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Flow-X

Liquid USC Application Manual

Operation
Configuration

Product	Flow-X Liquid USC Application Manual
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Author	H. v. Dal

Disclaimer

Special note

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Document Control

Revision Coding

Our documents are supplied with a revision code. This code has the following format: <major revision letter>.<minor revision number>. Initially, the document has revision code A.0. When in the next release of the document minor changes were implemented, the minor revision number increases. When major changes have been implemented, the major revision number increments.

Example document:

A.0 First revision
A.1 Second revision with minor changes implemented
A.2 Third revision, with other minor changes
B.0 Fourth revision, with (a) major change(s).

The revision coding will be modified for each new release of a document.

All software packages and software modules or components will be provided with a version number. This number consists of three parts: A release number, a major revision number and a minor revision number separated by decimal points. A release number identifies the generation number of the software, the major number refers to the main functionality of the program, seen from the user's point of view, while the minor revision number identify a new software version.

Example program:

1.01.001 Initial release
1.01.002 Minor change
1.02.001 Major change
2.01.001 Family change

Revision History

Revision A.0

Author : J.C.H.M. van Dal
Date : February 2010

Initial, preliminary release of the Flow-X Manual Volume IIB - Liquid US Customary Application.

Revision B.0

Author : J.C.H.M. van Dal
Date : June 2010

Second release describing the added features, such as batch stack, product stack and historical data archives.

Revision B.1

Author : J.C.H.M. van Dal
Date : July 2010

Added description of batch recalculations and PID Control. Added API 1952 calculations

Revision C.0

Author : J.C.H.M. van Dal
Date : July 2010

Major update describing the new functionality

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Chapter 1 - Introduction

Flow-X set of manuals

Welcome to the exciting world of Flow-X!

Using one of our Flow-X products, you are able to create your own flow-measurement solution, fully adapted to your specific needs.

This manual is the Installation manual for all Flow-X models.
There are three reference manuals:

- Volume I - Installation manual, with the installation instructions.
- Volume II- The manuals for basic operation and configuration of the Flow-X flow computers when using our standard Flow-X software applications.

  IIA - Operation and configuration
  IIB - Gas Metric application
  IIC - Liquid Metric application
  IID - Gas US customary units application *[not available yet]*
  IIE - Liquid US customary units application

- Volume III - The manuals for solutions that exceed our standard applications. This volume consists of 1 part:

  IIIB - Function reference

Purpose of this manual

The Flow-X manuals are written for a variety of readers:

- The **application developer**, who is interested in all details required to develop a complete flow measurement solution with a Flow-X product.
- The **Instrumentation engineer,** who selects the appropriate flow computer model, assigns inputs and outputs and designs transmitter loops and flow computer functionality
- A more generally **interested reader**, who wonders if the capabilities and features of **Flow-X** will satisfy his/her project requirements.

This manual expects the reader to be commonly acquainted with flow measurement principles, such as turbine, orifice and ultrasonic measurements. This manual is not an introduction to these techniques.

Overview

This manual works in conjunction with manual IIA 'Operation and Configuration' that covers the **common** operation and configuration aspects of the Flow-X flow computer.

The Flow-X flow computer family comes with the following standard software applications:

- Gas Metric
- Liquid Metric
- Gas US Customary
- Liquid US Customary

This application manual describes the additional functions and capabilities of the **Liquid US Customary** Application.

In this first chapter, an introduction is given to this manual. Various terms and definitions as used throughout this book are given.

In Chapter 3 - Operation lists the features of this application and shows typical meter run configurations that are covered by it.

Chapter 4 - Configuration describes the configuration settings (i.e. the parameters or constants) that are specific to this application.

Chapter 5 - Maintenance mode describes the maintenance mode function that allows for working on and testing of the flow computer without affecting the custody transfer data.

Chapter 6 - Flow computations, specifies the flow calculations as used by this application.

Chapter 7 - Reports describes the reports that are provided by the standard application.

Chapter 8 - Communication, describes the communications lists that are specific to this application.

Chapter 9 - Historical Data Archives, describes the historical data archives that are defined in the standard application.

Abbreviations

Throughout this document the following abbreviations are used:

ADC	**A**nalog to **D**igital **C**onverter
AI	**A**nalog **I**nput
AO	**A**nalog **O**utput
API	**A**pplication **P**rogramming **I**nterface An interface that allows an application to interact with another application or operating system, in our case, **Flow-X**. Most of the **Flow-X** API is implemented through Excel worksheet functions.
ASCII	**A**merican **S**tandard **C**ode for **I**nformation **I**nterchange. A set of standard numerical values for printable, control, and special characters used by PCs and most other computers. Other commonly used codes for character sets are ANSI (used by Windows 3.1+), Unicode (used by Windows 95 and Windows NT), and EBCDIC (Extended Binary-Coded Decimal Interchange Code, used by IBM for mainframe computers).

BS&W	**B**asic (or **B**ottom) **S**ediment and **W**ater BS&W includes free water, sediment (sand, mud) and emulsion and is measured as a volume percentage is measured from a liquid sample of the production stream.
CPU	**C**entral **P**rocessing **U**nit
DAC	**D**igital to **A**nalog **C**onverter
DCS	**D**istributed **C**ontrol **S**ystem
DDE	**D**ynamic **D**ata **E**xchange A relatively old mechanism for exchanging simple data among processes in MS-Windows.
DI	**D**igital **I**nput
DO	**D**igital **O**utput
EGU	**Eng**ineering **U**nits
EIA	**E**lectrical **I**ndustries **A**ssociation
FET	**F**ield **E**ffect **T**ransistor
GUI	**G**raphical **U**ser **I**nterface
HART	**H**ighway **A**ddressable **R**emote **T**ransducer. A protocol defined by the HART Communication Foundation to exchange information between process control devices such as transmitters and computers using a two-wire 4-20mA signal on which a digital signal is superimposed using Frequency Shift Keying at 1200 bps.
HMI	**H**uman **M**achine **I**nterface. Also referred to as a GUI or MMI. This is a process that displays graphics and allows people to interface with the control system in graphic form. It may contain trends, alarm summaries, pictures, and animations.
I/O	**I**nput/**O**utput
IEEE	**I**nstitute for **E**lectrical and **E**lectronics **E**ngineers
ISO	**I**nternational **S**tandards **O**rganization
MMI	**M**an **M**achine **I**nterface (see HMI)
MIC	**M**achine **I**dentification **C**ode. License code of **Flow-X** which uniquely identifies you computer.
OEM	**O**riginal **E**quipment **M**anufacturer
P&ID	**P**iping and **I**nstrumentation **D**iagram

PC	**P**ersonal **C**omputer
PCB	**P**rinted **C**ircuit **B**oard
PLC	**P**rogrammable **L**ogic **C**ontroller. A specialized device used to provide high-speed, low-level control of a process. It is programmed using Ladder Logic, or some form of structured language, so that engineers can program it. PLC hardware may have good redundancy and fail-over capabilities.
RS232	EIA standard for point to point serial communications in computer equipment
RS422	EIA standard for two- and four-wire differential unidirectional multi-drop serial
RS485	EIA standard for two-wire differential bidirectional multi-drop serial communications in computer equipment
RTU	**R**emote **T**erminal **U**nit
SCADA	**S**upervisory **C**ontrol **and** **D**ata **A**cquisition
SQL	**S**tandard **Q**uery **L**anguage
SVC	**S**uper**v**isory **C**omputer
TCP/IP	**T**ransmission **C**ontrol **P**rotocol/**I**nternet **P**rotocol. Transmission Control Protocol/Internet Protocol. The control mechanism used by programs that want to speak over the Internet. It was established in 1968 to help remote tasks communicate over the original ARPANET.
TTL	**T**ransistor-**T**ransistor **L**ogic
UART	**U**niversal **A**synchronous **R**eceiver & **T**ransmitter
URL	**U**niform **R**esource **L**ocator. The global address for documents and resources on the World Wide Web.
XML	**E**xtensible **M**arkup **L**anguage. A specification for Web documents that allows developers to create custom tags that enable the definition, transmission, validation and interpretation of data contained therein.

Terms and definitions

Throughout this manual the following additional terms and definitions are used:

API gravity	Measure for the density of petroleum liquid. The heavier the liquid the lower the API gravity. The API scale was designed so that most values would fall between 10 and 70 API gravity degrees
Asynchronous	A type of message passing where the sending task does not wait for a reply before continuing processing. If the receiving task cannot take the message immediately, the message often waits on a queue until it can be received.
Client/server	A network architecture in which each computer or process on the network is either a client or a server. Clients rely on servers for resources, such as files, devices, and even processing power. Another type of network architecture is known as a peer-to-peer architecture. Both client/server and peer-to-peer architectures are widely used, and each has unique advantages and disadvantages. Client/server architectures are sometimes called two-tier architectures
Device driver	A program that sends and receives data to and from the outside world. Typically a device driver will communicate with a hardware interface card that receives field device messages and maps their content into a region of memory on the card. The device driver then reads this memory and delivers the contents to the spreadsheet.
Engineering units	Engineering units as used throughout this manual refers in general to the units of a tag, for example ‘psi’, or ‘ºF’, and not to a type of unit, as with ‘metric’ units, or ‘imperial’ units.
Ethernet	A LAN protocol developed by Xerox in cooperation with DEC and Intel in 1976. Standard Ethernet supports data transfer rates of 10 Mbps. The Ethernet specification served as the basis for the IEEE 802.3 standard, which specifies physical and lower software layers. A newer version, called 100-Base-T or Fast Ethernet supports data transfer rates of 100 Mbps, while the newest version, Gigabit Ethernet supports rates of 1 gigabit (1000 megabits) per second.
Event	Anything that happens that is significant to a program, such as a mouse click, a change in a data point value, or a command from a user.
Exception	Any condition, such as a hardware interrupt or software error-handler, that changes a program's flow of control.
Fieldbus	A set of communication protocols that various hardware manufacturers use to make their field devices talk to other field devices. Fieldbus protocols are often supported by manufacturers of sensor hardware. There are debates as to which of the different fieldbus protocols is the best. Popular types of fieldbus protocol include Modbus, Hart, Profibus, Devicenet, InterBus, and CANopen.

Factored density	The density as measured by a densitometer or a gravitometer corrected for DCF (Density Correction Factor). DCF is determined from a calibration. It is also called 'Observed density', 'Measured density' or 'Flowing density'.
Flowing density	The density at the flowing conditions of pressure and temperature This is typically the density as measured by a densitometer or a gravitometer. It is also called 'Observed density', 'Measured density' or 'Factored density'. The 'Measured density' is the density of the fluid at the temperature and pressure at the density measurement point, which is therefore not necessarily the same as the density value at the flow meter.
Gross volume	The corrected actual volume; as indicated by the flow meter and corrected for the flow meter calibration curve (if applicable), the meter factor, the meter body expansion and the viscosity influence (for helical turbine and PD meters).
Indicated volume	The uncorrected actual volume; as indicated by the flow meter without any correction being applied.
Kernel	The core of Flow-X that handles basic functions, such as hardware and/or software interfaces, or resource allocation.
Measured density	The density as measured a densitometer or a gravitometer. It is also called 'Observed density', 'Flowing density' or 'Factored density'. The 'Measured density' is the density of the fluid at the temperature and pressure at the density measurement point, which is therefore not necessarily the same as the density value at the flow meter.
Meter density	The density at of the fluid at the flow meter conditions of temperature and pressure. The meter density is calculated from the standard density and the Ctl and Cpl factors.
Observed density	The density as observed (measured) by the densitometer or a gravitometer. It is also called 'Flowing density', 'Measured density' or 'Factored density' The 'Observed density' is the density of the fluid at the temperature and pressure at the density measurement point, which is therefore not necessarily the same as the density value at the flow meter.
Peer-to-peer	A type of network in which each workstation has equivalent capabilities and responsibilities. This differs from client/server architectures, in which some computers are dedicated to serving the others. Peer-to-peer networks are generally simpler, but they usually do not offer the same performance under heavy loads. Peer-to-peer is sometimes shortened to the term P2P.

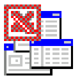
Polling	A method of updating data in a system, where one task sends a message to a second task on a regular basis, to check if a data point has changed. If so, the change in data is sent to the first task. This method is most effective when there are few data points in the system. Otherwise, exception handling is generally faster.
Process visualization software	A system for monitoring and controlling for production processes, and managing related data. Typically such a system is connected to external devices, which are in turn connected to sensors and production machinery. The term ‘process visualization software’ in this document is generally used for software with which SCADA software, HMI software, or supervisory computer software applications can be built. In this document, although strictly not correct, the terms ‘SCADA, ‘HMI, ‘supervisory’, and ‘process visualization’ are alternately used, and refer to the computer software applications that can be realized with eXLerate, Spirit FC’s PC-based supervisory software.
Protocol	An agreed-up format for transmitting data between two devices. In this context, a protocol mostly references to the Data Link Layer in the OSI 7-Layer Communication Model.
Query	In SCADA/HMI terms a message from a computer to a client in a master/client configuration utilizing the message protocol with the purpose to request for information. Usually, more than 1 data-point is transmitted in a single query.
Real-time	The characteristic of determinism applied to computer hardware and/or software. A real-time process must perform a task in a determined length of time. The phrase "real-time" does not directly relate to how fast the program responds, even though many people believe that real-time means real-fast.
Relative density	Same as specific gravity. It is the ratio between the density of the liquid relative to the density of water.
Resource	Any component of a computing machine that can be utilized by software. Examples include: RAM, disk space, CPU time, real-world time, serial devices, network devices, and other hardware, as well as O/S objects such as semaphores, timers, file descriptors, files, etc.
Specific gravity	Same as relative density. It is the ratio between the density of the liquid relative to the density of water.
Standard density	The density at the reference conditions of temperature and pressure, typically 60 °F and 0 psig. For NGL/LPG products the reference pressure typically is the equilibrium vapor pressure (EVP), which is either typically calculated by GPA TP-15.
Synchronous	A type of message passing where the sending task waits for a reply before continuing processing.

Tag	A 'tag' as used within this document refers to a data point existing in the tag database, with a number of properties, such as its assigned I/O address, current value, engineering units, description, alias name, and many others.
Unfactored density	The uncorrected density as measured by a densitometer or a gravitometer
Web Server	A computer that has server software installed on it and is used to deliver web pages to an intranet/Internet.

Document conventions

When the book symbol as displayed at the left appears in the text in this manual, a reference is made to another section of this or another manual. At the referred section, more detailed, or other relevant information is given.

When in this manual a symbol as displayed at the left appears in the text, certain specific operating instructions are given to the user. In such as case, the user is assumed to perform some action, such as the selection of a certain object, worksheet, or typing on the keyboard.



A symbol as displayed at the left indicates that the user may read further on the subject in one of the sample workbooks as installed on your machine.

When an important remark is made in the manual requiring special attention, the symbol as displayed to the left appears in the text.

Chapter 2 - Application overview

The Liquid USC application is set up for liquid flow metering stations consisting of one or more parallel meter runs with all values and flow computations in US Customary units.

The application supports batch type of operation as well as continuous operation with hourly and daily custody transfer data.

The application handles meter proving based on a pipe or a compact prover. Single or dual densitometers installed either on a common header or in each meter run separately are supported as well.

For meter stations the meter runs may run independently or with a common density/gravity input and/or product definition.

The following typical meter stations are supported:

- Single meter run
- Two 100 % meter runs (redundant runs) with an optional cross-over valve for master meter proving.
- Meter station with independent meter runs that run different products and an optional single/twin densitometer installed on each run.
- Meter station with multiple meter runs that run one common product and share a common single/twin densitometer.

The application supports any number of meter runs within the meter station. The maximum number of meter runs however is limited by the type of Flow-X flow computer, i.e. a maximum of 4 meter runs applies for a Flow-X/P and 8 meter runs for a Flow-X/R.

Input and output signals

Flow meter input

The Liquid USC application supports one flow meter input per meter run.

The following types of flow meter input are supported:

Pulse input	Any flow meter that provides a single or dual pulse output that represents the volumetric or mass quantity. Typically used for: - Turbine meters - PD meters - Ultrasonic flow meters - Coriolis flow meters .. or any volumetric or mass flow meter providing a pulse signal

Smart input	Any flow meter that provides a Modbus, HART or analog signal that represents the volumetric or mass quantity or rate, where the flow quantity value naturally only applies for Modbus and HART signals. The Instromet Uniform protocol (for ultrasonic flow meters) is supported as well. Typically used for: - Ultrasonic flow meters - Coriolis flow meters
Smart & pulse input	Typically used for ultrasonic and coriolis flow meter that provide both a communications and a pulse output. Either output signal may be selected as the primary. The secondary signal serves as a backup / comparison signal and might be used automatically in case the primary signal should fail.
Orifice	Orifice plates in accordance with AGA-3

Process inputs

A process input is a live signal that is a qualitative measurement of the fluid and can be any of the following kinds:

- Analog input (0-20 mA, 4-20 mA, 0-5 Vdc, 1-5 Vdc)
- Pt100 inputs (only for temperature measurement)
- HART input
- Modbus input
- Fixed value

The following process inputs are part of the USC liquid application:

Meter temperature	Pressure at the flow meter. For an orifice flow meter either the temperature at the upstream or downstream tapping or the temperature at the location where the pressure has fully recovered may be used.
Meter pressure	Pressure at the flow meter. For an orifice flow meter either the temperature either the pressure at the upstream or downstream tapping or the fully recovered pressure may be used.
Density temperature	Pressure at the point where the density measurement is taken. This input is only used when there is a live density / gravity measurement, based on a densitometer input or on a density / gravity process input (e.g. a mA signal).
Density pressure	Pressure at the point where the density / gravity measurement is taken. This input is only used when there is a live density / gravity measurement, based on a densitometer input or on the density process input.
Observed density /	The measured density or gravity. The application supports the following units

gravity	for density / gravity: • API gravity • Relative density / specific gravity • Density [g/cc] *[g/cc] is the default unit. Other units, e.g. [lb/bbl] are supported as well* Must be the density or gravity of the fluid at the density temperature and density pressure. Instead of calculating the standard density / gravity from a measured density / gravity the application can also take a direct input signal or a constant for the standard density / gravity.
Standard density /gravity	Density or gravity at the standard conditions of temperature and pressure, typically 60°F and 0 psig. Same units as for observed density / gravity are supported
BS&W	Base Sediment and Water input. Used for to calculate the net standard volume.
Viscosity	Viscosity input. Viscosity value can be used for viscosity correction of the turbine or PD flow meter
Prover inlet and outlet temperature	The application supports separate prover inlet and outlet temperature inputs. When only one prover temperature input is used then both inputs can be assigned to the same physical input
Prover inlet and outlet pressure	The application supports separate prover inlet and outlet pressure inputs. When only one prover pressure input is used then both inputs can be assigned to the same physical input
Piston rod temperature Piston plenum pressure	Applies for compact provers only. Only applies for Brooks (Daniel / Emerson) compact provers.

Other process inputs can be added through user-defined 'Calculations' and spreadsheet logic

Digital I/O

The application supports the following status inputs and status and control outputs.

Valve control I/O	Open and close command and status signals.
Data validity input	Can be used in case the flow meter provides a status signal that indicates the validity of the flow meter signal. It is typically used by ultrasonic and coriolis flow meters in combination with a pulse signal. The input is used for alarming purposes and to control the accountable totals required for MID approval.
Prove detectors	Up to 4 prove detector signal inputs are available.
4-way valve leakage	Used to detect a metering integrity problem during proving. Prove run will be aborted when the leakage signal is active while the sphere or piston is in the calibrated volume.
	... further status inputs and outputs and control outputs can be added through user-defined 'Calculations' and spreadsheet logic

Other digital I/O can be added through user-defined 'Calculations' and spreadsheet logic

Analog outputs

The application supports the following type of analog outputs:

Flow and process values	To output the actual flow rate, density, pressure, temperature
PID control	For flow and pressure control or any other PID application.
	... ... further analog outputs can be added through user-defined 'Calculations' and spreadsheet logic

Other analog outputs can be added through user-defined 'Calculations' and spreadsheet logic

Densitometers

The application supports single and twin liquid densitometers of make Solartron, Sarasota, UGC and Densitrak either on meter run or station level. In case of two densitometers the application uses the primary densitometer for its calculations and switches to the backup densitometer in case the primary densitometer should fail.

Pulse outputs

The application supports the configuration of up to 3 pulse outputs per flow module to drive electro-mechanical counters and samplers. The application provides sophisticated control of both single and twin sampling systems.

Batch operation

The flow computer maintains separate totalizers and averages to support batch operations. The flow computer performs batching either for each meter run individually or for all meter runs at the same time (i.e. at station level). Batches can be ended automatically based on a product interface change, at a daily basis at a specific hour and based on a set of scheduled date and time. A stack of 6 batches can be pre-defined on station level or on meter run level.

The meter ticket of the last 4 previous batches can be recalculated based on a different density or gravity, BS&W and meter factor value.

Proving capability

The application supports the following type of proving:

- Bi-directional sphere prover
- Uni-directional sphere prover
- Brooks (Daniel / Emerson) compact prover
- Calibron compact prover
- Flow MD compact prover

For small volume sphere provers, i.e. with a proved volume of less than 10000 meter pulses as in accordance with API standards, there is the option to apply double chronometry (i.e. pulse interpolation).

The number of prove runs and passes per run are and Repeatability limit can be set either to a fixed value (typically 0.05%) or be determined dynamically in accordance with API MPMS Chapter 4,8 appendix A.

The application supports a common input as well as 2 separate inputs for the start and stop detector switches. Also the usage of a 2nd stop detector is supported, leading to 2 calibrated volumes, one for smaller and one for larger meters. Finally a 2nd start detector may be connected as well providing 4 separate calibrated prover volumes in total .

Repeatability checks are performed on pulse count or meter factor. Either a fixed or a dynamic repeatability limit can be applied to determine when the required number of successful runs has been reached. The dynamic limit is in accordance with the method described in API 4.8 appendix A,

Control features

The application supports control of single and twin can **samplers**. Several flow and time proportional methods are provided. Sampler control is started and stopped automatically. Can fill levels are either calculated from the actual grab counts or indicated by an analog input signal.

By default one sampler can be controlled. Additional samplers can be easily defined in Flow-Xpress Professional.

The application provides control of meter run inlet and outlet **valves**, run to prover valves, the prover 4-way valve and the prover outlet valve.

Additional valves and **valve sequencing** logic can be defined in FlowXpress through additional *Calculations*. Well-documented examples are provided in application file 'Calculation Examples.xls'.

PID control is provided as well. By default the application supports a flow control valve with optional secondary pressure control for each run and for the prover. In FlowXpress Professional sophisticated PID logic including cascading can be defined. Examples are provided in application file 'PID Control.xls'.

Chapter 3 - Operation

This chapter describes the operational features of the flow computer that are specific for the Liquid USC application. General operational functions such as report printing and alarm acknowledgement are described in manual IIA 'Operation and Configuration'.

For the description of the operation of the LCD display, the touch screen (Flow-X/P) and the web interface, please refer to manual IIA 'Operation and Configuration'.

Meter K-factor

Only available when **Meter device type** is **'Pulse input'** or **'Smart / pulse'**

To convert meter pulses in metered volume a meter K-factor is used. The meter K-factor value can be defined in two ways, either as a nominal meter K-factor value that is applied for all flow rates or as a calibration curve, where a number of calibrated K-factors is defined a function of the actual pulse frequency.

Display → Flow meter, Run <x>, Meter K-factor

With <x> the module number of the meter run

Name	*Security level*	*Description*
Forward / reverse nominal K-factor	1000	The number of pulses per barrel [pls/bbl] or per pound [pls/lbm]. Separate values are used for forward flow and reverse flow.
K-factor curve	1000	Controls whether the nominal K-factor or the calibration curve is used. 0: Disabled Nominal K-factor is used 1: Enabled Calibration curve is used Separate curves are used for forward flow and reverse flow.
Extrapolation allowed	1000	Controls if extrapolation is allowed when the pulse frequency is outside the calibration curve 0: No When the pulse frequency is below the first calibration point or above the last calibration point, then respectively the first or the last calibration K-factor will remain in-use. 1: Yes The interpolation is extrapolated when the pulse frequency is outside the calibrated range.

Point x – Frequency	1000	Pulse frequency [Hz} of the calibration point
Point x – K-factor	1000	Meter K-factor of the calibration point, wither the number of pulses per barrel [pls/bbl] or per pound [pls/lbm]

- Pulse frequency must be in ascending order
- Up to 12 points can be defined. For unused points, leave the pulse frequency to 0. E.g. when the curve has 6 points, the pulse frequency of points 7 through 12 should be set to 0.

Meter factor

Only available when **Meter device type** is **'Pulse input'** or **'Smart / pulse'**

Optionally a meter factor can be used to correct the metered volume as indicated by the flow meter. Either a single nominal meter factor can be used or a meter factor curve that contains a number of calibrated meter factors as a function of flow rate.

Nominal meter factors and meter factors are product-dependent. For each of he up to 16 products a different nominal meter factor or meter factor curve is applied.

By default a nominal meter factor of 1 is used, so effectively disabling the correction.

Display → Flow meter, Run <x>, Meter factor

With <x> the module number of the meter run

Meter Factor Curve	1000	Controls whether the nominal meter factor or the calibration curve is used. 0: Disabled Nominal value is used (defined in section 'Product') 1: Enabled Calibration curve is used. Separate curves are used for forward flow and reverse flow.
Extrapolation Allowed	1000	Only applies when 'Meter Factor Curve' is enabled. Controls if extrapolation is allowed when the flow rate is outside the Meter Factor Curve 0: No When the flow rate is below the first calibration point or above the last calibration point, then respectively the first or the last calibration error will remain in-use. 1: Yes

		The interpolation is extrapolated when the pulse frequency is outside the calibrated range.
Product #1..16 Nominal Meter Factor	1000	The nominal meter factor used for the entire flow range for the 16 different products. This value will be used when 'Meter Factor Curve' is disabled.
Product #1..16 Point #1..12 - Flow rate	1000	Flow rate [unit/h} at the calibration point 1 through 12 for the 16 different products
Point #1..12 - Meter factor	1000	Meter factor at the calibration point 1 through 12 for the 16 different products.

- Flow rate must be in ascending order
- Up to 12 points can be defined. For unused points, leave the flow rate to 0. E.g. when the curve has 6 points, the pulse frequency of points 7 through 12 should be set to 0.

Temperature

Two temperature inputs are used at meter run level, the meter temperature and, in case of a live density / gravity measurement at meter run level, the density temperature (i.e. the temperature at the point where the density or gravity is measured).

In case of a live density / gravity measurement at station level, the density temperature is available as station level as well.

Display → Temperature

Depending on the actual configuration settings are available for the following temperature inputs:

- <Run>, Meter temperature
- <Run>, Density temperature
- Station, Density temperature
- Prover, Prover inlet temperature
- Prover, Prover outlet temperature
- Prover, Prover rod temperature

The following operational settings are available for each applicable temperature variable

Override	500	Temperature override selection 0: Disabled Input value is used for the calculations 1: Enabled Override value is used for the calculations

Override	500	Temperature override value [°F]
Lo lo limit	500	Limit for the temperature low low alarm [°F]
Lo limit	500	Limit for the temperature low alarm [°F]
Hi limit	500	Limit for the temperature high alarm [°F]
Hi hi limit	500	Limit for the temperature high high alarm [°F]
ROC limit	500	Limit for the temperature rate of change alarm [°F/sec]

Pressure

Two pressure inputs are used at meter run level, the meter pressure and, in case of a live density / gravity measurement at meter run level, the density pressure (i.e. the pressure at the point where the density or gravity is measured).

In case of a live density / gravity measurement at station level, the density pressure is available as station level as well.

Display → Pressure

Depending on the actual configuration settings are available for the following pressure inputs:

- <Run>, Meter pressure
- <Run>, Density pressure
- Station, Density pressure
- Prover, Prover inlet pressure
- Prover, Prover outlet pressure
- Prover, Prover plenum pressure (only applies for a Brooks compact prover)

The following operational settings are available for each applicable pressure variable

Override	500	Pressure override selection 0: Disabled Input value is used for the calculations 1: Enabled Override value is used for the calculations
Override	500	Pressure override value [psig]
Lo lo limit	500	Limit for the pressure low low alarm [psig]
Lo limit	500	Limit for the pressure low alarm [psig]
Hi limit	500	Limit for the pressure high alarm [psig]
Hi hi limit	500	Limit for the pressure high high alarm [psig]
ROC limit	500	Limit for the pressure rate of change alarm [psi/sec]

Density

Display → Density

Depending on the configuration density settings are either on meter run or station level.

Observed & Standard density / gravity

Inputs units	1000	(*) The engineering unit used for the observed and standard density is as indicated on the display and is one of the following (depending on the configuration): ***Relative density*** ***API gravity*** ***Density [g/cc]***
Override	500	Density override selection 0: Disabled Input value is used for the calculations 1: Enabled Override value is used for the calculations
Override	500	Density/gravity override value (*)
Lo lo limit	500	Limit for the density/gravity low low alarm (*)
Lo limit	500	Limit for the density/gravity low alarm (*)
Hi limit	500	Limit for the density/gravity high alarm (*)
Hi hi limit	500	Limit for the density/gravity high high alarm (*)
ROC limit	500	Limit for the density/gravity rate of change alarm [(*)/sec]

Single densitometer

These settings are only available when density input type is set to 'Single densitometer'.

The time period inputs of the densitometer can be manually overridden. This feature is meant for test purposes only. It requires security level 1000 ('Engineer')

Override	1000	Time period input override selection 0: Disabled Input value is used for the calculations

1: Enabled Override value is used for the calculations

Override 1000 Time period input override value [microseconds]

Lo lo limit 1000 Limit for the time period input low low alarm [microseconds]

Lo limit 1000 Limit for the time period input low alarm [microseconds]

Hi limit 1000 Limit for the time period input high alarm [microseconds]

Hi hi limit 1000 Limit for the time period input high high alarm [microseconds]

ROC limit 1000 Limit for the time period input rate of change alarm [microseconds /sec]

Dual densitometer

These settings are only available when density input type is set to Dual densitometer'.

The time period inputs of the dual densitometers can be manually overridden. This feature is meant for test purposes only. It requires security level 1000 ('Engineer')

Densitometer select mode 1000 Densitometer selection mode.

1: Auto-A
Densitometer B only used when densitometer A fails and densitometer B is healthy. Densitometer A is used in all other cases.

2: Auto-B
Densitometer A is only used when densitometer B fails and densitometer A is healthy. Densitometer B is used in all other cases.

3: Manual-A
Always use densitometer A irrespective of its failure status

4: Manual-B
Always use densitometer B irrespective of its failure status

Time Period A/B Override 1000 Time period input override selection

0: Disabled Input value is used for the calculations
1: Enabled Override value is used for the calculations

Time Period A/B Override 1000 Time period input override value [microseconds]

Time Period A/B lo lo limit 1000 Limit for the time period input low low alarm [microseconds]

Time Period A/B lo limit	1000	Limit for the time period input low alarm [microseconds]
Time Period A/B hi limit	1000	Limit for the time period input high alarm [microseconds]
Time Period A/B hi hi limit	1000	Limit for the time period input high high alarm [microseconds]
Time Period A/B ROC limit	1000	Limit for the time period input rate of change alarm [microseconds /sec]

Product

This display shows the current product values.

Products are defined in the product stack: display ‘Configuration\(Run <x>)\Products’ or ‘Configuration\ Station\Products’

The actual product in-use is defined in the batch stack: display 'Batch\(Run <x>)\Batch stack' or 'Batch\Station\Batch stack'

Batching

Displays to end a batch, define the batch stack, recalculate a previous batch and view the current and previous batch data.

The batch stack may automatically be shifted upwards at each batch end, so allowing up to 6 batches to be pre-programmed in the flow computer.

Ending the current batch

Display → Batching, Run <x>, Batch control

Display → Batching, Station, Batch control

With <x> the module number of the meter run

Batch end command	500	Ends the current batch. Command may be disabled depending o actual status (e.g. flow rate > 0) and system settings (e.g. batch end only allowed when current batch has a batch volume > 0).
Batch official	500	Mark the batch as official or unofficial. This is shown on the meter ticket (Saudi Aramco reports only)

Defining the batch stack

A stack of up to 6 batches can be defined either on meter run or on station level.

Display → Batching, Run <x>, Batch stack

Display → Batching, Station, Batch stack

With <x> the module number of the meter run

Note: through the LCD display only numbers can be entered.

Batch ID	500	The alpha-numeric identification of the batch
Product nr.	500	The product number [1..16] of the batch
Batch size	500	The target batch size expressed in standard volume [bbl].
Delete seq. #	500	Deletes the entered batch from the batch stack
Insert before seq. #	500	Insert a batch before the entered batch. Deletes the last batch from the batch stack

Recalculate a previous batch

Up to the last 4 previous can be recalculated based on modified input data. Recalculations can be repeated with the number of recalculations indicated on top of the recalculated meter ticket.

Display → Batching, Run <x>, Batch recalculation

Display → Batching, Station, Batch recalculation

With <x> the module number of the meter run

Note: through the LCD display only numbers can be entered.

Selected previous batch	500	The selected previous batch 1: Previous batch 2: 2nd latest batch 3: 3rd latest batch 4: 4th latest batch
Recalculate & print	500	Recalculates and generates the recalculated meter ticket based on the entered recalculation input data
Fwd/rev recalc. batch	500	New standard density [g/cc] to be used for the recalculation of the forward / reverse batch totalizers

standard density		
Fwd/rev recalc. batch standard API	500	New meter factor to be used for the recalculation of the forward / reverse batch totalizers
Fwd/rev recalc. batch standard RD / SG	500	New relative density / specific gravity to be used for the recalculation of the forward / reverse batch totalizers
Fwd/rev recalc. batch meter factor	500	New meter factor to be used for the recalculation of the forward / reverse batch totalizers
Fwd/rev recalc. batch BS&W	500	New BS&W value to be used for the recalculation of the forward / reverse batch totalizers

Proving

Displays to view the status of the current and previous prove sequence can be accessed through option "Proving" from the main menu.

The following settings / commands related to proving can be entered.

Display → Proving → Proving operation

Meter to be proved	500	Number of the meter to be proved. Number corresponds to physical position of the related flow module in the flow computer.
Start prove sequence	500	Starts a prove sequence for the meter to be proved. The new meter factor will be activated automatically, provided that the prove sequence finishes successfully, the new meter factor passes all the test criteria and automatic meter factor acceptance is enabled.
Selected prover volume	1000	Selects the in-use prover base volume (i.e, the pair of detectors used for proving). Only applies for 3 or 4 detector inputs. For 1 or 2 inputs 'Volume 1 (A-C)' will be used automatically. Reset to 'Volume 1 (A-C) when he selection is invalid..
Start trial prove	500	Starts a trial prove sequence for the meter to be proved. A trial prove is the same as a normal prove except that the new meter factor will not be activated, independent of any settings.

Abort prove sequence	500	Aborts the current prove sequence in progress
Accept new meter factor?	500	Activates the new meter factor as the in-use meter factor, provided that: • A normal prove sequence has been started (no trial) • The prove sequence has completed successfully • The new meter factor has passed all test criteria • The meter factor is not already accepted automatically • The acceptance time-out period has not elapsed yet
Reject new meter factor?	500	Rejects the new meter factor. Also disables the 'Accept new meter factor' option for the current prove.

Sampling

By default the application supports one sampler only. Additional samplers can be added by copying the logic and displays (requires the Flow-Xpress Professional license).

The following sampling modes are provided:

- Single can
- Twin can
- Multiple cans for up to 4 different products

Both the flow-proportional and time-proportional method are supported. The flow-proportional method can be based on a fixed volume between grabs value or on an estimated total volume to be sampled. Time-proportional sampling can be based on fixed time between grabs value, an estimated (batch) end time or a time period.

The amount of grabs in the sampler reservoir is limited by a configurable limit. A 'Grabs lost' alarm is generated when the limit is reached. Another limit value (configurable) is used to generate an 'Overspeed alarm' when more pulses are generated than the sampler can handle.

The can fill indication can be based on the actual grab count, a digital input (indicating the can full state) or an analog input. The sampler may be stopped automatically when the can is full or when there is no flow. Automatic can switchover is also supported. Operator commands are available to start, stop and reset. Stopping the sampler will effectively pause the generation of pulses, stop the flow accumulation and clear the pulse reservoir.

The 'Reset sampler' command, which implies the stop command, resets the accumulated number of grab in the cans and also the total sampled volume to 0. There is also a manual command to reset the number of grabs for either can. Displays to control and monitor the sampler can be accessed through option "Sampling" from the main menu.

Display → Sampling

Start sampler	500	Starts the outputting of pulses to the sampler based on the configured sampling method
Stop sampler	500	Pauses the generation of pulses, stops the accumulation of flow in the 'Total sampled volume' and clears the pulse reservoir (in case of an overspeed condition pulses are stored in reservoir).
Reset sampler	500	Same as the 'Stop sampler' command and also resets the accumulated number of grabs in the can as well as the 'Total sampled volume' to 0.
Volume between grabs	500	Sets the ‘Volume between grabs’ value. A grab is issued every time the required volume has been accumulated. Only used when sampling method is ‘Flow (fixed value)’.
Selected can	500	Switches control to the other can
Can 1 / 2	500	Enables / disables can 1 / can 2
Reset can 1 / 2	500	Resets the number of grabs in the can to 0. Command is not used when 'Can fill indication method is set to 'Analog'.

Valve control

By default the application supports control of the 'run inlet', 'run outlet' and 'run to prover' valves for each meter run and of the prover 4-way and prover outlet valves. Additional valves may be added through user-defined 'Calculations'.

Display → Valve control

The following settings and commands are available for each valve

Auto/manual mode	500	Toggles the valve between automatic and manual mode of operation. The automatic mode of operation is meant for systems where valve sequencing is applied, either through the flow computer itself or by an external device (e.g. the DCS or the supervisory computer).
Manual open command	500	Issues the command to open the valve. Only used when the valve operates in manual mode.
Manual close command	500	Issues the command to close the valve. Only used when the valve operates in manual mode.

Flow control

By default the application supports control of a Flow Control Valve for each meter run and for the prover Additional PID control loops be added on worksheets (requires the Flow-Xpress Professional license).

Display → Flow control

The following settings and commands are available for each FCV.

Setpoint value	1000	The control loop will try to achieve the setpoint value provided that current control mode is 'Flow' (and not 'Pressure') and 'Manual mode' is disabled. Same units as the controlled flow rate.
Manual control mode	1000	When this input is enabled the control output %' is set equal to 'Manual output % When this input is disabled the PID algorithm is applied based on the actual setpoint value
Manual control output	1000	The control output % will be set this value when 'Manual mode' is enabled

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Chapter 4 - Configuration

This chapter describes the configuration items of the flow computer that are specific for the Liquid USC application.

Introduction

The configuration procedure for any Flow-X flow computer is described in manual IIA- Operation and Configuration.

The procedure basically consists of the following steps:

- Setting up the flow computer device
- Configuring the HART and communications devices
- Defining the configuration settings
- Defining the reports and printers
- Defining the communication lists.

All the steps are described in manual IIA.

Manual IIA describes how to use the user interface to access the configuration settings. The actual settings however are dependent on the actual application. This chapter describes all the settings that are part the Liquid USC application in a sequence that is logical from a configuration point of view.

Setting up the I/O

A logical first step in the configuration process is to define the physical I/O points that involve all the transmitters, controllers and devices that are or will be physically wired to the I/O terminals of the flow computer.

Each Flow-X/M flow module has the following amount of I/O.

- 6 analog inputs
- 2 PRT inputs
- 4 analog outputs
- 16 digital I/O

Note : a Flow-X/P4 has 4 times this amount of IO.

The total number of pulse inputs, time period inputs, status inputs, pulse outputs and status outputs is 16.

The I/O points can later on be assigned to the related station and meter run variables.

Analog inputs

Display → Configuration, <Module IO <x.>, Analog inputs, Analog input <y>

with <x> the number of the module to which the input is physically connected and <y> the relative input number

Each flow module has 6 analog inputs. For each analog input the following settings are available.

Tag	1000	Alphanumeric string representing the tag name of the transmitter, e.g. "PT-1001A". Only used for display and reporting purposes.
Input type	1000	Type of input signal 1= 4-20 mA 2= 0-20 mA 3= 1-5 Vdc 4= 0-5 Vdc
Averaging	1000	The method to average the individual samples within every calculation cycle. 15 samples per second are taken, so with a cycle time of 250 ms 3 to 4 samples are available per cycle. 1= Arithmetic mean 2= Root mean square Enter '2: Root Mean Square' for differential pressure flow transmitters. Enter '1: Arithmetic Mean' for other transmitters
Zero scale	1000	The value in engineering units that corresponds with the zero scale value. E.g. for a 4-20 mA temperature transmitter with a range of -30..+80 deg. C the value -30 should be entered
Full scale	1000	The value in engineering units that corresponds with the full scale value. E.g. for a 4-20 mA temperature transmitter with a range of -30..+80 (deg. C) the value 80 should be entered

RTD inputs

Display → Configuration, <Module IO <x.>, PRT inputs, PRT input <y>

with <x> the number of the module to which the input is physically connected and <y> the relative input number

Each flow module has 2 PRT inputs that can be connected to a Pt100 element. For each PRT input the following settings are available.

Tag	1000	Alphanumeric string representing the tag name of the transmitter, e.g. "PT-1001A". Only used for display and reporting purposes.
Input type	1000	Type of Pt100 element

1: European (most commonly used)
Alpha coefficient 0.00385 Ω/ Ω /°C
As per DIN 43760, BS1905,IEC751
Range - 200..+850 °C

2: American
Alpha coefficient 0.00392 Ω/ Ω /°C
Range - 100..+457 °C

Analog outputs

Display → Configuration, <Module IO <x.>, Analog outputs, Analog output <y>

with <x> the number of the module to which the output is physically connected and <y> the relative output number

Each flow module has 4 analog outputs. For each analog output the following settings are available.

Tag 1000 Alphanumeric string representing the tag name of the output signal, e.g. "AO-045". Only used for display and reporting purposes.

Dampening factor 1000 Filtering level [0..8]. Can be used to obtain a smooth output signal. The value represents the number of calculation cycles * 8 that are required to get to the new setpoint.

0: No filtering
1: It takes 8 calculation cycles to get to the new setpoint
2: It takes 16 calculation cycles to get to the new setpoint
etc.

For example: following filtering is used when setpoint is set to 1.

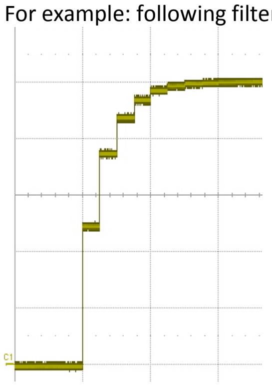


Figure 1: Analog output dampening factor

Digital IO assignments

Each flow module provides 16 multi-purpose digital channels that can be assigned to any type of input or output.

Tag	1000	Alphanumeric string representing the tag name of the transmitter, e.g. "MOV-3401O". display and reporting purposes.
Signal type	1000	Assigns the digital signal to a specific purpose

0 = Not used	
1 = Digital input	e.g. status input
2 = Digital output	e.g. status output, control output
3 = Pulse input A	single pulse / channel A of dual pulse
4 = Pulse input B	channel B of dual pulse)
5 = Time period input 1	for densitometers and SG transducers
6 = Time period input 2	
7 = Time period input 3	
8 = Time period input 4	
9 = Pulse output 1	to drive an E/M counter or a sampler
10 = Pulse output 2	
11 = Pulse output 3	
12 = Pulse output 4	
13= Common/start det. (A)	prover detector switch A; common detector input or 1st sta
14= 2nd start detector (B)	2nd start detector B
15= Stop Detector (C)	1st stop detector C
16= 2nd stop Detector (D)	2nd stop detector D
17= Prover bus A	(meter pulse A output to separate prover computer)
18 =Prover bus B	(meter pulse B output, not used normally)

Digital IO settings

Additional settings for the 16 digital channels

Polarity	1000	1: Normal 2: Inverted Refer to setting 'Input latch mode' for more details.
Threshold level	1000	Each digital channel has 2 threshold levels, which are as follows (all relative to signal ground): Channels 1 through 8: 1: + 1.25 Volts 2: + 12 Volts Channels 9 through 16: 1: + 3.75 Volts 2: + 12 Volts
Input latch mode	1000	Only applies when signal type is 'Digital output' 1: Actual 2: Latched

Polarity = ***Positive*** & Input latch *mode* = ***Actual*** then digital input is

0:OFF	when signal is currently below threshold
1:ON	when signal is currently above threshold

Polarity = ***Positive*** & Input latch *mode* = ***Latched*** then digital input is

0:OFF	when signal has not been above threshold
1:ON	when signal is or has been above threshold in the last calculation cycle

Polarity = ***Negative*** & Input latch *mode* = ***Actual*** then digital input is

0:OFF	when signal is currently above threshold
1:ON	when signal is currently below threshold

Polarity = ***Negative*** & Input latch *mode* = ***Latched*** then digital input is

0:OFF	when signal has not been below threshold
1:ON	when signal is or has been below threshold in the last calculation cycle

Output min. activation time	1000	Only applies when signal type is 'Digital output' Minimum period of time that the signal will remain activated. After the minimum activation time has elapsed the output signal will remain activated until the control value becomes 0.
Output delay time	1000	Only applies when signal type is 'Digital output' Period of time that the control signal must be high (> 0) without interruption before the output will be activated. If the control signal becomes 0 before the time has elapsed, then the output signal will not be activated The value 0 disables the delay function

Pulse input

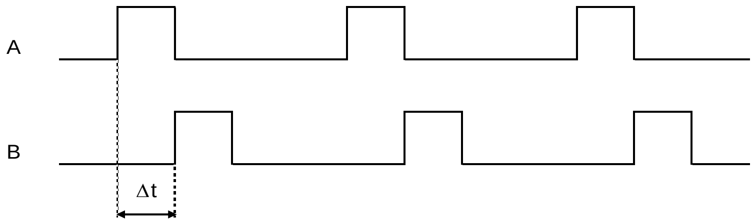
As for any digital signal a pulse input has a threshold level (Volts) that determines whether the actual signal is considered as on or off.

The actual threshold level is defined on display 'Digital IO settings'.

Meant for a flow meter that provides a single or a dual pulse output signal. Each flow module supports either 1 single or 1 dual pulse input.

A dual pulse signal is a set of two pulse signals ('pulse trains') A and B that originate from the same flow meter. The two pulse trains are similar but shifted in phase (typically 90°).
The primary purpose of the dual signal is to allow for **pulse integrity checking**. Added or missing pulses on either pulse train are detected and corrected for and simultaneous noise pulses are rejected.

The function provides detailed information on the raw, corrected and bad pulses for both channels and for both the forward and reverse flow direction.
The phase shifted pulse train signal also allows for automatic detection of flow direction. Each A pulse is followed by a B pulse within a time period (Δt) in case the flow runs in the forward direction. In case the flow runs in the reverse direction, the opposite is the case, i.e. each B pulse is followed by an A pulse within the same time period Δt.



Channel B lags channel A

Figure 2: Flow direction from dual pulse signal

There is also the option to conditionally output the raw pulse signal, which is useful in case a separate flow computer is used for proving purposes. The proving flow computer takes the pulse output from the flow computer that processes the meter on prove to perform prove measurements including double chronometry if required. The prover output signal is generated at 10 MHz, the same frequency at which the raw pulse input signals are sampled.

The Flow/X series of flow computers provides **Level A** pulse_security as defined in ISO 6551, which means that bad pulses are not only detected (level B) but also corrected for.

Pulse correction is optional so both level A and B pulse fidelity checking are supported.

Display → Configuration, <Module IO <x.>, Pulse input

with <x> the number of the module to which the input is physically connected

Each flow module has 1 pulse input, which may be either a single or a dual type of signal. The following settings are available for the pulse input of each flow module.

Error pulses limit	1000	When the number of error pulses reaches this limit, then a corresponding alarm will be raised. The value 0 disables this limit check Not used for a single pulse input (channel B = 0).
Good pulses reset limit	1000	When the number of consecutive good pulses (so without any error pulse) exceeds this limit then the number of error pulses will automatically be reset to 0. The value 0 disables this reset function Not used for a single pulse input (channel B = 0)

Error rate limit	1000	When the absolute difference in the pulse frequency between channel A and B exceeds this limit, then a corresponding alarm will be raised. The value 0 disables this limit check Not used for a single pulse input (channel B = 0)
Proving output A	1000	Enables proving output A. Meant for systems using a common prover bus to a separate prover flow computer. The flow module will output the raw pulse signal A directly to the defined output channel. Channel is assigned on display 'Digital IO assignments
Proving output B	1000	Enables proving output B. Normally not used, because only meter pulse A is used for proving.

Time period inputs

As for any digital signal a pulse input has a threshold level (Volts) that determines whether the actual signal is considered as on or off.

The actual threshold level is defined on display 'Digital IO settings'.

Display → Configuration, <Module IO <x.>, Time period inputs, Time period input <y>

with <x> the number of the module to which the input is physically connected and <y> the relative input number

Each flow module has 4 time period inputs, which can be used for densitometer and specific gravity transducer inputs.

For each time period input the following settings are available.

Difference limit	1000	Maximum allowable difference in microseconds. When the time period between two consecutive pulses differs more than this limit from the previous time period, the reading is considered to be abnormal. Following an abnormal reading there must be 3 consecutive readings within the limit before the time period value is considered normal again. When no 3 consecutive readings within the limit are available in the last 5 readings then the input signal is considered to be invalid. Resolution of the limit value is 100 nanoseconds

Pulse outputs

Pulse outputs can be used to feed pulses to an electro-mechanical (E/M) counter or to control a sampling system.

A reservoir is used to accumulate the pulses. Pulses are taken from the reservoir and fed to the output at a rate that will not exceed the specified output rate

Display → Configuration, <Module IO <x.>, Pulse outputs, Pulse output <y>

with <x> the number of the module to which the output is physically connected and <y> the relative output number

Each flow module has 3 pulse outputs. For each pulse output the following settings are available.

Max outp rate	Maximum frequency at which pulses will be generated. This option is to protect electro-mechanical counters and samplers from overspeeding. Default value 5 Hz.
Reservoir limit	Maximum number of pulses in the reservoir. An alarm will be generated when the limit is reached.

Forcing I/O

For testing purposes all inputs and outputs can be forced to a defined value or state. This option is available at the highest security option only.

Display → IO, Force IO

Overall setup

The overall settings relate the flow computer device itself and to settings that are common for all meter runs.

Overall setup

Display → Configuration, Overall setup, Overall setup

Prover type	1000	The type of prover connected to the flow computer 0: None 1: Bi-directional ball 2: Uni-directional ball 3: Calibron / Flow MD compact 4: Brooks compact 5: Master meter
Station totals and rates	1000	Determines whether or not the flow computer maintains station totals, station flow rates and station averages. 0: Disabled No station values are maintained 1: Enabled Station totals, rates and averages are maintained

Common product / batch	1000	Defines if a common product setup is used for all meter runs or if each meter run uses its own product setup. 0: Disabled Each meter run has a separate product setup 1: Enabled A common product setup is used for all meter runs
Common dens/grav input	1000	Defines if a common density / gravity input (e.g. densitometer) is used for all meter runs or if each meter run uses its own density input. 0: Disabled Each meter run has a separate density / gravity input 1: Enabled A common density / gravity input is used for all runs
Common BS&W input	1000	When enabled a common BS&W input is used for all meter runs, else a separate BS&W input is used for each meter run.
Common viscosity input	1000	When enabled a common viscosity input is used for all meter runs, else a separate viscosity input is used for each meter run.
Reverse totals	1000	Determines whether reverse totals are enabled or not. 0: Disabled: only forward totals 1: Enabled: forward and reverse totals
Flow-weighted averaging method	1000	Determines the weigh factor for all Flow-Weighted Averages. 1: Volume 2: Mass
Atmospheric pressure	1000	The local atmospheric pressure[psia] is used to convert gauge pressure to absolute pressure and vice versa.
Weight of water	1000	The weight of water [lb/bbl] is used to calculate the specific gravity / relative density.
Disable totals if meter is inactive	1000	Controls if totals should be disabled when the meter is inactive (i.e. flow / dP is below cut-off limit). 0: No 1: Yes
Disable limit alarms if meter is inactive	1000	Controls if limit alarms should be suppressed when the meter is inactive (i.e. flow / dP is below cut-off limit). 0: No 1: Yes
Disable limit alarms in maintenance mode	1000	Controls if limit alarms should be suppressed when the meter is put in maintenance mode. 0: No 1: Yes

Set flow rate 0 if meter is inactive	1000	Controls if the flow rates should be set to 0 when the meter is inactive. 0: No 1: Yes
Allow batch end if meter active	1000	Controls if it is allowed to end a batch when the meter is active (i.e. flow rate >= flow cut-off limit). Note: this option avoids that running batches are ended before the flow has stopped
Allow batch end if total 0	1000	Controls if it is allowed to end a batch when the current batch total is 0, so when there was no flow since the previous batch end. Note: this option avoids 'empty' meter tickets are generated.
Force period end at batch end	1000	When enabled the hourly and daily totals are ended at each batch end.
Standard density / gravity API rounding	1000	0: No The calculation of the standard density, or standard API gravity or standard relative density / specific gravity is performed with **full precision**. 1: Yes The calculation of the standard density, or standard API gravity or standard relative density / specific gravity is performed in accordance with the selected API standard, including all **rounding** and **truncating rules**.
Correction factors API rounding	1000	0: No The calculation of the Ctl (VCF), Cpl and Ctpl factors for the meter tickets is performed with **full precision**. 1: Yes The calculation of the Ctl (VCF), compressibility factor F, Cpl and Ctpl factors for the meter tickets is performed in accordance with the selected API standard, including all **rounding** and **truncating rules**.
Ctl decimal places	1000	Defines the number of decimal places for Ctl. Note that when API rounding is enabled, the Ctl factor will already be rounded to the number of decimal places required by the selected PAI standard.
Ctl decimal places	1000	Defines the number of decimal places for Ctl. Note that when API rounding is enabled, the Ctl factor will already be rounded to the number of decimal places required by the selected PAI standard.

Cpl decimal places	1000	Defines the number of decimal places for Cpl. Note that when API rounding is enabled, the Cpl factor will already be rounded to the number of decimal places required by the selected PAI standard.
Ctpl decimal places	1000	Ctpl is calculated from the rounded Ctl and rounded Cpl. The resulting value will be rounded to the specified number of decimal places.
Date format	1000	Date format to be used on displays and reports 1: mm/dd/yy 2: dd/mm/yy
Report type	1000	Switches between generic reports and Saudi Aramco type reports

Period settings

The application provides custody transfer data for 4 different periods, the hourly period, the daily period and 2 freely definable periods A and B.

The start of the daily period is configurable. Periods A and B can be used for any period type and any period start, e.g. a 2 weekly period starting at Tuesday 06:00 or a 2nd fiscal day starting at 08:00.. The flow computer maintains the same totals and averages for the user-definable periods as for the hourly and daily periods.

Display → Configuration, Overall setup, Periods

Day start hour	1000	Hour if the day that the daily period starts, e.g. '6' for 6:AM or '18' for 6:PM.
Period <X> type	1000	Type of period 1: Second 2: Minute 3: Hour 4: Day 5: Week 6: Month 7: Quarter 8: Year
Period <X> duration	1000	Period duration, i.e. number of period types. E.g. for a 2 weekly period, enter a 2.
Period offset days	1000	Period offset from start of year ('January 1') expressed in number of days, e.g. 10 means 'January 11
Period offset	1000	Period offset from midnight in number of hours. e.g. 6 means 6:AM

hours		
Period offset minutes	1000	Period offset from the whole hour in number of minutes, e.g. 30 means 30 minutes after the hour

Totalizer settings

Display → Configuration, Overall setup, Totals

Volume total decimal places	1000	The number of decimal places for the indicated and gross volume cumulative totals.
Mass decimal places	1000	The number of decimal places for the mass cumulative totals.
Volume total rollover value	1000	The rollover value for the indicated and gross volume cumulative totals.
Mass total rollover value	1000	The rollover value for the mass cumulative totals.

Display levels

Only the following displays are shown when no user has logged in to the flow computer.

- Live Data   Shows the actual in-use process values and flow rates.
- Alarms
- Audit Trail

All other displays have a minimum security level that needs to be activated (by a log-in) before the displays are shown and therefore accessible.

The following settings define the minimum security level required to access the associated displays. The displays will be hidden when the active security level is below the setting.

Display → Configuration, Overall setup, Totals

Detailed data display level	5000	Minimum security level for all displays that contain detailed information
Batch control display level	5000	Minimum security level for batch control display on which the batch can be ended manually.
Sampler control	5000	Minimum security level to access the display on which the sampler can

display level		be controlled.
Batch control display level	5000	Minimum security level for batch control display on which te batch can be ended manually.
Proving display level	5000	Minimum security level for the proving displays
Valve control display level	5000	Minimum security level for the controlling the motor-operated valves
Flow control display level	5000	Minimum security level for controlling the flow control valves
Product display level	5000	Minimum security level for defining the 16 products
Reports display level	5000	Minimum security level for generating and reviewing the reports
IO calibration display level	5000	Minimum security level for accessing the displays to calibrate the analog IO
Configuration display level	5000	Minimum security level for accessing the configuration displays
Batch stack display level	5000	Minimum security level for the batch stack display
Batch recalculation display level	5000	Minimum security level for the batch recalculation displays

Auto batch end

Display → Configuration, Overall setup, Auto batch end

Automatic batch end mode	1000	Determines if and how batches are ended automatically	
		0: Disabled	Batches are not ended automatically
		1: Daily	Automatic batch end every day at 'Hour of day for automatic batch end'
		2: Scheduled	Automatic batch ends at the scheduled dates
		3: Batch size	Automatically ends the batch when the defined batch size (in batch stack) has been reached
Shift stack on batch end	1000	Shifts the batch stack upwards at each batch end	
Hour of day for automatic	1000	Hour of the day to automatically end the batch when 'Automatic batch end mode' is set to 'Daily'.	

batch end		
Batch end date <x>	1000	Up to 5 scheduled dates and times to automatically end the batch. Only used when 'Automatic batch end mode' is set to 'Scheduled'.

System data

Display → Configuration, System data

System tag	1000	Tag number for the meter station or in case of a single stream flow computer, the meter run, e.g. “YY-100”
System location	1000	Name of the location of the meter station or in case of a single stream flow computer, the meter run, e.g. “Green field ,South section”
System description	1000	Description of the meter station or in case of a single stream flow computer, the meter run, e.g. “Export stream 2”
System company	1000	Name of the company that owns the meter station or in case of a single stream flow computer, the meter run, e.g. “LiqTransco”
Flow computer tag	1000	Tag number of the flow computer, e.g. “FY-1001A”

Meter run setup

Run setup

Display → Configuration, Run <x.>, Run setup

with <x> the relative number of the flow module that processes the flow meter

Meter device type 1000

The following meter device types are supported:

1:Pulse

Any flow meter that provides a single or dual pulse signal representing the volumetric or mass flow.
Typically used for turbine and PD (Positive displacement) flow meters.

2: Smart

Any flow meter that provides its flow rate and / or total value through an analog or HART signal or via a Modbus communications link.

		Typically used for ultrasonic and coriolis flow meters.. For a HART signal and a Modbus communications link the corresponding communications device (refer to [HOLD]) needs to be defined as well. 3: Smart / pulse Any flow meter that provides its flow rate and / or total value through an analog or HART signal or via a Modbus communications link and also outputs a single or dual pulse signal. Either the smart or the pulse signal may be defined as the primary signal for totalization. Also a deviation check between the two signals is performed. Typically used for ultrasonic and coriolis flow meters that provide both a communications link and a pulse signal. 4: Orifice Orifice plate with up to 3 differential pressure transmitters.
Standard dens/grav input type	1000	Defines how the standard density / gravity is determined 0: Calculated (from observed dens.) The standard density/gravity is calculated from the observed density / gravity value 1: From product table Use this option when a fixed value is used for the standard density / gravity. This fixed value is retrieved from the product table 2: Analog input 4: HART 5: Custom The value that is written to tag 'Standard dens/grav custom value' will be used as the observed density / gravity. Use this option when the standard density / gravity value is sent to the flow computer over a communications link or when you want to apply a custom-made calculation for the standard density /gravity value.
Standard dens/grav input units	1000	Units to be used for the standard density / gravity. 1: API gravity — The standard density is expressed in degrees API 2: Relative density — Relative density / specific gravity 3: Density [g/cc] — Density in g/cc
Observed dens/grav input type	1000	Defines how the observed density / gravity is determined 0: None There is no observed density / gravity input

1: Always use override

Use this option when a fixed value is used for the observed density

2: Analog input

4: HART

5: Custom

The value that is written to tag 'Observed dens/grav custom value' will be used as the observed density. Use this option when the observed density / gravity value is sent to the flow computer over a communications link or when you want to apply a custom-made calculation for the observed density / gravity value.

6: Single densitometer

7: Dual densitometer

8: Smart flow meter

Uses the Modbus density value from the Coriolis flow meter

Observed dens/grav input units 1000 Units to be used for the observed density / gravity input signal.

1: API gravity	The input signal represents API gravity
2: Relative density	The input signal represents the relative density (or the specific gravity)
3: Density [g/cc]	The input signal represents the density in g/cc. Typically used for densitometers

Flow meter setup

The type of flow meter is set up under *Configuration, Run <x>, Run Setup*.

Display → Configuration, Run <x.>, Flow meter, Meter data

with <x> the relative number of the flow module that processes the flow meter

Meter tag	1000	Flow meter tag, e.g. 'FT-1023AA'
Meter ID	1000	Flow meter ID, e.g. 'Check meter export 2'
Meter serial number	1000	Flow meter serial number, e.g. 'H1009245'

Meter manufacturer	1000	Flow meter serial number, e.g. 'H1009245'
Meter model	1000	Flow meter model, e.g. 'Promass 83'
Meter size	1000	Flow meter size, e.g. '120 mm' or ' 11" '

Pulse input

These parameters are only available when **Meter device type** is either **'Pulse'** or **'Smart / Pulse'.**

Display → Configuration, Run <x.>, Flow meter, Pulse input

with <x> the relative number of the flow module that processes the flow meter

Pulse input quantity type	1000	Either 'Volumetric' for a volumetric flow meter (e.g. turbine, PD, ultrasonic) or 'Mass' for a mass flow meter (e.g. coriolis)
Single or dual pulse input	1000	Defines whether the pulse input is a single or a dual signal. In case of a dual signal, pulse fidelity checking is enabled and the A and B pulse signals are compared and possible error pulses are accumulated and reported. In case of a single pulse signal no fidelity checking is performed at all. 1: Single 2: Dual
Meter actv threshold freq	1000	When the actual frequency (Hz) is below this threshold value, the meter is considered to be inactive and the flow rates are forced to 0. Note: Setting '**Disable totals when meter inactive**' (refer to display *'Configuration, System, Totals'*) defines whether or not the flow totals should be stopped when the meter is inactive.
Pulse fidelity level A	1000	When enabled the corrected pulses (ISO-6651 level A) are used for flow totalization. When disabled the raw pulses (ISO-6651 level B) of channel A or, in case channel A does not provide any pulses, of channel B are used instead.

Smart meter

Only available when **Meter device type** is either **'Smart'** or **'Smart / Pulse'.**

Display → Configuration, Run <x.>, Flow meter, Smart meter

with <x> the relative number of the flow module that processes the flow meter

Smart meter input type	1000	Type of input used for the 'smart' flow meter 1: HART/Modbus (Serial, Ethernet or HART) 2: Analog input
Use flowrate or total	1000	Only applies when input type = 'HART'. Determines whether the flow rate or the flow total value as provided by the flow meter is used for flow totalization. 1: Flow rate 2: Flow total Note: an analog input always represents a flow rate.
Analog input quantity type	1000	Only applies when input type = 'Analog input' 1: Volume 2: Mass For communication inputs this is determined automatically from the 'Communication template' of the assigned communication device.
Analog input module	1000	Only applies when input type = 'Analog input' Number of the flow module to which the analog signal is physically connected. Default is the local module, i.e. the module of this meter run
Analog input channel	1000	Only applies when input type = 'Analog input' Number of the analog input channel to which the analog signal is physically connected.
HART/Modbus internal device nr.	1000	Only applies when input type = 'HART/Modbus'. Internal device nr. of the communication device as assigned in by the configuration software (Flow-Xpress, section 'Ports & Protocols')
HART to analog fallback	1000	Only applies for a single HART transmitter, where the 4-20 mA signal is provided together with the HART signal. 0: Disabled The 4-20 mA signal will not be used when the HART signal fails. Instead value corresponding with the 'Fallback type' will be used. 1: Enabled The 4-20 mA signal will be used when the HART signal fails. When both the HART and the mA signal fail the value corresponding with the 'Fallback type' will be used.

Meter active threshold FR	1000	Meter will be considered inactive when the flow rate is below this limit value. The value should have the same units as used by the flow rate that is indicated by flow meter. Note: Setting '**Disable totals when meter inactive**' (refer to display *'Configuration, System, Totals'*) defines whether or not the flow totals should be stopped when the meter is inactive
Pulse is primary	1000	Only applies when meter type is 'Smart / pulse'. Controls whether the pulse input or the smart input is used as the primary source for flow totalization. 1: No -> Smart input is primary 2: Yes -> Pulse input is primary When the primary input fails, while the secondary input is healthy, then the secondary input will be used for totalization. Note that a single pulse input is always considered to be healthy.
Flow deviation limit smart / pulses	1000	Only applies when meter type is 'Smart / pulse'. The flow rate as indicated by the smart and pulse inputs are compared and an alarm is raised when the absolute deviation between the two is larger than the '*Flow deviation limit*'.
Flow Meter Total Rollover		Only applies for a smart meter when 'Flow total' is used for flow accumulation of flow. Defines the value at which the total as received from the flow meter rolls-over to 0. When the current total value indicated by the flow meter is smaller than the previous value total, then the Flow-X calculates the increment assuming that a roll-over occurred. It then checks that the increment does not exceed the 'Flow Meter Max. Change In Total'.
Flow Meter Max. Change in Total		Only applies for a smart meter when 'Flow total' is used for flow accumulation of flow. Any increments in the flow total as received from the flow meter larger than this value will be considered <u>invalid</u>.

Orifice

For orifice plates in accordance with AGA Report 3.

Only available when **Meter device type** is **'Orifice'**

General

Display → Configuration, Run <x.>, Flow meter, Orifice *with <x> the relative number of the flow module that processes the flow meter*

Meter active threshold dP	1000	When the actual differential pressure is below this threshold value, the meter is considered to be inactive and the flow rates are forced to 0. Note: Setting '**Disable totals when meter inactive**' (refer to display *'Configuration, System, Totals'*) defines whether or not the flow totals should be stopped when the meter is inactive.
Pipe diameter	1000	Internal pipe diameter [Inches]
Pipe reference temperature	1000	Pipe reference temperature that corresponds with the specified diameter [°F]
Pipe expansion factor -Type	1000	Selects the pipe material used to set the pipe linear thermal expansion factor 1: Carbon steel 6.2e-6 [1/°F] 2: Stainless steel 304 6.9e-6 [1/°F] 3: Stainless steel 316 8.83e-6 [1/°F] 4: Monel 7.95e-6 [1/°F] 5: User-defined (uses the 'Pipe expansion factor - User')
Pipe expansion factor -User	1000	User-defined value for pipe linear thermal expansion factor [1/°F] Only used when 'Pipe expansion factor - Type' is set to 'User-defined'
dP device diameter	1000	Orifice diameter [mm]
dP device reference temperature	1000	Orifice reference temperature that corresponds with the specified diameter [°F]
dP device expansion factor - Type	1000	Selects the orifice material used to set the orifice linear thermal expansion factor 1: Carbon steel 6.2e-6 [1/°F] 2: Stainless steel 304 6.9e-6 [1/°F] 3: Stainless steel 316 8.83e-6 [1/°F] 4: Monel 7.95e-6 [1/°F] 5: User-defined (uses the 'dP device expansion factor - User')
dP device expansion factor - User	1000	User-defined value for orifice linear thermal expansion factor [1/°F] Only used when 'dP device expansion factor - Type' is set to 'User-defined'
Pressure location	1000	Location of the pressure tap used for the static pressure relative to the orifice plate.

		1: Upstream 2: Downstream When '2: downstream' is selected, a correction of the meter pressure to upstream conditions is applied. Refer to chapter Calculations for more details
Temperature location	1000	Location of the temperature element relative to the orifice plate 1: Upstream At the upstream tap 2: Downstream At the downstream tap 3: Recovered Downstream at the location where the pressure has fully recovered. When '2: downstream' or '3: Recovered' is selected, a correction of the meter temperature to upstream conditions is applied. Refer to chapter Calculations for more details
Temperature correction	1000	This parameter specifies how the temperature must be corrected from downstream to upstream conditions 1: $(1-\kappa)/\kappa$ Isentropic expansion using $(1-\kappa)/\kappa$ as the temperature referral exponent 2: Constant Isentropic expansion using the 'Pressure Exponent' parameter value as the temperature referral exponent [-]. Please note that the 'Pressure Exponent' must be < 0 3: Joule Thomson Isenthalpic expansion using input 'Pressure Exponent' as the Joule Thomson coefficient [°F/psi].
Temperature exponent	1000	Only used when temperature has to be corrected to upstream conditions and when type of temperature correction is either '*2: Constant*' or '3*: Joule Thomson*'.

dP inputs

Only available when **Meter device type** is **'Orifice'**

Up to 3 differential pressure can be used for dP measurement, required for orifice, venturi en v-cone flow meters.

The flow computer can handle the following type of cell range configurations:

- 1 cell
- 2 cells, 1 with low and 1 with high range
- 2 cells, both with equal range
- 3 cells, with low, mid and high range
- 3 cells. 1 with low and 2 with high range
- 3 cells with equal range

The flow computer selects between 2 or 3 input cells based on the actual measured value and the failure status of each cell.

The selection logic is described in chapter Calculations.

dP selection

Display → Configuration, Run <x.>, Flow meter, dP inputs

with <x> the relative number of the flow module that processes the flow meter

dP selection type	1000	dP selection type 1: high (1 cell) 2: low high (2 cells) Cell A at low range Cell B at high range 3: high high (2 cells) Cell A and B at same range 4: low mid high (3 cells) Cell A at low range Cell B at mid range Cell C at high range 5: low high high (3 cells) Cell A at low range Cell B and C at high range 6: high high high (3 cells) Cell A, B and C at same range
Switch up percentage	1000	Switch-up value expressed as percentage of span of the lower range. Only used for 2 or 3 cells when more than one dP range is used. Refer to chapter 'Calculations' for more information on its usage.
Switch down percentage	1000	Switch-down value expressed as percentage of span of the lower range. Only used for 2 or 3 cells when more than one dP range is used. Refer

		to chapter 'Calculations' for more information on its usage.
dP auto switchback	1000	Determines whether or not to switch to a dP transmitter when it becomes healthy after a failure. Refer to chapter 'Calculations' for more information on its usage. 0: Disabled 1: Enabled

dP input A, B and C

Only available when **Meter device type** is **'Orifice'**

Display → Configuration, Run <x.>, Flow meter, dP input A/B/C

with <x> the relative number of the flow module that processes the flow meter

dP input type	1000	Type of input for dP cell 1: Analog input 2: HART input 3: Communication value When option 3: Communication value is shown then the actual value should be written to the corresponding tag in the flow computer via a communications link.
dP analog input module	1000	Only applies when input type is '1: Analog input' Number of flow module to which the dP signal is physically connected to. Default is the local module, i.e. the module of this meter run
dP analog input channel	1000	Only applies when input type is '1: Analog input' Number of analog input channel to which the dP signal is physically connected to.
dP HART internal device nr.	1000	Only applies when input type is '2: HART' Internal device nr. of the HART transmitter (or communication device) as assigned in the configuration software (Flow-Xpress, section 'Devices & Protocols')
dP HART variable value	1000	Only applies when input type is '2: HART' Determines which of the 4 HART variables as provided by the HART transmitter represents the dP value Usually this is the 1st (primary) variable.
dP HART	1000	Only applies when input type is '2: HART'

variable percentage	Determines which of the 4 HART variables as provided by the HART transmitter represents the **dP percentage of range [%]**.The percentage of range is required for dP selection in case of multiple dP transmitters with different ranges are used (low and high range).

Data valid input

Only available when **Meter device type** is either **'Pulse'** or **'Smart / Pulse'.**

The Data Valid input is **not** actually used within the standard application. It can be used for informative purposes and within user-defined calculations

Display → Configuration, Run <x.>, Flow meter, Data valid input

with <x> the relative number of the flow module that processes the flow meter

Data valid input type	1000	Type of input used for the 'smart' flow meter 0: None 1: Digital input 2: Smart meter 3: Custom
Data valid input module	1000	Applies when type is 'Digital input'. Number of Flow-X/M module to which the input is connected.
Data valid input channel	1000	Applies when type is 'Digital input'. Channel number used for the digital input.

Flow direction input

Only available when **Reverse totals** are **Enabled.**

Display → Configuration, Run <x.>, Flow meter, Flow direction input

with <x> the relative number of the flow module that processes the flow meter

Data valid input type	1000	Type of input used for the 'smart' flow meter 0: None 1: Meter pulse phase ***Based on 90° phase shift for a dual pulse input*** 2: Digital input 2: Smart meter input ***Based on Modbus from smart flow meter*** 3: Custom

Data valid input module	1000	Applies when type is ‘Digital input’. Number of Flow-X/M module to which the input is connected.
Data valid input channel	1000	Applies when type is ‘Digital input’. Channel number used for the digital input.
Smart meter device	1000	Applies when input type is ‘Smart meter input’ and defines the actual smart flow meter.

Meter body correction

Only available when **Meter device type** is either **'Smart'** or **'Smart / Pulse'.**

The meter body correction facility is meant for ultrasonic flow meters for which a correction of the expansion of the meter body may be required.

Display → Configuration, Run <x.>, Flow meter, Meter body correction

with <x> the relative number of the flow module that processes the flow meter

Meter body correction	900	Controls if the correction is enabled or not 0: Disabled 1: Enabled
Linear temperature expans coef	900	Linear temperature expansion coefficient [1/°F]
Body corr reference temp	900	Reference temperature for body correction [°F]
Linear pressure expans coef	900	Linear pressure expansion coefficient [1/psi]
Body corr reference pres	900	Reference pressure for body correction [psig]

Refer to chapter Calculations for more details

Setting up the temperature

Two temperature inputs are used at meter run level, the meter temperature and, in case of a live density / gravity measurement at meter run level, the density temperature (i.e. the temperature at the point where the density or gravity is measured).

At station level also two temperature inputs are available, the station temperature and, in case of a live density / gravity measurement at station level, the density temperature.

Display → Configuration, Run <x.>, Pressure (, Meter temperature)
Display → Configuration, Run <x.>, Pressure, Density temperature
Display → Configuration, Station, Pressure (, Station temperature)
Display → Configuration, Station, Pressure, Density temperature
Display → Configuration, Proving, Pressure, Prover inlet temperature
Display → Configuration, Proving, Pressure, Prover outlet temperature
Display → Configuration, Proving, Pressure, Prover rod temperature

with <x> the relative number of the flow module that processes the flow meter

The density temperature at either meter run or station level is only available when the following parameters are configured as indicated:

Density temperature measurement <u>at meter run level</u> requires the following settings:

Display:	*Configuration, Overall setup, Overall setup*
Parameter	*Common density input*
Value	*No*

Display:	*Configuration, Run <x>, Density (, Density setup)*
Parameter	*Density input type*
Value	*Densitometer* or *Density process input*

When the density temperature measurement is <u>at station level</u> the following settings need to be defined:

Display:	*Configuration, Overall setup, Overall setup*
Parameter	*Common density input*
Value	*Yes*

Display:	*Configuration, Station, Density (, Density setup)*
Parameter	*Density input type*
Value	*Densitometer* or *Density process input*

Input type 1000 Type of input

0: None

Meaning of option 'None' depends on the actual variable:

Density temperature : Meter temperature will be used instead
Prover inlet temperature : Meter temperature will be used instead
Prover outlet temperature : Prover inlet temperature will be used instead

This option is not applicable for meter temperature.

1: Always use override
2: Analog input

		3: Pt100 input 4: HART 5: Custom When option 5: Custom is selected then the actual value should be written to the corresponding tag in the flow computer via a communications link or via user-defined logic.
Analog / Pt100 input module	1000	Only applies when input type is '2: Analog input' or '3: Pt100 input' Number of flow module to which the signal is physically connected to. 'Local module' means the Flow-X flow module to which the meter run is assigned to through 'Device setup'.
Analog / Pt100 input channel	1000	Only applies when input type is '2: Analog input' or '3: Pt100 input' Number of analog input channel to which the signal is physically connected to.
HART internal device nr.	1000	Only applies when input type is '4: HART Internal device nr. of the communication device as assigned in by the configuration software (Flow-Xpress, section 'Devices & Protocols')
HART variable	1000	Only applies when input type is '4: HART' Determines which of the 4 HART variables as provided by the HART transmitter represents the dP value. Usually this is the 1st (primary) variable.
Fallback type	1000	Determines what to do in case the input fails. 1: Last good value Keep on using the last value that was obtained while the input was still healthy. 2: Fallback value Use the value as specified by parameter 'Fallback value' The fallback value is usually a fixed value (typically 0) and never changed during the lifetime of the flow computer. 3: Override value Use the value as specified by parameter 'Override value'
Fallback value	1000	Only used when Fallback type is '2: Fallback value'. Represents the value in engineering units that should be used when the input fails.
HART to analog fallback	1000	Only applies for a single HART transmitter, where the 4-20 mA signal is provided together with the HART signal. 0: Disabled

The 4-20 mA signal will not be used when the HART signal fails. Instead value corresponding with the 'Fallback type' will be used.

1: Enabled

The 4-20 mA signal will be used when the HART signal fails. When both the HART and the mA signal fail the value corresponding with the 'Fallback type' will be used.

Setting up the pressure

Two pressure inputs are used at meter run level, the meter pressure and, in case of a live density or gravity measurement at meter run level, the density pressure (i.e. the pressure at the point where the density or gravity is measured).

At station level also two pressure inputs are available, the station pressure and, in case of a live density measurement at station level, the density pressure.

Display → Configuration, Run <x.>, Pressure (, Meter pressure)
Display → Configuration, Run <x.>, Pressure, Density pressure
Display → Configuration, Station, Pressure (, Station pressure)
Display → Configuration, Station, Pressure, Density pressure
Display → Configuration, Proving, Pressure, Prover inlet pressure
Display → Configuration, Proving, Pressure, Prover outlet pressure
Display → Configuration, Proving, Pressure, Plenum pressure

with <x> the relative number of the flow module that processes the flow meter

The density pressure at either meter run or station level is only available when the following parameters are configured as indicated:

Density pressure measurement <u>at meter run level</u> requires the following settings:

Display:	*Configuration, Overall setup, Overall setup*
Parameter	*Common density input*
Value	*No*
Display:	*Configuration, Run <x>, Density (, Density setup)*
Parameter	*Density input type*
Value	*Densitometer* or *Density process input*

When the density pressure measurement is <u>at station level</u> the following settings need to be defined:

Display:	*Configuration, Overall setup, Overall setup*
Parameter	*Common density input*
Value	*Yes*
Display:	*Configuration, Station, Density (, Density setup)*
Parameter	*Density input type*
Value	*Densitometer* or *Density process input*

Input type	1000	Type of input 0: None Meaning of option 'None' depends on the actual variable: *Density pressure* : Meter temperature will be used instead *Prover inlet pressure* : Meter temperature will be used instead *Prover outlet pressure* : Prover inlet temperature will be used instead This option is not applicable for meter temperature. 1: Always use override 2: Analog input 4: HART 5: Custom When option 4: Hart/Modbus is selected, then the actual value should be written to the corresponding tag in the flow computer via a communications link.
input module	1000	Only applies when input type is '2: Analog input' Number of flow module to which the signal is physically connected to. Local module means the Flow-X flow module to which the meter run is assigned to through 'Device setup'
input channel	1000	Only applies when input type is '2: Analog input' Number of analog input channel to which the signal is physically connected to.
HART internal device nr.	1000	Only applies when input type is '4: HART' Internal device nr. of the communication device as assigned in by the configuration software (Flow-Xpress, section 'Devices & Protocols')
HART variable	1000	Only applies when input type is '4: HART' Determines which of the 4 HART variables as provided by the HART transmitter represents the dP value. Usually this is the 1st (primary) variable.
Input units	1000	1: Absolute The input value is an absolute pressure 2: Gauge The input value is a gauge pressure (i.e. relative to the atmospheric pressure)
Fallback type	1000	Determines what to do in case the input fails.

		1: Last good value Keep on using the last value that was obtained while the input was still healthy. 2: Fallback value Use the value as specified by parameter 'Fallback value' The fallback value is usually a fixed value (typically 0) and never changed during the lifetime of the flow computer. 3: Override value Use the value as specified by parameter 'Override value'
Fallback value	1000	Only used when Fallback type is '2: Fallback value'. Represents the value in engineering units that should be used when the input fails.
HART to analog fallback	1000	Only applies for a single HART transmitter, where the 4-20 mA signal is provided together with the HART signal. 0: Disabled The 4-20 mA signal will not be used when the HART signal fails. Instead value corresponding with the 'Fallback type' will be used. 1: Enabled The 4-20 mA signal will be used when the HART signal fails. When both the HART and the mA signal fail the value corresponding with the 'Fallback type' will be used.

Setting up the density / gravity

In case the flow computer is used for 2 or more meter runs, the density / gravity input can be a common input for all the meter runs or a separate input for each meter run. E.g. a densitometer can be installed in the header of the metering station in which case one and the same density measurement is used for all meter runs.

Whether the density setup is on station or meter run level is controlled by parameter **Station product**, which is accessible through display *Configuration, Overall setup\Overall setup*.

Display → Configuration, Run <x.>, Density (, Density setup)
Display → Configuration, Station, Density (, Density setup)

with <x> the relative number of the flow module that processes the flow meter

Observed density/gravity

The following settings apply when the 'Observed dens/grav input type' is set to '2: Analog input', '4: HART' or '5: Custom'.

Display → Configuration, Run <x.>, Density (, Observed dens/grav)
Display → Configuration, Station, Density (, Observed dens/grav)

with <x> the relative number of the flow module that processes the flow meter

Input units	1000	Defines the unit for observed density / gravity input. The unit is used to scale the analog input (if applicable) and for the override value. 1: Relative density 2: API gravity 3: Density [g/cc]
Analog input module	1000	Only applies when input type is '2: Analog input' Number of flow module to which the signal is physically connected to. Local module means the Flow-X flow module to which the meter run is assigned to through 'Device setup'
Analog input channel	1000	Only applies when input type is '2: Analog input' Number of analog input channel to which the signal is physically connected to.
HART internal device nr.	1000	Only applies when input type is '4: HART' Internal device nr. of the communication device as assigned in by the configuration software (Flow-Xpress, section 'Devices & Protocols')
HART variable	1000	Only applies when input type is '4: HART' Determines which of the 4 HART variables as provided by the HART transmitter represents the dP value. Usually this is the 1st (primary) variable.
Fallback type	1000	Determines what to do in case the input fails. 1: Last good value Keep on using the last value that was obtained while the input was still healthy. 2: Fallback value Use the value as specified by parameter 'Fallback value' The fallback value is usually a fixed value (typically 0) and never changed during the lifetime of the flow computer. 3: Override value Use the value as specified by parameter 'Override value'

Fallback value	1000	Only used when Fallback type is '2: Fallback value'. Represents the value in engineering units that should be used when the input fails.
HART to analog fallback	1000	Only applies for a single HART transmitter, where the 4-20 mA signal is provided together with the HART signal. 0: Disabled The 4-20 mA signal will not be used when the HART signal fails. Instead value corresponding with the 'Fallback type' will be used. 1: Enabled The 4-20 mA signal will be used when the HART signal fails. When both the HART and the mA signal fail the value corresponding with the 'Fallback type' will be used.
Smart meter device	1000	Smart meter that provides the observed density value over Modbus

Densitometer

Following display is only available when 'Observed density input type' is set to 'Single densitometer' or 'Dual densitometer'

Display → Configuration, Run <x.>, Density, Densitometer(s)
Display → Configuration, Station, Density, Densitometer(s)

with <x> the relative number of the flow module that processes the flow meter

Densitometer select mode	1000	Only applies when 'Observed density input type' is set to 'Dual densitometer'. Densitometer selection mode. 1: Auto-A Densitometer B only used when densitometer A fails and densitometer B is healthy. Densitometer A is used in all other cases. 2: Auto-B Densitometer A is only used when densitometer B fails and densitometer A is healthy. Densitometer B is used in all other cases. 3: Manual-A Always use densitometer A irrespective of its failure status 4: Manual-B Always use densitometer B irrespective of its failure status

Fallback type	1000	Determines what to do in case the input fails. 1: Last good value Keep on using the last value that was obtained while the input was still healthy. 2: Fallback value Use the value as specified by parameter 'Fallback value' The fallback value is usually a fixed value (typically 0) and never changed during the lifetime of the flow computer. 3: Override value Use the value as specified by parameter 'Override value'
Fallback value	1000	Only used when Fallback type is '2: Fallback value'. Represents the value in engineering units that should be used when the input fails.
Densitometer A type	1000	Densitometer A device type. The application supports Solartron, Sarasota, UGC and Densitrak densitometers
Densitometer A corr factor	1000	Overall correction factor for densitometer A. The density as measured by densitometer A is multiplied by this factor.
Time period A input module	1000	Flow-X module to which the densitometer A signal is connected to.
Time period A input channel	1000	Defines the time period input of the Flow-X module for densitometer A. Each module has a maximum of 4 time period inputs.
Densitometer B type	1000	Only applies when 'Observed density input type' is set to 'Dual densitometer'. Densitometer B device type.
Densitometer B corr factor	1000	Only applies when 'Observed density input type' is set to 'Dual densitometer'. Overall correction factor for densitometer B. The density as measured by densitometer A is multiplied by this factor.
Time period B input module	1000	Only applies when 'Observed density input type' is set to 'Dual densitometer'. Flow-X module to which the densitometer B signal is connected to.
Time period B input channel	1000	Only applies when 'Observed density input type' is set to 'Dual densitometer'. Defines the time period input of the Flow-X module for densitometer B.

Each module has a maximum of 4 time period inputs.

Solartron / Sarasota / UGC / Densitrak densitometer setup

The densitometer constants are device-specific and can be defined on the following display.

Display → Configuration, Run <x.>, Density, Densitometer, Densitometer A / B
Display → Configuration, Station, Density, Densitometer, Densitometer A / B

with <x> the relative number of the flow module that processes the flow meter , and <Type> being Solartron, Sarasota, UGC or Densitrak.

All densitometer constants are at security level 1000.

Refer to section calculations for the meaning of these settings.

Standard density / gravity

The following settings apply when the 'Standard density input type' is set to '2: Analog input', '4: HART' or '5: Custom'.

Display → Configuration, Run <x.>, Density (, Standard dens/grav input)
Display → Configuration, Station, Density (,Standard dens/grav input)

with <x> the relative number of the flow module that processes the flow meter

Input units	1000	Defines the unit for standard density / gravity input. The unit is used to scale the analog input (if applicable) and for the override value. 1: Relative density 2: API gravity 3: Density [g/cc]
Analog input module	1000	Only applies when input type is '2: Analog input' Number of flow module to which the signal is physically connected to. Local module means the Flow-X flow module to which the meter run is assigned to through 'Device setup'
Analog input channel	1000	Only applies when input type is '2: Analog input' Number of analog input channel to which the signal is physically connected to.
HART internal device nr.	1000	Only applies when input type is '4: HART' Internal device nr. of the communication device as assigned in by the configuration software (Flow-Xpress, section 'Devices & Protocols')

HART variable 1000

Only applies when input type is '4: HART'

Determines which of the 4 HART variables as provided by the HART transmitter represents the dP value. Usually this is the 1st (primary) variable.

Fallback type 1000

Determines what to do in case the input fails.

1: Last good value
  Keep on using the last value that was obtained while the input was still healthy.

2: Fallback value
  Use the value as specified by parameter 'Fallback value'

  The fallback value is usually a fixed value (typically 0) and never changed during the lifetime of the flow computer.

3: Override value
  Use the value as specified by parameter 'Override value'

Fallback value 1000

Only used when Fallback type is '2: Fallback value'.

Represents the value in engineering units that should be used when the input fails.

HART to analog fallback 1000

Only applies for a single HART transmitter, where the 4-20 mA signal is provided together with the HART signal.

0: Disabled
  The 4-20 mA signal will not be used when the HART signal fails. Instead value corresponding with the 'Fallback type' will be used.

1: Enabled
  The 4-20 mA signal will be used when the HART signal fails. When both the HART and the mA signal fail the value corresponding with the 'Fallback type' will be used.

Setting up a BS&W input

The application supports a BS&W input. The BS&W value is used for the calculation of the net standard volume flow rate.

Display → Configuration, Run <x.>, BSW
Display → Configuration, Station, BSW

with <x> the relative number of the flow module that processes the flow meter

Input type 1000

Type of input

0: Not used (forces BSW to 0)

		1: Always use override 2: Analog input 4: HART 5: Custom When option 4: HART value is shown then the actual value should be written to the corresponding tag in the flow computer via a communications link.
input module	1000	Only applies when input type is '2: Analog input' Number of flow module to which the signal is physically connected to. Local module means the Flow-X flow module to which the meter run is assigned to through 'Device setup'
input channel	1000	Only applies when input type is '2: Analog input' Number of analog input channel to which the signal is physically connected to.
HART internal device nr.	1000	Only applies when input type is '4: HART' Internal device nr. of the communication device as assigned in by the configuration software (Flow-Xpress, section 'Devices & Protocols')
HART variable	1000	Only applies when input type is '4: HART' Determines which of the 4 HART variables as provided by the HART transmitter represents the dP value. Usually this is the 1st (primary) variable.
Fallback type	1000	Determines what to do in case the input fails. 1: Last good value Keep on using the last value that was obtained while the input was still healthy. 2: Fallback value Use the value as specified by parameter 'Fallback value' The fallback value is usually a fixed value (typically 0) and never changed during the lifetime of the flow computer. 3: Override value Use the value as specified by parameter 'Override value'
Fallback value	1000	Only used when Fallback type is '2: Fallback value'. Represents the value in engineering units that should be used when the input fails.
HART to	1000	Only applies for a single HART transmitter, where the 4-20 mA signal is

analog fallback provided together with the HART signal.

0: Disabled

The 4-20 mA signal will not be used when the HART signal fails. Instead value corresponding with the 'Fallback type' will be used.

1: Enabled

The 4-20 mA signal will be used when the HART signal fails. When both the HART and the mA signal fail the value corresponding with the 'Fallback type' will be used.

Setting up a viscosity input

The application supports a viscosity input. The viscosity value is used to correct for the influence of the viscosity on turbine and PD flow meters. Refer to section *Configuration\...\Flow meter\Viscosity correction*.

Display → Configuration, Run <x.>, Viscosity
Display → Configuration, Station, Viscosity

with <x> the relative number of the flow module that processes the flow meter

Input type 1000

Type of input

0: Not used
1: Always use override
2: Analog input
4: HART
5: Custom

When option 4: HART value is shown then the actual value should be written to the corresponding tag in the flow computer via a communications link.

input module 1000

Only applies when input type is '2: Analog input'

Number of flow module to which the signal is physically connected to.

Local module means the Flow-X flow module to which the meter run is assigned to through 'Device setup'

input channel 1000

Only applies when input type is '2: Analog input'

Number of analog input channel to which the signal is physically connected to.

HART internal device nr. 1000

Only applies when input type is '4: HART'

Internal device nr. of the communication device as assigned in by the configuration software (Flow-Xpress, section 'Devices & Protocols')

HART variable	1000	Only applies when input type is '4: HART' Determines which of the 4 HART variables as provided by the HART transmitter represents the dP value. Usually this is the 1st (primary) variable.
Input units	1000	1: Absolute The input value is an absolute pressure 2: Gauge The input value is a gauge pressure (i.e. relative to the atmospheric pressure)
Fallback type	1000	Determines what to do in case the input fails. 1: Last good value Keep on using the last value that was obtained while the input was still healthy. 2: Fallback value Use the value as specified by parameter 'Fallback value' The fallback value is usually a fixed value (typically 0) and never changed during the lifetime of the flow computer. 3: Override value Use the value as specified by parameter 'Override value'
Fallback value	1000	Only used when Fallback type is '2: Fallback value'. Represents the value in engineering units that should be used when the input fails.
HART to analog fallback	1000	Only applies for a single HART transmitter, where the 4-20 mA signal is provided together with the HART signal. 0: Disabled The 4-20 mA signal will not be used when the HART signal fails. Instead value corresponding with the 'Fallback type' will be used. 1: Enabled The 4-20 mA signal will be used when the HART signal fails. When both the HART and the mA signal fail the value corresponding with the 'Fallback type' will be used.

Setting up pulse outputs

Each flow module provides a maximum of 4 pulse outputs.

Pulse outputs can be set up both at meter run level for run totals and at station level for station totals.

The station pulse outputs are only available when the following parameter has been set.

Display:	*Configuration, Overall setup, Overall setup*
Parameter	*Station totals and rates*
Value	*Enabled*

Display → Configuration, Run <x.>, Pulse outputs
Display → Configuration, Station, Pulse outputs

with <x> the relative number of the flow module that processes the flow meter

Totalizer	1000	The totalizer that is used for the pulse output. When the configuration is at meter run level the run total will be used, while at station level the station total will be used. -1:Custom 0: Not assigned 1: Indicated volume (forward) 2: Gross volume (forward) 3: Gross standard volume (forward) 4: Net standard volume (forward) 5: Mass (forward) 6: Good pulses (forward; only for runs) 7: Error pulses (forward; only for runs) 8: Indicated volume (reverse) 9: Gross volume (reverse) 10: Gross standard volume (reverse) 11: Net standard volume (reverse) 12: Mass (reverse) 13: Good pulses (reverse; only for runs) 14: Error pulses (reverse; only for runs)
Module	1000	Number of flow module to which the signal is physically connected to.
Index	1000	Pulse output number of the specified module to which the signal is physically connected to.
Significance	1000	Factor that specifies the relation between the input value and the number of output pulses. E.g. a value of 100 means that 1 pulse is generated whenever 100 input units (e.g. bbl) have been accumulated.

Setting up analog outputs

Each flow module provides 4 analog outputs, which can be set up at meter run level and at station level.

The station analog outputs are only available when the following parameter has been set.

Display: *Configuration, Overall setup, Overall setup*

Parameter *Station totals and rates*
Value *Yes*

Display → Configuration, Run <x.>, Analog outputs
Display → Configuration, Station, Analog outputs

with <x> the relative number of the flow module that processes the flow meter

Variable	1000	The variable that is used for outputting the analog output. When the configuration is at meter run level the run total will be used, while at station level the station total will be used. -1: Custom 0: Not assigned 1: Indicated volume flow rate 2: Gross volume flow rate 3: Gross standard volume rate 4: Net standard volume rate 5: Mass flow rate 6: Standard density 7: Meter temperature 8: Meter pressure
Module	1000	Number of flow module to which the signal is physically connected to.
Channel	1000	Analog output channel of the specified module to which the signal is physically connected to.
Zero scale	1000	The zero scale value for the variable. When the variable is at this value the output will be 4 mA. For flow rates the value should specified on an hourly basis, i.e. bbl/h, and Klbm/hr
Full scale	1000	The full scale value for the variable. When the variable is at this value the output will be 20 mA. For flow rates the value should specified on an hourly basis, i.e. bbl/h and Klbm/hr

Product definition

Up to 16 products can be defined. The actual product in-use is defined in the batch stack (display 'Batch\(Run <x>)\Batch stack'

Whether the product definition is on station or meter run level is controlled by parameter '**Common product / batch'**, which is accessible through display *Configuration, Overall setup, Overall setup*.

Display → Configuration, Run <x.>, Products
Display → Configuration, Station, Products

with <x> the relative number of the flow module that processes the flow meter

Product #<x> name — 500 — Current product name

Product #<x> dens /grav method — 1000 — Method to convert the density to and from standard conditions

1: 5/6A: 1980 Crude
API-2540 table 5A / 6A: crude oil at 60 °F.

2: 5/6B: 1980 Auto
API-2540 table 5B / 6B: Refined product at 60 °F.
Automatically determines the table B product range

3: 5/6B: 1980 Gasoline
API-2540 table 5B / 6B: Gasoline at 60 °F

4: 5/6B: 1980 Transition
API-2540 table 5B / 6B: Transition area at 60 °F

5: 5/6B: 1980 Jet fuel
AP -2540 table 5B / 6B: Jet fuel at 60 °F

6: 5/6B: 1980 Fuel oil
AP -2540 table 5B / 6B: Fuel oil at 60 °F

7: 5/6D: 1982 Lub oil
API-2540 table 5D /54D: Lubricating oil at 60 °F

8 23/24A: 1980 Crude
API-2540 table 23A / 24A: crude oil at 60 °F.

9: 23/24B: 1980 Auto
API-2540 table 23B / 24B: Refined product at 60 °F.
Automatically determines the table B product range

10: 23/24B: 1980 Gasoline
API-2540 table 23B / 24B: Gasoline at 60 °F

11: 23/24B: 1980 Transition
API-2540 table 23B / 24B: Transition area at 60 °F

12: 23/24B: 1980 Jet fuel
API-2540 table 23B / 24B: Jet fuel at 60 °F

13: 23/24B: 1980 Fuel oil
API -2540 table 23B / 24B: Fuel oil at 60 °F

14: 23/24D: 1980 Lub oil
API-2540 table 23D / 24D: Lubricating oil at 60 °F

15: 5/6A: 2004 Crude
API 11.1:2004 table 5A / 6A: crude oil at 60 °F.

16: 5/6B: 2004 Auto
API 11.1:2004 table 5B / 6B: Refined product at 60 °F.
Automatically determines the table B product range

17: 5/6B: 2004 Gasoline
API 11.1:2004 table 5B / 6B: Gasoline at 60 °F

18: 5/6B: 2004 Transition
API 11.1:2004 table 5B / 6B: Transition area at 60 °F

19: 5/6B: 2004 Jet fuel
AP -2540 table 5B / 6B: Jet fuel at 60 °F

20: 5/6B: 2004 Fuel oil
AP -2540 table 5B / 6B: Fuel oil at 60 °F

21: 5/6D: 2004 Lub oil
API 11.1:2004 table 5D /54D: Lubricating oil at 60 °F

22 23/24A: 2004 Crude
API 11.1:2004 table 23A / 24A: crude oil at 60 °F.

23: 23/24B: 2004 Auto
API 11.1:2004 table 23B / 24B: Refined product at 60 °F.
Automatically determines the table B product range

24: 23/24B: 2004 Gasoline
API 11.1:2004 table 23B / 24B: Gasoline at 60 °F

25: 23/24B: 2004 Transition
API 11.1:2004 table 23B / 24B: Transition area at 60 °F

26: 23/24B: 2004 Jet fuel
API 11.1:2004 table 23B / 24B: Jet fuel at 60 °F

27: 23/24B: 2004 Fuel oil
API 11.1:2004 table 23B / 24B: Fuel oil at 60 °F

28: 23/24D: 2004 Lub oil
API 11.1:2004 table 23D / 24D: Lubricating oil at 60 °F

29: 23/24E: 2007 NGL/LPG
API MPMS 11.2.4 (GPA TP-27) NGL /LPG at 60 °F.
Fully complies with GPA TP-25.

30: Propylene (API 11.3.3.2)
In compliance with API MPMS 11.3.3.2 Propylene Compressibility Tables, 1974, Reaffirmed 1997.

31: Ethylene (IUPAC)
In compliance with IUPAC International Thermodynamic Tables of the Fluid State Vol. 10 (1988),

32: 5/6: 1952
In compliance with Tables 5 and 6 of ASTM-IP Petroleum Measurement Tables - American Edition - 1952

33: 23/24: 1952
In compliance with Tables 23 and 24 of ASTM-IP Petroleum Measurement Tables - American Edition - 1952

Product #<x> std dens/grav override — 1000

The standard density / gravity override value.

The meaning of the value depends on the setting 'Standard dens/grav input unit': relative density, API gravity or density [g/cc]

Used when *Density input type* is *1: Always use override*, or when standard density/gravity is overridden with a override value

Product #<x> std dens/grav units — 1000

The standard density / gravity units used for the override value and, in case there is a standard density/ gravity input signal, for the input value as well.

1: Relative density
2: API gravity
3: Density [g/cc]

Product #<x> vapor pres mode — 1000

Method to determine the equilibrium pressure.

1: Override
The 'Equilibrium pres set value' is used for the calculation of CPL
2: Calculate (TP-15)
The equilibrium pressure is calculated in accordance with GPA TP-15

As opposed to API MPMS 11.1:1980 (API-2540), method 1 does not apply for API MPMS 11.1:2004, because the latter standard assumes an equilibrium pressure of 0 psig.

Method 2 (GPA TP-15) only applies for NGL / LPG.

Product #<x> vapor pressure override — 1000

The fixed equilibrium pressure value.

Only is used when *Equilibrium pres method* equals *1: Use set value.*

Product #<x> F factor override — 1000

Enables or disables the override of compressibility factor F calculation. The in-use compressibility factor F is used to calculate the CPL value.

Product #<x> F factor override	1000	The value used for compressibility factor F when the compressibility override function is enabled.
Product #<x> P100 correlation	1000	Controls whether the standard or the improved GPA TP-15 correlation is applied. The standard correlation is commonly used for pure products such as propane, butane and natural gasoline. It only requires the relative density and the temperature to calculate the vapor p The improved correlation requires the vapor pressure at 100°F. This method is better suited for varied NGL mixes, where different product mixes could have the same specific gravity but different equilibrium pressure
Product #<x> vapor pres at 100F	1000	The equilibrium pressure of the product at 100 °F. Only used when the GPA-TP15 improved correlation function is enabled.
Product #<x> dynamic viscosity	1000	Dynamic viscosity of the liquid in centiPoise at flowing conditions [cP]. Only used for mass flow rate calculation for differential pressure flow meters
Product #<x> isentropic	1000	Isentropic exponent of the fluid at flowing conditions [dimensionless] Only used for mass flow rate calculation in case of differential pressure flow meters

Proving

The Flow-X supports both sphere (ball/pipe) and compact provers. Master meter proving will be supported in the near future.

The actual settings on the displays shown under 'Configuration\Proving' depend on the type of prover.

The type of prover is defined in display '**Configuration / Overall setup / Overall setup** ',

Prover setup

Display → Configuration, Proving, Prover setup

Prover tag name	1000	The prover tag number, e.g. "PR-003" (in accordance with the P&ID)
Prover ID	1000	The prover ID, e.g. "16 inch prover".

Prover manufacturer	1000	Manufacturer of the prover
Prover material	1000	Material of which the prover body is made, e.g. 'Stainless'
Prover serial number	1000	Serial number of the prover (as assigned by the supplier), e.g. 'PU-98756DF'
Prover internal diameter	1000	Prover internal diameter [inches]. Used to calculate the prover steel expansion coefficients.
Prover wall thickness	1000	Prover wall thickness [inches]. Used to calculate the prover steel expansion coefficients.
Prover cubic expansion coefficient	1000	*Only applies for bi-directional and unidirectional pipe provers.* Prover cubic expansion coefficient [(in^3/in^3)/°F]. Used to calculate the prover Ctsp. Typical values are: 2.88 e-5 for 304 stainless steel, 2.65 e-5 for 316 stainless steel, 1.74e-5 for carbon steel and 1.86 e-5 for mild steel.
Prover square expansion coefficient	1000	*Only applies for compact provers (Calibron, Flow MD and Brooks).* Prover square (area) expansion coefficient [(in^2/in^2)/°F]. Used to calculate the prover Ctsp. Typical values are 1.92e-5 for 304 stainless steel, 1.77e-5 for 316 stainless steel, 1.16e-5 for carbon steel and 1.24e-5 for mild steel.
Rod linear expansion coefficient	1000	*Only applies for compact provers (Calibron, Flow MD and Brooks).* Piston rod linear expansion coefficient [(in/in)/°F]. Used to calculate the prover Ctsp. Typical values are 8e-7 for Invar (applies for Brooks compact provers), 9.6e-6 for 304 stainless steel and 8.83e-6 for 316 stainless steel. 0 disables correction.
Prover modulus of elasticity	1000	Modulus of elasticity [Psi*(in/in)]. Used to calculate the prover Ctsp. Typical values are 3.0e7 for carbon / mild steel, 2.85e7 for stainless steel
Prover reference temperature	1000	Reference temperature for Ctsp calculation. Typically 60 °F.
Prover reference pressure	1000	Reference pressure for Cpsp calculation. Usually 0 psig.
Detector configuration	1000	The application supports the following combinations of prover detector inputs signals.

1: 1 common (detector	The start and stop detectors are combined in one common signal input A)
2: 2 inputs	1 start detector (detector input A) and 1 stop detector (detector input C)
3: 3 inputs	1 start detector (detector input A) and 2 stop detectors (inputs C and D). 2 calibrated volumes need to be defined (volume A-C and volume A-D)
4: 4 inputs	2 start (inputs A and C) and 2 stop detectors (inputs B and D) 4 calibrated volumes need to be defined (volume A-C, A-D, B-C and B-D)

The input channel number for detector signals a, B, C and D are defined in display 'IO\Configuration\Digital IO assignments'. A common prove detector signal should be assigned to 'Detector input A'

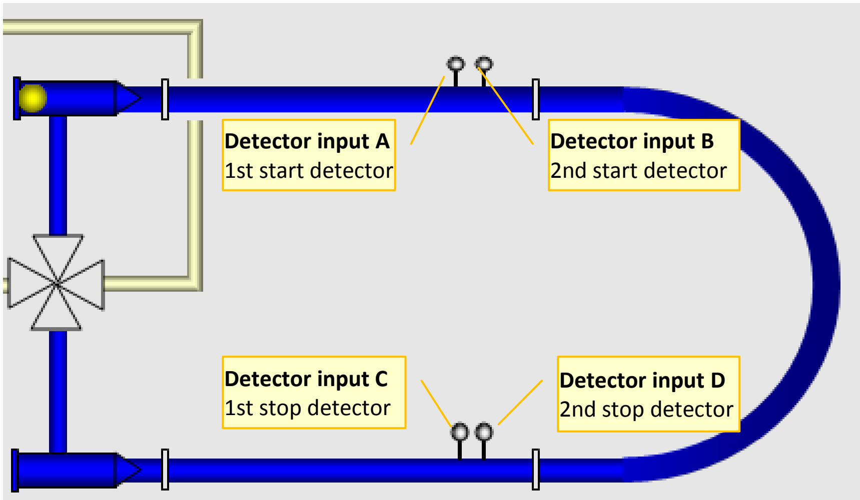


Figure 3: Prover detector switches

Single detector delay	1000	Debounce time used for detector inputs Prove detectors switches are mechanical devices that may provide a bouncing signal causing the flow computer to abort the prove sequence when not debounced adequately. Therefore a proper debounce time (e.g. 0.2 seconds) has to be defined in case of a common detector input.
Prover volume 1..4	1000	Up to 4 calibrated prover base volumes [bbl]. For provers with a single start and a stop detector only 'Volume 1' applies. In case of 3 detectors (1 start, 2 stop) two base volumes ('Volume 1' and 'Volume 2') apply and in case of 4 inputs all 4 volumes apply.
Selected prover volume	1000	Selects the in-use prover base volume (i.e, the pair of detectors used for proving). Only applies for 3 or 4 detector inputs. For 1 or 2 inputs 'Volume 1 (A-C)' will be used automatically. Reset to 'Volume 1 (A-C) when he selection is invalid.

Pre-travel delay time	1000	Usually set to 0 [sec] The activation of the detector(s) will not be considered before this time has elapsed after start of the prove run. Useful when the piston prover first needs to travel upstream before the prove measurement actually can start in the downstream direction. A delay time larger than 0 will ignore the activation of the detectors in the upstream direction.
Travel time-out mode	1000	Prover pre-travel and over-travel time-out limits are based on either specified time-out limits (in seconds) or calculated from specified pre- and over-travel volumes. The latter method automatically adjusts for the actual flow rate. So at a low flow rate the allowable time-out period will be longer and for higher flow rate it will be shorter. .
Max. pre-travel time	1000	Maximum time allowed for the sphere / piston to activate the start detector switch. Used when 'Travel time-out mode' is set to 'Time'
Max. time between detectors	1000	Maximum time allowed for the sphere / piston to activate the stop detector switch after having activate the start detector switch Used when 'Travel time-out mode' is set to 'Time'
Over-travel time-out		Time to wait after the sphere / piston has activated the stop detector and before the next command is issued. The next command depends on the type of prover. Bi-directional pipe provers — Issue the next 4-way forward/reverse command Uni-directional prover — Issue the next prover valve open command Calibron / Flow MD — issue the next Prove Start command Brooks piston — Lower the Prove Run command such that the travels back in upstream direction Used when 'Travel time-out mode' is set to 'Time'
Pre-travel volume	1000	Used to calculate the maximum time allowed for the sphere / piston to activate the start detector switch. *Time [s] = Volume [bbl] / Actual flow rate [bph] * 3600 * 1.25* (i.e. margin of 25%) Used when 'Travel time-out mode' is set to 'Volume'
Over-travel volume	1000	Used to calculate the time to wait after the sphere /piston has activated the stop detector and before the next command is issued. The next command depends on the type of prover, refer to setting 'Overall travel time-out' for further details. *Time [s] = Volume [bbl] / Actual flow rate [bph] * 3600 * 1.25* (i.e. margin of 25%) Used when 'Travel time-out mode' is set to 'Volume'
Seal integrity	1000	*Applies for bi-directional and unidirectional provers only*

DI module		Module number of the 'Prover valve seal' digital input signal
		By default the 'Prover valve sealed' state is not used by proving logic. It is typically used to abort the prove sequence when the prover valve is not sealed while the sphere is between the detectors (i.e. in the calibrated volume. Corresponding logic can be configured as a 'Calculation' in Flow-Xpress.
Seal integrity DI channel	1000	*Applies for bi-directional and unidirectional provers only* Channel number of the 'Prover valve sealed' digital input signal
Prove start DO module	1000	*Applies for Calibron, Flow-MD and unidirectional ball provers only* Module number of the 'Prove start' digital output signal that is raised for each prove pass.
Prove start DO channel	1000	*Applies for Calibron and Flow-MD compact provers only* Channel number of the 'Prove start' digital output signal that is raised for each prove pass.
Plenum pressure control	1000	*Brooks compact prover only.* Enables or disables the control of the pressure in the plenum chamber
Plenum pressure check timeout	1000	*Brooks compact prover only.* Maximum allowable time for plenum pressure to be within control limits at start of prove sequence
Plenum pressure constant R	1000	*Brooks compact prover only.* The Plenum Pressure Constant R is used to calculate the plenum pressure needed to operate the Brooks compact prover .The calculation is as following: Plenum Pressure = (Prover Pressure / Plenum Constant R) + 60 psig Constant R depends on the size of the prover. 8 inch 3.5 12 inch Mini 3.2 12-inch 3.2 18 inch 5 24-inch 5.88 34-inch 3.92 40-inch 4.45
Plenum pressure control deadband	1000	*Brooks compact prover only.* Deadband [%] applied on required plenum pressure to control the plenum pressure Actual plenum pressure < Required plenum pressure * (100 - Deadband) / 100

		--> issue the charge command Actual plenum pressure >Required plenum pressure * (100 + Deadband) / 100 --> issue the vent command
Plenum pressure alarm deadband	1000	*Brooks compact prover only.* If the actual plenum pressure deviates more from the required value than the alarm limit, then the prove sequence will be aborted.
Prover orientation	1000	*Brooks compact prover only.* The orientation of the prover (horizontal or vertical) has to be taken into account for the calculation of the required plenum pressure.
Run command DO module	1000	*Brooks compact prover only.* Module number of the 'Prove run command' digital output signal
Run command DO channel	1000	*Brooks compact prover only.* Channel number of the 'Prove run command' digital output signal
Piston upstream DI module	1000	*Brooks compact prover only.* Module number of the 'Piston in upstream position' digital input signal
Piston upstream DI channel	1000	*Brooks compact prover only.* Channel number of the ' Piston in upstream position ' digital input signal
Charge plenum DO module	1000	*Brooks compact prover only.* Module number of the 'Charge plenum pressure' digital output signal
Charge plenum DO channel	1000	*Brooks compact prover only.* Channel number of the 'Charge plenum pressure' digital output signal
Vent plenum DO module	1000	*Brooks compact prover only.* Module number of the 'Vent plenum pressure' digital output signal
Vent plenum DO channel	1000	*Brooks compact prover only.* Channel number of the 'Vent plenum pressure' digital output signal
Low nitrogen DI module	1000	*Brooks compact prover only.* Module number of the 'Low nitrogen level' digital input signal This signal is not used by default. It could be used for alarming and to abort the prove sequence.
Low nitrogen	1000	*Brooks compact prover only.*

DI channel Channel number of the 'Low nitrogen level' digital input signal

Operational settings

Display → Configuration, Proving, Operational settings

Maximum nr of runs 1000 The maximum number of prove runs allowed to achieve sufficient consecutive runs within the repeatability limit.

Passes per runs 1000 *Applies for compact proving*

The number of passes per run in case of a compact prover (Calibron, Flow MD, Brooks).

Typically set to 1 for pipe provers

Required successful runs 1000 Required number of consecutive runs within the repeatability limit before the prove sequence is completed successfully.

Repeatability test method 1000 Determines if the repeatability calculation is based on pulse count or on the meter factor. Achieving repeatability based on meter factor might be more difficult to achieve, because meter factor not only depends on the pulse count but also on the temperature, pressure, density etc.

Repeatability is calculated as (max - min) / max * 100%.

Run repeatability mode 1000 The method to check if sufficient consecutive runs are within the required repeatability limit.

1: Static — The prove sequence is completed successfully when the 'Required successful runs' are performed consecutively within the 'Run repeatability fixed limit'.

2. Dynamic — At least the 'Required successful runs' are performed consecutively within the repeatability limit that is in accordance with API 4.8 appendix A.

App. A defines the repeatability limit as a function of the number or runs.

Nr of runs	*Repeatability limit [%]*
3	0.02
4	0.03
5	0.05
6	0.06
7	0.08
8	0.09
9	0.10
10	0.12

Typically used for compact provers.

Repeatability 1000 The repeatability limit used when 'Run repeatability mode' is set to 'Fixed'

test fixed limit

Double chronometry 1000 Determines whether or not double-chronometry method of pulse interpolation is applied in accordance with API MPMS 4.6.

API requires that pulse interpolation is performed when lass than 10000 pulses are acquired within a single prover pass.

This feature is typically enabled for compact provers and disabled for large volume pipe provers.

Auto-implement new MF 1000 Determines whether or not a new meter factor is implemented automatically at the end of a successful prove sequence, provided that the repeatability criteria are met and the meter factors tests have passed.

MF manual accept timeout 1000 The maximum allowable time to manually accept a new meter factor after the prove sequence has ended successfully, provided that the repeatability criteria are met and the meter factors tests have passed. If the operator does not accept the new meter factor within this time limit, then the new meter factor will be rejected automatically.

Stability check

Display → Configuration, Proving, Stability check

Initial stability check 1000 Determines whether or not the initial stability check is performed. When enabled, the prove sequence will not start before the initial stability check has passed successfully.

During the initial stability check the following variables are monitored for the stability sample time (e.g. 30 seconds):

- Prover inlet temperature
- Prover outlet temperature
- Meter temperature
- Prover inlet pressure
- Prover outlet pressure
- Meter pressure
- Flow rate

The initial stability check passes as soon as all the variables do not change more than their corresponding limit, during the required stability **sample time** (default 5 seconds).

Prove sequence stability 1000 Determines whether or not the deviation between the prover and meter temperature and pressure is checked during proving. The check is only performed when the sphere / piston is between the detectors (i.e. in the

check		calibrated volume).
Max. stabilization time	1000	The maximum time allowed for the initial stability check (default 30 seconds)
Stabilization sample time	1000	The sample time for the initial stability check
Temperature change limit	1000	The limit for the temperature to change during the sample time for the initial stability check
Pressure change limit	1000	The limit for the pressure to change during the sample time for the initial stability check
Flow rate change limit	1000	The limit for the flow rate to change during the sample time for the initial stability check
Max. temperature deviation prover/meter	1000	The maximum deviation limit between the prover temperature (average of inlet and outlet) and the meter temperature
Max. pressure deviation prover/meter	1000	The maximum deviation limit between the prover temperature (average of inlet and outlet) and the meter pressure

Meter factor tests

A number of tests is performed on each newly proved meter factor. The new factor will be rejected automatically if one or more tests should fail.

Display → Configuration, Proving, Meter factor test

Previous MF test	1000	The new meter factor will rejected if it deviates more from previous meter factor than the 'Previous MF deviation limit', provided that 'Previous MF test' is enabled.
Previous MF deviation limit	1000	Limit for the 'Previous MF test'
Historical avg MF test	1000	The application keeps track of the last 10 proved meter factors for each flow meter. When the 'Historical average MF test' is enabled, the new meter factor will rejected if it deviates more from average of the last 'Nr of hist MF avg' meter factors than the 'Hist avg MF deviation limit'..
Historical avg MF	1000	Limit for the 'Historical average MF test'

deviation limit		
Nr of historical MF avg	1000	Number of historical meter factors to be used for the 'Historical average MF test'
Base MF test	1000	*This test only applies if a meter factor curve is applied.* The 'Base MF test' checks if difference between the proved meter factor and the 'meter factor determined from the meter factor curve at the proved flow rate' is not greater than 'Base MF deviation limit'.
Base MF deviation limit	1000	Limit for the 'Base MF test'

Prove report

The 'Prove report' display contains the settings that define the number of decimal places for the meter factor and the intermediate correction factors. The display also contains settings that determine if the API truncating and rounding rules are applied for the calculation.

Display → Configuration, Proving, Prove report

Meter factor decimal places	1000	The number of decimal places for the meter factor
API rounding proving	1000	Determines if the rounding and truncating rules of the API standard are applied or not.
Volume decimal places proving	1000	The number of decimal places used to round the metered and proved volumes.
Cts decimal places proving	1000	The number of decimal places used to round for the correction factor for the effects of temperature on the prover steel Ctsp
Cps decimal places proving	1000	The number of decimal places used to round for the correction factor for the effects of pressure on the prover steel Cpsp
Ctl decimal places proving	1000	The number of decimal places used to round for the correction factor for the effects of temperature on the liquid in the prover Ctl
Cpl decimal places proving	1000	The number of decimal places used to round for the correction factor for the effects of pressure on the liquid in the prover Cpl
CCF decimal places proving	1000	The number of decimal places used to round for the combined correction factor CCF.

Sampler control

The application supports one sampler by default. Additional samplers may have been added.

Display → Configuration, Sampling

Sampler control 1000
Determines whether the control of the sampler is enabled or not. Disabling control will inhibit the outputting of grab command (pulses).

Can selection control 1000
Control mode for can selection.

0: Single can	(no control signal for can selection available)
1: Twin can	(1 output used to switch between 2 cans)
2: Multiple cans	(up to 4 outputs for different product cans)

Sampled flow 1000
Used for Flow proportional sampling methods only.

Determines which flow rate value is used to calculate the total sampled volume for the current sampling can. The first selection is 'Station' which applies for a sampler that is installed on the station inlet or outlet header.

Sampling method 1000
The method to determine the required volume between grabs, either flow- or time-proportional. A grab command (pulse output) is issued whenever this volume has been accumulated.

1: Flow (fixed value)
Flow proportional method based on setting 'Volume between grabs fixed value'. This method does not consider the remaining can volume.

2: Flow (estimated volume)
Flow proportional method where the required volume between grabs is calculated from settings 'Expected total volume', the remaining can volume and the 'Grab size'

3: Flow (batch volume)
Flow proportional method where the required volume between grabs is calculated from the required 'Batch size' of the current batch (as defined in the batch stack),the remaining can volume and the 'Grab size'

4: Time (fixed value)
Time proportional method based on setting 'Time between grabs fixed value'. This method does not consider the remaining can volume.

5: Time (estimated end time)

		Time proportional method with the time between grabs calculated from setting 'Expected end time for sampling', the remaining can volume and the 'Grab size'. 6: Time (period) Time proportional method with the time between grabs calculated from setting 'Can fill period [hours]', the remaining can volume and the 'Grab size'.
Volume between grabs fixed value	1000	*Used when 'Sampling method' is 'Flow (fixed value)'* Volume that needs to be accumulated before the next grab command is raised.
Expected total volume	1000	*Used when 'Sampling method' is 'Flow (estimated volume)'* Estimated total volume to be sampled in order to fill the can.
Time between grabs fixed value	1000	*Used when 'Sampling method' is 'Time (fixed value)'* Grab commands (pulses) are issued at this interval period.
Expected end time for sampling	1000	*Used when 'Sampling method' is 'Time (estimated end time)'* Date and time that the sampler can should be filled to the 'Can target fill percentage'
Can fill period	1000	*Used when 'Sampling method' is 'Time (period)'* The total period over which the can needs to be filled.
Can volume	1000	Can storage capacity in [cc]
Grab size	1000	Volume per grab in [cc]
Minimum time between grabs	1000	Used to determine the maximum pulse output frequency. If more pulses are generated than the maximum frequency allows for, then pulses are accumulated in a reservoir.
Can target fill percentage	1000	The target level to fill the can. Used to switch over to the other can (if Auto-switch on van full enabled).
Can maximum fill percentage	1000	The maximum fill level of the can. If this level is reached sampling will be stopped.
Stop sampling on can full	1000	Stops sampling when either the can is full (for 'Single can' and 'Multiple can' mode) or in case of twin sampling both cans are full.
Auto-switch can on can full	1000	Only applies for 'Twin can' mode. Changes over the 'Selected can' output to the other can, provided that the other can is not full.

		Not used when 'Sampling method' is 'Flow (batch volume)' or 'Time (estimated end time)' In case the sampler provides a control signal to physically switch over to the other can, the 'Select can' value can be used in Calculation to set a corresponding flow computer digital output.
Stop sampler on batch end	1000	Stops the sampler if a batch end is given.
Auto-switch can on batch end	1000	Applies for 'Twin can' mode only. Switches to the other can if a batch end is given, so that the new batch starts using the other can.
Stop sampler on product change	1000	Stops the sampler when changing to the next product. Only applies for 'Multiple cans' mode.
Sampler overspeed alarm limit	1000	In case the number of pulses accumulated in the reservoir reaches this limit, the sampler overspeed alarm is raised
Max. number of outstanding samples	1000	The maximum number of pulses buffered in the reservoir. Additional pulses will be lost (raises the 'Grabs lost' alarm).
Sample pulse output module	1000	The module to which the pulse output signal is physically connected
Sample pulse output channel	1000	The channel number of the pulse output
Sample pulse output duration	1000	The duration of the sample pulse [s]
Can fill indication method	1000	1: Number of grabs To be used in case no physical signal is available) 2: Digital input Sampler provides a digital input that indicates that can is full. The can fill level will be determined from the number of grabs 3: Analog input Sampler provides an analog input that indicates the can fill level (0-100%).
Can 1/2 fill indication module	1000	The module to which the fill indication signal of can 1/2 is physically connected

Can 1/2 fill indication channel	1000	The channel number of the fill indication signal of can 1/2. If 'Can fill indication method' is 'digital input' this is the digital channel number (1-16). If 'Can fill indication method' is 'analog input' this is the analog input channel (1-6)
Twin can selection digital output module	1000	Applies for 'Twin can' mode only. The module to which the can selection output is physically connected
Twin can selection digital output channel	1000	Applies for 'Twin can' mode only. The channel number of the can selection output (digital output 1-16)
Can 1/2/3/4 product number	1000	Applies for 'Multiple cans' mode only. The actual product number (1..16) to be used for the can selection
Can 1/2/3/4 digital output module	1000	Applies for 'Multiple cans' mode only. The module to which the can selection output is physically connected
Can 1/2/3/4 digital output channel	1000	Applies for 'Multiple cans' mode only. The channel number of the can selection output (digital output 1-16)

Valve control

By default the application provides control of the following valves:

- Run inlet valve (one per meter run)
- Run outlet valve (one per meter run)
- Run to prover valve (one per meter run)
- Prover 4-way valve (only applies for a bi-directional prover)
- Prover outlet valve

The control logic is based on 2 input signals for the valve position (Open and Closed) and 1 common or 2 separate output signals for the valve open and close commands.

The valve position is determined as following:

- If no inputs are available, then the position is determined from the latest issued valve command.
- If a single input is available (for either open or closed position), then the valve is considered to be in the opposite position in case the position signal is OFF
- If two inputs are available, then the position is 'Moving' when both inputs are OFF and 'Faulty' when both inputs are ON.

The I/O signals may be digital signals that are hardwired to the Flow-X or external values communicated to or calculated by the flow computer.

Separate open and close commands are available for manual and auto modes of operations. Manual mode is meant for direct control by the operator, automatic mode is meant for logic.

Open / close commands are ignored when the valve is already in the required position. A time-out limit is applied on the valve travel time. The travel timer is reset at start of movement or when the required position has been reached. A failure alarm is generated when the travel timer has reached the limit and also when the valve looses its required position

Permissive flags are available to interlock the opening or closing of valves. The permissive flags are ON by default and can be set through user-defined *Calculations*.

Display → Configuration, Valve control

The following settings apply for each individual valve

Control signals 1000

0: no control

1: Two pulsed outputs
2 separate outputs for open and close commands. The outputs stay ON for the 'Minimum activation time' as defined in display 'IO\Configuration\Digital IO settings'

2: Two maintained outputs
2 separate outputs for open and close commands. The outputs remain ON until
the valve has reached its position

3: One output - ON is open
1 output to open the valve. At the valve open command the output stays ON for the 'Minimum activation time' as defined in display 'IO\Configuration\Digital IO settings'.

4: One output - ON is close
1 output to close the valve. At the valve close command the output stays ON for the 'Minimum activation time' as defined in display 'IO\Configuration\Digital IO settings'

Position signals 1000

0: no inputs

1: Two inputs
2 separate inputs for open and close commands.

2: One input (open position)
1 input that is ON when the valve is in the open or forward position, else OFF.

3: One input (closed position)
1 input that is ON when the valve is in the closed or reverse position, else OFF.

Travel timeout period	1000	Maximum allowed time [s] for the valve to move to the required position. The valve timeout alarm is raised when valve does not reach the required position within this limit.
Position DI module	1000	Module to which the position signal is physically connected
Position DI channel	1000	Digital channel number of the position signal
Control DO module	1000	Module to which the control output signal is physically connected
Control DO channel	1000	Digital channel number of the control output signal

Flow control

The application supports the PID control of Flow Control Valves with additional pressure control. Primary control is on flow. When the pressure gets above / below a configurable limit, then the control loop reverts to pressure control to ensure a minimum delivery pressure or a maximum back pressure.

A permissive flag is variable for each FCV. The permissive flag is ON by default and can be controlled through user-defined *Calculations*.

Display → Configuration, Flow control

The following settings apply for each individual FCV

Flow control - Input mode	1000	Actual flow rate value used for PID Control. 0: None : PID Control is disabled. 1: Gross Volume 2: Mass 3: Custom : Custom value is used as process value
Flow control - Proportional Gain	1000	Controller output = Proportional gain * Actual error. Proportional Gain a= 100 / Proportional Band
Flow control - Integral gain	1000	Integral gain = 1 / [Repeats per sec], e.g. value of 0.02 means 1 repeat per 50 seconds.
Flow control – Low scale value	1000	Process / setpoint value that corresponds to 4 mA. Units same as process value.
Flow Control –	1000	Process / setpoint value that corresponds to 20 mA.

High scale value		Units same as process value.
Flow control - Reverse mode	1000	Select 'Disabled' if flow rate drops when valve closes. Select 'Enabled' when flow rate drops when valve opens.
Pressure Control	1000	When enabled the pressure will not be allowed to rise or drop below the limit.
Pressure Limit Mode	1000	1: Maximum Pressure will not be allowed to rise above the limit 2: Minimum Pressure will not be allowed to drop below the limit.
Pressure Limit Value	1000	The pressure will not be allowed to drop below or rise above this limit, depending on the Pressure limit mode'. Only used when 'Pressure control' is enabled.
Pressure Control Proportional Gain	1000	Controller output = Proportional gain * Actual error. Proportional Gain a= 100 / Proportional Band
Pressure Control Integral gain	1000	Integral gain = 1 / [Repeats per sec], e.g. value of 0.02 means 1 repeat per 50 seconds.
Pressure Control Low scale value	1000	Process / setpoint value that corresponds to 4 mA. Units same as process value.
Pressure Control High scale value	1000	Process / setpoint value that corresponds to 20 mA. Units same as process value.
Pressure Control Reverse mode	1000	Select 'Disabled' if pressure drops when valve closes. Select 'Enabled' when pressure drops when valve opens.
Analog output module	1000	Module to which the analog output signal is connected.
Analog output channel	1000	Channel number for the analog output signal.
Bumpless transfer	1000	Controls bumpless transfers between auto and manual mode and also between 'Flow control' and 'Pressure control'
Control output minimum limit	1000	The control output % will not be allowed to go below this limit
Control output maximum limit	1000	The control output % will not be allowed to go above this limit
Control output downwards slew rate [%/sec]	1000	The control output will not be allowed to decrease faster than this limit. 0 disables this function

Control output upwards slew rate [%/sec]	1000	The control output will not be allowed to increase faster than this limit. 0 disables this function
Flow Control - Downwards setpoint clamp rate	1000	The in-use flow setpoint will not be allowed to decrease faster than this limit per second. 0 disables this function
Flow Control - Upwards setpoint clamp rate	1000	The in-use flow setpoint will not be allowed to increase faster than this limit per second. 0 disables this function
Idle output %		Value used for control output when the PID permissive flag is not set

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Chapter 5 - Maintenance mode

Maintenance mode is a special mode of operation intended for testing the flow computer functionality, typically its calculations.

Maintenance mode is enabled and disabled for each meter run separately.

Maintenance mode is the same as normal operation mode except that in Maintenance Mode all the custody transfer totals are inhibited. Instead flow is accumulated in separate Maintenance totals.

Furthermore analog outputs are forced to 4 mA and pulse outputs are inhibited in maintenance mode.

A permissive flag is used to enter and exit maintenance mode. By default the flag is always 1, i.e. it is always permitted to enter/exit maintenance mode. However the permissive flag may be controlled by custom-made logic through 'Calculations'. E.g. entering/exiting maintenance mode to is only permitted when the meter is inactive.

To enable maintenance mode go to the following display.

Display → Configuration, Run, Maintenance mode

Maintenance mode enabled	1000	Enables maintenance mode provided that switch permissive flag is set.

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Chapter 6 - Flow computations

This chapter specifies the flow calculations performed by the Liquid US Customary application. The different parameters are accessible through the display menu.

Calculations in compliance with a measurement standard, such as API-2540 and GPA TP-27, are not detailed in full in this manual. Please refer to the standards for more details on these calculations.

API Petroleum Measurement Tables

The first version of the API Petroleum Measurement Tables was published in **1952**. In those days measurement readings were taken manually and the tables were used to convert the observed density or gravity at the observed temperature to the value at the reference temperature. So the table values were the actual standard.

The 1952 Tables consists of 58 tables containing all kind of correction and conversion factors used in the measurement of hydrocarbon liquids. Each table deals with a particular conversion of units, correction of density, or correction of volume. The 1952 tables that have to do with the conversion of density and volume are: 5, 6, 23, 24, 53 and 54.
Table 5, 6, 23 and 24 convert density or volume to or from to a reference temperature of 60ºF, while tables 53 and 54 refer to 15ºC.

In **1980** a complete new set of tables was published together with computer routines to allow electronic devices to automatically calculate the volume conversion factors and API gravity / (relative) density at the reference temperature. Back then most electronic devices were not capable of performing double-precision floating point calculations, so the standard prescribed all kind of rounding and truncating rules to make sure that the calculations would always provide the same result. For the 1980 version the calculation procedures are the standard rather than the table values.

In the 1980 version, which is also referred to as **API-2540,** the tables are divided into 3 product groups and a letter designation was used to distinguish between the sub-tables. "A" was used for crude oil, "B" for refined products and "C" for special applications. The 1980 tables, however, did not cover the LPGs and NGLs density ranges and the 1952 Tables were left valid for these products. Furthermore, the lubricating oil tables (designated as "D") were not complete at the time of the printing in 1980 and were released two years later. As opposed to the A, B and C tables no implementation procedures were defined for the D tables.

In 1988 the Institute of Petroleum released its Paper No. 3 with tables 59 and 60 that are based on a reference temperature of 20ºC.

This resulted in the following Petroleum Measurement Tables dealing with the conversion of volume and density to and from a reference temperature.

Number	Title
5	API Gravity Reduction to 60ºF
6	Reduction of Volume to 60ºF Against API Gravity at 60ºF
23	Reduction of Observed Specific Gravity to Specific Gravity 60/60ºF
24	Reduction of Volume to 60o F Against Specific Gravity 60/60ºF
53	Reduction of Observed Density to Density at 15ºC

54	Reduction of Volume to 15ºC Against Density at 15ºC
59	Reduction of Observed Density to Density at 20ºC
60	Reduction of Volume to 20ºC Against Density at 20ºC

In **2004** the API MPMS 11.1 1980 tables were superseded by a new set of tables primarily for the following reasons:

- API 11.1:2004 includes the correction for both temperature and pressure in one and the same algorithm
- Taken into account the progress in electronics (and for other reasons) the complex truncating and rounding rules were abandoned. Instead the calculation procedures use double-precision floating point math. The input and output values are still rounded in order to obtain consistent results.
- The convergence methods for the correction of observed density to base density have been improved.
- On-line density measurement by densitometers became common practice, requiring the pressure and temperature correction to be incorporated in one ands the same procedure
- The tables are extended in both temperature and density to cover lower temperatures and higher densities.
- The previous standard used a significant digit format which resulted in 4 or 5 decimal places depending on whether the observed temperature was above or below the reference temperature. The new standard prescribes 5 decimal places if or both cases.
- The IP paper No. 3 tables were added to accommodate conversion to 20ºC.

Tables for lubricating oils including the implementation procedures are now part of the standard.

Volume correction for pressure

The API MPMS 11.1:1980 Tables only cover the correction for temperature. The correction for pressure was published in API MPMS standards 11.2.1 and 11.2.2.
The correction for pressure is to the atmospheric pressure or, for products within the lower density range, to the equilibrium vapor pressure.
To calculate the equilibrium vapor pressure an Addendum was added to API MPMS 11.2.2. This addendum is also known as **GPA TP-15** (1988). In September 2007 the addendum was replaced by a new API standard 11.2.5 and at the same time GPA TP-15 (1988) was updated with a new 2007 revision.

NGL and LPG tables

For NGL and LPG products volume correction tables 24E and 23E (at 60 ºF) were published in **GPA TP-25** (1988), so the letter 'E" was used to distinguish the tables from the related API MPMS A, B, C and D tables.
GPA TP-25 has been superseded by **GPA TP-27** / API MPMS 11.2.4 (2007), which includes tables 53E, 54E, 59E and 60E to convert to 15ºC and 20ºC as well. All text from TP-25 is included without technical change, so TP-25 is still viable for conversion to and from 60 °F.

Overview of hydrocarbon liquid conversion standards

- ASTM-IP Petroleum Measurement Tables, Historical Edition, 1952

- API MPMS Chapter 11.1 - 1980* (Pressure VCFs for Generalized Crude Oils, Refined Products, and Lubricating Oils): Historical; Published in 14 separate volumes

  Also known as
  - API Standard 2540 (API-2540)
  - ASTM D1250
  - IP 200

* In 1982 chapters XIII and XIV were published containing tables 5D, 6D, 53D and 54D for lubricating oils.

- API MPMS Chapter 11.1 - 2004 (Pressure & Pressure VCFs for Generalized Crude Oils, Refined Products and Lube Oils)
- API MPMS Chapter 11.2.1- 1984 (Compressibility Factors for Hydrocarbons: 0-90°API): Historical: now incorporated into Chapter 11.1-2004
- API MPMS Chapter 11.2.1M- 1984 (Compressibility Factors for Hydrocarbons: 638-1074 lb/ft3): Historical: now incorporated into Chapter 11.1-2004
- API MPMS Chapter 11.2.2 - 1984 (Compressibility Factors for Hydrocarbons: 0.350-0.637 Relative Density and –50°F to 140°F)
- API MPMS Chapter 11.2.2M - 1986 (Compressibility Factors for Hydrocarbons: 350-637 lb/ft3 Density (15°C) and –46°C to 60°C)
- API MPMS Chapter 11.2.2A - 1984 (Addendum to Correlation of Vapor Pressure Correction for NGL): Superseded by Chapter 11.2.5
- API Publication/GPA TP-25/ASTM Publication (Pressure Correction for the volume of Light Hydrocarbons – Tables 24E and 23E: Superseded by API MPMS Chapter 11.2.4

  GPA TP-25 was published in 1998 and replaced the 1952 tables 23, 24 for Light Hydrocarbon Liquids and GPA Technical Publication TP-16, which were previously used for volumetric measurement of LPG.

- API MPMS Chapter 11.2.4 - 2007 / GPA TP-27 / ASTM Publication (Pressure Correction for the Volume of NGL and LPG – Tables 23E, 24E, 53E, 54E, 59E, 60E): Supersedes GPA TP-25
- API MPMS Chapter 11.2.5 - 2007 / GPA TP-15 / ASTM Publication (A Simplified Vapor Pressure Correlation for Commercial NGLs): Supersedes Addendum to Chapter 11.2.2 (11.2.2A)
- IP No. 3 - 1988 (Energy Institute (formerly Institute of Petroleum), Petroleum Measurement Paper No 3 Computer Implementation Procedures for Correcting Densities and Volumes to 20 C. Superseded by IP No.3 - 1997
- IP No. 3 - 1997 (Energy Institute (formerly Institute of Petroleum), Petroleum Measurement Paper No 3 Computer Implementation Procedures for Correcting Densities and Volumes to 20 C. Supersedes IP No.3 - 1988
- ISO 91-1 - 1982 Petroleum measurement tables Part 1: Tables based on reference temperatures of 15 ºC and 60 ºF. Superseded by ISO 91-1 1992.
- ISO 91-1 - 1992 Petroleum measurement tables Part 1: Tables based on reference temperatures of 15 ºC and 60 ºF. Supersedes ISO 91-1 1982.
- ISO 91-2 - 1991 Petroleum measurement tables Part 2: Tables based on reference temperatures of 20 ºC

- OIML R 63 - 1994 Petroleum measurement tables

Overview of the functions

The following table lists the volume conversion functions for hydrocarbon liquids as provided by the Liquid USC application

Function	Pressure correction	Pressure correction	Input	Output
Crude Oils, Refined Products and Lubricating Oils (API 1952 / API 11.1:1980 / API-2540)				
API_Table5 (1952)	API 1952 Table 5	API 11.2.1:1984	RD (T,P)	RD (60ºF, Pe)
API_Table6 (1952)	API 1952 Table 6	API 11.2.1:1984	RD(60ºF, Pe)	RD (T, P)
API_Table23 (1952)	API 1952 Table 23	API 11.2.1:1984	RD (T, P)	RD (60ºF, Pe)
API_Table24 (1952)	API 1952 Table 24	API 11.2.1:1984	RD (60ºF, Pe)	RD (T, P)
API_Table5 (1980)	API 11.1:1980 Tables 5A, 5B and 5D	API 11.2.1:1984	°API (T, P)	°API (60ºF, Pe)
API_Table6 (1980)	API 11.1:1980 Tables 6A, 6B and 6D	API 11.2.1:1984	°API (60ºF, Pe)	°API (T, P)
API_Table23 (1980)	API 11.1:1980 Tables 23A and 23B	API 11.2.1:1984	RD (T, P)	RD (60ºF, Pe)
API_Table24 (1980)	API 11.1:1980 Tables 24A and 24B	API 11.2.1:1984	RD (60ºF, Pe)	RD (T, P)
Crude Oils, Refined Products and Lubricating Oils (API MPMS 11.1:2004)				
API_Table5 (2004)	API 11.1:2004	API 11.1:2004	°API (T, P)	°API (60ºF, 0 psig)
API_Table6 (2004)	API 11.1:2004	API 11.1:2004	°API (60ºF, 0 psig)	°API (T, P)
API_Table23 (2004)	API 11.1:2004	API 11.1:2004	RD (T, P)	RD (60ºF, 0 psig)
API_Table24 (2004)	API 11.1:2004	API 11.1:2004	RD (60ºF, 0 psig)	RD (T, P)
NGL and LPG (API 11.2.4)				
API_Table23E	API 11.2.4: 2007 Table 23E	API 11.2.2:1986 GPA TP-15:1988 GPA TP-15:2007	RD (T, P)	RD (60ºF, Pe)
API_Table24E	API 11.2.4: 2007 Table 24E	API 11.2.2:1986 GPA TP-15	RD (60ºF, Pe)	RD (T, P)

Table 1 : Supported API MPMS standards

Hydrometer Correction

The API MPMS 11.1 1980 Standard (API-2540) assumes that the API gravity or relative density is observed with a glass hydrometer. Therefore a correction may be applied for the change of volume of the glass hydrometer with temperature.
The hydrometer correction applies for tables 5A, 5B, 23A and 23B.

The 2004 standard does not include a correction for a glass hydrometer.

API-2540 Input Data Limits

API MPMS 11.1:1980 (API 2540) is based on published data that lie within the so-called 'Data' range. The other table values were obtained from extrapolation and lie within the 'Extrapolated' range. It is recommended not to use API-2540 outside the 'Data' and 'Extrapolated' ranges.

For the lubricating oil tables no difference is made between data that is table values that are based on published data and table values that are determined by extrapolation.

Range	API Gravity [◦API]	Relative Density [-]	Density [lb/ft3]	Pressure [◦F]
Data Range	0 .. 40 40 .. 50 50 .. 55	1.0760 .. 0.8250 0.8250 .. 0.7795 0.7795 .. 0.7585	1075.0 .. 824.0 824.0 .. 778.5 778.5 .. 758.0	0 .. 250 0 .. 200 0 .. 150
Extrapolated Range	0 .. 40 40 .. 50 50 .. 55 55 .. 100	1.0760 .. 0.8250 0.8250 .. 0.7795 0.7795 .. 0.7585 0.7585 .. 0.6110	1075.0 .. 824.0 824.0 .. 778.5 778.5 .. 758.0 758.0 .. 610.5	250 .. 300 200 .. 250 150 .. 200 0 .. 200
Applies for:	Table 5A Table 6A	Table 23A	Table 24A	Table 5A Table 6A Table 23A Table 24A

Table 2: Table A input data limits for API MPMS 11.1:1980 (API 2540)

Range	API Gravity [°API]	Relative Density [-]	Density [lb/ft3]	Pressure [°F]
Data Range	0 .. 40 40 .. 50 50 .. 85	1.0760 .. 0.8250 0.8250 .. 0.7795 0.7795 .. 0.6535	1075.0 .. 824.0 824.0 .. 778.5 778.5 .. 653.0	0 .. 250 0 .. 200 0 .. 150
Extrapolated Range	0 .. 40 40 .. 50 50 .. 85	1.0760 .. 0.8250 0.8250 .. 0.7795 0.7795 .. 0.6535	1075.0 .. 824.0 824.0 .. 778.5 778.5 .. 653.0	250 .. 300 200 .. 250 150 .. 200
Applies for:	Table 5B Table 6B	Table 23B	Table 24B	Table 5B Table 6B Table 23B Table 24B

Table 3: Table B input data limits for API MPMS 11.1:1980 (API 2540)

Range	API Gravity [°API]	Relative Density [-]	Density [lb/ft3]	Pressure [°F]
Data Range	-10..45	0.8..1.165	800..1164	0 .. 300
Applies for:	Table 5D Table 6D	Table 23D* Table 24D*	Table 53D Table 54D	Table 5D Table 6D Table 23D* Table 24D*

* Values derived from Table 5D/6D

Table 4: Table D input data limits for API MPMS 11.1:1982

API-2540 - Rounding and truncating rules

For each table API Standard 2540 specifies an explicit 'Calculation Procedure' that includes the rounding and truncating of all the input, intermediate and output values. The 'Calculation Procedure' is considered to be the standard rather than the table values or a set of equations.

The function provides the option to either apply the full API rounding and truncating requirements or to perform the calculation procedure without any rounding and truncating being applied.

For tables 6A, 6B, 24A and 24B the standard makes a distinction between computational and table values for the calculated VCF. The table values are always rounded to 4 decimal places, Whereas the computational values has 4 decimal places when the VFC >=1 and 5 decimal places when the VCF < 1.

When API rounding is enabled the convergence limit is set to the limit value as specified in the standard. When the API rounding is disabled the convergence limit is set to 0.00001 lb/ft3 to obtain highest precision.

API-11.1:2004 Limits

Range	Density	Pressure	Pressure
Crude Oil	610.6..1163.5 lb/ft3 @ 60°F 100..-10 API @ 60°F 0.61120..1.16464 RD @ 60°F	-58..302 °F	0..1500 psig
Refined products	610.6..1163.5 lb/ft3 @ 60°F 100..-10 API @ 60°F 0.61120..1.16464 RD @ 60°F	-58..302 °F	0..1500 psig
Lubricating oils	800.9..1163.5 lb/ft3 @ 60°F 45..-10 API @ 60°F 0.80168..1.1646 RD @ 60°F	-58..302 °F	0..1500 psig

Table 5: API-11.1: 2004 input data limits

API constants

For the tables in US customary units the following constants apply (both for the 1980 and the 2004 tables):

Product	API Table	K0	K1	K2
Crude oil	A	341.0957	0.0	0.0
Gasoline	B	192.4571	0.2438	0.0
Transition area	B	1489.0670	0.0	-0.00186840
Jet fuels	B	330.3010	0.0	0.0
Fuel oils	B	103.8720	0.2701	0.0
Lubricating oils	D	0.0	0.34878	0.0

Table 6: API-11.1 constants

Volume Correction factor C_{TL}

The volume correction factor for temperature Ctl is determined based on the selected 'Density conversion method' (refer to display 'Configuration\Run (or Station)\Product').

$$C_{TL} = \exp^{(\alpha_T \times \Lambda T \times [1 \;\; + (0.8 \times \alpha_T \times \Lambda t)]}$$

Equation 6-1: Volume Correction Factor C_{TL}

$$\alpha_T = \frac{K_0 + K_1 \times \rho_{STD} + K_2 \times \rho_{STD}{}^2}{\rho_{STD}{}^2}$$

Equation 6-2: Tangent thermal expansion coefficient α_T

Where:

C_{TL}	Volume Correction Factor	[-]
α_T	Tangent thermal expansion coefficient per °F at reference temperature	
ΔT	Reference temperature – meter (flowing) temperature	[°F]
ρ_{STD}	Standard density	[lbm/scf]

Volume Correction factor C_{PL}

The correction for pressure was published in API MPMS standards 11.2.1 and 11.2.2. The correction for pressure is to the atmospheric pressure or, for products within the lower density range, to the equilibrium vapor pressure.

To calculate the equilibrium vapor pressure for NGL/LPG an Addendum was added to API MPMS 11.2.2. This addendum is also known as **GPA TP-15** (1988). In September 2007 the addendum was replaced by a new API standard 11.2.5 and at the same time GPA TP-15 (1988) was updated with a new 2007 revision.

$$C_{PL} = \frac{1}{1 - (P - Pe) \times F}$$

Equation 6-3: Volume Correction Factor C_{PL}

Where:

C_{PL}	Volume correction factor for pressure	-
P	Line Pressure	psig
Pe	Equilibrium Vapor Pressure (EVP)	
F	Compressibility Factor as calculated with the selected API standard	-

Density calculations

The density value depends on the type of fluid and the temperature and pressure conditions. The following fluid density related properties are distinguished within the application:

- Observed density — Density at the corresponding density input conditions
- Meter density — Density at the flow meter conditions
- Standard density — Density at the reference conditions

The actual calculations that are used to calculate these properties depend on the way that the observed and standard density are determined, which is controlled through configuration settings 'Standard density input type' and 'Observed density input type'. Refer to section/display 'Configuration, Run, Run setup" or, in case of product definition on station level, "Configuration, Overall setup, Overall setup" for more information on these settings.

In case the observed density is determined by a densitometer, then it is calculated according section 'Densitometer calculations'

The standard density is either calculated from the observed density based on the selected density conversion method or is a direct input value that is set manually through the operator interface or remotely via a communications link.

The meter density (or flowing density) is the density at the temperature and pressure conditions at the flow meter and is calculated from the standard density, and the Ctl and Cpl factors.

$$\rho_F = \rho_{STD} \times C_{TL} \times C_{PL}$$

Equation 6-4: Meter density calculation

Where:

ρ_F	Meter density (flowing density)	lbm/cf
ρ_{STD}	Standard density	lbm/scf
Ctl	Ctl factor	
Cpl	Cpl factor	

The relationship between the standard density and the API gravity is as follows:

$$\rho_{STD} = \frac{141.5 \times \rho_{H_2O}}{API_{STD} + 131.5}$$

Equation 6-5: Standard density calculation

ρ_{H2O}	Density of water at reference temperature	[g/cc]
API_{STD}	API gravity at reference temperature	

The relationship between the relative density and the standard density is as follows:

$$RD_{STD} = \frac{\rho_{STD}}{\rho_{H2O}}$$

Equation 6-6: Relative density calculation

RD_{STD}	Standard relative density / specific gravity	[-]
ρ_{STD}	Standard density	[g/cc]
ρ_{H2O}	Density of water at reference temperature	[g/cc]

Densitometer calculations

The flow computer supports the following type of densitometers:

- Solartron
- Sarasota
- UGC
- Densitrak

Solartron densitometers

The flow computer provides the option to calculate the density from a frequency input signal provided by a Solartron densitometer and to correct it for temperature and velocity of sound effects

$$\rho_i = K0 + K1 \cdot \tau + K2 \cdot \tau^2$$

Equation 6-7: Uncorrected density (Solartron)

Where:

ρ_i	The uncorrected density	lb/ft3
K0	Obtained from the calibration certificate	-
K1	Obtained from the calibration certificate	-
K2	Obtained from the calibration certificate	-
τ	The time period in µs	µs

$$\rho_t = \rho_i \cdot [1 + K18 \cdot (t - t_R)] + K19 \cdot (t - t_R)$$

Equation 6-8: Density corrected for temperature (Solartron)

Where:

ρ_t	The density corrected for temperature	lb/ft3
K18	Obtained from the calibration certificate	-
K19	Obtained from the calibration certificate	-
t	The line temperature	°F
t_R	The reference temperature	°F

$$\rho_{PT} = \rho_t \left[1 + \left(K_{20} \times P_f\right) + \left(K_{21} \times P_f\right)\right]$$
$$K_{20} = K_{20A} + \left(K_{20A} \times P_f\right)$$
$$K_{21} = K_{21A} + \left(K_{21B} \times P_f\right)$$

Equation 6-9: Density corrected for Pressure (Solartron)

Where:

ρ_t	The density corrected for temperature	lb/ft3
K_{18}	Obtained from the calibration certificate	-
K_{19}	Obtained from the calibration certificate	-
K_{20A}	Obtained from the calibration certificate	-
K_{20B}	Obtained from the calibration certificate	-
K_{21A}	Obtained from the calibration certificate	-
K_{21B}	Obtained from the calibration certificate	-
P_f	Pressure at the densitometer	psig

Sarasota densitometers

$$\rho_C = d_0 \quad \frac{\tau \quad \tau_C}{\tau_C} \quad 2 + K \quad \frac{\tau \quad \tau_C}{\tau_C}$$
$$\tau_C = \tau_0 + t_{COEF} \cdot \left(t - t_{CAL}\right) + p_{COEF} \cdot \left(p - p_{CAL}\right)$$

Equation 6-10: Corrected density (Sarasota)

Where:

ρ_C	The corrected density	lb/ft3
d_0	Obtained from the calibration certificate	lb/ft3
τ_0	Obtained from the calibration certificate	µs
K	Obtained from the calibration certificate	-
d_0	Obtained from the calibration certificate	-
p_{COEF}	Obtained from the calibration certificate	µs/psi
t_{COEF}	Obtained from the calibration certificate	µs/°F
t	Line temperature	°F
t_{CAL}	Reference temperature	°F
p	Line temperature	psig
p_{CAL}	Reference pressure	psig
τ_C	Time periodic input corrected for temperature and pressure	µs
τ	The time period in µS	µs

UGC densitometers

$$\rho_i = K0 + K1 \cdot \tau + K2 \cdot \tau^2$$

Equation 6-11: Uncorrected density (UGC)

Where:

ρ_i	The uncorrected density	lb/ft3
K0	Obtained from the calibration certificate	-
K1	Obtained from the calibration certificate	-
K2	Obtained from the calibration certificate	-
τ	The time period in µS	µs

$$\rho_t = \rho_i + \left[K_{P1} + K_{P2} \cdot \rho_i + K_{P3} \cdot \rho_i^{\ 2}\right] \cdot (p - p_R) + \left[K_{T1} + K_{T2} \cdot \rho_i + K_{T3} \cdot \rho_i^{\ 2}\right] \cdot (t - t_R)$$

Equation 6-12: Corrected density (UGC)

Where:

ρ_t	The density corrected for temperature and pressure	lb/ft3
K_{P1}	Obtained from the calibration certificate	-
K_{P2}	Obtained from the calibration certificate	-
K_{P3}	Obtained from the calibration certificate	-
K_{T1}	Obtained from the calibration certificate	-
K_{T2}	Obtained from the calibration certificate	-
K_{T3}	Obtained from the calibration certificate	-
t	The line temperature	°F
t_R	The reference temperature	°F
p	The line pressure	psig
p_R	The reference pressure	psig

Densitrak densitometers

$$\rho_i = K0 + K1 \cdot \tau + K2 \cdot \tau^2$$

Equation 6-13: Uncorrected density (Densitrak)

Where:

ρ_i	The uncorrected density	lb/ft3
K0	Obtained from the calibration certificate	-
K1	Obtained from the calibration certificate	-
K2	Obtained from the calibration certificate	-
τ	The time period in µS	µs

$$\rho_t = \rho_i + K_{Tv} . \rho_i . (t - t_R) + K_{T0} . (t - t_R) + K_{T1} . (t - t_R)^2$$

Equation 6-14: Density corrected for temperature (Densitrak)

Where:

ρ_t	The density corrected for temperature	lb/ft3
K_{Tv}	Obtained from the calibration certificate	-
K_{T0}	Obtained from the calibration certificate	-
K_{T1}	Obtained from the calibration certificate	-
t	The line temperature	°F
t_R	The reference temperature	°F

$$\rho_{pt} = \rho_t + K_{Pv} \cdot \rho_t \cdot p + K_{P0} \cdot p + K_{P1} \cdot p^2$$

Equation 6-15: Density corrected for temperature (Densitrak)

Where:

ρ_{pt}	The density corrected for temperature and pressure	lb/ft3
K_{Pv}	Obtained from the calibration certificate	-
K_{P0}	Obtained from the calibration certificate	-
K_{P1}	Obtained from the calibration certificate	-
p	The line pressure	psig

Viscosity correction

When enabled a correction for product viscosity is applied on the volume flow rate indicated by the flow meter.

A different correction is applied for a (helical) turbine and a positive displacement flow meter.

Turbine flow meter:

LCF = A + B*x + C*x^2 +D*x^3 + E*x ^4 +F*x^5 +G*x^6

Equation 6-16: Viscosity correction factor for turbine flow meters

Positive displacement flow meter:

LCF = A + (x^^{C})/B

Equation 6-17: Viscosity correction factor for positive displacement flow meters

where:

LCF	Viscosity correction factor	[-]
x	Qi / Vis	
Qi	Indicated volume flow rate	[bbl/hr]
Vis	In-use product viscosity	[cSt]
A..F	Correction constants, usually provided by the flow meter manufacturer	

Correction for Sediment and Water (BS&W)

$$C_{BSW} = 1 - \frac{BSW}{100}$$

Equation 6-18: Volume Correction Factor C_{BSW}

Where:

C_{BSW}	Correction for the base sediment and water content in the fluid.	-
BSW	Percentage of sediment and water content in the fluid.	[%]

Flow Rate for Volumetric Flow Meters

The following equations apply for any flow meter that provides a volumetric quantity as a pulse input signal or as a smart signal (communications, HART or analog input)

It typically applies for the following type of meters:

- Turbine flow meter
- Positive displacement (PD) flow meter
- Ultrasonic flow meter providing a pulse signal

Indicated volume flow rate

For a flow meter that provides a pulse signal the meter K-factor is applied to obtain the flow rate from the pulse frequency.

$$Qi = f / MKF * 3600$$

Equation 6-19: Indicated volume flow rate

where:

Qi	Indicated volume flow rate	[bbl/hr]
MKF	Meter K-factor	[pulses/bbl]
f	Pulse frequency	[Hz]

For smart flow meters the indicated volume flow rate is obtained directly from the flow meter.

> If the flow rate value indicated by the flow meter already includes the correction for meter body expansion, then the 'Meter Body Correction' in the flow computer must be disabled.

Gross volume flow rate

The gross volume flow rate (also called corrected flow rate) is derived from the indicated flow rate (or uncorrected flow rate) as following:

$$Q_{GV} = Qi * MF * MBF * LCF$$

Equation 6-20: Gross volume flow rate (volumetric flow meters)

where:

Q_{GV}	Gross volume flow rate	[bbl/hr]
Qi	Indicated volume flow rate	[bbl/hr]
MF	Meter factor	[-]
MBF	Meter body correction factor	[-]
LCF	Viscosity correction factor	[-]

Mass flow rate

$$Q_M = Q_{GV} * \rho * N_{ft3bbl} /1000$$

where:

Equation 6-21: Mass volume flow rate (volumetric flow meters)

where:

Q_M	Mass flow rate	[Klbm/hr]
Q_{GV}	Gross volume flow rate	[bbl/hr]
ρ	Fluid density at the flow meter conditions	[lbm/ft3]
N_{ft3bbl}	Conversion factor cubic foot to barrel 1 bbl = 5.61458266 ft3 (configurable)	[ft3/bbl]

Gross standard volume flow rate

$$Q_{GSV} = Q_V * \rho / \rho_{STD}$$

Equation 6-22: Gross standard volume flow rate (volumetric flow meters)

where:

Q_{GSV}	Gross standard volume flow rate	[bbl/hr]
Q_V	Gross volume flow rate	[bbl/hr]
ρ	Fluid density at the flow meter conditions	[lbm/ft3]
ρ_{STD}	Fluid density at the standard conditions	[lbm/ft3]

Net standard volume flow rate

$$Q_{NSV} = Q_{GSV} * C_{BSW}$$

Equation 6-23: Net standard volume flow rate (volumetric flow meters)

where:

Q_{NSV}	Net standard volume flow rate	[bbl/hr]
Q_{GSV}	Gross standard volume flow rate	[bbl/hr]
C_{BSW}	Correction for the percentage of sediment and water content in the fluid.	[-]

Flow Rate for Mass Flow Meters

The following equations apply for any flow meter that provides a mass quantity as a pulse input signal or as a smart signal (communications, HART or analog input). It typically applies for Coriolis flow meters.

In case the flow meter provides a pulse signal, the meter K-factor is applied to obtain the flow rate from the pulse frequency.

Note: Indicated volume flow rate is not calculated for mass flow meters.

Mass volume flow rate

$$Q_M = f / MKF * 3600 * MF * MBF * LCF / 1000$$

Equation 6-24: Mass flow rate (mass flow meters with pulse signal)

where:

Q_M	Mass flow rate	[Klbm/hr]
MKF	Meter K-factor	[pulses/lbm]
f	Pulse frequency	[Hz]
MF	Meter factor	[-]
MBF	Meter body correction factor	[-]

$$Q_M = Q_{M,I} * MF * MBF * LCF$$

Equation 6-25: Mass flow rate (mass flow meters with smart signal)

where:

$Q_{M,I}$	Flow rate as indicated by the flow meter	[Klbm/hr]
Q_M	Mass flow rate	[Klbm/hr]
MF	Meter factor	[-]
MBF	Meter body correction factor	[-]

If the flow rate value indicated by the flow meter already includes the correction for meter body expansion, then the 'Meter Body Correction' in the flow computer must be disabled.

Gross volume flow rate

$Q_{GV} = Q_M * 1000 / (\rho * N_{ft3bbl})$

Equation 6-26: Gross volume flow rate (mass flow meters)

where:

Q_{GV}	Gross volume flow rate	[bbl/hr]
Q_M	Mass flow rate	[Klbm/hr]
ρ	Fluid density at the flow meter conditions	[lbm/ft3]
N_{ft3bbl}	Conversion factor cubic foot to barrel 1 bbl = 5.61458266 ft3 (configurable)	[ft3/bbl]

Gross standard volume flow rate

$Q_{GSV} = Q_M * 1000 / (\rho_{STD} * N_{ft3bbl})$

Equation 6-27: Gross volume flow rate (mass flow meters)

where:

Q_{GSV}	Gross standard volume flow rate	[bbl/hr]
Q_M	Mass flow rate	[Klbm/hr]
ρ_{STD}	Fluid density at the flow meter conditions	[lbm/scf]
N_{ft3bbl}	Conversion factor cubic foot to barrel 1 bbl = 5.61458266 ft3 (configurable)	[ft3/bbl]

Net standard volume flow rate

$Q_{NSV} = Q_{GSV} * C_{BSW}$

Equation 6-28: Net standard volume flow rate (mass flow meters)

where:

Q_{NSV}	Net standard volume flow rate	[bbl/hr]
Q_{GSV}	Gross standard volume flow rate	[bbl/hr]
C_{BSW}	Correction for the percentage of sediment and water content in the fluid.	[-]

Flow rate for Liquid Orifice Plate Meters

The method uses the equations expressed in AGA Report Number 3, 1992.

Mass flowrate (AGA-3)

$$q_M = N_1 \times C_d \times E_v \times Y \times d^2 \sqrt{\rho \times \Delta P}$$

Equation 6-29: AGA-3 mass flow rate

Where

q_m	Mass flowrate	lbm/sec
N_1	Factor of combined conversion and numerical constants – 0.997424	-
C_d	Coefficient of Discharge	-
E_v	Velocity of approach – 1.0 for incompressible fluids	-
Y	Expansion factor – 1.0 for incompressible fluids	-
D^2	Orifice diameter at line temperature	in
ρ	Flowing density at line conditions	lbm/ft3
ΔP	Differential pressure	inH2O @ 60F

Mass flowrate in practical working units [Klbm/hr]

$Q_M = q_M * 3600 / 1000$

Equation 6-30: Mass flow rate in practical working units (orifice plate)

Gross volume flow rate

$Q_{GV} = Q_M * 1000 / (\rho * N_{ft3bbl})$

Equation 6-31: Gross volume flow rate (orifice plate)

where:

Q_{GV}	Gross volume flow rate	[bbl/hr]
Q_M	Mass flow rate	[Klbm/hr]
ρ	Fluid density at the flow meter conditions	[lbm/ft3]
N_{ft3bbl}	Conversion factor cubic foot to barrel 1 bbl = 5.61458266 ft3 (configurable)	[ft3/bbl]

Gross standard volume flow rate

$Q_{GSV} = Q_M * 1000 / (\rho_{STD} * N_{ft3bbl})$

Equation 6-32: Gross volume flow rate (orifice plate)

where:

Q_{GSV}	Gross standard volume flow rate	[bbl/hr]
Q_M	Mass flow rate	[Klbm/hr]

ρ_{STD}	Fluid density at the flow meter conditions	[lbm/scf]
N_{ft3bbl}	Conversion factor cubic foot to barrel 1 bbl = 5.61458266 ft3 (configurable)	[ft3/bbl]

Net standard volume flow rate

$Q_{NSV} = Q_{GSV} * C_{BSW}$

Equation 6-33: Net standard volume flow rate (orifice plate)

where:

Q_{NSV}	Net standard volume flow rate	[bbl/hr]
Q_{GSV}	Gross standard volume flow rate	[bbl/hr]
C_{BSW}	Correction for the percentage of sediment and water content in the fluid.	[-]

Orifice Plate and pipe diameter (Corrected) at operating temperature

$$d = d_r\left[1 + \alpha_1\left(T_L - T_R\right)\right]$$

Equation 6-34: Orifice Diameter correction

$$D = D_r\left[1 + \alpha_1\left(T_L - T_R\right)\right]$$

Equation 6-35: Pipe Diameter correction

Where:

d	Orifice diameter at operating temperature	°F
d_r	Orifice diameter at reference temperature	°F
D	Pipe diameter at operating temperature	°F
D_r	Pipe diameter at reference temperature	°F
α_1	Coefficient of expansion of orifice and pipe material	in/in/°F
T_L	Fluid temperature at operating conditions	°F
T_R	Reference temperature of the Orifice/Pipe.	°F

Diameter (Beta) Ratio

$$\beta = \frac{d}{D}$$

Equation 6-36: Beta ratio calculation

Reynolds Number

$$R_D = \frac{4 \times q_m}{\pi \times \mu \times D}$$

Equation 6-37: AGA3 Reynolds Number based on Pipe diameter

Where:

R_D	Reynolds Number	-
q_m	Mass flowrate	Lbm/sec
π	3.14159	-
μ	Fluid dynamic viscosity	Lbm/ft-sec
D	Pipe diameter	inches

Velocity of Approach Factor (E_v)

$$E_v = \frac{1}{\sqrt{1-\beta^4}}$$

Equation 6-38: AGA3 Velocity of Approach calculation

Fluid Expansion Factor Y

The AGA-3 equation for the Fluid Expansion factor only applies for gas. For liquid the Fluid Expansion factor is set to 1

AGA-3 defines the following equation for the Fluid Expansion Factor.

$$Y = 1 \quad \left(0.41 + 0.35 \times \beta^4\right) \times \frac{X_1}{\kappa}$$

Equation 6-39: AGA3 Reynolds Expansion Factor (Gas)

Where:

Y	Expansion Factor	-
β	Beta ratio	-
X_1	Ratio of differential pressure to absolute static pressure at the upstream tap	
κ	Isentropic exponent	-

When upstream line pressure is measured. Then

$$X_1 = \frac{\Delta P}{N_3 \times P_{f_2}}$$

When downstream line pressure is measured. The

$$X_1 = \frac{\Delta P}{N_3 \times P_{f_2} + \Delta P}$$

Where:

ΔP	Differential Pressure	In,wg	-
N3	Conversion factor (27.707)	-	-
P_{f1}	Pressure at the upstream pressing tapping	Psig	
P_{f2}	Pressure at the downstream pressure tapping	Psig	-

Differential pressure cell selection

When more than 1 differential pressure measurement is applied on a differential pressure flow device, then one of the measurements will be used for the calculation of the mass flow rate. The flow computer provides several different selection methods meter runs using 2 or 3 differential pressure cells.

2 cells, range type = 'Lo Hi'
When cell A is currently selected

- Select cell B when cell A value is above or equal to the switch-up percentage of its range and cell B is healthy.
- Select cell B when cell A fails while cell B is healthy

When cell B is currently selected

- Select cell A when cell A value is below or equal to the switch-down percentage of its range and cell A is healthy
- Select cell A when cell B fails and cell A is healthy

2 cells, range type = 'Hi Hi'
When cell A is currently selected

- Select cell B when cell A value fails and cell B is healthy

When cell B is currently selected

- Select cell A when cell A is healthy and 'Auto switchback' is enabled
- Select cell A when cell B fails and cell A is healthy.

3 cells, range type = 'Lo Mid Hi'
When cell A is currently selected

- Select cell B when cell A value is above or equal to the switch-up percentage of its range and cell B is healthy.
- Select cell B when cell A fails while cell B is healthy
- Select cell C when cell A and cell B fail and cell C is healthy

When cell B is currently selected

- Select cell C when cell B value is above or equal to the switch-up percentage of its range and cell C is healthy

- Select cell A when cell A value is below or equal to the switch-down percentage of its range and cell A is healthy
- Select cell A when cell B fails while cell A is healthy
- Select cell C when cell B and cell A fail and cell C is healthy

When cell C is currently selected

- Select cell B when cell B value is below or equal to the switch-down percentage of its range and cell B is healthy
- Select cell B when cell C fails while cell B is healthy
- Select cell A when cell C and cell B fail and cell A is healthy

3 cells, range type = 'Lo Hi Hi'
When cell A is currently selected

- Select cell B when cell A value is above or equal to the switch-up percentage of its range and cell B is healthy.
- Select cell C when cell A value is above or equal to the switch-up percentage of its range and cell B fails and cell C is healthy.
- Select cell B when cell A fails while cell B is healthy
- Select cell C when cell A and cell B fail and cell C is healthy

When cell B is currently selected

- Select cell A when cell A value is below or equal to the switch-down percentage of its range and cell A is healthy
- Select cell C when cell B fails while cell C is healthy
- Select cell A when cell B and cell C fail and cell A is healthy

When cell C is currently selected

- Select cell A when cell A value is below or equal to the switch-down percentage of its range and cell A is healthy
- Select cell B when cell B is healthy and 'Auto switchback' is enabled
- Select cell A when cell C and cell B fail and cell A is healthy

3 cells, range type = 'Hi Hi Hi'
When cell A is currently selected

- Select cell B when cell A value fails and cell B is healthy
- Select cell C when cell A and cell B fail and cell C is healthy

When cell B is currently selected

- Select cell A when cell A is healthy and 'Auto switchback' is enabled
- Select cell A when cell B fails and cell A is healthy
- Select cell C when cell B and A fail and cell C is healthy

When cell C is currently selected

- Select cell A when cell A is healthy and 'Auto switchback' is enabled
- Select cell B when cell B is healthy and cell A fails and 'Auto switchback' is enabled

- Select cell A when cell C fails and cell A is healthy
- Select cell B when cell C and A fail and cell B is healthy

Prover Calculations

The proved meter factor is calculated as following:

$$MF_P = \frac{PV_B \times C_{TSP} \times C_{PSP} \times C_{TLP} \times C_{PLP}}{\frac{P_f}{MKF} \times C_{TLM} \times C_{PLM}}$$

Equation 6-40: Prover Meter Factor.

Where:

MF_P	Meter factor calculated from proving	-
PV_B	Prover Base Volume at 60 °F and 0 psig	bbl
MKF	Meter K-factor	pulses/bbl
P_f	Pulse count (whole pulses or interpolated, depending on whether double chronometry is enabled or not)	pulses
C_{TSP}	Correction factor for the effects of Pressure on the Prover volume ('S' stand for Steel)	-
C_{PSP}	Correction factor for the effects of Pressure on the Prover volume ('S' stands for Steel)	-
C_{TLP}	Correction for the effects of Pressure on the Liquid at the Prover	-
C_{PLP}	Correction for the effects of Pressure on the Liquid at the Prover	-
C_{TLM}	Correction for the effects of Pressure on the Liquid at the Meter	-
C_{PLM}	Correction for the effects of Pressure on the Liquid at the Meter	-

The calculations of C_{TLM} and C_{PLM} is defined in sections 'Volume Correction factor C_{TL}' and 'Volume Correction factor C_{PL}'

The calculation of C_{TLP} and C_{PLP} is similar to that of C_{TLM} and C_{PLM}, except that the average meter pressure and temperature is used instead.

Average prover pressure = (Prover inlet pressure + Prover outlet pressure) / 2

Average prover temperature = (Prover inlet temperature + Prover outlet temperature) / 2

The calculation of C_{TSP} is different for pipe provers and compact provers.

$$C_{TSP} = 1 + \left[\left(\overline{T} - \overline{T_b}\right) \times t_{coef}\right]$$

Equation 6-41: C_{TSP} calculation for pipe provers

Where

T	Average Prover Pressure	°F
Tb	Base Prover temperature	°F
tcoef	**Cubical** thermal expansion coefficient of the prover steel	$in^3/in^3/°F$

$$C_{TSP} = \left|1 + \left[\left(\overline{T} - \overline{T_b}\right) \times t_{coef_P}\right] \times \left(1 + \left[\left(\overline{Ti} - \overline{T_b}\right) \times t_{coef_i}\right]\right)\right|$$

Equation 6-42: C_{TSP} calculation for compact provers

Where

TT	Average prover temperature	°F
Ti	Average prover (Invar) switch rod temperature	°F
Tb	Prover base volume temperature	°F
Tcoefp	Square (area) thermal expansion coefficient of expansion of the prover steel	in^2/in^2/°F
Tcoefi	Linear thermal expansion coefficient of expansion of the switch rod	in/in/°F

The calculation of C_{PSP} is the same for all prover types.

$$C_{PSP} = 1 + \frac{(P - P_b) \times D}{E \times t}$$

Equation 6-43: C_{PSP} calculation

Where:

P	Average prover pressure	Psig
Pb	Prover Base Pressure	Psig
D	Prover Internal diameter	Inches
E	Modulus of elasticity of prover	Psi*(in/in)
t	Prover wall thickness	Inches

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Chapter 7 - Reports

Reports of the Flow-X flow computer are freely configurable. The layout of the standard reports can be modified and other user-defines reports may be added. Refer to manual IIA 'Operation and Configuration', chapter 'Reports' for further explanation.

Standard reports

The Liquid US Customary application provides the following standard reports:

Report name	Report description
Snapshot	Shows a consistent snapshot of the actual input and calculated values. All values are of the same calculation cycle.
SN_BiDir	Snap shot report for a bi-directional flow meter
Meter ticket	The meter ticket that is generated automatically at the end of every batch. Sometimes also called batch report.
MT_BiDir	Meter ticket for a bi-directional flow meter
RT_BiDir	This meter ticket that is recalculated when new values have been entered for the standard density / gravity meter factor and/or BS&W.
Daily	Daily report for the meter run
DY_BiDir	Daily report for a bi-directional meter run
CompactProver	Generated automatically at the end of a proving sequence when prover type is set to Calibron, Flow MD or Brooks compact prover.
PipeProver	Generated automatically at the end of a proving sequence when prover type is set to bi-directional or unidirectional ball prover.

Table 7: Standard reports

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Chapter 8 - Communication

Communication with the Flow-X flow computer is freely configurable. Communication lists for Modbus and HART may be modified and added, refer to manual IIA 'Operation and Configuration', chapter 'Communication' for all details.

Standard Modbus communication list

Besides the communication lists used to communicate with flow meters and optional process analyzers, the Liquid US Customary application provides an overall Modbus communication list that contains all commonly used variables and parameters of all the meter runs and the meter station. This communication list can be used for serial and Ethernet communication links.

This overall communication list can be used 'as is', and can also be modified.

The Modbus list requires the 'Flow-Xpress Professional' license for viewing and editing.

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Chapter 9 - Historical Data Archives

Historical Data Archives provide a convenient way to store, view and hand-off all relevant historical batch and period data. For Flow-X historical data archives are freely configurable. Existing archives may be modified and new archives may be added.

Standard Data Archives

The application maintains the following historical data archives

- Batch Contains the data of the meter tickets of the last 90 days (configurable)
- Daily Contains the daily metering data of last 90 days (configurable)

The Flow-X support the Omni Raw Data Archive RDA polling method (Omni archives 701-710).

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