Liquid
Turbine Flowmeter

Quick User Manual

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Thanks for choosing our flowmeter products. Please read this manual carefully to learn how to install and use this product to ensure best performance.

Table of Contents

1 General

Turbine Flow Meters are a class of Flow meters sometimes called an Impeller Flowmeter. The Sensor responds to the average velocity of a fluid utilizing a multi-bladed rotor, or turbine to indicate the instantaneous flow value and the electronics accumulates the total flow value. The RPM of the turbine is measured by a hall effect switch within the flow body and isolated from the fluid stream.

The Turbine Flow Meter It is ideal for measuring liquids with a kinematic viscosity under $5*10^{-6}$ m^2/s and are free from particulates and fibers or corrosive materials not compatable with 304 or 316 stainless steel or the Al_2O_3 bearings on some smaller models. Liquids with kinematic viscosities above $5*10^{-6} m^2/s$ can be measured if calibrated with the desired liquid.

1.1 Turbine Flow Measuring principle:

As the liquid flows through the sensor, the turbine impeller begins to turn, where the velocity is in direct proportion to average flow in the pipe. The turbine is coupled to the measuring system using a Hall Effect switch to determine the turbine RPM. This is then correlated, as the k, or Flowmeter factor, which is stamped on the instrument housing label. This factor is derived in the calibration process and is related to the flow rate using NIST traceable gravimetric calibration standards with water.

Turbine Flowmeter Flow Rate Equation:

(1) Basic equation:

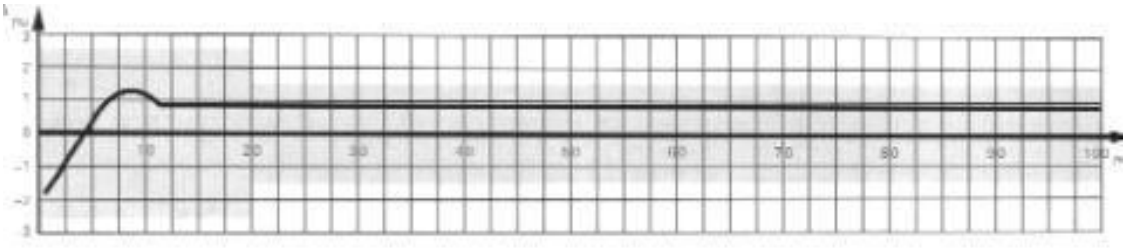
$$Q_{v=} f / k$$

$$Q_m = Q_v \, v \, \rho$$

Q_v refers to volume flow rate, (unit : m^3/s)
Q_m refers to mass flow rate, (unit kg/s)
f : refer to output signal frequency (unit Hz)
k : refer to the Flowmeter factor, (unit P/m^3).

The curve of a typical flowmeter factor and flow rate is in shownin the graph below. The factor curve can be divided into two parts of the linear range and the low end non-linear range. The linear part accounts for two-thirds of the entire curve which feature is related to the sensor design and sizes, as well as fluid viscosity.

The non-linear part is dominated by the friction forces from the bearings and the viscosity resistance of liquid. When flow rate is below the lower limit of sensor, the instrument factor can be seen to increase rapidly with flow. The pressure loss and the flow rate are square relations. If the flow rate exceeds the upper limit it is important to ensure there is no cavitation that can damage the turbine meter.



(Turbine flowmeter characteristic curve).

(2) Theoretical flow rate equation:

According moment of momentum theorem we can list the equation of motion for an impeller.

J **dw dt** $=M_1-M_2-M_3-M_4$

where,

J: impeller inertial moment;

dw dt: rotational acceleration;

M_1 : Liquid-driven torque

M_2 : Viscous resistance moment

M_3 : Bearing friction moment

M_4 : Magnetic moment.

When impeller is rotating at a constant velocity, J **dw dt** =0, and $M_1=M_2+M_3+M_4$. Through the analysis in theory and verification in experiment, the formula can be calculated as follows:

$n=Aq_v+B-$ **C** $\mathbf{q_v}$

where,

n: refers to impeller rotational speed;

$\mathbf{q_v}$: refers to volume flow rate;

A: Is a bundled factor related to fluid physical properties (include density, viscosity etc.), impeller structure parameters (blade angle, impeller diameter, flow channel cross-sectional area, etc.);

B: A Bundled factor related to top vane gap, and fluid flow velocity distribution;

C: A factor related to frictional moment.

1.3 Features:

- High accuracy (regular accuracy±1%R, ±0.5%R, highest accuracy±0.2% R);
- Good repeatability (short-term0.05%--0.2%)
- Pulse frequency signal output may be utilized for instant and total flow indication
- High frequency (3-4kHz) response.
- Wide turn down ratio: medium or large diameter 20:1, and small diameters 10:1.
- Compact and light weight design, easy installation and maintenance.
- Insertion meters avaiable for pipe sizes over 8” are available.

1.3 Specifications:

Nominal Diameter(mm) and Connection options	4, 6, 10, 15, 20, 25, 32, 40 (NPT thread connection) 15, 20, 25, 32, 40 (NPT thread and flange connection)

	50, 65, 80, 100, 125, 150, 200 (flange connection)
Accuracy	Standard accuracy ±0.5%R Regular accuracy ±1%R Highest accuracy ±0.2% R
Measurement Range Rate	10:1, 15:1, 20:1
Instrument material	304 stainless steel; 316L stainless steel; Viton, Al_2O_3Ceramic
Fluid Temperature Range	－20 to 120 C
Ambient Conditions Range	Temperature: －10 to ＋55 Deg C, Relative Humidity: 5to 90% Atmospheric Pressure:8 to 106Kpa
Signal Output	Pulse frequency signal, low level≤0.8V high level≥8V. Transmitter: current signal 4- 20mA DC two wires, self powered, common ground. ModBus RTU
Supply Power	Transducer: +24V DC Optional Operation with 3.2V Lithium cell LCD display but no 4-20, Frequency, or ModBus output
Transmission Distance	≤1000m
Wire connections	Internal thread M20×1.5
Enclosure Class	ExdIIBT6
Protection Class	IP65

1.4 Flow Measurement range and Working pressure for liquids

150# Flange size	Standard Flow rate (m3/h)	Expanded flow rate (m3/h) Special Order	Standard Max pressure(MPa)	High pressure Option(MPa) Special Order
1/2"	0.6—6	0.4—8	2.5	4.0, 6.3, 12, 16, 25
3/4"	0.8—8	0.45—9	2.5	4.0, 6.3, 12, 16, 25
1"	1—10	0.5—10	2.5	4.0, 6.3, 12, 16, 25
1 1/4"	1.5—15	0.8—15	2.5	4.0, 6.3, 12, 16, 25
1 1/2"	2—20	1—20	2.5	4.0, 6.3, 12, 16, 25
2"	4—40	2—40	2.5	4.0, 6.3, 12, 16, 25
2 1/2"	7—70	4—70	2.5	4.0, 6.3, 12, 16, 25
3"	10—100	5—100	2.5	4.0, 6.3, 12, 16, 25
4"	20—200	10—200	2.5	4.0, 6.3, 12, 16, 25
6"	30—300	15—300	1.6	2.5, 4.0, 6.3, 12, 16
8"	80--800	40—800	1.6	2.5, 4.0, 6.3, 12, 16

2 Installation

2.1 Select the Most Suitable Location

(1) Ambient temperature

Do not install the flowmeter in a location where the temperature dramatically changes over time. If the meter is in close proximity to any radiating source, please utilize effective radiative heat insulation as well as a cooling method, such as a fan.

(2) Atmosphere

Do not install the meter at a location with a high level of corrosive materials, such as H2S, common in wastewater plants. If you cannot install the meter in an ideal location, ensure there is sufficient ventilation.

(3) Vibration

Do not install the meter in at a location where there is excessive vibration. If the mounting location has high vibration energy the pipeline should be held steady using a support racking system.

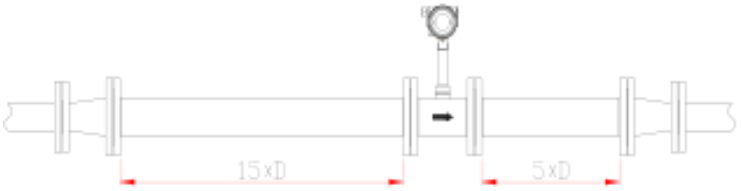
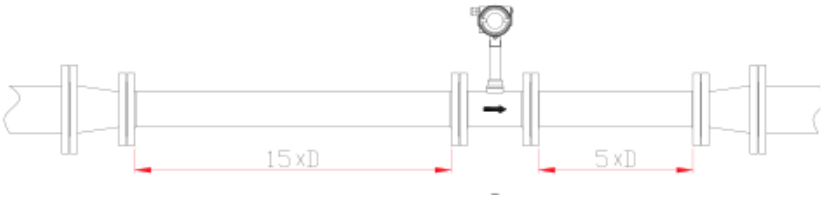
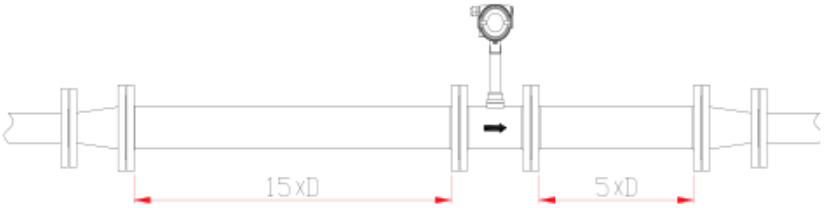
(4) Caution

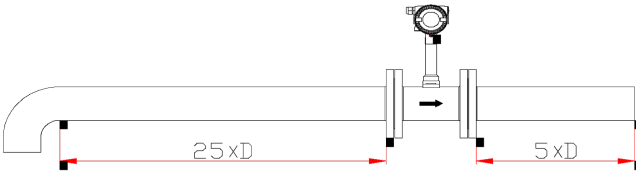
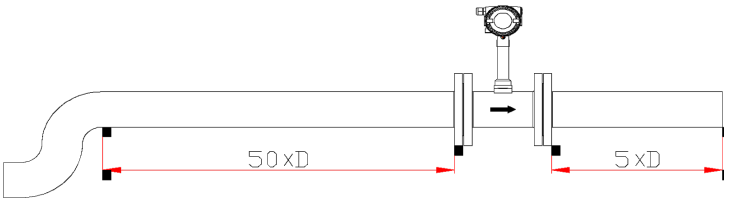
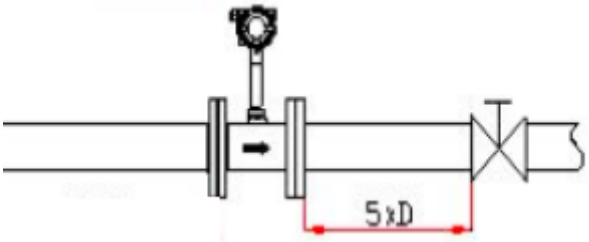
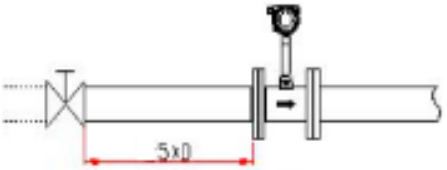
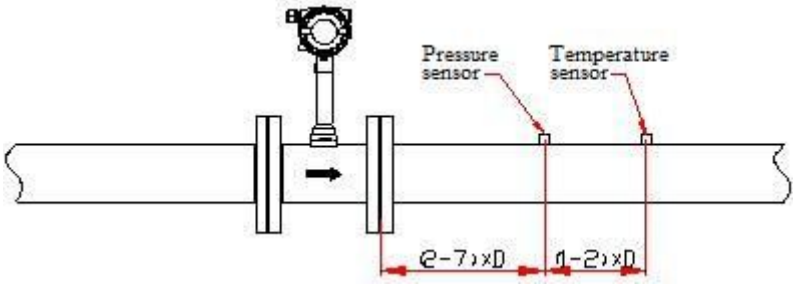
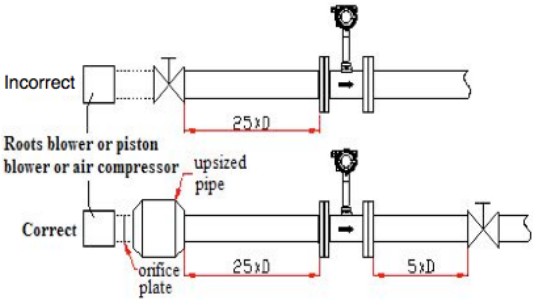
(a) All enclosure, screws, nuts, and bolts should be properly tightened before using the meter.

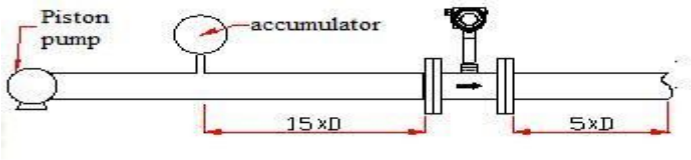
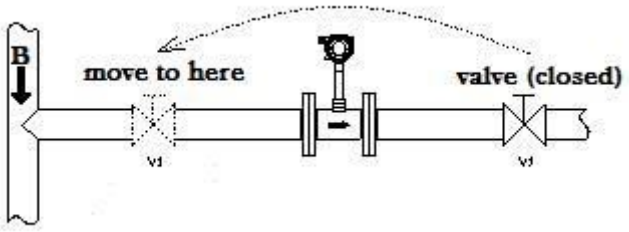
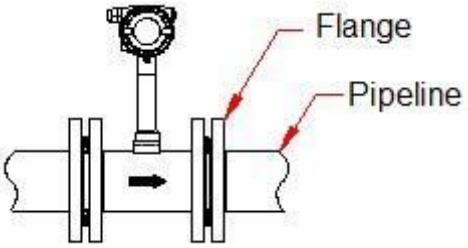
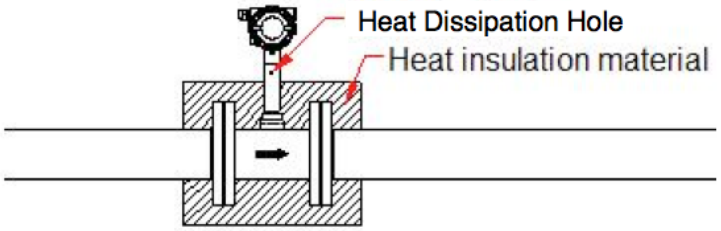
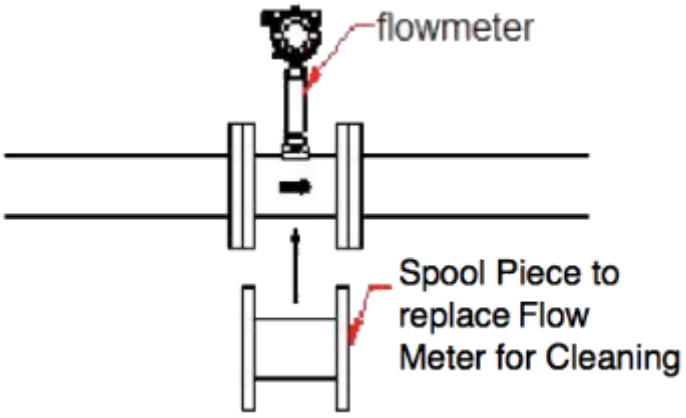
(b) Ensure there are no leaks in any of the connection points, including the electronics.

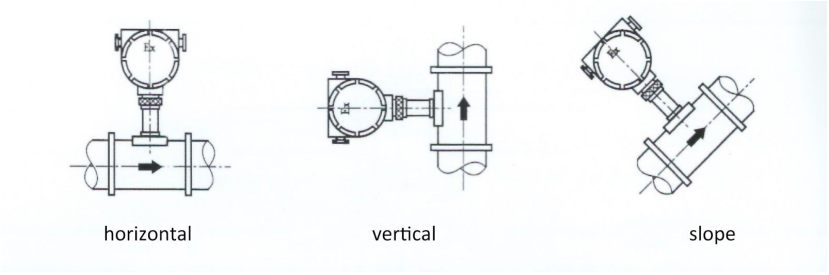
(c) Ensure the process pressure is LESS than the meter's rated pressure.

2.2 Plumbing requirements

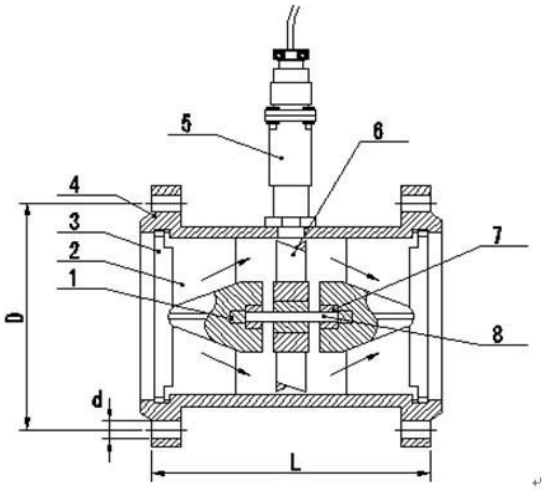
Same pipe ID	
Reducer inlet and outlet	
Expansion	

90 Degree Elbow Inlet	
Double 90 Degree Inlet out of plane	
Downstream Valve	
Upstream Valve	
External Pressure sensor location: 2 - 7 D downstream of flowmeter **Temperature sensor location: 1 - 2 D downstream of pressure sensor**	
Compressor or Roots Blower Upstream	 Compressor or Roots Blower upstream may cause vibration of the fluid itself. To eliminate this vibration, install an orifice plate or a expansion pipe at about 25D

	upstream of the meter. Any valves should be located downstream the flowmeter for this condition. Note the TOP drawing is Incorrect.
Piston Pump upstream	 Please install an accumulator to reduce the vibration
T type pipeline in upstream	 When using a T type pipeline installation the valve must be located downstream.
Ensure flange gaskets do not protrude into the flow area.	
Heat insulation: If the fluid is at a high temperature ensure the heat insulation material does not cover the heat dissipation hole on flow meter	
Cleaning: If the pipeline needs to be cleaned ensure a spool piece is put in place of the flow meter to avoid damage to the shedder bar and sensor.	

The flow should be going UP as shown for either a vertical or slope mount for liquids so the fluid completely fills the pipe.	

2.3 General Dimensions



Details:
1.Ball Bearing 2. Impeller retaining ring 3. O ring 4. Body 5. Preamplifier 6. Impeller 7. Bearing 8. Shaft

150# ANSI Flange size (in)	Nominal diameter (mm)	L(mm)	L (in)	D(mm)	D (in)	d (mm)	d (in)	Flange Holes
1/2"	15	75	2.95	65	2.559	14	0.551	4
3/4"	20	80	3.15	75	2.953	14	0.551	4
1"	25	100	3.94	85	3.346	14	0.551	4
1 1/4"	40	140	5.51	110	4.331	18	0.709	4
1 1/2"	50	150	5.91	125	4.921	18	0.709	4
2"	65	170	6.69	145	5.709	18	0.709	4
2 1/2"	80	200	7.87	160	6.299	18	0.709	8
3"	100	220	8.66	180	7.087	18	0.709	8
4"	125	250	9.84	210	8.268	25	0.984	8
6"	150	300	11.81	250	9.843	25	0.984	8
8"	200	360	14.17	295	11.614	25	0.984	12

3 Turbine Meter Wiring

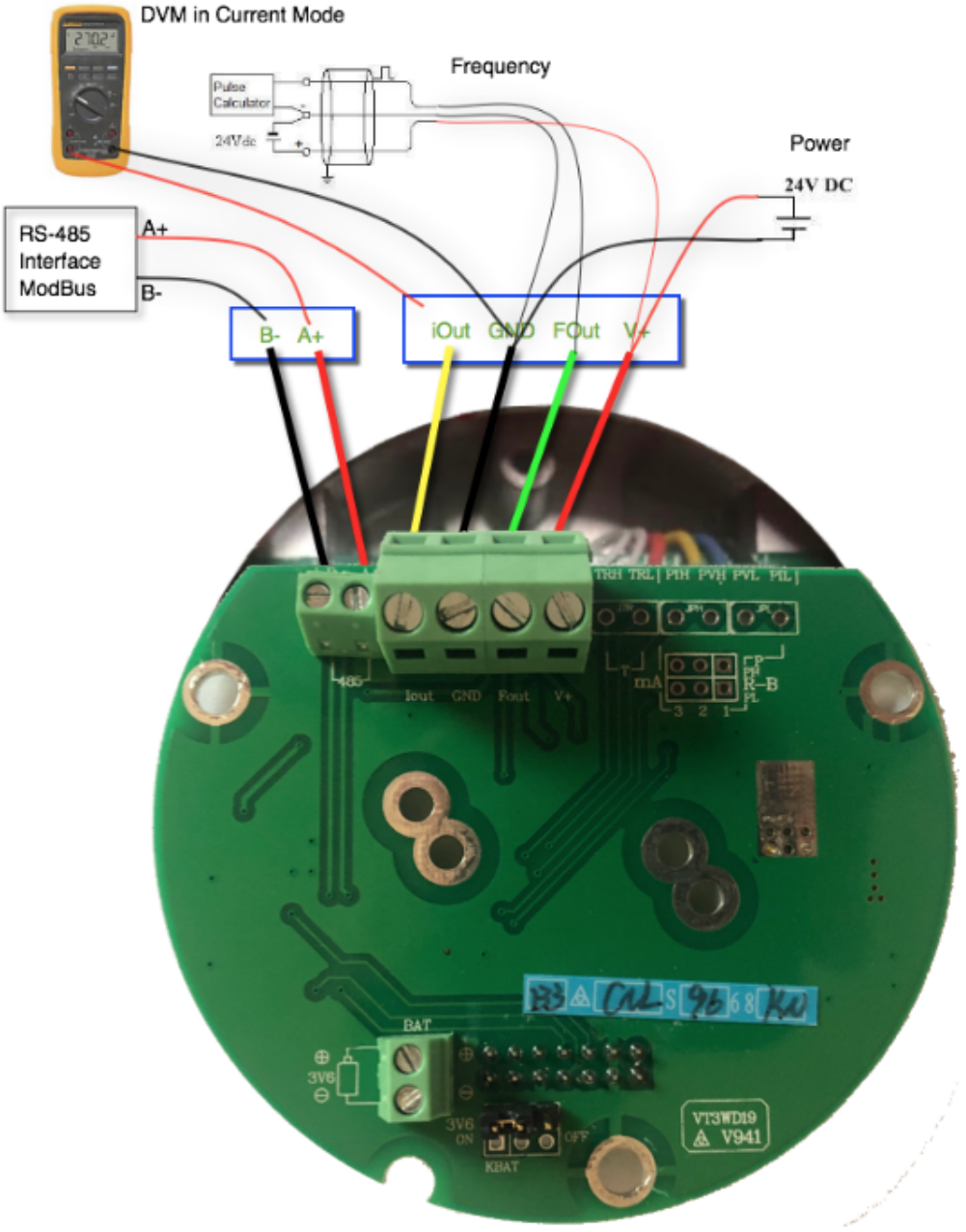


Figure. 3.1 Wiring guidelines for the 4-20, Frequency and ModBus. The 4-20 is a POWERED 4-20 and connection to a 4-20 input device is ideal. As well, the user may elect to place a 250 Ohm resistor across iOut and V+ and read 1 -5 VDC for 0 to Full Scale as a voltage.

Lower left connections: Optionally configured models have a Jumper for an optional 3.6 VDC C-Size Lithium Battery. BOTH the battery and the 24 VDC may be plugged in at the same time. The meter may be used with the 3.6 VDC Lithium Battery in the Intrinsically Safe mode that supports driving the LCD but not the ModBus or 4-20 mA Output.	

3.1 Electronics grounding and minimizing electrical interference

The flowmeter power supply for the signal processing circuit is isolated from the outside power supply by use of an isolation type DC-DC transmitter with advanced grounding technology . The field frequency interference is also well filtered.

The "V-" of power supplier should not be connected directly to ground. When the flow meter is used in an environment with high EMI fields , the electronics should be connected with earth ground through the cable. Do not locate in close proximity to devices such as a VFD.

3.4 Wiring Requirements

1) Only connect wiring when the power is off in an explosive environment.

2) Open the rear cover first, then insert the cable into back of housing through the water-proof cable gland

3) Connect the wiring according to Figure 3.1 above.

4) Prepare a wiring "drip loop" wiring to avoid the water entering into the housing through the cable.

4 Display

The flowmeter has a local display to display several variables on the local multifunction LCD display.

4.1 LCD display Introduction

The Turbine Flow meter shows "Mass flow", "Total Flow", and a bar graph. Please refer to Figure 4.1 below.

The icon in the lower right hand corner indicates the meter is powered with 24 VDC and is not on the optional 3.6 VDC battery power.

If there is battery power the plug in the lower right hand corner will be replaced by a battery charge status indicator like this:  .

4.2 Two Button LCD User Interface

TFM201 series digital vortex flowmeters has two buttons on the top and behind the display as follows: ENTER button  (on the right at 1 O'Clock) and + Button  (in the left at 11:00 O'Clock) refer to Figure 4.5 below

Figure 4.5 buttons

Use the "Enter" to select the display contents, use "+ button" to move to the left and right. Long Holding of the + button will allow editing the variable. Hit "Enter button" to select or confirm your choice with a Long Hold. Refer to the Button User Interface below.

4.3 Resetting the totalizer

The Totalizer can be reset by holding down BOTH buttons (and) for approximately 2 seconds.
Confirmed with a "Please wait…" and the totalizer will go to 0.000

Note: If you wish to reset using the button commands shown below the password to reset the totalizer, in the Clear Q screen, is 70. Itis much easier to reset with the 2 buttons held at the same time.

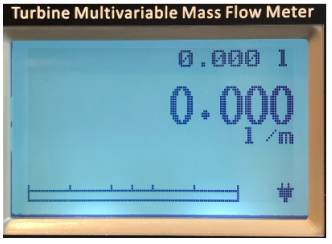


Figure 4.1 LCD display

4.4 2 Button User Interface with Password 22

Invoke editing as follows: Press + Hold < for 3 seconds Hit + to enter the first digit of the password 22 Hit < to advance to the units place Hit + to advance the second digit to 2 You have now Entered the Password 22 to access these variables. Hold < for 3 seconds. The following will appear in the display that you may edit. They are not in any particular order. When you have the unit selected hold the < for 3 seconds. When finished hold the + for 3 seconds and then tap it to go to the main screen

Menu Display	Description	Values
Q Unit	Flow unit selection （	l/m,l/h,m3/m,m3/h,kg/m,kg/h,t/m,t/h,
Q Mode	Algorithm Selection Default Qwv actual	Qvw actual: Special: Qm steam [T&P]: Qm steam [P]: Qm steam[T]: Qmg[dn@TnPn]: Qvn[@TnPn]: Qm[dw]:
Q Factor K [P/m3]	Flow Coefficientfor meter determined in calibration. Will match what is on the label.	Set the meter factor， UnitsP/m³ Note a label showing 810.4 will show up as 801400
Q20mA	Full Scale Output flow（Default 100% Flow in Q Units)	Instrument output of 4-20mA Analog signal at Full Scale
Density [kg/m3] set to 1000 for water as default.	Density setting Default 1000	When the algorithm is using mass flow， This must be set， Units: kg/m³
Q Cut-Zero	Zero Cutoff in % of flow	When the% value of full-scale to supress flow below this value between 0-100， For Current Mode and Pulse type Range. Default = 0
Comm Address	Set RS485 serial communication	Range：0-255
Damp S [S]	Setting the display output damping time in seconds	Default 4 Seconds
Clear Q	Clear the total flow	Clear the total flow Select 70 as password
Q Dn Al	Low Alarm in selected units	Default = 0
Q Up Al	High Alarm in selected units	Default = Full Scale

4.5 Total flow display

The flow meter can display 9 digits to the left of the decimal point and 3 digits after the decimal point.

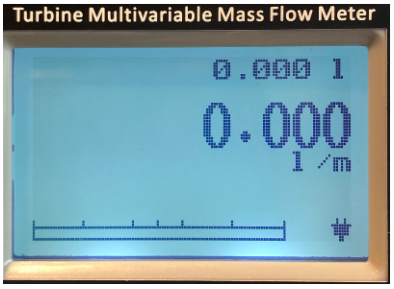


Figure 4.6 Display example

5 LCD Settings

Note: Every turbine flowmeter has been set up according to your requirements. Please do not change any of the setting variables unless it is necessary and under factory instruction! The most critical is the value shown in the graphic in Figure 5.0

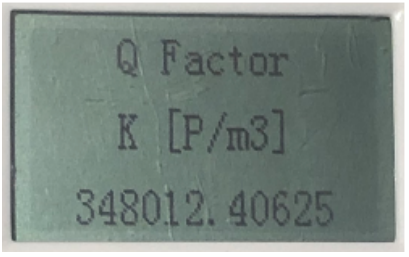
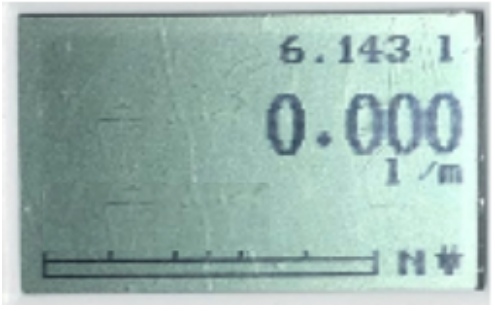
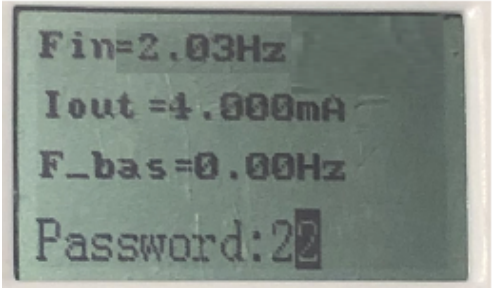


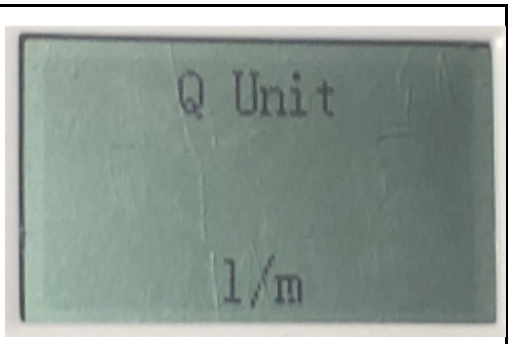
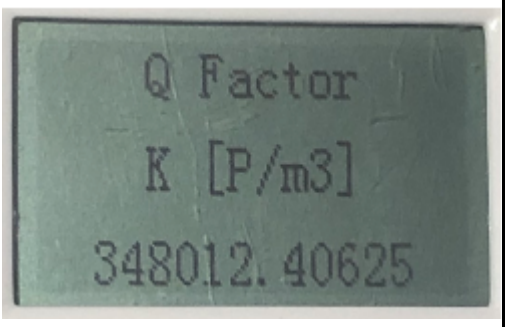
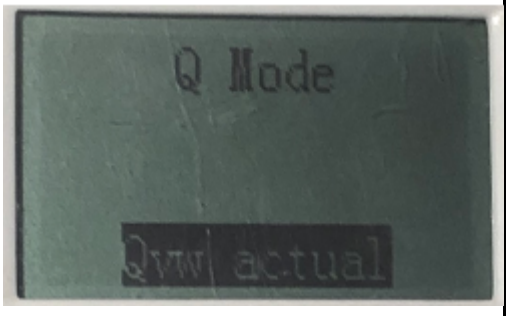
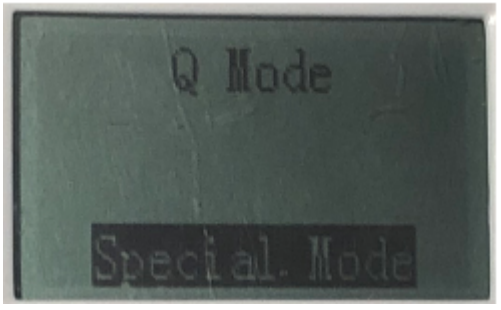
Figure 5.0 do not edit this value. This number will be stamped on the label of the meter and can be recovered should one accidently edit it. The value is in Pulses per cubic meter and if the calibration is in liters remember to add the multiplier from liters to cubic meters.

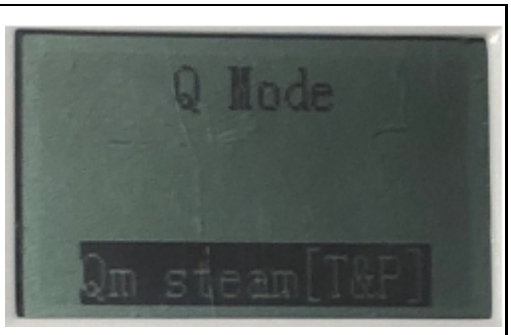
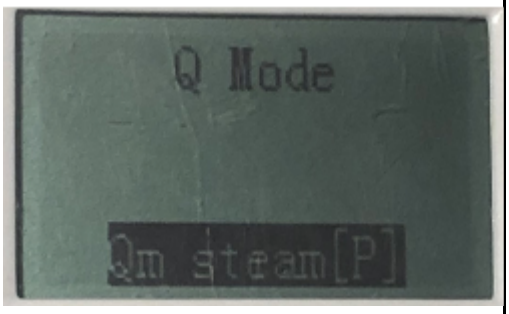
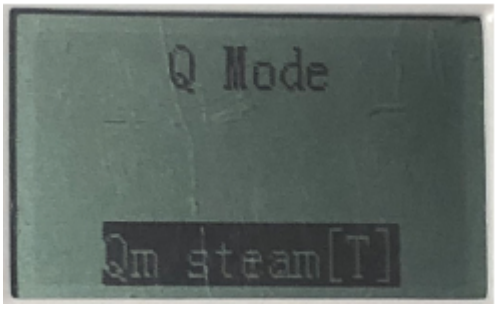
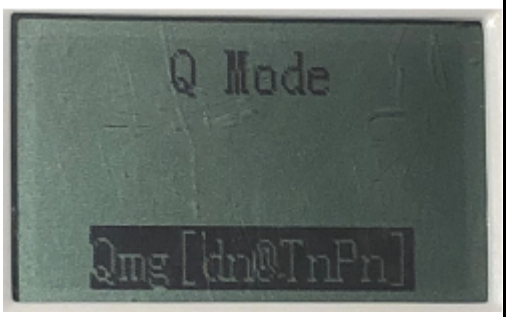
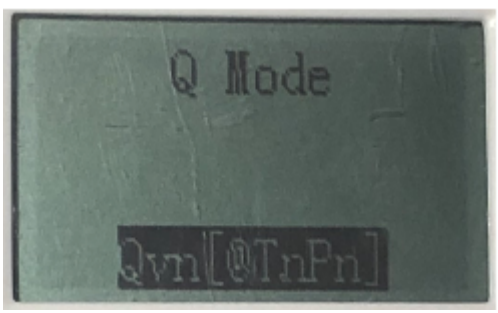
5.1 LCD Settings list

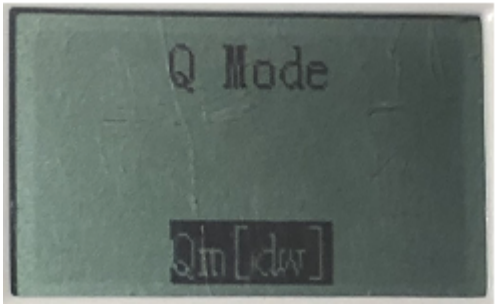
We show each screen accessible by hitting the + button and then holding the ENTER button for 3 seconds, and then use the + to increment the password to 22 and then hold the ENTER button for 3 seconds to scroll thru the list. When you want to edit the value hold the ENTER button for 3 seconds and edit as required. When done hold ENTER for 3 seconds and when done hit the + button for 3 seconds. An example video is on the bottom of the website here: https://www.tacticalflowmeter.com/collections/flow-meter/products/1-2-to-4-multivariable-vortex-mass-flow-meter (Note: The Vortex Meter and Turbine meter use the same electronics stack)

Instrument panel Operating Instructions:

Main screen showing TOTAL flow on the top, as 6.143 l (liters) The Flow Rate is in large digits in the middle as 0.000 l/m (liters per minute)	
The first line shows the output frequency at 2.03 Hz The 4-20 mA output is at 4.0 mA The frequency output is at 0.00 Hz out of 1000 HZ. Toggle between this screen and the screen above with the + button. When on THIS screen hold the ENTER button for 2 or 3 seconds. Advance the digit with the + and tap ENTER to move to the next digit. Hold the ENTER button for 2 or 3 seconds to access the screens below.	

Flow Meter units:m3/m, m3/h, kg/m, hg/h, t/m, t/h, l/m, l/h,	
DO NOT EDIT THIS VALUE. This is the value on your meter tag. This describes the calibration coefficient that relates the vortex shedding frequency to the fluid velocity.	
Comm Address, or Slave ID between 1-99 ModBus protocol is 0x03 PLC Mode, Default BAUD is 9600, No Parity, 1 Stop Bit The BAUD rate is set with Password 33 using the same method as password 22.	
One of 8 Multivariable Modes Actual LIQUID VOLUME flow with no Pressure and temperature corrections for l/h and l/m	
Two of 8 Multivariable Modes	

Three of 8 Multivariable Modes Multivariable Superheated Steam with pressure and temperature compensation for mass flow.	
Four of 8 Multivariable Modes Multivariable Saturated Steam with pressure compensation.	
Five of 8 Multivariable Modes Multivariable Saturated Steam with temperature compensation.	
Six of 8 Multivariable Modes Multivariable Gas Mass Flow Rate with temperature and pressure compensation.	
Seven of 8 Multivariable Modes Multivariable Gas VOLUME Flow Rate	

Eight of 8 Multivariable Modes Actual LIQUID MASS flow with Pressure and temperature corrections	

6 RS485 Modbus RTU Communication

6.1 Modbus Registers & Specifications

- The communication interface is via the RS485 standard, Baud rate is defaulted at 9600 BAUD
- The Modbus RTU wiring terminals are labelled “A” and “B”.
- The communication complies with the MODBUS-RTU standard.

Message Structure: Address code - function code – data segment CRC. The time between two characters should not be longer than the time for one single character, or it will be considered as the beginning of a new message or the end of a old message. The message is comprised of hexadecimal arrays.

6.2 Modbus Configuration with Password 22 and 33

The Slave ID is set with Password 22 as shown above. Slave BAUD/Parity is set with Password 33 and selecting the Comm Param screen and selecting 9600, No for 9600, No parity, 1 Stop. The other selections are:
9600,Even
9600,Odd
4800,No
4800, Even
4800, Odd

Once selecteed hold down the < button for 3 seconds to select it as with password 22.

ModBus Default Configuration:
Comm Address, Slave ID: 1
BAUD: 9,600
Parity: None
Stop BIts: 1
ModBus FCode: 3
PLC Mode
IEEE 752 Float BYTE Order ABCD
LONG BYTE order ABCD

Note: BAUD rate and Parity is selected with Password 33

6.2.1: ModBus Register addresses

data	Decimal Address	Hex Address	Type	Bytes
Flow rate	0	0x0000	floating point	4
Not Used	4	0x0004	floating point	4
Low level total flow	8	0x0008	Long	4
High level total flow	12	0x000C	Long	4
temperature	16	0x0010	floating point	4
pressure	20	0x0014	floating point	4
frequency	24	0x0018	floating point	4
NOT USED	28	0x001C	floating point	4
unit Index	32	0x0020	Byte	1

Unit index from Register Address 32, 0x0020 shown below in Fig 6.1

Code	0	1	2	3	4	5	6	7
unit	m3/h	m3/m	l/h	l/m	t/h	t/m	kg/h	kg/m

Figure 6.1: Units of m3/h, m3/m l/h and l/m are volume measurements that can be corrected to mass flow with pressure and temperature. The STP , Standard Temperature and Pressure may be selected and the DEFAULT STANDARD temperature is 0 Deg C and the STANDARD Reference pressure is 1 Atm, or 101.325 kPa

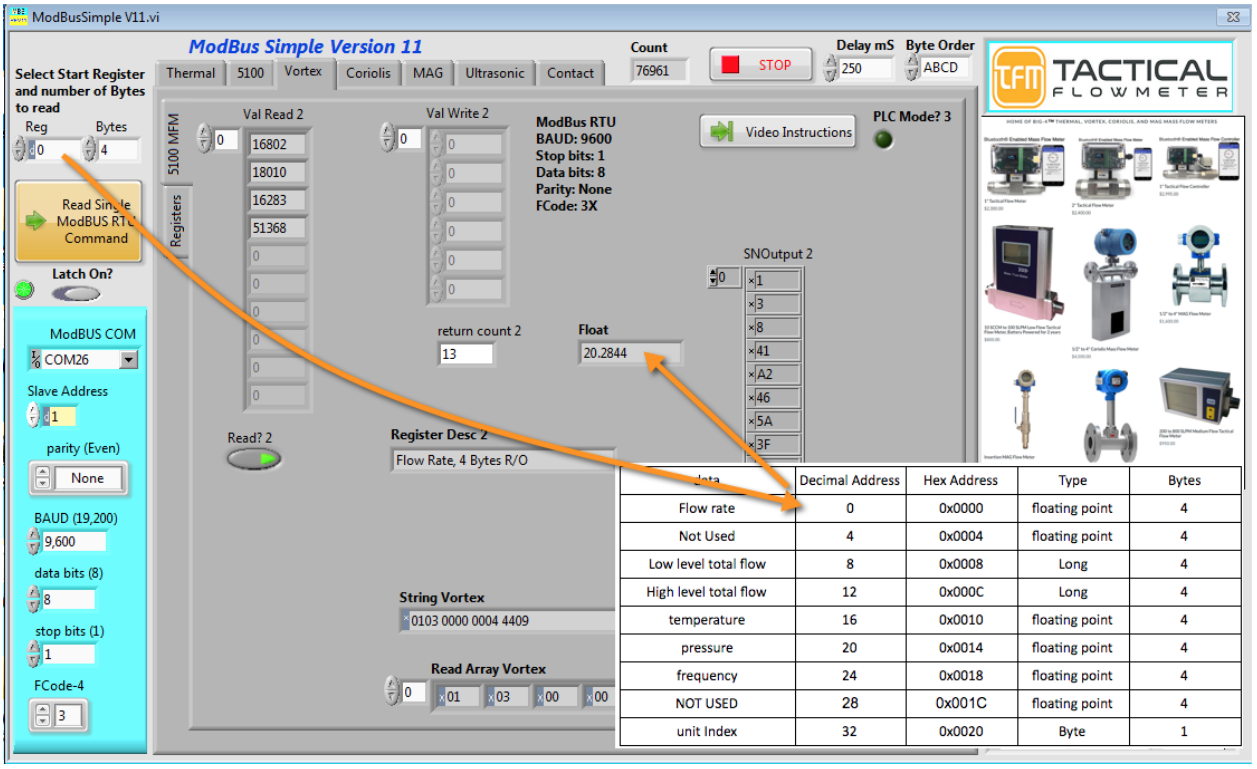


Figure 6.2: Example of a ModBus Simple Terminal reading the Turbine Flow Meter.

6.2 CRC and parity code Calculation.

Request	Response
01 : Address	N1 CRC=0FFFFH is initial value
10 : Function code	N2 XOR operation the CRCL and N1
00 : Register address higher	N3 CRC move 1 bit right , if move out is 1 bit
01 : Register address lower	N4 CRC=CRC XOR A001H
00 : Register quantity higher	N5 if move out is 0 , CRC=CRC
04 : Register quantity lower	N6 Move right for 8 times to finish the N1 calculation
04 : Date quantity	N7 …
80 : Data 1	N8 XOR operation the CRCL and N11
04 : Data 2	N9 CRC move 1 bit right , if move out is 1 bit
80 : Data 3	N10 CRC=CRC XOR A001H
80 : Data 4	N11 if move out is 0 , CRC=CRC
CRCL : CRC Parity code lower	Move right for 8 times to finish the N11 calculation
CRCH ： CRC Parity code higher	Get the CRC calibration value

6.3 Float data format

The 4 byte float format is as below:

Address: 0 1 2 3

Content: MMMMMMMM MMMMMMMM EMMMMMMM SEEEEEEE

Use IEEE standard method, if top digit is 1we represent a negative number; if the top digit is 0, we represent a positive number. The 23 bit mantissa and a 1 on top the digit, which is hidden, constitute a 24 bits fixed point true form decimal. The lowest 8 bits are exponent-marker using the IEEE shift code method. The exponent marker equals to the actual value minus 127. For example: 7=86H-7FH, -10=75H-7FH

e.g.: 100=0x00,0x00,0x42,0xc8

-100=0x00,0x00, 0xc2,0xc8

0=0x00.0x00.0x00.0x00 (exponent-marker is 0, the number is 0)

6.4 Float byte order

ABCD

9 Troubleshooting and repair

9.1 Safety Information

Do not open ANY covers on the enclosure if in a explosive environment.

When wiring the power, frequency, 4-20 mA or an RS485 device, make sure that the process of wiring the device into the loop complies with best practices safety requirements. It is best practices to complete the wiring in a non-explosive environment.

BEFORE power is connected, make sure the front and rear electronics covers are properly secured and closed.

9.2 Troubleshooting and repair

Problem and Solution

Symptom	Possible cause	Solution
No flow showing when you know flow exists..	Check: 1)open circuitloose contact (wire power wire\fuse\coil\PCB） 2)the turbine is not rotating	1)locate the problem with electrical meter 2)clean or replace turbine assembly ,and assure there is no interference or friction or fiber, hair and the like.
The flow is gradually decreasing	1) filter cloged 2) valve in pipe is loose to 3) Turbine has particulate, hair or fiber	1) clean the filter 2) repair or replace the valve 3) clean the sensor, then need to calibrate again
Screen shows flow showing when liquid has no flow	1) the cable has a bad ground wire 2) the pipe vibrates that causes the error signal 3) the cutoff valve leaks 4) internal circuit or display is damaged	1) repair or replace with a good ground wire; 2) strengthen the pipe line, or install blacket to prevent from vibrating 3) maintain or replace valve 4) discover the interference source.
The displayed value has	1) The sensor’s wiring is	1)-3)Ensure flow is within range

an obvious difference with known flows.	incorrect; 2) Flow is cavitating; 3) The flow is not within the normal range	of the flow meter and the meter has not been over reved.

Contact information:

TACTICAL FLOWMETER

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