Innova-Sonic™ Model 210 Portable

Instruction Manual

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Important Customer Notice

Thank you for choosing the Innova-Sonic® Model 210 Transit-Time Ultrasonic Flow Meter. Before installing and operating the flowmeter, please read this manual carefully and follow its instructions. This manual contains important information about your meter.

- ü Sierra has verified the conformity between the contents in this manual and the hardware and software described. However, errors may still exist. We regularly review the materials covered in this manual and correct errors with revisions. Any suggestions for improvement will be appreciated.
- ü Go to www.sierrainstruments.com/products/downloads.html for a most current electronic version of this manual.
- ü We reserve the right to change the content of this manual without prior notification.
- ü If you have any questions or problems regarding this manual, please contact Sierra's Customer Service

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WARNINGS IN THIS MANUAL

Caution and warning statements are used throughout this book to draw your attention to important information.

WARNING

"Warning" statement appears with information that is important to protect people and equipment from damage. Pay very close attention to all warnings that apply to your application. Failure to comply with these instructions may damage the meter.

ATTENTION

Failure to comply with these instructions may result in faulty operation.

NOTE

"Note" indicates that ignoring the relevant requirements or precautions may result in flowmeter damage or malfunction.

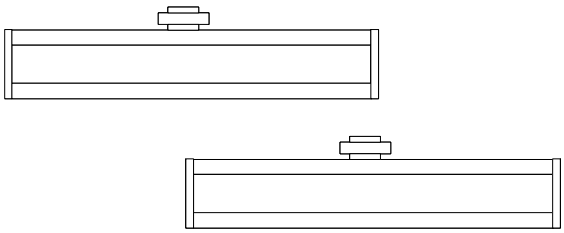
TRADEMARKS
Innova-Sonic® is a registered trademark of Sierra Instruments, Inc. Other product and company names listed in this manual are trademarks or trade names of their respective manufacturers.

Product Components

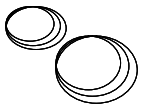
An inspection should be made of the desired area before installing the flowmeter. Check to see if the spare parts are present in accordance with the packing list. Make sure that there is no shipping damage. If you have any questions, please contact your representative as soon as possible.

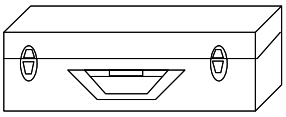
Transmitter

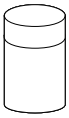
Transducer

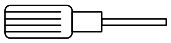


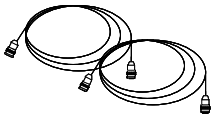
Accessory


Pipe Strap

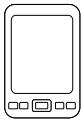

Toolbox

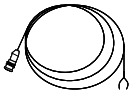

Coupling compound

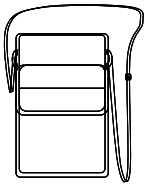

Screw Driver

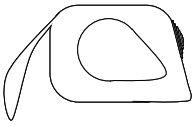

Cable

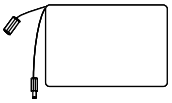

Software

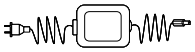

PDA


4-20mA Signal Cable


Satchel


Tape


Battery


Charge

Document

1. Instruction Manual
2. Packing List
3. Certified 3-Point Factory Calibration
4. Position drawing
5. Application Worksheet

Content

Update Information:

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1. Transmitter Installation and Connection

1.1. Inspection Prior to Transmitter Installation

Check the packing list and contents to ensure that all necessary and ordered parts are on hand. Should any parts be missing or damaged, please contact Sierra Instruments as soon as possible.

1.2. Power Supply Connections

1.2.1. Direct Mount Method

The 210 is powered by 11.1V batteries. Batteries can be recharged and a standby power supply can be connected through the battery recharge port on the panel.

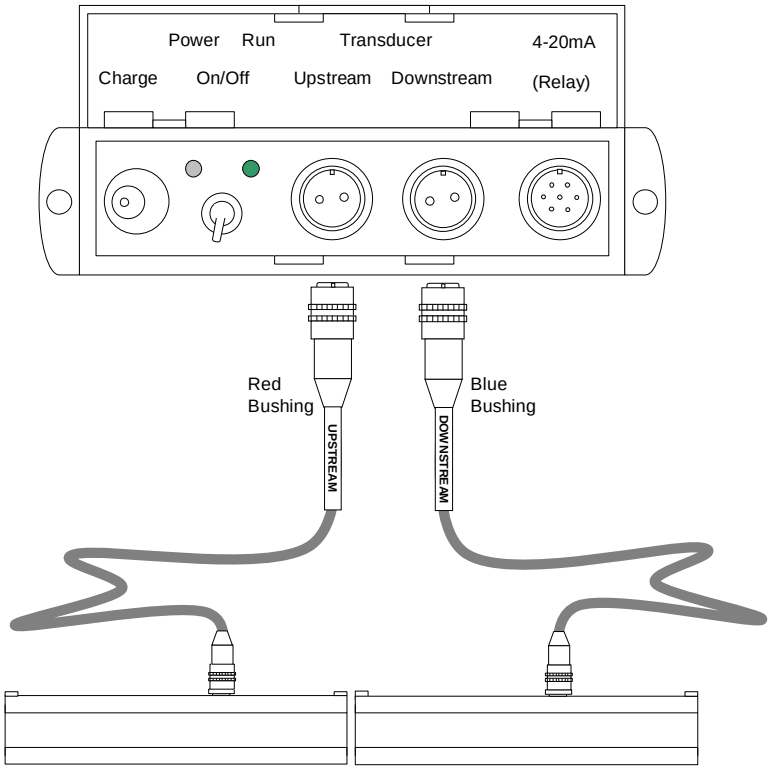
WARNING

Use only the supplied charger to charge the batteries.

Make sure the electronics, the spare battery and PDA are fully charged before using.

1.2.2. Connecting The Wiring

Open the hinged front cover of the electronics. Shown from left to right on the panel of the PORTABLE are the battery recharge port (charge the transmitter or connect to the standby power supply), power switch, power light (red), run indicator (green), upstream transducer connector, downstream transducer connector, output connector(4~20mA output and Relay output).



WARNING

When the battery power is less than 15% (use time is less than 40 seconds), the power indicator light will change to orange.

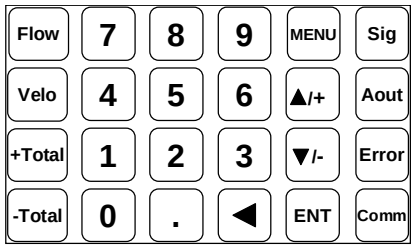
1.3. Powering on

As soon as the Flowmeter is switched on, the self-diagnosis program will start to run. If any error is detected, an error code will displayed on the screen (see Error Diagnostics on page 58). After that, the system will run automatically using the programmed parameters.

Normal operation is indicated by code "*R" on the upper left corner of the screen.

1.4. Keypad Functions

Follow these guidelines when using the Flowmeter keypad (Refer to Keypad Figure):



0 ~ 9 and • Input numbers.

◄ Backspace or delete characters to the left.

▲/+ and ▼/- Return to the last menu or open the next menu. Acts as "+" and "-" functions when entering numbers.

Menu Select a menu. Press this key first, input a two-digit menu number and the selected menu data will be displayed. For example, to input a pipe outside diameter, press Menu 1 1, where "11" is the window ID to display the pipe outside diameter.

Flow, Velo, +Total, -Total, Sig, Aout, Error and Comm are shortcut keys (explained later).

1.5. Keypad Operation

The instrument setup and measurement displays are subdivided into more than 100 independent menus. The operator can input parameters, modify settings or display measurement results by "visiting" a specific menu. These menus are arranged by 2-digit serial numbers from 00~99, then using +0, +1, etc. Each menu ID code has a defined meaning. For example, menu 11 is the pipe outside diameter, while menu 25 is the mounting spacing between the transducers. Each menu is discussed later in this manual.

To visit a specific menu, press the Menu key, then input the 2-digit menu ID code and that menu will be displayed.

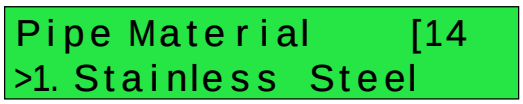
Another method to visit a particular menu is to press the ▲/+ ▼/- keys to scroll through the menus. For example, if the current menu ID code is 03, press ▲/+ key to enter menu 02, press the ▲/+ button again to enter menu 01; then press the ▼/- key to go back to menu 02, then press the ▼/- key again to enter menu 03.

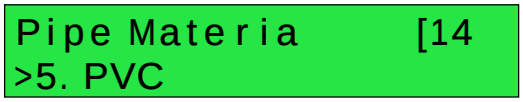
Example 1: To enter a pipe outer diameter of 219.234, the procedure is as follows:

Press Menu 1 1 keys to enter menu 11 (the numerical value displayed currently is the previous pipe outer diameter). Now press ENT key. The symbol ">" and a flashing cursor are displayed at the left end of the second line on the screen. The new value can now be entered.

2 1 9 • 2 3 4 ENT

Example 2: If the pipe material is "Stainless Steel", press Menu 1 4 to enter Menu 14, then press ENT to modify the options. Then, select "1. Stainless Steel" from the drop-down menu (you may cycle through the choices by pressing the ▲/+ and ▼/- keys) and then press ENT to confirm the selection. It is also possible to press the 1 key to change the selection and wait until "1. Stainless Steel" is displayed on the second line of the screen. Then press the ENT key to confirm.





ATTENTION

The ENT key is used to enter or modify data. If you cannot do so after pressing the ENT key, it means that someone has enabled password protection. To "unlock" it, select "unlock" in menu 47 and enter the password (this password has to be set by the user).

1.6. Flowmeter Menu Descriptions

Menus are assigned as follows:

00~09	Display menus: Used to display flow rate, positive total, negative total, net total, velocity, date & time etc.
10~29	Setup menus: Used to enter pipe outer diameter, pipe wall thickness, fluid type, transducer type, transducer mounting and spacing etc.
30~38	Flow units selection and totalizer operating menus: Used to select units of measurement. Other menus set/reset the various totalizer modes.
40~49	System menus: Flow correction operating menus and system lock menus etc.
55~83	Input and output setup menus: current loop mode select, 4mA or 0mA output value, etc.
90~94	Diagnostics: signal strength quality (menu 90), TOM/TOS*100 (menu 91), sound velocity (menu 92), total time and delta time of the measured signal (menu 93), Reynolds number and K factor (menu 94).
+0~+9	Appendix: Power on/off time, total working hours, on/off times etc.
-0~-9	4~20mA correction menus.

ATTENTION

"missing" menus are for hardware adjustment (set by the manufacturer).

2. Pipe Parameter Entry Shortcuts

Example: Lets say we have a DN200 (8") pipe, measuring water, Material is carbon steel with no liner. These parameters should be entered as follows:

Step 1. Pipe outside diameter

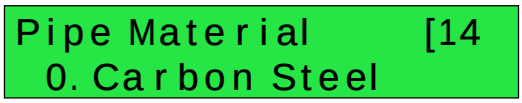
Press Menu 1 1 keys to enter menu 11, enter the pipe outside diameter 200, then press the ENT key.

Step 2. Pipe wall thickness

Press the Menu 1 2 key to enter menu 12, enter the pipe wall thickness (wall thickness for various pipe schedules can be found in the appendix), then press the ENT key.

Step 3. Pipe material

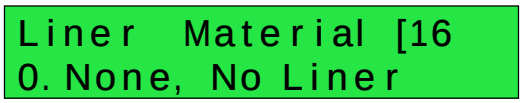
Press the Menu 1 4 key to enter menu 14, press the ENT key, use the ▲/+ or ▼/- key to select the pipe material from the drop-down menu, then press the ENT key.



Step 4. Liner material parameters

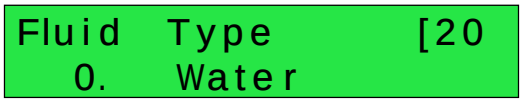
(including thickness and sound velocity, if needed)

Press the Menu 1 6 key to enter menu 16, press the ENT key, use the ▲/+ or ▼/- key to select liner material from the drop-down menu, then press the ENT key.



Step 5. Fluid type

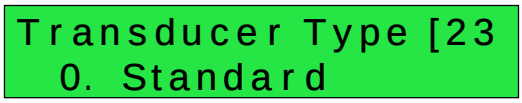
Press the Menu 2 0 key to enter menu 20, press the ENT key, use the ▲/+ or ▼/- key to select fluid type from the drop-down menu, then press the ENT key.



Step 6. Transducer type

(The transmitter is available for various transducer types)

Press the Menu 2 3 key to enter menu 23, press the ENT key, use the ▲/+ or ▼/- key to select transducer type from the drop-down menu, then press the ENT key.



ATTENTION

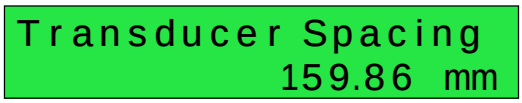
Unless otherwise directed, you will use 0. standard here. High T sensors are being developed and eventually may be selected here. (along with other specialty sensors)

Step 7. Transducer mounting methods

Press the Menu 2 4 key to enter menu 24, press the ENT key, use the ▲/+ or ▼/- key to select transducer-mounting from the drop-down menu, then press the ENT key.

Step 8. Adjust Transducer spacing

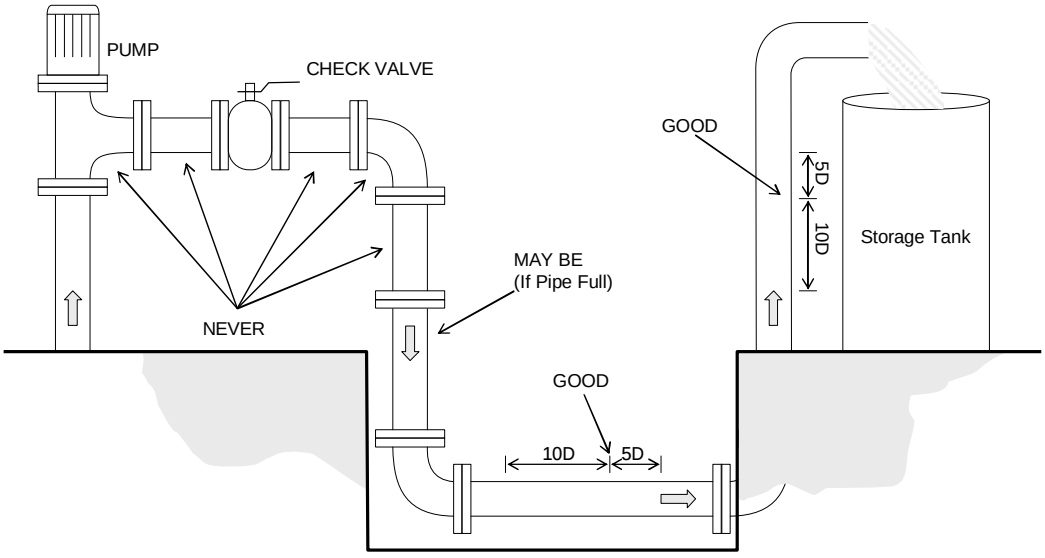
Press the Menu 2 5 key to enter menu 25, accurately install the transducer according to the displayed transducer mounting spacing and the selected mounting method (Refer to Installing the Transducers in this chapter).



3. Measurement Site Selection

When selecting a measurement site, it is important to select an area where the fluid flow profile is fully developed to guarantee a highly accurate measurement. Use the following guidelines to select a proper installation site:

Choose a section of pipe that is always full of liquid, such as a vertical pipe with flow in the upward direction or a full horizontal pipe.

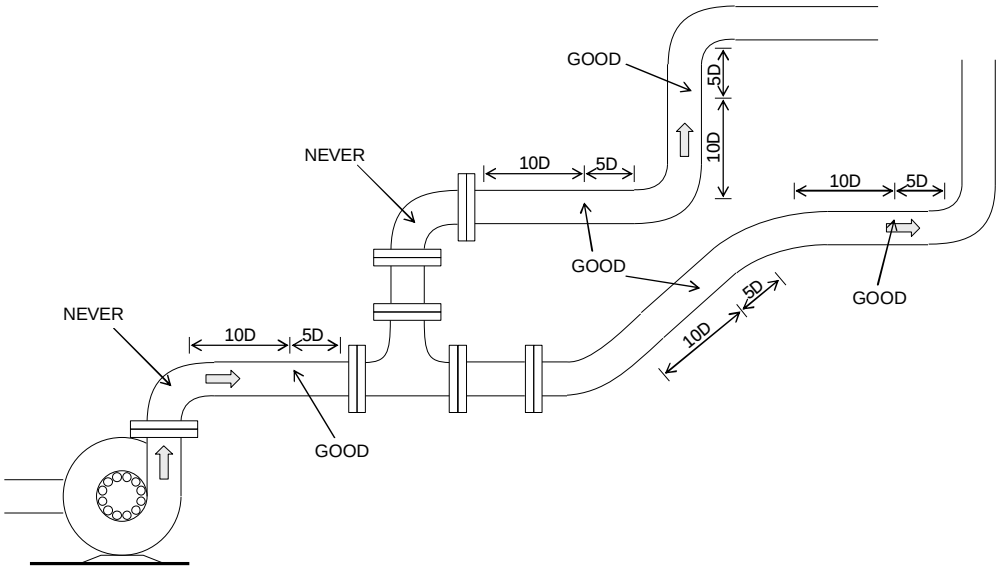


The site should have a straight pipe run length equal to at least 10 pipe diameters upstream and 5 pipe diameters downstream from any throttling valves or other flow disturbance producing elements, such as pipe reducers, elbows, tees, etc.

Ensure that the pipe surface temperature at the measuring point is within the transducer temperature limits.

Consider the inside condition of the pipe carefully. If possible, select a section of pipe where the inside is free of excessive corrosion or scaling.

Examples of acceptable measurement sites are illustrated on the figure below.



4. Transducer Installation

4.1. Installing the Transducers

Before installing the transducers, clean the pipe surface where the transducers are to be mounted. Remove any rust, scale or loose paint and make a smooth surface. Apply a wide band of sonic coupling compound down the center of the face of each transducer as well as on the pipe surface, and then attach the transducers to the pipe with the straps provided and tighten them securely.

Note:

The two transducers should be mounted at the pipe's centerline on horizontal pipes.

Make sure that the transducer mounting direction is parallel with the flow.

During the installation, there should be no air bubbles or particles between the transducer and the pipe wall. On horizontal pipes, the transducers should be mounted in the 3 o'clock and 9 o'clock positions of the pipe section in order to avoid any air bubbles inside the top portion of the pipe. (Refer to Transducer Mounting). If the transducers cannot be mounted horizontally symmetrically due to limitation of the local installation conditions, it may be necessary to mount the transducers at a location where there is a guaranteed full pipe condition (the pipe is always full of liquid).

4.1.1. Transducer Spacing

After entering the required parameters, the spacing between the ENDS of the two transducers is considered as the standard transducer spacing (Refer to Top View on transducer mounting methods). Check the data displayed in Window M25 and space the transducers accordingly.

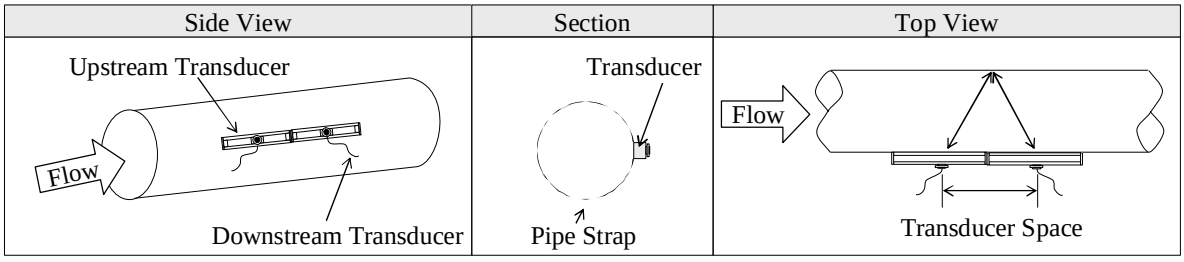
4.1.2. Transducer Mounting Methods

Four transducer mounting methods are available. They are respectively: V method, Z method, N method and W method. The V method is primarily used on small diameter pipes (DN100~400mm, 4"~16"). The Z method is used in applications where the V method cannot work due to poor signal or no signal detected. In addition, the Z method generally works better on larger diameter pipes (over DN300mm, 12") or cast iron pipes.

The N method is an uncommonly used method as well as is the W method. They are used on smaller diameter pipes (below DN50mm, 2").

4.1.3. V Method

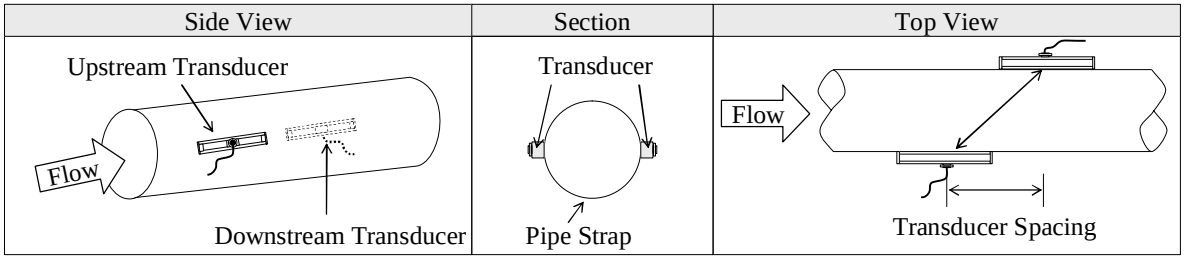
The V method is considered as the standard method. It usually gives a more accurate reading and is used on pipe diameters ranging from 25mm to 400mm (1~16") approximately. Also, it is convenient to use, but still requires proper installation of the transducer, contact on the pipe at the pipe's centerline and equal spacing on either side of the centerline.



4.1.4. Z Method

The signal transmitted in a Z method installation has less attenuation than a signal transmitted with the V method. This is because the Z method utilizes a directly transmitted (rather than reflected) signal which transverses the liquid only once.

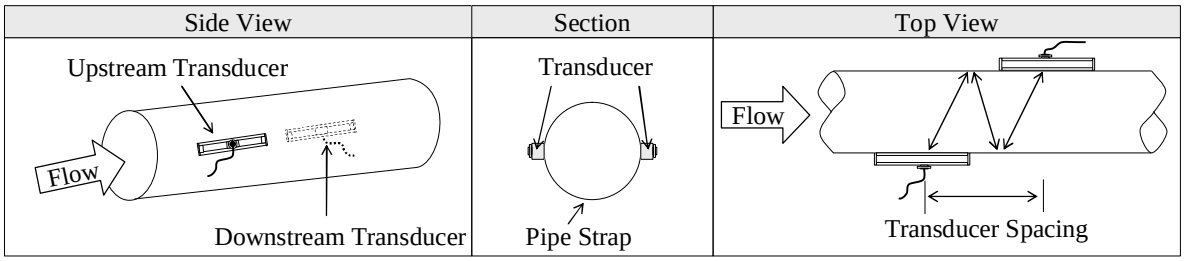
The Z method is able to measure on pipe diameters ranging from 100mm to 3000mm (4”~120”) approximately. Therefore, we recommend the Z method for pipe diameters over 300mm (12”).



4.1.5. N Method (not commonly used)

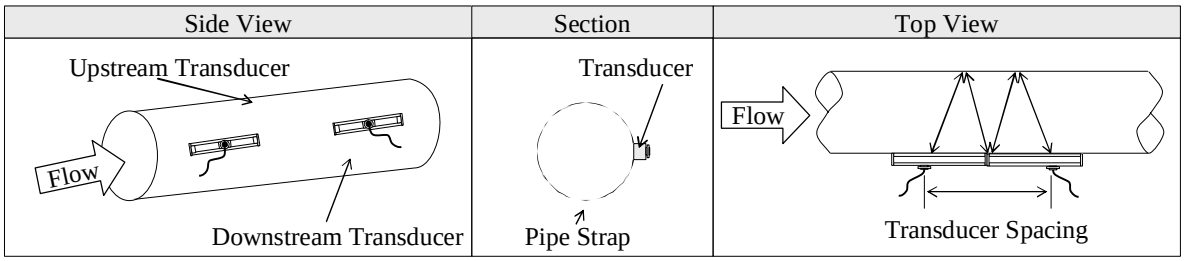
With the N method, the sound waves traverse the fluid twice and bounce three times off the pipe walls. It is suitable for small pipe diameter measurement.

The measurement accuracy can be improved by extending the transit distance with the N method (uncommonly used).



4.1.6. W Method (very rarely used)

As with the N method, the measurement accuracy can also be improved by extending the transit distance with the W method. The sound wave traverses the fluid four times and bounces four times off the pipe walls. It is suitable for very small pipe (diameters less than 50mm, 2”).



4.2. Transducer Mounting Inspection

Check to see if the transducer is installed properly and if there is an accurate and strong enough ultrasonic signal to ensure proper operation and high reliability of the transducer. It can be confirmed by checking the detected signal strength, total transit time, delta time as well as transit time ratio. These checks are explained below.

The “mounting” condition directly influences the flow value accuracy and system reliability. In most instances, apply a wide bead of sonic coupling compound lengthwise on the face of the transducer and stick it to the outside

pipe wall to get good measurement results. However, the following inspections still need to be carried out in order to ensure a high reliability of the measurement and long-term operation of the instrument.

4.2.1. Signal Strength

Signal strength (displayed in menu 90) 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. 00.0 represents no signal detected while 99.9 represent maximum signal strength.

Normally, the stronger the signal strength detected, the better the measurement.

Adjust the transducer spacing to the best position and check to ensure that enough sonic coupling compound is applied during installation in order to obtain the maximum signal strength. This is essentially fine tuning the calculated spacing shown in menu 25 (transducer spacing). It may be slightly different.

System normal opperation 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 (Z has the highest signal strength).

4.2.2. Signal Quality (Q value)

Q value is short for Signal Quality (displayed in menu 90). It indicates the level of the signal detected. Q value is indicated by numbers from 00~99. 00 represents the minimum signal detected while 99 represent the maximum.

The transducer position may be adjusted and enough coupling used to get the signal quality detected as strong as possible.

4.2.3. Total Time and Delta Time

“Total Time and Delta Time” are displayed in menu 93. The measurement calculations in the flowmeter 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 resulted of poor pipe-installation conditions, inadequate transducer installation or incorrect parameter input.

Generally, “Delta Time” fluctuation should be less than±20%. Only when the pipe diameter is too small or velocity is too low can the fluctuation be wider.

4.2.4. Transit Time Ratio

Transit Time Ratio indicates if the transducer mounting spacing is accurate. The normal transit time ratio should be 100±3 if the installation is proper. Check it menu 91.

ATTENTION

If the transit time ratio is over 100±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 accordance with the display in menu 25,

(3) If the transducer is mounted at the pipe’s centerline on the same diameter,

(4) If the scale is too thick or the pipe mounting is distorted in shape, etc.

Warnings

Pipe parameters entered must be accurate; otherwise the flowmeter will not work properly.

(1) During the installation, apply enough coupling compound 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 are obtained. The larger the pipe diameter, the more the transducer may have to be moved.

(2) Check to be sure the mounting spacing is as calculated in menu 25 and the transducer is mounted at the pipe's centerline on the same diameter. Note that you can adjust the spacing slightly as described above to fine tune the device.

(3) 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 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. Once you have ruled out all these reasons, if there is still no signal detected, the measurement site has to be changed.

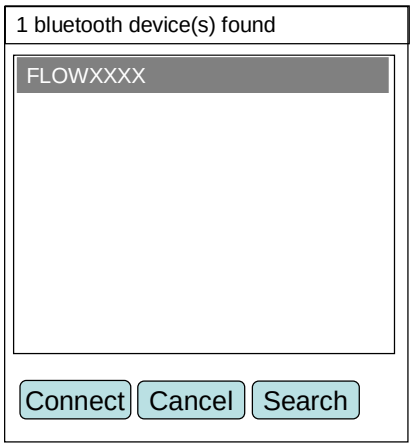
5. Operating Instructions

5.1. Establishing Bluetooth communications

Once the unit is fully charged, you are now ready to commence the configuration setup for your specific application. In order to accomplish this, you must first establish Bluetooth Communications between the PDA and the Electronics unit.

Turn the Electronics unit on. Observe the RED LED Power light illuminate. This must be in sequence, the Electronics MUST be turned on FIRST, then the PDA. Failure to do so in this sequence will result in a lack of Blue Tooth Communications.

Turn on the PDA. Observe the PDA Boot up Sequence. The unit will then automatically launch the Sierra 210 application and search for Bluetooth devices. It will show a list of compatible Bluetooth devices (typically cell phones and laptops) within range. Select the FLOWXXX device if there are multiple devices listed. It will then establish communications and you should observe the Green/Amber Run light on the Electronics flashing while communicating.



5.1.1. IF COMMUNICATIONS FAIL

First, ENSURE the Electronics unit is turned on and the RED power LED is Illuminated.

In the event that a Data Window appears asking for a Password, enter the password of 1234. This will unlock the unit and allow communications to proceed.

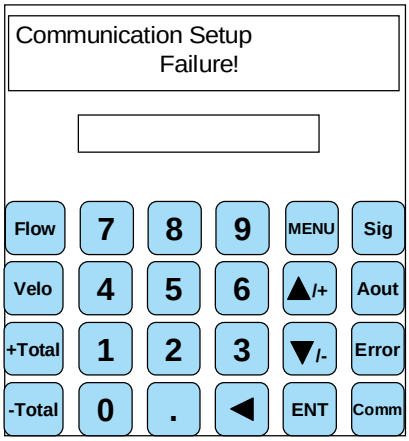
Should the PDA not discover the Electronics unit, you will see the following screens. Simply follow the steps below and you will be guided to re-establishing communications.

NOTE

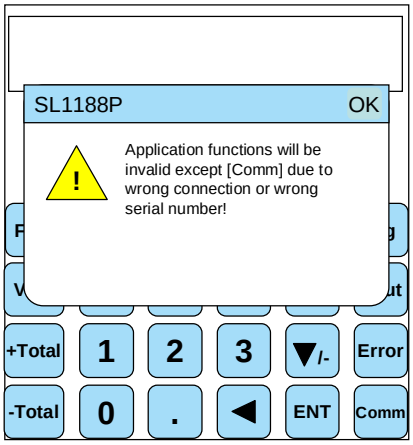
The range of the Bluetooth Communications is a function of the level of battery life in both devices. Initially, with a fully charged PDA and Electronics, the Bluetooth with have a functioning range of approximately 30 feet. As the charge depletes, the range may also decrease.

On the PDA, you will see "Serial Number Error" Select OK.

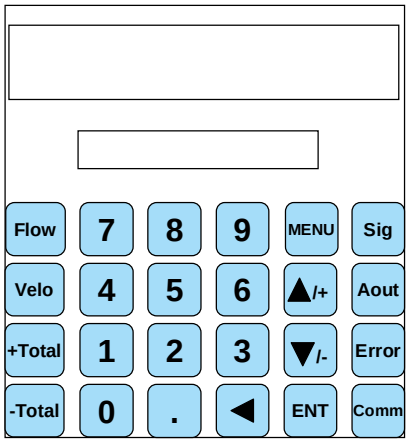
PDA will search again for Bluetooth Devices.



If none are found, you will see "Application Error". Application Functions will be invalid due to wrong connection or wrong serial number. Select OK.



This will take you to the main PDA Desktop screen.

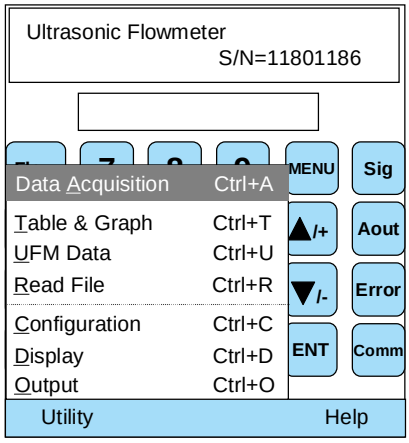


5.1.2. Alternative Method for Application Programming

On the ID Area – Window Frame if you tap once in the Blue Window frame, two selectable tabs appear.

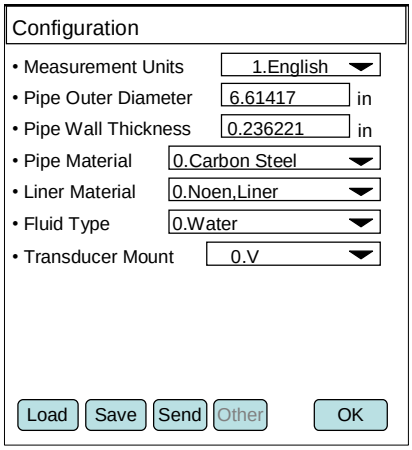
Utility and Options. Under the Utility Tab, you will see the choices for the following;

Data Acquisition\Table & Graph\Configuration\Display\Output.



Selecting the Configuration Option will bring up a 1 page synopsis of the currently entered data. You may change the data here, rather than entering each separate menu section. Simply tap a data section and it will either activate a cursor in that label or display a selection box with choices to enter.

IMPORTANT! ONCE YOU ENTER THIS DATA, YOU MUST SELECT THE SEND BUTTON, OR THE PDA WILL NOT UPLOAD IT TO THE ELECTRONICS. Once complete, you will still need to enter MENU 25 to read the transducer spacing prior to mounting them on the pipe.



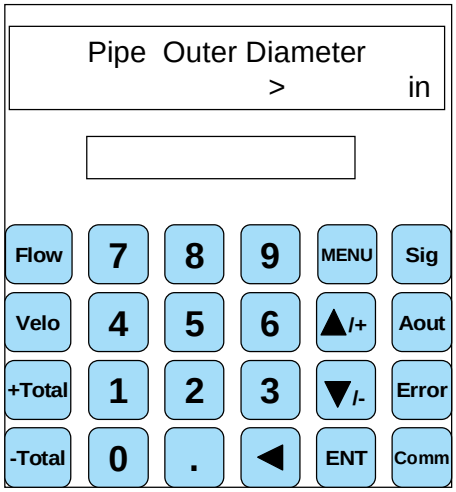
Selecting the OPTIONS Tab will provide you with the Instrument Serial Number and Software Version Data.

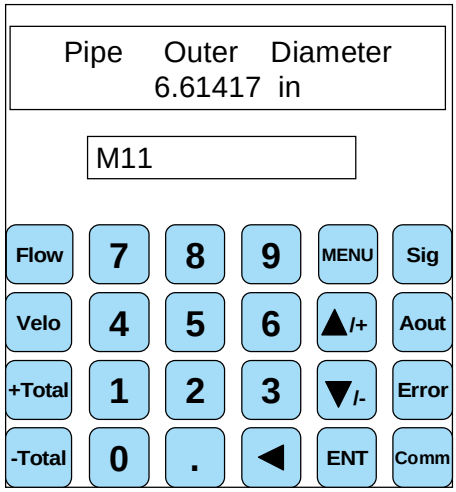
The other options under the Utility Tab will be discussed in detail later in this manual.

5.2. Entering Data In The PDA Menu

In order to input the required data, you must navigate to that data window. Page 37 has all the data windows

outlined in a chart format. So, to enter the Pipe Outer Diameter, we need Menu 11. Navigate to Menu 11 by pressing the MENU and "1", "1" keys on the PDA.

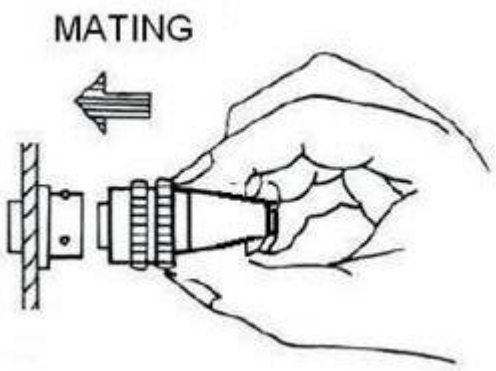




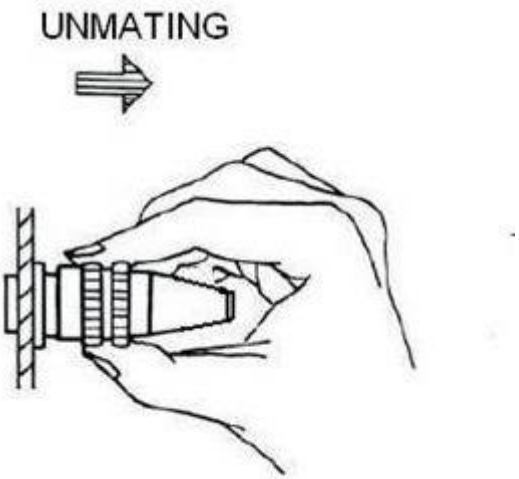
Observe the data window with the existing Pipe Outer Diameter Displayed in the Display section on the PDA. To change this data and input the new pipe dimensions, press the ENT Key. {This is the enter key and will be referred to as the Enter key from this point in the manual.} When you select the enter key, you will see a cursor that looks like this >. At this point, simply type in the data and press the enter key again. This will over write the existing information in the PDA and save the new data.

5.3. Connecting the Transmitter

Once the transducers are securely mounted on the pipe, connect the cables to each transducer and then to the electronics box. Care should be taken here as the transducer cable ends are keyed to fit into the transducers wiring connection and then fastened with a circular connector. The opposite end is a circular connector plug that simply inserts into the corresponding Upstream and Downstream connection point. Once these 2 cables are securely connected, you are ready to read the flow.

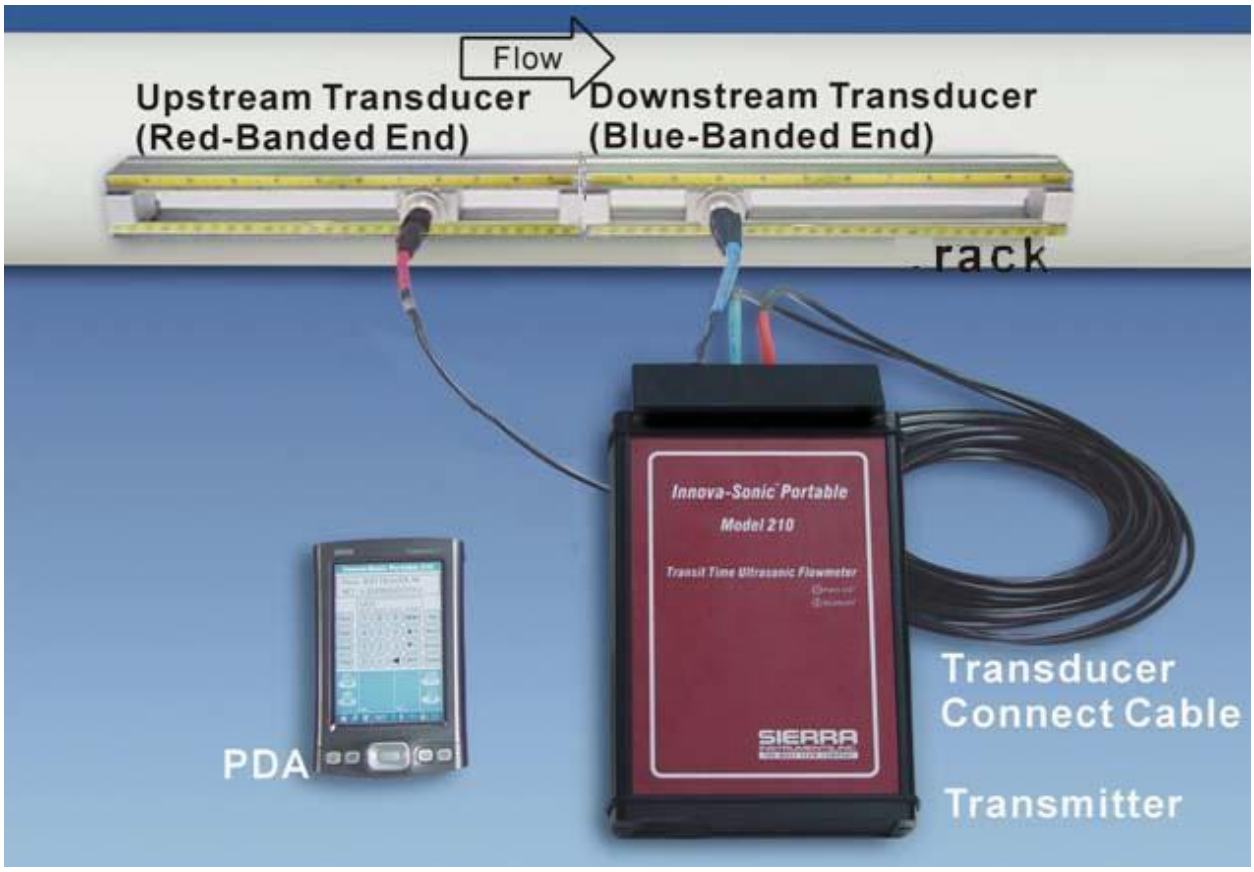


MATING: As drawing shows, hold the smooth part in back of the plug and push when the key of the plug are in line. The connector is fully seated when a click is heard or felt from the quick disconnect ring.



UNMATING: As drawing shows, hold the coupling nut and pull to unmate.

The upstream transducer cable has red terminal ends and downstream transducer cable has blue terminal ends.



When installing transducers to relatively small pipes {sizes under 8" in most applications}, the transducer spacing displayed in MENU25 may be less than 7.5" (190mm), then we can install the transducers in single slide ruler rack. The installation method is unscrewing a transducer off the rack at first,

then install the two transducers to one rack face-to-face.

The flow meter will now work as usual. Exercise caution during this procedure as the transducers are spring loaded in the racks.

When finished installing both transducers in a single rack, they should appear as shown in the photo below. The oval transducer crystals should be facing each other. They are designed to send signals back and forth to one another, and if they are installed backwards, they will not function.

Each transducer has a flow direction arrow or an Upstream / Downstream Identification. Additionally, each rack has the flow direction arrow depicted on it. Ensure the arrows point in the correct direction to ensure proper operation.

NOTE

The 2 transducers must be fixed at the front position (i.e. 3 or 9 o'clock position of the pipe) to prevent signal loss which can be caused by sediment along the bottom of the pipe or air bubbles and air pockets along the upper part in the pipe.

Once the cables are connected, simply select MENU 00 and you will display the flow rate. You can then use the shortcut keys for additional flow information as desired.

5.4. System Normal Identification

Press the Menu 0 8 keys. If the letter "*R" displays on the screen, it indicates system normal.

If the letter "E" is displayed, it indicates that the current loop output is over ranged by 120%. This refers to the settings in menu 57. Enter a larger value in menu 57, and the letter "E" will disappear. It can be ignored if no current loop output is used.

If the letter "Q" is displayed, it indicates that the frequency output is over ranged by 120%, and this refers to the settings in menu 69. Increase the input value in menu 69, and the letter "Q" will disappear. It can be ignored if no frequency output is used.

If the letter "H" is displayed, it indicates that the ultrasonic signal detected is poor. For more information, please refer to "Error Diagnoses".

If the letter "G" is displayed, it indicates that system is adjusting the signal gain prior to the measurement. Also, it means system normal. Only when the adjustment takes too long without stopping, can system be identified as abnormal.

Letter "I" indicates no signal is being detected. Check the transducer wiring connections are correct, the transducers are installed firmly, etc.

Letter "J" indicates a hardware defect exists. Normally, such defect is temporary; it could be eliminated by system reboot (power off and restart).

For further information, please refer to "Error Diagnoses".

5.5. Zero Set Calibration

Once zero flow occurs, a zero point may indicate on each measuring instrument, i.e. as the measurement value reaches zero flow, it is indicated as zero. 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, an offset will occur. For an ultrasonic Flowmeter, the measurement difference from zero point cannot be ignored at low flow. It is necessary to perform a zero set calibration to improve low flow measurement accuracy.

5.6. Scale Factor

Scale factor refers to the ratio between "actual value" and "reading value". For example, when the measurement is 2.00, and it is indicated as 1.98 on the instrument, the scale factor reading is 2/1.98. This means that the best scale factor constant is 1.

However, it is difficult to keep the scale factor as "1" on the instrument especially in batch control operations. The difference is called "consistency". High quality products always require high consistency.

The scale factor default is "1" for each instrument prior to shipment from the factory. The reason is that the scale factors in the Flowmeter are only limited by two parameters, i.e. the crystal oscillation frequency and the transducer. It has no relation to any circuit parameters.

During operation, there still exists possible difference in pipe parameters, etc. The "scale factor" may be necessary when used on different pipes. Thus, scale factor calibration is specially designed for calibrating the differences that result from application on different pipes. The scale factor entered must be one that results from actual calibration.

5.7. System Lock (Unlock)

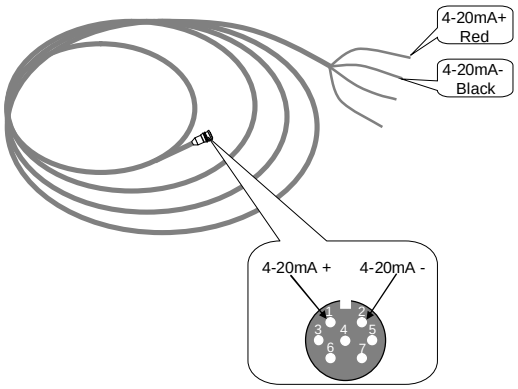
System lock is readable but uninterested to prevent operation error due to unauthorized tampering by unauthorized personnel.

Press the Menu 4 7 ENT keys, move ▲/+ or ▼/- key to select "Lock", press the ENT key, enter a 1~4 numerically long password, and then press the ENT key to confirm.

Unlock using the selected password only. Press Menu 4 7 ENT, move ▲/+ or ▼/- to select "Unlock", press ENT, enter the correct password, then press ENT to confirm.

Keep the password in mind or recorded in a safe place or the instrument cannot be used.

5.8. 4~20mA Current Loop Verification



The 4~20mA current output connects to the 7-pin din jack on the panel. The color of cable core is red（4-20mA+）and black (4-20mA-). With an accuracy of 0.1%, The current output of the 210 PORTABLE is fully programmable and can be set to various output modes such as 4~20mA or 0~20mA. Use Window M55 to select the output mode.

The max load of 4-20mA DC is 750Ω. Exercise care on polarity when connecting.

5.9. Totalizer Pulse Output

Each time the Flowmeter reaches a unit flow, it may generate a Totalizer pulse output to a remote counter. To configure the unit flow, please refer to Windows M32 and M33.

The Totalizer pulse output can be transmitted through OCT or a relay. So, it is necessary to configure OCT and the relay accordingly.(Please refer to Window M78 and M79).

For example, if it is necessary to transmit the positive Totalizer pulse through a relay, and each pulse represents a flow of 0.1m3, ; the configuration is as follows:

In Window M33, select Totalizer the flow unit "Cubic Meters (m3)";

In Window M34, select the scale factor "x0.1";

In Window M79, select "9. Positive Totalizer pulse output";

ATTENTION

Make sure to select a suitable Totalizer pulse, since the output may be extended if it is too large. If it is too small, the relay may activate too frequently and shorten its life. Furthermore, if it operates too fast, it may generate a pulse loss error. Therefore, a rate of 1~60/minute is recommended.

5.10.Recover the Factory Default

If it is necessary to recover the factory default, press Menu 3 7 • ◄ keys after the above-mentioned characters are displayed on the screen.

Generally, it is unnecessary to activate this function except during the initial installation.

5.11. Analog Output Calibration

ATTENTION

Each Flowmeter has been calibrated before leaving factory. It is unnecessary to carry through this step except when the current value (detected while calibrating the current loop) displayed in Window M58 is not identical with the actual output current value.

The hardware detect window must be activated prior to calibration. The procedure is as follows:

Press Menu ▼/- 0 ENT enter password "4213068", then press ENT to activate the detect menu. With no effect to next power on, this window will close automatically as soon as the power is turned off.

Press Menu ▼/- 1 ENT to calibrate the current loop 4mA output. Use an ammeter to measure the current loop output current. At the same time, move ▲/+ or ▼/- to adjust the displayed numbers. Watch the ammeter until it reads 4.00. Stop at this point, the 4mA has been calibrated.

Then, press ENT to calibrate the current loop 20mA output. The method is as same as in 4mA calibration.

The result is saved in EEPROM. Switch off the power supply has not lost.

5.12. 210 PORTABLE Software Usage

The 210 PORTABLE software contains two parts: 210.prc that runs on the PDA and UFM Data processing program working under Microsoft Windows operating system.

Under normal conditions, to complete all measurement tasks and data acquisition, data browsing and setup guide operations, only the PDA software 210.prc is needed. If you need further data processing, copy the data from PDA to your PC and carry out statistical analysis, graphic display, printing and other operations on the data using UFM Data (UFM Data will be provided and will need to be installed in your PC).

210.prc exploits the powerful computing capabilities of the PDA, offering the following functions in addition to normal measurement:

Data Acquisition: Collects data from the Flowmeter and stores it in the memory of the PDA. The collected data can be browsed in a table or graph on the PDA and simple analysis can be conducted.

Setup Guide: Allows the meter to be configured in steps with a setup wizard. Users can save the settings in a file, which can be recalled directly later on to simplify the setup process. The setup guide greatly simplifies the operation of the meter, allowing personnel who are unfamiliar with the Flowmeter to configure its settings easily.

Full Screen Display: The program has the ability to display MENU00~04 and shortcut keys Flow, Velo, +Total, -Total in full screen view. Operators can check the data easily.

5.12.1. Data Acquisition and Analysis

5.12.1.1. PDA Data Acquisition and Analysis Program

This program stores the collected data into the PDA's Flash memory in the form of files.

For 210 Portable kits equipped with the PDA, the data is stored on the SD card. The Data Files may be accessed by starting the "Card Reader" program while attached to your PC. This will allow you to transfer the data files to your PC for use with the UFM Data program.

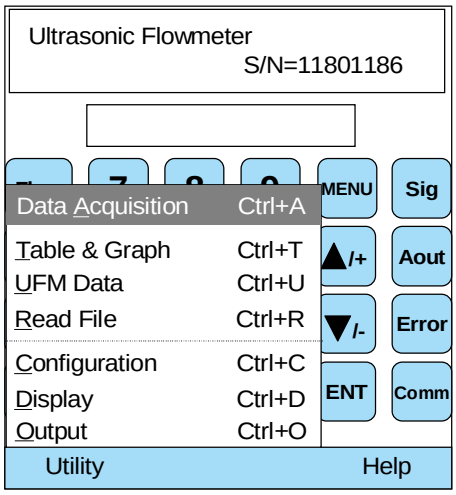
The data files are stored in the following directory. Press the "file" icon in the PDA window and go to the following directory: ***PDA\start\explorer\memorizer***. You can see four directories: 210, Display, Output, and Setup. The "210" directory is used for storing the collected Flowmeter data, "Output" for storing output setup files of the Flowmeter, "Display" for storing the display setup files of the Flowmeter and "Setup" for storing setup and configuration files of the Flowmeter.

During data acquisition, 1800 data points can be collected each hour (i.e. each data point requires 2 seconds). Data amount for each hour is 144K. Assuming the data storage of the PDA is 128M, each extension card is able to store

over 900 hours of data or 160000 data points. If needed, users can choose extension cards with more storage.

5.12.1.2. Main Interface

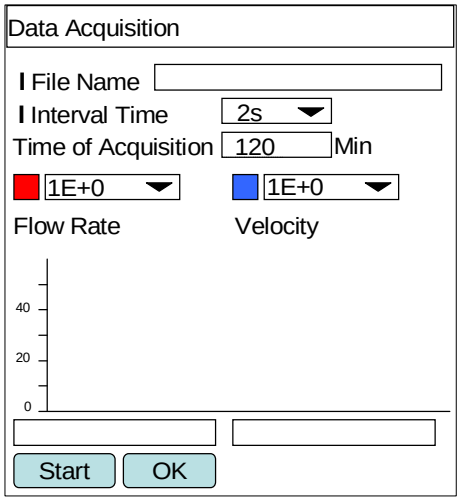
The main menu is divided into two items: Utility and Options. Submenus under Utility are further classified into two modules: Data Acquisition, Table & Graph, UFM Data (internal SD card data acquisition) and Read file (read the data in the SD card) are menus used to perform data acquisition and display data table and graph, while Configuration, Display and Output are menus used for Flowmeter setup. Options menu is used to display software copyright and version information.



5.12.1.3. Data Acquisition

To collect data, click “Data Acquisition” menu to enter Data Acquisition mode. After inputting the File Name and Time of Acquisition, operators can click the “start” button to enter data acquisition mode. The Data that can be collected include: date & time, flow rate, flow velocity, net total flow, positive Total flow, negative total flow, Electronic Serial Number, pipe inner diameter, pipe outer diameter, pipe material, liner material and fluid type. Collected data will be stored under the “210” directory of the PDA extension card. Acquisition of each data point requires 2 seconds.

During data acquisition, graphs and data values of the flow rate and flow velocity are displayed on the screen in real time, each of them distinguished by different colors. If a curve exceeds the display range of the coordinate, it will be readjusted to be within the optimal display area. If necessary, you can also adjust it manually using a multiplier.



File Name: Give a name for the collected data. Input the name above the line manually, otherwise the name will be generated automatically.

Time of Acquisition: A period of time in which the data is collected. Input the time manually in minutes. The

default time is 120 min.

Start Button: Click to start acquisition. During acquisition, this button becomes a “stop” button. If clicked, “stop” can stop the acquisition.

Done Button : Click to exit this page.

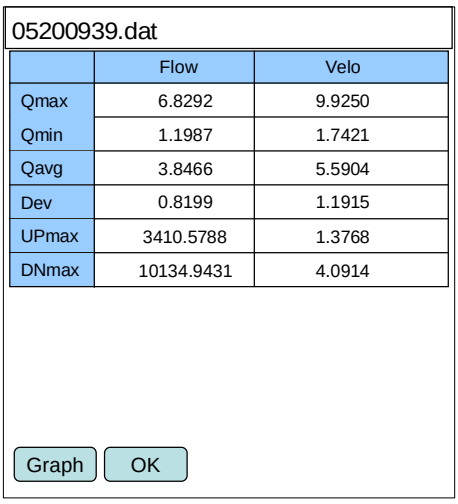
Coordinate: Curves that display Flow Rate and Flow Velocity during data acquisition.

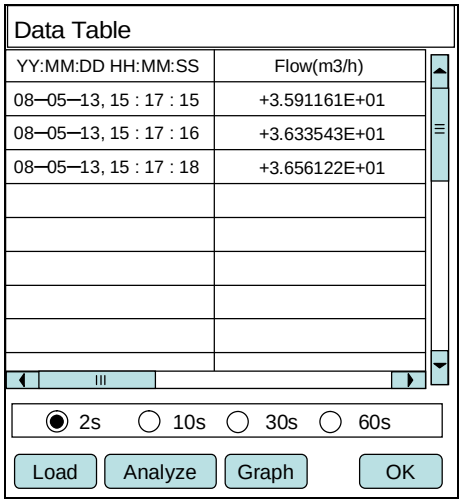
Red Box: Displays the value of the Flow Rate.

Blue Box: Displays the value of the Flow Velocity.

5.12.1.4. Data Analysis and Graph

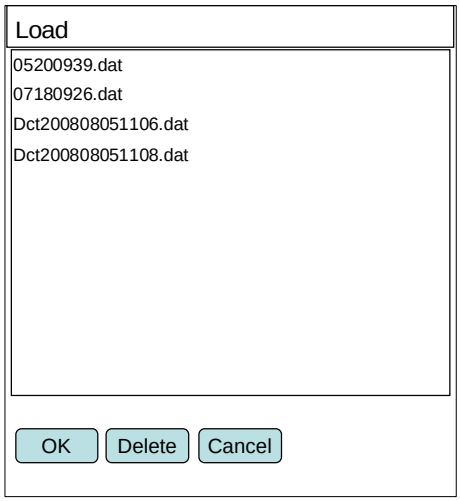
Select “Table & Graph” from the “Utility” menu to enter the data analysis mode. This page is presented as a table where the date & time, flow rate, flow velocity, net Totalizer, positive total flow, negative total flow of the collected data are shown in the form of a data table. To view the data more easily, you can adjust the display time interval by pressing different Time buttons. Press Left/Right/Up/Down arrow buttons to turn page.



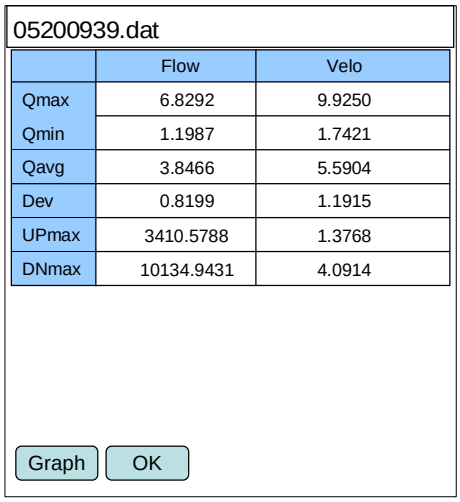


There are 4 buttons below the main page: “Load”, “Analyze”, “Graph” and “Done”. These buttons are used for loading data file, data analysis, graph display and exiting respectively.

“Load” page: Press “Load” button to enter the Load page. After clicking a file and pressing the “OK” button, the contents of the selected file are displayed in a table. You can delete data files from this page by selecting a file and pressing the “Delete” button.



“Analyze” page : Click “Analyze” button to enter Data Analyze page. This table shows the analysis results of the flow rate and flow velocity in the “Data Table”.



Qmax: Maximum values of flow rate and flow velocity;

Qmin: Minimum values of flow rate and flow velocity;

Qavg: Average values of flow rate and flow velocity;

Dev: Deviation of flow rate and flow velocity;

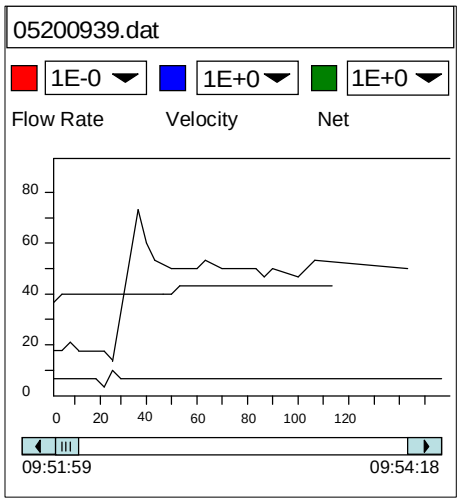
UPmax: Maximum upwards variable rate of flow rate and flow velocity;

DPmax: Maximum downwards variable rate of flow rate and flow velocity;

"Graph" Page: Click "Graph" button to enter Data Curve Graph page.

Data Curve Graph page displays curves of flow rate, flow velocity, net Totalizer for the current file. Different curves are shown in different colors, which are indicated by the boxes with filled-in colors. Below the boxes are curve names that the boxes indicate. You can adjust the display area of a curve by using a multiplier. The time below the coordinate shows the time range of the curve currently displayed on the screen. You can browse through the page using Left/Right arrow button, or move data points using Left/Right triangle button.

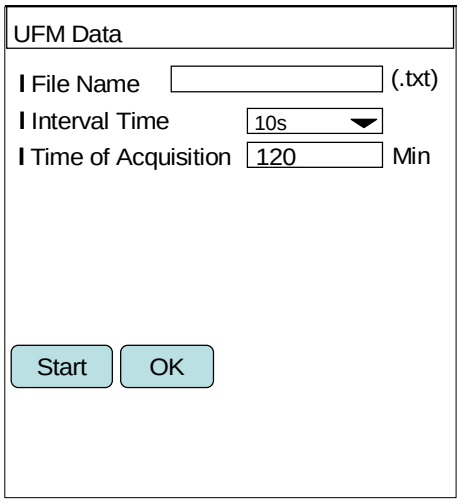
When clicking a point within the graph display area, a cursor intersecting with the curve appears. At the same time, the value of the curve at the intersection point is displayed.



5.12.1.5. Data Acquisition Control For The Internal SD Card

Click "UFM Data" menu to enter the data acquisition control page for the internal SD card. Input the file name after the "File name". Select the interval time among the options after "Interval time". Input the time of acquisition (Unit: min) after "Time of Acquistion". Then click "Start" button to enter the data collecting status. The content of the data logging contains: Date and Time, Flow rate, Flow velocity, Net Totalizer, Pos Totalizer, Neg Totalizer, ESN, Pipe Inner Diameter, Pipe Outer Diameter, Pipe material, Liner material and Fluid Type.

When data logging the display will show the actual flow rate and flow velocity value.



"File name": the file name for the acquisiotion data, input the name on the line. If user dose not input a name, the system will create an "xxxxxxxx" format file name automatically. "x" indicates numbers. The 1-4 digit indicate the current month and date, and the last four digit indicate the current time. Such as "10260955" indicates the current time is Oct. 26th 9:55am. The file will be saved as *.TXT format.

"Interval time": the interval time for the data acquisition. There are "2S, 10S, 30S, 60S" 4 options to select.

"Time of Acquisition": the time of acquisition for the data.. Input by the users. Unit: min. Factory default is "120 min".

"Start": click "Start" to start the data acquisition. During the data acquisition this button will change to "Stop" button automatically. Click "Stop" to stop the data acquisition.

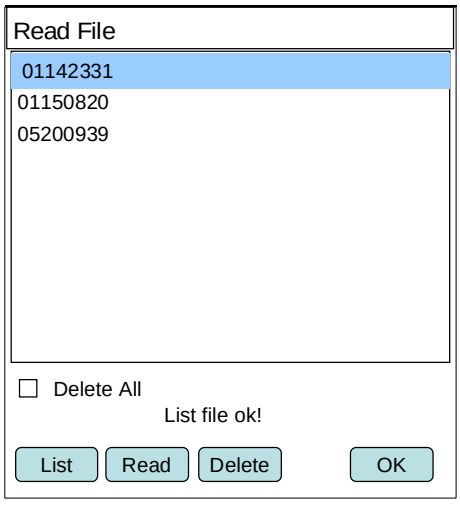
"Done": click "Done" to quit the page.

NOTE

The SD card can only support 256 files. If the file is over 256, the system will cover the oldest file automatically.

5.12.1.6. Data Reading For The SD Card

Click "Read File" menu to enter the data reading page for the SD card. This page is the data reading page for the internal SD card.



"List": read the files content in the SD card.

"Read": read the selected file to PDA, and convert the file to *.dat format.

"Delete": delete the selected file.

"Done": click to quit the page.

"Delete all": select this option, click "delete" will delete all the files in the SD card.

5.12.2. UFM Data Analysis and Printing Program

NOTE

Skip this section if you will not use a PC to process the collected data.

Running under the Windows operating system (Windows98 or above) at a PC terminal, the UFM Data data analysis and printing program is used to process the ultrasonic Flowmeter data collected by the PDA. The purpose of this program is to supplement the data processing function of the PDA. This program allows users to display graphs, print or save the files in Excel format, or browse and analyze the collected data in a table, enabling users to manage the Flowmeter data more conveniently.

Flowmeter data are stored under the 210 directory of the PDA. You can set the PDA to "Driver Mode" and connect it with your PC.

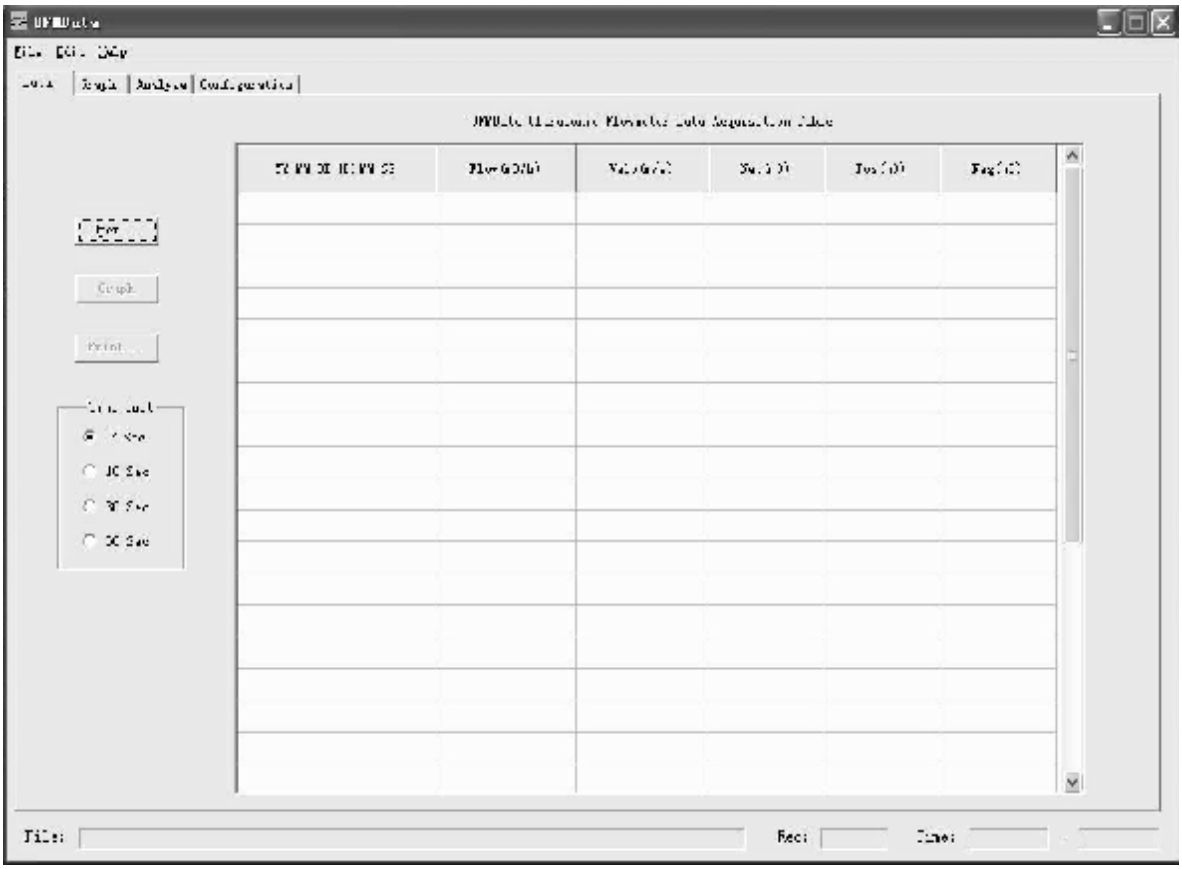
NOTE

For information about how to connect the PDA with your PC, see Tungsten PDA_handbook_CS.pdf in the PDA CD-ROM.

The main window of this program is divided up into 4 pages: Data page, Graph page, Analyze page, Configuration page.

5.12.2.1. Data Browsing and Printing

After the program starts, the data browsing page will be displayed. This page allows you to browse and print the loaded data in a table, or adjust the display time of the data.



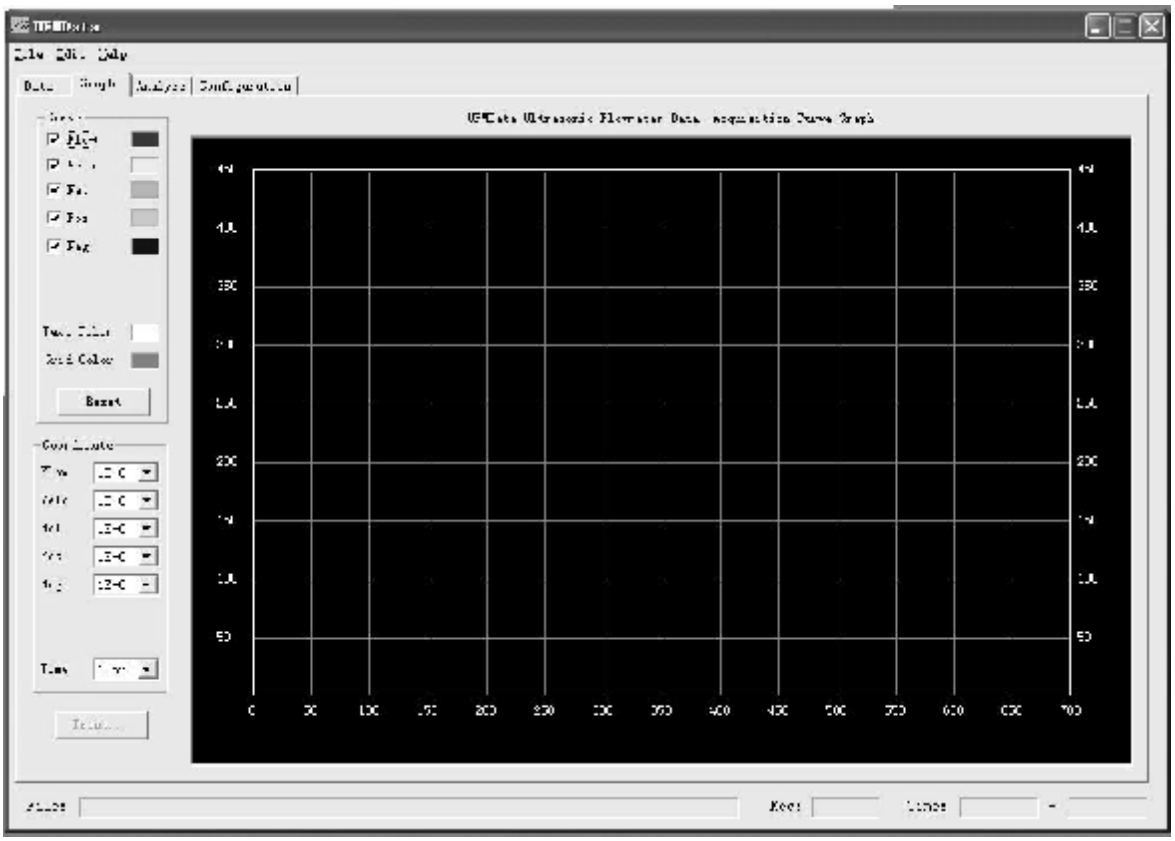
"Open" button: Press this button to read in the Flowmeter data files under "210" directory. Theses files are data collected by the PDA.
"Graph" button: Press this button to jump to the "Graph" page, where data are displayed in graphs.

"Print…" button: Press this button to print the table. Basic printing settings can be set in the Print dialog box.

"Time Unit" button: These buttons are used to adjust the display time. Available time units include 2 sec, 10 sec, 30 sec, and 60 sec. The default unit is 2 sec. When a time unit other than 2 sec is selected, the data in the table will be displayed and printed according to the selected time interval.
Below the data table, the "File" text box shows the File Path, "Rec" shows the number of the data and "Time" shows the time range for data acquisition.
The contents of the data table are: date & time, flow rate, flow velocity, net total flow, positive total flow and negative total flow.

5.12.2.2. Graph Display and Printing

Click "Graph" button in the data table to enter the Graph display page. This page allows you to display and print loaded data by graphs intuitively. Users can adjust the color of the curve or change display unit as required.



This page is divided up into 2 parts: the graph display area with black background is the main page and the left is the graph display setup area.

“Curve” check box: Placing a check mark to the left of the graph name displays the corresponding graph in the graph area. Clicking the color box to the right of the graph name changes the color of the graph. You can change the text color of the coordinate by clicking the color box to the right of “Text Color”, or change the coordinate grid color by clicking “Grid Color” color box.

“Coordinate” check box: Select to display the graph at different magnifications. Magnification can be changed in the range of 10-4~108 (default is 100). Once it is changed, the curve displayed on the vertical ordinate will be changed accordingly. “Time”: Used to change range of the time scale. 1mul stands for 50 sec per scale, 2mul for 25 sec, 5mul for 10 sec and 10mul for 5sec. Once it is changed, the curve displayed on the horizontal ordinate will be changed accordingly.

“Reset” button: Press to restore the colors of the curves into defaults.

“Print” button: Press to print the graph.

At the bottom of the page, the “File” text box shows the File Path; “Rec” shows the number of the data and “Time” shows the time range for the data acquisition.

5.12.2.3. Data Analysis and Printing

The data analysis page is used to perform statistical analysis on collected Flowmeter data. Its contents include:

Qmax: Maximum values of flow rate and flow velocity;

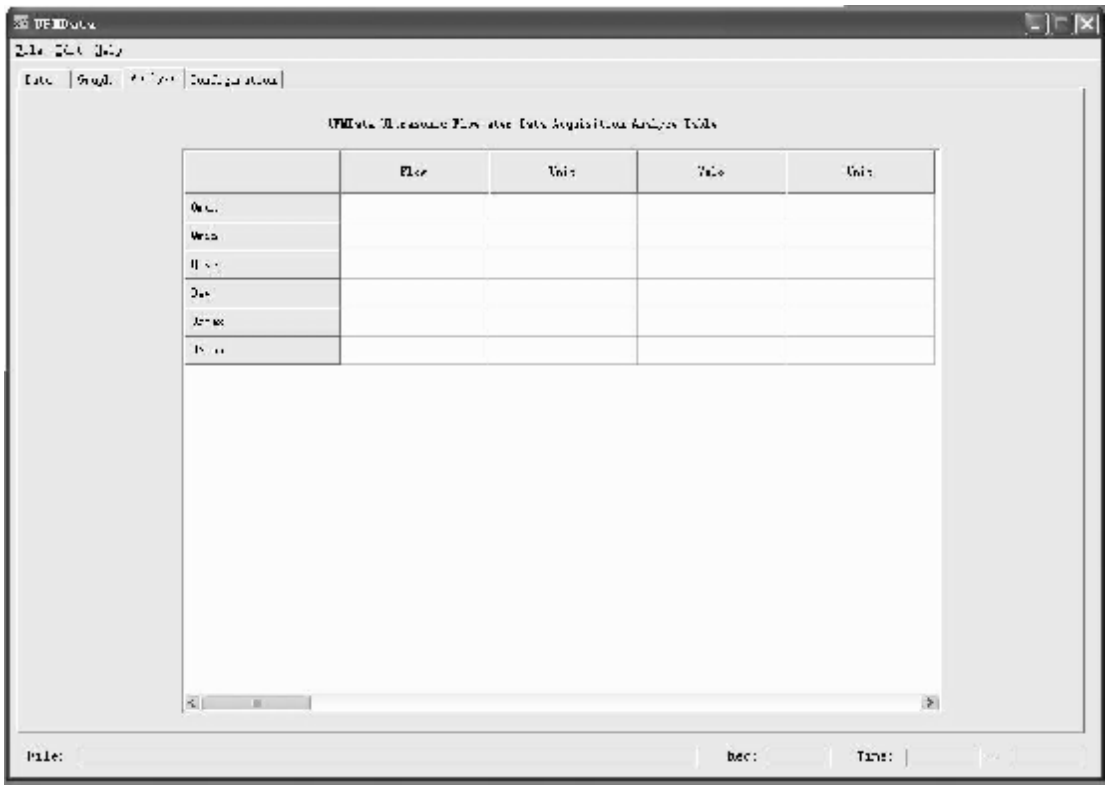
Qmin: Minimum values of flow rate and flow velocity;

Qavg: Average values of flow rate and flow velocity;

Dev: Deviation of flow rate and flow velocity;

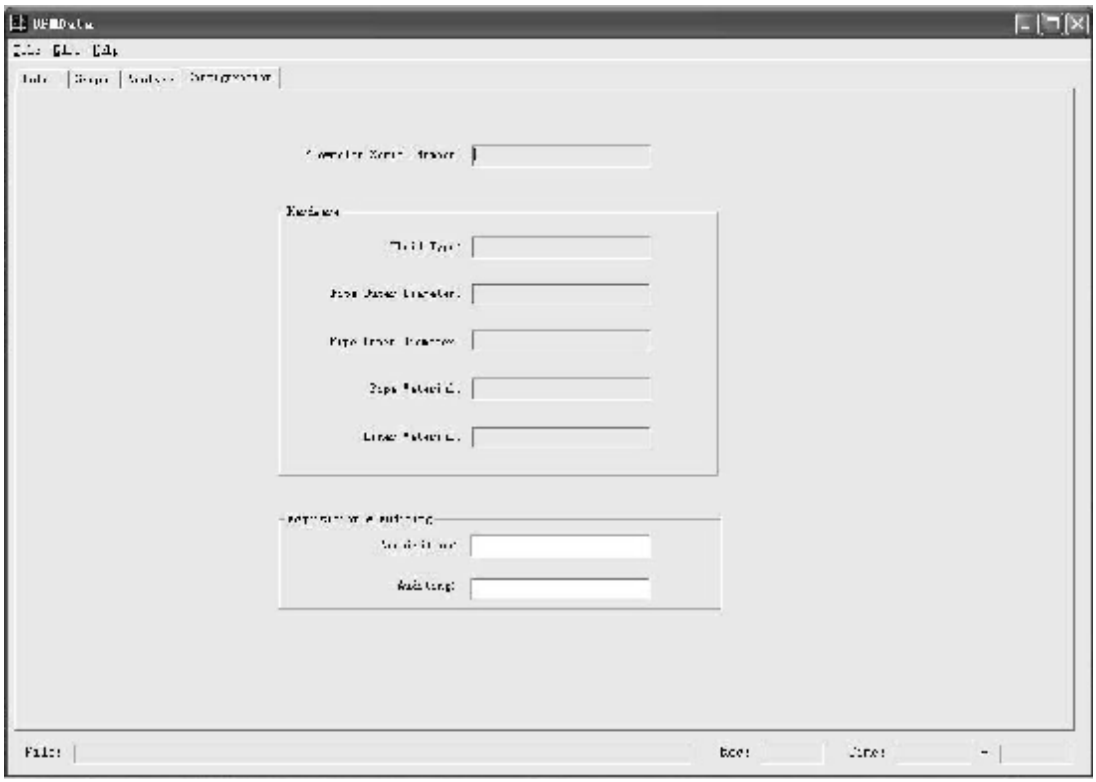
UPmax: Maximum upwards variable rate of flow rate and flow velocity;

DPmax: Maximum downwards variable rate of flow rate and flow velocity;



5.12.2.4. Configuration Information Display

This page displays the configuration information of the Flowmeter. This page cannot be printed.



Flowmeter Serial Number: Displays Flowmeter serial number;

Fluid Type: Displays fluid type being measured;

Pipe Outer Diameter: Displays pipe outer diameter;

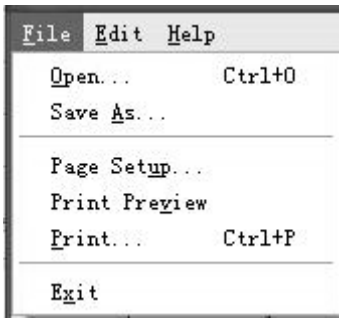
Pipe Inner Diameter: Displays pipe inner diameter;

Pipe Material: Displays pipe material;

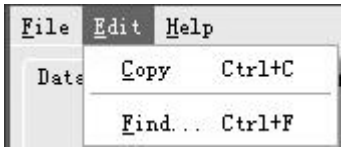
Liner Material: Displays liner material.

5.12.2.5. Menu Functions

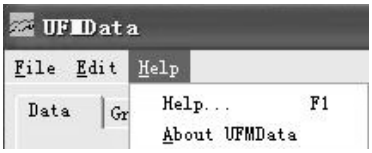
There are three menus in the Menu bar of the program: “File”, “Edit” and “Help” the File submenu has the following functions:



“Open”: Opens the data files stored under the “210” directory;
“Save As”: Saves reports as text files (.txt) and Excel files (.xls);
“Print”: Prints data tables or graphs;
“Page Setup”: Sets the paper settings for printing, such as Paper Size, Paper Direction, etc.
“Print Preview”: Previews the printing contents.
the “Edit” submenu has the following functions:



“Copy”: Copies the selected region.
“Find”: Searches the data in the report.
the “Help” submenu has the following functions:



“Help”: Operating instructions for this software.

“About”: Software copyright, version information, and so on.

5.13. Analog Voltage Output

Connect a 250Ω resistance to the current loop in parallel to transform 4~20mA into 1~5V voltage output.

5.14. Date and Time Settings

Generally, it is unnecessary to modify date time as the system is provided with a highly reliable perpetual calendar chip. If necessary, key in the Menu 6 0 buttons to enter the window, then press ENT to see ‘>’ displayed on the bottom left line of the screen. It indicates that the screen is ready for the modification. Press • to skip the numbers that do not need to be changed, and then press ENT again to confirm the modification.

5.15. Check Flow of Every Day/Month/Year

Window M82 allows you to read flow data history and the operating state of the instrument in the past 64 days.

Press Menu 8 2 key and select sub item No.0 "Day". Then, the character is displayed as shown in right. The "00" – "63" in the upper left corner stands for serial number, the "00-07-21" in the middle for date and the "--------" in the upper right corner for operating state. Only "--------" being displayed on the status bar indicates the instrument was working properly at that working day. If there are other characters displayed, see the error code instruction for reference. The data 3412.53 in the bottom shows the net total flow of that working day.

To read the total flow of a month, press Menu 8 2 key and select sub item No.1 "Month".

To read the total flow of a year, press Menu 8 2 key and select sub item No.2 "Year".

5.16. Automatic Flow Correction

In Window M83, select "Yes", the lost flow during an offline session will be automatically recovered into the flow Totalizer as soon as the next power on. Select "No" to neglect this function.

5.17. Working Timer

Window M72 displays the total running hours since last reset.

Press ENT , select "Yes" to reset the working timer.

5.18. Manual Totalizer

Press Menu 3 8 ENT to start the Totalizer. Press ENT key to stop it.

5.19. Analog Output Calibration

Each Flowmeter has been calibrated strictly before leaving factory. It is unnecessary to carry through this step except when the current value (detected while calibrating the current loop) displayed in Window M58 is not identical with the actual output current value.

The hardware detect window must be activated prior to calibration. The procedure is as follows:

Press Menu ▼/- 0 ENT enter password "4213068", then press ENT to activate the detect menu. With no effect to next power on, this window will close automatically as soon as the power is turned off.

Press ▼/- ENT to calibrate the current loop 4mA output. Use an ammeter to measure the current loop output current. At the same time, move ▲/+ or ▼/- to adjust the displayed numbers. Watch the ammeter until it reads 4.00. Stop at this point, the 4mA has been calibrated.

Then, press ENT to calibrate the current loop 20mA output. The method is as same as in 4mA calibration.

The results is saved in EEPROM. Switch off the power supply has not lost.

5.20. ESN

We provide the Flowmeter with a unique electronic serial number to identify each Flowmeter for the convenience of the manufacturer and customers. The ESN, instrument types and versions are able to view in Window M61.

ATTENTION

Other Operating Refer to "Windows Display Explanations".

6. Windows Display Explanations

6.1. Windows Display Codes

Flow Totalizer Display	
00	Flow Rate/Net Totalizer
01	Flow Rate/Velocity
02	Flow Rate/POS Totalizer
03	Flow Rate/NEG Totalizer
04	Date Time/Flow Rate
08	System Error Codes
09	Net Flow Today
Initial Parameter setup	
10	Pipe Outer Perimeter
11	Pipe Outer Diameter
12	Pipe Wall Thickness
13	Pipe Inner Diameter
14	Pipe Material
15	Pipe Sound Velocity
16	Liner Material
17	Liner Sound Velocity
18	Liner Thickness
20	Fluid Type
21	Fluid Sound Velocity
22	Fluid Viscosity
23	Transducer Type
24	Transducer Mounting
25	Transducer Spacing
26	Parameter Setups
27	Cross-sectional Area
28	Holding with Poor Sig
29	Empty Pipe Setup
Flow Units Options	
30	Measurement Units
31	Flow Rate Units
32	Totalizer Units
33	Totalizer Multiplier
34	Net Totalizer
35	POS Totalizer
36	NEG Totalizer
37	Totalizer Reset
38	Manual Totalizer
Setup Options	
40	Damping
41	Low Flow Cutoff Value
42	Set Zero
43	Reset Zero
44	Manual Zero Point
45	Scale Factor
47	System Lock
Input and output setup	
55	CL Mode Select
56	CL 4mA Output Value
57	CL 20mA Output Value
58	CL Check
59	CL Current Output
60	Date and Time
61	ESN
72	Working Timer
82	Date Totalizer
83	Automatic Correction
Diagnoses	
90	Signal Strength and Quality
91	TOM/TOS*100
92	Fluid Sound Velocity
93	Total Time and Delta
94	Reynolds Number and Factor
Appendix	
+0	Power ON/OFF time
+1	Total Working Hours
+2	Last Power Off Time
+3	Last Flow Rate
+4	ON/OFF Times
+5	Calculator
Shortcut Keys	
Flow	Flow Rate
Velo	Flow Velocity
+Total	Positive Total
-Total	Negative Total
Sig	signal Strength and Quality
Aout	Analog Output
Error	Error Code
Comm	Communication Information Between PDA

NOTE：The menu features from other manufacturers to retain.

6.2. Display Explanation

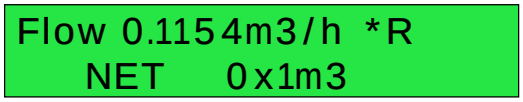
While reading this section, please compare it with the instrument in order to improve your understanding.

Menu 0 0

Flow Rate / Net Totalizer

Display flow rate and net Totalizer.

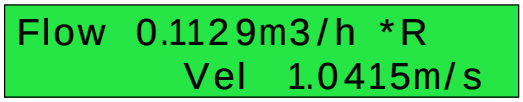
If the net Totalizer has been turned off (refer to M34), the net Totalizer value displayed is the total prior to its turn off.



Menu 0 1

Flow Rate / Velocity

Display flow rate and velocity.



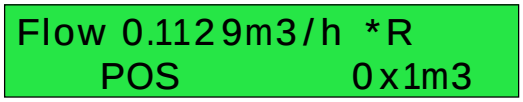
Menu 0 2

Flow Rate / Positive Totalizer

Display flow rate and positive Totalizer.

Select the positive Totalizer units in Window M31.

If the positive Totalizer has been turned off, the positive Totalizer value displayed is the total prior to its turn off.



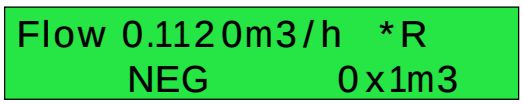
Menu 0 3

Flow Rate / Negative Totalizer

Display flow rate and negative Totalizer.

Select the negative Totalizer value in Window M31.

If the negative Totalizer has been turned off (refer to M36), the value displayed is the total prior to turn off.

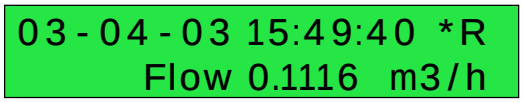


Menu 0 4

Date Time / Flow Rate

Display the current date time and flow rate.

The time setting method is found in Window M60.

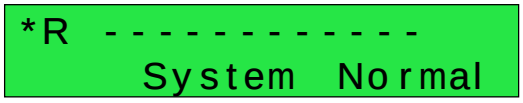


Menu 0 8

System Error Codes

Display the working condition and the system error codes. More than one error code can occur at the same time.

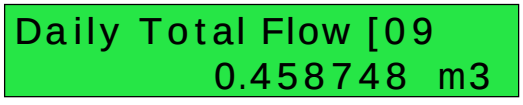
The explanations of error codes and detailed resolution methods can be found in "Error Diagnoses".



Menu 0 9

Net Flow Today

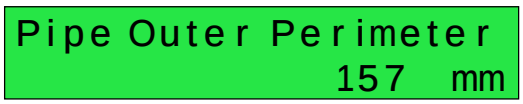
Display net total flow today.



Menu 1 0

Pipe Outer Perimeter

Enter the pipe outer perimeter. If the diameter of the know, enter it in window M11.



Menu 1 1

Pipe Outside Diameter

Enter the pipe outside diameter, The pipe outside diameter must range from 10mm to 6000mm.

Menu 1 2

Pipe Wall Thickness

Enter the pipe wall thickness. If the pipe inside diameter is already known, skip this window and enter it in Window M13.

Menu 1 3

Pipe Inner Diameter

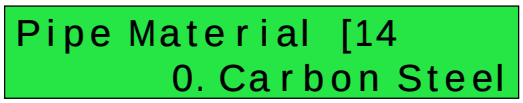
Enter the pipe inside diameter. If the pipe outside diameter and pipe wall thickness has been entered, press ▼/- to skip this window.

Note: Enter either pipe wall thickness or pipe inside diameter.

Menu 1 4

Pipe Material

Enter pipe material. The following options are available (by ▲/+、▼/- buttons or numerical keys):



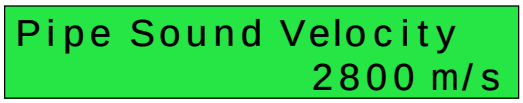
0. Carbon Steel	1. Stainless Steel
2. Cast Iron	3. Ductile Iron
4. Copper	5. PVC
6. Aluminum	7. Asbestos
8. Fiber Glass-Epoxy	9. Other

Refer to item 9 "Other"; it is possible to enter other materials, which are not included in previous eight items. Once item 9 is selected, the relevant pipe sound velocity must be entered in Window M15.

Menu 1 5

Pipe Sound Velocity

Enter pipe sound velocity. This function is only used when item 9 "Other" is selected in Window M14. At the same time, this window cannot be visited. System will calculate automatically according to the existing parameters.



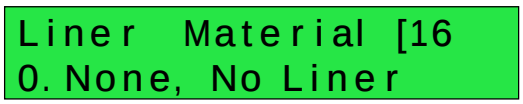
Menu 1 6

Select the Liner Material

The following options are available:

0. None ,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

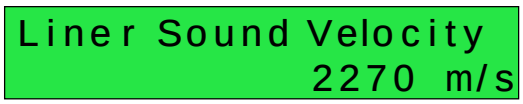
Item 11 "Other" is available to enter other materials that are not included in previous ten items. Once the "Other" is selected, the relevant liner sound velocity must be entered in Window M17.



Menu 1 7

Liner Sound Velocity

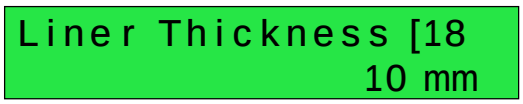
Enter liner sound velocity. It only can be visited when item " Other" in Window M16 is selected.



Menu 1 8

Liner Thickness

Enter liner thickness. It only can be visited when a definite liner is selected in Window M16.



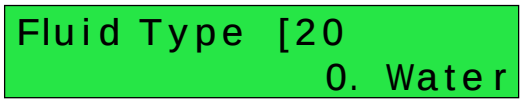
Menu 2 0

Select Fluid Type

The following options are available:

0. Water	1. Sea Water
2. Kerosene	3. Gasoline
4. Fuel Oil	5. Crude Oil
6. Propane (-45℃)	7. Butane (0℃)
8. Other	9. Diesel Oil
10. Castor Oil	11. Peanut Oil
12. Gasoline #90	13. Gasoline #93
14. Alcohol	15. Water (125℃)

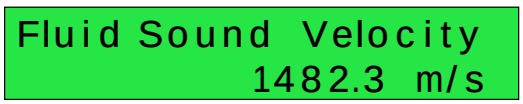
"Other" refers to any fluid. The relevant sound velocity must be entered in Window M21.



Menu 2 1

Fluid Sound Velocity

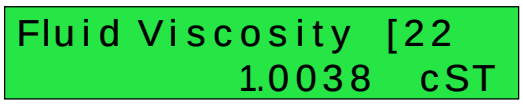
Enter the fluid sound velocity. It only can be used when item "Other" is selected in Window M20, i.e. it is unnecessary to enter all the fluids listed in Window M20.



Menu 2 2

Fluid Viscosity

Enter fluid's kinematics viscosity. It only can be used when item "Other" is selected in Window M20, i.e. it is unnecessary to enter all the fluids that listed in Window M20.



Menu 2 3

Select transducer type

Please select "0.Standard".

Menu 2 4

Transducer Mounting

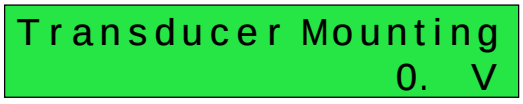
Four mounting methods are available:

V(sound wave bounces 2 times)

Z(sound wave bounces once. The most commonly use method)

N (small pipe, sound wave bounces 3 times.)

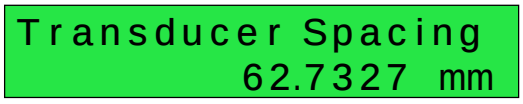
W (small pipe, sound wave bounces 4times.)



Menu 2 5

Transducer Spacing (this value is Calculated by the Flowmeter)

The operator must mount the transducer according to the transducer spacing displayed (be sure that the transducer spacing must be measured precisely during installation). The system will display the data automatically after the pipe parameter had been entered.



Menu 2 6

Initial Parameter Setups and Save

Load and save the parameters. 18 different sets of setup conditions/groups are available to load and save by three methods (i.e.-you can load and save 18 different applications):

0. Entry to Save
1. Entry to Load
2. To Browse

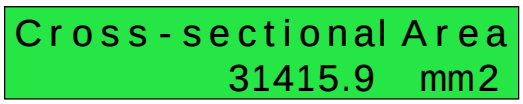
Select "Entry to Save", press ENT. An ID code and the original parameters are displayed in the window. Press UP or DOWN ARROW to move the ID code, then press the ENT key again to save the current parameter in the current ID room.

When selecting "Entry to Load", press ENT, and the system will read and calculate the parameters automatically and display the transducer mounting spacing in Window M25.

Menu 2 7

Cross-Sectional Area

Display the cross-sectional area inside the pipe.



Menu 2 8

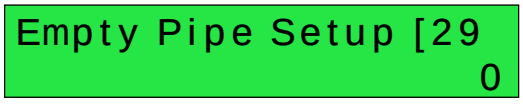
Holding With Poor Sig

Select "Yes" to hold last good flow signal displayed if the Flowmeter experiences a poor signal condition. This function will allow continued data calculation without interruption.

Menu 2 9

Empty Pipe Setup

This value may be used to solve the problem of air traffic control. In the empty pipe, it may be because the flow meter signal transmission through the wall and show the "normal work", in order to avoid such a situation arise, set this value to Flowmeter in the small signal of this is not a numerical measure.



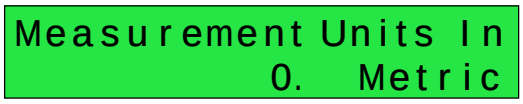
Menu 3 0

Measurement Units

Select the measurement unit as follows:

0. Metric
1. English

Factory default is metric.



Menu 3 1

Flow Rate Units Options

The following flow rate units are available:

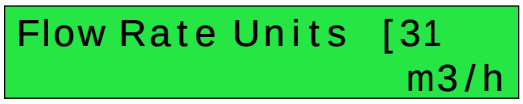
0. Cubic Meters (m3)
1. Liters (1)
2. USA Gallons (GAL)
3. Imperial Gallons (Imp gal)
4. Million Gallons (mg)
5. Cubic Feet (cf)
6. USA Barrels (US bbl)
7. Imperial Barrels (Imp bbl)
8. Oil Barrels (Oil bbl)

The following time units are available:

/Day /Hour

/Min /Sec

Factory default is Cubic Meters/hour.



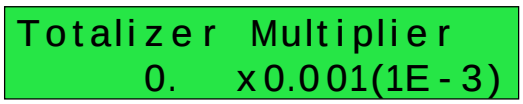
Menu 3 2

Totalizer Units Options

Select Totalizer units. The available unit options are as same as those found in Window M31. The user can select units as their required. Factory default is Cubic Meters.

Menu 3 3

Totalizer Multiplier Options



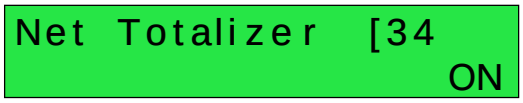
The Totalizer multiplier acts as the function to increase the Totalizer indicating range. Meanwhile, the Totalizer multiplier can be applied to the positive Totalizer, negative Totalizer and net Totalizer at the same time. The following options are available:

0. X0.001(1E-3)
1. X0.01
2. X0.1
3. X1
4. X10
5. X100
6. X1000
7. X10000(1E+4)

Factory default factor is x1

Menu 3 4

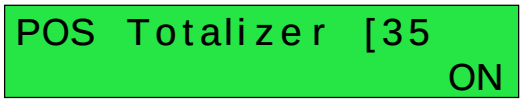
ON/OFF Net Totalizer



On/off net Totalizer. "ON" indicates the Totalizer is turned on, while "OFF" indicates it is turned off. When it is turned off, the net Totalizer displays in Window M00 will not change. Factory default is "ON".

Menu 3 5

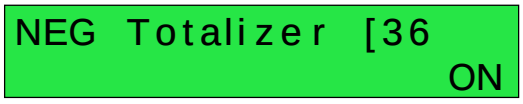
ON/OFF POS Totalizer



On/off positive Totalizer. "ON" indicates the Flowmeter starts to totalize the value. When it is turned off, the positive Totalizer displays in Window M02. Factory default is "ON".

Menu 3 6

ON/OFF NEG Totalizer



ON/OFF negative Totalizer. "ON" indicates the Totalizer is turned on. When it is turned off, the negative Totalizer displays in Window M03.

Factory default is "ON".

Menu 3 7

Totalizer Reset

Totalizer reset; all parameters are reset. Press ENT; move ▲/+ or ▼/- arrow to select "YES" or "NO". After "YES" is selected, the following options are available:

None, All, NET, POS, NEG

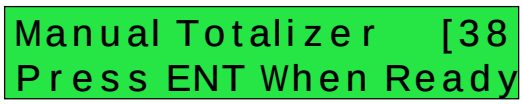
If it is necessary to recover the factory default, press • ◄ keys after the above-mentioned characters are displayed on the screen.

Generally, it is unnecessary to activate this function

except during the initial installation.

Menu 3 8

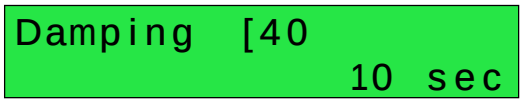
Manual Totalizer



The manual Totalizer is a separate Totalizer. Press ENT to start, and press ENT to stop it. It is used for flow measurement and calculation.

Menu 4 0

Damping

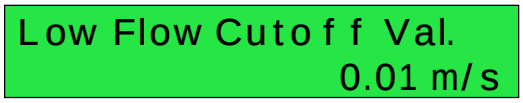


The damping function will stabilize the flow display. Essentially, it is a part of the signal filter. Enter a coefficient. Increasing the coefficient increases the stability. However, the measurement displayed may be slightly delayed due to over damping. Logging too long may result in no response to real-time fluctuation, especially when flow rate fluctuates wildly. Therefore, damping should be kept at a minimum and increased just enough to reduce the fluctuation to an acceptable degree by 3 to 10 seconds.

The damping factor ranges from 0～999 seconds.0 indicates no damping; 999 indicate the maximum damping.Usually a damping factor of 3 to 10 is recommend in applications.

Menu 4 1

Low Flow Cutoff Value

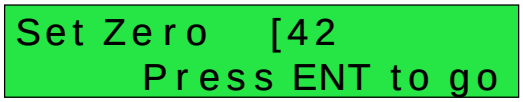


If the flow rate falls below the low flow cutoff value, the flow indication is driven to zero. This function can prevent the Flowmeter from reading flow after a pump as shut down but there is still liquid movement in the pipe, which will result in totalization error.

Generally, 0.03m/s is recommended to enter as the low flow cutoff point. The low flow cutoff value has no relation to the measurement results once the velocity increases over the low flow cutoff value

Menu 4 2

Set Zero



When fluid is in the static state, the displayed value is called “Zero Point”. When “Zero Point’ is not at zero in the Flowmeter, the difference is going to be added into the actual flow values and measurement differences will occur in the Flowmeter.

Set zero must be carried out after the transducers are installed and the flow inside the pipe is in the absolute static state (no liquid movement in the pipe). Thus, the “Zero Point” resulting from different pipe mounting location and parameters can be eliminated. The measuring accuracy at low flow is enhanced by doing this and flow offset is eliminated.

Press ENT , wait for the processing instructions at the

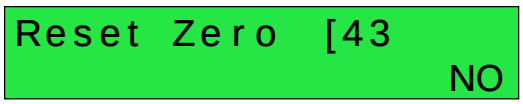
bottom right corner to reach 0.

Performing Set zero with existing flow may cause the flow to be displayed as "0". If so, it can be recovered via Window M43.

Menu 4 3

Reset Zero

Select "YES"; reset "Zero Point" which was set by the user.



Menu 4 4

Manual Zero Point

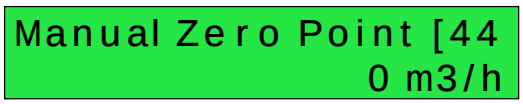
This method is not commonly used. It is only suitable for experienced operators to set zero under conditions when it is not preferable to use other methods. Enter the value manually to add to the measured value to obtain the actual value. For example:

Actual measured value ＝250 m3/H

Value Deviation ＝-10 m3/H

Flowmeter Display ＝240 m3/H

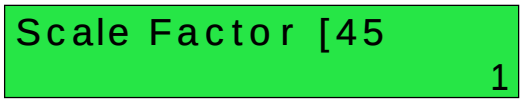
Normally, set the value as "0".



Menu 4 5

Scale Factor

The scale factor is used to modify the measurement results. The user can enter a numerical value other than "1" according to calibration results.

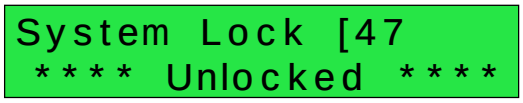


Menu 4 7

System Lock

Lock the instrument.

Once the system is locked, any modification to the system is prohibited, but the parameter is readable. "Unlock" using your designated password. The password is composed of 1 to 4 numbers.



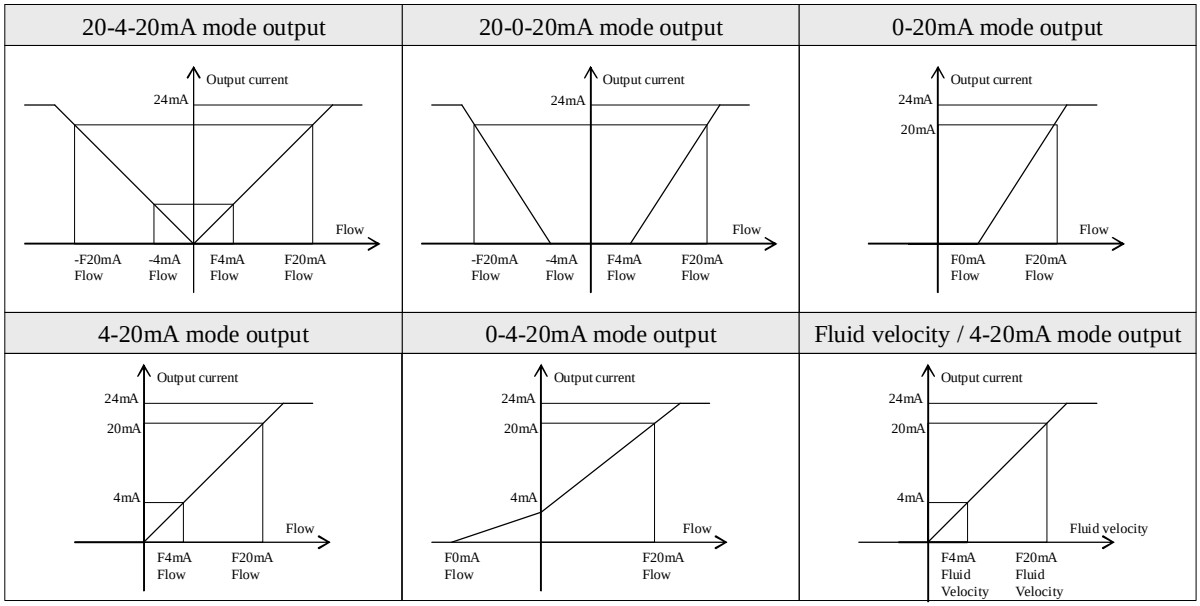
Menu 5 5

Current Loop Mode Select

Select the current loop mode. The following options are available:

0.	4-20mA Output Mode	set up the output range from 4-20mA
1.	0-20mA Output Mode	set up the output range from 0-20mA
2.	RS232 controls 0-20mA	set up to control by Serial Port
3.	Turn off the current loop	turn off the current loop to save battery life(Factory default value)
4.	20-4-20mA Mode	set up the output range from 20-4-20mA
5.	0-4-20mA Mode	set up the output range from 0-4-20mA
6.	20-0-20mA Mode	set up the output range from 20-0-20mA

7. 4-20mA Corresponding Velocity set up the CL output range from 4-20mA
8. 4-20mA Corresponding Heat Flow set up the CL output range from 4-20mA



The Serial Port controls the output according to the command and parameter entered in the RS232 to output a definite current value through the current loop. The command formats are narrated in the command explanations to Serial Port controls. For example, if it is necessary to output a 6mA current through the current loop, it can be realized by setting Window M56 to the mode "0-20mA Via RS232" and giving a command as "AO6 (CR)". This function is able to make the Flowmeter operate a control valve conveniently.

Other different current output characteristics are displayed in above figures. The user can select one of them according to his actual requirements.

0. 4-20mA
1. 0 - 20 mA
2. 0 - 20 mA Via RS232
3. 4 - 20 mA VS. Fluid
4. 20-4-20 mA
5. 0-4-20 mA
6. 20-0-20 mA
7. 4-20mA vs. Vel
8. 4-20mA vs. Energy

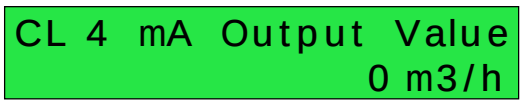
In six graphs shown above, flow F_{0mA} or F_{4mA} indicates the value that user entered in Window M57; and flow F_{20mA} indicates the value that customer entered in Window M58. In the 4-20mA and 0-20mA modes, F_{0mA}(or F_{4mA})and F_{20mA} can be selected as a positive or negative flow value as long as the two values are not the same. As for modes 20-4-20mA and 20-0-20mA, the Flowmeter ignores the positive and negative value of the actual flow; therefore, both F_{0mA}(or F_{4mA})and F_{20mA} must be selected as positive flow values.

In mode 0-4-20mA, F_{0mA} must be select as a negative value and F_{20mA} as a positive value. Furthermore, in mode 4-20mA, the output current is indicated as velocity.

Menu 5 6

CL 4mA or 0mA Output Value

Set the CL output value according to the flow value at 4mA or 0MA.(4mA or 0mA are determined by the settings in Window M56). The flow unit's options are as same as those in Window M31. Once "velocity 4-20mA"is selected in Window M56, the unit should

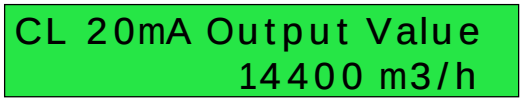


be set as m/s.

Menu 5 7

20mA Output Value

Set the CL output value according to the flow value at 20mA. The flow unit is the as same as that found in Window M31.



Menu 5 8

CL Check Verification

Check if the current loop has been calibrated before leaving the factory. Press ENT move ▲/+ or ▼/- separately to display 0mA, 4mA till 24mA, and at the same time, check with an ammeter to verify that CL output terminals M31 and 32 agree with the displayed values. It is necessary to re-calibrate the CL if over the permitted tolerance. For more information, refer to "Analog Outputs Calibration".

Menu 5 9

CL Current Output

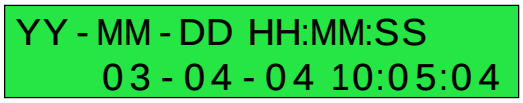
Display CL current output. The display of 10.0000mA indicates that CL current output value is 10.0000mA. If the difference between displaying value and CL output value is too large, the current loop then needs to be re-calibrated accordingly.

Menu 6 0

Date and Time Settings

Generally, it is unnecessary to modify date time as the system is provided with a highly reliable perpetual calendar chip.

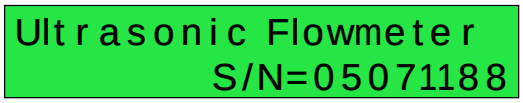
The format for setting time setting is 24 hours. Press ENT, wait until ">" appears, the modification can be made.



Menu 6 1

ESN

Display electronic serial number (ESN) of the instrument. This ESN is the only one assigned to each Flowmeter ready to leave the factory. The factory uses it for files setup and for management by the user.



Menu 7 2

Working Timer

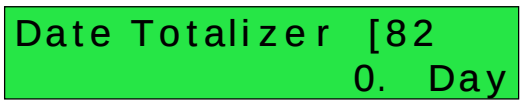
Display the totalized working hours of the Flowmeter since last reset. It is displayed by HH:MM:SS. If it is necessary to reset it, press ENT, and select "YES".

Menu 8 2

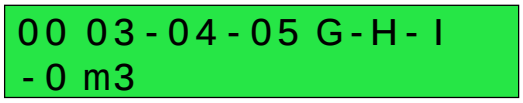
Date Totalizer

The following options are available:

0. Day
1. Month
2. Year



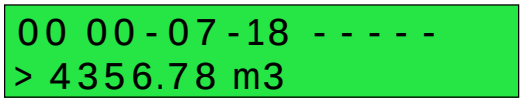
In this window, it is possible to review the historical flow data Totalizer for any day for the last 64 days, any month for last 64 months and any year for last 5 years.



Press ENT , use the ▲/+ or ▼/- to review Totalizer in days, months and years. Left upper corner: "00-63" indicates the serial numbers;

In the middle: "03-04-05" indicates the date; Upper right corner: "G-H-I" indicates the working condition. If there is only "--------" displayed, it indicates the system was normal during that time period. If other characters displayed, please refer to the "Error Code and 5 Resolutions".

For example, to display the flow total for July 18, 2000, the display "----------" at the upper right corner of the screen indicates that it was working properly the whole day. On the contrary, if "G" is displayed, it indicates that the instrument gain was adjusted at least once. Probably it was offline once on that day. If "H" is displayed, it indicates that poor signal was detected at least once. Also, it indicates that the operation was interrupted or problems occurred in the installation.



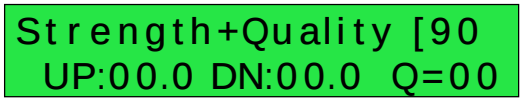
Menu 8 3

Automatic Flow Correction

With the function of automatic flow correction, the flow lost in an offline session can be estimated and automatically adjusted. The estimate is based on the average value, which is obtained from flow rate before going offline and flow measured after going online the next time, multiplied times the time period that the meter was offline. Select "NO" to cancel this function.

Menu 9 0

Signal Strength and Signal Quality



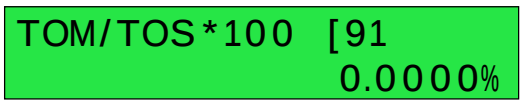
Display the measured signal strength and signal quality Q value upstream and downstream.

Signal strength is indicated from 00.0～99.9. A reading of 00.0 indicates no signal detected, while 99.9 indicates maximum signal strength. Normally the signal strength should be ≥60.0. Signal quality Q is indicated by 00～99. Therefore, 00 indicates the poorest signal while 99 indicates the best signal. Normally, signal quality Q value should be better than 50.

Menu 9 1

TOM/TOS*100

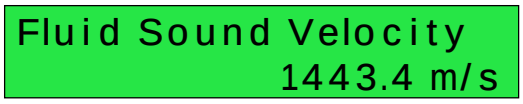
Display the ratio between the actual measured transmit time and the calculated transmit time according to customer's requirement. Normally the ratio should be 100±3%. If the difference is too large, the user should check that the parameters are entered correctly, especially the sound velocity of the fluid and the installation of the transducers. This data is of no use before the system is ready.



Menu 9 2

Fluid Sound Velocity

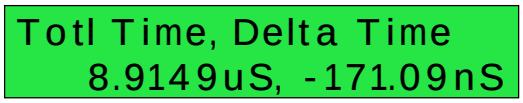
Display the measured fluid sound velocity. Normally this value should be approximately equal to the entered value in Window M21. If the difference is too large, it probably results from an incorrect value entered in Window M21 or improper installation of the transducers.



Menu 9 3

Total Time and Delta Time

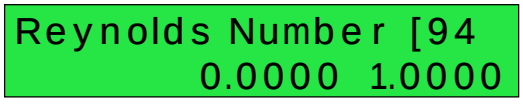
Display the measured ultrasonic average time (unit: nS) and delta time of the upstream and downstream (unit: nS) time. The velocity calculation in the Flowmeter is based on the two readings. The delta time is the best indication that the instrument is running steadily. Normally the fluctuation in the ratio of the delta time should be lower than 20%. If it is not, it is necessary to check if the transducers are installed properly or if the parameters have been entered correctly.



Menu 9 4

Reynolds Number and Factor

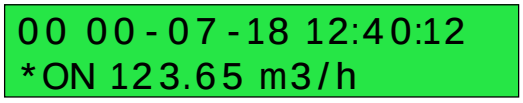
Display the Reynolds number that is calculated by the Flowmeter and the factor that is set currently by the Flowmeter. Normally this scaling factor is the average of the line and surface velocity factor inside the pipe.



Menu ▲/+ 0

Power ON/OFF Time

To view the power on/off time and flow rate for the last 64 update times to obtain the offline time period and the corresponding flow rate. Enter the window, press ENT to display the last update before the last 64 times of on/off time and flow rate values. "ON" on right hand indicates that time power is on; "00" on the upper left corner indicates "00-07-18 12:40:12" the date time; flow rate is displayed in the lower right corner.



Menu ▲/+ 1

Total Working Hours

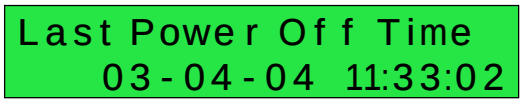
With this function, it is possible to view the total working hours since the Flowmeter left the factory.

The figure on the right indicates that the total working hours since the Flowmeter left the factory is 1107 hours 1 minute 41 seconds.

Menu ▲/+ 2

Last Power Off Time

Display the last power off time.



Menu ▲/+ 3

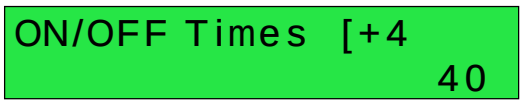
Last Flow Rate

Display the last flow rate.

Menu ▲/+ 4

Total ON/OFF Times

Display total on/off times since the Flowmeter left the factory.



Menu ▲/+ 5

Calculator

This window works as a calculator with an internal calculation function. To use the calculator, enter the first parameter X, select a calculating operator; if there is a second parameter, enter it as parameter Y, then combine the calculation results into parameter X. For example:

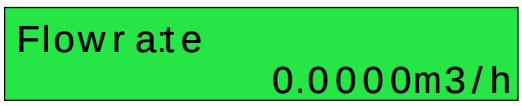
To calculate 1+2, then it is necessary to press Menu ▲/+ 5 1 ENT, use ▲/+ or ▼/- to select "+", press ENT 2 ENT to confirm. This calculator is also provided with a register function. To select it, use the Sam as same as used with calculators.

Note: Using the calculator while the system is running will not influence the measurement.

Flow

Shortcut Key for Flow rate

Displays flow rate, which equals to the contents of Flow when issuing command M00.



Velo

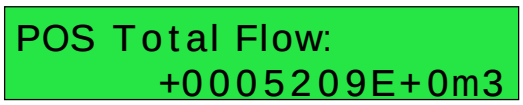
Shortcut Key for Flow Velocity

Displays flow velocity, which equals to the contents of Vel after issuing command M01.

+Total

Shortcut Key for POS Total Flow

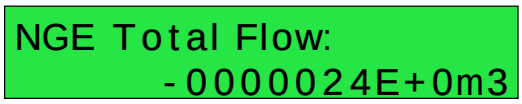
Displays positive total flow, which equals to the contents of POS after issuing command M02.



-Total

Shortcut Key for NEG Total Flow

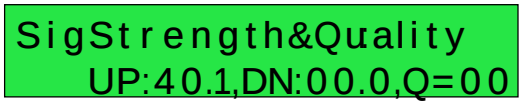
Display negative total flow, which equals to the contents of NEG after issuing command M03.



Sig

Shortcut Key for Signal Strength and Quality

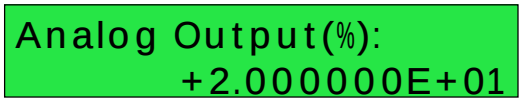
Displays signal strength and quality, which equals to the contents displayed in the window after issuing command M90.



Aout

Shortcut Key for Analog Output

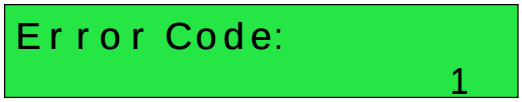
Displays analog output（ 4~20mA）information.



Error

Shortcut Key for Error Code

Display error codes during an operation. See chapter 5 for error code contents.



Comm

Shortcut Key for Communication Setup

Display the communication condition between the PDA and the Flowmeter. This window Display “OK” if the connection has been made correctly. If not, it displays “Failure”, and you should check the Bluetooth Communications. Under normal conditions, you should not conduct detection repeatedly using this button, otherwise you may cause the PDA to shutdown.

7. Error Diagnoses

The ultrasonic Flowmeter has advanced self-diagnostics functions and displays any errors in the upper right corner of the LCD via definite codes in a date/time order. Hardware error diagnostics are usually performed upon each power on. Some errors can be detected during normal operation. Undetectable errors caused by incorrect settings and unsuitable measurement conditions can be displayed accordingly. This function helps to detect the errors and determine causes quickly; thus, problems can be solved in a timely manner according to the solutions listed in the following tables.

Errors displayed in the Flowmeter are divided into two categories:

Table 1 is for errors displayed during self-diagnostics upon power on. "*F" may be displayed on the upper left corner of the screen after entering the measuring mode. When this occurs, it is necessary to power on for self-diagnostics once again to detect and solve possible errors using the table below. If a problem still exists, please contact the factory or the factory's local representative for assistance.

Table 2 applies when errors caused by incorrect settings and signals are detected and are announced by error codes displayed in Window M08.

7.1. Table 1. Self-diagnoses and Error Solutions (upon power on)

LCD Display	Cause	Solution
Rom Parity Error	System ROM illegal or error	Contact the factory
Stored Data Error	System stored data block error	Power on again or contact the factory
SCPU Fatal Error	SCPU circuit fatal error	Power on again or contact the factory
Timer Slow Error Timer Fast Error	System clock error	Contact the factory
CPU or IRQ Error	CPU or IRQ problem	Power on again
System RAM Error	System RAM questionable	Power on again or contact the factory
Time or Bat Error	System date time chip error	Power on again or contact the factory
No Display, Erratic or Abnormal Operation	Bad wiring connection	Check wiring connections
Stroke Key - No Response	Keypad locked or bad plug connection	Enter the unlock password if the keypad is locked

7.2. Table 2. Error Codes and Solutions (during operation)

Code	M08 Display	Cause	Solution
*R	System Normal	System normal	No errors
*J	SCPU Fatal Error	Hardware defect	Contact the factory
*I	Signal Not Detected	Signal not detected.	Attach transducer to the pipe and tighten it securely. Apply a plenty of coupling compound on transducer and pipe wall.
		Spacing is not correct between the transducers or not enough coupling compound applied to face of transducers.	Remove any rust, scale, or loose paint from the pipe surface. Clean it with a file.
		Transducers installed improperly.	Check the initial parameter settings.
		Scale is too thick.	Remove the scale or change the scaled pipe section. Normally, it is possible to change a measurement location. The instrument may run properly at a new site with less scale.
		New pipe liner.	Wait until liners solidified and saturated.
*H	Low Signal Strength	Low signal strength. Cause refers to above-mentioned reasons.	Solution refers to above-mentioned solutions.
*H	Poor Signal Quality	Poor signal quality All reasons are included in the above-mentioned causes.	Solution refers to above-mentioned solutions.
*E	Current Loop over 20mA (No influence normally. Ignore it if no current output is being used.)	4-20mA current loop over 120%. Improper settings to current loop output.	Check settings(refer to Window M56)and confirm if actual flow is too high.
*Q	Frequency output over set value No influence normally. Ignore it if no frequency output is being used.	Frequency output over 120%. Improper settings to frequency output or actual flow are too high.	Check settings(refer to Window M66-M69)and confirm if the actual flow is too high.
*F	Refer to Table 1.	Error in self-diagnoses during power on.	Power on again; resolve it by the method listed in Table 1. If it is still a problem, contact the factory.
		Permanent hardware error.	Contact the factory.
*G	Adjusting Gain>S1 Adjusting Gain>S2 Adjusting Gain>S3 Adjusting Gain>S4 (Display in Windows M00,M01,M02,M03)	Adjusting gain for normal measurement. Stop in S1 or S2 and only switch between S1 and S2 indicates a poor waveform or low signal strength. All reasons may be included in above-mentioned items.	
*K	Pipe Empty. Set in Window M29	No fluid in pipe or settings incorrect.	Once fluid is detected in the pipe, set 0 in Window M29.

7.3. Frequently Asked Questions and Answers

Question: New pipe, high quality material, and all installation requirements met: why still no signal detected?

Answer: Check pipe parameter settings, installation method and wiring connections. Confirm if the coupling compound is applied adequately, the pipe is full of liquid, transducer spacing agrees with the screen readings and the transducers are installed in the right direction.

Question: Old pipe with heavy scale inside, no signal or poor signal detected: how can it be resolved?

Answer: Check if the pipe is full of fluid. Try the Z method for transducer installation (If the pipe is too close to a wall, or it is necessary to install the transducers on a vertical or inclined pipe with flow upwards instead of on a horizontal pipe).

Carefully select a good pipe section and fully clean it, apply a wide band of coupling compound on each transducer face (bottom) and install the transducer properly.

Slowly and slightly move each transducer with respect to each other around the installation point until the maximum signal is detected. Be careful that the new installation location is free of scale inside the pipe and that the pipe is concentric (not distorted) so that the sound waves do not bounce outside of the proposed area.

For pipe with thick scale inside or outside, try to clean the scale off, if it is accessible from the inside. (Note: Sometimes this method might not work and sound wave transmission is not possible because of the a layer of scale between the transducers and pipe inside wall).

Question: Why is there no CL (current loop) output?

Answer: Check if the desired current output mode is set in Window M55. See if the CL is powered off by " CL Off" settings.

Open the electronics enclosure to inspect the hardware circuit. Check to see if the short-circuit terminal near terminal 3 is in place, i.e. Direct Output Mode(set CL output as Transmitter Mode with external power supply).

Question: Why is the CL output abnormal?

Answer: Check to see if the desired current output mode is set in Window M55.

Check to see if the maximum and minimum current values are set properly in Windows M56 and M57.

Re-calibrate CL and verify it in Window M49.

Question: Why is the flow rate still displayed as zero while there is fluid obviously inside the pipe and a symbol of "R" displayed on the screen?

Answer: Check to see if "Set Zero" was carried out with fluid flowing inside the pipe(Refer to Window M42). If it is confirmed, recover the factory default in Window M43.

Question: With a poor measurement site environment in the plant and the voltage and power supplies fluctuating widely, is the instrument really able to keep running 24 hours a day repeatedly without stopping and last for several years under such conditions?

Answer: Flowmeter is designed to work with high reliability under such conditions. It is provided with an intelligent signal conditioning circuit and internal correction circuitry. It will work under strong interference conditions and is able to adjust itself with strong or weak sound waves. It will work in a wide band of voltage: 90-245VAC or 10V~36VDC voltage.

8. Product Overview

8.1. Introduction

The 210 PORTABLE Ultrasonic Liquid Flow Meter consists of a flow sensor (two ultrasonic transducers), a flow transmitter and a Personal Digital Assistant (PDA).

The Model 210 PORTABLE Ultrasonic Flowmeter is a state-of-the-art universal transit-time Flowmeter designed using SLSI technology and low-voltage broadband pulse transmission. While principally designed for clean liquid applications, the instrument is tolerant of liquids with the small amounts of air bubbles or suspended solids found in most industrial environments.

8.2. Features of 210

Easy data acquisition and processing. By using the PDA data acquisition and processing program of the 210 PORTABLE, you can perform data acquisition and processing conveniently. Using the PDA, you can also perform such operations as browsing the collected data, making statistical analysis, displaying graphs, etc. The PC applications of the 210 PORTABLE make it even easier to implement the above operations or print data tables.

With distinctive features such as high precision, high reliability, high capability and low cost, the Flowmeter features other advantages:

Low consumption power, high reliability, anti-jamming and outstanding applicability.

Clear, user-friendly menu selections make Flowmeter simple and convenient to use.

U.S., British and Metric measurement units are available. Meanwhile, almost all-universal measurement units worldwide may be selected to meet customer's requirements.

Daily, monthly and yearly totalized flow: Totalized flow for the last 64 days and months as well as for the last 5 years are may be viewed.

You can be convenient to use the high capacity memerized SD card for long time data logging on the scene.

Clear, user-friendly operating interface. The fully-windowed software supplied with this instrument allows users to set parameters or types easily, including British or Metric measurement units, pipe size, pipe material, wall thickness, fluid type, output signal, etc. The setup guide of the PDA makes it more convenient for users to configure the setup parameters, display settings and output settings. Instead of memorizing a large number of commands, you can complete these configurations simply by following the instructions on the screen. Different settings can be saved as different files that can be recalled easily.

Power on/off function: allows the viewing of time and flow rate as power is switched on and off 64 times. Also, the Flowmeter has manual or automatic amendment during offline sessions.

Self-contained signal output, including relay, open collector, frequency and 4~20mA current loop analog outputs, etc.

Parallel operation of positive, negative and net flow totalizes with scale factor (span) and 7 digit display, while the output of totalize pulse and frequency output are transmitted via relay and open collector.

8.3. Theory of Operation

When the ultrasonic signal is transmitted through the flowing liquid, there will be a difference between the upstream and downstream transit time (travel time or time of flight), which is proportional to flow velocity, according to the formula below.

$$V = \frac{MD}{\sin 2q} \times \frac{\Delta T}{T_{up} \bullet T_{down}}$$

Remarks:

V Medium Velocity

M Ultrasonic frequency of reflection

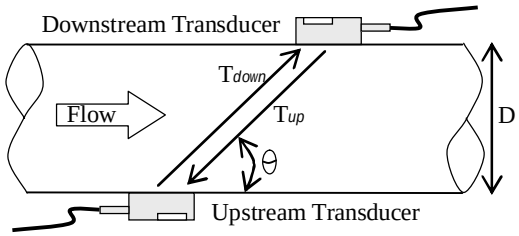
D Pipe Diameter

θ The angle between the ultrasonic signal and the flow

T_{up} Transit time in the forward direction

T_{down} Transit time in the reverse direction

$\Delta T=T_{up}-T_{down}$



8.4. Applications

- Water, sewage (with low particle content) and seawater
- Water supply and drainage water
- Power plants (nuclear power plant, thermal and hydropower plants), heat energy, boiler feed water and energy management system
- Metallurgy and mining applications (cooling water and acid recovery, for example)
- Petroleum and chemicals
- Food, beverage and pharmaceutical
- Marine operation and maintenance
- Energy economy supervision and water conservation management
- Pulp and paper
- Pipeline leak detection
- Regular inspection, tracking and collection
- Energy measuring and balance
- Network monitoring systems and energy/flow computer management

8.5. Specifications

Performance	
Flow range	0~±40ft/s (0~±12m/s)
Accuracy	±1% of measured value
Repeatability	0.3%
Pipe size	Clamp-on: 1″~200″(25~5000mm)
Functional	
Outputs	Analog output: 0/4~20mADC (standard)
Power supply	12VDC Battery Power (continuous operation of main battery 8 hours + spare battery for 24 hours)
Display and Operation	PDA
Storage	PDA with 1GB memory card, 1GB card within the meter
Temperature	Transmitter: -40℉~140℉ (-40℃~60℃) Measuring medium: -40℉~176℉ (-40℃~80℃)
Humidity	0~99%RH, non-condensing
Physical	
Transmitter	Aluminum case
Transducer	Encapsulated design Standard cable length: 15ft.(5m)
Weight	Transmitter +Transducer: approximately 6lbs (2.8kg)

9. Appendix1 - Flow Application Data

9.1. Sound Velocity and Viscosity for Fluids Commonly Used

Fluid	Sound Velocity (m/s)	Viscosity
water 20℃	1482	1.0
water 50℃	1543	0.55
water 75℃	1554	0.39
water100℃	1543	0.29
water125℃	1511	0.25
water150℃	1466	0.21
water175℃	1401	0.18
water200℃	1333	0.15
water225℃	1249	0.14
water250℃	1156	0.12
Acetone	1190	
Carbine	1121	
Ethanol	1168	

Alcohol	1440	1.5
Glycol	1620	
Glycerin	1923	1180
Gasoline	1250	0.80
Benzene	1330	
Toluene	1170	0.69
Kerosene	1420	2.3
Petroleum	1290	
Retinal	1280	
Aviation kerosene	1298	
Peanut oil	1472	
Castor oil	1502	

9.2. Sound Velocity for Various Materials Commonly Used

Pipe Material	Sound Velocity (m/s)
Steel	3206
ABS	2286
Aluminum	3048
Brass	2270
Cast iron	2460
Bronze	2270
Fiber glass-epoxy	3430
Glass	3276
Polyethylene	1950
PVC	2540

Titanium	3150
Cement	4190
Bitumen	2540
Porcelain enamel	2540
Glass	5970
Plastic	2280
Polyethylene	1600
PTFE	1450
Rubber	1600

9.3. Sound Velocity In Water (1 atm) At Different Temperatures

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

9.4. Sound Velocity and Viscosity of Common Liquid

Liquid	Velocity of Sound(m/s)	Viscosity (mm^2/s)
Water 20℃	1482	1.0
Water 50℃	1543	0.55
Water 75℃	1554	0.39
Water 100℃	1543	0.29
Water 125℃	1511	0.25
Water 150℃	1466	0.21
Water 175℃	1401	0.18
Water 200℃	1333	0.15
Water 225℃	1249	0.14
Water 250℃	1156	0.12
Acetone	1190	
Carbonyl	1121	
Ethanol	1168	
Alcohol	1440	1.5
Ketone	1310	
Acetaldehyde	1180	
Glycol	1620	
Glycerin	1923	1180
Gas	1250	0.80
66#Gas	1171	
80#Gas	1139	
0#Gas	1385	
Benzene	1330	
Methylbenzene	1340	
Toluene	1170	0.69
Tetra chloromethane	938	
Kerosene	1420	2.3
Petroleum	1290	
Pine oil	1280	
Chloroethylene	1050	0.82
Dagang jet fuel	1298	
Daqing 0#jet fuel	1290	
Arachis oil	1472	
Castor oil	1502	

9.5. Sound Velocity of Common Materials

Pipe Material	Sound Velocity (m/s)
Steel	3206
ABS	2286
Aluminum	3048
Brass	2270
Cast iron	2460
Bronze	2270
Fiber glass-epoxy	3430
lass	3276
Polyethylene	1950
PVC	2540
Titanium	3150
Cement	4190
Bitumen	2540
Porcelain enamel	2540
Glass	5970
Plastic	2280
Polyethylene	1600
PTFE	1450
Rubber	1600

9.6. Sound Velocity In Water (1 atm) At Different Temperatures

Temperature		Sound Speed in Water	
℃	℉	m/s	Ft/s
61	141.8	1,551	5,089
62	143.6	1,552	5,092
63	145.4	1,552	5,092
64	147.2	1,553	5,095
65	149.0	1,553	5,095
66	150.8	1,553	5,095
67	152.6	1,554	5,099
68	154.4	1,554	5,099
69	156.2	1,554	5,099
70	158.0	1,554	5,099
71	159.8	1,554	5,099
72	161.6	1,555	5,102
73	163.4	1,555	5,102
74	165.2	1,555	5,102
75	167.0	1,555	5,102
76	168.8	1,555	5,102
77	170.6	1,554	5,099
78	172.4	1,554	5,099
79	174.2	1,554	5,099
80	176.0	1,554	5,099
81	177.8	1,554	5,099
82	179.6	1,553	5,095
83	181.4	1,553	5,095
84	183.2	1,553	5,095
85	185.0	1,552	5,092
86	186.8	1,552	5,092
87	188.6	1,552	5,092
88	190.4	1,551	5,089
89	192.2	1,551	5,089
90	194.0	1,550	5,086
91	195.8	1,549	5,082
92	197.6	1,549	5,082
93	199.4	1,548	5,079
94	201.2	1,547	5,076

Temperature		Sound Speed in Water	
95	203.0	1,547	5,076
96	204.8	1,546	5,072
97	206.6	1,545	5,069
98	208.4	1,544	5,066
99	210.2	1,543	5,063
100	212.0	1,543	5,063
104	220.0	1,538	5,046
110	230.0	1,532	5,026
116	240.0	1,524	5,000
121	250.0	1,526	5,007
127	260.0	1,507	4,944
132	270.0	1,497	4,912
138	280.0	1,487	4,879
143	290.0	1,476	4,843
149	300.0	1,465	4,807
154	310.0	1,453	4,767
160	320.0	1,440	4,725
166	330.0	1,426	4,679
171	340.0	1,412	4,633
177	350.0	1,398	4,587
182	360.0	1,383	4,538
188	370.0	1,368	4,488
193	380.0	1,353	4,439
199	390.0	1,337	4,387
204	400.0	1,320	4,331
210	410.0	1,302	4,272
216	420.0	1,283	4,210
221	430.0	1,264	4,147
227	440.0	1,244	4,082
232	450.0	1,220	4,003
238	460.0	1,200	3,937
243	470.0	1,180	3,872
249	480.0	1,160	3,806
254	490.0	1,140	3,740
260	500.0	1,110	3,642

9.7. Common Pipe Dimensions (English)

OD	INCH		SCHEDULE		WALL	ID
1/8"	0.405"	10		10S	0.049"	0.307"
1/8"	0.405"	STD	40	40S	0.068"	0.269"
1/8"	0.405"	XS	80	80S	0.095"	0.215"
1/4"	0.540"	10		10S	0.065"	0.410"
1/4"	0.540"	STD	40	40S	0.088"	0.364"
1/4"	0.540"	XS	80	80S	0.119"	0.302"
3/8"	0.675"	10		10S	0.065"	0.545"
3/8"	0.675"	STD	40	40S	0.091"	0.493"
3/8"	0.675"	XS	80	80S	0.126"	0.423"
1/2"	0.840"	5		5S	0.065"	0.710"
1/2"	0.840"	10		10S	0.083"	0.674"
1/2"	0.840"	STD	40	40S	0.109"	0.622"
1/2"	0.840"	XS	80	80S	0.147"	0.546"
1/2"	0.840"	160			0.188"	0.464"
1/2"	0.840"	XX			0.294"	0.252"
3/4"	1.050"	5		5S	0.065"	0.920"
3/4"	1.050"	10		10S	0.083"	0.884"
3/4"	1.050"	STD	40	40S	0.113"	0.824"
3/4"	1.050"	XS	80	80S	0.154"	0.742"
3/4"	1.050"	160			0.219"	0.612"
3/4"	1.050"	XX			0.308"	0.434"
1"	1.315"	5		5S	0.065"	1.185"
1"	1.315"	10		10S	0.109"	1.097"
1"	1.315"	STD	40	40S	0.133"	1.049"
1"	1.315"	XS	80	80S	0.179"	0.957"
1"	1.315"	160			0.250"	0.815"
1"	1.315"	XX			0.358"	0.599"
11/4"	1.660"	5		5S	0.065"	1.530"
11/4"	1.660"	10		10S	0.109"	1.442"
11/4"	1.660"	STD	40	40S	0.140"	1.380"
11/4"	1.660"	XS	80	80S	0.191"	1.278"
11/4"	1.660"	160			0.250"	1.160"
11/4"	1.660"	XX			0.382"	0.896"
11/2"	1.900"	5		5S	0.065"	1.770"
11/2"	1.900"	10		10S	0.109"	1.682"
11/2"	1.900"	STD	40	40S	0.145"	1.610"
11/2"	1.900"	XS	80	80S	0.200"	1.500"

11/2"	1.900"	160			0.281"	1.388"
11/2"	1.900"	XX			0.400"	1.100"
2"	2.375"	5		5S	0.065"	2.245"
2"	2.375"	10		10S	0.109"	2.157"
2"	2.375"	STD	40	40S	0.154"	2.067"
2"	2.375"	XS	80	80S	0.218"	1.939"
2"	2.375"	160			0.344"	1.687"
2"	2.375"	XX			0.436"	1.503"
21/2"	2.875"	5		5S	0.083"	2.709"
21/2"	2.875"	10		10S	0.120"	2.635"
21/2"	2.875"	STD	40	40S	0.203"	2.469"
21/2"	2.875"	XS	80	80S	0.276"	2.323"
21/2"	2.875"	160			0.375"	2.125"
21/2"	2.875"	XX			0.552"	1.771"
3"	3.500"	5		5S	0.083"	3.334"
3"	3.500"	10		10S	0.120"	3.260"
3"	3.500"	STD	40	40S	0.216"	3.068"
3"	3.500"	XS	80	80S	0.300"	2.900"
3"	3.500"	160			0.438"	2.624"
3"	3.500"	XX			0.600"	2.300"
31/2"	4.000"	5		5S	0.083"	3.834"
31/2"	4.000"	10		10S	0.120"	3.760"
31/2"	4.000"	STD	40	40S	0.226"	3.548"
31/2"	4.000"	XS	80	80S	0.318"	3.364"
31/2"	4.000"	XX			0.636"	2.728"
4"	4.500"	5		5S	0.083"	4.334"
4"	4.500"	10		10S	0.120"	4.260"
4"	4.500"				0.156"	4.188"
4"	4.500"				0.188"	4.124"
4"	4.500"	STD	40	40S	0.237"	4.026"
4"	4.500"	XS	80	80S	0.337"	3.826"
4"	4.500"	120			0.438"	3.624"
4"	4.500"	160			0.531"	3.438"
4"	4.500"	XX			0.674"	3.152"
41/2"	5.000"	STD	40	40S	0.247"	4.506"
41/2"	5.000"	XS	80	80S	0.355"	4.290"
41/2"	5.000"	XX			0.710"	3.580"
5"	5.563"	5		5S	0.109"	5.345"
5"	5.563"	10		10S	0.134"	5.295"
5"	5.563"	STD	40	40S	0.258"	5.047"

5"	5.563"	XS	80	80S	0.375"	4.813"
5"	5.563"	120			0.500"	4.563"
5"	5.563"	160			0.625"	4.313"
5"	5.563"	XX			0.750"	4.063"
6"	6.625"	5		5S	0.109"	6.407"
6"	6.625"	10		10S	0.134"	6.357"
6"	6.625"				0.188"	6.249"
6"	6.625"	STD	40	40S	0.280"	6.065"
6"	6.625"	XS	80	80S	0.432"	5.761"
6"	6.625"	120			0.562"	5.501"
6"	6.625"	160			0.719"	5.187"
6"	6.625"	XX			0.864"	4.897"
7"	7.625"	STD	40	40S	0.301"	7.023"
7"	7.625"	XS	80	80S	0.500"	6.625"
7"	7.625"	XX			0.875"	5.875"
8"	8.625"			5S	0.109"	8.407"
8"	8.625"	10		10S	0.148"	8.329"
8"	8.625"	20			0.250"	8.125"
8"	8.625"	30			0.277"	8.071"
8"	8.625"	STD	40	40S	0.322"	7.981"
8"	8.625"	60			0.406"	7.813"
8"	8.625"	XS	80	80S	0.500"	7.625"
8"	8.625"	100			0.594"	7.437"
8"	8.625"	120			0.719"	7.187"
8"	8.625"	140			0.812"	7.001"
8"	8.625"	XX			0.875"	6.875"
8"	8.625"	160			0.906"	6.813"
9"	9.625"	STD	40	40S	0.342"	8.941"
9"	9.625"	XS	80	80S	0.500"	8.625"
9"	9.625"	XX			0.875"	7.875"
10"	10.750"			5S	0.134"	10.482"
10"	10.750"			10S	0.165"	10.420"
10"	10.750"				0.188"	10.374"
10"	10.750"	20			0.250"	10.250"
10"	10.750"	30			0.307"	10.136"
10"	10.750"	STD	40	40S	0.365"	10.020"
10"	10.750"	XS	60	80S	0.500"	9.750"
10"	10.750"	80			0.594"	9.562"
10"	10.750"	100			0.719"	9.312"
10"	10.750"	120			0.844"	9.062"

10"	10.750"	140			1.000"	8.750"
10"	10.750"	160			1.125"	8.500"
11"	11.750"	STD	40	40S	0.375"	11.000"
11"	11.750"	XS	80	80S	0.500"	10.750"
11"	11.750"	XX			0.875"	10.000"
12"	12.750"			5S	0.156"	12.438"
12"	12.750"			10S	0.180"	12.390"
12"	12.750"	20			0.250"	12.250"
12"	12.750"	30			0.330"	12.090"
12"	12.750"	STD		40S	0.375"	12.000"
12"	12.750"	40			0.406"	11.938"
12"	12.750"	XS		80S	0.500"	11.750"
12"	12.750"	60			0.562"	11.626"
12"	12.750"	80			0.688"	11.374"
12"	12.750"	100			0.844"	11.062"
12"	12.750"	120			1.000"	10.750"
12"	12.750"	140			1.125"	10.500"
12"	12.750"	160			1.312"	10.126"
14"	14.000"			10S	0.188"	13.624"
14"	14.000"	10			0.250"	13.500"
14"	14.000"	20			0.312"	13.376"
14"	14.000"	STD	30	40S	0.375"	13.250"
14"	14.000"	40			0.438"	13.124"
14"	14.000"	XS		80S	0.500"	13.000"
14"	14.000"	60			0.594"	12.812"
14"	14.000"	80			0.750"	12.500"
14"	14.000"	100			0.938"	12.124"
14"	14.000"	120			1.094"	11.812"
14"	14.000"	140			1.250"	11.500"
14"	14.000"	160			1.406"	11.188"
16"	16.000"			10S	0.188"	15.624"
16"	16.000"	10			0.250"	15.500"
16"	16.000"	20			0.312"	15.376"
16"	16.000"	STD	30	40S	0.375"	15.250"
16"	16.000"	XS	40	80S	0.500"	15.000"
16"	16.000"	60			0.656"	14.688"
16"	16.000"	80			0.844"	14.312"
16"	16.000"	100			1.031"	13.938"
16"	16.000"	120			1.219"	13.562"
16"	16.000"	140			1.438"	13.124"

16"	16.000"	160			1.594"	12.812"
18"	18.000"			10S	0.188"	17.624"
18"	18.000"	10			0.250"	17.500"
18"	18.000"	20			0.312"	17.376"
18"	18.000"	STD		40S	0.375"	17.250"
18"	18.000"	30			0.438"	17.124"
18"	18.000"	XS		80S	0.500"	17.000"
18"	18.000"	40			0.562"	16.876"
18"	18.000"	60			0.750"	16.500"
18"	18.000"	80			0.938"	16.124"
18"	18.000"	100			1.156"	15.688"
18"	18.000"	120			1.375"	15.250"
18"	18.000"	140			1.562"	14.876"
18"	18.000"	160			1.781"	14.438"
20"	20.000"			10S	0.218"	19.564"
20"	20.000"	10			0.250"	19.500"
20"	20.000"	STD	20	40S	0.375"	19.250"
20"	20.000"	XS	30	80S	0.500"	19.000"
20"	20.000"	40			0.594"	18.812"
20"	20.000"	60			0.812"	18.376"
20"	20.000"	80			1.031"	17.938"
20"	20.000"	100			1.281"	17.438"
20"	20.000"	120			1.500"	17.000"
20"	20.000"	140			1.750"	16.500"
20"	20.000"	160			1.969"	16.062"
22"	22.000"		10	10S	0.250"	21.500"
22"	22.000"	STD	20	40S	0.375"	21.250"
22"	22.000"	XS	30	80S	0.500"	21.000"
22"	22.000"	60			0.875"	20.250"
22"	22.000"	80			1.125"	19.750"
22"	22.000"	100			1.375"	19.250"
22"	22.000"	120			1.625"	18.750"
22"	22.000"	140			1.875"	18.250"
22"	22.000"	160			2.125"	17.750"
24"	24.000"		10	10S	0.250"	23.500"
24"	24.000"	STD	20	40S	0.375"	23.250"
24"	24.000"	XS		80S	0.500"	23.000"
24"	24.000"	30			0.562"	22.876"
24"	24.000"	40			0.688"	22.624"
24"	24.000"	60			0.969"	22.062"

24"	24.000"	80			1.219"	21.562"
24"	24.000"	100			1.531"	20.938"
24"	24.000"	120			1.812"	20.376"
24"	24.000"	140			2.062"	19.876"
24"	24.000"	160			2.344"	19.312"
26"	26.000"		10		0.312"	25.376"
26"	26.000"	STD		40S	0.375"	25.250"
26"	26.000"	XS		80S	0.500"	25.000"
28"	28.000"		10		0.312"	27.376"
28"	28.000"	STD		40S	0.375"	27.250"
28"	28.000"		20	80S	0.500"	27.000"
28"	28.000"		30		0.625"	26.750"
30"	30.000"		10		0.312"	29.376"
30"	30.000"	STD		40S	0.375"	29.250"
30"	30.000"	XS	20	80S	0.500"	29.000"
30"	30.000"		30		0.625"	28.750"
32"	32.000"		10		0.312"	31.376"
32"	32.000"	STD			0.375"	31.250"
32"	32.000"		20		0.500"	31.000"
32"	32.000"		30		0.625"	30.750"
32"	32.000"		40		0.688"	30.264"
34"	34.000"		10		0.312"	33.376"
34"	34.000"	STD			0.375"	33.250"
34"	34.000"		20		0.500"	33.000"
34"	34.000"		30		0.625"	32.750"
34"	34.000"		40		0.688"	32.624"
36"	36.000"		10		0.312"	35.376"
36"	36.000"	STD		40S	0.375"	35.250"
36"	36.000"	XS		80S	0.500"	35.000"
42"	42.000"	STD		40S	0.375"	41.250"
42"	42.000"	XS		80S	0.500"	41.000"
42"	42.000"		40		0.750"	40.500"
48"	48.000"	STD		40S	0.375"	47.250"
48"	48.000"	XS		80S	0.500"	47.000"

9.8. Common Pipe Dimensions (DIN)

N.B(inches)	N.B(mm)	O.D(mm)	WALL(mm)	Identification	
				STD,XS,XXS	Schedule Number
1	25	33.4	3.4	STD	40
1	25	33.4	4.5	XS	80
1	25	33.4	6.4		160
1	25	33.4	9.1	XXS	
1 ¼	32	42.2	3.6	STD	40
1 ¼	32	42.2	4.9	XS	80
1 ¼	32	42.2	6.4		160
1 ¼	32	42.2	9.7	XXS	
1 ½	40	48.3	3.7	STD	40
1 ½	40	48.3	5.1	XS	80
1 ½	40	48.3	7.1		160
1 ½	40	48.3	10.2	XXS	
2	50	60.3	3.9	STD	40
2	50	60.3	5.5	XS	80
2	50	60.3	8.7		160
2	50	60.3	11.1	XXS	
2 ½	65	73.0	5.2	STD	40
2 ½	65	73.0	7.0	XS	80
2 ½	65	73.0	9.5		160
2 ½	65	73.0	14.0	XXS	
3	80	88.9	5.5	STD	40
3	80	88.9	7.6	XS	80
3	80	88.9	11.1		160
3	80	88.9	15.2	XXS	
3 ½	90	101.6	5.7	STD	40
3 ½	90	101.6	8.1	XS	80
4	100	114.3	6.0	STD	40
4	100	114.3	8.6	XS	80
4	100	114.3	11.1		120
4	100	114.3	13.5		160
4	100	114.3	17.1	XXS	
5	125	141.3	6.6	STD	40
5	125	141.3	9.5	XS	80
5	125	141.3	12.7		120
5	125	141.3	15.9		160
5	125	141.3	19.0	XXS	
6	150	168.3	7.1	STD	40
6	150	168.3	11.0	XS	80
6	150	168.3	14.3		120
6	150	168.3	18.3		160
6	150	168.3	21.9	XXS	
8	200	219.1	6.4		20
8	200	219.1	7.0		30
8	200	219.1	8.2	STD	40
8	200	219.1	10.3		60
8	200	219.1	12.7	XS	80
8	200	219.1	15.1		100
8	200	219.1	18.3		120
8	200	219.1	20.6		140
8	200	219.1	22.2	XXS	

8	200	219.1	2300		160
10	250	273.0	6.4		20
10	250	273.0	7.8		30
10	250	273.0	9.3	STD	40
10	250	273.0	12.7	XS	60
10	250	273.0	15.1		80
10	250	273.0	18.3		100
10	250	273.0	21.4		120
10	250	273.0	25.4	XXS	140
10	250	273.0	28.6		160
12	300	323.9	6.4		20
12	300	323.9	8.4		30
12	300	323.9	9.5	STD	
12	300	323.9	10.3	XS	40
12	300	323.9	12.7		
12	300	323.9	14.3		60
12	300	323.9	17.5		80
12	300	323.9	21.4		100
12	300	323.9	25.4	XXS	120
12	300	323.9	28.6		140
12	300	323.9	33.3		160
14	350	355.6	6.4		10
14	350	355.6	7.9		20
14	350	355.6	9.5	STD	30
14	350	355.6	11.1		40
14	350	355.6	12.7	XS	
14	350	355.6	15.1		60
14	350	355.6	19.0		80
14	350	355.6	23.8		100
14	350	355.6	27.8		120
14	350	355.6	31.8		140
14	350	355.6	35.7		160
16	400	406.4	6.4		10
16	400	406.4	7.9		20
16	400	406.4	9.5	STD	30
16	400	406.4	12.7	XS	40
16	400	406.4	16.7		60
16	400	406.4	21.4		80
16	400	406.4	26.2		100
16	400	406.4	31.0		120
16	400	406.4	36.5		140
16	400	406.4	40.5		160
18	450	457.0	6.4		10
18	450	457.0	7.9		20
18	450	457.0	9.5	STD	
18	450	457.0	11.1		30
18	450	457.0	12.7	XS	
18	450	457.0	14.3		40
18	450	457.0	19.0		60
18	450	457.0	23.8		80
18	450	457.0	29.4		100
18	450	457.0	34.9		120
18	450	457.0	39.7		140
18	450	457.0	45.2		160
20	500	508.0	6.4		10

20	500	508.0	9.5	STD	20
20	500	508.0	12.7	XS	30
20	500	508.0	15.1		40
20	500	508.0	20.6		60
20	500	508.0	26.2		80
20	500	508.0	32.5		100
20	500	508.0	38.1		120
20	500	508.0	44.4		140
20	500	508.0	50.0		160
22	550	559.0	6.4		10
22	550	559.0	9.5	STD	20
22	550	559.0	12.7	XS	30
22	550	559.0	22.2		60
22	550	559.0	28.6		80
22	550	559.0	34.9		100
22	550	559.0	41.3		120
22	550	559.0	47.6		140
22	550	559.0	54.0		160
24	600	610.0	6.4		10
24	600	610.0	9.5	STD	20
24	600	610.0	12.7	XS	
24	600	610.0	14.3		30
24	600	610.0	17.5		40
24	600	610.0	24.6		60
24	600	610.0	31.0		80
24	600	610.0	38.9		100
24	600	610.0	46.0		120
24	600	610.0	52.4		140
24	600	610.0	59.5		160
26	650	660.0	7.9		10
26	650	660.0	9.5	STD	
26	650	660.0	12.7	XS	20
28	700	711.0	7.9		10
28	700	711.0	9.5	STD	
28	700	711.0	12.7	XS	20
28	700	711.0	15.9		30
30	750	762.0	7.9		10
30	750	762.0	9.5	STD	
30	750	762.0	12.7	XS	20
30	750	762.0	15.9		30
32	800	813.0	7.9		10
32	800	813.0	9.5	STD	
32	800	813.0	12.7	XS	20
32	800	813.0	15.9		30
32	800	813.0	17.5		40
34	850	864.0	7.9		10
34	850	864.0	9.5	STD	20
34	850	864.0	12.7	XS	30
34	850	864.0	15.9		40
34	850	864.0	17.5		
36	900	914.0	7.9		10
36	900	914.0	9.5	STD	
36	900	914.0	12.7	XS	20
36	900	914.0	15.9		30
36	900	914.0	19.0		40

9.9. Cement Lined Pipes Liner Thicknesses

Size(in)	Nominal Pipe Length(ft)	Standard Thickness			Double Thickness		
		Minimum Thickness(in)	Weight Per Foot(lb)	Weight Per Length(lb)	Minimum Thickness(in)	Weight Per Foot(lb)	Weight Per Length(lb)
4	20	1/16	0.87	17	1/8	1.71	34
6	20	1/16	1.3	26	1/8	2.57	51
8	20	1/16	1.74	35	1/8	3.45	69
10	20	1/16	2.15	43	1/8	4.28	86
12	20	1/16	2.57	51	1/8	5.12	102
14	20	3/32	4.49	90	3/16	8.93	179
16	20	3/32	5.13	103	3/16	10.19	204
18	20	3/32	5.76	115	3/16	11.47	229
20	20	3/32	6.4	128	3/16	12.73	255
24	20	3/32	7.68	154	3/16	15.31	306
30	20	1/8	12.76	255	1/4	25.42	508
36	20	1/8	15.31	306	1/4	30.51	610
42	20	1/8	17.82	356	1/4	35.53	711
48	20	1/8	20.35	407	1/4	40.6	812
54	20	1/8	22.89	458	1/4	45.68	914
60	20	1/8	24.71	494	1/4	49.32	986
64	20	1/8	26.35	527	1/4	52.61	1052

9.10. Cast Iron Pipe Data

Nominal Pipe Size (in.)	Class A		Class B		Class C		Class D	
	Outside Diameter (in.)	Wall Thickness (in.)	Outside Diameter (in.)	Wall Thickness (in.)	Outside Diameter (in.)	Wall Thickness (in.)	Outside Diameter (in.)	Wall Thickness (in.)
3	3.80	0.39	3.96	0.42	3.96	0.45	3.96	0.48
4	4.80	0.42	5.00	0.45	5.00	0.40	5.00	0.52
6	6.90	0.44	7.10	0.48	7.10	0.51	7.10	0.55
8	9.05	0.46	9.05	0.51	9.30	0.56	9.30	0.60
10	11.10	0.50	11.10	0.57	11.40	0.62	11.40	0.68
12	13.20	0.54	13.20	0.62	13.50	0.68	13.50	0.75
14	15.30	0.57	15.30	0.66	15.65	0.74	15.65	0.82
16	7.40	0.60	17.40	0.70	17.80	0.80	17.80	0.89
18	19.50	0.64	19.50	0.75	19.92	0.87	19.92	0.96
20	21.60	0.67	21.60	0.80	22.06	0.92	22.06	1.03
24	25.80	0.76	25.80	0.89	26.32	1.05	23.32	1.16
30	31.74	0.88	32.00	1.03	32.40	1.20	32.74	1.37
32	37.96	0.99	38.30	1.15	38.70	1.36	39.16	1.58
42	44.20	1.10	44.50	1.28	45.10	1.54	45.58	1.78
48	50.50	1.26	50.80	1.42	51.40	1.71	51.98	1.99
54	56.66	1.35	57.10	1.55	57.80	1.90	58.40	2.23
60	62.80	1.39	63.40	1.67	64.20	2.00	64.82	2.38
72	75.34	1.62	76.00	1.95	76.88	2.39		
84	87.54	1.72	88.54	2.22				

Nominal Pipe Size (in.)	Class E		Class F		Class G		Class H	
	Outside Diameter (in.)	Wall Thickness (in.)	Outside Diameter (in.)	Wall Thickness (in.)	Outside Diameter (in.)	Wall Thickness (in.)	Outside Diameter (in.)	Wall Thickness (in.)
3	3.80	0.39	3.96	0.42	3.96	0.45	3.96	0.48
4	4.80	0.42	5.00	0.45	5.00	0.40	5.00	0.52
6	7.22	0.58	7.22	0.61	7.38	0.65	7.38	0.69
8	9.42	0.66	9.42	0.66	9.60	0.75	9.60	0.80
10	11.60	0.74	11.60	0.80	11.84	0.86	11.84	0.92
12	13.78	0.82	13.78	0.89	14.08	0.97	14.08	1.04
14	15.98	0.90	15.98	0.99	16.32	1.07	16.32	1.16
16	18.16	0.90	18.16	1.08	18.54	1.18	18.54	1.27
18	20.34	1.07	20.34	1.17	20.78	1.28	20.78	1.39
20	22.54	1.15	22.54	1.27	23.02	1.39	23.02	1.51
24	26.90	1.31	26.90	1.45	27.76	1.75	27.76	1.88
30	33.10	1.55	33.46	1.73				
32	39.60	1.80	40.04	2.02				
42								
48								
54								
60								
72								
84								

9.11. Ductile Iron Pipe Data

Nominal Pipe Size (in.)	Outside Diameter (in.)	Pipe Wall Thickness(in.)						
		Class50	Class51	Class52	Class53	Class54	Class55	Class56
3	3.96		0.25	0.28	0.31	0.43	0.37	0.40
4	4.80		0.26	0.29	0.32	0.35	0.38	0.41
6	6.90	0.25	0.28	0.31	0.34	0.37	0.40	0.43
8	9.05	0.27	0.30	0.33	0.36	0.39	0.42	0.45
10	11.10	0.29	0.32	0.35	0.38	0.44	0.47	
12	13.20	0.31	0.34	0.37	0.40	0.43	0.46	0.49
14	15.30	0.33	0.36	0.39	0.42	0.45	0.48	0.51
16	17.40	0.34	0.37	0.40	0.43	0.46	0.49	0.52
18	19.50	0.35	0.38	0.41	0.44	0.47	0.50	0.53
20	21.60	0.36	0.39	0.42	0.45	0.48	0.51	0.54
24	25.80	0.38	0.41	0.44	0.47	0.50	0.53	0.56
30	32.00				0.51	0.55	0.59	0.63
32	38.30				0.58	0.63	0.68	0.73
42	44.50				0.65	0.71	0.77	0.83
48	50.80				0.72	0.79	0.86	0.93
54	57.10				0.81	0.89	0.97	1.05

9.12. Sound Speeds In Various Fluids

Substance	Chemical Formula	All data given at 25℃(77℉)unless otherwise noted					
		Specific Gravity	Sound speed		△V/℃	Kinematic Viscosity×10^{-6}	
			m/s	ft/s	m/s/℃	㎡/s	ft^2/s
Acetic anhydride(22)	$(CH_3CO)_2O$	1.082 (20℃)	1180	38714	2.5	0.769	8274
Acetic acid, anhydride(22)	$(CH_3CO)_2O$	1.082 (20℃)	1180	38714	2.5	0.769	8274
Acetic acid, nitrile	C_2H_3N	0.783	1290	42323	4.1	0.441	4745
Acetic acid, ethyl ester(33)	$C_4H_8O_2$	0.901	1085	35597	4.4	0.467	5025
Acetic acid, methyl ester	$C_3H_6O_2$	0.934	1211	39731		0.407	4379
Acetone	C_3H_6O	0.791	1174	38517	4.5	0.399	4293
Acetonitrile	C_2H_3N	0.783	1290	42323	4.1	0.441	4745
Acetonylacetone	$C_6H_{10}O_2$	0.729	1399	45899	3.6		
Acetylen dichloride	$C_2H_2Cl_2$	1.26	1015	33301	3.8	0.400	4.304
Acetylene tetrabromide(47)	$C_2H_2Br_4$	2.966	1027	33694			
Acetylene tetrachlonde(47)	$C_2H_2Cl_4$	1.595	1147	37631		1.156 (15℃)	12438 (59℉)
Alcohol	C_2H_6O	0.789	1207	3960	4.0	1.396	1502
Alkazene-13	$C_{15}H_{24}$	0.86	1317	43209	3.9		
Alkazene-25	$C_{10}H_{12}Cl_2$	1.20	1307	42881	3.4		
2-Amino-ethanol	C_2H_7NO	1.018	1724	56562	3.4		
2-Aminotolidine(46)	C_7H_9N	0.999 (20℃)	1618	53084		4.394 (20℃)	47297 (68℉)
4-Aminotolidine(46)	C_7H_9N	0.966 (45℃)	1480	48556		1.863 (50℃)	20045 (122℉)
Ammonia(35)	NH_3	0.771	1729 (-33℃)	56726 (-27℉)	6.68	0.292 (-33℃)	3141 (-27℉)
Amorphous Polyolefin		0.98	962.6 (190℃)	31582 (374℉)		26600	286000
t-Amyl alcohol	$C_5H_{12}O$	0.81	1204	39501	4.0	4.374	47064
Aminobenzene(41)	$C_6H_5NO_2$	1.022	1639	53773	4.0	3.63	39058
Aniline(41)	$C_6H_5NO_2$	1.022	1639	53773		3.63	39058
Argon(45)	Ar	1.400 (-188℃)	853 (-188℃)	27986 (-306℉)			
Azine	C_6H_5N	0.982	1415	46424	4.1	0.992 (20℃)	10.673 (68℉)
Benzene(29,40,41)	C_6H_6	0.879	1306	42848	4.65	0.711	7.65
Benzol(29,40,41)	C_6H_6	0.879	1306	42848	4.65	0.711	7.65
Bromine(21)	Br_2	2.928	889	29167	3.0	0.323	3.475
Bromo-benzene(46)	C_6H_5Br	1.522	1170 (20℃)	38386 (68℉)		0.693	7.456
1-Bromo-butane(46)	C_4H_9Br	1.276 (20℃)	1019 (20℃)	33432 (68℉)		0.49 (15℃)	5.272 (59℉)
Bromo-ethane(46)	C_2H_5Br	1.460 (20℃)	900 (20℃)	29528 (68℉)		0.275	2.959
Bromoform(46,47)	$CHBr_3$	2.89 (20℃)	918	30118	3.1	0.654	7.037
n-Butane(2)	C_4H_{10}	0.601 (0℃)	1085 (-5℃)	35597 (23℉)	5.8		

2-Butanol	$C_4H_{10}O$	0.81	1240	40682	3.3	3.239	34.851
Sec-Butylalochol	$C_4H_{10}O$	0.81	1240	40682	3.3	3.239	34.851
n-Butyl bromide(46)	C_4H_9Br	1.276 (20℃)	1019 (20℃)	33432 (68℉)		0.49 (15℃)	5.272 (59℉)
n-Butyl chloride(22,46)	C_4H_9Cl	0.887	1140	37402	4.57	0.529	5.692 (59℉)
tert Butyl chloride	C_4H_9Cl	0.84	984	32283	4.2	0.646	6.95
Butyl oleate	$C_{22}H_{42}O_2$		1404	46063	3.0		
2,3Butylene glycol	$C_4H_{10}O_2$	1.109	1484	48688	1.51		
Cadmium(7)	Cd		22377 (400℃)	73415 (752℉)		1.355cp (440℃)	14.579 (824℉)
Carbinol(40,41)	CH_4O	0.791 (20℃)	1076	35302	2.92	0.695	7.478
Carbitol	$C_6H_{14}O_3$	0.988	1458	47835			
Carbon diaxide(26)	CO_2	1.101 (-37℃)	839 (-37℃)	27526 (-35℉)	7.71	0.137 (-37℃)	1.474 (-35℉)
Carbon disulphide	CS_2	1.261 (22℃)	1149	37697		0.278	2.991
Carbon tetrachloride (33, 35, 47)	CCl_4	1.595 (20℃)	926	3038.1	2.48	0.607	6.531
Carbon tetrachloride(14) (Freon 14)	CF_4	1.75 (-150℃)	875.2 (-150℃)	2871.5 (-238℉)	6.61		
Cetane(23)	$C_{16}H_{34}$	0.773 (20℃)	1338	4389.8	3.71	4.32	46.483
Chloro-benezene	C_6H_5Cl	1.106	1273	4176.5	3.6	0.722	7.768
1-Chloro-butane(22, 26)	C_4H_9Cl	0.887	1140	3740.2	4.57	0.529 (15℃)	5.692 (59℉)
Chloro-diFluoromethane(3) (Freon 22)	$CHClF_2$	1.491 (-69℃)	893.9 (-50℃)	2932.7 (-58℉)	4.79		
Chloroform(47)	$CHCl_3$	1.489	979	3211.9	3.4	0.55	5.918
1-Chloro-propane(47)	C_3H_7Cl	0.892	1058	3471.1		0.378	4.067
Chlorotrifluorornrthane(5)	$CClF_3$		724 (-82℃)	2375.3 (-116℉)	5.26		
Cinnamaldehyde	C_9H_8O	1.112	1554	5098.4	3.2		
Cinnamic aldehyde	C_9H_8O	1.112	1554	5098.4	3.2		
Colamine	C_2H_7NO	1.018	1724	5656.2	3.4		
o-Cresol(46)	C_7H_8O	1.047 (20℃)	1541 (20℃)	5055.8 (68℉)		4.29 (40℃)	46.16 (104℉)
m-Cresol(46)	C_7H_8O	1.034 (20℃)	1500 (20℃)	4921.3 (68℉)		5.979 (40℃)	64.334 (104℉)
Cyanomthane	C_2H_3N	0.783	1290	4232.3	4.1	0.441	4.745
Cyclohexane(15)	C_6H_{12}	0.779 (20℃)	1248	4094.5	5.41	1.31 (17℃)	14.095 (63℉)
Cyclohexanol	$C_6H_{12}O$	0.962	1454	4770.3	3.6	0.071 (17℃)	0.764 (63℉)
Cyclohexanone	$C_6H_{10}O$	0.948	1423	4668.6	4.0		
Decane(45)	$C_{10}H_{22}$	0.730	1252	4107.6		1.26 (20℃)	13.55 (68℉)
1-Decene(27)	$C_{10}H_{20}$	0.746	1235	4058.1	4.0		
n-Decylene(27)	$C_{10}H_{20}$	0.746	1235	4058.1	4.0		
Diacetyl	$C_4H_6O_2$	0.99	1236	4055.1	4.6		

Diamylamine	$C_{10}H_{23}N$		1256	4120.7	3.9		
1,2 Dibromo-ethane(47)	$C_2H_4Br_2$	2.18	995	3264.4		0.79 (20℃)	8.5 (68℉)
Trans-1,2-Dibromoethene (47)	$C_2H_2Br_2$	2.231	935	3067.6			
Dibutyl phthalate	$C_8H_{22}O_4$		1408	4619.4			
Dichloro-t-butyl alcohol	$C_4H_8Cl_2O$		1304	4278.2	3.8		
2,3Dichlorodioxane	$C_2H6Cl_2O_2$		11391	4563.6	3.7		
Dichlorodifluoromethane (3)(Freon 12)	CCl_2F_2	1.516 (40℃)	774.1	2539.7	4.24		
1,2 Dichloro ethane(47)	$C_2H_4Cl_2$	1.253	1193	3914		0.61	6.563
Cis1,2-Dichloro ethane (3,47)	$C_2H_2Cl_2$	1.284	10611	3481			
trans1,2-Dichloro-ethene (3,47)	$C_2H_2Cl_2$	1.257	1010	3313.6			
Dichloro-fluoromethane (3)(Freon 21)	$CHCl_2F$	1.426 (0℃)	891 (0℃)	2923.2 (32℉)	3.97		
1-2-Dichlorohenxafluoro -Cyclobutane(47)	$C_4Cl_2F_6$	1.654	669	2194.9			
1-3-Dichoro-isobutane	$C_4H_8Cl_2$	1.14	1220	4002.6	3.4		
Dichloro methane(3)	CH_2Cl_2	1.327	1070	3510.5	3.94	0.31	3.335
1,1-Dichloro-1,2.2.2 Tetra fluoroethane	$CClF_2$-$CClF_2$	1.455	665.3 (-10℃)	2182.7 (14℉)	3.73		
Diethyl ether	$C_4H_{10}O$	0.713	985	3231.6	4.87	0.311	3.346
Diethylene glycol	$C_4H_{10}O_3$	1.116	1586	5203.4	2.4		
Diethylene glycol Monoethyl ether	$C_6H_{14}O_3$	0.988	1458	4783.5			
Diethylenimide oxide	C_4H_9NO	1.00	1442	4731	3.8		
1,2-bis(DiFluoramino) Butane(43)	$C_4H_8(NF_2)_2$	1.216	1000	3280.8			
1,2-bis(DiFluoramino) 2-methylpropane(43)	$C_4H_9(NF_2)_2$	1.213	900	2952.8			
1,2-bis(DiFluoramino) propane(43)	$C_3H_6(NF_2)_2$	1.265	960	3149.6			
2,2-bis(DiFluoramino Propane(43)	$C_3H_6(NF_2)_2$	1.254	890	2920			
2,2-Dihydroxydiethylether	$C_4H_{10}O_3$	1.116	1586	5203.4	2.4		
Dihydroxyethane	$C_2H_6O_2$	1.113	1658	5439.6	2.1		
1,3-Dimethyl-benzene(46)	C_8H_{10}	0.868 (15℃)	1343 (20℃)	4406.2 (68℉)		0.749 (15℃)	8.059 (59℉)
1,2-Dimethyl-benzene	C_8H_{10}	0.897 (20℃)	1331.5	4368.4	4.1	0.903 (20℃)	9.716 (68℉)
1,4-Dimethyl-benzene(46)	C_8H_{10}		1334 (20℃)	4376.6 (68℉)		0.662	7.123
2,2-Dimethyl-butance (29,33)	C_6H_{14}	0.649 (20℃)	1079	3540			
Dimethyl ketone	C_3H_6O	0.791	1174	3851.7	4.5	0.399	4.293
Dimethyl ptntane(47)	C_7H_{16}	0.674	1063	3487.5			
Dimethyl phthalate	$C_8H_{10}O_4$	1.2	1463	1799.9			
Diiodo-methane	CH_2I_2	3.235	980	3215.2			
Dioxane	$C_4H_8O_2$	1.033	1376	4514.4			
Dodecane(23)	$C_{12}H_{26}$	0.749	1279	4196.2	3.85	1.8	19.368
1,2-Ethanediol	$C_2H_6O_2$	1.113	1658	5439.6	2.1		
Ethanenitrile	C_2H_3N	0.783	1290	4232.2		0.441	4.745
Ethanoic anhydride(22)	$(CH_3CO)_2O$	1.082	1180	3871.4		0.769	8.274

Ethanol	C_2H_6O	0.789	1207	3960	4.0	1.39	14.956
Ethanol amide	C_2H_7NO	1.018	1724	5656.2	3.4		
Ethoxyethane	$C_4H_{10}O$	0.713	985	3231.6	4.87	0.311	3.346
Ethyl acetate(33)	$C_4H_8O_2$	0.901	1085	3559.7	4.4	0.489	5.236
Ethyl alcohol	C_2H_6O	0.789	1207	3960	4.0	1.396	15.020
Ethyl benzene(46)	C_8H_{10}	0.867 (20℃)	1338 (20℃)	4389.8 (68℉)		0.797 (17℃)	8.575 (63℉)
Ethyl bromide(46)	C_2H_5Br	1.461 (20℃)	900 (20℃)	2952.8 (68℉)		0.275 (20℃)	2.929 (68℉)
Ethyliodide(46)	C_2H_5I	1.950 (20℃)	875 (20℃)	2874 (68℉)		0.29	3.12
Ether	$C_4H_{10}O$	0.713	985	3231.6	4.87	0.311	3.346
Ethyl ether	$C_4H_{10}O$	0.713	985	3231.6	4.87	0.311	3.346
Ethelene bromide(47)	$C_2H_4Br_2$	2.18	995	3264.4		0.79	8.5
Ethylene chloride(47)	$C_2H_4Cl_2$	1.253	1193	3914		0.61	6.563
Ethylene glycol	$C_2H_6O_2$	1.113	1658	5439.6	2.1	17.208 (20℃)	185.158 (68℉)
d-fenochone	$C_{10}H_{16}O$	0.947	1320	4330.7		0.22	2.367
d-2-Fenechanone	$C_{10}H_{16}O$	0.947	1320	4330.7		0.22	2.367
Fluorine	F	0.545 (-143℃)	403 (-143℃)	1322.2 (-225℉)	11.31		
Fluoro-benzene(46)	C_6H_5F	1.024 (20℃)	1189	3900.9		0.584 (20℃)	6.238 (68℉)
Formaldehyde Methyl ester	$C_2H_4O_2$	0.974	1127	3697.5	4.02		
Formamide	CH_3NO	1.134 (20℃)	1622	5321.5	2.2	2.91	31.311
Formic acid,amide	CH_3NO	1.134 (20℃)	1622	5321.5		2.91	31.311
Freon R12			774.2	2540			
Furfural	$C_5H_4O_2$	1.157	1444	4737.5	3.7		
Furfuryl alcohol	$C_5H_4O_2$	1.135	1450	4757.2	3.4		
Fural	$C_5H_4O_2$	1.157	1444	4737.5	3.7		
2-Furaldehyde	$C_5H_4O_2$	1.157	1444	4737.5	3.7		
2-Furancarboxaldehyde	$C_5H_4O_2$	1.157	1444	4737.5	3.7		
2-Furyl-Methanol	$C_5H_6O_2$	1.135	1450	4757.2	3.4		
Gallium	Ga	6.095	2870 (30℃)	9416 (86℉)			
Glycerin	$C_3H_8O_3$	1.26	1940	6246.7	2.2	757.1	8081.836
Glycerin	$C_3H_8O_3$	1.26	1940	6246.7	2.2	757.1	8081.836
Glycerol	$C_2H_6O_2$	1.113	1658	5439.6	2.1		
50% Glycol/50%			1578	5177			
Helium(45)	He_4	0.125 (-269℃)	183 (-269℃)	600.4 (-452℉)		0.025	0.269
Heptane(22,23)	C_7H_{16}	0.384 (20℃)	1131	3710.6	4.25	0.598 (20℃)	6.434 (68℉)
n-Heptane(29,33)	C_7H_{16}	0.684 (20℃)	1180	3871.3	4.0		
Hexachloro-Cyclopentandiene(47)	C_5Cl_6	1.7180	1150	3773			
Hexadecane(23)	$C_{16}H_{34}$	0.773 (20℃)	1338	4389.8	3.71	4.32 (20℃)	46.483 (68℉)

Hexalin	$C_6H_{12}O$	0.962	1454	4770.3	3.6	70.69 (17℃)	760.882 (68℉)
Hexane(16,22,23)	C_6H_{14}	0.659	1112	3648.3	2.71	0.446	4.798
n-Hexane(29,33)	C_6H_{14}	0.649	1079	3540	4.53		
2,5-Hexanedione	$C_6H_{10}O_2$	0.729	1399	4589.9	3.6		
n-Hexanol	$C_6H_{14}O$	0.819	1300	4265.1	3.8		
Hexahydrobenzene(15)	C_6H_{12}	0.779	1248	4094.5	5.41	1.31 (17℃)	14.095 (63℉)
Hexahydrophenol	$C_6H_{12}O$	0.962	1454	4770.3	3.6		
Hexamethylene(15)	C_6H_{12}	0.779	1248	4094.5	5.41	1.31 (17℃)	14.095 (63℉)
Hydrogen(45)	H_2	0.071 (-256℃)	1187 (-256℃)	3894.4 (429℉)		0.003 (-256℃)	0.032 (-429℉)
2-Hydroxy-toluene(46)	C_7H_8O	1.047 (20℃)	1541 (20℃)	5.55.8 (68℉)		4.29 (40℃)	46.16 (104℉)
3-Hydroxy-toluene(46)	C_7H_8O	1.034	1500	4921.3 (68℉)		5.979 (40℃)	64.334 (104℉)
Lodo-benzene(46)	C_6H_5l	1.823	1114	3654.9 (68℉)		0.954	
Lodo-ethane(46)	C_2H_5l	1.950 (20℃)	876	2874 (68℉)		0.29	3.12
lodo-methane	CH_3l	2.28 (20℃)	978	3208.7		0.211	2.27
Lsobutyl acetate(22)	$C_6H_{12}O$		1180 (27℃)	3871.4 (81℉)	4.85		
Isobutanol	$C_4H_{10}O$	0.81 (20℃)	1212	3976.4			
Iso-Butane			1219.8	4002			
Isopentane(36)	C_5H_{12}	0.62 (20℃)	980	3215.2	4.8	0.34	3.658
Isopropanol(46)	C_3H_8O	0.785 (20℃)	1170 (20℃)	3838.6 (68℉)		2.718	29.245
Isopropyl alcohol(46)	C_3H_8O	0.785 (20℃)	1170 (20℃)	3838.6 (68℉)		2.718	29.245
Kerosene		0.81	1324	4343.8	3.6		
Ketohexamethylene	$C_6H_{10}O$	0.948	1423	4668.6	4.0		
Lithium fluoride(42)	LiF		2485 (900℃)	8152.9 (1652℉)	1.29		
Mercury(45)	Hg	13.594	1449 (24℃)	4753.9 (75℉)		0.114	1.226
Mesityloxide	C_6H1_6O	0.85	1310	4297.9			
Methane(25,28,38,39)	CH_4	0.162 (-89℃)	405 (-89℃)	1328.7 (-128℉)	17.5		
Methanol(40,41)	CH_4O	0.791 (20℃)	1076	3530.2	2.92	0.695	7.478
Methyl acetate	$C_3H_6O_2$	0.934	1211	3973.1		0.407	4.379
0-Methylaniline(46)	C_7H_9N	0.999 (20℃)	1618	5308.4		4.394 (20℃)	47.297 (68℉)
4-Methylaniline(46)	C_7H_9N	0.966 (45℃)	1480	4855.6		1863 (50℃)	20.095 (122℉)
Methyl alcohol(40,44)	CH_4O	0.791 (20℃)	1076	3530.2	2.92	0.695	7.478
Methyl benzene(16,52)	C_7H_8	0.867	1328 (20℃)	4357 (68℉)	4.27	0.644	7.144
2-Methyl-butane(36)	C_5H_{12}	0.62	980	3215.2		0.34	3.658

		(20℃)					
Methyl carbinol	C_2H_6O	0.789	1207	3960	4.0	1.396	
Methyl-chloroform(47)	$C_2H_3Cl_3$	1.33	985	3231.6		0.902 (20℃)	9.705 (68℉)
Methyl-cyanide	C_2H_3N	0.783	1290	4232.3		0.441	4.745
3-Methyl cyclohexanol	$C_7H_{14}O$	0.92	1400	4593.2			
Methylene chloride(3)	CH_2Cl_2	1.327	1070	3510.5	3.94	0.31	3.335
Methylene iodide	CH_2I_2	3.235	980	3215.2			
Methyl formate(22)	$C_2H_4O_2$	0.974 (20℃)	1127	3697.5	4.02		
Methyl iodide	CH_3I	2.28 (20℃)	978	3208.7		0.211	2.27
a- Methyl naphthalene	$C_{11}H_{10}$	1.090	1510	4954.1	3.7		
2- Methylphenol(46)	C_7H_8O	1.047 (20℃)	1541 (20℃)	5055.8 (68℉)		4.29 (40℃)	46.16 (104℉)
3- Methylphenol(46)	C_7H_8O	1.034 (20℃)	1500 (20℃)	4921.3 (68℉)		5.979 (40℃)	64.334 (104℉)
Milk, homogenized			1548	5080			
Morpholine	C_4H_9NO	1.00	1442	4731	3.8		
Naphtha		0.76	1225	4019			
Natural Gas(37)		0.316 (-103℃)	753 (-103℃)	2470.5 (-153℉)			
Neon(45)	Ne	1.207 (-246℃)	595 (-246℃)	1952.1 (-411℉)			
Nitrobenzene(46)	$C_6H_5NO_2$	1.204 (20℃)	1415 (20℃)	4642.4 (68℉)		1.514	16.29
Nitrogen(45)	N_2	0.808 (-199℃)	962 (-199℃)	3156.2 (-328℉)		0.217 (-199℃)	2.334 (-326℉)
Nitromethane(43)	CH_3NO_2	1.135	1300	4265.1	4.0	0.549	5.907
Nonane(23)	C_9H_2O	0.718 (20℃)	1207	3960	4.04	0.99 (20℃)	10.652 (68℉)
1-Nonene(27)	C_9H_{18}	0.736 (20℃)	1207	3960	4.0		
Octane(23)	C_8H_{18}	0.703	1172	3845.1	4.14	0.73	7.857
n-Octane(29)	C_8H_{18}	0.704 (20℃)	1212.5	3978	3.50	0.737	0.930
1-Octane(27)	C_8H_{16}	0.723 (20℃)	1175.5	3856.6	4.10		
Oil of Camphor Sassafras			1390	4560.4	3.8		
Oil, Car(SAE 20a.30)		1.74	870	2854.3		190	2045.093
Oil, Castor	$C_{11}H_{10}O_{10}$	0.969	1477	4845.8	3.6	0.670	7.209
Oil, Diesel		0.80	1250	4101			
Oil, Fuel AA gravity		0.99	1485	4872	3.7		
Oil (Lubricating X2000)			1530	5019.9			
Oil (Olive)		0.912	1431	4694.9	2.75	100	1076.365
Oil (Peanut)		0.936	1458	4783.5			
Oil (Sperm)		0.88	1440	4724.4			
Oil, 6			1509 (22℃)	4951 (72℉)			
2,2-Oxydiethanol	$C_4H_{10}O_3$	1.116	1586	5203.4	2.4		
Oxygen(45)	O_2	1.155 (-186℃)	952 (-186℃)	3123.4 (-303℉)		0.173	1.861
Pentachloro-ethane(47)	C_2HCl_5	1.687	1082	3549.9			
Pentalin(47)	C_2HCl_5	1.687	1082	3549.9			
Pentane(36)	C_5H_{12}	0.626	1020	3346.5		0.363	3.905

		(20℃)					
n-Pentane(47)	C_5H_{12}	0.557	1006	3300.5		0.41	4.413
Perchlorocyclopentadiene (47)	C_5Cl_6	1.718	1150	3773			
Perchloro-ethylene(47)	C_2Cl_4	1.632	1036	3399			
Perfluoro-1-Hepten(47)	C_7F_{14}	1.67	583	1912.7			
Perfluoro-n-Hexane(47)	C_6F_{14}	1.672	508	1666.7			
Phene(29,40,41)	C_6H_6	0.879	1306	4284.8	4.65	0.711	7.65
b-Phenyl acrolein	C_9H_8O	1.112	1554	5098.4	3.2		
Phenylamine(41)	$C_6H_5NO_2$	1.022	1639	5377.3	4.0	3.63	39.058
Phenyl bromide(46)	C_6H_5Br	1.522	1170 (20℃)	3838.6 (68℉)		0.693	7.456
Phenyl chloride	C_6H_5Cl	1.106	1273	4176.5	3.6	0.722	7.768
Phenyl iodide(46)	C_6H_5I	1.823	1114 (20℃)	3654.9 (68℉)		0.954 (15℃)	10.265 (59℉)
Phenyl methane(16,52)	C_7H_8	0.867 (20℃)	1328 (20℃)	4357 (68℉)	4.27	0.644	6.929
3-Phenyl propenal	C_9H_8O	1.112	1554	5098.4	3.2		
Phthalardione	$C_8H_4O_3$		1125 (152℃)	3691 (306℉)			
Phthalic acid, anhyaride	$C_3H_4O_3$		1125\ (152℃)	3691 (306℉)			
Pthalic anhyaride	$C_8H_4O_3$		1125 (152℃)	3691 (306℉)			
Pimelic ketone	$C_6H_{10}O$	0.948	1423	4668.6	4.0		
Plexiglas, Lucite, Acrylic			2651	8698			
Polyterpene Resin		0.77	1099.8 (190℃)	3608.4 (374℉)		39,000	419.500
Potassium bromide(42)	KBr		1169 (900℃)	3835.3 (1652℉)	0.71	715cp (900℃)	7.693 (1652℉)
Potassium fluoride(42)	KF		1792 (900℃)	5879.3 (1652℉)	1.03		
Potassium lodide(42)	KI		985 (900℃)	3231.6 (1652℉)	0.64		
Potassium nitrate(48)	KNO_3	1.859 (352℃)	1740.1 (352℃)	5709 (666℉)	1.1	1.19 (327℃)	12.804 (621℉)
Propane(2, 13) (-45℃～130℃)	C_3H_8	0.585 (-45℃)	1003 (-45℃)	3290.6 (-49℉)	5.7		
1,2,3-Propanetriol	$C_3H_8O_3$	1.26	1904	6246.7	2.2	000757	
1-Propanol(46)	C_3H_8O	0.78 (20℃)	1222 (20℃)	4009.2 (68℉)			
2-Propanol(46)	C_3H_8O	0.785 (20℃)	1170 (20℃)	3838.6 (68℉)		2.718	29.245
1-Propanone	C_3H_60	0.791	1174	3851.7	4.5	0.399	4.293
Propene(17, 18, 35)	C_3H_6	0.563 (-13℃)	963 (-13℃)	3159.4 (9℉)	6.32		
n-Propyl ocetate(22)	$C_5H_{10}O_2$		1280 (2℃)	4199 (36℉)	4.63		
n-Propyl-alcohol	C_3H_8O	0.78(20℃)	1222 (20℃)	4009.2 (68℉)		2.549	27.427
Propylchloride(47)	C_3H_7Cl	0.892	1058	3471.1		0.378	4.067

Propylene(17,18,35)	C_3H_6	0.563 (-13℃)	963 (-13℃)	3159.4 (9℉)	6.32		
Pyridine	C_6H_5N	0.982	1415	4642.4	4.1	0.992 (20℃)	10.673 (68℉)
Refrigerant 11(3,4)	CCl_3F	1.49	828.3 (0℃)	2717.5 (32℉)	3.56		
Refrigerant 12(3)	CCl_2F_2	1.516 (-40℃)	774.1 (-40℃)	2539.7 (-40℉)	4.24		
Refrigerant 14(14)	CF_4	1.75 (-150℃)	875.24 (-150℃)	2871.5 (-238℉)	6.61		
Refrigerant 21(3)	$CHCl_2F$	1.426 (0℃)	891 (0℃)	2923.2 (32℉)	3.97		
Refrigerant 22(3)	$CHClF_2$	1.491 (-69℃)	893.9 (50℃)	2932.7 (122℉)	4.79		
Refrigerant 113(3)	CCl_2F -$CClF_2$	1.563	783.7 (0℃)	2571.2 (32℉)	3.44		
Refrigerant 114(3)	$CClF_2$ -$CClF_2$	1.455	665.3 (-10℃)	2182.7 (14℉)	3.73		
Refrigerant 115(3)	C_2ClF_5		656.4 (-50℃)	2153.5 (-58℉)	4.42		
Refrigerant C318(3)	C_4F_8	1.62 (-20℃)	574 (-10℃)	1883.2 (14℉)	3.88		
Selenium(8)	Se		1072 (250℃)	3517.1 (482℉)	0.38		
Silicone(30 cp)		0.993	990	3248		30	322.8
Sodium fluoride(42)	NaF	0.877	2082 (1000℃)	6830.7 (1832℉)	1.32		
Sodium nitrate(48)	$NaNO_3$	1.884 (336℃)	1763.3 (336℃)	5785.1 (637℉)	0.74	1.37 (336℃)	14.74 (637℉)
Sodium nitrite(48)	$NaNO_2$	1.805 (292℃)	1876.8 (292℃)	6157.5 (558℉)			
Solvesso #3		0.877	1370	4494.8	3.7		
Spirit of wine	C_2H_6O	0.789	1207	3960	4.0	1.396	15.02
Sulfur(7, 8, 10)	S		1177 (250℃)	3861.5 (482℉)	-1.13		
Sulfuric Acid(1)	H_2SO_4	1.841	1257.6	4126	1.43	11.16	120.081
Tellurium(7)	Te		991 (450℃)	3251.3 (842℉)	0.73		
1,1,2,2-Tetrabromo -ethane(47)	$C_2H_2Br_4$	2.966	1027	3369.4			
1,1,2,2-Tetrabromo -ethane(67)	$C_2H_2Cl_4$	1.595	1147	3763.1		1.156 (15℃)	12.438 (59℉)
Tetrabromoethane(46)	$C_2H_2Cl_4$	1.553 (20℃)	1170 (20℃)	3838.6 (68℉)		1.19	12.804
Tetrabromo-ethene(47)	C_2Cl_4	1.632	1036	3399			
Tetrabromo-Methane (33, 47)	CCl_4	1.595 (20℃)	926	3038.1		0.607	6.531
Tetradecane(46)	$C_{14}H_3O$	0.763 (20℃)	1331 (20℃)	4366.8 (68℉)		2.86 (20℃)	30.773 (68℉)
Tetraethylene glycol	$C_8H_{18}O_5$	1.123	1586	5203.4	3.0		
Tetrafluoro-methane(14) (Freon 14)	CF_4	1.75 (-150℃)	875.24 (-150℃)	2871.5 (-238℉)	6.61		
Tetrahydro-1, 4-isoxazine	C_4H_9NO	1.000	1442	4731	3.8		
Toluene(16, 52)	C_7H_8	0.867 (20℃)	1328 (20℃)	4357 (68℉)	4.27	0.644	6.929

o-Toluidine(46)	C_7H_9N	0.999 (20℃)	1618	5308.4		4.394 (20℃)	47.279 (68℉)
p-Toluidine(46)	C_7H_9N	0.966 (45℃)	1480	4855.6		1.863 (50℃)	20.053 (122℉)
Toluol	C_7H_8	0.866	1308	4291.3	4.2	0.58	6.24
Tribromo-methane (46, 47)	$CHBr_3$	2.89 (20℃)	918	3011.8		0.654	7.037
1,1,1-Trichloro-ethane (47)	$C_2H_3Cl_3$	1.33	985	3231.6		0.902 (20℃)	9.705 (68℉)
Trichloro-ethane(47)	C_2HCl_3	1464	1028	3372.7			
Trichloro-fluoromethane (3)(Freon 11)	CCl_3F	1.49	828.3 (0℃)	2717.5 (32℉)	3.56		
Trichloro-methane(47)	$CHCl_3$	1.489	979	3211.9	3.4	0.55	5.918
1,1,2-Trichloro-1,2,2-Trifluoro-Etham	CCl_2F -$CClF_2$	1.563	783.7 (0℃)	2571.2 (32℉)			
Triethyl-amine(33)	$C_6H_{15}N$	0.726	1123	3684.4	4.47		
Triethylene glycol	$C_6H_{14}O_4$	1.123	1608	5275.6	3.8		
1,1,1-Trifluoro-2-Chloro -2-Bromo-Ethane	$C_2HClBrF_3$	1.869	693	2273.6			
1,2,2-Trifluorotrichloro--ethane(Freon 1.13)	CCl_2F -$CClF_2$	1.563	783.7 (0℃)	2571.2 (32℉)	3.44		
d-1,3,3 -Trimethylnorrcamphor	$C_{10}H_{16}O$	0.947	1320	4330.7		0.22	2.37
Trinitrotoluene(43)	$C_7H_5(NO_2)_3$	1.64	1610 (81℃)	5282.2 (178℉)			
Turpentine		0.88	1255	4117.5		1.4	15.064
Unisis 800		0.87	1346	4416			
Water, distilled(49, 50)	H_2O	0.996	1498	4914.7	2.4	1.00	10.76
Water, heavy	D_2O		1400	4593			
Water, sea		1.025	1531	5023	2.4	1.00	10.76
Wood Alcohol(40, 41)	CH_4O	0.791 (20℃)	1076	3530.2	2.92	0.695	7.478
Xenon(45)	Xe		630 (-109℃)	2067 (-164℉)			
m-Xylene(46)	C_8H_{10}	0.868 (15℃)	1343 (20℃)	4406.2 (68℉)		0.749 (15℃)	8.059 (59℉)
o-Xylene(29, 46)	C_8H_{10}	0.897 (20℃)	1331.5	4368.4	4.1	0.903 (20℃)	9.716 (68℉)
p-Xylene(46)	C_8H_{10}		1334 (20℃)	4376.6 (68℉)		0.662	7.123
Xylene hexafluoride	C_8H_{10}	1.37	879	2883.9		0.613	6.595
Zinc(7)	Zn		3298 (450℃)	10820.2 (842℉)			

9.13. Sound Speed in Various Pipe Materials

Material	Sound Speed* Shear Wave(25℃)		Sound Speed* Long Wave(25℃)	
	m/s	ft/s	Mm/us	In./us
Steel, 1% Carbon, Hardened	3150	10335	5.88	0.2315
Carbon Steel	3230	10598	5.89	0.2319
Mild Steel	3235	10614	5.89	0.2319
Steel, 1% Carbon	3220	10565		
302 Stainless Steel	3120	10236	5.690	0.224
303 Stainless Steel	3120	10236	5.640	0.222
304 Stainless Steel	3141	10306	5.920	0.233
304L Stainless Steel	3070	10073	5.790	0.228
316 Stainless Steel	3272	10735	5.720	0.225
347 Stainless Steel	3095	10512	5.720	0.225
Aluminum	3100	10171	6.32	0.2488
Aluminum(rolled)	3040	9974		
Copper	2260	7415	4.66	0.1835
Copper (annealed)	2325	7628		
Copper (rolled)	2270	7448		
CuNi (70%Cu 30%Ni)	2540	8334	5.03	0.1980
CuNi (90%Cu 10%Ni)	2060	6759	4.01	0.1579
Brass (Naval)	2120	6923	4.43	0.1744
Gold (hand-drawn)	1200	3937	3.24	0.1276
Inconel	3020	9909	5.82	0.2291
Iron (electrolytic)	3240	10630	5.90	0.2323
Iron (Armco)	3240	10630	5.90	0.2323
Ductile Iron	3000	9843		
Cast Iron	2500	8203	4.55	0.1791
Monel	2720	8924	5.35	0.2106
Nickel	2960	9712	5.63	0.2217
Tin, rolled	1670	5479	3.32	0.1307
Titanium	3125	10253	6.10	0.2402
Tungsten, annealed	2890	9482	5.18	0.2039
Tungsten, drawn	2640	8661		
Tungsten, carbide	3980	13058		
Zinx, rolled	2440	8005	4.17	0.1642
Glass, Pyrex	3280	10761	5.61	0.2209
Glass, heavy silicate flint	2380	7808		
Glass, light borate crown	2840	9318	5.26	0.2071
Nylon	1150	3772	2.40	0.0945
Nylon, 6-6	1070	3510		
Polyethylene(HD)			2.31	0.0909
Polyethylene(LD)	540	1772	1.94	0.0764
PVC, CPVC	1060	3477	2.40	0.0945
Acrylic	1430	4690	2.73	0.1075
Asbestos Cement			2.20	0.0866
Tar Epoxy			2.00	0.0787
Mortar			2.50	0.0984
Rubber			1.90	0.0748

Refer to the sound velocity of other fluids and materials, please contact the factory.

10. Appendix

10.1. Install 210 Software on PDA

Note: Read this section before reinstalling the PDA program.

To install communication software (take Palm DeskTop V4.1 as an example) using the HotSync Manager of the PDA , follow the following steps:

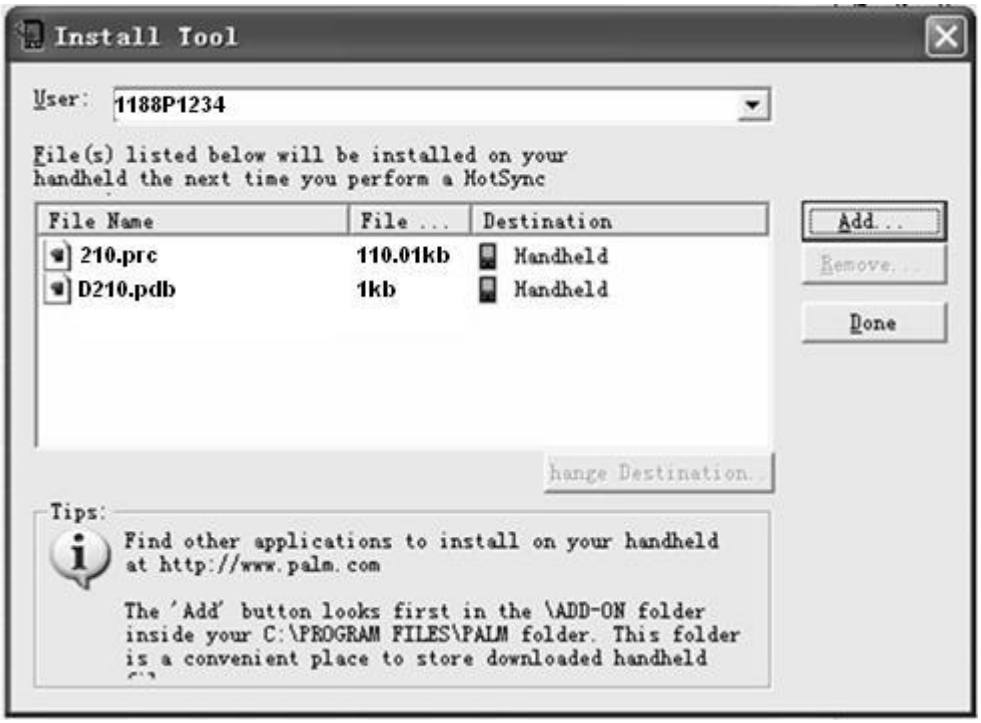
1. Install Palm Desktop to your computer. For details, see the PDA user's manual.
2. Connect the PDA to your computer with USB cable (or serial port cable) according to the HotSync manager on the Windows system disk.

Choose Sync Connection Mode of the PDA and Desktop Computer

3. Run Palm Desktop, and select [View] -> [Quick Install] on the menu or click "Install" icon.

Run sync software

4. Select the corresponding user on the pop-up window and click [Add] button to install communication software application INNOVA SONIC PORTABLE.prc and serial number file Dslp.pdb.



Select a User Name and Sync File 210.prc and Dctp.pdb

5. Click the HotSync icon of the PDA or press the HotSync key on the sync jack and install the application according to the clue.

Press sync button to synchronize

6. For application icons displayed on the PDA after installation.

The Application Icons Displayed on the PDA After Installation

When not using the PDA for a extended period of time, or there is not enough battery charge, please recharge it in time.

10.2. UFM Data Installation

10.2.1. Hardware requirements

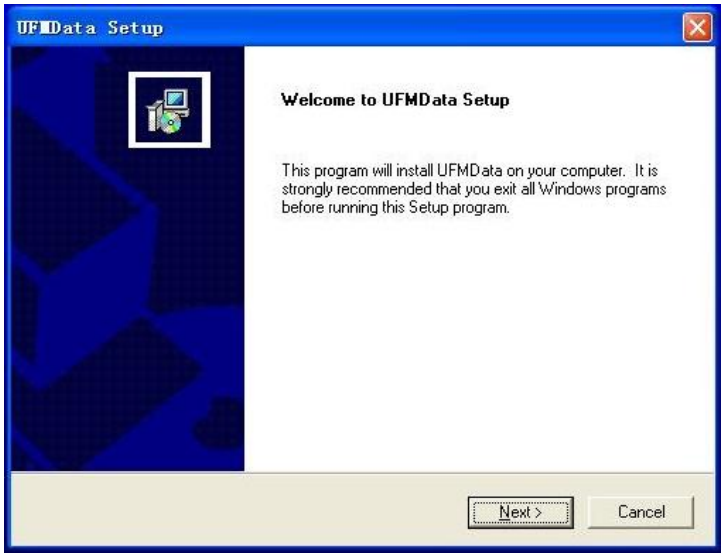
CPU: PII266 or faster， Memory: 64M or more， Display resolution: 1024*768 or higher.

10.2.2. OS Requirements

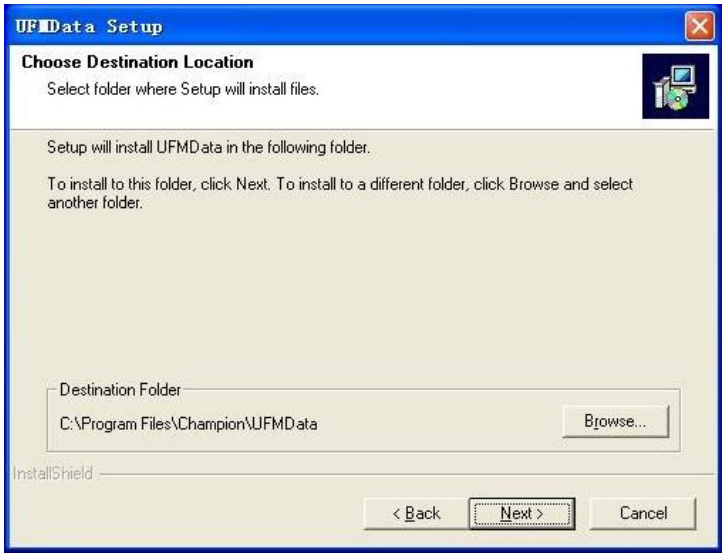
Windows 98SE 4.10.2222A or later, IE4.01 or later.

10.2.3. Installing Method

Step 1: Open Setup file in the UFM Data directory to enter installation page. Click “Next” to proceed.



Step 2: Select an installation directory. Click “Next” to accept the default directory. If you want to change the installation directory, click “Browse” to select a directly and click “next” to continue to the next step.



Step 3: Select a program folder, then click "Next" to enter next step.

Step 4: Click "Finish" to finish installation.