



TF1100-CH
Transit Time Ultrasonic Flow Meter
Handheld

Operation & Maintenance

Manual

REV 5/2017

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PART-1 INTRODUCTION

1.1 GENERAL

Series TF1100-CH ultrasonic flow meters feature advanced Transit-Time measuring technology, providing accurate and reliable flow rate and total flow display. The TF1100-CH utilizes a non-invasive transducer which is hand-held or strapped to the outside of a pipe, which will provide benefits of non-fouling operation and ease of installation.

TF1100-CH transit time flow meters utilize two transducers that function as both ultrasonic transmitters and receivers.

The transducers are clamped on the outside of a closed pipe at a specific distance from each other. The transducers can be mounted in V-mode where the sound transverses the pipe two times, W-mode where the sound transverses the pipe four times, or in Z mode where the transducers are mounted on opposite sides of the pipe and the sound crosses the pipe once. This selection is based on pipe and liquid characteristics. The flow meter operates by alternately transmitting and receiving a frequency modulated burst of sound energy between the two transducers and measuring the time interval that it takes for sound to travel between the two transducers. The difference in the time interval measured is directly related to the velocity of the liquid in the pipe.

1.2 APPLICATION VERSATILITY

The TF1100-CH flow meter can be successfully applied on a wide range of metering applications. The simple to program transmitter allows the standard product to be used on pipe sizes ranging from 20mm -6000mm internal diameters. A variety of liquid applications can be accommodated: ultra-pure liquids, potable water, chemicals, raw sewage, reclaimed water, cooling water, river water, plant effluent, etc. Because the transducers are non-contacting and have no moving parts, the flow meter is not affected by system pressure, fouling or wear. Standard transducers are rated to 85° C.

1.3 USER SAFETY

The TF1100-CH employs modular construction and provides electrical safety for the operator. The display face contains voltages no greater than 5Vdc. All user connections are made through sealed bulk-head plugs located on the side of the TF1100-CH enclosure.

1.4 DATA INTEGRITY

Non-volatile flash memory retains all user-entered configuration values in memory for several years, even if power is lost or the unit is turned off. Data Logger values are stored in flash memory in the logger. Password protection is provided as part of the Security menu and prevents inadvertent configuration changes or totalizer resets. A time-keeper is integrated in the flow meter for the index of date totalizing and works as the time base of flow accumulation. It keeps operating as long as the battery's terminal voltage is over 1.5V. In case of battery failure, the time-keeper will not keep running and it will lose proper time values. The user must re-enter proper time values in case the battery becomes totally exhausted. An improper time value affects no other functions but the date totalizer.

1.5 USER FRIENDLY

The TF1100-CH features the ease of operation, high accuracy and outstanding reliability, while the software provides a very user friendly interface and much more functions. It employs a patent balanced lower voltage multi-pulse igniting circuit which increases the anti-interference ability magnificently so that the flow meter will work properly even in demanding industrial environments such as those with power frequency transmitter working nearby. The signal receiving circuits feature self-adapting performance so as to ensure that the user can easily operate the instrument without any adjustment. The built-in rechargeable Ni-H battery can work continuously for more than 12 hours without recharge.

1.6 PRINCIPLE OF MEASUREMENT

The TF1100-CH ultrasonic flow meter is designed to measure the fluid velocity of liquid within a closed conduit. The transducers are a non-contacting, clamp-on type, which will provide benefits of non-fouling operation and easy installation.

The TF1100-CH transit time flow meter utilizes two transducers that function as both ultrasonic transmitters and receivers. The transducers are clamped on the outside of a closed pipe at a specific distance from each other. The transducers can be mounted in V-method where the sound transverses the pipe twice, or W-method where the sound transverses the pipe four times, or in Z-method where the transducers are mounted on opposite sides of the pipe and the sound crosses the pipe once. This selection of the mounting method depends on pipe and liquid characteristics. The flow meter operates by alternately transmitting and receiving a frequency modulated burst of sound energy between the two transducers and measuring the transit time that it takes for sound to travel between the two transducers. The difference between the transit-time is directly and exactly related to the velocity of the liquid in the pipe, as shown in Figure 1.

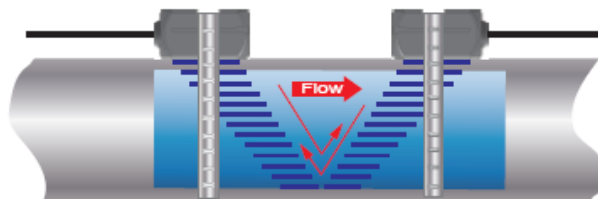


Figure 1

$$V_f = Kdt / TL$$

Where: V_f Liquid velocity
 K Constant
 dt Difference in time of flight
 TL Average Transit Time

1.7 PRODUCT IDENTIFICATION

Each set of the TF1100-CH Series flow meter has a unique product identification or ESN written into the software that can only be modified with a special tool by the manufacturer. In case of any hardware failure, please provide this number which is located on menu window number M61 when contacting the manufacture.

1.8 SPECIFICATIONS

Transmitter:

Measurement principle	Ultrasonic transit-time difference correlation principle
Flow velocity range	0.01 to 12 m/s, bi-directional
Resolution	0.25mm/s
Repeatability	0.2% of reading
Accuracy	±1.0% of reading at rates >0.3 m/s);±0.003 m/s of reading at rates<0.3 m/s
Response time	0.5s
Sensitivity	0.003m/s
Damping of displayed value	0-99s(selectable by user)
Liquid Types Supported	both clean and somewhat dirty liquids with turbidity <10000 ppm
Power Supply	AC: 85-265V Up to 14 h with fully charged internal batteries
Enclosure type	Handheld
Degree of protection	IP65 according to EN60529
Operating temperature	-20°C to +60°C
Housing material	ABS
Display	4 line×16 English letters LCD graphic display, backlit
Units	User Configured (English and Metric)
Rate	Rate and Velocity Display
Totalized	gallons, ft ³ , barrels, lbs, liters, m ³ ,kg
Communication	OCT, RS232,Data logger
Security	Keypad lockout, system lockout
Size	Transmitter:212*100*36mm Case:140*320*80mm
Weight	0.5kg

Transducer:

Degree of protection	IP65 according to EN60529.(IP67 or IP68 Upon request)
Suited Liquid Temperature	Std. Temp.: -35°C~85°C for short periods up to 120°C High Temp.: -35°C~200°C for short periods up to 250°C
Pipe diameter range	20-50mm for type S, 40-1000mm for type M, 1000-6000mm for type L
Transducer Size	Type S 52(h)*28(w)*28(d)mm Type M 60(h)*34(w)*32(d)mm Type L 80(h)*40(w)*42(d)mm
Material of transducer	Aluminum for standard temp. sensor, and peek for high temp. sensor
Cable Length	Std: 5m

PART-2 START OPERATING INSTRUCTIONS

2.1 POWER ON

Press the key to switch on the instrument and press the to turn off the power.

Once the flow meter is switched on, it will run a self diagnostic program, checking first the hardware and then the software integrity. If there is any abnormality, corresponding error messages will display.

Generally, there should be no display of error messages, and the flow meter will go to the most commonly used Menu Window Number 01 (short for M01) to display the Velocity, Flow Rate, Positive Totalizer, Signal Strength and Signal Quality, based on the pipe parameters configured last time by the user or by the initial program.

The flow measurement program always operates in the background of the user interface. This means the flow measurement will keep on running regardless of any user menu window browsing or viewing. Only when the user enters new pipe parameters will the flow meter change measurement to the new parameter changes.

When new pipe parameters have been entered or when the power has been just switched on, the flow meter will enter an adjusting mode to make the signals magnified with proper amplification. By this step, the flow meter is going to find the best threshold of receiving signal. The user will see the progress by the number 1, 2, or 3, which are indicated on the right lower corner of the LCD display.

When the transducers have been adjusted on the pipe by the user, the flow meter will re-adjust the signal automatically.

Any user-entered configuration value will be retained into the NVRAM of the flow meter, until it is modified by the user.

2.2 KEYPAD

The keypad for the operation of the flow meter has 16+2 keys, as shown by the right via Keys ~ and are keys to enter numbers, Key is the going UP key, when the user wants to go to the upper menu window. It also works as + key when entering numbers

Key is the going DOWN key, when the user wants

to go down-sided menu window. It also works as the

‘-‘ key when entering numbers.

Key is backspace key, when the user wants

go left or wants backspace the left character that

is located to the left of the cursor.

Key **ENT** is the ENTER key for any inputting or selections.

Key **MENU** is the key for the direct menu window jump over. Whenever the user wants to proceed to a certain menu window, the user can press this key followed by 2-digit numbers.

The **MENU** key is shortened as the 'M' key afterward when referring to the menu windows.

The **ON** key is for the power on.

The **OFF** key is for the power off.

2.3 MENU WINDOWS

The user interface of this flow meter comprises about 100 different menu windows that are numbered by M00, M01, M02 ... M94 etc.

There are 2 methods to enter certain menu window:

(1) Direct going/entering. The user can press the **MENU** key followed by two-digit number keys. For example, the menu window M20 is for the entering of Fluid Type. The display will go to the M20 menu window after the user presses **MENU** **2** **0**.

(2) Pressing **^/+** and **∇/-** keys. Each time of the **^/+** key pressing will proceed to the lower-numbered menu window. For example, if the current window is on M12, the display will go to the number M11 window after pressing the **^/+** key or M13 after pressing the **∇/-** key.

There are three different types of menu windows:

(1) Menu windows for number entering, like M11 for the entering of pipe outer diameter.

(2) Menu windows for option selection/selecting options, like M14 for the selection of pipe materials.

(3) Displaying windows only, like M00 to display Velocity, Flow Rate etc.

For number entering windows, the user can directly press the starting digit key when the user is going to modify the value. For example, when the current window is on M11, and the user is going to enter 154.6 as the pipe outer diameter, the user can get the numbers entered by pressing the following serial keys: **1** **5** **4** **.** **6** **ENT**.

For the option selection windows, the user should first press the **ENT** key to a selection modification mode and then select the relevant options by pressing the **^/+** and **∇/-** keys or the digit keys to select the option with a number antecedent to the option. In the end, the **ENT** key must be pressed to make the selection. For example, with menu window M14 for the selection of pipe material selection, (the **MENU** **1** **4** should be pressed first to

enter this menu window if the current menu window is on a different window. The pipe material is stainless steel which has a number “1” antecedent to “stainless steel” on the display, the user should first press the **ENT** key to enter into a selection modification mode, then either make the selection by pressing the **^/+** and **∇/-** keys to make the cursor on the line that displays “1. Stainless Steel”, or make the selection by pressing the **1** key directly.

Generally, the **ENT** key must be pressed to enter a modification mode. If the “Locked M47 Open” message is indicated on the lowest line of the LCD display, it means the modification operations is locked out. In such cases, the user should go to M47 to have the instrument unlocked first before any further modification can be made.

2.4 MENU WINDOWS ARRANGEMENT

M00~M09 windows for the display of the flow rate, velocity, date time, totalizers, battery voltage and estimated working hours for the battery.

M10~M29 windows for entering the pipe parameter.

M30~M38 windows for flow rate unit selections and totalizer unit selections.

M40~M49 windows for response time, zeroing, calibration and modification password setup.

M50~M53 windows for the built-in logger

M60-M78 windows for time-keeper initialization, version and ESN information viewing and alarms.

M82 window for viewing date totalizer.

M90~M94 are diagnostic windows for a more accurate measurement.

M+0~M+8 are windows for some additional functions, including a scientific calculator, viewer on records such as total working hours, turn-on and turn-off times, dates and times when the flow meter has been turned on or turned off.

Other menu windows such as M88 have no functions, or functions were cancelled because they are not applied to this version of the software.

The major reason why the menu windows are arranged in this way is that the software programmer hopes that the menu window arrangement for this version has the most compatibility with the previous versions of the TF1100-CH dedicated model software. This will make it easier for the former version users with this flow meter series.

2.5 STEPS TO CONFIGURE THE PARAMETERS

The following parameters need to be configured for a proper measurement:

- (1) Pipe outer diameter (O.D.)
- (2) Pipe wall thickness
- (3) Pipe materials (for non-standard pipe materials*, the sound speed for the material must be configured too)

*Standard pipe materials and standard liquids refer to those with the sound parameters that have already been programmed into software of the flow meter; therefore there is no need to configure them.

- (4) Liner material and its sound speed and thickness, if there is any liner.
- (5) Liquid type (for non-standard liquids, the sound speed of the liquid is also needed)
- (6) Transducer type adapted to the flow meter. Generally the Standard M1 or the Frame M-sized transducers will be the selected option.
- (7) Transducer mounting methods (the V-method or Z-method is the common option)
- (8) Check up the Space displayed on M25 and install the transducers accordingly.

For standard pipe materials and standard liquids, the following detailed step-by-step setup is recommended.

- (1) Press keys **MENU** **1** **1** to enter M11 window to input the digits for the pipe outer diameter, and then press **ENT** key.
- (2) Press key **▽/-** to enter M12 window to input the digits for the wall thickness and then press **ENT** key.
- (3) Press key **▽/-** to enter M14 window, and press **ENT** key to enter the pipe material. Use keys **△/+** and **▽/-** to scroll up and down to the intended pipe material, and then press **ENT** key. If you select “Other”, you must enter Menu15, pipe sound speed.
- (4) Press key **▽/-** to enter M16 window, press **ENT** key to enter the option selection mode, use keys **△/+** and **▽/-** to scroll up and down to the liner material, and then press **ENT** key. Select “No Liner”, if there is no liner, If you select “Other”, you must enter Menu17, liner sound speed.
- (5) Enter “Liner Thickness” in Menu18.
- (5) Press key **▽/-** to enter M20 window, press **ENT** key to enter Fluid Type, use keys **△/+** and **▽/-** to scroll up and down to the proper liquid, and then press **ENT** key. If you select “Other”, you must enter Menu21, Fluid sound speed and Menu 22, Fluid Viscosity
- (6) Press key **▽/-** to enter M23 window, press **ENT** key to enter the Transducer Type, use keys **△/+** and **▽/-** to scroll up and down to the proper Transducer Type (Standard S, M, L) you selected, and then press **ENT** key. Plug Type C and B are for Insertion transducer, no matter with Clamp-on transducers.
- (7) Press key **▽/-** to enter M24 window to select Transducer Mounting mode, and then press **ENT** key. Refer to **2.7.2** Transducer Mounting Mode for detail.
- (8) When above steps finished, Menu 25 will display transducer install spacing. Refer to **2.7.1** for detail.

(9) Enter Menu 90 and 91, to adjust the transducer spacing for good run status. Try to move one transducer, let this value closer to 100.0%. Meter display will be more accurate.

Please read Part 4, Menu Windows details, it will help you have a good operation.

The first-time users may need some time to get familiar with the operation. However, the user friendly interface of the instrument makes the operation quite easy and simple. Before long, the user will configure the instrument with very little key pressing, since the interface allows the user to go to the desired operation directly without any extra steps.

The following tip will facilitate the operation of this instrument.

- (1) When the window display is between M00 to M09, press MENU key, then press a number key , the user will go directly to the M0x window. For example, if the current window displays M01, press 7 and the user will go to M07.
- (2) When the window display is under M00 to M09, press the ENTER key and the user will go to Menu90; Menu 90 display the meter run status, press ENTER key to return. Press the dot key to go to M11

2.6 TRANSDUCERS MOUNTING LOCATING

The first step in the installation process is the selection of an optimum location in order to obtain a more accurate measurement. For this to be completed effectively, a basic knowledge about the pipe straight running would be advisable. An optimum location would be defined as a straight pipe length full of liquid that is to be measured. The piping can be in vertical or horizontal position. The following table shows examples of optimum locations.

Principles to selection of an optimum location

- (1) Install the transducers on a longer length of the straight pipe. The longer the better, and make sure that the pipe is completely full of liquid.
- (2) Make sure that the temperature on the location does not exceed the range for the transducers. Generally speaking, the closer to the room temperature, the better.
- (3) Take the pipe fouling into consideration. Select a straight length of a relatively newer pipe. If the condition is not satisfying, consider the fouling thickness as part of the liner for a better result.
- (4) Some pipes have a kind of plastic liner, and between the outer pipe and the liner there may be a certain thickness difference that will prevent the ultrasonic waves from direct traveling. Such conditions will make the measurement very difficult. Whenever possible, try to avoid this kind of pipes. If impossible, try our plug-in transducers that are installed permanently on the pipe by drilling holes on the pipe while liquid is running inside.

2.7 TRANSDUCERS MOUNTING

The transducers used by the TF1100-CH series ultrasonic flow meter are made of piezoelectric crystals both for transmitting and receiving ultrasonic signals through the wall of liquid piping system. The measurement is realized by measuring the traveling time difference of the ultrasonic signals. Since the difference is very small, the spacing and the

alignment of the transducers are critical factors to the accuracy of the measurement and the performance of the system. Meticulous care should be taken for the installation of the transducers.

Steps to the installation of the transducers

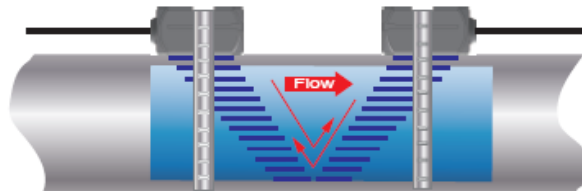
- (1) Locate an optimum position where the straight pipe length is sufficient, and where pipes are in a favorable condition, e.g., newer pipes with no rust and ease of operation.
- (2) Clean any dust and rust. For a better result, polishing the pipe with a sander is strongly recommended.
- (3) Apply adequate coupler to the spot where the transducers are to be installed and leave no gap between the pipe surface and the transducers.

Take care to avoid any sand or dust particles left between the pipe outer surface and the transducers.

To avoid gas bubbles inside the upper part of the pipe, the transducers should be installed horizontally by the side of the pipe.

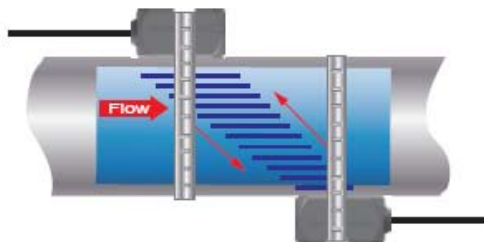
2.7.2 TRANSDUCER MOUNTING MODE

Transducer Mounting Modes



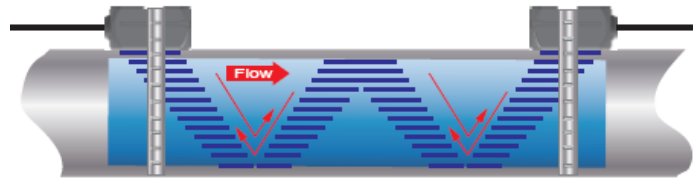
V method

V-Mount is the most widely used mode for daily measurement with pipe inner diameters ranging from 20 millimeter to 300 millimeter. It is also called standard mode or method. But if the meter displays error code or low signal strength and bad signal quality, for instance, some old pipe etc., user should select **Z-Mount**.



Z method

Z-Mount is commonly used when the pipe diameter is between 300 millimeters and 4500 mm.



W method

W-Mount is usually used on plastic pipes with a diameter from 10 mm to 50 mm.

2.8 INSTALLATION CHECKUP

Through the checkup of the installation, one can: check the receiving signal strength, the signal quality Q value, the traveling time difference of the signals, the estimated liquid speed, the measured traveling time of the signals and the calculated traveling time ratio. Therefore, optimum measurement result and longer running time of the instrument can be achieved.

2.8.1 SIGNAL STRENGTH

Signal strength indicates the amplitude of receiving ultrasonic signals by a 3-digit number. [00.0] means there is no signal detected and [99.9] refers to the maximum signal strength that can be received.

Although the instrument works well if the signal strength ranges from 50.0 to 99.9, stronger signal strength should be pursued, because a stronger signal means a better result. The following methods are recommended to obtain stronger signals:

- (1) Relocate a more favorable location, if the current location is not good enough for a stable and reliable flow reading, or if the signal strength is lower than 700.
- (2) Try to polish the outer surface of the pipe, and apply more coupler to increase the signal strength.
- (3) Adjust the transducers both vertically and horizontally while checking the varying signal strength, stop at the highest position, and then check the transducers spacing to make sure the transducers spacing is the same as what the M25 shows.

2.8.2 SIGNAL QUALITY (M90)

Signal quality is indicated as the Q value in the instrument. A higher Q value would mean a higher Signal and Noise Ratio (short for SNR), and accordingly a higher degree of accuracy would be achieved. Under normal pipe condition, the Q value is in the range 60-99, the higher the better.

Causes for a lower Q value could be:

- (1) Interference of other instruments and devices such as a powerful converter working nearby. Try to relocate the flow meter to a new place where the interference can be reduced.
- (2) Bad sonic coupling for the transducers with the pipe. Try to apply more coupler or clean the surface, etc.
- (3) Pipes are difficult to be measured. Relocation is recommended.

2.8.3 TOTAL TRANSIT TIME AND DELTA TIME

The numbers displayed on menu window M93 are called total transit time and delta time respectively. They are the primitive data for the instrument to calculate the flow rate inside the pipe. So the flow rate indication will vary accordingly with the total time and delta time.

The total transit time should remain stable or vary little.

If the delta time fluctuates higher than 20%, it means there are certain kinds of problems with the transducer installation.

2.8.4 TIME RATIO BETWEEN THE MEASURED TOTAL TRANSIT TIME AND THE CALCULATED TIME (M91)

This ratio would be used to check the transducer installation. If the pipe parameters are entered correctly and the transducers are installed properly, the value for this ratio (M91) should be in the range of 100 ± 3 . If this range is exceeded, the user should check:

- (1) If the pipe parameters are correctly entered.
- (2) If the actual spacing of the transducers is right and the same as what the window M25 shows.
- (3) If the transducers are installed properly in the right directions.
- (4) If the mounting location is good and if the pipe has changed shape or if there is too much fouling inside the pipes
- (5) Other poor conditions

PART-3 HOW TO USE MENU OPERATION

3.1 HOW TO JUDGE WHETHER THE INSTRUMENT WORKS PROPERLY

Generally speaking, when 'R' is displayed in the lowest right corner of LCD display, the instrument is working properly.

If an 'H' flashes on that place, there could be poor signal received. Please refer to the chapters on diagnosis.

If an 'I' is displayed, it means that there is no signal detected.

If a 'J' is displayed, it means that the hardware of this instrument could be out of order. Refer to the chapter on diagnosis.

3.2 HOW TO JUDGE THE LIQUID FLOWING DIRECTION

- (1) Make sure that the instrument works properly
- (2) Check the flow rate for the indication. If the displayed value is POSITIVE, the direction of the flow will be from the RED transducers to the BLACK transducers; if the displayed value is NEGATIVE, the direction will be from the BLACK transducers to the RED transducers.

3.3 HOW TO CHANGE THE UNITS SYSTEMS

Use menu window M30 for the selection of unit system in English or Metric system.

3.4 HOW TO SELECT A REQUIRED FLOW RATE UNIT

Use menu window M31 to select the flow unit first and then the timing unit.

3.5 HOW TO USE THE TOTALIZER MULTIPLIER

Use window M33 to select a proper totalizer. Make sure that the totalizer pulse is appropriately speeded. It should not be too fast and neither too slow. A speed of producing a pulse in several seconds or minutes is preferable.

If the totalizer multiplier is too small, there can be a loss of accumulation pulse because the output device can output only one pulse in a measurement period (500milliseconds)

If the totalizer multiplier is too large, the output pulse will be too fewer for the devices that are connected with the instrument for a quicker response.

3.6 HOW TO OPEN OR SHUT THE TOTALIZERS

Use M34, M35 and M36 to turn on or turn off the NET, POS, or NEG totalizer respectively.

3.7 HOW TO RESET THE TOTALIZERS

Use M37 to reset the proper totalizer.

3.8 HOW TO RESET THE DEFAULT SETUPS

Use M37, when the 'selection' message is displayed. Press the dot key first and the message 'Master Erase' will display, then press the backspace key 

The master erase step will erase all the parameters entered by the user and setup the instrument with default values.

3.9 HOW TO USE THE DAMPING

The damping acts as a filter for a stable reading. If '0' is entered in window M40, that means there is no damping. A bigger number brings a more stable effect. But bigger damping numbers will prevent the instrument from acting quickly.

Numbers 0 to 10 are commonly used for the damping value.

3.10 HOW TO USE THE ZERO-CUTOFF FUNCTION





The number displayed in window M41 is called the low-cutoff value. The flow meter will replace these flow rate values that are absolutely less than the low-cutoff value with '0'. This means the flow meter will avoid any invalid accumulation when the actual flow is below the zero-cutoff value.

The low-cutoff value does not affect the flow measurement when the actual flow is absolutely greater than the low-cutoff value.

3.11 HOW TO SETUP A ZERO POINT

It is necessary to establish the true zero flow condition and program that set point into the instrument. If the zero set point is not at true zero flow, a measurement difference may occur. Because every flow meter installation is slightly different and sound waves can travel in slightly different ways through these various installations, a provision is made in this entry to establish "True Zero" flow – SETUP ZERO.

There exists a 'Zero Point' with certain installation which means the flow meter will display a non-zero value when the flow is absolutely stopped. In this case, setting a zero point with the function in window M42 will bring a more accurate measurement result. When do a calibration test, it is also very important.

Make sure that the pipe is full of liquid and the flow is absolutely stopped - securely close any valves and allow time for any settling to occur. Then run the function in window M42 by press the    keys, then press  key and wait until the counter readings displayed in the lower right corner of the screen goes to "00"; thus, the zero set is

completed and the instrument indicates the results automatically through Window No.01. Repeat zero set calibration if it still needs to be minimized, i.e. the velocity reading is still high.

3.12 HOW TO GET A SCALE FACTOR FOR CALIBRATION

The scale factor is the ratio between the ‘actual flow rate’ and the indicated value by the flow meter.

The scale factor can be determined by calibration with flow calibration equipment.

3.13 HOW TO USE THE OPERATION LOCKER

The system locker provides a means of preventing inadvertent configuration changes or totalizer resets.

When the system is locked, menu window browsing can be done without affecting any change, but any modifications are prohibited.

The system can be locked without a password or with a one 1 to 4 digit password. With a no-password locking, directly press the ENT key when the password input prompt displays.

If the password is forgotten, please contact the factory.

3.14 HOW TO USE THE BUILT-IN DATA MEMORY

The data memory has a space of 24K bytes of memory, which will hold about 2000 lines of data.

Use M50 to turn on the data memory and for the selection for the items that is going to be logged.

Use M51 for the times when the logging begins and at how long an interval sustains and how long the data logging will last.

Use M52 for the direction of logging data. The default setting will permit the logging data to be stored in the data memory buffer.

Logging data can be redirected to the RS-232C interface without being stored into the data memory buffer. Dumping the logging data through the RS-232C interface and the clearing of the buffer can be operated with a function in window M52.

Use M53 to view the data in the data memory buffer.

3.15 HOW TO USE THE FREQUENCY OUTPUT

Only For Flow Rate Output.

There is a Frequency Output in all series TF1100 flow meters. This frequency output signal,

which represents the flow rate, is intended to connect with other instruments.

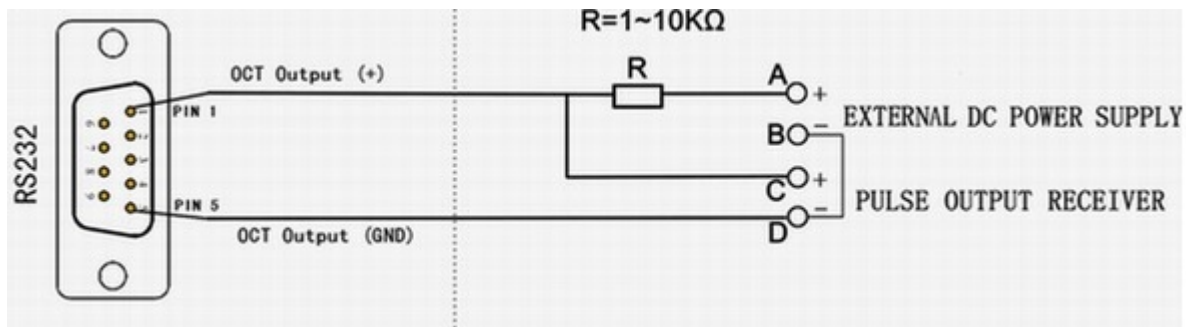
The Frequency Output is totally user-configurable. Generally, four parameters should be configured for the setups.

Enter the lower flow rate value in window M68 and the higher flow rate value in window M69. Enter the frequency range in window M67.

For example, assume that the flow rate varies in a range 0m³/h to 2000m³/h, and an output signal is at a maximum frequency of 1000Hz, the minimum of 200Hz is going to be required for other instrumentation. The user should enter 0 in M68 and 2000 in M69, and enter 200 and 1000 in window M67.

Please note that the user has to make the selection with OCT (**Open Collect Transistor**) output setups in window M78 by selecting the 13th option reading like ‘FO output’ to direct the frequency output to the OCT OUTPUT hardware device.

The OCT output shares pins with the RS-232C interface, and the terminal is at Pin 1 for OCT + and the ground is at Pin 5.



A, B is DC power supply based on pulse receiver voltage, 5-24V is allowable. C, D is pulse input for receiver. Select a resistor that is a maximum of 10% of the input impedance of the receiving device, but do not exceed 10k ohms.

OCT: Black+ ; Yellow-



3.16 HOW TO PRODUCE AN ALARM SIGNAL

There are 2 types of hardware alarm signals that are available with this instrument. One is the Buzzer, and the other is the OCT output.

Both for the Buzzer and OCT output the triggering sources of the event include the following:

- (1) Alarms on when there is no receiving signal
- (2) Alarms on when there is poor signal received.
- (3) Alarms on when the flow meter is not in normal measurement modes.
- (4) Alarms on reverse flow.
- (5) Alarms on the overflow of the Frequency Output
- (6) Alarms on when the flow is out of a designated range set by the user.

There are two out-of-normal-range alarms in this instrument. They are called #1 Alarm and #2 Alarm. The flow range can be user-configurable through M73, M74, M75, M76.

For example, assume that the Buzzer should start beeping when the flow rate is less than $300\text{m}^3/\text{h}$ and greater than $2000\text{m}^3/\text{h}$, the following steps for setups would be recommended.

- (1) Enter 300 under M73 for #1 alarm low flow rate
- (2) Enter 2000 under M74 for #1 alarm high flow rate
- (3) Select the item reading like '6. Alarm #1' under M77.

3.17 HOW TO USE THE BUILT-IN BUZZER

The built-in buzzer is user-configurable. It can be used as an alarm. Use M77 for setups.

3.18 HOW TO MODIFY THE BUILT-IN CALENDAR

No modification on the built-in calendar will be needed in most cases. The calendar runs on insignificant amount of power supply. Modification will be required only in such cases as when the battery is totally consumed, or when the changing of the battery takes a long time.

Press the ENT key under M61 for Modification. Use the dot key to skip over these digits that need no modification.

3.19 HOW TO ADJUST THE LCD CONTRAST

Use M70 to the LCD contrast. The adjusted result will be stored in the EEPROM so that the MASTER ERASE will make no effect on the contrast.

3.20 HOW TO USE THE RS232 SERIAL INTERFACE

Use M62 for the setup of the RS-232C serial interface.

3.21 HOW TO VIEW THE DATE TOTALIZERS

Use M82 to view the date totalizers that are comprised of a daily totalizer, a monthly totalizer and a yearly totalizer.

3.22 HOW TO USE THE WORKING TIMER

Use the working timer to check the time that has passed with a certain kind of operation. For example, use it as a timer to show how long a fully-charged battery will last.

Under M72, press ENT key and then select YES to reset the timer.

3.23 HOW TO USE THE MANUAL TOTALIZER

Use M28 for the manual totalizer. Press ENT key to start and stop the totalizer.

3.24 HOW TO CHECK THE ESN AND OTHERS

Every set of the TF1100-CH series flow meter utilizes a unique ESN to identify the meter. The ESN is an 8-digit number that provides the information of version and manufacturing date. The user can also employ the ESN for instrumentation management. The ESN is displayed in window M61.

Other details about the instrument are the total working hours displayed in window M+1, and the total power-on times displayed in window M+4.

3.25 HOW TO KNOW HOW LONG THE BATTERY WILL LAST AND HOW TO CHARGE THE BUILT-IN BATTERY

Use M07 to check how long the battery will last. The instrument can operate either from the built-in Ni-H rechargeable battery, which will last over 10 hours of continuous operation when fully recharged, or from an external AC/power supply from the battery charger.

The battery charging circuits employ a scheme of constant-current and constant-voltage. It has a characteristic of fast charging at the beginning and very slow charging when the battery approaches to full recharge. Generally, when the green LED starts coming on, the battery would be nearly 95% recharged and when the red LED is off, the battery would be 98% recharged.

Since the charging current becomes tapered when the battery recharge is nearly completed, i.e. the charging current becomes smaller and smaller, therefore, there should be no over-recharging problem. That means the charging progress can last very long.


When fully recharged, the terminal voltage reaches around 4.25V. The terminal voltage is displayed on window M07. When the battery is nearly consumed, the battery voltage drops to below 3V. The user can obtain an approximate battery working time from the battery voltage.

A software battery working time estimator is integrated in this instrument based on the terminal voltage. Please note that the estimator may have relatively bigger errors in the estimated working time, especially when the voltage is in the range of around 3.70 to -3.90 volt.

PART-4 MENU WINDOW DETAILS

Menu window No.	Function
M00	Display positive negative net totalizers, signal strength, signal quality
M01	Display POS totalizer, flow rate, velocity, signal strength, signal quality
M02	Display NEG totalizer, flow rate, velocity, signal strength, signal quality
M03	Display NET totalizer, flow rate, velocity, signal strength, signal quality
M04	Display date and time, flow rate, signal strength, signal quality
M05	Display date and time, velocity, signal strength, signal quality
M06	Display the wave shape of the receiving signal
M07	Display the battery terminal voltage and its estimated lasting time
M08	Display Error Code, signal strength, signal quality
M09	Display today's total flow, velocity, signal strength, signal quality and working status
Above is display Menu	
M10	Window for entering the outer perimeter of the pipe
M11	Window for entering the outer diameter of the pipe 0 to 6000mm is the allowed range of the value.
M12	Window for entering pipe wall thickness
M13	Window for entering the inner diameter of the pipe
M14	Window for selecting pipe material: Standard pipe materials (that the user need not know the speed) include: (0) Carbon steel (1) Stainless steel (2) Cast iron (3) Ductile iron (4) Copper (5) PVC (6) Aluminum (7) Asbestos (8) Fiberglass (9) Other
M15	If in Menu 14, select "9, Other", please ENTER "Pipe Sound Velocity" value.
M16	Window for selecting the liner material, select none for pipes without any liner: Standard liner materials that the user don't need to know the speed include: (0) No Liner (1) Tar Epoxy (2) Rubber (3) Mortar (4) Polypropylene (5) Polystryol (6)Polystyrene (7) Polyester (8) Polyethylene (9) Ebonite (10) Teflon (11) Other
M17	Window for entering the liner material Sound Velocity value only for non-standard liner materials, i.e., in Menu16, user select "11, Other".
M18	Window for entering the liner thickness, if there is a liner
M19	Window for entering the ABS thickness of the inside wall of the pipe
M20	Window for selecting fluid type: For standard liquids that the user need not know the liquid speed include: (0) Water (1) Sea Water (2) Kerosene (3) Gasoline (4) Fuel oil (5) Crude Oil (6) Propane at -45°C

	(7) Butane at 0°C (8)Other liquids (9) Diesel Oil (10)Castor Oil (11)Peanut Oil (12) #90 Gasoline (13) #93 Gasoline (14) Alcohol (15) Hot water at 125°C																											
M21	Window for entering the fluid sound speed only for non-standard liquids, i.e., in Menu20, user select “8, Other Liquids”.																											
M22	Window for entering the viscosity of the non-standard liquids																											
M23	<p>Window for selecting the proper transducers (XDCCR)types:</p> <p>There are different types of transducers for TF1100-CH, options: Standard-M, Standard-S, standard-L, TF1100-EC is Plug-in type B45.</p> <p>Standard-S: Clamp-on small pipe, 15-40mm Standard-M: Clamp-on standard pipe, 40-1200mm Standard-L: Clamp-on large pipe, 1000mm-4500mm Plug-in B45: Insertion, hot-tapped transducer, 65-4500mm</p> <div style="border: 1px solid black; padding: 5px; width: fit-content; margin-left: 200px;"> <p>M23 XDCCR Type 0. Standard-M</p> </div>																											
M24	Window for selecting the transducer mounting methods Four methods can be selected: (0) V-method (1) Z-method (2) N-method (3) W-method																											
M25	Display the transducer mounting spacing.																											
M26	Entry to store the parameter configuration into the internal memory. this menu is not useful for common application.																											
M27	Entry to load one set of saved parameters, this menu is not useful for common application.																											
M28	Select YES or NO for the instrument to determine whether or not to hold (or to keep) the last correct value when poor signal condition occurs. YES is the default setup																											
M29	Empty Pipe Setup, this is very useful for user, Empty pipe line or pipe shaking etc., meter may display error or undesired read, user can setup a Q value less than normal Q value, for example, normal Q value is 60-70, user can enter Empty Pipe Setup value 50, such, meter will display 0 flow rate when Q value is less than 50. In good pipe status, please do not setup this value too small.																											
M30	Window for selecting unit system. Default value is ‘Metric’. The change from English to Metric or vice versa will not affect the unit for totalizers.																											
M31	<p>Window for selecting flow rate that will be used by the instrument afterward.</p> <p>Flow rate can be in:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 40%;">0. Cubic Meter</td> <td style="width: 20%;">short for</td> <td style="width: 40%;">(m3)</td> </tr> <tr> <td>1. Liter</td> <td></td> <td>(l)</td> </tr> <tr> <td>2. USA Gallon</td> <td></td> <td>(gal)</td> </tr> <tr> <td>3. Imperial Gallon</td> <td></td> <td>(igl)</td> </tr> <tr> <td>4. Million USA Gallon</td> <td></td> <td>(mgl)</td> </tr> <tr> <td>5. Cubic Feet</td> <td></td> <td>(cf)</td> </tr> <tr> <td>6. USA Liquid Barrel</td> <td></td> <td>(bal)</td> </tr> <tr> <td>7. Imperial Liquid Barrel</td> <td></td> <td>(ib)</td> </tr> <tr> <td>8. Oil Barrel</td> <td></td> <td>(ob)</td> </tr> </table> <p>The flow unit in terms of time can be per day, per hour, per minute or per</p>	0. Cubic Meter	short for	(m3)	1. Liter		(l)	2. USA Gallon		(gal)	3. Imperial Gallon		(igl)	4. Million USA Gallon		(mgl)	5. Cubic Feet		(cf)	6. USA Liquid Barrel		(bal)	7. Imperial Liquid Barrel		(ib)	8. Oil Barrel		(ob)
0. Cubic Meter	short for	(m3)																										
1. Liter		(l)																										
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3. Imperial Gallon		(igl)																										
4. Million USA Gallon		(mgl)																										
5. Cubic Feet		(cf)																										
6. USA Liquid Barrel		(bal)																										
7. Imperial Liquid Barrel		(ib)																										
8. Oil Barrel		(ob)																										

	second. So there are 36 different flow rate units in total for selection.
M32	Window for selecting the totalizers' working unit
M33	Select totalizer multiplier The multiplier ranges from 0.001 to 10000
M34	Turn on or turn off the NET totalizer
M35	Turn on or turn off the POS totalizer
M36	Turn on or turn off the NEG totalizer
M37	(1) Totalizer reset (2) Restore the instrument to the default parameters as the manufacturer did (Reset system) by pressing the dot key  followed by the ◀ key. Take care or make note on the parameters before doing restoration.
M38	Manual Totalizer. Press-a-key-to-run or to stop totalizer for easier calibration application etc.
M40	Flow rate damper for a stable value. The input range is 0 to 999 seconds. 0 means there is no damping. Default value is 10 seconds
M41	<p>Low Flow Cutoff, may be used in order to force a zero display at lower flows and avoid incorrect totalizer.</p> <p>For instance, this value is 0.01m/s, the meter will display zero when flow rate is less than $\pm 0.01\text{m/s}$.</p> <div style="border: 1px solid black; padding: 5px; display: inline-block; margin-left: 20px;"> <p>M41 Low Flow Cutoff 0.01m/s</p> </div>
M42	<p>Set Zero, when the fluid is in the static state, the displayed value is called "zero point". When the "Zero Point" is not really at zero, the incorrect read value is going to be added into the actual flow values.</p> <p>Set Zero must be carried out after the transducers are right installed and the flow inside is in the absolute static state (no liquid moved in the pipe line). Set Zero also is very important step when recalibrating the meter in lab. Doing this step enhances the measuring accuracy and flow offset can be eliminated.</p>
M43	Clear the zero point set by the user, and restore the zero point set by the manufacturer
M44	Manual Zero Point. Set up a manual flow bias. Generally this value should be 0.
M45	The Scale Factor is used to modify the measurement results, factory default is 1.0 or other value depend on calibration, please see the calibration data sheet and save this sheet. If really necessary, the user can enter a numerical value other than factory default value according to re-calibration results.
M46	Network environment Identification Number. Any integer can be entered except 13(ODH, carriage return), 10 (0AH, line feeding), 42 (2AH), 38, 65535. Every set of the instrument in a network environment should have a unique IDN. Please refer to the chapter for communication.
M47	System locker to avoid modification of the parameters (The universal password is 0808)
M49	Communication tester

<p>M50</p>	<p>“Option” selection for the logger. It is the functions as the switch of external 16GB data logger. If select data logger output, please select “ON”, then, press “ENTER”, then must select all the items “ON”, i.e., from item 1 to 11, all the items must be selected as “ON”.</p>							
<p>M51</p>	<p>Time setup for the data logger, if “Go On” time is longer than 24 hours, please use dot key <input type="checkbox"/> on Keypad, will display * symbol, as below: **:**:**, it means no time limit.</p>							
<p>M52</p>	<p>(1) Data logging direction control, use the \wedge or \vee key to select ‘To RS-232’, then press “ENTER” key, all the data produced by the data logger will be transmitted out through the RS-232 interface (2) If ‘To buffer ‘ is selected, the data will be stored into the built-in logger memory (3) Buffer transferring and buffer clearing</p>							
<p>M53</p>	<p>Logger buffer browser. It functions as a file editor. Use Dot, backspace UP and DN keys to browse the buffer. If the logger is ON, the viewer will automatically refresh once new data are stored</p>							
<p>M60</p>	<p>99-year calendar. Press ENTER for modification. Use the dot key to skip the digits that need no adjusting. User can setup Date as YEAR-MONTH-D (all setups are two digits.)</p>							
<p>M61</p>	<p>Display Version information and Electronic Serial Number (ESN) that are unique for each TF1100-CH series flow meter. The users can employ the ESN for instrumentation management.</p>							
<p>M62</p>	<p>RS-232C communication setup Commonly, user should select “9600, None” 9600 is baud rate; parity check bit is “None”.</p>							
<p>M67</p>	<p>Input the frequency range for the frequency output. The biggest range is 0Hz-9999Hz. Default value is 1-1001 Hz. Note: see “OCT terminal wiring”.</p>							
<p>M68</p>	<p>Setup the Low Frequency Output corresponding Value of Flow Rate. This value correspond to the lowest Frequency value entered in M67.</p>	<table border="1" style="width: 100%; text-align: center;"> <tr> <td colspan="2">M68</td> </tr> <tr> <td colspan="2">Low FO Flow Rate</td> </tr> <tr> <td colspan="2">0 m³/h</td> </tr> </table>	M68		Low FO Flow Rate		0 m ³ /h	
M68								
Low FO Flow Rate								
0 m ³ /h								
<p>M69</p>	<p>Setup the High Frequency Output corresponding Value of Flow Rate. This value correspond to the highest Frequency value entered in M67.</p>	<table border="1" style="width: 100%; text-align: center;"> <tr> <td colspan="2">M69</td> </tr> <tr> <td colspan="2">High FO Flow Rate</td> </tr> <tr> <td colspan="2">3000 m³/h</td> </tr> </table>	M69		High FO Flow Rate		3000 m ³ /h	
M69								
High FO Flow Rate								
3000 m ³ /h								
<p>M70</p>	<p>LCD display backlight control. The entered value indicates how many seconds the backlight will be on with every key pressing.</p>							
<p>M71</p>	<p>LCD contrast control. The LCD will become darker when a small value is entered.</p>							

M72	Working timer. It can be cleared by pressing ENT key, and then select YES. Before instrument shipped, We have calibrated and tested, so working timer is usually not zero.
M73	Enter Lower Flow Rate value that will trigger the #1 Alarm. There are two virtual alarms in the system. By “virtual” we mean that the user must redirect the output of the alarms by setting up the output hardware in M78 and M77
M74	Enter the higher flow rate value that will trigger the #1 Alarm.
M75	Enter the lower flow rate value that will trigger the #2 Alarm.
M76	Enter the higher flow rate value that will trigger the #2 Alarm.
M77	Buzzer setup. If a proper input source is selected, the buzzer will beep when the trigger event occurs
M78	OCT (Open Collect Transistor)Output setup: By selecting a proper input source, the OCT hardware will close when the trigger event occurs
M82	View Data Totalizer. View by Day/Month/Year
M90	<p>Display signal strength, signal quality,</p> <p>IMPORTANT</p> <p>When installing the transducers,</p> <p>Let Q Value at least ≥ 60</p> <div style="border: 1px solid black; padding: 5px; display: inline-block; margin-left: 20px;"> <p>M90 Strength + Quality S=00.0, 00.0 Q=00</p> </div>
M91	<p>Displays the Time Ratio between the Measured Total Transit Time and the Calculated time. If the pipe parameters are entered correctly and the transducers are properly installed, the ratio value should be in the range of $100\pm 3\%$. Otherwise the entered parameters and the transducer installation should be checked.</p> <div style="border: 1px solid black; padding: 5px; display: inline-block; margin-left: 20px;"> <p>M91 TOM/TOS*100 0.0000%</p> </div>
M92	Displays the measured fluid sound speed. Normally this value should be approximately equal to the entered value in Menu 21 when M20 the fluid type select “Other”. If this value has an obvious difference with the actual fluid sound speed, pipe parameters entered and the transducer installation should be checked again. If Menu20, the fluid type doesn’t select “Other”, this window is no matter with user.
M93	Displays total transit time and delta time(transit time difference)
M94	Displays the Reynolds number and the pipe factor used by the flow rate program.
M+0	Browse the 64 recorded instrument power-on and power-off date and time with

	the flow rate at the time of power on and off
M+1	Displays the total working time of the instrument
M+2	Displays the last power-off date and time
M+3	Displays the last power-off flow rate
M+4	Displays the times of instrument powered on(the instrument has been powered on). Before instrument shipped, We have calibrated and tested, so the times is usually not zero.
M+5	A scientific calculator for the convenience of field working. All the values are in single accuracy. The drawback is that the user can't operate it by direct key-pressing
M+8	Ultrasonic Wave Shape

Note: The pulse output is utilized to transmit information to external counters and PID systems via a frequency output that is proportional to system flow rate or total flow (can be configured in Menu). The frequency output range of the Pulse is 0–9999 Hz. The type of pulse output is an open-collector transistor (OCT) type that does not source voltage at its output, requiring an external power source and pull-up resistor. Resistor selection is based on the input impedance of the receiving device. Select a resistor that is a maximum of 10% of the input impedance of the receiving device, but do not exceed 10k-ohms. See the Figure 3.3, the voltage value of External DC power Supply is depending on Pulse Output receiver, 3-12V is allowable.

PART-5 TROUBLESHOOTING

5.1 POWER-ON ERROR DISPLAYS AND COUNTER-MEASURES

The TF1100-CH series ultrasonic flow meter provides an automatic power-on diagnosis for the hardware problems. When any message (with the power on) in the following table displays, counter-measures should be taken.

Error message	causes	Counter-measures
ROM Testing Error	Problem with the software	(1)Power on again
Segment Test Error		(2)Contact with factory
Stored Data Error	The parameters entered by the user lose integration.	When this message displays, the user should press ENT key, and all the configuration will be restored to the default state.
Timer Slow Error	Problem with the timer-keeper or the crystal oscillator.	(1)Power on again
Timer Fast Error		(2)Contact with factory
Date Time Error	Number errors with the calendar	Initialize the calendar by menu window M61
Reboot repetitively	Hardware problems	Contact the factory

5.2 ERROR CODE AND COUNTER-MEASURES

The TF1100-CH series ultrasonic flow meter will show Error Code in the lower right corner with a single letter like I, R etc. on menu windows M00, M01, M02, M03, M90 and M08. When any abnormal Error Code shows, counter-measures should be taken.

Error code	Correspondent Message displayed on M08	Causes	Counter-measures
R	System Normal	No error	
I	Detect No Signal	(1)No Signals detected (2)Transducers installed improperly (3)Too much fouling (4)Pipe liners are too thick. (5)Transducer	(1)Relocate measuring location (2)Clean the spot (3)Check the cords

		cords are not properly connected	
J	Hardware Error	Hardware problem	Contact the factory
H	PoorSig Detected	<p>(1) Poor signal detected</p> <p>(2) Transducers installed improperly</p> <p>(3) Too much fouling</p> <p>(4) The pipe liners are too thick.</p> <p>(5) Problem with transducers cords</p>	<p>(1) Relocate measuring place</p> <p>(2) Clean the spot</p> <p>(3) Check the cords</p> <p>(4) Check the coupler</p>
Q	Freq. Output Over	The actual frequency for the Frequency Output is out of the range set by the user	Check the value entered at M66, M67, M68 and M69, and try to enter a larger value on M69
F	<p>System RAM Error</p> <p>Date Time Error</p> <p>CPU or IRQ Error</p> <p>ROM Parity Error</p>	<p>(1) Temporary problems with RAM, RTC</p> <p>(2) Permanent problems with hardware</p>	<p>(1) power on again</p> <p>(2) contact factory</p>
1 2 3	Adjusting Gain	Instrument is in the progress of adjusting the gain for the signal, and the number indicates the progressive steps	
K	Empty pipe	<p>(1) No liquid inside pipe</p> <p>(2) Setup error on M29</p>	<p>(1) Relocate where the pipe is full of liquid</p> <p>(2) Enter 0 on M29</p>

5.3 OTHER PROBLEMS AND SOLUTIONS

- (1) When the actual flow inside the pipe is not standstill, but the instrument displays 0.0000 for the flow rate, and 'R' displaying signal strength and the signal quality Q (value) has a satisfactory value?

The problems are likely caused by the user who has used the 'Set Zero' function on this non-standstill flowing pipe. To solve this problem, use the 'Reset Zero' function on menu window M43.

- (2) The displayed flow rate is much lower or much higher than the actual flow rate in the pipe under normal working conditions.
 - (a) There is probably an offset value wrongly entered by the user in M44. Enter '0' in M44.
 - (b) Problem with transducer installation.
 - (c) There is a 'Zero Point'. Try to 'zero' the instrument by using M42 and make sure that the flow inside the pipe should be standstill.
- (3) The battery can't work as long as the time period as indicated by M07
 - (a) Battery should be replaced due to the end of the service life.
 - (b) Newly changed battery does not fit the battery estimating software. Customizing the battery with the software should be taken. Please contact the factory.
 - (c) The battery has not been fully recharged or the recharge has been stopped too many times halfway.
 - (d) There is indeed a time difference between the actual working time and the estimated one, especially when the terminal voltage is in the range 3.70 and 3.90 volt. Please refer to battery voltage for a closer estimated working time.

5.4 USE MENU WINDOWS FOR TRANSDUCER MOUNTING INSPECTION

5.4.1 Signal Strength

Signal strength (displayed in Window M90) indicates a detected strength of the signal both from upstream and downstream directions. The relevant signal strength is indicated by numbers from 00.0~99.9 in the TF1100. 00.0 represents no signal detected while 99.9 represents maximum signal strength.

Normally, the stronger the signal strength detected, the instrument will work more reliably, as well as the more stable the measurement value obtained.

Adjust the transducer to the best position and check to ensure that enough sonic coupling compound is applied adequately during installation in order to obtain the maximum signal strength. System normally requires signal strength over 60.0, which is detected from both upstream and downstream directions. If the signal strength detected is too low, the transducer installation position and the transducer mounting spacing should be re-adjusted and the pipe should be re-inspected. If necessary, change the mounting to the Z method.

5.4.2 Signal Quality (Q value)

Q value is short for Signal Quality (displayed in Window M90). It indicates the level of the signal detected. In the TF1100, Q value is indicated by numbers from 00~99. 00 represents the minimum signal detected while 99 represent the maximum. Normally, the transducer position should be adjusted repeatedly and coupling compound application should be

checked frequently until the signal quality detected is as strong as possible.

5.4.3 Total Time and Delta Time

“Total Time and Delta Time”, which displays in Window No.93, indicates the condition of the installation. The measurement calculations in the flow meter are based upon these two parameters. Therefore, when “Delta Time” fluctuates widely, the flow and velocities fluctuate accordingly. This means that the signal quality detected is too poor. It may be the result of poor pipe-installation conditions, inadequate transducer installation or incorrect parameter input. Generally, “Delta Time” fluctuation should be less than $\pm 20\%$. Only when the pipe diameter is too small or velocity is too low can the fluctuation be wider.

5.4.4 Transit Time Ratio (M91, Very important for transducer mounting spacing)

Transit Time Ratio indicates if the transducer mounting spacing is accurate. The normal transit time ratio should be $100\pm 3\%$ if the installation is proper. Check it in Window M91. If the transit time ratio is over $100\pm 3\%$, it is necessary to check (1) if the parameters (pipe outside diameter, wall thickness, pipe material, liner, etc.) have been entered correctly, (2) if the transducer mounting spacing is in accordance with the display in Window M25, (3) if the transducer is mounted at the pipe’s centerline on the same diameter, or (4) if the scale is too thick or the pipe mounting is distorted in shape, etc.

5.4.5 Warnings

1. Pipe parameters entered must be accurate; otherwise the flow meter will not work properly.
2. During the installation, apply enough coupling compounds in order to stick the transducer onto the pipe wall. While checking the signal strength and Q value, move the transducer slowly around the mounting site until the strongest signal and maximum Q value can be obtained. Make sure that the larger the pipe diameter, the more the transducer should be moved. Check to be sure the mounting spacing is in accordance with the display in Window M25 and the transducer is mounted at the pipe’s centerline on the same diameter. Pay special attention to those pipes that formed by steel rolls (pipe with seams), since such pipe is always irregular. If the signal strength is always displayed as 0.00, that means there is no signal detected. Thus, it is necessary to check that the parameters (including all the pipe parameters) have been entered accurately. Check to be sure the transducer mounting method has been selected properly, the pipe is not worn-out, and the liner is not too thick. Make sure there is indeed fluid in the pipe or the transducer is not very close to a valve or elbow, and there are not too many air bubbles in the fluid, etc. With the exception of these reasons, if there is still no signal detected, the measurement site has to be changed.
3. Make sure that the flow meter is able to run properly with high reliability. The stronger the signal strength displayed, the higher the Q value reached. The longer the flow meter runs accurately, the higher the reliability of the flow rates displayed. If there is interference from ambient electromagnetic waves or the signal detected is too poor, the flow value displayed is not reliable; consequently, the capability for reliable operation is reduced.
4. After the installation is complete, power on the instrument and check the result accordingly.

PART-6 COMMUNICATION PROTOCOL

6.1 GENERAL

The TF1100-CH ultrasonic flow meter integrates a standard RS-232C communication interface.

6.2 INTERFACE PIN-OUT DEFINITION

Pin	1	OCT output +
	2	RXD
	3	TXD
	4	not used
	5	GND, OCT OUTPUT - GND
	6	for battery recharge, negative input, GND
	7	for battery recharge, positive input, +12V
	8	+5V
	9	not used



OCT: Pin1(black) and 5 (yellow)
 RS232: Pin 2 (brown), 3 (red) and 5(yellow)

6.3 THE PROTOCOL

The protocol is comprised of a set of basic commands that is a string in ASCII format, ending with a carriage (CR) and line feed (LF). Commonly used commands are listed in the following table.

Command	Function	Data Format
DQD(CR)	Return flow rate per day	±d.dddddE±dd(CR) (LF) *
DQH(CR)	Return flow rate per hour	±d.dddddE±dd(CR) (LF)
DQM(CR)	Return flow rate per minute	±d.dddddE±dd(CR) (LF)
DQS(CR)	Return flow rate per second	±d.dddddE±dd(CR) (LF)
DV(CR)	Return flow velocity	±d.dddddE±dd(CR) (LF)
DI+(CR)	Return POS totalizer	±ddddddE±d(CR) (LF) **
DI-(CR)	Return NEG totalizer	±ddddddE±d(CR) (LF)
DIN(CR)	Return NET totalizer	±ddddddE±d(CR) (LF)
DID(CR)	Return Identification	dddd(CR) (LF)

	Number	
DL(CR)	Return signal strength and quality	S=ddd,ddd Q=dd (CR)(LF)
DT(CR)	Return date and time	yy-mm-dd hh:mm:ss(CR)(LF)
M@(CR)***	Send a key value as if a key is pressed	
LCD(CR)	Return the current window display	
FOddd(CR)	Force the FO output with a frequency in dddd Hz	
ESN(CR)	Return the ESN for the instrument	Dddddddd(CR)(LF)
RING(CR)	Handshaking Request by a MODEM	
OK(CR)	Response from a MODEM	No action
GA	Command for GSM messaging	Please contact factory for detail
GB	Command for GSM messaging	
GC	Command for GSM messaging	
DUMP(CR)	Return the buffer content	In ASCII string format
DUMP0(CR)	Clear the whole buffer	In ASCII string format
DUMP1(CR)	Return the whole buffer content	In ASCII string Format, 24KB in length
W	Prefix before an Identification Number in a network environment. The IDN is a word, ranging 0-65534.	
N	Prefix before an Identification Number in a network environment. The IDN is a single byte value, ranging 00-255.	
P	Prefix before any command	
&	Command connector to make a longer command by combining up to 6 commands	

Notes * CR stands for Carriage Return and LF for Line Feed.

** 'd' stands for the 0~9 digit numbers.

*** @ stands for the key value, e.g., 30H for the '0' key.

6.4 PROTOCOL PREFIX USAGE

(1) Prefix P

The prefix P can be added before any command in the above table to have the returning data followed with two bytes of CRC check sum, which is the adding sum of the original character string.

Take the DI+(CR) command as an example. Assume that DI+(CR) would return +1234567E+0m3(CR)(LF) (the string in hexadecimal is 2BH, 31H, 32H, 33H, 34H, 35H, 36H, 37H, 45H, 2BH, 30H, 6DH, 33H, 20H, 0DH, 0AH), then PDI+(CR) would return +1234567E+0m3!F7(CR)(LF). '!' acts as the starter of check sum which is yielded by adding up the string 2BH, 31H, 32H, 33H, 34H, 35H, 36H, 37H, 45H, 2BH, 30H, 6DH, 33H, 20H.

Please note that there will be SPACES (20H) before '!'.

(2) Prefix W

The prefix W should be used in the network environment. The usage format is W + digit string which stands for the IDN (Identification Number of the meter) + basic command.

The digit string should have a value between 0 and 65534 except 13(0DH), 10 (0AH), 42(2AH,*), 38(26H, &).

For example, if the IDN=254 instrument is addressed and returning the velocity of that instrument is requested, the command will be W254DV(CR).

(3) Prefix N

The prefix N is a single byte IDN network prefix, not recommended in a new design. It is reserved only for the purpose of the compatibility with the former versions

(4) Command Connector &

The & command connector can connect up to 6 basic commands to form a longer command so that it will make the programming much easier.

For example, assume that the measurement of an instrument with DID=254 are going to be returned, and (then) all the following 3 values--- (1) flow rate (2) velocity (3)POS totalizer---will be returned simultaneously. The combined command would be W254DQD&DV&DI+(CR), and the result would be:

+1.234567E+12m3/d(CR)

+3.1235926E+00m/s(CR)

+1234567E+0m3(CR)

6.5 CODES FOR THE KEYPAD

The codes for the keypad should be used when the instrument is connected with other terminals that operate the instrument by transmitting the 'M' command along with the keypad code. By this function, remote operation of this instrument can be realized, even via the Internet.

Key	Hexadecimal Key code	Decimal Key code	ASCII Code
0	30H	48	0
1	31H	49	1
2	32H	50	2
3	33H	51	3
4	34H	52	4
5	35H	53	5
6	36H	54	6
7	37H	55	7
8	38H	56	8
9	39H	57	9
.	3AH	58	:
◀	3BH,0BH	59	;
ME NU	3CH,0CH	60	<
EN T	3DH,0DH	61	=
△ /+	3EH	62	>
▽/-	3FH	63	?

PART-7 WARRANTY AND SERVICE

7.1 WARRANTY

The manufacturer provides one year warranty on all products, free of charge, but the users should be responsible for the one-way transportation fee from the customer to the factory.

7.2 SERVICE

The manufacturer provides instrument installation for our customers, and the charges will be made according the cost.

- (1) For any hardware failure of the instrument, we recommend that our customers send back the instrument to our factory for service, due to the fact that the instrument is made of microprocessors and it will be difficult to perform field maintenance. Before sending back the instrument, please try to contact the factory first to make sure what the problem is.
- (2) For other operational problems, please contact our local distributor by telephone, fax or email. In most cases, the problem could be solved immediately.

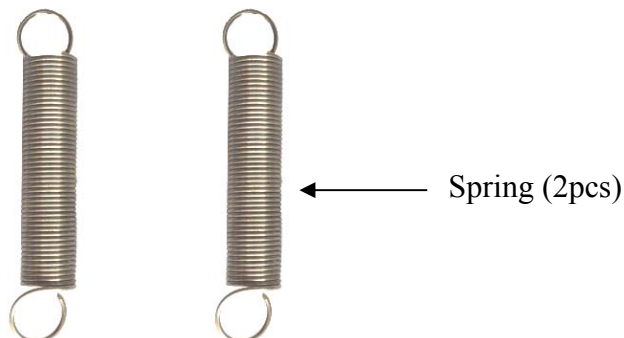
APPENDIX 1 TRANSDUCER GUIDE RAIL INSTALLATION

Introduction

The guide rail is designed for clamp-on transducer installation, it make the installation simple, allocation precise, fixation stable, and it also can meet to multiple transducer mounting methods.

Preparation

1. Before you attach the transducers you should first ensure that the proposed location satisfies the distance requirements as Table 2.1, otherwise the resulting accuracy of the flow readings may be affected.
2. Prepare the pipe by degreasing it and removing any loose material or flaking paint in order to obtain the best possible surface. A smooth contact between pipe surface and the face of the transducers is an important factor in achieving a good ultrasound signal strength and therefore maximum accuracy.
3. Parts prepare



Installation steps

1. Installation Steps for V and W Transducer Mounting Method

When using V or W method to install transducers, install the two transducers on the same side of pipeline.



Steps:

1. Connect the chains and spring.
2. Lay on enough couplant on the transducer.
3. Connect the transducers cable.
4. Enter the application parameters in transmitter to get the XDCR spacing in menu 25.
5. Install and fix the transducers on the ruler using knurled screws.(note if the wrong space is applied, the measurement fails or the measurement will have wrong values)
6. Fix the transducers using the chains and springs.
7. Approach the transducers to the pipe by adjusting the knurled screw until the transducer is pressed slightly onto the pipe.

2 Installation Steps for Z and N Transducer Mounting Method

When using Z or N method to install transducers, install the two transducers respectively on the opposite sides of pipeline. Installation steps are same as for W and V transducer mounting method without ruler.

When finishing the installation, it will show as follow:

**Notes:**

1. Equally spread couplant on measuring side of transducer, and then put transducer into bracket from broadside, make sure pipeline and transducer have good coupling.
2. Do not over tighten to prevent couplant extrusion.
3. Ensure that the two brackets are on the same axial surface.

APPENDIX 2 DATA LOGGER USEGE

Meter Setting Before Using Data Logger

Before using the data logger, please check the following items of meter settings (otherwise, the data logger will not work normally):

I. In Menu 60, it is time setup for meter, the format should be:

YY-MM-DD (For example, it is Aug 14, 2015 today, the Menu 60 setting should be 15-08-14)

HH-MM-SS (Hour-minute-second, in 24 hour format)

M60
Date 15-08-14
Time 15:16:46

**II. In Menu 50
Select
Logger Options
ON**

M50
Logger Options
ON

III. Menu51, you setup start time (later than Menu 60 time, had better at least later 2 minutes), or setting up start time as: Start **::** is also Okay.**

M51 Logger Setup
Start 15:20:00
Intervl 00:00:05
Go On **:**:**

or

M51 Logger Setup
Start **:**:**
Intervl 00:00:05
Go On **:**:**

**IV. Menu 52,
Select
0. To RS-232**

M52
Data Output
0. To RS-232

**V. Menu 62
Select
Baudrate: =9600
Parity: None**

M62
RS-232C Setup
Baudrate: =9600
Parity: None

Then insert the Data Logger module. The meter will restart, which means the data logger works well.

IMPORTANT: Restart the meter is a must before data logger working. Only insert the SD card the meter will not restart, and the data logger will **stop recording data.**

5.6.3 Read Data

When downloading data, it will create a new .csv file named for date,, the naming rules of the

file is the data storage date. For example,

Naming rules of “csv” file

xx(year)-xx(month)-xx(date).csv

16-03-25.CSV

Save another file by naming rules when the “csv” file has recorded 2000 data.

(Default data number: without limit, according to requirement, the number can change, please consult factory)

When opening the “csv” file, the data are shown as below:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	Date	TimeStamp	Flow	unit	Vel	unit	NET	unit	POS	unit	NEG	unit	EFR	unit	E.T	unit	Tin[°C]	Tout[°C]	T.D	
2	2016/3/25	15:15:29	4.55328	1/s	0.491558	m/s	4	m3	4	m3	0	m3	224.73	KW	13000	KWh	32.2996	20.3649	11.9347	
3	2016/3/25	15:16:29	4.56521	1/s	0.492846	m/s	4	m3	4	m3	0	m3	225.011	KW	13000	KWh	32.2909	20.3649	11.926	
4	2016/3/25	15:17:29	4.5783	1/s	0.494259	m/s	4	m3	4	m3	0	m3	226.186	KW	14000	KWh	32.2996	20.3432	11.9564	
5	2016/3/25	15:18:29	4.57987	1/s	0.494428	m/s	4	m3	4	m3	0	m3	226.621	KW	14000	KWh	32.317	20.3693	11.9477	
6	2016/3/25	15:19:29	4.5675	1/s	0.493094	m/s	4	m3	4	m3	0	m3	227.538	KW	14000	KWh	32.3474	20.3083	12.0391	
7	2016/3/25	15:20:29	4.58037	1/s	0.494483	m/s	4	m3	4	m3	0	m3	227.607	KW	14000	KWh	32.33	20.304	12.026	
8	2016/3/25	15:22:29	4.574	1/s	0.493795	m/s	4	m3	4	m3	0	m3	228.147	KW	15000	KWh	32.3561	20.2996	12.0565	
9	2016/3/25	15:23:29	4.57332	1/s	0.493721	m/s	4	m3	4	m3	0	m3	228.762	KW	15000	KWh	32.3691	20.2953	12.0738	
10	2016/3/25	15:25:29	4.54864	1/s	0.491057	m/s	4	m3	4	m3	0	m3	227.918	KW	15000	KWh	32.3822	20.2865	12.0957	
11	2016/3/25	15:27:29	4.59105	1/s	0.495189	m/s	5	m3	5	m3	0	m3	228.944	KW	15000	KWh	32.3691	20.2996	12.0695	
12	2016/3/25	15:29:29	4.56672	1/s	0.493009	m/s	5	m3	5	m3	0	m3	229.693	KW	16000	KWh	32.3822	20.2343	12.1479	
13	2016/3/25	15:30:29	4.55305	1/s	0.491533	m/s	5	m3	5	m3	0	m3	229.352	KW	16000	KWh	32.4082	20.2343	12.1739	
14	2016/3/25	15:32:29	4.55373	1/s	0.491851	m/s	5	m3	5	m3	0	m3	229.535	KW	16000	KWh	32.4082	20.2256	12.1826	
15	2016/3/25	15:33:29	4.57246	1/s	0.493629	m/s	5	m3	5	m3	0	m3	229.567	KW	17000	KWh	32.3778	20.2299	12.1479	
16	2016/3/25	15:34:29	4.5706	1/s	0.493428	m/s	5	m3	5	m3	0	m3	230.087	KW	17000	KWh	32.3822	20.2169	12.1653	
17	2016/3/25	15:35:29	4.57454	1/s	0.492803	m/s	5	m3	5	m3	0	m3	229.41	KW	17000	KWh	32.3691	20.2169	12.1522	
18	2016/3/25	15:36:29	4.56386	1/s	0.492701	m/s	5	m3	5	m3	0	m3	229.339	KW	17000	KWh	32.3865	20.2256	12.1609	
19	2016/3/25	15:37:29	4.55195	1/s	0.491414	m/s	5	m3	5	m3	0	m3	229.255	KW	18000	KWh	32.3822	20.2038	12.1784	
20	2016/3/25	15:38:29	4.55141	1/s	0.491356	m/s	5	m3	5	m3	0	m3	230.606	KW	18000	KWh	32.3908	20.1602	12.2306	
21	2016/3/25	15:39:29	4.56454	1/s	0.492773	m/s	5	m3	5	m3	0	m3	230.489	KW	18000	KWh	32.3691	20.1602	12.2089	
22	2016/3/25	15:40:29	4.55548	1/s	0.491795	m/s	5	m3	5	m3	0	m3	229.229	KW	18000	KWh	32.3517	20.1602	12.1915	
23	2016/3/25	15:41:29	4.55682	1/s	0.491941	m/s	5	m3	5	m3	0	m3	229.7	KW	19000	KWh	32.3387	20.1602	12.1785	
24	2016/3/25	15:43:29	4.56909	1/s	0.493265	m/s	5	m3	5	m3	0	m3	230.694	KW	19000	KWh	32.3257	20.1559	12.1698	
25	2016/3/25	15:45:29	4.59885	1/s	0.496478	m/s	5	m3	5	m3	0	m3	230.498	KW	19000	KWh	32.2909	20.1515	12.1394	
26	2016/3/25	15:46:29	4.59512	1/s	0.496373	m/s	5	m3	5	m3	0	m3	210.692	KW	20000	KWh	31.1876	20.1123	11.0753	
27	2016/3/25	15:50:29	4.57622	1/s	0.494035	m/s	5	m3	5	m3	0	m3	188.603	KW	20000	KWh	30.0626	20.1036	9.959	
28	2016/3/25	15:51:29	4.58291	1/s	0.494757	m/s	5	m3	5	m3	0	m3	174.672	KW	20000	KWh	29.2982	20.0862	9.212	
29	2016/3/25	15:52:29	4.5731	1/s	0.494588	m/s	5	m3	5	m3	0	m3	160.652	KW	20000	KWh	29.0123	20.0882	9.51000	

Handheld can storage: data, time, flow, velocity, net totalizer, positive totalizer, and negative totalizer

Wall-mounted and portable flowmeter can storage: data, time, flow, velocity, net totalizer, positive totalizer, negative totalizer, EFR, E.T, Tin, Tout and T.D.

APPENDIX 3 FLUID CHARACTERISTIC (SOUND SPEED)

1. FLUID PROPERTIES

Fluid	Specific Gravity	Sound Speed		delta-v/degree C	Kinematic Viscosity	Absolute viscosity
	20 degrees C	m/s	ft/s	m/s/degree C	Centistokes	Centipoise
Acetate, Butyl		1270	4163.9			
Acetate, Ethyl	0.901	1085	3559.7	4.4	0.489	0.441
Acetate, Methyl	0.934	1211	3973.1		0.407	0.380
Acetate, Propyl		1280	4196.7			
Acetone	0.79	1174	3851.7	4.5	0.399	0.316
Alcohol	0.79	1207	3960.0	4.0	1.396	1.101
Alcohol, Butyl	0.83	1270	4163.9	3.3	3.239	2.688
Alcohol, Ethyl	0.83	1180	3868.9	4	1.396	1.159
Alcohol, Methyl	0.791	1120	3672.1	2.92	0.695	0.550
Alcohol, Propyl		1170	3836.1			
Alcohol, Propyl	0.78	1222	4009.2		2.549	1.988
Ammonia	0.77	1729	5672.6	6.7	0.292	0.225
Aniline	1.02	1639	5377.3	4.0	3.630	3.710
Benzene	0.88	1306	4284.8	4.7	0.711	0.625
Benzol, Ethyl	0.867	1338	4389.8		0.797	0.691
Bromine	2.93	889	2916.7	3.0	0.323	0.946
n-Butane	0.60	1085	3559.7	5.8		
Butyrate, Ethyl		1170	3836.1			
Carbon dioxide	1.10	839	2752.6	7.7	0.137	0.151
Carbon tetrachloride	1.60	926	3038.1	2.5	0.607	0.968
Chloro-benzene	1.11	1273	4176.5	3.6	0.722	0.799
Chloroform	1.49	979	3211.9	3.4	0.550	0.819
Diethyl ether	0.71	985	3231.6	4.9	0.311	0.222
Diethyl Ketone		1310	4295.1			
Diethylene glycol	1.12	1586	5203.4	2.4		
Ethanol	0.79	1207	3960.0	4.0	1.390	1.097
Ethyl alcohol	0.79	1207	3960.0	4.0	1.396	1.101
Ether	0.71	985	3231.6	4.9	0.311	0.222
Ethyl ether	0.71	985	3231.6	4.9	0.311	0.222
Ethylene glycol	1.11	1658	5439.6	2.1	17.208	19.153
Freon R12		774.2	2540			
Gasoline	0.7	1250	4098.4			
Glycerin	1.26	1904	6246.7	2.2	757.100	953.946
Glycol	1.11	1658	5439.6	2.1		
Isobutanol	0.81	1212	3976.4			
Iso-Butane		1219.8	4002			
Isopentane	0.62	980	3215.2	4.8	0.340	0.211
Isopropanol	0.79	1170	3838.6		2.718	2.134
Isopropyl alcohol	0.79	1170	3838.6		2.718	2.134
Kerosene	0.81	1324	4343.8	3.6		
Linalool		1400	4590.2			

Linseed Oil	.925-.939	1770	5803.3			
Methanol	0.79	1076	3530.2	2.92	0.695	0.550
Methyl alcohol	0.79	1076	3530.2	2.92	0.695	0.550
Methylene chloride	1.33	1070	3510.5	3.94	0.310	0.411
Methylethyl Ketone		1210	3967.2			
Motor Oil (SAE 20/30)	.88-.935	1487	4875.4			
Octane	0.70	1172	3845.1	4.14	0.730	0.513
Oil, Castor	0.97	1477	4845.8	3.6	0.670	0.649
Oil, Diesel	0.80	1250	4101			
Oil (Lubricating X200)		1530	5019.9			
Oil (Olive)	0.91	1431	4694.9	2.75	100.000	91.200
Oil (Peanut)	0.94	1458	4783.5			
Paraffin Oil		1420	4655.7			
Pentane	0.626	1020	3346.5		0.363	0.227
Petroleum	0.876	1290	4229.5			
1-Propanol	0.78	1222	4009.2			
Refrigerant 11	1.49	828.3	2717.5	3.56		
Refrigerant 12	1.52	774.1	2539.7	4.24		
Refrigerant 14	1.75	875.24	2871.5	6.61		
Refrigerant 21	1.43	891	2923.2	3.97		
Refrigerant 22	1.49	893.9	2932.7	4.79		
Refrigerant 113	1.56	783.7	2571.2	3.44		
Refrigerant 114	1.46	665.3	2182.7	3.73		
Refrigerant 115		656.4	2153.5	4.42		
Refrigerant C318	1.62	574	1883.2	3.88		
Silicone (30 cp)	0.99	990	3248		30.000	29.790
Toluene	0.87	1328	4357	4.27	0.644	0.558
Transformer Oil		1390	4557.4			
Trichlorethylene		1050	3442.6			
1,1,1-Trichloro-ethane	1.33	985	3231.6		0.902	1.200
Turpentine	0.88	1255	4117.5		1.400	1.232
Water, distilled	0.996	1498	4914.7	-2.4	1.000	0.996
Water, heavy	1	1400	4593			
Water, sea	1.025	1531	5023	-2.4	1.000	1.025
Wood Alcohol	0.791	1076	3530.2	2.92	0.695	0.550
m-Xylene	0.868	1343	4406.2		0.749	0.650
o-Xylene	0.897	1331.5	4368.4	4.1	0.903	0.810
p-Xylene		1334	4376.8		0.662	

2. WATER SOUND SPEED

Water Sound Speed table (pressure: 1 bar)

Units: Sound Speed: m/s

Temperature °C	Sound Speed	Temperature °C	Sound Speed	Temperature °C	Sound Speed	Temperature °C	Sound Speed
0	1402.3	25	1496.6	50	1542.5	75	1555.1
1	1407.3	26	1499.2	51	1543.5	76	1555.0
2	1412.2	27	1501.8	52	1544.6	77	1554.9
3	1416.9	28	1504.3	53	1545.5	78	1554.8
4	1421.6	29	1506.7	54	1546.4	79	1554.6
5	1426.1	30	1509.0	55	1547.3	80	1554.4
6	1430.5	31	1511.3	56	1548.1	81	1554.2
7	1434.8	32	1513.5	57	1548.9	82	1553.9
8	1439.1	33	1515.7	58	1549.6	83	1553.6
9	1443.2	34	1517.7	59	1550.3	84	1553.2
10	1447.2	35	1519.7	60	1550.9	85	1552.8
11	1451.1	36	1521.7	61	1551.5	86	1552.4
12	1454.9	37	1523.5	62	1552.0	87	1552.0
13	1458.7	38	1525.3	63	1552.5	88	1551.5
14	1462.3	39	1527.1	64	1553.0	89	1551.0
15	1465.8	40	1528.8	65	1553.4	90	1550.4
16	1469.3	41	1530.4	66	1553.7	91	1549.8
17	1472.7	42	1532.0	67	1554.0	92	1549.2
18	1476.0	43	1533.5	68	1554.3	93	1548.5
19	1479.1	44	1534.9	69	1554.5	94	1547.5
20	1482.3	45	1536.3	70	1554.7	95	1547.1
21	1485.3	46	1537.7	71	1554.9	96	1546.3
22	1488.2	47	1538.9	72	1555.0	97	1545.6
23	1491.1	48	1540.2	73	1555.0	98	1544.7
24	1493.9	49	1541.3	74	1555.1	99	1543.9

3. PIPE MATERIAL SOUND SPEED TABLE

Pipe Material Sound Speed Table	Sound Speed(m/s)	Liner Material	Sound Speed (m/s)
Steel	3206	Teflon	1225
ABS	2286	Titanium	3150
Aluminum	3048	Cement	4190
Brass	2270	Tar Epoxy	2540
Cast Iron	2460	Porcelain Enamel	2540
Bronze	2270	Glass	5970
Fiber Glass	3430	Plastic	2280
Glass	3276	Polyethylene	1600
Polyethylene	1950	PTFE	1450
PVC	2540	Rubber	1600



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