version 2.05 and later, correction factors for most liquids are calculated according to the 2004 edition of API MPMS Chapter 11.1, enhanced with additional CPL calculations if required in order to allow selection of a non-standard base (reference) pressure. For lighter liquids (NGLs and LPGs), to which the 2004 Chapter 11.1 does not apply, the CTL and density correction calculations of GPA TP-27 are enhanced with the incorporation of the CPL calculations of MPMS Chapters 11.2.1 and 11.2.2 in a manner analogous to the method of the 2004 Chapter 11.1, to permit density correction to account for the effect of pressure and to yield the combined correction factor CTPL. For all liquids the option is available to use the vapor pressure correlation of GPA TP-15 June 1988.

For firmware version 2.04 and earlier, correction factors are calculated as described in the following paragraphs.

Temperature Correction Factor CTL

(According to Several "Tables" of MPMS Ch 11.1 (1980, except E Tables 1998 = GPA TP-25) and Other Standards)

Calculation of CTL (= VCF, Volume Correction Factor) from flowing temperature and density at standard temperature depends on the measurement system (SI or US), the product type (crude or refined), and the density range (high or low).

SI units:

D ≥ 610 kg/m3 Table 54A (Crude&NGL) or 54B (Refined Products)

500 ≤ D < 610 (LPG) ASTM-IP-API Petroleum Measurement Tables for Light Hydrocarbon Liquids 500-653 kg/m3 1986 ISBN 0 471 90961 0

US units:

D ≥ 0.610 RD60 Table 24A (Crude&NGL) or 24B (Refined Products),

0.350 ≤ D < 0.610 (LPG) Table 24E - TP25

The low density range of 0.350 RD60 in US units is considerably lower than the 500 kg/m3 in SI units, because the E Tables are available only for US units.

Correction of density from flowing temperature to standard temperature is a converging iteration which includes the calculation of the VCF (Volume Correction Factor). Standards applied are those listed above except that Tables n3x are used instead of Tables n4x.

An option is available to iteratively correct the density calculation for elevated flowing pressure according to the condition given in bold type in MPMS Ch12.2 1995 Part 1 Appendix B Section B.1 (page 21).

Compressibility Factor F

(According to MPMS Ch 11.2 (US) or11.2M (SI) 1986)

- Vapor pressure correlation according to GPA TP-15 June 1988.
- Pressure Correction Factor (CPL) is calculated from F and pressure above equilibrium according to MPMS ch12.2 1995, where "atmospheric pressure" is read as "base pressure" and "gage pressure" is read as "pressure above base". The module considers:

Pressure process input + barometric pressure = absolute pressure

14.3 Sealable Parameters

Sealable parameters are Site and Meter configuration options that directly affect measurement calculations. for example, orifice diameter, or K-factor.

Prover

- Process input alarm
- Prover classification
- Prover options
- Prover run counts
- Prover input format codes
- Prover size characteristics
- Prover reference conditions
- Prover parameter value
- Prover variation limits
- Prover process input scaling

Site

- Site options
- Site parameter value
- Arbitrary event-logged value

Meter

- Process input calibration / alarm
- Meter classification
- Reference conditions
- Meter options
- Input scaling
- Analysis component selection map
- Pulse input rollover
- Units
- Accumulator rollovers
- Meter parameter value
- Analysis precision, stream assignment
- Densitometer

Stream

- Stream options
- Stream parameter value
- Meter factor curve
- Analysis mole fraction, Ushort
- Analysis mole fraction, Float

14.4 Wedge Meter Applications

For Wedge Meter applications you must convert some parameters from the meter manufacturer's data sheet before entering these values to the AFC Manager. The following spreadsheets can be used to calculate the AFC Manager parameters according to the meter manufacturer as follows:

Filename	Application
WEDGE_ABB.xls	ABB Wedge Meter
WEDGE_PRESO.xls	PRESO Wedge Meter

You must initially configure the meter as a differential type. Then you must configure it as a V-Cone Device (**Meter Configuration** / **Calculation Options**).

Refer to the spreadsheet for instructions on how to enter the correct values into AFC Manager.

14.5 Configurable Archive Registers

The following table shows the possible registers that can be included in the archive definition. Use the Insert and Remove buttons on the Archive Configuration dialog box to customize the list of registers for each meter archive.

Description	Meter-Relative Address	Length
Analysis molar fraction, component 1	720	1 word
Analysis molar fraction, component 2	721	1 word
Analysis molar fraction, component 3	722	1 word
Analysis molar fraction, component 4	723	1 word
Analysis molar fraction, component 5	724	1 word
Analysis molar fraction, component 6	725	1 word
Analysis molar fraction, component 7	726	1 word
Analysis molar fraction, component 8	727	1 word
Analysis molar fraction, component 9	728	1 word
Analysis molar fraction, component 10	729	1 word
Analysis molar fraction, component 11	730	1 word
Analysis molar fraction, component 12	731	1 word
Analysis molar fraction, component 13	732	1 word
Analysis molar fraction, component 14	733	1 word
Analysis molar fraction, component 15	734	1 word
Analysis molar fraction, component 16	735	1 word
Analysis molar fraction, component 17	736	1 word
Analysis molar fraction, component 18	737	1 word
Analysis molar fraction, component 19	738	1 word
Analysis molar fraction, component 20	739	1 word
Analysis molar fraction, component 21	740	1 word
Analysis molar fraction, component 22	741	1 word
Analysis molar fraction, component 23	742	1 word
Analysis molar fraction, component 24	743	1 word
Input pulse count, archive reset, daily	840	2 words
Input pulse count, archive reset, hourly	842	2 words
Previous input pulse count	846	2 words
Current master pulse count	848	2 words
Non-resettable accumulator, mass, totalizer	850	2 words
Non-resettable accumulator, mass, residue	852	2 words
Non-resettable accumulator, energy, totalizer	854	2 words
Non-resettable accumulator, energy, residue	856	2 words
Non-resettable accumulator, net, totalizer	858	2 words
Non-resettable accumulator, net, residue	860	2 words
Non-resettable accumulator, gross, totalizer	862	2 words
Non-resettable accumulator, gross, residue	864	2 words

Description	Meter-Relative Address	Length
Non-resettable accumulator, gross standard, totalizer	866	2 words
Non-resettable accumulator, gross standard, residue	868	2 words
Non-resettable accumulator, water, totalizer	870	2 words
Non-resettable accumulator, water, residue	872	2 words
Resettable accumulator 1, totalizer	874	2 words
Resettable accumulator 1, residue	876	2 words
Resettable accumulator 2, totalizer	878	2 words
Resettable accumulator 2, residue	880	2 words
Resettable accumulator 3, totalizer	882	2 words
Resettable accumulator 3, residue	884	2 words
Resettable accumulator 4, totalizer	886	2 words
Resettable accumulator 4, residue	888	2 words
Accumulator, archive period, daily, totalizer	890	2 words
Accumulator, archive period, daily, residue	892	2 words
Accumulator, archive period, hourly, totalizer	894	2 words
Accumulator, archive period, hourly, residue	896	2 words
Process input, scaled float, temperature	1520	2 words
Process input, scaled float, pressure	1522	2 words
Process input, scaled float, dif prs / flow rate / freq	1524	2 words
Process input, scaled float, flowing density	1526	2 words
Process input, scaled float, water and sediment	1528	2 words
Process input, scaled integer, temperature	1540	1 word
Process input, scaled integer, pressure	1541	1 word
Process input, scaled integer, dif prs / flow rate / freq	1542	1 word
Process input, scaled integer, flowing density	1543	1 word
Process input, scaled integer, water and sediment	1544	1 word
Temperature, absolute	1570	2 words
Upstream pressure, absolute	1572	2 words
Densitometer frequency	1574	2 words
AGA 7 temperature base factor, Ftb	1594	2 words
AGA 7 pressure base factor, Fpb	1596	2 words
Meter alarms	1601	1 word
Orifice characterization error	1602	1 word
Analysis characterization error	1603	1 word
AGA 8 calculation error	1604	1 word
Density correction error	1605	1 word
Temperature correction error	1606	1 word
Vapor pressure error	1607	1 word
Pressure correction error	1608	1 word
Scan count, process input	1618	1 word

Description	Meter-Relative Address	Length
Scan count, calculation	1619	1 word
AGA 8, Molar mass of mixture	1620	2 words
AGA 8, Ideal gas relative density	1622	2 words
AGA 8, Compressibility at reference	1624	2 words
AGA 8, Molar density at reference	1626	2 words
AGA 8, Density at reference	1628	2 words
AGA 8, Relative density at reference	1630	2 words
AGA 8, Compressibility, flowing	1632	2 words
AGA 8, Molar density, flowing	1634	2 words
AGA 8, Density, flowing	1636	2 words
AGA 8, Supercompressibility, Fpv	1640	2 words
Previous timer tick count	1661	1 word
Scan period (seconds)	1662	2 words
AGA 3, Pressure extension	1664	2 words
AGA 3, Differential pressure in static pressure units	1666	2 words
AGA 3, Orifice bore diameter at temperature	1668	2 words
AGA 3, Meter tube internal diameter at temperature	1670	2 words
Reserved	1672	2 words
AGA 3, Density, flowing	1674	2 words
AGA 3, Mass flow rate, Qm	1678	2 words
AGA 3, Velocity of approach factor, Ev	1680	2 words
AGA 3, Expansion factor, Y	1682	2 words
AGA 3, Coefficient of discharge, Cd	1684	2 words
AGA 3, Composition factor	1686	2 words
AGA 7, Temperature factor, Ftm	1694	2 words
AGA 7, Pressure factor, Fpm	1696	2 words
AGA 7, C-prime	1698	2 words
Molar heating value, MJ/kmol	1700	2 words
Mass heating value	1702	2 words
Volumetric heating value	1704	2 words
MPMS Ch 11, Density at API base temperature	1738	2 words
MPMS Ch 11, Hydrometer correction factor	1740	2 words
MPMS Ch 11, Density at reference	1742	2 words
MPMS Ch 11, Vapor pressure	1744	2 words
MPMS Ch 11, CPL low density factor A	1746	2 words
MPMS Ch 11, CPL low density factor B	1748	2 words
MPMS Ch 11, CPL factor F	1750	2 words
MPMS Ch 11, Temperature correction factor, CTL	1752	2 words
MPMS Ch 11, Pressure correction factor, CPL	1754	2 words
MPMS Ch 11, Sediment and water correction factor, CSW	1756	2 words

Description	Meter-Relative Address	Length
Density calculation select	1759	1 word
AGA 8, Ideal gas relative density - scaled integer	1761	1 word
AGA 8, Compressibility at reference - scaled integer	1762	1 word
AGA 8, Relative density at reference - scaled integer	1765	1 word
AGA 8, Compressibility, flowing - scaled integer	1766	1 word
AGA 8, Supercompressibility, Fpv - scaled integer	1770	1 word
Reserved	1786	1 word
AGA 3, Velocity of approach factor - scaled integer	1790	1 word
AGA 3, Expansion factor - scaled integer	1791	1 word
AGA 3, Coefficient of discharge - scaled integer	1792	1 word
MPMS Ch 11, Density at reference	1821	1 word
MPMS Ch 11, Vapor pressure	1822	1 word
MPMS Ch 11, Temperature correction factor, CTL	1826	1 word
MPMS Ch 11, Pressure correction factor, CPL	1827	1 word
MPMS Ch 11, Sediment and water correction factor, CSW	1828	1 word
Startup input pulse count	1840	2 words
Current input pulse count	1842	2 words
Pulse increment	1844	2 words
Pulse frequency	1846	2 words
Interpolated/static K-factor	1848	2 words
Interpolated/static meter factor	1850	2 words
Multiplier, mass flow rate	1864	2 words
Multiplier, energy flow rate	1866	2 words
Multiplier, volume flow rate	1868	2 words
Multiplier, mass accumulator	1870	2 words
Multiplier, energy accumulator	1872	2 words
Multiplier, volume accumulator	1874	2 words
Accumulator increment, mass	1876	2 words
Accumulator increment, energy	1878	2 words
Accumulator increment, net	1880	2 words
Accumulator increment, gross	1882	2 words
Accumulator increment, gross standard	1884	2 words
Accumulator increment, water	1886	2 words
Flow rate, mass	1888	2 words
Flow rate, energy	1890	2 words
Flow rate, net	1892	2 words
Flow rate, gross	1894	2 words
Flow rate, gross standard	1896	2 words
Flow rate, water	1898	2 words

14.5.1 Information for Users of AFC Manager Versions Older Than 2.01.000

If you are using AFC Manager versions older than 2.01.000, you must set these bits using the Modbus master interface in the AFC Manager. Please refer to the AFC Manager User Manual for further information about the Modbus Master interface feature.

Refer to the following words to configure the archive options directly to the Modbus database:

Address	Description
8341	Meter 1 daily archive configuration word
8421	Meter 1 hourly archive configuration word
10341	Meter 2 daily archive configuration word
10421	Meter 2 hourly archive configuration word
12341	Meter 3 daily archive configuration word
12421	Meter 3 hourly archive configuration word
14341	Meter 4 daily archive configuration word
14421	Meter 4 hourly archive configuration word
16341	Meter 5 daily archive configuration word
16421	Meter 5 hourly archive configuration word
18341	Meter 6 daily archive configuration word
18421	Meter 6 hourly archive configuration word
20341	Meter 7 daily archive configuration word
20421	Meter 7 hourly archive configuration word
22341	Meter 8 daily archive configuration word
22421	Meter 8 hourly archive configuration word

Each archive configuration word has the following bitmap structure:

Bit	Description
0	Period select, hourly
1	Archive upon period end
2	Archive upon event
3	Reserved
4	Reset resettable accumulator 1 upon period end
5	Reset resettable accumulator 2 upon period end
6	Reset resettable accumulator 3 upon period end
7	Reset resettable accumulator 4 upon period end
8	Reset resettable accumulator 1 upon event
9	Reset resettable accumulator 2 upon event
10	Reset resettable accumulator 3 upon event
11	Reset resettable accumulator 4 upon event
12	Reserved
13	Reserved
14	Reserved
15	Reserved

Note: Bit 0 must be set only for the hourly archives.

Changes made directly to the Modbus table in this manner are not automatically made to your open AFC configuration. To incorporate these changes into your configuration so that they may be saved in the AFC file on your hard disk, you must read back the meter configuration from the module after making the change by using the "Read Configuration" button on the Meter Configuration window.

14.6 Archive Data Format

There are 3 columns associated with each archive data:

Column	Description
Ofs	Shows the offset location of the data in each archive. The maximum offset value will depend on the *Record Size* value you configured. If the value has a "+" value (for example 0+) it means that the data occupies 2 words of data.
Reg	Shows the Primary Modbus Slave Address of the data. This is a meter-relative address. For example: a Reg value of 890+ for meter 1 would be equivalent to Modbus addresses 8890 and 8891.
Description	Data Description.

14.6.1 Timestamp Date and Time Format

The date and time format used in the archives is stored in a highly compressed form in order to represent the date and time using only 2 words of data:

Word	Description
0	Date
1	Time

In order to extract the information from the date format use the following arithmetic:

Date Word

Year = ([Bits 15 thru 9] from Word 0) + 1996

Month = ([Bits 8 thru 5] from Word 0) + 1

Day = ([Bits 4 thru 0] from Word 0) + 1

Time Word

Hour = ([Bits 15 thru 11] from Word 1)

Minute = ([Bits 10 thru 5] from Word 1)

Second = ([Bits 4 thru 0] from Word 1)* 2

The first 10 words of data (archive header) are common for all archives:

14.6.2 Pre-defined Header

These archive areas are included in the default archive data, and cannot be reconfigured by the user.

Start Offset	End Offset	Data Format	Type	Description
0	1	Timestamp	Snapshot	Closing timestamp of archive
2		Word	Calculated	Flowing period
3		Bitmap	Calculated	Cumulative meter alarms
4		Bitmap	Calculated	Cumulative status
5		Word	Snapshot	Event counter
6	7	Double word	Calculated	Flowing period, seconds
8	9	Timestamp	snapshot	Opening timestamp of archive

Additional areas are also included in the default archive data, according to the meter type and product group associated with the meter.

The cumulative meter alarms are defined as follows:

Offset	Description
0	Current archive, daily, cumulative meter alarm: Input out of range, temperature
1	Current archive, daily, cumulative meter alarm: Input out of range: pressure
2	Current archive, daily, cumulative meter alarm: Input out of range: differential pressure
3	Current archive, daily, cumulative meter alarm: Input out of range: flowing density
4	Current archive, daily, cumulative meter alarm: Input out of range: water content
5	Current archive, daily, cumulative meter alarm: Differential Pressure Low
6	Current archive, daily, cumulative meter alarm: Orifice Pressure Exception
7	Current archive, daily, cumulative meter alarm: Accumulation overflow
8	Current archive, daily, cumulative meter alarm: Orifice characterization error
9	Not Used
10	Current archive, daily, cumulative meter alarm: Current archive, daily, cumulative meter alarm: Analysis characterization error
11	Current archive, daily, cumulative meter alarm: Compressibility calculation error
12	Current archive, daily, cumulative meter alarm: Reference density error
13	Current archive, daily, cumulative meter alarm: Temperature correction error
14	Current archive, daily, cumulative meter alarm: Vapor pressure error
15	Current archive, daily, cumulative meter alarm: Pressure correction error

The cumulative status bits are defined as follows:

Offset	End Offset
00	Stream 1 active
01	Stream 2 active
02	Stream 3 active
03	Stream 4 active
11	Meter enabled
12	Backplane Communication Fault
13	Measurement Configuration Changed
14	Power up
15	Cold Start

The following 20 words (default configuration) will depend on the meter type and product group as follows:

14.6.3 Orifice (Differential) Meter with Gas Product

Start Offset	End Offset	Data Format	Type	Description
10	11	Accumulator	Snapshot	Accumulator totalizer, net
12	13	Floating point	Snapshot	Accumulator residue, net
14	15	Floating point	Flow weighted average	Flow rate, net
16	17	Floating point	Flow weighted average	Temperature
18	19	Floating point	Flow weighted average	Pressure
20	21	Floating point	Flow weighted average	Differential pressure
22		Word	Flow weighted average	Relative density, e-4
23		Word	Flow weighted average	Compressibility, reference, e-4
24		Word	Flow weighted average	Compressibility, flowing, e-4
25		Word	Flow weighted average	Supercompressibility, e-4
26		Word	Flow weighted average	Velocity of approach factor, Ev, e-4
27		Word	Flow weighted average	Expansion factor, Y, e-4
28		Word	Flow weighted average	Coefficient of discharge, Cd, e-4
29		Word		(available)

14.6.4 Pulse (Linear) Meter with Gas Product

Start Offset	End Offset	Data Format	Type	Description
10	11	Accumulator	Snapshot	Accumulator totalizer, net
12	13	Floating point	Snapshot	Accumulator residue, net
14	15	Floating point	Flow weighted average	Flow rate, net
16	17	Floating point	Flow weighted average	Temperature
18	19	Floating point	Flow weighted average	Pressure
20	21	Floating point	Flow weighted average	K-Factor
22	23	Floating point	Flow weighted average	Meter Factor
24		Word	Flow weighted average	Relative density, e-4
25		Word	Flow weighted average	Compressibility, reference, e-4
26		Word	Flow weighted average	Compressibility, flowing, e-4
27		Word	Flow weighted average	Supercompressibility, e-4
28	29	Double Word	Snapshot	Pulse Count

14.6.5 Orifice (Differential) Meter with Liquid Product

Start Offset	End Offset	Data Format	Type	Description
10	11	Accumulator	Snapshot	Accumulator totalizer, net
12	13	Floating point	Snapshot	Accumulator residue, net
14	15	Floating point	Flow weighted average	Flow rate, net
16	17	Floating point	Flow weighted average	Temperature
18	19	Floating point	Flow weighted average	Pressure
20	21	Floating point	Flow weighted average	Differential pressure
22	23	Floating point	Flow weighted average	Density input
24		Word	Flow weighted average	Corrected density (scaled integer)
25		Word	Flow weighted average	CTL e-4
26		Word	Flow weighted average	CPL e-4
27		Word	Flow weighted average	Velocity of approach factor, Ev, e-4
28		Word	Flow weighted average	Expansion factor, Y, e-4
29		Word	Flow weighted average	Coefficient of discharge, Cd, e-4

14.6.6 Pulse (Linear) Meter with Liquid Product

Start Offset	End Offset	Data Format	Type	Description
10	11	Accumulator	Snapshot	Accumulator totalizer, net
12	13	Floating point	Snapshot	Accumulator residue, net
14	15	Floating point	Flow weighted average	Flow rate, net
16	17	Floating point	Flow weighted average	Temperature
18	19	Floating point	Flow weighted average	Pressure
20	21	Floating point	Flow weighted average	K-Factor
22	23	Floating point	Flow weighted average	Meter Factor
24	25	Floating point	Flow weighted average	Density Input
26		Word	Flow weighted average	Water content, % e-2
27		Word	Flow weighted average	Corrected density (scaled integer)
28		Word	Flow weighted average	CTL e-4
29		Word	Flow weighted average	CPL e-4

14.6.7 Flow Rate Integration with Gas Product

Start Offset	End Offset	Data Format	Type	Description
10	11	Accumulator	Snapshot	Accumulator totalizer, net
12	13	Floating point	Snapshot	Accumulator residue, net
14	15	Floating point	Flow weighted average	Flow rate, net
16	17	Floating point	Flow weighted average	Temperature
18	19	Floating point	Flow weighted average	Pressure
20	21	Floating point	Flow weighted average	Flow Rate Input
22		Word	Flow weighted average	Relative density, e-4
23		Word	Flow weighted average	Compressibility, reference, e-4
24		Word	Flow weighted average	Compressibility, flowing, e-4
25		Word	Flow weighted average	Supercompressibility, e-4
26		Word		(available)
27		Word		(available)
28		Word		(available)
29		Word		(available)

14.6.8 Pulse Frequency Integration with Gas Product

Start Offset	End Offset	Data Format	Type	Description
10	11	Accumulator	Snapshot	Accumulator totalizer, net
12	13	Floating point	Snapshot	Accumulator residue, net
14	15	Floating point	Flow weighted average	Flow rate, net
16	17	Floating point	Flow weighted average	Temperature
18	19	Floating point	Flow weighted average	Pressure
20	21	Floating point	Flow weighted average	K-Factor
22	23	Floating point	Flow weighted average	Meter Factor
24		Word	Flow weighted average	Relative density e-4
25		Word	Flow weighted average	Compressibility, reference, e-4
26		Word	Flow weighted average	Compressibility, flowing, e-4
27		Word	Flow weighted average	Supercompressibility, e-4
28	29	Floating point	Flow weighted average	Pulse Frequency

14.6.9 Flow Rate Integration with Liquid Product

Start Offset	End Offset	Data Format	Type	Description
10	11	Accumulator	Snapshot	Accumulator totalizer, net
12	13	Floating point	Snapshot	Accumulator residue, net
14	15	Floating point	Flow weighted average	Flow rate, net
16	17	Floating point	Flow weighted average	Temperature
18	19	Floating point	Flow weighted average	Pressure
20	21	Floating point	Flow weighted average	Flow Rate Input
22	23	Floating point	Flow weighted average	Density Input
24		Word	Flow weighted average	Corrected density (scaled integer)
25		Word	Flow weighted average	CTL e-4
26		Word	Flow weighted average	CPL e-4
27		Word		(available)
28		Word		(available)
29		Word		(available)

14.6.10 Pulse Frequency Integration with Liquid Product

Start Offset	End Offset	Data Format	Type	Description
10	11	Accumulator	Snapshot	Accumulator totalizer, net
12	13	Floating point	Snapshot	Accumulator residue, net
14	15	Floating point	Flow weighted average	Flow rate, net
16	17	Floating point	Flow weighted average	Temperature
18	19	Floating point	Flow weighted average	Pressure
20	21	Floating point	Flow weighted average	K-Factor
22	23	Floating point	Flow weighted average	Meter Factor
24	25	Floating point	Flow weighted average	Density Input
26		Word	Flow weighted average	Water content, % e-2
27		Word	Flow weighted average	Corrected density (scaled integer)
28	29	Floating point	Flow weighted average	Pulse Frequency

Example 1

Find the Net Accumulator addresses at archive 1 (latest daily archive) for the first 4 meters.

Primary Modbus Slave *Input* Register Address	**Description**
10 and 11	Net Accumulator Totalizer from archive 1 - Meter 1
2510 and 2511	Net Accumulator Totalizer from archive 1 - Meter 2
5010 and 5011	Net Accumulator Totalizer from archive 1 - Meter 3
7510 and 7511	Net Accumulator Totalizer from archive 1 - Meter 4

Example 2

Find the Net Accumulator addresses at archive 0 (current daily archive) for the first 4 meters.

Primary Modbus Slave *Holding* Register Address	**Description**
9910 and 9911	Net Accumulator Totalizer from archive 0 - Meter 1
11910 and 11911	Net Accumulator Totalizer from archive 0 - Meter 2
13910 and 13911	Net Accumulator Totalizer from archive 0 - Meter 3
15910 and 15911	Net Accumulator Totalizer from archive 0 - Meter 4

14.7 Modbus Addressing Common to Both Primary and Virtual Slaves

Address	Type	Description
Ch00000	Char	Firmware product code, group Low byte: platform High byte: application class
Ch00001	Char	Firmware product code, item Low byte: number of streams High byte: number of meters
Ch00002	Int	Firmware version number Low byte: minor version number High byte: major version number
Ch00003	Int	Firmware revision number
Ch00004 to Ch00005	Int	Serial number

Address	Type	Description
Ch00006	Bm	Site status bit 0 - AFC released Latched when both bit 15 (cold start) and bit 12 (Processor offline) first become clear, remaining so until any subsequent cold start. While this bit remains clear events are not logged, allowing an initial configuration to be fully completed without filling up the event log. bit 1 - Checksum alarm Set when any bit in the "Checksum Alarms" registers, for site and each meter, is set; clear when all such bits are clear. bit 2 - [reserved] bit 3 - [reserved] bit 4 - Processor halted, offline, or missing Set while backplane communication is faulty, which typically occurs when the Processor is switched to program mode. While set, measurement continues using the latest process input values obtained from the processor. Upon resumption of backplane communication, the AFC compensates for the downtime by computing an accumulator increment in a manner that depends on the meter type. For differential (orifice) meters, the first measurement scan acquires a scan period equal to the period of downtime as computed from the system timer, hence periods of processor downtime shorter than the rollover period of the system timer cause no loss of product. For linear (pulse) meters, the first measurement scan acquires a pulse increment equal to the difference between the processor-supplied pulse count of the current scan and that of the last scan before communication loss, hence periods of processor downtime shorter than the rollover period of the counter module cause no loss of product. bit 5 - Measurement configuration changed Set when any bit in the "Measurement Configuration Changed" registers is set; clear when all such bits are clear. bit 6 - Power up Set upon power-up, and cleared upon setting the wallclock for the first time.. bit 7 - Cold start Upon power-up, AFC's non-volatile storage is checked for validity, by verifying a checksum and confirming that certain known values are present in their proper locations. If the storage is invalid, then it is initialized with a default configuration, and this bit is set. The bit remains set, even through subsequent power cycles, until at least one meter is enabled at which time the bit is cleared. bit 8 - A copy of the "Hard Passwords" site option, made available here so that an external application such as AFC Manager can learn all it needs to know in order to connect to the module by reading the first 20 holding registers from the Modbus table. bit 9 - [reserved] bit 10 - [reserved] bit 11 - [reserved] bit 12 - [reserved] bit 13 - [reserved] bit 14 - [reserved] bit 15 - [reserved]
Ch00007	By	Processor offline code: 0 online, 1 offline
Ch00008	By	Zero / primary slave address This value distinguishes the two slaves. When read from the primary slave this value is zero; when read from the virtual slave this value is the primary slave address.
Ch00009	Wd	Password, write-enable
Ch00010 to Ch00015	Wd	Wallclock (Y,M,D,h,m,s) The wallclock has a resolution of 1 second.
Ch00016 to Ch00017	Bm	Wallclock (packed) The packed wallclock has a resolution of 2 seconds.

Address	Type	Description
Ch00018	Bm	accessed port and authorization bits 0- 3 - Accessed port; 0 = gateway bit 4 - Password authorization waived for read bit 5 - Password authorization waived for write bit 6 - Password authorization granted for read bit 7 - Password authorization granted for write
Ch00019	Wd	Password, read-enable
Ch00020 to Ch00089	--	[reserved] Reserved for use by diagnostic and similar procedures.
Ch00090 to Ch00099	Wd	Arbitrary event-logged registers. A Modbus master (such as the processor using Modbus Gateway) can use these to record in the Event Log changes to values unrelated to flow measurement.

14.8 Modbus Port configuration

Configuration of the serial ports is stored in these blocks of the Modbus table:

Address	Type	Description
Ph00102 to Ph00105	Bm	Port 1 configuration
Ph00106 to Ph00109	Bm	Port 2 configuration
Ph00110 to Ph00113	Bm	Port 3 configuration

Each group of registers specifies configuration of the corresponding serial port. The four registers of each block are interpreted as follows:

Ofs	Type	Tag	Contents
+0	Bm	Uart	UART parameters and port options
+1.L	By	TmoC	LSB: Timeout for CTS
+1.H	By	TmoR	MSB: Master mode receive timeout
+2	By	Dly1	Delay before first data after CTS
+3	By	Dly0	Delay after last data before ~RTS

The CTS timeout and both delays are in units of 5ms (200Hz system clock), with valid values from 0 thru 255, and are significant only for transmission of outgoing Modbus messages. The receive timeout is in units of 0.1 second, with valid values from 0 thru 255 (where 0 implies the default of 5, that is, one-half second), and is significant only for the last port when configured as a Modbus master. The UART parameters and port options word is a bitmap:

Bit	Parameter	Value
bits 0 to 2	Baud	000: none; see below 001: 300 baud 010: 600 baud 011: 1200 baud 100: 2400 baud 101: 4800 baud 110: 9600 baud 111: 19200 baud
bits 3 to 4	Parity	00: no parity 01: odd parity 10: even parity 11: no parity (should not be used)
bit 5	Data bits	0: 8 data bits 1: 7 data bits
bit 6	Stop bits	0: 1 stop bit 1: 2 stop bits
bit 7	Modbus mode	0: RTU mode 1: ASCII mode
bit 8	Modbus orientation	0: slave 1: master (permitted only for last port)
bit 9	Primary slave accessibility (not meaningful for master port)	0: primary slave accessible through this port 1: primary slave not accessible (not permitted for Port 1)
bit 10		Swap Modbus bytes
bit 11		Swap Modbus words
bit 12		Disable pass-thru (not meaningful for master port)
bits 13 to 15		[reserved]

A change in configuration takes effect after transmission of the response to the Modbus command that causes the change; the response is sent using the old configuration, but subsequent Modbus commands to the reconfigured port must use the new one. Writing a baud code of 0 means that the current configuration is not to be changed, and all other items are ignored. Default values are 6 for the bitmap (9600,N,8,1,RTU,slave,primary,noswap,passthru) and 0 for the timeout and both delays. The message transmission procedure is:

- Raise RTS.
- If TmoC is zero ignore CTS, else wait up to TmoC clock ticks for CTS.
- Delay for Dly1 clock ticks.
- Transmit message.
- Delay for Dly0 clock ticks.
- Drop RTS.

14.9 Startup Basics and Frequently Asked Questions

The Automatic Flow Computer (AFC) is a powerful rack flow computer solution for PLC platforms. The design intent of the module is to simplify the setup and maintenance of a meter installation. With this in mind, the sample ladder logic was created to accomplish the following:

- Pass meter run variables to the module.
- Return meter results to the processor.
- Allow individual meters to be enabled or disabled.
- Allow resets of individual meter runs.
- Allow transfer of a new gas analysis to an individual meter run.

Actual meter setup includes units of measure setup, range checking for input variables, and the type of meter being used. This setup is handled by the AFC Manager software. The intended design is to have the processor only handle the variables of an actual process and the AFC Manager handle the setup and configuration of necessary meter variables.

The sample ladder logic included with the system is intended to fulfill this requirement and works for many applications. Should you feel that your application requires more than this, then a very intimate knowledge of the operations of the module are required to be successful in the implementation of the application. It is highly recommended that the sample be used as a starting point for any application.

14.9.1 How does the module work?

Ignoring the fundamentals of a meter run, the module's operation is very simply divided into two operations, those being the transfer of data from the Processor to the module (variables as a rule) and the second being the transfer of data from the module to the Processor (results).

Refer to the Backplane section of the AFC User Manual for your module for more information on backplane operation.

14.9.2 Why should I use the AFC Manager?

The AFC Manager should be used to configure the module project parameters (Site Configuration) and each meter (Meter Configuration).

Once your project is up and running, you can also use the AFC Manager to monitor each meter run (Meter Monitor), archives, and events.

14.9.3 Why can't the AFC Manager connect to the module?

Check the cable used in your project: a null-modem cable should be used to connect the module with the local PC serial port. Make sure that the baud rate, data bits, mode, parity and primary slave address are the same (both in PC and module).

If you change the primary slave address and later forget the new address, the module will not establish communications. You must read the primary slave address value (address 100) over the backplane using the Modbus Gateway Transaction Block.

14.9.4 Why do I have to enable or disable a meter?

A meter channel will only perform flow calculation if it is enabled. For performance reasons you should disable all meter channels that are not being used. You cannot change a meter type and/or product group for a meter channel that is currently enabled.

14.9.5 Why does the card not calculate results, or why did it stop calculating results?

This could be caused by a couple of things.

1 The first thing to check is that the module actually received a clock. If the card does not get a clock it will not be able to schedule storage of historical records.

2 The next possibility is that the meter is not enabled or some parameter for the run is not correct. Check to see if the run is enabled and that no errors exist in configuration or data for the run in question. Check for alarms arising from the calculations. The AFC Manager software can be a great help with this as it will highlight problem areas.

14.9.6 What is the Virtual Modbus Slave?

The AFC Modbus database can be accessed using the Primary Modbus Slave address. More than 100.000 registers may be accessed using this slave.

You may want to use certain values from the Modbus database in a different order than the one presented in the Primary Modbus Slave. One example is if you want to poll certain values from the Modbus database using a Modbus master device in the field. Instead of using several commands to poll from different locations in the Modbus database, it is better to remap these values to other locations in order to optimize the master polling.

This is the reason the AFC module offers a second slave: the Virtual Modbus Slave. Using the AFC Manager software, you can remap up to 20.000 registers from the Primary Modbus Slave in any order. The Virtual Modbus Slave Address must be configured using the AFC Manager software (Site Config dialog box).

The Virtual Modbus Slave is also used when using the Modbus Pass-Thru function block.

14.9.7 How does the AFC Manager transfer the configuration to the module?

You can configure the site and meter parameters at the local PC saving the project as a .AFC file. You may then download the configuration by clicking on **Project** / **Download Configuration**. In this case, all configuration will be downloaded from the local PC to the module, except for the Virtual Slave Re-mapping (must be written separately).

Once you download the entire configuration, you may perform smaller adjustments (Site Configuration and Meter Configuration) by clicking on the Write button.

14.9.8 What is the password used for?

The password protects the module from any changes to "sealable" parameters. Sealable parameters directly affect measurement calculations (for example, orifice diameter, or K-factor).

The password is stored in the module so different computers should always use the same password.

14.9.9 Why do I receive an Illegal Data Value warning when I try to write a meter configuration or download the entire configuration to the module?

Follow these steps:

- Ensure that any parameters you had changed (from the default configuration) are acceptable according to applicable standards. The white rectangle (Site Configuration and Meter Configuration) shows the correct range of values for each parameter.
- The module will not accept a downloaded configuration that changes the meter type and/or the product group of a meter that is currently enabled. Disable the meter first, then proceed with the meter download.
- Look at the number of events currently stored in the module. You can check this using *Monitor / Event Log* and then click on the Read button. If the *number of events not yet downloaded* is 1999 it means that the event log is full. In this case, if the project also has the *event log unlocked* option clear, the module will not accept any further configuration downloads generating the *Illegal Data Value* at any attempt. Delete all events from the module event buffer (refer to the Event Log section). You may want to select (check) the *Event Log Unlocked* check box. This setting allows the module to overwrite the oldest event from the buffer when the buffer is full.

14.9.10 Why is the Molar Analysis button disabled?

In order to transfer the molar analysis values between the module and the local computer, it is required that the module’s configuration and the configuration at the local computer should match. In order to accomplish this, you can perform either a **Meter Configuration** / **Read** or a **Meter Configuration** / **Write** operation.

14.9.11 Why does the AFC Manager show a "Communication Timeout" warning?

The communication parameters for the AFC Manager and the module should match. Look at the communication parameters and cables (RS-232 null-modem). Also ensure that the setup jumper on the module is OFF.

14.9.12 What is the difference between Net Accumulator and Gross Accumulator?

The module initially calculates the Gross Accumulator value. It then uses the Gross Accumulator value and corrects it for pressure and temperature before calculating the Gross Standard Accumulator value.

For Gases, Gross Standard Accumulator = Net Accumulator

For Liquids, Gross Standard Accumulator - Water = Net Accumulator

14.9.13 What are the accumulator’s totalizer and residue values?

The totalizer is the integer part and the residue is the fractional part. The accumulator will be calculated by:

Accumulator = Totalizer + Residue

14.9.14 Do I have to enter all molar concentrations for the gas product?

Yes, the module uses the Detail Characterization Method that requires all molar concentration values.

14.9.15 Can I update the molar concentration values dynamically?

Yes, if the values are generated from a gas chromatograph you can update these values from the processor to the module (via backplane). Refer to the module's user manual for more information about this subject.

14.9.16 Why do the accumulator values not update?

Follow these steps:

1. Check if the Wallclock is running. The Wallclock should be set every time the module powers up by ladder logic. If the Wallclock is not running, some very early versions of the AFC will not perform the applicable calculation.
2. Determine if the meter has an alarm using the Meter Monitor dialog box. If the alarm field is red, it indicates that the meter has at least one alarm.
3. Determine if the meter is enabled. If the meter is not enabled, it will not perform the applicable calculation.
4. Look at the input variables in the AFC Manager. Make sure the values that are being copied from the processor match the input variables displayed at the AFC Manager Meter Monitor dialog box.

14.9.17 What is the Wallclock?

The Wallclock is the internal module clock that is used by the module to perform the applicable calculation. Typically, the Wallclock will be copied from the processor at every power up operation, otherwise the module will not perform time-of-day-dependent calculations.

14.9.18 Can I read the Primary (or Virtual) Slave values using the AFC Manager?

Yes, the Modbus Master interface (**Communications** / **Modbus Master**) allows you to easily read (or write) to any register in both slaves.

14.9.19 When are the archives generated?

There are two types of archives: the *daily* archives (which are generated once a day) and the *hourly* archives (which are generated once a hour). The Site Configuration dialog box has two parameters that allow you to configure when the archives will be generated:

- End-of-Day minute = the minute of the day when the daily archives will be written
- End-of-Hour minute = the minute of the hour when the hourly archives will be written

15 Support, Service & Warranty

In This Chapter

Contacting Technical Support

ProSoft Technology, Inc. (ProSoft) is committed to providing the most efficient and effective support possible. Before calling, please gather the following information to assist in expediting this process:

1 Product Version Number
2 System architecture
3 Network details

If the issue is hardware related, we will also need information regarding:

1 Module configuration and associated ladder files, if any
2 Module operation and any unusual behavior
3 Configuration/Debug status information
4 LED patterns
5 Details about the serial, Ethernet or fieldbus devices interfaced to the module, if any.

Note: *For technical support calls within the United States, an after-hours answering system allows 24-hour/7-days-a-week pager access to one of our qualified Technical and/or Application Support Engineers. Detailed contact information for all our worldwide locations is available on the following page.*

Internet	Web Site: www.prosoft-technology.com/support E-mail address: support@prosoft-technology.com
Asia Pacific (location in Malaysia)	Tel: +603.7724.2080, E-mail: asiapc@prosoft-technology.com Languages spoken include: Chinese, English
Asia Pacific (location in China)	Tel: +86.21.5187.7337 x888, E-mail: asiapc@prosoft-technology.com Languages spoken include: Chinese, English
Europe (location in Toulouse, France)	Tel: +33 (0) 5.34.36.87.20, E-mail: support.EMEA@prosoft-technology.com Languages spoken include: French, English
Europe (location in Dubai, UAE)	Tel: +971-4-214-6911, E-mail: mea@prosoft-technology.com Languages spoken include: English, Hindi
North America (location in California)	Tel: +1.661.716.5100, E-mail: support@prosoft-technology.com Languages spoken include: English, Spanish
Latin America (Oficina Regional)	Tel: +1-281-2989109, E-Mail: latinam@prosoft-technology.com Languages spoken include: Spanish, English
Latin America (location in Puebla, Mexico)	Tel: +52-222-3-99-6565, E-mail: soporte@prosoft-technology.com Languages spoken include: Spanish
Brasil (location in Sao Paulo)	Tel: +55-11-5083-3776, E-mail: brasil@prosoft-technology.com Languages spoken include: Portuguese, English

15.1 Return Material Authorization (RMA) Policies and Conditions

The following Return Material Authorization (RMA) Policies and Conditions (collectively, "RMA Policies") apply to any returned product. These RMA Policies are subject to change by ProSoft Technology, Inc., without notice. For warranty information, see Limited Warranty (page 259). In the event of any inconsistency between the RMA Policies and the Warranty, the Warranty shall govern.

15.1.1 Returning Any Product

a) In order to return a Product for repair, exchange, or otherwise, the Customer must obtain a Return Material Authorization (RMA) number from ProSoft Technology and comply with ProSoft Technology shipping instructions.
b) In the event that the Customer experiences a problem with the Product for any reason, Customer should contact ProSoft Technical Support at one of the telephone numbers listed above (page 255). A Technical Support Engineer will request that you perform several tests in an attempt to isolate the problem. If after completing these tests, the Product is found to be the source of the problem, we will issue an RMA.
c) All returned Products must be shipped freight prepaid, in the original shipping container or equivalent, to the location specified by ProSoft Technology, and be accompanied by proof of purchase and receipt date. The RMA number is to be prominently marked on the outside of the shipping box. Customer agrees to insure the Product or assume the risk of loss or damage in transit. Products shipped to ProSoft Technology using a shipment method other than that specified by ProSoft Technology, or shipped without an RMA number will be returned to the Customer, freight collect. Contact ProSoft Technical Support for further information.
d) A 10% restocking fee applies to all warranty credit returns, whereby a Customer has an application change, ordered too many, does not need, etc. Returns for credit require that all accessory parts included in the original box (i.e.; antennas, cables) be returned. Failure to return these items will result in a deduction from the total credit due for each missing item.

15.1.2 Returning Units Under Warranty

A Technical Support Engineer must approve the return of Product under ProSoft Technology's Warranty:

a) A replacement module will be shipped and invoiced. A purchase order will be required.
b) Credit for a product under warranty will be issued upon receipt of authorized product by ProSoft Technology at designated location referenced on the Return Material Authorization
   i. If a defect is found and is determined to be customer generated, or if the defect is otherwise not covered by ProSoft Technology s warranty, there will be no credit given. Customer will be contacted and can request module be returned at their expense;
   ii. If defect is customer generated and is repairable, customer can authorize ProSoft Technology to repair the unit by providing a purchase order for 30% of the current list price plus freight charges, duties and taxes as applicable.

15.1.3 Returning Units Out of Warranty

a) Customer sends unit in for evaluation to location specified by ProSoft Technology, freight prepaid.
b) If no defect is found, Customer will be charged the equivalent of $100 USD, plus freight charges, duties and taxes as applicable. A new purchase order will be required.
c) If unit is repaired, charge to Customer will be 30% of current list price (USD) plus freight charges, duties and taxes as applicable. A new purchase order will be required or authorization to use the purchase order submitted for evaluation fee.

The following is a list of non-repairable units:

- 3150 - All
- 3750
- 3600 - All
- 3700
- 3170 - All
- 3250
- 1560 - Can be repaired, only if defect is the power supply
- 1550 - Can be repaired, only if defect is the power supply
- 3350
- 3300
- 1500 - All

15.2 LIMITED WARRANTY

This Limited Warranty ("Warranty") governs all sales of hardware, software, and other products (collectively, "Product") manufactured and/or offered for sale by ProSoft Technology, Incorporated (ProSoft), and all related services provided by ProSoft, including maintenance, repair, warranty exchange, and service programs (collectively, "Services"). By purchasing or using the Product or Services, the individual or entity purchasing or using the Product or Services ("Customer") agrees to all of the terms and provisions (collectively, the "Terms") of this Limited Warranty. All sales of software or other intellectual property are, in addition, subject to any license agreement accompanying such software or other intellectual property.

15.2.1 What Is Covered By This Warranty

a) *Warranty On New Products*: ProSoft warrants, to the original purchaser, that the Product that is the subject of the sale will (1) conform to and perform in accordance with published specifications prepared, approved and issued by ProSoft, and (2) will be free from defects in material or workmanship; provided these warranties only cover Product that is sold as new. This Warranty expires three (3) years from the date of shipment for Product purchased **on or after** January 1st, 2008, or one (1) year from the date of shipment for Product purchased **before** January 1st, 2008 (the "Warranty Period"). If the Customer discovers within the Warranty Period a failure of the Product to conform to specifications, or a defect in material or workmanship of the Product, the Customer must promptly notify ProSoft by fax, email or telephone. In no event may that notification be received by ProSoft later than 39 months from date of original shipment. Within a reasonable time after notification, ProSoft will correct any failure of the Product to conform to specifications or any defect in material or workmanship of the Product, with either new or remanufactured replacement parts. ProSoft reserves the right, and at its sole discretion, may replace unrepairable units with new or remanufactured equipment. All replacement units will be covered under warranty for the 3 year period commencing from the date of original equipment purchase, not the date of shipment of the replacement unit. Such repair, including both parts and labor, will be performed at ProSoft's expense. All warranty service will be performed at service centers designated by ProSoft.

b) *Warranty On Services*: Materials and labor performed by ProSoft to repair a verified malfunction or defect are warranteed in the terms specified above for new Product, provided said warranty will be for the period remaining on the original new equipment warranty or, if the original warranty is no longer in effect, for a period of 90 days from the date of repair.

15.2.2 What Is Not Covered By This Warranty

a) ProSoft makes no representation or warranty, expressed or implied, that the operation of software purchased from ProSoft will be uninterrupted or error free or that the functions contained in the software will meet or satisfy the purchaser's intended use or requirements; the Customer assumes complete responsibility for decisions made or actions taken based on information obtained using ProSoft software.

b) This Warranty does not cover the failure of the Product to perform specified functions, or any other non-conformance, defects, losses or damages caused by or attributable to any of the following: (i) shipping; (ii) improper installation or other failure of Customer to adhere to ProSoft's specifications or instructions; (iii) unauthorized repair or maintenance; (iv) attachments, equipment, options, parts, software, or user-created programming (including, but not limited to, programs developed with any IEC 61131-3, "C" or any variant of "C" programming languages) not furnished by ProSoft; (v) use of the Product for purposes other than those for which it was designed; (vi) any other abuse, misapplication, neglect or misuse by the Customer; (vii) accident, improper testing or causes external to the Product such as, but not limited to, exposure to extremes of temperature or humidity, power failure or power surges; or (viii) disasters such as fire, flood, earthquake, wind and lightning.

c) The information in this Agreement is subject to change without notice. ProSoft shall not be liable for technical or editorial errors or omissions made herein; nor for incidental or consequential damages resulting from the furnishing, performance or use of this material. The user guide included with your original product purchase from ProSoft contains information protected by copyright. No part of the guide may be duplicated or reproduced in any form without prior written consent from ProSoft.

15.2.3 Disclaimer Regarding High Risk Activities

Product manufactured or supplied by ProSoft is not fault tolerant and is not designed, manufactured or intended for use in hazardous environments requiring fail-safe performance including and without limitation: the operation of nuclear facilities, aircraft navigation of communication systems, air traffic control, direct life support machines or weapons systems in which the failure of the product could lead directly or indirectly to death, personal injury or severe physical or environmental damage (collectively, "high risk activities"). ProSoft specifically disclaims any express or implied warranty of fitness for high risk activities.

15.2.4 Intellectual Property Indemnity

Buyer shall indemnify and hold harmless ProSoft and its employees from and against all liabilities, losses, claims, costs and expenses (including attorney's fees and expenses) related to any claim, investigation, litigation or proceeding (whether or not ProSoft is a party) which arises or is alleged to arise from Buyer's acts or omissions under these Terms or in any way with respect to the Products. Without limiting the foregoing, Buyer (at its own expense) shall indemnify and hold harmless ProSoft and defend or settle any action brought against such Companies to the extent based on a claim that any Product made to Buyer specifications infringed intellectual property rights of another party. ProSoft makes no warranty that the product is or will be delivered free of any person's claiming of patent, trademark, or similar infringement. The Buyer assumes all risks (including the risk of suit) that the product or any use of the product will infringe existing or subsequently issued patents, trademarks, or copyrights.

a) Any documentation included with Product purchased from ProSoft is protected by copyright and may not be duplicated or reproduced in any form without prior written consent from ProSoft.
b) ProSoft's technical specifications and documentation that are included with the Product are subject to editing and modification without notice.
c) Transfer of title shall not operate to convey to Customer any right to make, or have made, any Product supplied by ProSoft.
d) Customer is granted no right or license to use any software or other intellectual property in any manner or for any purpose not expressly permitted by any license agreement accompanying such software or other intellectual property.
e) Customer agrees that it shall not, and shall not authorize others to, copy software provided by ProSoft (except as expressly permitted in any license agreement accompanying such software); transfer software to a third party separately from the Product; modify, alter, translate, decode, decompile, disassemble, reverse-engineer or otherwise attempt to derive the source code of the software or create derivative works based on the software; export the software or underlying technology in contravention of applicable US and international export laws and regulations; or use the software other than as authorized in connection with use of Product.
f) **Additional Restrictions Relating To Software And Other Intellectual Property**

   In addition to compliance with the Terms of this Warranty, Customers purchasing software or other intellectual property shall comply with any license agreement accompanying such software or other intellectual property. Failure to do so may void this Warranty with respect to such software and/or other intellectual property.

15.2.5 Disclaimer of all Other Warranties

The Warranty set forth in What Is Covered By This Warranty (page 259) are in lieu of all other warranties, express or implied, including but not limited to the implied warranties of merchantability and fitness for a particular purpose.

15.2.6 Limitation of Remedies **

In no event will ProSoft or its Dealer be liable for any special, incidental or consequential damages based on breach of warranty, breach of contract, negligence, strict tort or any other legal theory. Damages that ProSoft or its Dealer will not be responsible for include, but are not limited to: Loss of profits; loss of savings or revenue; loss of use of the product or any associated equipment; loss of data; cost of capital; cost of any substitute equipment, facilities, or services; downtime; the claims of third parties including, customers of the Purchaser; and, injury to property.

** Some areas do not allow time limitations on an implied warranty, or allow the exclusion or limitation of incidental or consequential damages. In such areas, the above limitations may not apply. This Warranty gives you specific legal rights, and you may also have other rights which vary from place to place.

15.2.7 Time Limit for Bringing Suit

Any action for breach of warranty must be commenced within 39 months following shipment of the Product.

15.2.8 No Other Warranties

Unless modified in writing and signed by both parties, this Warranty is understood to be the complete and exclusive agreement between the parties, suspending all oral or written prior agreements and all other communications between the parties relating to the subject matter of this Warranty, including statements made by salesperson. No employee of ProSoft or any other party is authorized to make any warranty in addition to those made in this Warranty. The Customer is warned, therefore, to check this Warranty carefully to see that it correctly reflects those terms that are important to the Customer.

15.2.9 Allocation of Risks

This Warranty allocates the risk of product failure between ProSoft and the Customer. This allocation is recognized by both parties and is reflected in the price of the goods. The Customer acknowledges that it has read this Warranty, understands it, and is bound by its Terms.

15.2.10 Controlling Law and Severability

This Warranty shall be governed by and construed in accordance with the laws of the United States and the domestic laws of the State of California, without reference to its conflicts of law provisions. If for any reason a court of competent jurisdiction finds any provisions of this Warranty, or a portion thereof, to be unenforceable, that provision shall be enforced to the maximum extent permissible and the remainder of this Warranty shall remain in full force and effect. Any cause of action with respect to the Product or Services must be instituted in a court of competent jurisdiction in the State of California.

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