USER MANUAL

Z-FLOWCOMPUTER / Z-FLOWCOMPUTER-B

Computer for the calculation of flow and energy of liquids, gas and steam

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MI00409-6-EN

Date	Revision	Notes
22/05/2015	1.00	First issue.
29/05/2015	1.01	Chapter on the update of the display software added
	1.02	Changed from No. 4 to No. 1 digital inputs digital inputs, No. 3 for future use
26/09/2016	1.03	Added support to Natural Gas (AGA8-92DC, AGA8 Gross method 2, SGERG88) Added Support for the real gas (RK, RKS) Added calculations tables for Natural Gas
02/11/2020	MI00409-4	Added Z-FLOWCOMPUTER-B model
10/03/2021	MI00409-5	Update for Easy Flow Computer 1.64 Update for new program "steam" rev v1255 with T2 also read from IN3 Added alarms on HMI

Contents

Seneca Z-FLOWCOMPUTER

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1. GLOSSARY

- *MODBUS RTU*

An open serial communication protocol developed by Modicon Inc. (AEG Schneider Automation International S.A.S.). Simple and robust, it has de facto become a standard communication protocol.

For further information: http://www.modbus.org/specs.php

- *MODBUS TCP-IP*

Modbus RTU protocol with TCP interface that operates through the Ethernet network, rather than serial connection.

For further information: http://www.modbus.org/specs.php

- *MODBUS RTU MASTER-SLAVE*

The Master is connected to one or more slaves. The slave waits for a register request from the Master. Only one Master is allowed in a Modbus network. To remedy to this limitation, a Modbus gateway is required.

- *MODBUS TCP-IP CLIENT-SERVER*

The Client (called "Master" in the Modbus RTU protocol), establishes a connection with the server (called "Slave" in the Modbus RTU protocol). The server waits for an input connection from the Client. Once the connection has been established, the server supplies/writes the registers requested by the Client.

- *WEB SERVER*

A software that saves, processes, and supplies web pages for clients. Web clients can be PCs, smart phones, tablets. To access the web pages, a browser is required (Chrome, Internet Explorer, Firefox, etc...).

- *Z-FLOWCOMPUTER PROGRAM*

A program is a set of instructions that enables Z-FC to perform applications. There are currently 2 programs: Program 1 (for water and steam calculation applications) and Program 2 (for ideal, real and natural gas volume correction). To change the program, the Easy FlowComputer software must be used.

2. ACRONYMS

The following acronyms are used in this document:

Z-FC = Z-FLOWCOMPUTER

IAPWS-IF97 or IAPWS97 = International Association for Properties of Water and Steam Industrial Formulation 1997

RK = Redlich Kwong Formula

RKS = Redlich Kwong Soave Formula

3. INTRODUCTION

Z-FC is an integrated device that by using international calculation standards is capable of calculating the mass flow rate and the heat quantity based on the associated volume flow rate, pressure and temperature.

Z-FC is capable of determining all the main steam and water thermodynamic parameters.

It also has resettable and non-resettable meters for the calculation of consumptions or heat exchange in general.

In addition to water and steam calculations, Z-FLOWCOMPUTER can perform volume correction on natural, ideal, or real gases.

3.1. GENERAL SPECIFICATIONS

GENERAL SPECIFICATIONS	
Ethernet Port	No. 1 10-100 Mbps
USB micro port (side)	No. 1
microSD card slot	Max. 32 GB
Power supply insulation	1500 Vac in relation to the remaining low voltage circuits
Rechargeable backup batteries	For correct closure of the filesystem on SD card and for preservation of date/time
Supported calculation standards:	IAPWS IF-97, AGA8 GROSS METHOD 2, AGA8-92DC (ISO 12213-2), SGERG88 (ISO 12213-3), Redlich-Kwong (RK) and Redlich-Kwong-Soave (RKS) formulas, ideal gas law
Display Z-FLOWCOMPUTER MODEL ONLY	Graphic, resistive touch, connected to Z-FLOWCOMPUTER by means of an Ethernet cable
ANALOGUE INPUTS	
No. 2 Voltage/Current inputs	0-30 Volts / 0-20mA, ADC 16 Bit
No. 1 RTD/Voltage/Current input	0-10 Volt / 0-20mA / PT100 2, 3 or 4 wires / Ni100 2, 3, 4 wires / PT500 2, 3, 4 wires / PT1000 2, 3, 4 wires. ADC 15 bit
DIGITAL INPUTS	
No. 1 used, No. 3 for future use	Suitable for NPN/PNP configuration, also usable as meters (Max 250 Hz, default PNP)
DIGITAL OUTPUTS	
No. 2	With Relay
ANALOGUE OUTPUT	
No. 1	Voltage/Current configurable
SUPPORTED COMMUNICATION PROTOCOLS	
Modbus RTU Slave on serial connection	Available through terminal
Modbus TCP-IP	Server through Ethernet (max. 1 Modbus TCP-IP client)
FTP Server	Max 1 Client
Web Server	Max 1 Client

4. Z-FLOWCOMPUTER FACTORY CONFIGURATION

The factory configuration of Z-FLOWCOMPUTER is as follows:

STATIC IP

IP address = 192.168.90.101

Gateway:IP = 192.168.90.1

Loaded program: Program 1, water and steam

5. MEANING OF THE Z-FLOWCOMPUTER LEDS

LED	***STATUS***	***LED meaning***
PWR/STS Green	ON	The device is powered correctly
SD/STS Red	Flashing	Accessing the microSD card
ETH ACT Yellow	Flashing	Packet transit on Ethernet port
ETH LNK Green	Flashing	Connection on RJ45 activate
DI1 Red	ON	PNP digital input 1 closed at + 12V
DI1 Red	OFF	PNP digital input 1 open
DI2 Red	ON	PNP digital input 2 closed at + 12V
DI2 Red	OFF	PNP digital input 2 open
DI3 Red	ON	PNP digital input 3 closed at + 12V
DI3 Red	OFF	PNP digital input 3 open
DI4 Red	ON	PNP digital input 4 closed at + 12V
DI4 Red	OFF	PNP digital input 4 open
DO1 Red	ON	Digital output 1, relay energised
DO1 Red	OFF	Digital output 1, relay de-energised
DO2 Red	ON	Digital output 2, relay energised
DO2 Red	OFF	Digital output 2, relay de-energised
485 ACT Green	Flashing	Reading internal I/O card

6. INTEGRATION OF MEASUREMENTS: CUT-OFF and OUT OF RANGE

Z-FC carries out the integration and the counting procedures only if the input measurements are in the correct measurement range and the flow rate is not in cut-off mode.

Cut-off mode and outside range only work with analogue measurements (therefore, they do not work with flow rate sensors with pulse outputs).

For Z-FC, cut-off mode is active if the flow rate measurement is 4% below the bottom of the scale set.

For Z-FC, out of range mode is active if the flow rate, or the pressure, or the temperature measurement is 4% above the bottom of the scale set, and 4% below the start of the scale set.

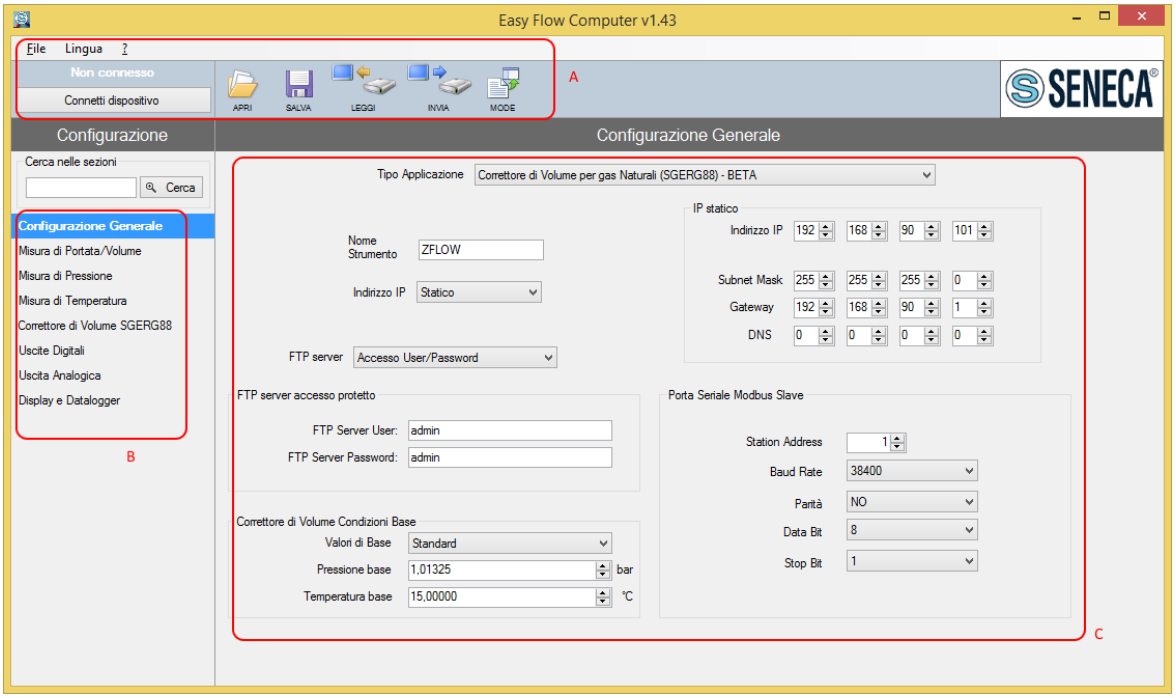
7. CONFIGURING Z-FLOWCOMPUTER USING EASY FLOWCOMPUTER

Z-FC is configured using the Easy FLOWCOMPUTER software, which can be installed on Microsoft Windows™ operating systems.

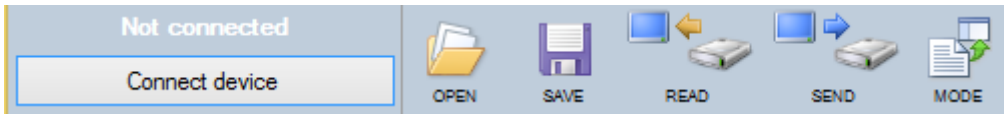
The software can be downloaded free of charge from the Z-FlowComputer section of the www.seneca.it website.

The software has 3 main sections:

A) The connection and management menu
B) The menu of the sections available (depending on the type of application selected)
C) The connection parameter page



7.1. CONNECTING Z-FLOWCOMPUTER TO THE PC



To connect Z-FLOWCOMPUTER to the PC use a micro USB cable.

To change the factory program, an Ethernet cable must also be connected to the PC.

Once the USB cable has been connected, press the "Connect device" button.

It is now possible to use the available buttons.

OPEN

Open a configuration previously saved on file

SAVE

Save the current configuration on file

READ

Read the configuration currently present on Z-FLOWCOMPUTER using the USB cable

SEND

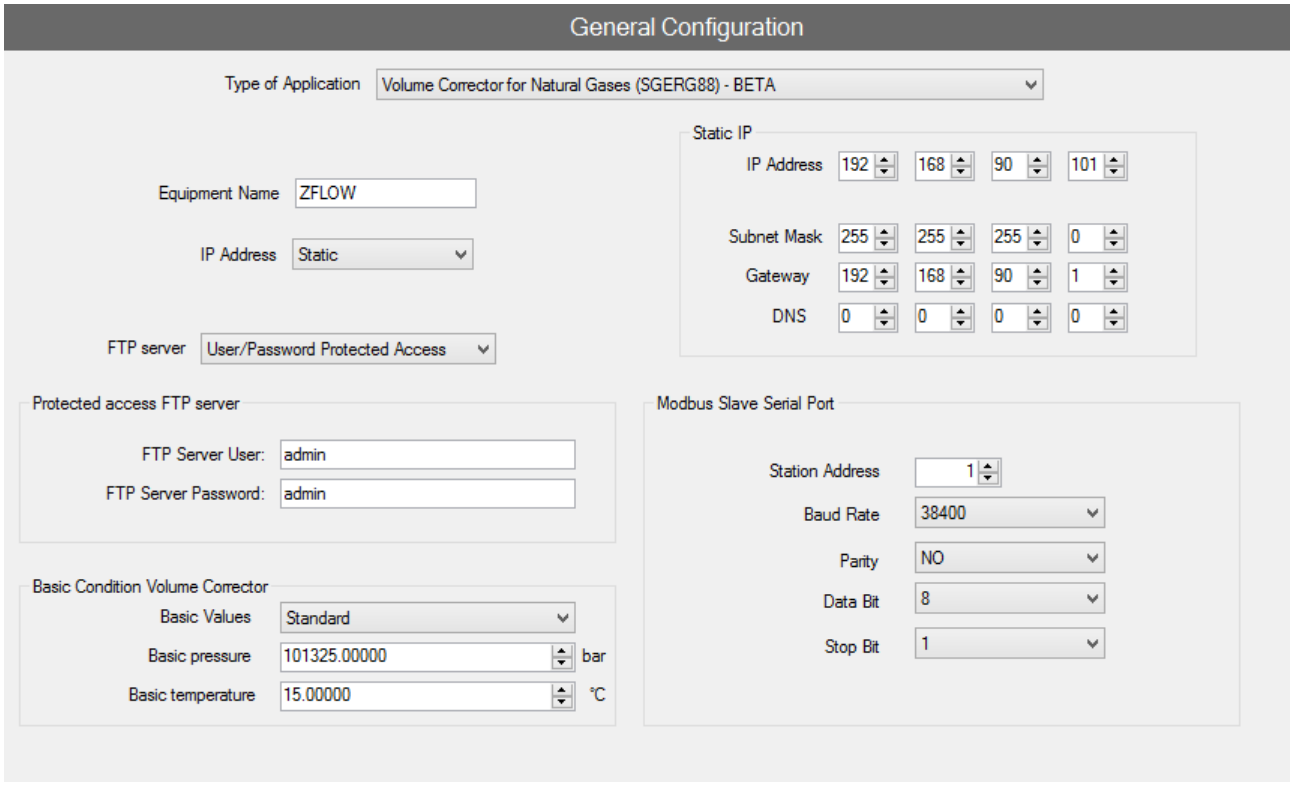
Send the configuration to Z-FLOWCOMPUTER using the USB cable

MODE

Used to change or update the Z-FLOWCOMPUTER program using the Ethernet cable

7.2. GENERAL CONFIGURATION PAGE

The general configuration page contains the configuration parameters for the communication and the calculation parameters required for certain applications:



TYPE OF APPLICATION

It gives the possibility of selecting the type of application to be used by Z-FLOWCOMPUTER. The following applications are available:

TYPE OF APPLICATION	***PROGRAM TO USE***
MASS AND STEAM CALCULATION	PROGRAM 1
STEAM - WATER THERMAL DIFFERENCE (HEATING)	PROGRAM 1
STEAM - WATER THERMAL DIFFERENCE (COOLING)	PROGRAM 1
VOLUME CORRECTOR FOR NATURAL GASES (SGERG88)	PROGRAM 2
VOLUME CORRECTOR FOR NATURAL GASES (SGERG88)	PROGRAM 2
VOLUME CORRECTOR FOR NATURAL GASES (AGA8 GROSS METHOD 2)	PROGRAM 2
VOLUME CORRECTOR FOR NATURAL GASES (AGA8 92-DC)	PROGRAM 2
VOLUME CORRECTOR FOR NATURAL GASES (RK, RKS)	PROGRAM 2
VOLUME CORRECTOR FOR IDEAL GASES	PROGRAM 2

EQUIPMENT NAME

This is the name that identifies the Z-FLOWCOMPUTER being used. It is also the prefix of the name of each file that will be created in the microSD card using datalogger.

IP ADDRESS

Select which mode to use for the IP address, either DHCP or static. In case of DHCP, the DHCP server will automatically provide an IP address, in static mode, the parameters will need to be entered manually (if the DNS address is left as 0.0.0.0., the right address is recovered by the gateway).

FTP SERVER

It selects the mode of operation, between free access, and user name and password protected access to the FTP server

MODBUS SLAVE SERIAL PORT

It selects the configuration parameters of the Modbus RTU slave port on RS485/RS232 terminal port. (RS232/RS485 terminal port mode depends on the Z-FLOWCOMPUTER purchase code).

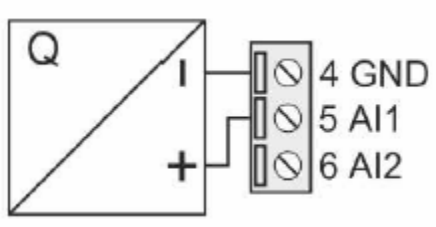
BASIC CONDITION VOLUME CORRECTOR

In applications with volume corrector, it gives the possibility to select if this is to be refereed to standard, normal, or custom conditions

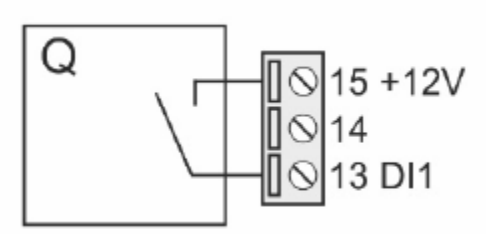
7.3. SUPPORTED FLOW METERS

Z-FC accepts many types of input flow meters.

Flow sensors with analogue output must be connected to analogue input 1:



Flow sensors with digital output (pulsed) must be connected to digital input 1:



7.3.1. ORIFICE CALIBRATED WITH LINEAR OUTPUT (VOLUMETRIC)

This type of meter is used for gas or steam measurements. The output is normally analogue, and is linear in relation to the speed of the fluid. It therefore provides a signal that is proportional to the volumetric flow.

7.3.2. ORIFICE CALIBRATED WITH SQUARE OUTPUT (VOLUMETRIC)

This type of meter is used for gas or steam measurements. The output is normally analogue, and is square in relation to the speed of the fluid. It therefore provides a signal that is proportional to the square of the volumetric flow.

7.3.3. TURBINE (VOLUMETRIC)

The turbine meter is normally used for measuring gas or liquids. The output can be digital, or seldom analogue. In the first case it provides a quantity pulse signal (frequency), in the second case it generates an analogue signal proportional to the volume.

7.3.1. VORTEX (VOLUMETRIC)

The Vortex meter is used for measuring gas, steam, or liquids. The output can be analogue or digital (frequency), and is linear in relation to the speed of the fluid. The output signal is proportional to the volumetric flow.

7.3.2. MAGNETIC (VOLUMETRIC)

The magnetic meter is used to measure liquids with electric conductivity other than zero. Typically water. The output can be digital or analogue. In the first case it provides a quantity pulse signal (frequency), in the second case it generates an analogue signal proportional to the volumetric flow.

7.3.3. VORTEX CALIBRATED ON P/T POINT (MASS)

The Vortex meter is used for measuring gas, steam, or liquids. The output can be analogue or digital (frequency), and is linear in relation to the speed of the fluid. The output signal is proportional to the travelling mass, after fixing the working pressure and temperature (P/T) values, and the type of fluid measured.

7.3.4. VORTEX WITH BUILT-IN COMPENSATOR (MASS)

The Vortex meter is normally used for measuring gas, steam, or liquids. The output can be analogue or digital (frequency), and is linear in relation to the speed of the fluid. The output signal is proportional to the travelling mass, as it is fitted with a built-in corrector and pressure and temperature sensors. By connecting the output of this meter to Z-FC, it is possible to calculate all the fluid parameters not normally supplied by the corrector.

7.3.1. ORIFICE CALIBRATED ON A P/T POINT WITH LINEAR OUTPUT (MASS)

This type of meter is used for gas or steam measurements. The output is normally analogue, and is linear in relation to the speed of the fluid. The output signal is proportional to the travelling mass, after fixing the working pressure and temperature (P/T) values.

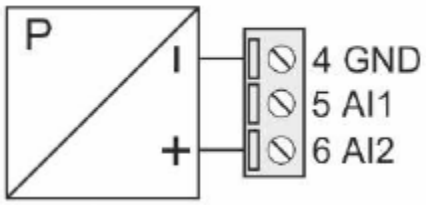
7.3.2. ORIFICE CALIBRATED ON A P/T POINT WITH SQUARE OUTPUT (MASS)

This type of meter is used for gas or steam measurements. The output is normally analogue, and is square in relation to the speed of the fluid. The output signal is proportional to the square of the travelling mass, after fixing the working pressure and temperature (P/T) values.

7.4. SUPPORTED PRESSURE METERS

The measurement of the pressure of the fluid is necessary for almost all applications. It is possible to use devices with current or voltage outputs, with absolute or relative measurement scale. This device must be installed near the flow meter, in order to measure the actual pressure of the fluid travelling through the flow meter itself.

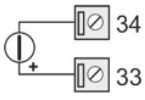
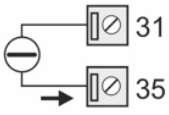
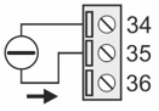
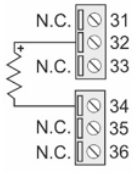
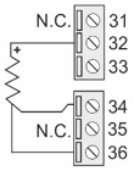
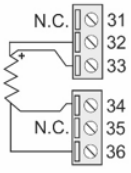
The pressure meter must be connected to analogue input 2:



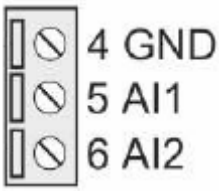
7.5. SUPPORTED TEMPERATURE SENSORS

The temperature of the fluid is necessary for almost all applications. It is possible to use devices with current, voltage outputs, PT100, PT1000, Ni100, PT500 This device must be installed near the flow meter, in order to measure the actual temperature of the fluid travelling through the flow meter itself. In case of measurement of the thermal difference, the T1 temperature is the temperature that must be detected near the flow meter (delivery temperature).

The delivery temperature meter (T1) must be connected to analogue input 3:

Input V	*Input mA active 4 wires*	*Input mA passive 2 wires*	*RTD input 2 wires*	*RTD input 3 wires*	*RTD input 4 wires*
					

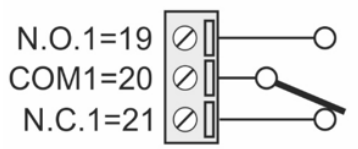
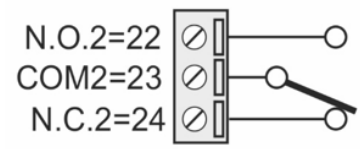
The return temperature meter T2 (only used in applications with thermal difference) can be connected to analogue inputs 1, 2 or 3. In this case, a sensor with voltage or current output must be used. For the connections refer to the following figure:



7.6. DIGITAL OUTPUTS

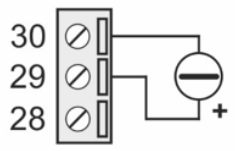
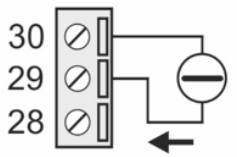
Digital outputs can be configured to obtain pulses for counting mass or volume, or to notify input measurement alarms (no signal, out of scale, etc.).

Digital outputs have a NO (normally open) and a NC (normally closed) terminal, as shown in the figure:

Digital output 1	*Digital output 2*	*Outputs with free contacts*
		The Z-FLOWCOMPUTER has two digital outputs with free contacts. The figures show the internal relay contacts available.

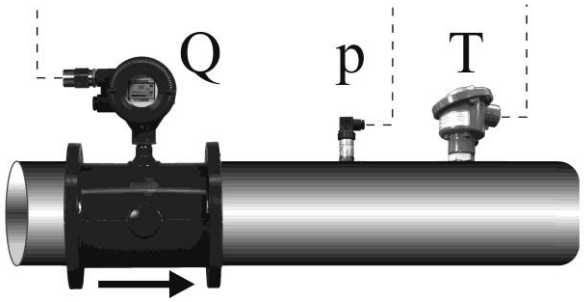
7.7. ANALOGUE OUTPUT

The analogue output can replicate one of the input measurements, in addition to the mass flow and the thermal flow. It is available both as 0/4...20mA current and 0..10V voltage output.

Analogue output (V)	*Analogue output (mA)*	*Configurable output*
		The Z-FLOWCOMPUTER has an analogue output that can be configured for either voltage or current. The figures show the connections.

8. APPLICATIONS WITH WATER AND STEAM: MASS AND STEAM CALCULATION

The object of this application is to measure the quantity of heat and the mass of the fluid travelling inside the pipe. For the measurement of overheated steam, the following are required: flow measurement, temperature and pressure measurements. For the measurement of saturated steam, the flow and pressure or temperature measurements (one of the two) are sufficient. For water measurement, only flow and temperature are required.



	Required inputs		
Type of fluid	*Flow measurement (Q)*	*Temperature measurement (T)*	*Pressure measurement (P)*
Overheated steam	Yes	Yes	Yes
Saturated steam	Yes	One of the two measurements	
Water	Yes	Yes	No

ATTENTION!

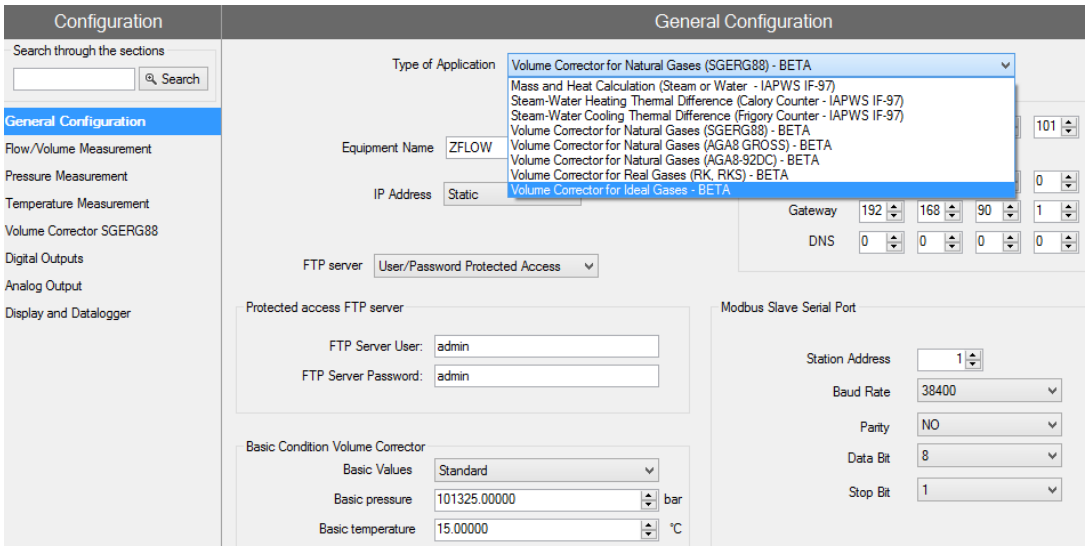
The temperature and pressure measurements must be taken near the flow meter.

The variables used by these applications are obtained starting from the IAPWS97 calculation standard (for further information refer to the chapter on calculation standards).

To correctly configure this application, refer to the next chapter. To continue, the latest version of the Easy FlowComputer software is required.

8.1. TYPE OF APPLICATION

In the "General Configuration" section select the "Mass and Heat Calculation" application type.



8.2. TYPE OF FLUID

In the menu select the "Type of Fluid" section and then select the type of fluid.

If "Saturated Steam" is selected, the associated pressure or temperature measurement must also be selected. For Overheated Steam, both measurements are required.

8.3. FLOW MEASUREMENT

In the menu select "Flow / Volume measurement", and then select the sensor used.

If the flow sensor has an analogue output, the correct type of input must be set (voltage or current), together with the correct scale of the sensor:

If the flow sensor has a digital output (pulsed), the weight of each pulse must be set:

With mass sensors, it is necessary to set the calibration point for pressure or temperature (recover this information from the instrument configuration details).

The unit of measure of the volume measurement is connected to the type of sensor being used (Volumetric or Mass); the software will indicate any errors at the bottom of the screen.

The flow measurement is always associated to Analogue input 1 or Digital input 1.

8.4. PRESSURE MEASUREMENT

The pressure measurement is required in case of overheated steam, while it can be used as an alternative to temperature for saturated steam.

For water, an average pressure value can be entered.

In Z-FC, the pressure values are always considered absolute. For relative pressure meters, the set up of the normalised atmospheric pressure (1.103 bar) is required.

Configure correctly the scale of the instrument and the value of the unit of measure used.

The pressure measurement is always associated to Analogue input 2.

ATTENTION!

For the purpose of internal calculations and displaying, all the pressure measurements are considered absolute.

8.5. TEMPERATURE MEASUREMENT

The temperature measurement is always necessary, with the exception of saturated steam, when the measurement of the pressure is available.

In this type of application, the measurement of the temperature is associated to analogue input 3 and it is possible to use a sensor with current or voltage output. In alternative, the same input can be configured for RTD PT100, PT500, PT1000, NI100 in 2, 3, or 4 wire mode.

In case of temperature measurement with sensor with voltage / current output, the scale and the unit of measure must be configured correctly:

In case of measurement with RTD (thermoresistance), it is not necessary to introduce any other information, apart from the type of measurement - 2, 3, or 4 wires - and the type of RTD used:

Measurement range of the RTD supported:

PT100	210 to 650°C
PT500	200 to 750°C
PT1000	200 to 210°C
NI100	60 to 250°C

8.6. DIGITAL OUTPUTS

The two digital outputs can be set to indicate a fault on the input measurements, or to relaunch the energy and/or mass pulses (variables integrated by Z-FC).

The two outputs can be configured individually.

To detect the faults on the input measurements select alarm mode. Here, it is possible to set the validity range of the measurements. It is enough for one measurement to fall outside the set range to trigger the alarm.

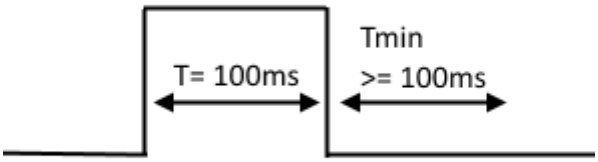
If the notification of the error of a particular measurement is not required, set the values outside the range of measurement of the sensor.

ATTENTION!

The alarm on the digital outputs does not stop the integration of the measurements.

To connect a variable to the pulse output, select pulse mode and enter every how many units the pulse must be sent. The unit depends on the unit of measure selected for that variable in the Display and Datalogger section.

The duration of the pulse is T=100 ms, the minimum waiting time for the next pulse is Tmin=100 ms



8.7. ANALOGUE OUTPUT

The analogue output can transmit to the other devices one of the variables available. Integrated or accounted variables are not available on the analogue output (use the digital pulse output).

Select the type of output, current or voltage, the variable to transmit, and then set the scale:

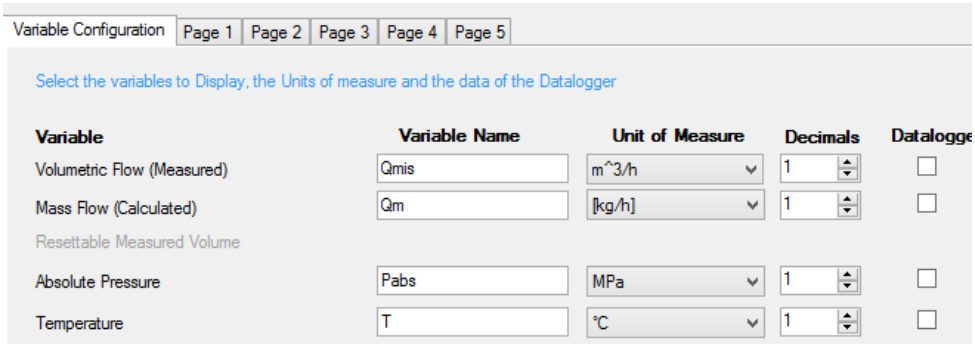
8.8. DISPLAY (Z-FLOWCOMPUTER MODEL ONLY) AND DATALOGGER

The Display and Datalogger section shows all the variables used by the specific application. It is possible to select which ones to show on the display, with how many decimal numbers, and in which specific pages.

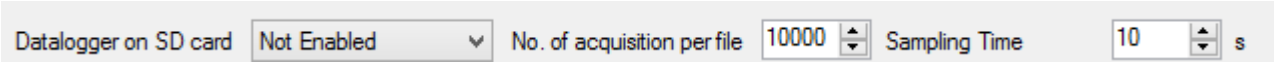
8.8.1. VARIABLE CONFIGURATION

In this section it is possible to select:

- *Which variables to show on the display*
- *Which name to give to the variables displayed*
- *The unit of measure of the variable*
- *How many decimal points must be shown in the variable*
- *If the variable must be logged*



At the end of the selection, it is possible to set the datalogger parameters:



If the datalogger is enabled, all the selected variables will be saved, together with the selected sampling time, in a text file (.CSV format) in the microSD card (/LOG folder).

The parameter "No. of acquisitions per file" indicates the maximum number of acquisitions (lines) before changing the file.

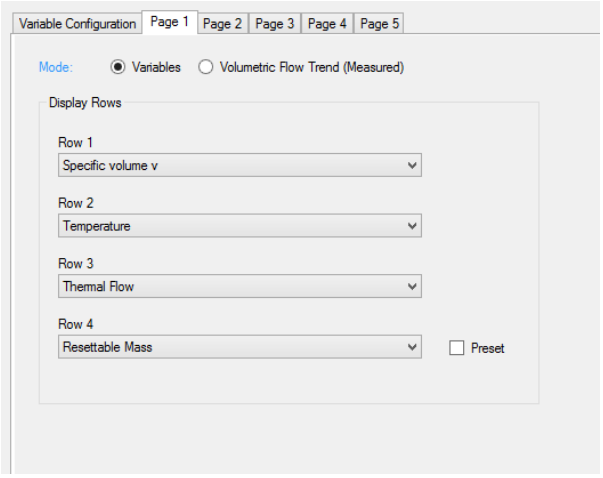
ATTENTION!

Do not remove the microSD card when the datalogger is active! The data stored in the microSD could be lost!

To collect the log files without switching Z-FC off, use the connection to the internal FTP server.

8.8.2. PAGE 1 .. PAGE 5

In this sub-section it is possible to select which variable should be shown in the 5 screens available in the display.



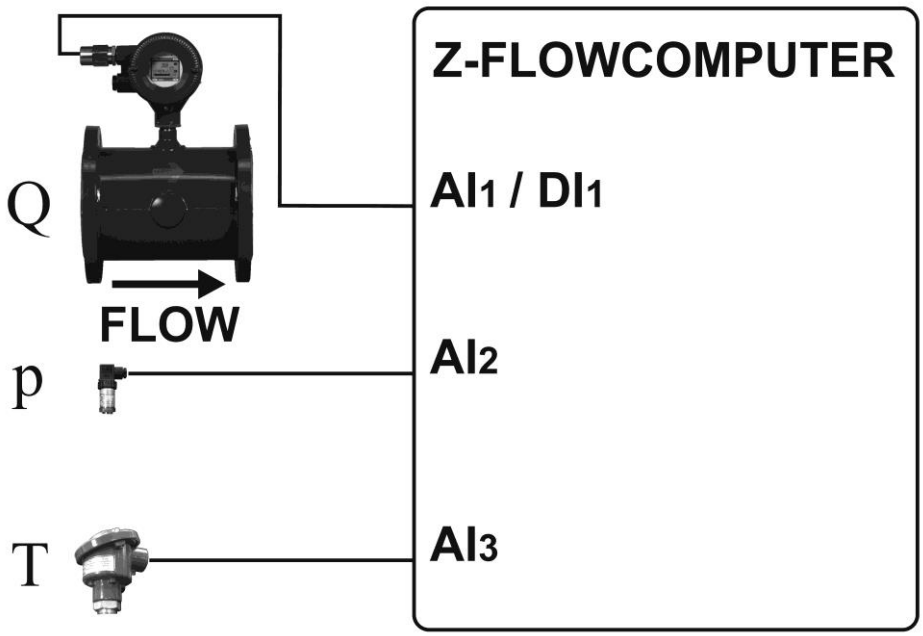
The page mode selects if the variables or a graphic trend of the input flow should be displayed.

In variable mode, it is possible to set a "Preset" button of the value of the meter for resettable and accumulated variables (if preset is selected, the operation is password protected).

The password for the preset of meters is 5477.

8.9. CONNECTIONS

Meter connection diagram for the "Mass and steam calculation" application



8.10. VARIABLES CALCULATED

VARIABLE	***Application Mass and Heat Calculation***
	With Mass Flow Meter
Mass flow (measured)	X
Mass Flow (Calculated)	X
Absolute Pressure	X
Temperature	X
Specific volume v	X
Density 1/v	X
Specific Iternal Energy u	X
Specific entropy s	X
Specific enthalpy h	X
Specific isobaric heat capacity cp	*
Specific isochoric heat capacity cv	*
Thermal capacity	X
Resettable thermal energy	X
Non-resettable thermal energy	X
Resettable specific energy	X
Specific Energy Non-resettable	X
Temperature difference	
Enthalpy difference	
Resettable mass	X
Non resettable mass	X
Temperature 2	
Mass flow (measured)	X
Mass Flow (Calculated)	X

(*) These variables are only calculated in some points of the steam status diagram. For the other points, the value will be 0.

9. APPLICATIONS WITH WATER AND STEAM: STEAM-WATER THERMAL DIFFERENCE

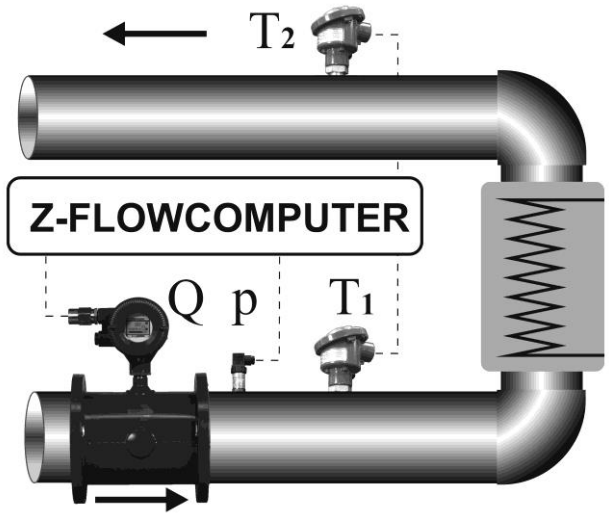
The object of this application is to measure the power and the energy transferred to another system. In the delivery piping is overheated steam, saturated steam, or water; in the return piping is the condensation water. Z-FC calculates the transit power in the delivery piping and in the return piping, and the difference. The result is the exchanged thermal power.

For the measurement of overheated steam, the following are required: flow measurement, pressure measurement, delivery temperature measurement (T1) and return temperature measurement (T2).

For this application, it is necessary to select digital input 1 for the flow measurement. As a consequence, the flow meter must have a digital input.

For the measurement of saturated steam, the following are required: flow measurement, delivery pressure or temperature measurement (T1) (only one), and return temperature measurement (T2).

For the measurement of water, the following are required: flow measurement, delivery temperature measurement (T1), return temperature measurement (T2).



	Required inputs			
Type of delivery fluid	*Flow (Q) Capacity*	*Delivery temperature (T1)*	*Delivery pressure (P)*	*Return temperature (T2)*
Overheated steam	Yes (pulses only)	Yes	Yes	Yes
Saturated steam	Yes	One of the two measurements		Yes
Water	Yes	Yes	Yes	No

ATTENTION!

The T1 temperature and P pressure measurements must be taken near the flow meter.

The variables used by these applications are obtained starting from the IAPWS97 calculation standard (for further information refer to the chapter on calculation standards).

To correctly configure this application, refer to the next chapter. To continue, the latest version of the Easy FlowComputer software is required.

9.1. TYPE OF APPLICATION

In the "General Configuration" section, select the application type "Water-Steam Heat Difference Heating (Calorie Counter)" or "Water-Steam Heat Difference Cooling (Refrigeration Counter)".

9.2. TYPE OF FLUID

In the menu select the "Type of Fluid" section and then select the type of fluid.

If "Saturated Steam" is selected, the associated pressure or temperature measurement must also be selected. For Overheated Steam , both measurements are required.

9.3. FLOW MEASUREMENT

In the menu select "Flow / Volume measurement", and then select the sensor used.

If the flow sensor has an analogue output, the correct type of input must be set (voltage or current), together with the correct scale of the sensor:

If the flow sensor has a digital output (pulsed), the weight of each pulse must be set:

With mass type sensors, the pressure/temperature calibration point is required (recover this information from the instrument configuration details).

The unit of measure of the pressure measurement is linked to the type of sensor being used (Volumetric or Mass); the software will indicate any errors at the bottom of the screen.

The flow measurement is always associated to Analogue input 1 or Digital input 1.

9.4. PRESSURE MEASUREMENT

The pressure measurement is required in case of overheated steam, while it can be used as an alternative to temperature for saturated steam.

For water, an average pressure value can be entered.

In Z-FC, the pressure values are always considered absolute. For relative pressure meters, the set up of the normalized atmospheric pressure (1.103 bar) is required.

Correctly configure the scale of the instrument and the value of the unit of measure used.

The pressure measurement is always associated to Analogue input 2.

ATTENTION!

For the purpose of internal calculations and displaying, all the pressure measurements are considered absolute.

9.5. FLOW (T1) AND RETURN (T2) TEMPERATURE MEASUREMENT

The flow temperature measurement T1 is always necessary, except in the case of saturated steam when the pressure measurement is available.

If input IN3 is used for temperature measurement, a sensor with current or voltage output can be used; alternatively, the same input can be configured for RTD PT100, PT500, PT1000, NI100 in 2, 3 or 4 wire mode.

In the case of temperature measurement with a sensor with voltage/current output, the scaling and unit of measurement must be configured correctly:

In the case of RTD (resistance thermometer) measurement it is not necessary to enter any information other than the type of 2, 3 or 4 wire measurement and the type of resistance thermometer used:

Measurement range of the RTD supported:

PT100	210 to 650°C
PT500	200 to 750°C
PT1000	200 to 210°C
NI100	60 to 250°C

The return temperature measurement (t2) can be carried out by analogue input 1, 2 or 3 (so the measurement can only be carried out in voltage or current). Then configure the scaling of the measurement.

ATTENTION!

Connect the temperature sensor to the unused analogue input. In case of error, the software will warn if the selected input is already being used.

9.6. DIGITAL OUTPUTS

The two digital outputs can be set to indicate a fault on the input measurements, or to relaunch the energy and/or mass pulses (variables integrated by Z-FC).

The two outputs can be configured individually.

To detect the faults on the input measurements select alarm mode. Here, it is possible to set the validity range of the measurements. It is enough for one measurement to fall outside the set range to trigger the alarm.

If the notification of the error of a particular measurement is not required, set the values outside the range of measurement of the sensor.

ATTENTION!

The alarm on the digital outputs does not stop the integration of the measurements.

To connect a variable to the pulse output, select pulse mode and enter every how many units the pulse must be sent. The unit depends on the unit of measure selected for that variable in the Display and Datalogger section.

The duration of the pulse is T=100 ms, the minimum waiting time for the next pulse is Tmin=100 ms

9.7. ANALOGUE OUTPUT

The analogue output can transmit to the other devices one of the variables available. Integrated or accounted variables are not available on the analogue output (use the digital pulse output).

Select the type of output, current or voltage, the variable to transmit, and then set the scale:

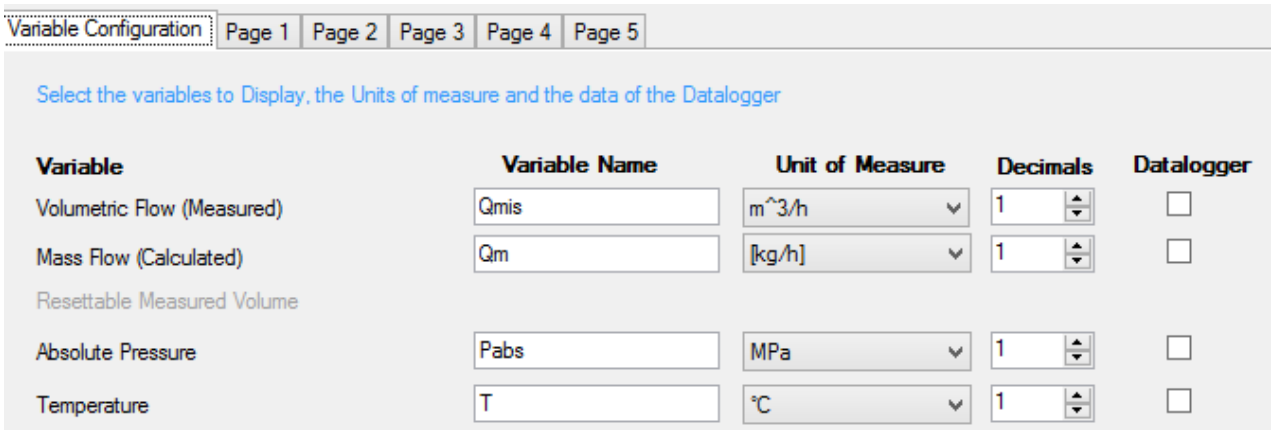
9.8. DISPLAY (Z-FLOWCOMPUTER MODEL ONLY) AND DATALOGGER

The Display and Datalogger section shows all the variables used by the specific application. It is possible to select which ones must be shown on the display, with how many decimal numbers, and in which specific pages.

9.8.1. VARIABLE CONFIGURATION

In this section it is possible to select:

- *Which variables to show on the display*
- *Which name to give to the variables displayed*
- *The unit of measure of the variable*
- *How many decimal points must be shown in the variable*
- *If the variable must be logged*



At the end of the selection, it is possible to set the datalogger parameters:

If the datalogger is enabled, all the selected variables will be saved, together with the selected sampling time, in a text file (.CSV format) in the microSD card (/LOG folder).

The parameter "No. of acquisitions per file" indicates the maximum number of acquisitions (lines) before changing the file.

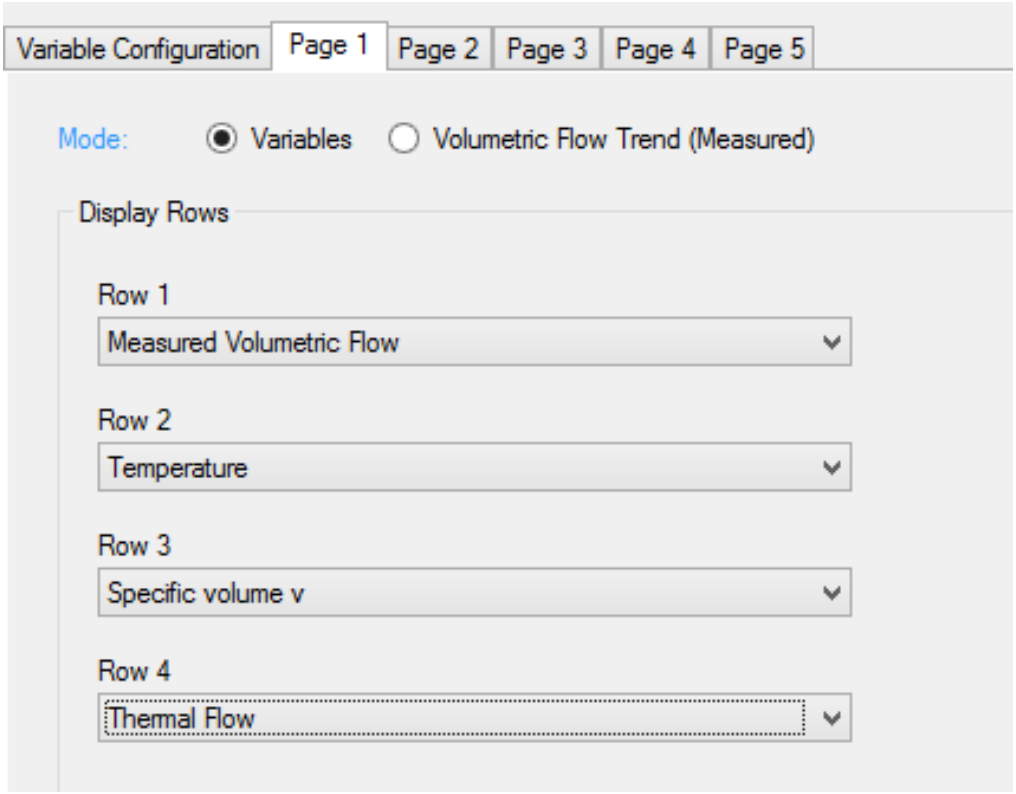
ATTENTION!

Do not remove the microSD card when the datalogger is active! The data stored in the microSD could be lost!

To collect the log files without switching Z-FC off, use the connection to the internal FTP server.

9.8.2. PAGE 1 .. PAGE 5

In this sub-section it is possible to select which variable should be shown in the 5 screens available in the display.



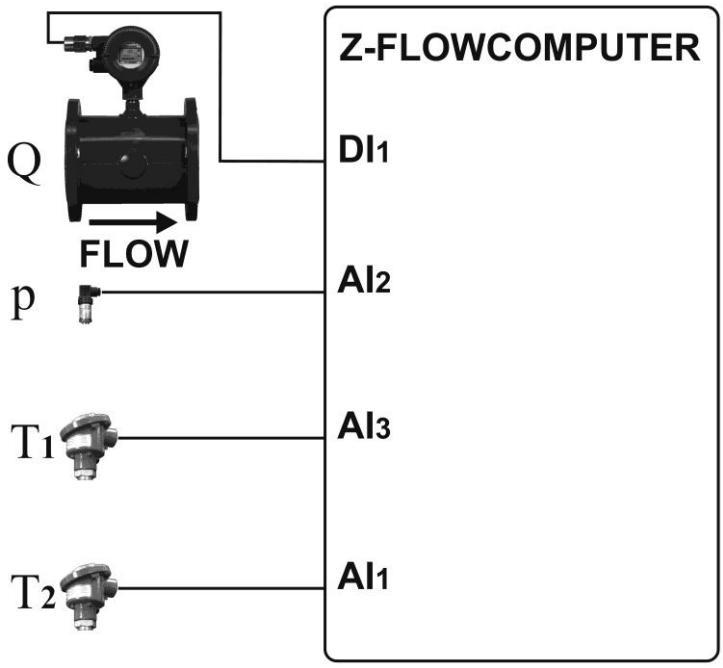
The page mode selects if the variables, or a graphic trend of the input flow, should be displayed.

In variable mode, it is possible to set a "Preset" button of the value of the meter for resettable and accumulated variables (if preset is selected, the operation is password protected).

The password for the preset of meters is 5477.

9.9. CONNECTIONS

Typical connection diagram for the meters for the applications "Heating water-steam thermal difference (calory count)" or "Cooling water-steam thermal difference (frigory count)":



9.10. VARIABLES CALCULATED

VARIABLE	***Application*** ***Calory count / Frigory count***
	With mass flow meter
Mass flow (measured)	X
Mass Flow (Calculated)	X
Absolute Pressure	X
Temperature	X
Specific volume v	X
Density 1/v	X
Specific Iternal Energy u	X
Specific entropy s	X
Specific enthalpy h	X
Specific isobaric heat capacity cp	*
Specific isochoric heat capacity cv	*
Thermal capacity	X
Resettable thermal energy	X
Non-resettable thermal energy	X
Resettable specific energy	X
Specific Energy Non-resettable	X
Temperature difference	X
Enthalpy difference	X
Resettable mass	X
Non resettable mass	X
Temperature 2	X
Mass flow (measured)	X
Mass Flow (Calculated)	X

(*) These variables are only calculated in some points of the steam status diagram. For the other points, the value will be 0.

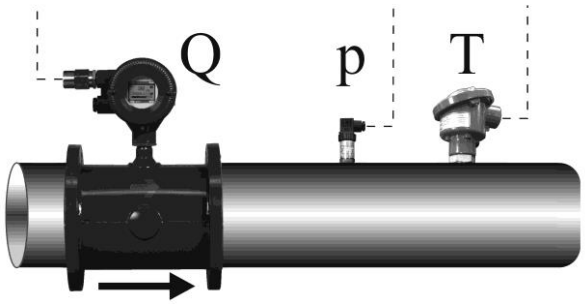
10. VOLUME CORRECTOR FOR NATURAL/REAL GASES

This application has as purpose the calculation of the flow rate and the volume of a gas to the base temperature Tb and pressure Pb from the working conditions of Q, P and T.

In order to obtain these, normed calculations algorithms are used.

Z-FLOWCOMPUTER for calculating the correct volume flow can use the following algorithms:

ALGORITHMS	APPLICATION
AGA8 GROSS METHOD 2	Volume Corrector for natural Gases
AGA8-92DC (ISO 12213-2)	Volume Corrector for natural Gases
SGERG88 (ISO 12213-3)	Volume Corrector for natural Gases
Redlich-Kwong (RK)	Volume Corrector for real Gases
Redlich-Kwong-Soave (RKS)	Volume Corrector for real Gases



WARNING!

The temperature and pressure measurements must be made in the proximity of the flowmeter.

To properly configure this application please refer to the following chapters, you need to have installed the latest version of Easy Flow Computer software.

10.1. APPLICATION TYPE

In the "General Settings", select the type application "Volume corrector for Natural / Real Gases":

At this point you must enter the basic conditions for the volume calculation: normal, standard or custom:

10.2. FLOW MEASUREMENT

In the menu select "Flow / Volume measurement", and then select the sensor used.

If the flow sensor has an analogue output, the correct type of input must be set (voltage or current), together with the correct scale of the sensor:

If the flow sensor has a digital output (pulsed), the weight of each pulse must be set:

With mass type sensors, the pressure/temperature calibration point is required (recover this information from the instrument configuration details).

The unit of measure of the pressure measurement is linked to the type of sensor being used (Volumetric or Mass); the software will indicate any errors at the bottom of the screen.

The flow measurement is always associated to Analogue input 1 or Digital input 1.

10.3. PRESSURE MEASUREMENT

The pressure measurement is required in case of overheated steam, while it can be used as an alternative to temperature for saturated steam.

For water, an average pressure value can be entered.

In Z-FC, the pressure values are always considered absolute. For relative pressure meters, the set up of the normalized atmospheric pressure (1.103 bar) is required.

Correctly configure the scale of the instrument and the value of the unit of measure used.

The pressure measurement is always associated to Analogue input 2.

ATTENTION!

For the purpose of internal calculations and displaying, all the pressure measurements are considered absolute.

10.4. TEMPERATURE MEASUREMENT

In this type of application, the measurement of the temperature is associated to analogue input 3 and it is possible to use a sensor with current or voltage output. In alternative, the same input can be configured for RTD PT100, PT500, PT1000, NI100 in 2, 3, or 4 wire mode.

In case of temperature measurement with sensor with voltage / current output, the scale and the unit of measure must be configured correctly:

In case of measurement with RTD (thermoresistance), it is not necessary to introduce any other information, apart from the type of measurement - 2, 3, or 4 wires - and the type of RTD used:

Measurement range of the RTD supported:

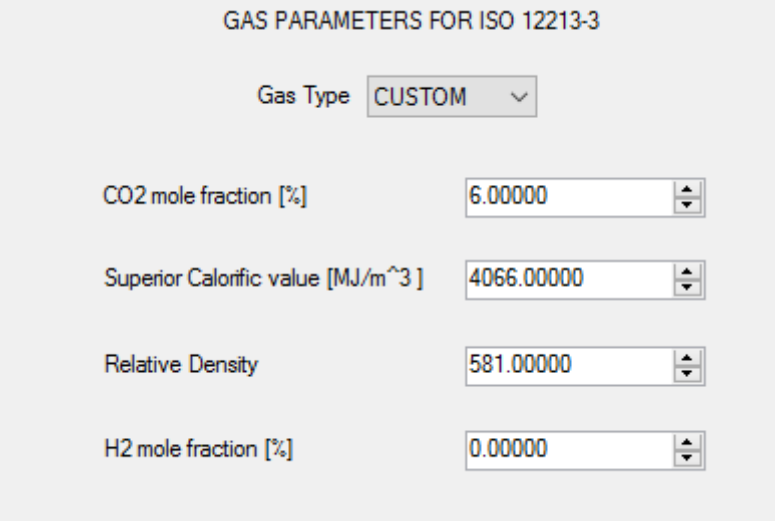
PT100	210 to 650°C
PT500	200 to 750°C
PT1000	200 to 210°C
NI100	60 to 250°C

10.5. VOLUME CORRECTOR

In this section, the software requires the gas characteristics based on the selected algorithm.

10.5.1. SGERG88 ISO 12213-3

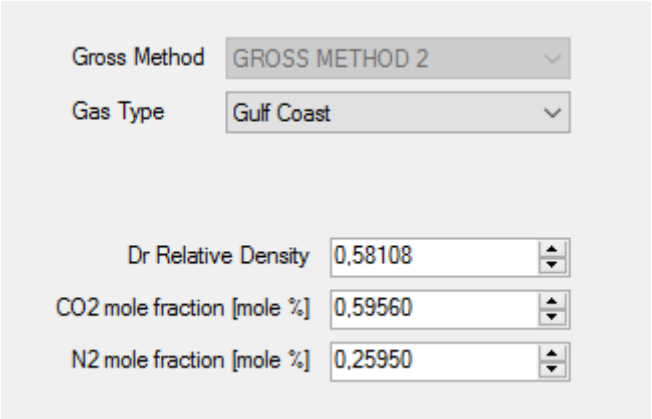
The Natural gas parameters required for the calculation according to ISO 12213-3 are:



Parameters from the ISO 12213-3 gases have already been entered, you can also choose a customized gas.

10.5.2. AGA8 GROSS METHOD2

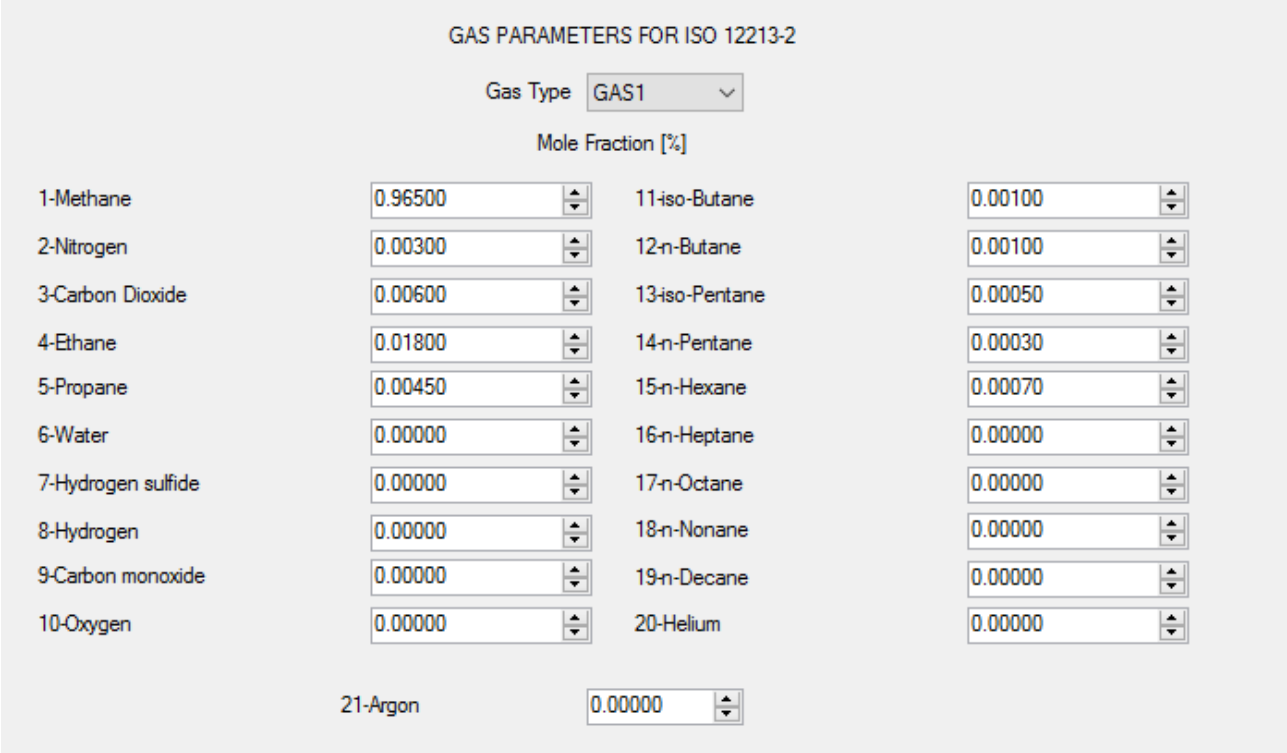
The Natural gas parameters required for the calculation according to AGA8 Gross Method2 are:



Parameters from the AGA8 document gases have already been entered, you can also choose a customized gas.

10.5.3. AGA8 92-DC ISO 12213-2

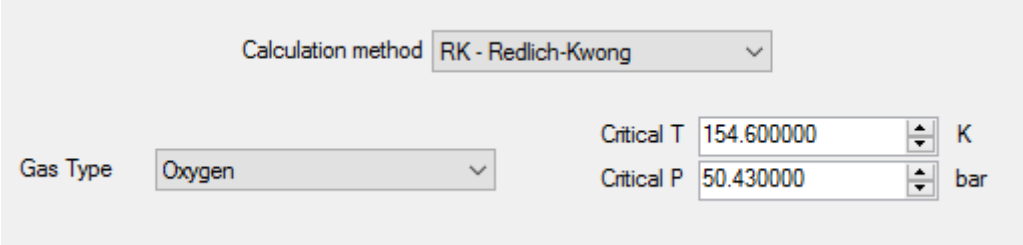
The Natural gas parameters required for the calculation according to ISO 12213-2 are:



Parameters from the ISO 12213-2 gases have already been entered, you can also choose a customized gas.

10.5.1. RK - Redlich-Kwong

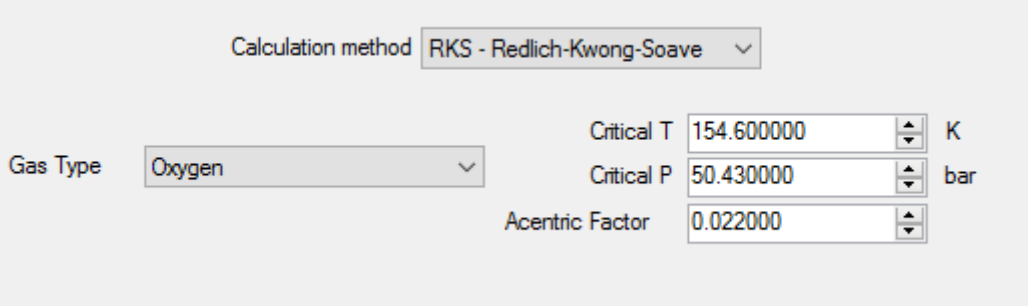
The gas parameters required for the calculation according to RK – Redlich – Kwong are:



It has already been entered the parameters of some gas or you can choose a customized gas type.

10.5.2. RKS - Redlich-Kwong-Soave

The gas parameters required for the calculation according to RKS – Redlich – Kwong – Soave are :



It has already been entered the parameters of some gas or you can choose a customized gas type.

10.6. DIGITAL OUTPUTS

The two digital outputs can be set to indicate a fault on the input measurements, or to relaunch the correct/measure volume pulses (variables integrated by Z-FC).

The two outputs can be configured individually.

To detect the faults on the input measurements select alarm mode. Here, it is possible to set the validity range of the measurements. It is enough for one measurement to fall outside the set range to trigger the alarm.

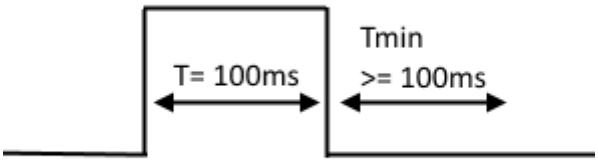
If the notification of the error of a particular measurement is not required, set the values outside the range of measurement of the sensor.

ATTENTION!

The alarm on the digital outputs does not stop the integration of the measurements.

To connect a variable to the pulse output, select pulse mode and enter every how many units the pulse must be sent. The unit depends on the unit of measure selected for that variable in the Display and Datalogger section.

The duration of the pulse is T=100 ms, the minimum waiting time for the next pulse is Tmin=100 ms



10.7. ANALOGUE OUTPUT

The analogue output can transmit to the other devices one of the variables available. Integrated or accounted variables are not available on the analogue output (use the digital pulse output).

Select the type of output, current or voltage, the variable to transmit, and then set the scale:

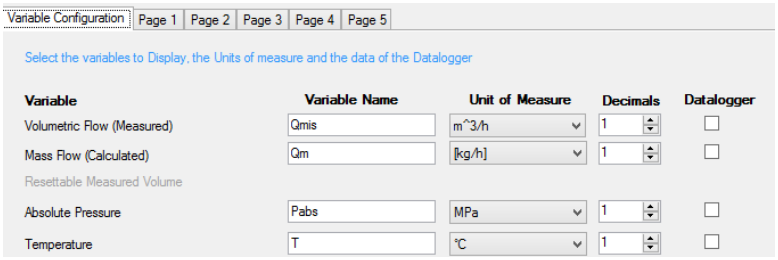
10.8. DISPLAY(Z-FLOWCOMPUTER MODEL ONLY) AND DATALOGGER

The Display and Datalogger section shows all the variables used by the specific application. It is possible to select which ones must be shown on the display, with how many decimal numbers, and in which specific pages.

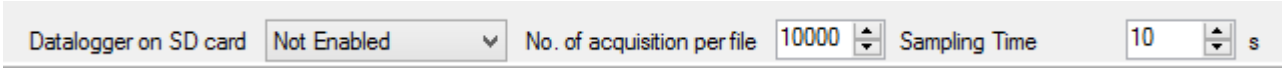
10.8.1. VARIABLE CONFIGURATION

In this section it is possible to select:

- *Which variables to show on the display*
- *Which name to give to the variables displayed*
- *The unit of measure of the variable*
- *How many decimal points must be shown in the variable*
- *If the variable must be logged*



At the end of the selection, it is possible to set the datalogger parameters:



If the datalogger is enabled, all the selected variables will be saved, together with the selected sampling time, in a text file (.CSV format) in the microSD card (/LOG folder).

The parameter "No. of acquisitions per file" indicates the maximum number of acquisitions (lines) before changing the file.

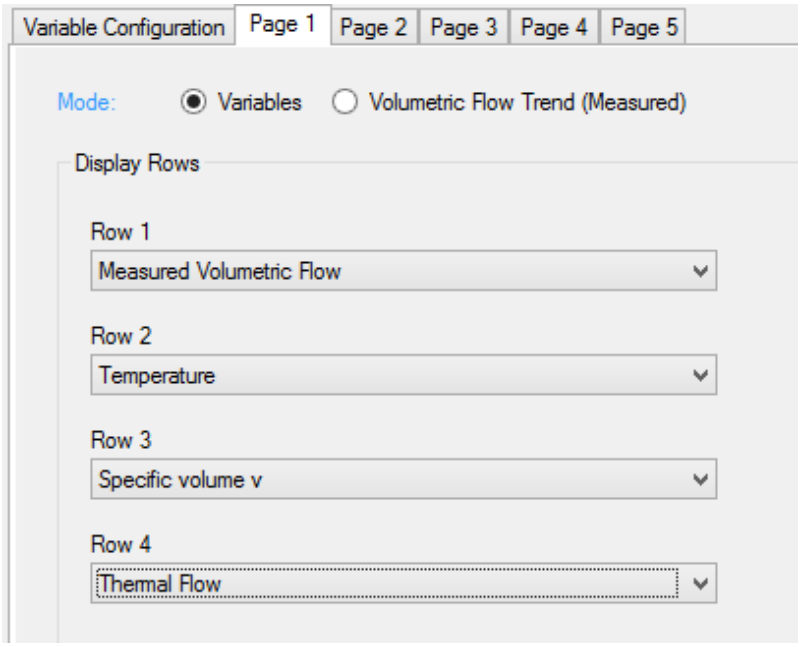
ATTENTION!

Do not remove the microSD card when the datalogger is active! The data stored in the microSD could be lost!

To collect the log files without switching Z-FC off, use the connection to the internal FTP server.

10.8.2. PAGE 1 .. PAGE 5

In this sub-section it is possible to select which variable should be shown in the 5 screens available in the display.



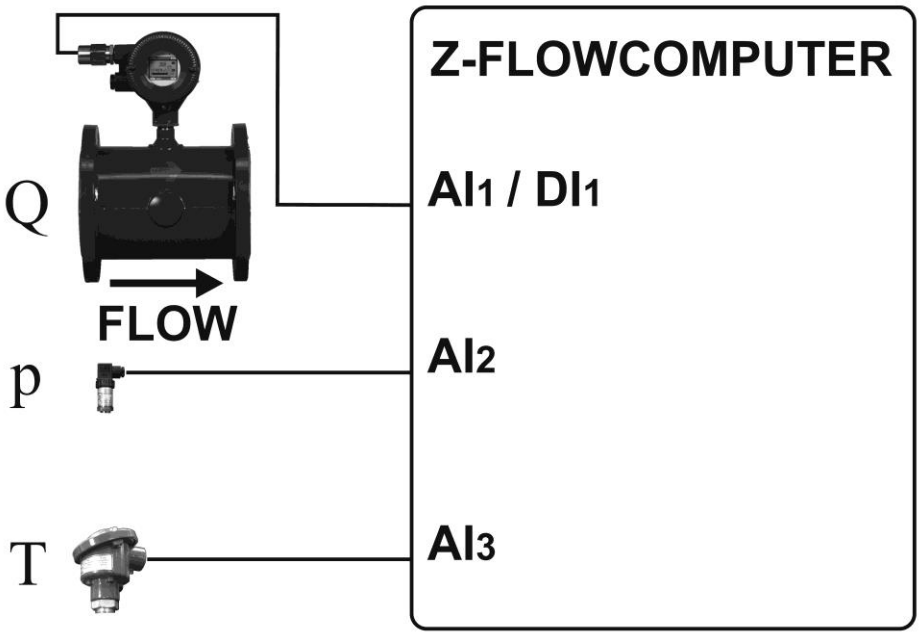
The page mode selects if the variables, or a graphic trend of the input flow, should be displayed.

In variable mode, it is possible to set a "Preset" button of the value of the meter for resettable and accumulated variables (if preset is selected, the operation is password protected).

The password for the preset of meters is 5477.

10.9. CONNECTIONS

Typical connection diagram for the meters for the applications "Volume Corrector ":



10.10. VARIABLES CALCULATED

Nell'applicazione correttore di volume è possibile utilizzare solo misuratori di portata di tipo volumetrico, le variabili calcolate/misurate sono:

In the Volume corrector application you can only use volumetric type flow rate, the calculated / measured variables are:

VARIABLE
Volumetric flow rate Measured
Correct Volumetric flow rate
Absolute pressure
Temperature
Correct Volume
Correct resettable Volume
Volume measured
Measured resettable Volume

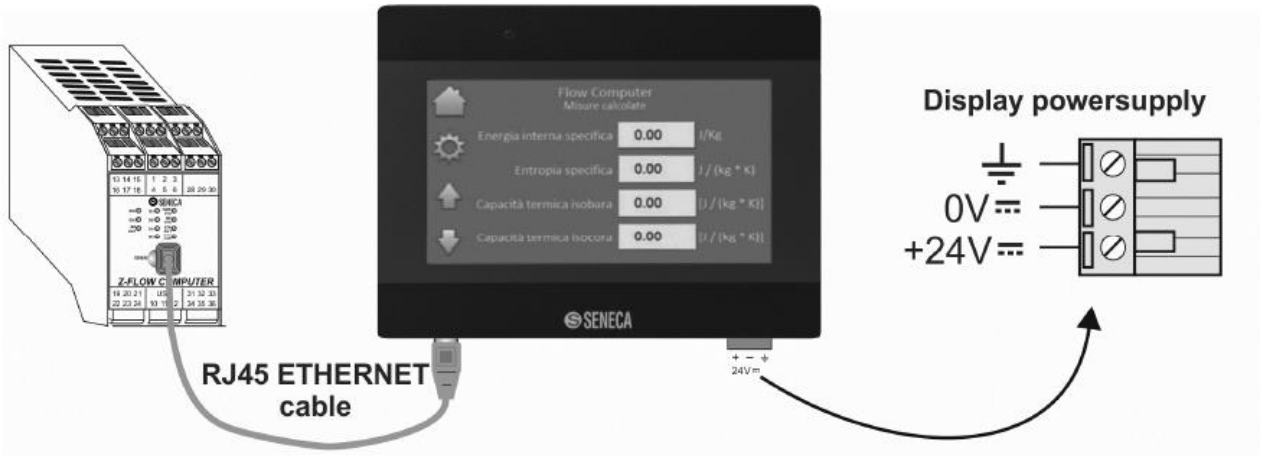
11. VOLUME CORRECTOR FOR IDEAL GASES

Available shortly.

12. USING THE Z-FLOWCOMPUTER DISPLAY(Z-FLOWCOMPUTER MODEL ONLY)

Using the display, it is possible to to view the parameters measured and calculated by Z-FC.

The display must be connected to the power supply and to Z-FC using and Ethernet cable. This is a touch-screen display. Therefore, by touching the relevant sections of the screen, it is possible to interact with the icons and the configurable fields.



For correct operation, the first three values of the IP address of the screen must be the same as those of Z-FC, while the last value will be different.

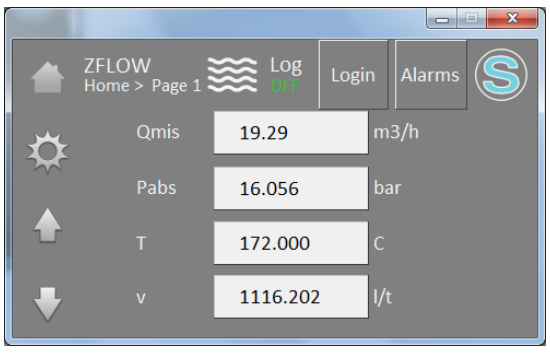
The factory configuration is as follows:

Display IP = 192.168.90.102

Z-FC IP = 192.168.90.101

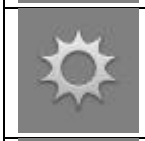
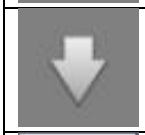
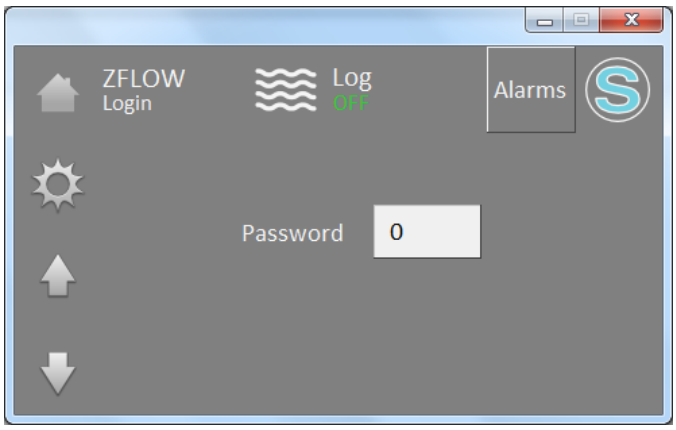
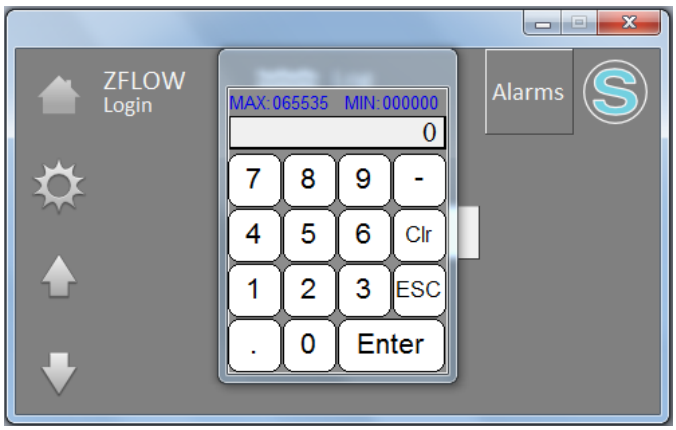
If the display and Z-FC are not connected to the company Ethernet network, changing the above IP addresses is not necessary.

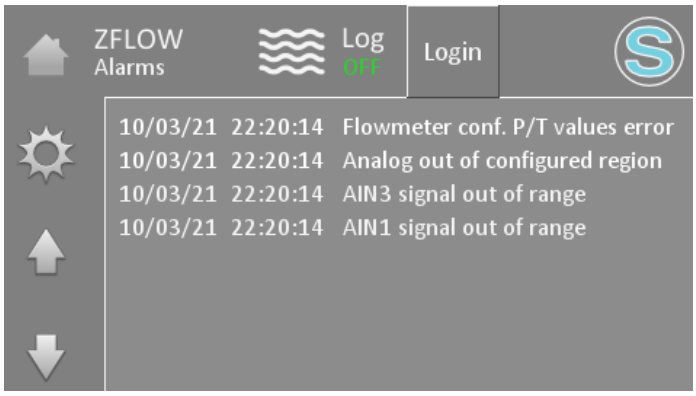
After being switched on, the display appears as shown below.



The touch sensitive icons are along the left and top edges, while at the centre are the variables selected during configuration. These variables are different for each page.

The following table shows the function of each icon

ICON	Action when touched
	Return to page no. 1
	Go to the configuration menu
	Go to the previous page
	Go to the next page
	Prompt to enter the password for authorization to reset the meters. The authorization code is 5477 and cannot be changed.  

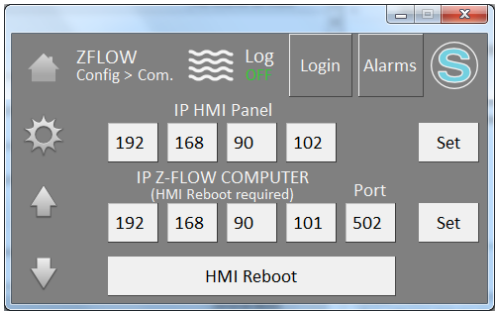
Alarms	Switch to alarm history page  The meaning of the alarms is as follows: - "AIN1 signal out of range". Appears on the screen if the sensor connected to the analogue input is in error or incorrectly connected. - AIN2 signal out of range Appears on the screen if the sensor connected to the analogue input is faulty or incorrectly connected. - AIN3 signal out of range Appears on the screen if the sensor connected to the analogue input is faulty or incorrectly connected. - "Analog out of configured region". Only valid for application "Fluid type" > "Superheated steam". Appears on the screen if the measured pressure (P) and temperature (T) values indicate an operating point that is not under superheated steam conditions. Remedy: Check that the system is in operation and check that the pressure and temperature sensors are correctly installed. - "Flowmeter conf. P/T values error". Appears on the screen if the parameters "Flowmeter calculation conditions" entered via Easy FlowComputer indicate a point P,T that does not belong to the regions (4,Saturated) or (2,Steam) Remedy: Check Easy FlowComputer configuration under "Flow/volume measurement" > "Meter calculation conditions".
	None; it indicates that Z-FC has been programmed using program 1 (water and steam applications)

	None; it indicates that Z-FC has been programmed using program 2 (gas volume correction applications)

12.1. IP ADDRESS SET UP

To set a different address proceed as follows:

- Switch the display on and wait for the initialising procedure to be completed
- Touch the  icon; the display firmware version must appear (HMI ver.)
- Keep touching the  icon until the following page appears:



- Touch the values to amend and enter the new values
- Complete the operation by touching the SET icon.
- Restart the display by touching the HMI Reboot icon.

12.2. DATE/TIME SETTING

The configuration menu of the display can also be used to set the date/time. Set the time and the date to ensure that datalogger provides a correct date/time.

Note:

Thanks to Z-FC the internal batteries, the date and time are preserved also when the device is switched off.

13. The Web server

Z-FC has a built-in web server for advanced configuration purposes.

To access the web server using the Z-FLOWCOMPUTER factory IP address enter:

http://192.168.90.101/maintenance/index.html

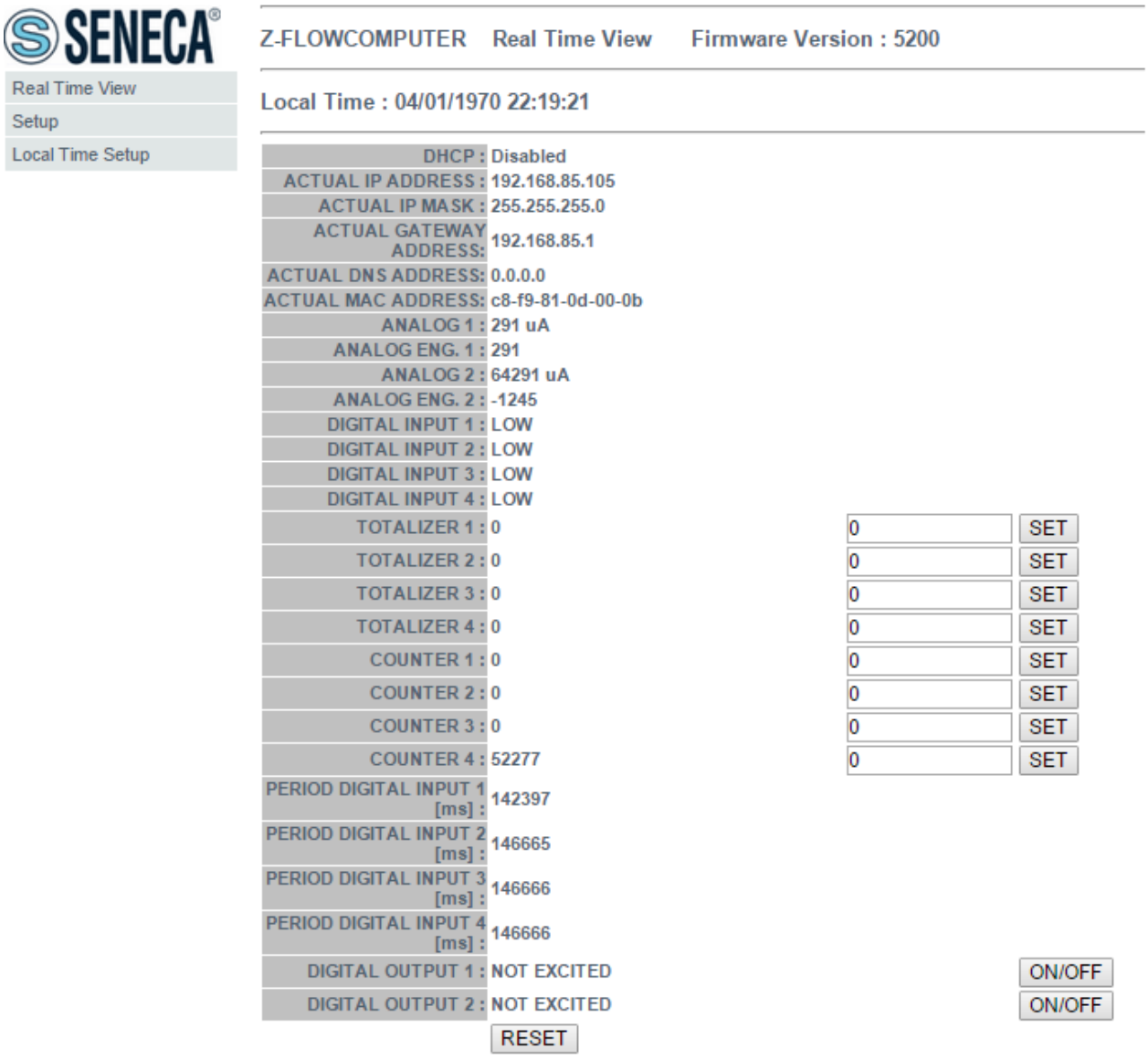
where 192.168.90.101 is the factory address.

13.1. Z-FLOWCOMPUTER ADVANCED CONFIGURATION USING THE WEB SERVER

Using the web server, it is possible to complete some advanced configurations that are not available through the Easy FlowComputer software

13.1.1. REAL TIME VIEW

In this section, it is possible to display in real time some parameters relating to Z-FLOWCOMPUTER and to analogue inputs 1 and 2.



13.1.2. SETUP

In this section, it is possible to configure the Z-FLOWCOMPUTER advanced parameters:

SENECA

Real Time View
Setup
Local Time Setup

Z-FLOWCOMPUTER Setup Firmware Version : 5200

	CURRENT	UPDATED
DHCP	Disabled	Disabled ▼
STATIC IP ADDRESS WHEN DHCP DISABLED	192.168.85.105	192.168.85.105
STATIC IP MASK WHEN DHCP DISABLED	255.255.255.0	255.255.255.0
STATIC GATEWAY ADDRESS WHEN DHCP DISABLED	192.168.85.1	192.168.85.1
DNS ADDRESS	0.0.0.0	0.0.0.0
ANALOG INPUTS SAMPLE TIME [ms]	10	10
INPUT TYPE ANALOG 1	Current	Current [uA] ▼
SAMPLES TO AVERAGE ANALOG 1	32	32
BEGIN SCALE ANALOG 1	0 uA	0
END SCALE ANALOG 1	20000 uA	20000
BEGIN SCALE ENG. ANALOG 1	0	0
END SCALE ENG. ANALOG 1	20000	20000
INPUT TYPE ANALOG 2	Current	Current [uA] ▼
SAMPLES TO AVERAGE ANALOG 2	32	32
BEGIN SCALE ENG. ANALOG 2	0 uA	0
END SCALE ENG. ANALOG 2	20000 uA	20000
BEGIN SCALE ENG. ANALOG 2	0	0
END SCALE ENG. ANALOG 2	20000	20000
WEB SERVER PORT	80	80
WEB SERVER AUTHENTICATION USER NAME	admin	admin
WEB SERVER AUTHENTICATION USER PASSWORD	admin	admin
FTP SERVER PORT	21	21
FTP SERVER AUTHENTICATION USER NAME	admin	admin
FTP SERVER AUTHENTICATION USER PASSWORD	admin	admin
SYNC CLOCK WITH TIME INTERNET	Enabled	ENABLED ▼
SYNC CLOCK UPDATE EVERY	DAY	DAY ▼
NTP SERVER 1 ADDRESS	193.204.114.232	193.204.114.232
NTP SERVER 2 ADDRESS	193.204.114.233	193.204.114.233
DAYLIGHT SAVING TIME	Disabled	DISABLED ▼
GMT	0	0
DIGITAL INPUT TYPE	PNP	PNP ▼
FILTER TIME DIGITAL INPUT 1 [ms]	0	0
FILTER TIME DIGITAL INPUT 2 [ms]	0	0
FILTER TIME DIGITAL INPUT 3 [ms]	0	0
FILTER TIME DIGITAL INPUT 4 [ms]	0	0
FAIL MODE DIGITAL OUTPUTS	Disabled	Disabled ▼
FAIL TIMEOUT DIGITAL OUTPUTS [s]	5	5
DIGITAL OUTPUT 1 STATE WHEN IN FAIL	Not Excited	NOT EXCITED ▼
DIGITAL OUTPUT 2 STATE WHEN IN FAIL	Not Excited	NOT EXCITED ▼
		FACTORY DEFAULT
		APPLY

DHCP

If active, it gives the possibility of obtaining an IP address from a DHCP server (typically the gateway/router) installed on the network.

STATIC IP

The IP address when DHCP mode is not active.

STATIC IP MASK

The network mask used

STATIC GATEWAY ADDRESS

The gateway address.

DNS ADDRESS

The address of the DNS server to use.

ANALOG INPUTS SAMPLE TIME

The analogue input sampling time

INPUT TYPE ANALOG

Select if the input must be a voltage or current input.

SAMPLES TO AVERAGE ANALOG

This is the number of analogue samples used to calculate the average.

BEGIN SCALE ANALOG

This is the input scale start.

END SCALE ANALOG

This is the input scale end

BEGIN ENG. SCALE ANALOG

This is the engineering value connected to the analogue scale start.

END ENG. SCALE ANALOG

This is the engineering value connected to the analogue scale end.

WEB SERVER PORT

This is the port on which the web server service is active.

WEB SERVER AUTHENTICATION USER NAME

This is the user name for access to the web server.

WEB SERVER AUTHENTICATION USER PASSWORD

This is the password for access to the web server.

SYNC CLOCK WITH TIME INTERNET

Enable or disable Internet date/time synchronisation.

SYNC CLOCK UPDATE EVERY

Select the Internet date/time synchronisation interval.

NTP SERVER

Set the Network Time Protocol server to obtain the date/time from the Internet.

DAYLIGHT SAVING TIME

Enable or disable the automatic switch to daylight saving time (European legal time).

GMT

Set the offset in relation to the Greenwich mean time (example: Italy +1).

DIGITAL INPUTS TYPE

Select if the digital input must be PNP or NPN type.

FILTER TIME DIGITAL INPUT

Set an ms filter on the digital inputs.

FAIL MODE DIGITAL OUTPUTS

Not used.

FAIL TIMEOUT DIGITAL OUTPUTS (s)

Not used.

DIGITAL OUTPUT STATE WHEN IN FAIL

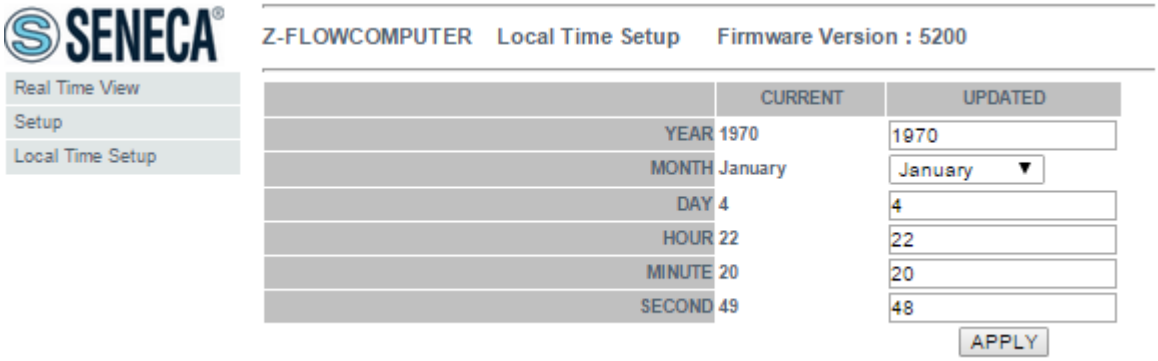
Not used.

FACTORY DEFAULT

Return all the parameters to the factory values

13.1.3. LOCAL TIME SETUP

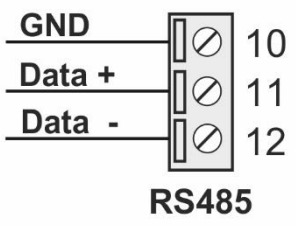
This section can be used to set the parameters regarding the local time and the day of the year.


SENECA
Real Time View
Setup
Local Time Setup
Z-FLOWCOMPUTER Local Time Setup Firmware Version : 5200
CURRENT
UPDATED
YEAR 1970 1970
MONTH January January
DAY 4 4
HOUR 22 22
MINUTE 20 20
SECOND 49 48
APPLY

14. THE MODBUS RTU AND THE MODBUS TCP-IP PROTOCOLS

Z-FLOWCOMPUTER supports Modbus RTU Slave and Modbus TCP-IP server protocols.

The Modbus RTU protocol is available from terminal 11-11-12 (serial RS485) and the USB port.



The Modbus TCP-IP protocol can be supported through the internet from port IP 502. One Modbus TCP client is supported.

For more information refer to the Modbus specifications.

http://www.modbus.org/specs.php

Holding Register type registers are supported, with the understanding that the first register (0 offset register) is register 40001.

For REAL32 variables (single precision floating point):

the variables have the most significant part in the lowest Modbus register. For example, variable Q is found in holding registers 41100 (most significant part) and 41101 (least significant part), which is Modbus register 1099 and 1100.

For UNSIGNED INT32 variables (32 bit whole without sign):

the variables have the most significant part in the lowest Modbus register. For example, variable CMD_AUX1 is found in holding registers 43005 (most significant part) and 43006 (least significant part), which is Modbus register 3004 and 3005.

14.1. TABLE OF THE MODBUS REGISTERS

VARIABLE	*MODBUS REGISTER (HOLDING REGISTER)*	*NUMBER REGISTERS*	*FORMAT*	*DESCRIPTION*	*TYPE R = READING ONLY R/W = READING/WRITING*
Q	41100-41101	2	REAL 32	Volumetric flow	R
Vmeas_par	41102-41103	2	REAL 32	Volume measured (resettable)	R
Vmeas	41104-41105	2	REAL 32	Volume measured (non resettable)	R
P	41106-41107	2	REAL 32	Absolute pressure	R
T	41108-41109	2	REAL 32	Delivery temperature	R
v	41110-41111	2	REAL 32	Specific volume	R
rho	41112-41113	2	REAL 32	Density	R
u	41114-41115	2	REAL 32	Specific Internal energy	R
s	41116-41117	2	REAL 32	Specific entropy	R
h	41118-41119	2	REAL 32	Specific enthalpy	R
cp	41120-41121	2	REAL 32	Specific isobaric heat capacity	R
cv	41122-41123	2	REAL 32	Specific isochoric heat capacity	R
Qm	41124-41125	2	REAL 32	Mass flow	R
QT	41126-41127	2	REAL 32	Thermal flow	R
TE_par	41128-41129	2	REAL 32	Thermal energy (resettable)	R
TE	41130-41131	2	REAL 32	Thermal energy (non resettable)	R
SE_par	41132-41133	2	REAL 32	Specific Energy (resettable)	R

SE	41134-41135	2	REAL 32	Specific energy (non resettable)	R
TD	41136-41137	2	REAL 32	Temperature difference	R
Dh	41138-41139	2	REAL 32	Enthalpy difference	R
Vref_par	41140-41141	2	REAL 32	Corrected volume (resettable)	R
Vref	41142-41143	2	REAL 32	Corrected volume (non resettable)	R
M_par	41144-41145	2	REAL 32	Mass (resettable)	R
M	41146-41147	2	REAL 32	Mass (non resettable)	R
T2	41148-41149	2	REAL 32	Temperature 2	R
Qref	41150-41151	2	REAL 32	Corrected volumetric flow	R
CMD_REG	42000	1	UNSIGNED INT 16	Command register	R/W
CMD_AUX1	43005-43006	2	UNSIGNED INT 32	Value to load - whole part	R/W
CMD_AUX2	43007-43008	2	REAL 32	Value to load - fractional part	R/W

14.2. FORWARDING OF COMMANDS USING THE MODBUS PROTOCOL

Z-FC commands can be sent using the CMD_REG register. Below is the list of supported commands:

COMMAND ***(hexadecimal value)***	***DESCRIPTION***
0xBEC1	Loads the value of the CMD_AUX1 register as a whole and that of CMD_AUX2 as fraction of the resettable volume variable.
0xBEC2	Loads the value of the CMD_AUX1 register as a whole and that of CMD_AUX2 as fraction of the non-resettable volume variable.
0xBEC3	Loads the value of the CMD_AUX1 register as a whole and that of CMD_AUX2 as fraction of the resettable thermal energy variable.
0xBEC4	Loads the value of the CMD_AUX1 register as a whole and that of CMD_AUX2 as fraction of the non-resettable thermal energy variable.
0xBEC5	Loads the value of the CMD_AUX1 register as a whole and that of CMD_AUX2 as fraction of the resettable specific energy variable.
0xBEC6	Loads the value of the CMD_AUX1 register as a whole and that of CMD_AUX2 as fraction of the non-resettable specific energy variable.
0xBEC7	Loads the value of the CMD_AUX1 register as a whole and that of CMD_AUX2 as fraction of the resettable corrected volume variable.
0xBEC8	Loads the value of the CMD_AUX1 register as a whole and that of CMD_AUX2 as fraction of the non-resettable corrected volume variable.
0xBEC9	Loads the value of the CMD_AUX1 register as a whole and that of CMD_AUX2 as fraction of the resettable mass flow variable.
0xBECA	Loads the value of the CMD_AUX1 register as a whole and that of CMD_AUX2 as fraction of the non-resettable mass flow variable.
0xABC0	Stops the datalogger (must be enabled).
0xABC1	Starts the datalogger (must be enabled).

15. Z-FC AND DISPLAY (Z-FLOWCOMPUTER MODEL ONLY) FIRMWARE AND SOFTWARE UPDATE

The Z-FC firmware can be updated using the internal ftp server or the microSD card.

15.1. Z-FC firmware update

15.1.1. Updating the firmware from the FTP server

To update the Z-FC firmware from the FTP server, it is necessary to insert a microSD card formatted using a FAT16 or FAT32 file system.

Connect to the Z-FC FTP server and copy the "zflow.bin" file with the new firmware in the main folder (root) of the FTP server.

Once the transfer of the file has been completed, Z-FC will turn on the 4 red LEDs and will start to update the firmware on the internal flash (duration 30 seconds).

At the end Z-FC will restart with the new software.

ATTENTION!

Do not switch off Z-FlowComputer before completing the firmware update procedure!

15.1.2. Firmware update using the microSD card

To update the firmware using the microSD card follow this procedure:

- *Switch off Z-FC*
- *Copy the "zflow.bin" file in the main folder (root) of the microSD (use a PC with a SD card reader)*
- *Insert the microSD card in Z-FC*
- *Switch on Z-FC*
- *Z-FC will turn on the 4 red LEDs and will start to update the software on the internal flash (duration about 30 seconds). At the end Z-FC will restart with the new software.*
- *The "zflow.bin" file will be deleted automatically from the microSD card.*

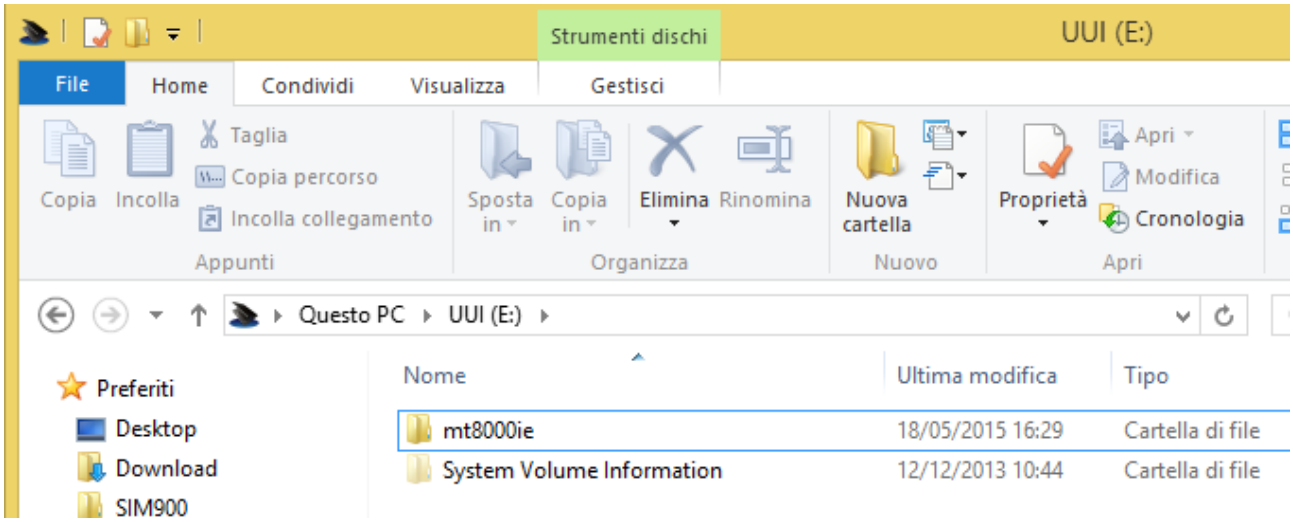
ATTENTION!

Do not switch off Z-FlowComputer before completing the firmware update procedure!

15.2. Display (Z-FLOWCOMPUTER MODEL ONLY) software update

It is possible to update the Z-FC display software using the following procedure. For this procedure, a USB flash drive is required.

- *Copy the mt8000ie folder and its content in the main folder of the USB flash drive:*



- *Switch the display on and insert the USB flash drive in the USB port of the display.*
- *A menu will appear on the display. Select "Download".*
- *Enter password 111111 and confirm.*
- *Select "USB Disk" and "Disk_a_1" and press OK.*
- *At the end of the operation the display returns to normal operation.*
- *Remove the USB flash drive from the display*

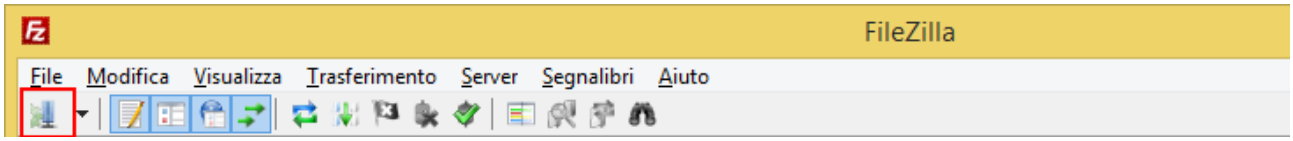
16. CONNECTION TO THE Z-FLOWCOMPUTER FTP SERVER

Z-FC has a FTP server. To access it, Seneca recommends the use of Filezilla Client.

Download the Filezilla Client from:

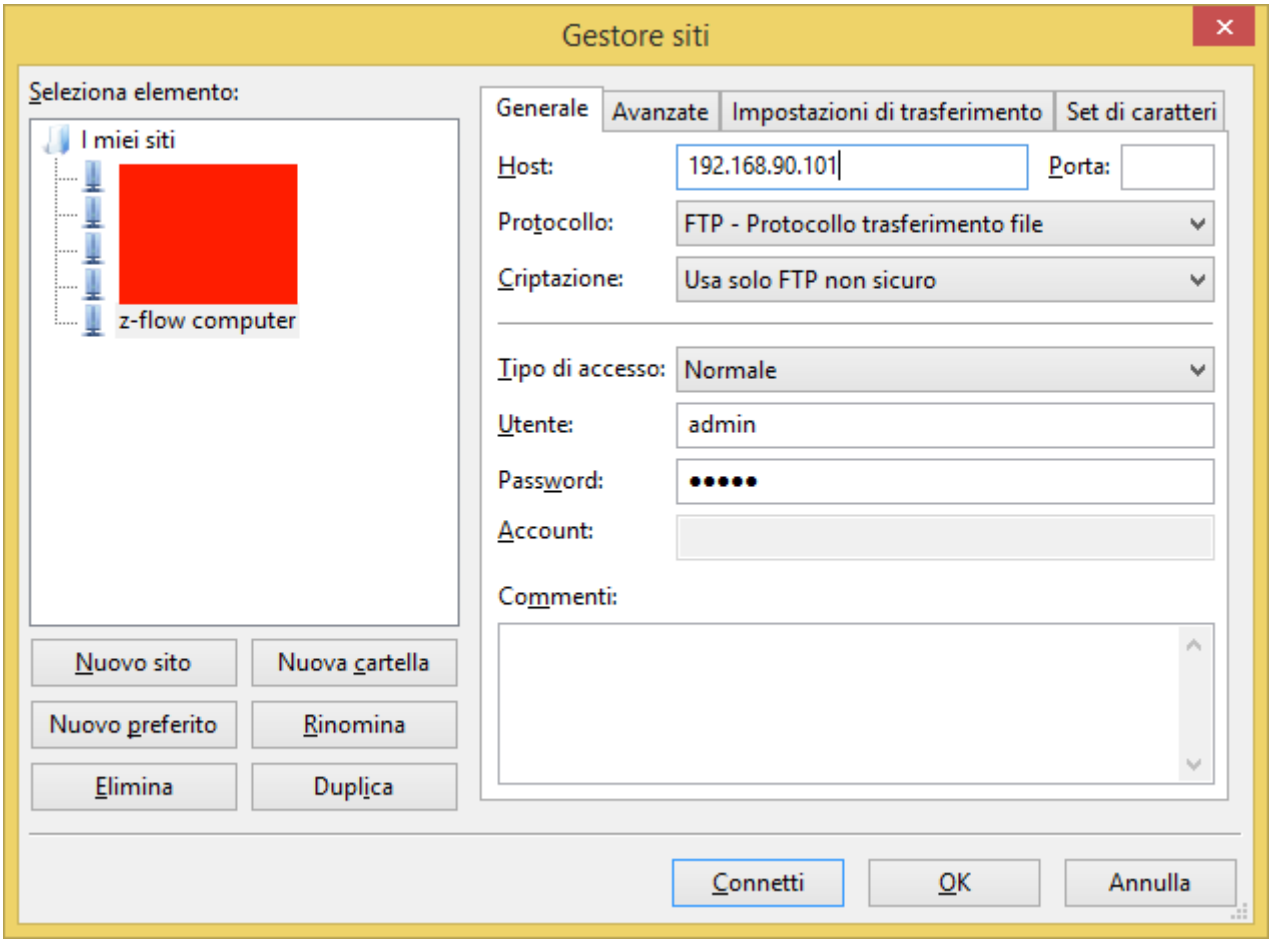
https://filezilla-project.org/download.php?show_all=1

Launch the installation and configure a new site:

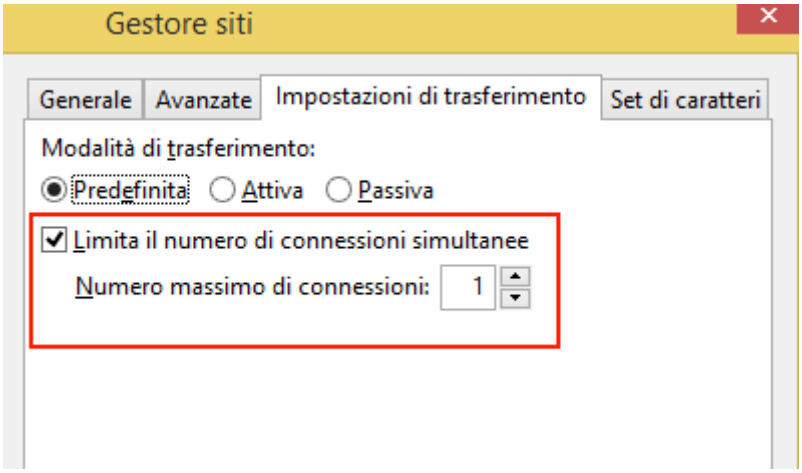


Enter the Z-FC IP (default 192.168.90.101) and the access credentials

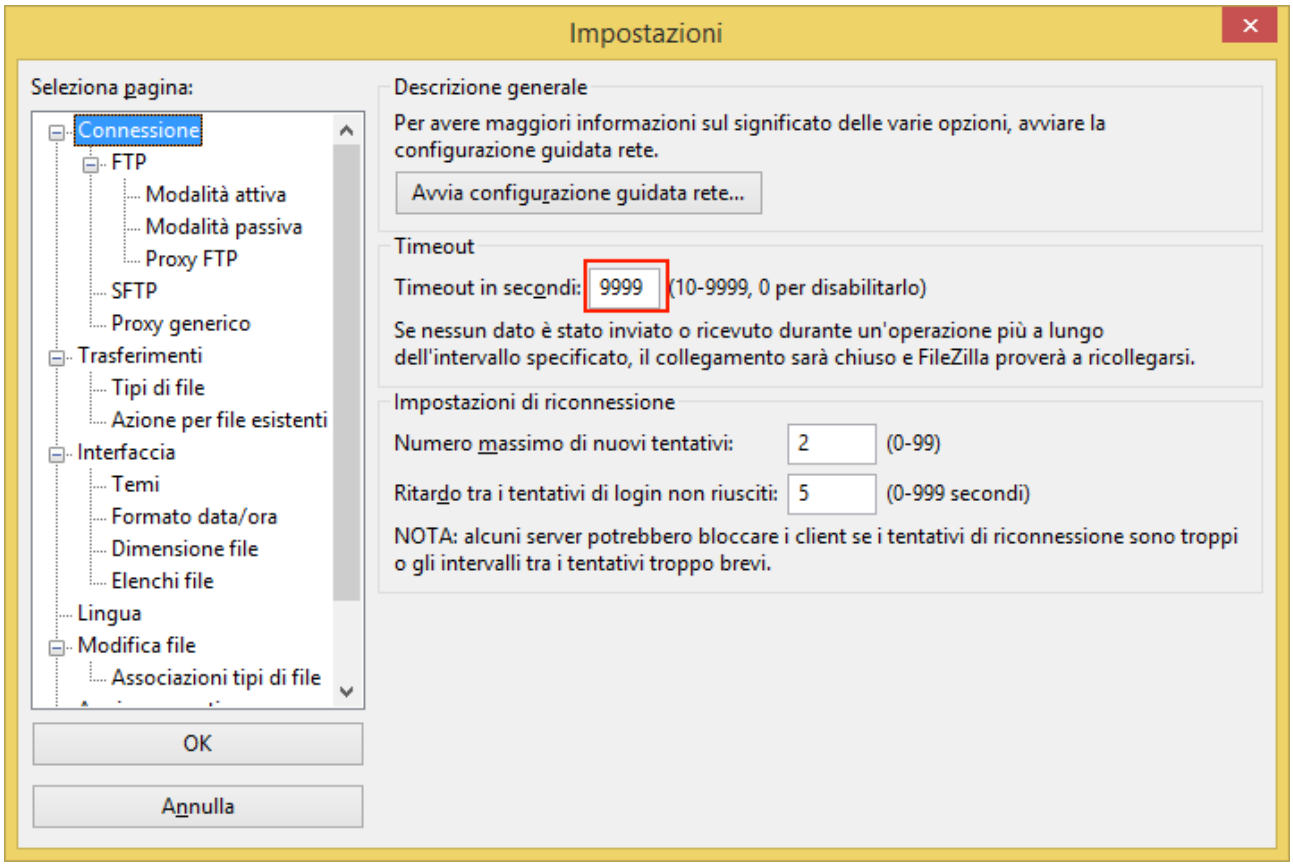
(default User: admin; Password: admin):



In the Transfer Settings section limit the maximum number of connections to 1:



Now in the main filezilla menu increase the maximum timeout to 999 seconds: Edit -> Settings


Impostazioni
Seleziona pagina:
Connessione
FTP
Modalità attiva
Modalità passiva
Proxy FTP
SFTP
Proxy generico
Trasferimenti
Tipi di file
Azione per file esistenti
Interfaccia
Temi
Formato data/ora
Dimensione file
Elenchi file
Lingua
Modifica file
Associazioni tipi di file
OK
Annulla
Descrizione generale
Per avere maggiori informazioni sul significato delle varie opzioni, avviare la configurazione guidata rete.
Avvia configurazione guidata rete...
Timeout
Timeout in secondi: 9999 (10-9999, 0 per disabilitarlo)
Se nessun dato è stato inviato o ricevuto durante un'operazione più a lungo dell'intervallo specificato, il collegamento sarà chiuso e FileZilla proverà a ricollegarsi.
Impostazioni di riconnessione
Numero massimo di nuovi tentativi: 2 (0-99)
Ritardo tra i tentativi di login non riusciti: 5 (0-999 secondi)
NOTA: alcuni server potrebbero bloccare i client se i tentativi di riconnessione sono troppi o gli intervalli tra i tentativi troppo brevi.

17. CALCULATION STANDARDS USED

17.1. IAPWS-IF 97 CALCULATION STANDARD

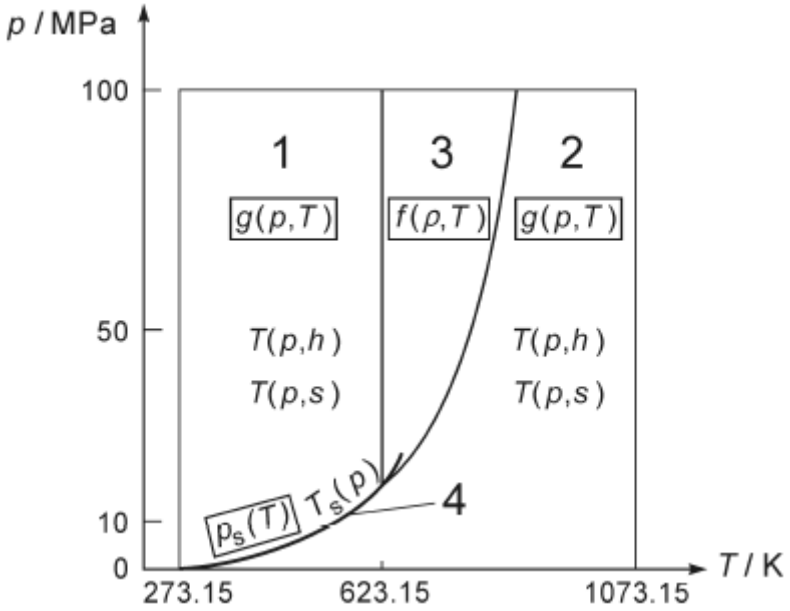
The applications of program 1 are based on the calculation standard IAPWS Industrial Formulation 1997.

The implementation used on Z-FC is valid for the following pressure and temperature ranges:

Temperature >= 0°C and <= 800°C

Pressure >= 0 MPa and <= 100 MPa

Within this range, 4 regions are identified, each characterised by different equations.



17.1.1. REGIONS IDENTIFIED BY IAPWS-IF 97

Region 1 represents water in liquid state.

Region 2 represents steam state.

Region 2 identifies the thermodynamic state near the critical point.

Region 4 is represented by the saturation curve (saturated fluid).

Regions 1 and 2 are each represented by a fundamental equation for the the Gibbs specific free energy g(p,T).

Region 3 is represented by a fundamental equation for the Helmholtz specific free energy f(ρ,T) (where p is density).

Region 4 is represented by a Ps(T) equation or by a Ts(P) equation.

The thermodynamic quantity calculated by Z-FC depends on the region in which they are calculated. In particular:

Thermodynamic quantities calculated in Region 1 (water in liquid state)

Specific volume (v)
Density (1/v)
Specific internal energy (u)
Specific entropy (s)
Specific enthalpy (h)
Specific isobaric heat capacity (cp)

Thermodynamic quantities calculated in Region 2 (steam)

Specific volume (v)
Density (1/v)
Specific internal energy (u)
Specific entropy (s)
Specific enthalpy (h)
Specific isobaric heat capacity (cp)

Thermodynamic quantities calculated in Region 3 (thermodynamic status near the critical point)

Density (1/v)
Specific internal energy (u)
Specific entropy (s)
Specific enthalpy (h)
Specific isochoric heat capacity (cv)

Thermodynamic quantities calculated in Region 4 (saturation curve)

Specific volume (v)
Density (1/v)
Specific internal energy (u)
Specific entropy (s)
Specific enthalpy (h)
Specific isobaric heat capacity (cp)

17.2. EQUATION OF STATE OF IDEAL GAS

In general, using the approximation of ideal gases it's possible to obtain a function of this type:

Qb = Q * (P / Pb) * (Tb / T) * (Zb / Z)

Where:

Qb = flow rate at base conditions

Q = flow to working conditions

Tb = temperature at base conditions

T = temperature at working conditions

Zb = compressibility at base conditions

Z = compressibility at working conditions

Since for an ideal gas the Zb / Z = 1, the equation simplifies to:

Qb = Q * (P / Pb) * (Tb / T)

So, it's possible to obtain the volume compensation from the working conditions (P, T) into the basic conditions (Pb, Tb).

17.3. EQUATION OF STATE OF REDLINCH-KWONG AND REDLINCH-KWONG-SOAVE (RK, RKS)

17.3.1. EQUATION OF STATE OF REDLINCH-KWONG

Introduced in 1949 the Redlich-Kwong equation of state was a considerable improvement over other equations of the time.

Although superior to the equation of van der Waals, it is not very precise in relation to the liquid phase and therefore can not be used for an accurate calculation of the vapor-liquid equilibria.

However it can be used for this purpose with the aid of separate correlations for the liquid phase.

The Redlich-Kwong equation of state is adequate for the calculation of the properties of gases where the pressure and the critical pressure ratio is less than half of the ratio between the temperature and the critical temperature.

Starting from the state equation of van der Waals:

$$P = \frac{RT}{v-b} - \frac{a}{v^2}$$

Where:

P = absolute pressure

T = absolute temperature

$$R = 8{,}314472\ \frac{\mathrm{J}}{\mathrm{mol}\cdot\mathrm{K}}$$

v = molar volume

a and b = constants of van der Waals.

This can be expressed in terms of the compressibility factor z:

$$z = \frac{v}{v-b} - \frac{a}{RTv}$$

Now, the term:

$$\frac{a}{RTv}$$

It also said attractive term.

The attractive term is modified by Redlich-Kwong as:

$$\frac{a}{(v+b)RT^{1,5}}$$

17.3.1. *EQUATION OF STATE OF* REDLINCH-KWONG-SOAVE

Soave (1972) has substantially modified the temperature dependence by using a function a(T) in the attractive term:

$$\frac{a(T)}{(v+b)RT}$$

Where a(T):

$$a(T) = 0,4274 \frac{R^2 T_C^2}{P_C} \left[1 + m\left(1 - T_R^{0,5}\right)\right]^2$$

Tc = Critic Temperature of the gas

Pc = Critic Pressure of the Gas

Tr = T / Tc

$$m = 0,480 + 1,57\omega - 0,176\omega^2$$

ω is the acentric factor (depending from the gas).

This change has permission to reproduce the vapor pressure of apolar substances, especially for values above 1 bar, with remarkable accuracy.

17.4. CALCULATION STANDARD - SGERG88 (ISO 12213-3)

The calculation uses the standard ISO 12213-3 “Natural gas - Calculation of compression factor - Part 3: Calculation using physical properties”.

The method uses equations which are based on the concept that the natural gas in the pipeline can be characterized solely for the calculation of its volumetric properties by an appropriate set of measurable physical properties. These features, together with the pressure and temperature, are used as input data for the method.

The method uses the following physical characteristics:

gross calorific value, relative density and carbon dioxide content.

The method is particularly useful in the common situation in which the total molar composition is not available, but may also be preferred for its relative simplicity.

For gases with a synthetic additive, the hydrogen content must be known.

17.4.1. TYPE OF GAS

The calculation method is valid only for gases which are within the following ranges:

absolute pressure 0 MPa <= p <= 12 MPa
temperature 263 K <= T <= 338 K
mole fraction of carbon dioxide 0 <= xCO2 <= 0,20
mole fraction of hydrogen 0 <= xH2 <= 0,10
superior calorific value 30 MJ·m−3 <= Hs <= 45 MJ·m−3
relative density 0,55 <= d <= 0,80

The molar fractions of other natural gas components are not required as input.
The following molar fractions, however, must remain within the following ranges:

methane 0,7 <= xCH4 <= 1,0
nitrogen 0 <= xN2 <= 0,20
ethane 0 <= xC2H6 <= 0,10
propane 0 <= xC3H8 <= 0,035
butanes 0 <= xC4H10 <= 0,015
pentanes 0 <= xC5H12 <= 0,005
hexanes 0 <= xC6 <= 0,001
heptanes 0 <= xC7 <= 0,0005
octanes plus higher hydrocarbons 0 <= xC8+ <= 0,0005
carbon monoxide 0 <= xCO <= 0,03
helium 0 <= xHe <= 0,005
water 0 <= xH2O <= 0,00015

The method is applicable only to mixtures in the gas state above the dew point at the conditions of temperature and pressure of interest.

For the pipeline gas, the method is applicable over wider ranges of temperature and pressure, but with greater uncertainty.

The extended range on which the method it's tested is:

absolute pressure 0 MPa <= p <= 12 MPa
temperature 263 K <= T <= 338 K
mole fraction of carbon dioxide 0 <= xCO2 <= 0,30
mole fraction of hydrogen 0 <= xH2 <= 0,10
superior calorific value 20 MJ·m−3 <= Hs <=u 48 MJ·m−3
relative density 0,55 <= d <= 0,90

It's also possible to expand mole fractions:

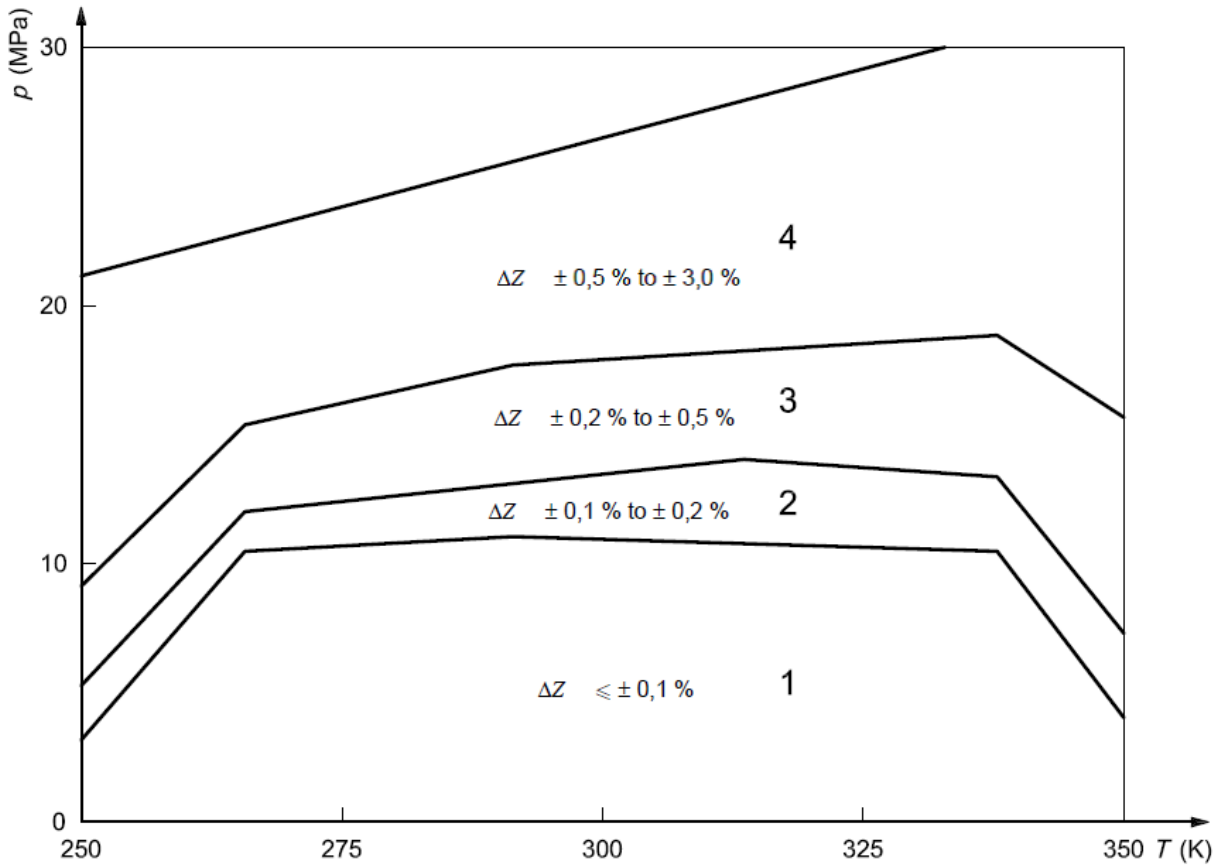
methane 0,5 <= xCH4 <= 1,0
nitrogen 0 <= xN2 <= 0,50
ethane 0 <= xC2H6 <= 0,20
propane 0 <= xC3H8 <= 0,05
butanes 0 <= xC4H10 <= 0,015
pentanes 0 <= xC5H12 <= 0,005

hexanes 0 <= xC6 <= 0,001
heptanes 0 <= xC7 <= 0,0005
octanes plus higher hydrocarbons 0 <= xC8+ <= 0,0005
carbon monoxide 0 <= xCO <= 0,03
helium 0 <= xHe <= 0,005
water 0 <= xH2O <= 0,00015

The method, therefore, can not be used outside of these ranges.

17.4.2. UNCERTAINTY

The uncertainty calculated ΔZ for the NOT extended range is represented in the figure:



For the calculation in the extended range, please refer to ISO 12213-3 Annex F.

17.5. CALCULATION STANDARD - AGA8 GROSS METHOD 2

The calculation uses the standard document issued by AGA-8 at the end of 1992, it allows to calculate the compressibility not as detailed on the ISO 12213-2 standard but, it follows the guidelines of ISO 12213-1.

The calculation standard requires the following data for the gas in question:

-Gas Relative Density

- CO2 Molar fraction [mol %]

- N2 Molar fraction [mol %]

17.5.1. TYPE OF GAS

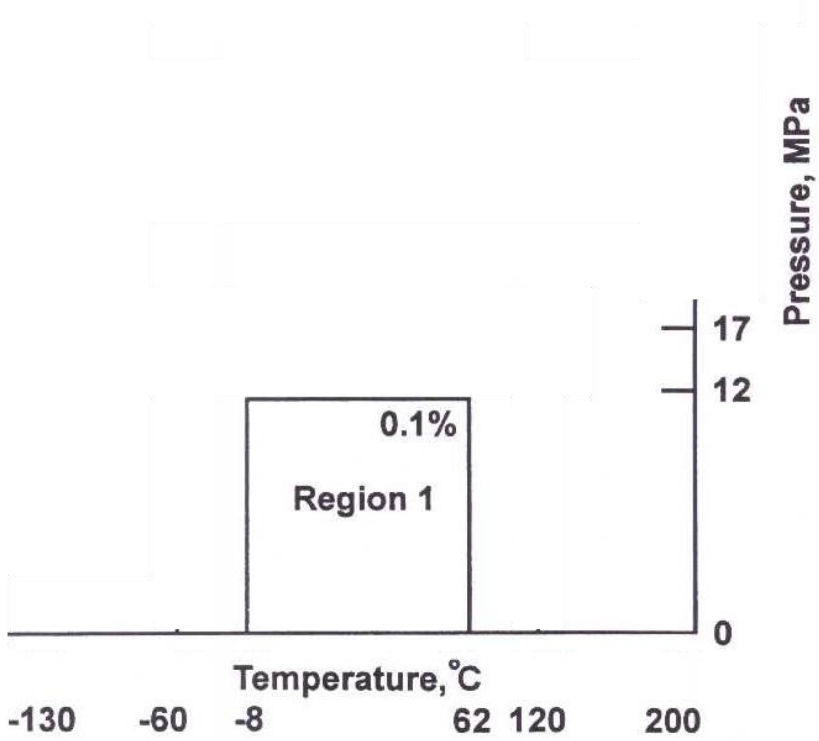
The calculation method is only valid for gases which are within the following ranges:

Quantity	Normal Range
Relative Density*	.554 to .87
Gross Heating Value**	477 to 1150 Btu/scf
Gross Heating Value***	18.7 to 45.1 MJ/m^3
Mole Percent Methane	45.0 to 100.0
Mole Percent Nitrogen	0 to 50.0
Mole Percent Carbon Dioxide	0 to 30.0
Mole Percent Ethane	0 to 10.0
Mole Percent Propane	0 to 4.0
Mole Percent Total Butanes	0 to 1.0
Mole Percent Total Pentanes	0 to 0.3
Mole Percent Hexanes Plus	0 to 0.2
Mole Percent Helium	0 to 0.2
Mole Percent Hydrogen	0 to 10.0
Mole Percent Carbon Monoxide	0 to 3.0
Mole Percent Argon	#
Mole Percent Oxygen	#
Mole Percent Water	0 to 0.05
Mole Percent Hydrogen Sulfide	0 to 0.02

* Reference Condition: Relative density at 60°F,14.73 psia
** Reference Conditions: Combustion at 60°F,14.73 psia; density at 60°F,14.73 psia.
*** Reference Conditions: Combustion at 25°C,0.101325 MPa; density at 0°C,0.101325 MPa.
# The normal range is considered to be zero for these compounds.

17.5.2. UNCERTAINTY

The American Gas Association has calculated the uncertainty of the calculation in the region 1 shown here:



L 'American Gas Association recommends, however, the use of the algorithm for calculation of the temperatures between 0 ° C and 55 ° C with a maximum pressure of 8.3 MPa.

17.6. CALCULATION STANDARD - AGA8 92-DC (ISO 12213-2)

The calculation standard is described in ISO 12213-2 “Natural gas Calculation of compression factor - Part 2: Calculation using molar-composition analysis”.

ISO 12213-2 specifies a method for the calculation of compression factors when the detailed composition of the gas by mole fractions is known, together with the relevant pressures and temperatures.

This analysis, together with the pressure and temperature, are used as input data for the method.

The method uses a molar analysis in which all components are present in an amount greater than the molar fraction of 0.00005.

17.6.1. TYPE OF GAS

The ranges for the application of the method are:

absolute pressure MPa 0 <= p <= 12 MPa

temperature 263 K <= T <= 338 K

Superior calorific value 30 MJm-3 <= HS <= 45 MJm-3

relative density 0.55 <= d <= 0.80

The molar fractions of natural gas components must be in the following ranges:

methane 0.7 <= xCH4 <= 1,00

nitrogen 0 <= XN2 <= 0.20

carbon dioxide 0 <= xCO2 <= 0.20

ethane 0 <= xC2H6 <= 0.10

propane 0 <= xC3H8 <= 0.035

butanes 0 <= xC4H10 <= 0.015

pentanes 0 <= xC5H12 <= 0.005

hexanes 0 <= XC6 <= 0.001

Heptanes 0 <= XC7 <= 0.0005

octanes plus higher hydrocarbons 0 <= XC8 + <= 0.0005

hydrogen 0 <= XH2 <= 0.10

carbon monoxide 0 <= XCO <= 0.03

helium 0 <= XHE <= 0.005

Water 0 <= xH2O <= 0.000 15

Each component for which xi is less than 0.00005 may be overlooked.

The method is applicable only to mixtures in the gaseous state above the dew point of interest under the conditions of temperature and pressure.

The application range tested beyond the limits given above is:

absolute pressure MPa 0 <= p <= 65 MPa

temperatures 225 K <= T <= 350 K

relative density 0.55 <= d <= 0.90

Superior calorific value 20 MJ·m-3 <= HS <= 48 MJ·m-3

The molar fractions of natural gas components must be in the following ranges:

methane 0.50 <= xCH4 <= 1,00

nitrogen 0 <= XN2 <= 0.50

carbon dioxide 0 <= xCO2 <= 0.30

ethane 0 <= xC2H6 <= 0.20

propane 0 <= xC3H8 <= 0.05

hydrogen 0 <= XH2 <= 0.10

butanes 0 <= xC4H10 <= 0.015

PENTANES 0 <= xC5H12 <= 0.005

hexanes 0 <= XC6 <= 0.001

Heptanes 0 <= XC7 <= 0.0005

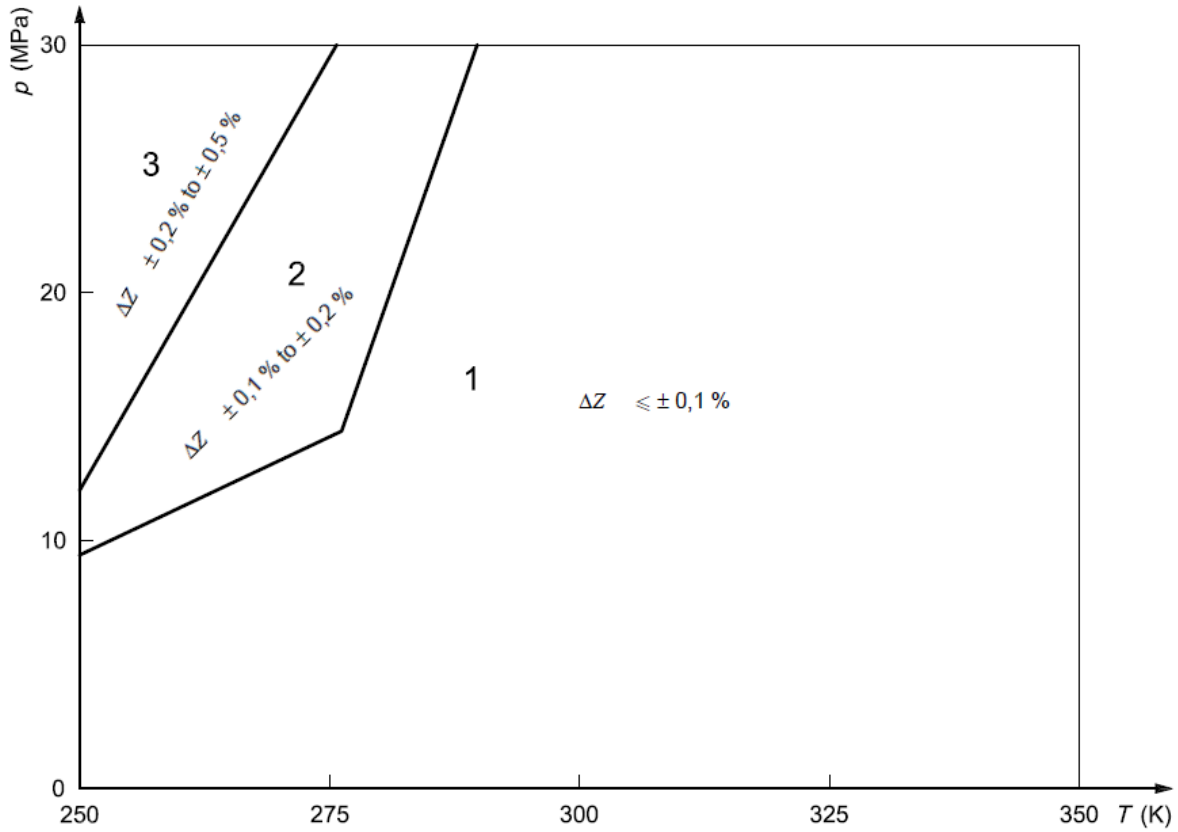
OCTANES plus higher hydrocarbons 0 <= XC8 + <= 0.0005

helium 0 <= XHE <= 0.005

Water 0 <= xH2O <= 0.000 15

17.6.2. UNCERTAINTY

The uncertainty calculated ΔZ for the NOT extended range is represented in the figure:



For the uncertainty calculation in the extended range, please refer to ISO 12213-2 Annex E.

18. ALGORITHM VERIFICATION FOR AGA8 GROSS METHOD 2

The following table shows the calculation results for the algorithm implemented on Z-FLOWCOMPUTER and values indicated in the document "Compressibility Factors of Natural Gas and Other Related Hydrocarbon Gases, Transmission Measurement Committee Report No. 8", Second edition, November 1992 Table B.6-4.

Conditions of gas-based: P = 14.73 psia, T = 60 F

Gas Types:

	GULF	***AMARILLO***	***EKOFISK***	***HIGH N2***	***HIGH CO2 & N2***
Gr	0,581078	0,608657	0,649521	0,644869	0,686002
N2 (mole %)	0,2595	3,1284	1,0068	13,4650	5,7021
CO2 (mole %)	0,5956	0,4676	1,4954	0,9850	7,5851

Compressibility factor calculated with method 2, in green the values provided in the table B.6-4 in comparison with the result obtained by Z-FLOWCOMPUTER (rounded to the 5th decimal place).

Conditions of the gas used in the algorithm based: Pressure = 14.73 psia, Temperature = 60 F

T [F]	*P [psia]*	*Gulf Coast (AGA8)*	*Gulf Coast (Z-FC)*	*Amarillo (AGA8)*	*Amarillo (Z-FC)*	*Ekofisk (AGA8)*	*Ekofisk (Z-FC)*	*High N2 (AGA8)*	*High N2 (Z-FC)*	*High Co2 (AGA8)*	*High Co2 (Z-FC)*
32	14,73	0.997408	0.997408	0,997310	0,99731	0,996794	0,99679	0,997682	0,99768	0,997222	0,99722
32	100	0.982375	0.982375	0,981701	0,98170	0,978120	0,97812	0,984272	0,98427	0,981083	0,98108
32	200	0.964691	0.964691	0,963323	0,96332	0,955976	0,95598	0,968582	0,96858	0,962048	0,96205
32	400	0.929268	0.929268	0,926463	0,92646	0,910983	0,91098	0,937449	0,93745	0,923738	0,92374
32	600	0.894059	0.894059	0,889768	0,88977	0,865334	0,86533	0,906940	0,90694	0,885400	0,88540
32	800	0.859563	0.859563	0,853785	0,85379	0,819681	0,81968	0,877516	0,87752	0,847573	0,84757
32	1000	0.826501	0.826501	0,819323	0,81932	0,775240	0,77524	0,849774	0,84977	0,811099	0,81110
32	1200	0.795840	0.795840	0,787484	0,78748	0,734024	0,73402	0,824432	0,82443	0,777179	0,77718
50	14,73	0.997705	0.997705	0,997618	0,99762	0,997151	0,99715	0,997957	0,99796	0,997540	0,99754
50	100	0.984422	0.984422	0,983822	0,98382	0,980599	0,98060	0,986167	0,98617	0,983285	0,98329
50	200	0.968862	0.968862	0,967651	0,96765	0,961069	0,96107	0,972427	0,97243	0,966548	0,96655
50	400	0.937919	0.937919	0,935459	0,93546	0,921743	0,92174	0,945356	0,94536	0,933134	0,93313
50	600	0.907474	0.907474	0,903748	0,90375	0,882375	0,88238	0,919082	0,91908	0,900079	0,90008
50	800	0.877944	0.877944	0,872976	0,87298	0,843550	0,84355	0,893979	0,89398	0,867847	0,86785
50	1000	0.849878	0.849878	0,843755	0,84376	0,806195	0,80620	0,870495	0,87050	0,837082	0,83708
50	1200	0.823951	0.823951	0,816847	0,81685	0,771638	0,77164	0,849137	0,84914	0,808610	0,80861
100	14,73	0.998360	0.998360	0,998295	0,99830	0,997943	0,99794	0,998557	0,99856	0,998239	0,99824
100	100	0.988916	0.988916	0,988476	0,98848	0,986058	0,98606	0,990273	0,99027	0,988089	0,98809
100	200	0.977963	0.977963	0,977082	0,97708	0,972193	0,97219	0,980715	0,98072	0,976299	0,97630
100	400	0.956544	0.956544	0,954785	0,95479	0,944810	0,94481	0,962196	0,96220	0,953178	0,95318
100	600	0.935947	0.935947	0,933331	0,93333	0,918132	0,91813	0,944627	0,94463	0,930867	0,93087
100	800	0.916409	0.916409	0,912980	0,91298	0,892521	0,89252	0,928209	0,92821	0,909639	0,90964

100	1000	0.898198	0.898198	0,894025	0,89403	0,868415	0,86842	0,913156	0,91316	0,889804	0,88980
100	1200	0.881593	0.881593	0,876778	0,87678	0,846323	0,84632	0,899679	0,89968	0,871699	0,87170
130	14,73	0.998653	0.998653	0,998599	0,99860	0,998300	0,99830	0,998822	0,99882	0,998550	0,99855
130	100	0.990919	0.990919	0,990551	0,99055	0,988507	0,98851	0,992080	0,99208	0,990217	0,99022
130	200	0.981995	0.981995	0,981261	0,98126	0,977142	0,97714	0,984342	0,98434	0,980586	0,98059
130	400	0.964691	0.964691	0,963235	0,96324	0,954894	0,95489	0,969484	0,96948	0,961865	0,96187
130	600	0.948242	0.948242	0,946091	0,94609	0,933474	0,93347	0,955560	0,95556	0,944010	0,94401
130	800	0.932817	0.932817	0,930012	0,93001	0,913137	0,91314	0,942712	0,94271	0,927215	0,92722
130	1000	0.918592	0.918592	0,915192	0,91519	0,894174	0,89417	0,931079	0,93108	0,911686	0,91169
130	1200	0.905742	0.905742	0,901825	0,90183	0,876893	0,87689	0,920793	0,92079	0,897635	0,89764

19. ALGORITHM VERIFICATION FOR AGA8 92-DC ISO 12213-2

The following tables shows the calculation values for the algorithm implemented on Z-FLOWCOMPUTER and the values given in ISO 12213-2.

Type of gas:

	Gas 1	*Gas 2*	*Gas 3*	*Gas 4*	*Gas 5*	*Gas 6*
xC02	0,0060	0,0050	0,0150	0,0160	0,0760	0,0110
xN2	0,0030	0,0310	0,0100	0,1000	0,0570	0,1170
xH2	0,00	0,00	0,00	0,0950	0,00	0,00
xCO	0,00	0,00	0,00	0,0100	0,00	0,00
xCH4	0,9650	0,9070	0,8590	0,7350	0,8120	0,8260
xC2H6	0,0180	0,0450	0,0850	0,0330	0,0430	0,0350
xC3H8	0,0045	0,0084	0,0230	0,0074	0,0090	0,0075
x•iso-C4H10	0,0010	0,0010	0,0035	0,0012	0,0015	0,0012
xn-C4H10	0,0010	0,0015	0,0035	0,0012	0,0015	0,0012
xiso-C5H12	0,0005	0,0003	0,0005	0,0004	0,00	0,0004
xn-C5H12	0,0003	0,0004	0,0005	0,0004	0,00	0,0004
xC6H14	0,0007	0,0004	0,00	0,0002	0,00	0,0002
xC7H16	0,00	0,00	0,00	0,0001	0,00	0,0001
xC8H18	0,00	0,00	0,00	0,0001	0,00	0,00

Compressibility factor calculated according to ISO 12213-2, in green values given in Table C.2 in comparison with the result obtained by Z-FLOWCOMPUTER (rounded to the 5th decimal place).

P [bar]	T [°C]	Gas 1 (AGA8)	Gas 1 (Z-FC)	Gas 2 (AGA8)	Gas 2 (Z-FC)	Gas 3 (AGA8)	Gas 3 (Z-FC)	Gas 4 (AGA8)	Gas 4 (Z-FC)	Gas 5 (AGA8)	Gas 5 (Z-FC)	Gas 6 (AGA8)	Gas 6 (Z-FC)
60	-3,15	0.84053	0.84053	0.83348	0.83348	0.79380	0.79380	0.88550	0.88550	0.82609	0.82609	0.85380	0.85380
60	6,85	0.86199	0.86199	0.85596	0.85596	0.82206	0.82206	0.90144	0.90144	0.84969	0.84969	0.87370	0.87370
60	16,85	0.88006	0.88006	0.87484	0.87484	0.84544	0.84544	0.91501	0.91501	0.86944	0.86944	0.89052	0.89052
60	36,85	0.90867	0.90867	0.90466	0.90466	0.88183	0.88183	0.93674	0.93674	0.90052	0.90052	0.91723	0.91723
60	56,85	0.93011	0.93011	0.92696	0.92696	0.90868	0.90868	0.95318	0.95318	0.92368	0.92368	0.93730	0.93730
120	-3,15	0.72133	0.72133	0.71044	0.71044	0.64145	0.64145	0.81024	0.81024	0.69540	0.69540	0.75074	0.75074
120	6,85	0.76025	0.76025	0.75066	0.75066	0.68971	0.68971	0.83782	0.83782	0.73780	0.73780	0.78586	0.78586
120	16,85	0.79317	0.79317	0.78475	0.78475	0.73123	0.73123	0.86137	0.86137	0.77369	0.77369	0.81569	0.81569
120	36,85	0.84515	0.84515	0.83863	0.83863	0.79697	0.79697	0.89913	0.89913	0.83022	0.83022	0.86311	0.86311
120	56,85	0.88383	0.88383	0.87870	0.87870	0.84553	0.84553	0.92766	0.92766	0.87211	0.87211	0.89862	0.89862

20. ALGORITHM VERIFICATION FOR SGERG88 ISO 12213-3

The following table shows the calculation values for the algorithm implemented on Z-FLOWCOMPUTER and the values given in ISO 12213-3.

Type of gas:

	Gas 1	***Gas 2***	***Gas 3***	***Gas 4***	***Gas 5***	***Gas 6***
xCO2	0,006	0,005	0,015	0,016	0,076	0,011
xH2	0,000	0,000	0,000	0,095	0,000	0,000
d	0,581	0,609	0,650	0,599	0,686	0,644
Hs (MJ.m-3)	40,66	40,62	43,53	34,16	36,64	36,580

Compressibility factor calculated according to ISO 12213-3, in green values given in Table C.2 in comparison with the result obtained by Z-FLOWCOMPUTER (rounded to the 5th decimal place).

P [bar]	***T [°C]***	***Gas 1 (SGERG88)***	***Gas 1 (Z-FC)***	***Gas 2 (SGERG88)***	***Gas 2 (Z-FC)***	***Gas 3 (SGERG88)***	***Gas 3 (Z-FC)***	***Gas 4 (SGERG88)***	***Gas 4 (Z-FC)***	***Gas 5 (SGERG88)***	***Gas 5 (Z-FC)***	***Gas 6 (SGERG88)***	***Gas 6 (Z-FC)***
60	-3,15	0.84084	0.84084	0.83397	0.83397	0.79415	0.79415	0.88569	0.88569	0.82664	0.82664	0.85406	0.85406
60	6,85	0.86202	0.86202	0.85615	0.85615	0.82210	0.82210	0.90150	0.90150	0.85017	0.85017	0.87388	0.87388
60	16,85	0.88007	0.88007	0.87500	0.87500	0.84553	0.84553	0.91507	0.91507	0.87003	0.87003	0.89071	0.89071
60	36,85	0.90881	0.90881	0.90491	0.90491	0.88223	0.88223	0.93684	0.93684	0.90124	0.90124	0.91736	0.91736
60	56,85	0.92996	0.92996	0.92690	0.92690	0.90893	0.90893	0.95302	0.95302	0.92394	0.92394	0.93690	0.93690
120	-3,15	0.72146	0.72146	0.71140	0.71140	0.64322	0.64322	0.80843	0.80843	0.69557	0.69557	0.74939	0.74939
120	6,85	0.75969	0.75969	0.75079	0.75079	0.69062	0.69062	0.83613	0.83613	0.73828	0.73828	0.78473	0.78473
120	16,85	0.79257	0.79257	0.78472	0.78472	0.73196	0.73196	0.85999	0.85999	0.77463	0.77463	0.81490	0.81490
120	36,85	0.84492	0.84492	0.83877	0.83877	0.79778	0.79778	0.89827	0.89827	0.83166	0.83166	0.86266	0.86266
120	56,85	0.88322	0.88322	0.87832	0.87832	0.84554	0.84554	0.92662	0.92662	0.87269	0.87269	0.89749	0.89749