ULTRASONIC FLOWMETER FUM-1000

Instruction Manual

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Flow & Level Instruments

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Important Customer Notice

Thank you for choosing the FUM-1000 Transit-Time Ultrasonic Flow Meter with SLSI CMOS and low-voltage wide-pulse sending technology. This manual contains important information about your meter. Before installing and operating this flow meter, please read this manual carefully and follow its instructions.

- FLOVEL 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.
- Go to http://www.flovel.co.kr/ for a most current electronic version of this manual.
- We reserve the right to change the content of this manual without prior notification.
- If you have any questions or problems regarding this manual, please contact FLOVEL Service

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WARNINGS IN THIS MANUAL

Warning, attention, and note 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 and personal injury.
	**ATTENTION** "Attention" statements in this manual indicate that failure to comply with stated instructions may result in damage to the meter or faulty operation of the flow meter.
	**NOTE** "Note" indicates that ignoring the relevant requirements or precautions may result in flowmeter damage or malfunction.

Product Components

An inspection should be made before installing the flow meter. Check to see if the spare parts are in accordance with the packing list. Make sure that there is no damage to the enclosure due to a loose screw or loose wire, or other damage that may have occurred during transportation. Any questions, please contact your representative as soon as possible.

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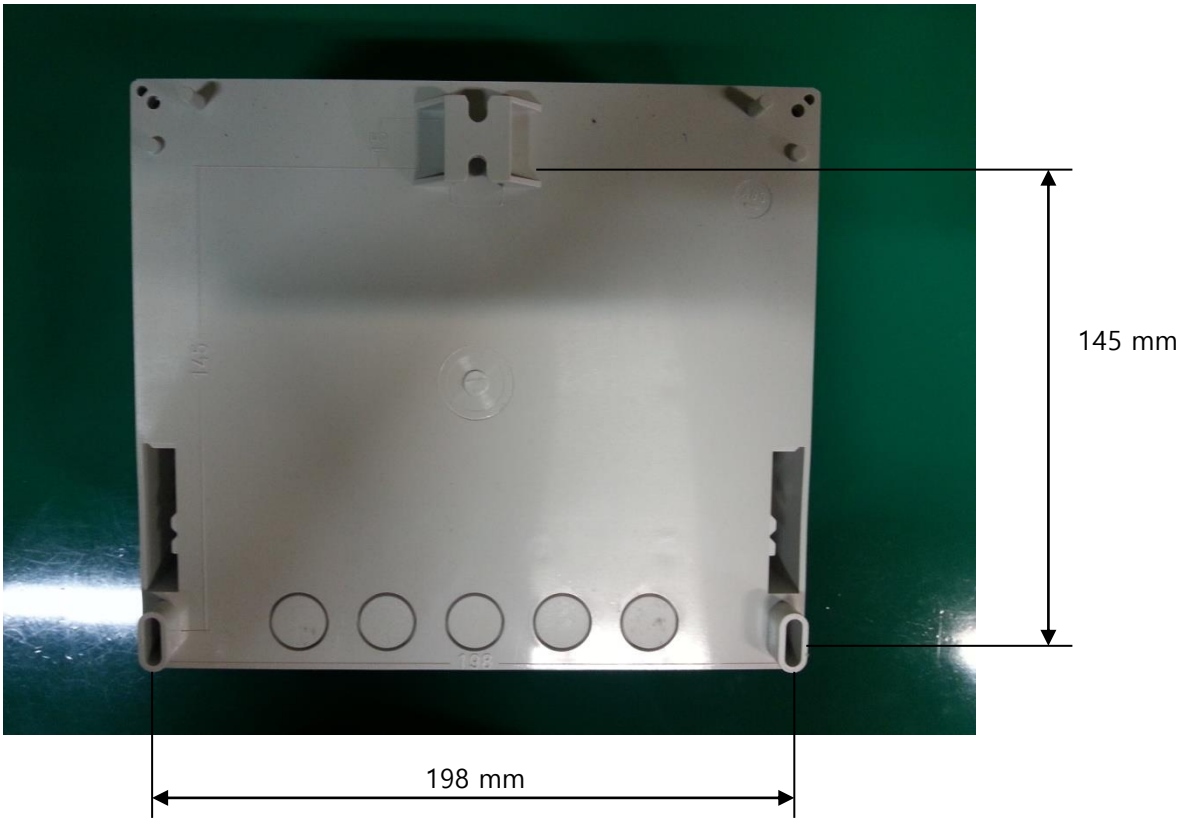
CONTENT

1. Transmitter Installation and Connect

1.1. Inspection Prior to Transmitter Installation

You will find a “Position Drawing” in the packing. Please use it as a template in the place that you are going to install the flow meter. Then drill 3 installation holes at the screw position shown on the drawing with the M5 mm aiguilles. (picture)



Instructions:

1. Screw M5X10mm 1 ea, M5X20mm 2ea tapping screws through the transmitter enclosure base and attach it to the wall.
2. Tighten the screws to secure to the enclosure on the wall.

	**ATTENTION** When installing please make sure that the installing face can afford the flow meter to avoid falling off. And make sure the installing face is dry.

1.2 Power Supply Connecting

1.2.1. Direct Mount Method

Please double check that power supply you ordered meets your equipment requirements. Factory standard power supply is 90~245 VAC.

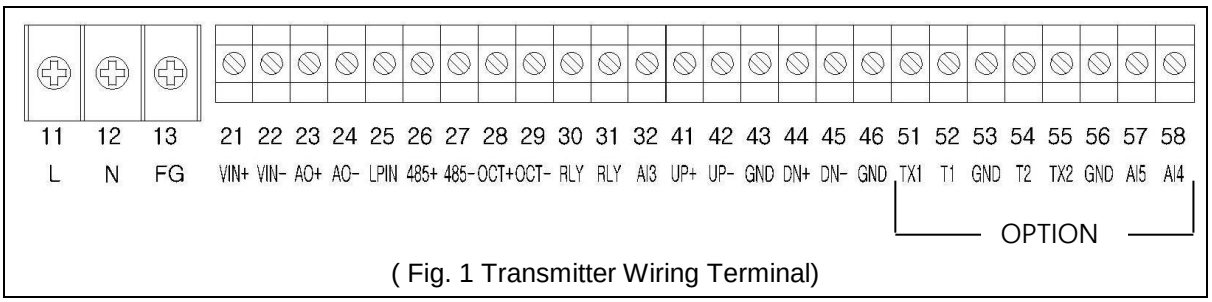
Observe the following precautions for installation procedures outlined in this chapter:

- Ensure that power connections are made in accordance with the indications shown on the connection terminals.
- Transmitters can be powered by two different power supplies: 90~245VAC or 10-36VDC

1.2.2. Connecting the Wiring

Once the electronics enclosure has been installed, the flow meter wiring can be connected. Open the case, terminals 11, 12, and 13 can be found at the left lower side. Connect to AC power. Terminal 13 is grounded (earth) while connecting. As per wiring diagram to connect 4-20mA Output (terminals 23, 24), Downstream transducer (terminals 44, 45, 46), Upstream transducer (terminals 41, 42, 43), OCT Output (terminals 28, 29) and Relay Output(terminals 30, 31).

For double-shielded transducer cable: "-" on the black wire, "+" on the red wire and "shield" on the shield.



(Fig. 1 Transmitter Wiring Terminal)

WARNING

Wire with power off.

Use either AC or DC power supply. Do not connect them both at the same time.

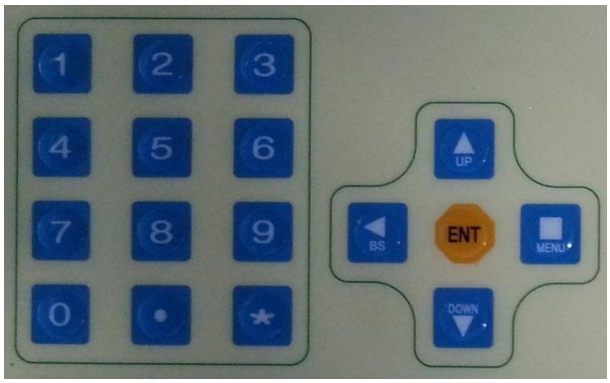
1.3. Powering on

As soon as the flow meter is switched on, the self-diagnosis program will start to run. If any error is detected, an error code will display on the screen (Refer - Error Diagnoses). After that, the system will run automatically according to the last input parameters.

If the installation is accomplished when system is switched on, gain adjustment can be monitored in Window M01. After S1, S2, S3, and S4 are displayed on the upper left corner of the screen, the system will activate the normal measurement condition automatically. It is indicated by code “*R” on

the upper left corner of the screen. The system will default to the last window settings and automatically display them at next power on.

1.4. Keypad Functions



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

0 ~ 9 And ● input numbers.

Backspace or delete characters to the left.

▲ And ▼ Return to the last menu or to open the next menu. These buttons act as "UP" and "DN" functions when entering numbers.

■ Select a menu. Press this key first, input two menu numbers and then enter the selected menu.

For example, To Input a pipe outside diameter, press ■ 1 1 keys where "11" is the window ID to display the parameter for pipe outside diameter.

1.5. Keypad Operation

With all of the parameters entered, the instrument setup and measurement displays are subdivided or consolidated into more than 100 independent windows. The operator can input parameters, modify settings or display measurement results by "visiting" a specific window. These window are arranged by 2-digit serial numbers (including "UP" sign) from 00~99, then to +0, +1, etc. Each window serial number, or so-called window ID code, has a defined meaning.

For example, Window M11 indicates the parameter input for pipe outside diameter, while Window M25 indicates the mounting spacing between the transducers, etc. (Refer DN Windows Display Explanations).

The keypad shortcut to visit a specific window is to press the ■ key at any time, then input the 2-digit window ID code. For example, to input or check the pipe outside diameter, just press the ■ 1 1 keys for window ID code 11.

Another method to visit a particular window is to press ▲ ▼ and ENT keys to scroll the screen. For example, if the current window ID code is 66, press ▲ key to enter Window M65, press the ▲ button again to enter Window M64; then, press the ▼ key to back Window M65, and press the /- key again to enter Window M66.

Example 1: To enter a pipe outside diameter of 219.234, the procedure is as follows: Press Menu 1 1 keys to enter Window M11 (the numerical value displayed currently is a previous value). Now press ENT key. The symbol “>” and the flashing cursor are displayed at the left end of the second line on the Screen. The new value can be entered then…2 1 9	
Example 2: If the pipe material is “Stainless Steel”, press keys Menu 1 4 to enter Window M 14 first. Then press ENT key to modify the options. Now, select the “1. Stainless Steel ” option by pressing UP and DN keys, and then press ENT key to confirm the selection. It is possible to press the 5 key to change the election and wait until “5. PVC” is displayed on the second line of the screen. Then press the ENT key to confirm.	 

ATTENTION

Generally, press ENT key first if operator wants to enter “modify” condition. If the “modify” is still not possible even after pressing the ENT key, it means that system is locked by a password. To “Unlock” it, select “Unlock” in Window M47 and enter the original password. The keypad will not respond if the keypad is locked. It only can be unlocked by the entering original password. Select keypad lock functions in Window M48.

1.6. Flowmeter Window Descriptions

The Flowmeter has the unique feature of windows processing for all operations.

These windows are assigned as follows:

00~09	Flow Totalizer Display: to display flow rate, positive total, negative total, net total, velocity, date & time, analog inputs for present flow, present operation and flow results today, etc.
10~29	Initial Parameter Setup: to enter pipe outside diameter, pipe wall thickness, fluid type, transducer type, transducer mounting and spacing, etc.
30~38	Flow Units Options: to select the flow unit, totalizer unit, measurement unit, turn totalizers on/off and reset totalizes, etc.
40~49	Setup options: Scaling factor, network IDN (Window M46), system lock (Window M47) and keypad lock code (Window M48), etc.
50~89	Input and output setup: relay output setup, 4-20mA outputs, flow batch controller, LCD backlit option, date and time, low/high output frequency, alarm output, date totalizer, etc.
90~95	Diagnoses: Signal strength and signal quality (Window M90), TOM/TOS*100 (Window M91), flow sound velocity (Window M92), total time and delta time (Window M93), Reynolds number and factor (Window M94), Data Interval (Window M95) etc.
+0~+5	Appendix: power on/off time, total working hours, on/off times and a single-accuracy function calculator.

ATTENTION

The other windows are for hardware adjustment by the manufacturer.

2. Pipe Parameter Entry Shortcuts

Below is an example of a typical shortcut keypad entry for pipe parameters. For example the parameters in this example are: measuring the diameter of DN125, measuring medium is water, pipe material is PVC, no liner material. This example can be operated as follows：

Step1. Pipe outside diameter: Press Menu 1 1 keys to enter Window M11, and enter the pipe outside diameter, and then press the ENT key.	Pipe Outer Diameter >140
Step2. Pipe wall thickness Press the DN key to enter Window M12, pipe wall thickness, and press the ENT key.	Pipe Wall Thickness >7.5
Step3. Pipe material Press the DN key to enter Window M14, press the ENT key, move the UP or DN key to select pipe material, and press the ENT key.	Pipe Material [14 >5. PVC
Step4. Liner material parameters (including thickness and sound velocity, if needed) Press the DN key to enter Window M16, press the ENT key, move the UP or DN key to select liner material, and press the ENT key.	Linner Material [16 >0. None, No Liner
Step5. Fluid type Press the DN key to enter Window M20, press the ENT key, move the UP or DN key to select fluid type, press the ENT key.	Fluid Type [20 >0. Water
Step6. Transducer type (The transmitter is available for various transducer types.) Press the DN key to enter Window M23, press the ENT key, move the UP or DN key to select transducer type, and press the ENT key.	Transducer Type [23 >23. Standard L2
Step7. Transducer mounting methods Press the DN key to enter Window M24, press the ENT key, move the UP or DN key to select transducer-mounting method, and press the ENT key.	Transducer Mounting >0. V

Step8. Adjust Transducer spacing Press the DN key to enter Window M25, accurately install the transducer according to the displayed transducer mounting spacing and the selected mounting method (Refer to Installing the Transducers in this chapter).	Transducer Spacing 73.413 mm
Step9. Initial Parameter Setups and Save Press the Manu 26 keys to ENT key.	Parameter Setups Entry to SAVE
Step10. Display measurement result Press the Menu 0 1 keys to enter Window M01 to display measurement result.	Flow 123.456 m3/h *R Vel 3.8764 m/s

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 measurement installation site:

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

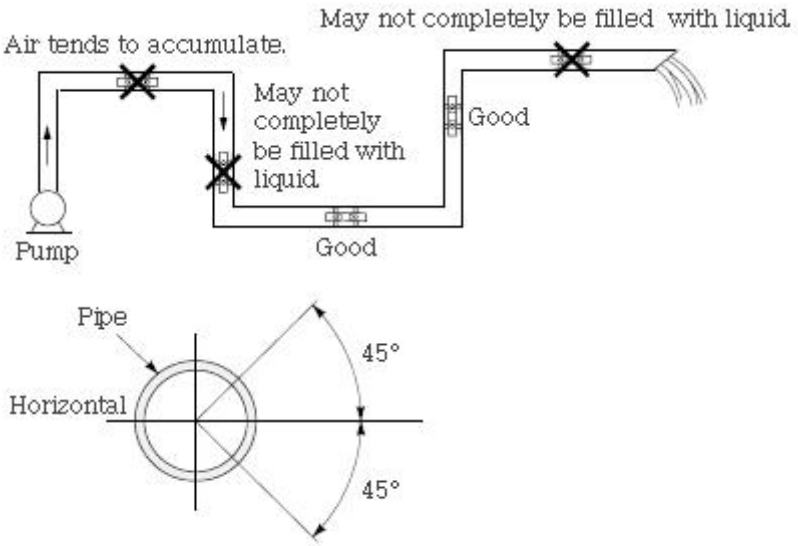


Fig 2. Select the installation location

3.1 Selection of Measurement point

To selecting the correct measuring point is the most important, precise measurements should be as follows in order.

1) Select the kinds of liquid and fill up liquid at inside of the pipes.
2) Choose measurement point at 10D from the upstream and at 5D from downstream. Any valves among the measurement points should not be installed.
3) Check the operating temperature of measurement points. (Check the fluid emperature)
4) A pump or curve pipe is installed straight pipe on point 30D.
5) Considering the state of the pipe wall, install a pipe on point of the clear condition.
6) For make it easier to launch ultrasonic, find average point and make contact with the surface of the pipe closely.

3.2 Installation of Ultrasonic Flowmeter (Upstream & Downstream Requirements)

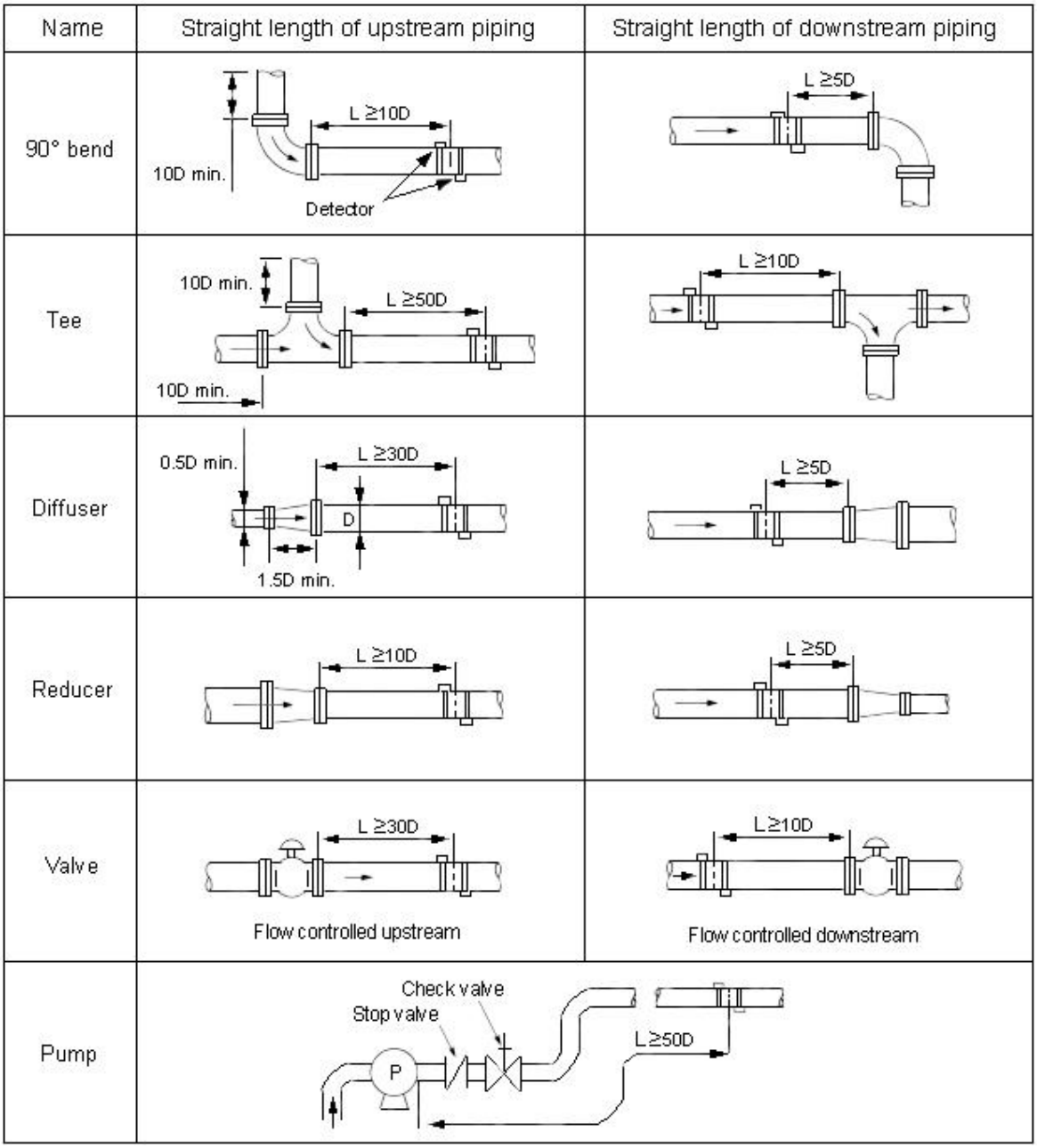


Fig 3. Installation Conditions

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. Choose a section of sound conducting pipe for installing the transducers. 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 guarantee 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 in diagram below). 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. The V method 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.

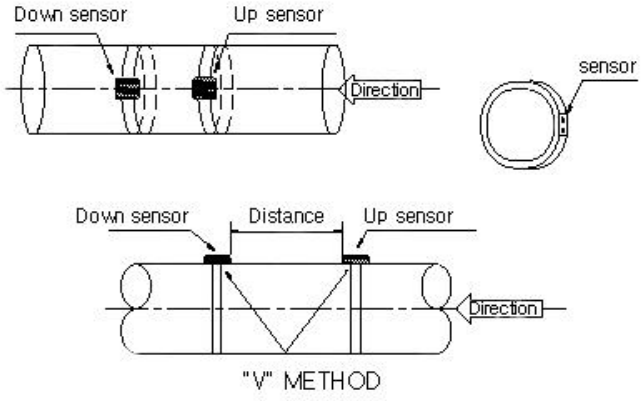


Fig 3. Sensor Installation (″V″ Method)

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”).

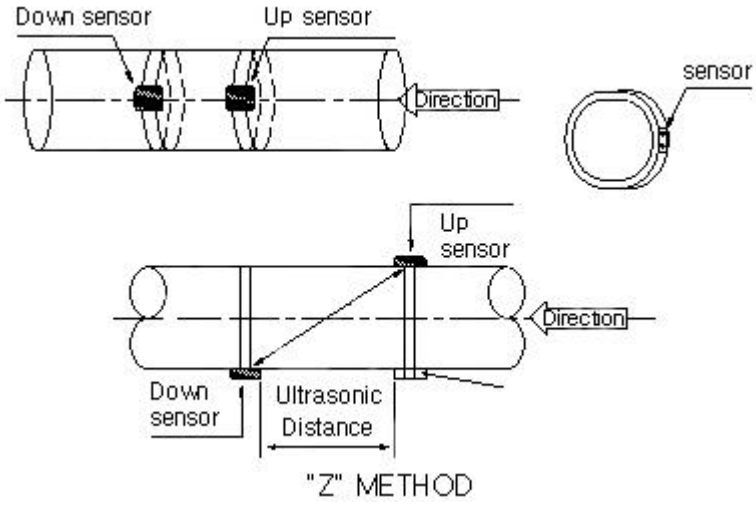


Fig 4. Sensor Installation (″Z″ Method)

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. You can confirm that the transducer is installed correctly by checking the detected signal strength, total transit time, and delta time as well as transit time ratio.

The “mounting” condition directly influences the flow value accuracy and system long-time running reliability. In most instances, only 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 the high reliability of the measurement and long-term operation of the instrument.

4.2.1. Signal Strength Inspection

Signal strength (displayed in Window M90) indicates a detected strength of the signal both from upstream and downstream directions. The relevant signal strength is indicated by numbers from 00.0~99.9. 00.0 represents no signal detected while 99.9 represent maximum signal strength. Normally, the stronger the signal strength detected, the longer the operation of the instrument reliably, as well as the more stable the measurement value obtained.

Adjust the transducer to the best position and check to ensure that enough sonic coupling compound is applied adequately during installation in order to obtain the maximum signal strength. The FUM-1000 system normally requires signal strength over 60.0, which is detected from both upstream and downstream directions. If the signal strength detected is too low, the transducer installation position and the transducer mounting spacing should be re-adjusted and the pipe should be re-inspected. If necessary, change the mounting to the Z method.

4.2.2. Signal Quality (Q value) Inspection

Q value is short for Signal Quality (displayed in Window M90). 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. Normally, the transducer position should be adjusted repeatedly and coupling compound application should be checked frequently until the signal quality detected is as strong as possible.

4.2.3. Total Time and Delta Time Inspection

"Total Time and Delta Time", which displays in Window M93, indicates the condition of the installation. The measurement calculations in the flow meter are based upon these two parameters. Therefore, when "Delta Time" fluctuates widely, the flow and velocities fluctuate accordingly. This means that the signal quality detected is too poor. It may be the results 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 in Window M91.

ATTENTION

If the transit time ratio is over 100±3, it is necessary to check:

A. If the parameters (pipe outside diameter, wall thickness, pipe material, liner, etc.) have been entered correctly,

B. If the transducer mounting spacing is accordance with the display in Window M25,

C. If the transducer is mounted at the pipe's centerline on the same diameter,

D. If the scale is too thick or the pipe mounting is distorted in shape, etc.

Warnings

A. Pipe parameters entered must be accurate; otherwise the flow meter will not work properly.

B. During the installation, apply enough coupling compounds in order to stick the transducer onto pipe wall. While checking the signal strength and Q value, move the transducer slowly around mounting site until the strongest signal and maximum Q value can be obtained. Make sure that larger the pipe diameter, the more the transducer should be moved.

	C. Check to be sure the mounting spacing is accordance with the display in Window M25 and transducer is mounted at the pipe's centerline on the same diameter. D. Pay special attention to those pipes that formed by steel rolls (pipe with seams), since such always irregular. If the signal strength is always displayed as 0.00, that means there is no detected. Thus, it is necessary to check that the parameters (including all the pipe parameters) 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 pipe or the transducer is not very close to a valve or elbow, and there are not too many air bubbles the fluid, etc. With the exception of these reasons, if there is still no signal detected, the measurement site has to be changed. E. Make sure that the flowmeter is able to run properly with high reliability. The stronger the strength displayed, the higher the Q value reached. The longer the flowmeter runs accurately, higher the reliability of the flow rates displayed. If there is interference from ambient electromagnetic waves or the signal detected is too poor, the flow value displayed is not reliable; consequently, capability for reliable operation is reduced. F. After the installation is complete, power on the instrument and check the result accordingly.

5. Operating Instructions

5.1. System Normal Identification format change of entire section

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 Window M57. Enter a larger value in Window M57, 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 Window M69. Increase the input value in Window M69, 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”.

5.2. 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, a measurement difference may occur. The smaller the physical measurement capacity is, the larger the measurement difference from the zero point will exist. Only when zero point is reduced to a definite degree, as compared with the physical measurement capacity, can the measuring difference from zero point be ignored.

NOTE

For an ultrasonic flow meter, 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.

5.3. 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 setting the scale factor default is that the scale factors in the flow meter are only limited by two parameters: 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.

5.4. System Lock (Unlock)

System lock is readable but unable 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.

ATTENTION

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

5.5. Keypad Lock

The keypad can be locked to prevent unauthorized use of your flow meter. Unlock it using the correct password only.

To lock it, first enter desired window, then press Menu 4 8 press ENT to enter a 1~8 numerically long password, and then it will return to the locked window automatically. For example, if Window M01 is required to display in the locked condition, enter Window M01 first (if already in this window, skip this step), press Menu 4 8 , press ENT to enter a password such as “1111”, press ENT again to return to the locked Window M01 automatically. The keypad is “invalidated” now. Unlock it by entering the password “1111” again.

5.6. 4~20mA Current Loop Verification

Possessing a current loop output exceeding an accuracy of 0.1%, the flow meter is programmable and configurable with multiple output modules such as 4 ~20mA or 0~20mA. Select in Window M55. For details, please refer to “Windows Display Explanations”.

In Window M56, enter a 4mA flow value. Enter the 20mA flow value in Window M57. For example, if the flow range in a specific pipe is 0~1000m3/h, enter 0 in Window M56 and 1000 in Window M57. If the flow ranges from -1000~0~2000m3/h, configure the 20~4~20mA module by selecting Window M55 when flow direction is not an issue. Enter 1000 in Window M56 and 2000 in Window M57. When flow direction is an issue, module 0~4~20mA is available. When the flow direction displays as negative, the current output is in range of 0~4mA, whereas the 4~20mA is for the positive direction. The output module options are displayed in Window M55. Enter “-1000” in Window M56 and 2000 in Window M57.

Calibrating and testing the current loop is performed in Window M58. Complete the steps as follows: Press Menu 5 8 ENT , move UP or DN display “0mA”, “4mA”, “8mA”, “16mA”, “20mA” readings, connect an ammeter to test the current loop output and calculate the difference. Calibrate it if the difference is within tolerance. If not, how to calibrate the current loop is to be found in *Section 5.11* in this chapter.

Check the present current loop output in Window M59 as it changes along with change in flow.

5.7. Frequency Output

The flow meter is provided with a frequency output transmitter function. The high or low frequency output displayed indicates the high or low flow rate reading. The user can reset the frequency output as well as flow rate per his requirements For example: if a pipe flow range is 0~3000m3/h, the relative frequency output required is 123~1000Hz, and the configuration is as follows:

In Window M68 (low limit frequency output flow value), input 0;

In Window M69 (high limit frequency output flow value), input 3000;

In Window M67 (low limit frequency), input 123

There is no output circuit specially assigned to frequency output. It only can be transmitted through OCT, i.e. select Window M78 (item “09. POS Int Pulse”).

5.8. 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 may probably 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.

5.9. Alarm Programming

The flow meter has two programmable alarms: audible alarm and on off output alarm. The audible alarm generates an internal beeper. Select the BEEPER trigger in Window M77. The on-off output alarm is generated through OCT or transmission to an external circuit by opening or closing a relay. The on-off output signal is activated under the following conditions:

(1) Signal not detected

(2) Poor signal detected

(3) The flow meter is not ready for normal measurement

(4) The flow is in the reverse direction (back flow)

(5) The analog outputs exceed span by 120%

(6) The frequency output exceeds span by 120%

(7) The flow rate exceeds the ranges configured (Configure the flow ranges using the software alarm system. There are two software alarms: Alarm#1 and Alarm #2. The lower limit value for

Alarm#1 is configured in Window M73, and the upper limit value is configured in Window M74. As for Alarm#2, the lower limit value is in M75 and the upper one is in Window M76).

Example 1: To program audible alarm, activated when the flow meter is not ready for normal measurement:

Select item 2 in Window M77: “2. NO*R”.

Example 2: To program the relay output alarm, activated when flow rate exceeds 300~1000m3/h:

(1) In Window M73, input 300

(2) In Window M74, input 1000

(3) In Window M79, select item 6: “6. Alarm #1 limit exceed”

Example 3: To program OCT output alarm signal, activated when flow rate exceeds 100~500m3/h; relay output alarm signal activated when flow rate exceeds 600~1000m3/h:

(1) In Window M73, input 100

(2) In Window M74, input 500

(3) In Window M75, input 600

(4) In Window M76, input 1000

(5) In Window M78, select item 6: “6. Alarm #1”

(6) In Window M79, select item 7: “7. Alarm #2”

5.10. Batch Controller Paragraph format change

The batch controller is able to perform flow quantity control, or the batching of specific volumes to control events in product production or chemical dosing, etc. The internal batch controller in the flow meter is able to take the high or low end of analog input signals as an input, or through the keypad, to perform control functions. The output can be transmitted through OCT or a relay.

When taking analog inputs as control signals, input an analog output which is over 2mA through the analog input terminal to indicate the condition of “1”; current “0” indicates the condition of “0”.

In Window M78(OCT output)、M79(relay output) or M80(Flow Batch CTRL), select Item 8 “Batch controller” and the OCT or relay output will generate output signals. Enter the batch value in Window M81. Start the batch controller after that. For details, please refer to “Windows Display Explanations”.

5.11. Analog Output Calibration

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

1. Press Menu DN 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.
2. Press Menu DN 0 ENT to calibrate the current loop 4mA output. Use an ammeter to measure the current loop output current. At the same time, move UP or DN to adjust the displayed numbers. Watch the ammeter until it reads 4.00. Stop at this point, the 4mA has been calibrated.
3. Then, press ENT to calibrate the current loop 20mA output. The method is as same as in 4mA calibration.
4. The result is saved in EEPROM(MENU 26). Switch off the power supply has not lost.

ATTENTION

Each flow meter 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.

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
05	Instantaneous Caloric/Totalized Caloric
06	Analog Input AI1, AI2
08	System Error Codes
09	Net Flow Today
Initial Parameter setup	
10	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	Metric and English
31	Flow Rate Unit Selection
32	Totalize Units
33	Total Multiplier
34	NET Totalizer
35	Positive Totalizer
36	Negative Totalizer
37	Totalize Reset
38	Manual Totalizer
Setup Options	
40	Damping Coefficient
41	Low Flow Cutoff
42	Static Set Zero
43	Reset Static Zero
44	Manual Zero Point Setup
45	Scale Factor
46	Network IDN
47	System Lock Code
48	Entry to Calibration Data
Input and Output setup	
55	Current Output Selection
56	4mA or 0mA Output Value
57	20 mA Output Value
58	Current Loop Check up
59	Current Loop Output value
60	Date and Time Setup
61	Software Version
63	Select Comm Protocol
67	Frequency Output signal Frequency Range
68	Flow Value of Low Frequency Output
69	Flow Value of High Frequency Output
70	LCD Backlight Controller
71	LCD Contrast Controller
72	Working Timer
73	Alarm #1 Low Value Set
74	Alarm #1 High Value Set
75	Alarm #2 Low Value Set

76	Alarm #2 High Value Set
77	Buzzer Setup
78	OCT Output Setup
79	RELAY Output Setup
80	Batch Trigger Select
81	Flow Batch Controller
82	Date Totalizer
83	Automatic Amending
Diagnostics menu	
90	Strength & Quality of Signal
91	Ratio of Transfer time
92	Fluid Sound Velocity
93	Total Time and Delta Time
94	Reynolds Number

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
+6	Media Vel. Threshold
+7	Total Flow for Month
+8	Total Flow This Year
+9	No-Ready Timer
-0	Hardware Adjusting

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.	Flow 123.4567 m3/h *R NET +123 x 1 m3
Menu 0 1 **Flow Rate** / **Velocity** Display flow rate and velocity.	Flow 123.4567 m3/h *R POS +123 x 1 m3
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.	Flow 123.4567 m3/h *R NEG 0 x 1 m3
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.	Flow 123.4567 m3/h *R NET 123 x 1m3
Menu 0 4 **Date Time** / **Flow Rate** Display the current date time and flow rate. The time setting method is found in Window M60.	13-07-01 09:04:15 *R Flow 23.4567 m3/h
Menu 0 5 **Caloric** / **Totalized Caloric** Display Instantaneous Caloric and Totalized Caloric.	EFR 123.4567 GJ/h *R E.T 0E+0 GJ
Menu 0 6 **Analog Input Value** Display Analog Input AI1, AI2 current value and corresponding temperature value.	T1= 37.123C, 114.46 T2= 37.123C, 114.46

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	*R-------------------------------- System Normal
Menu 0 9 **Net Flow Today** Display net total flow today.	Net Flow Today [09 23 m3
Menu 1 0 **Pipe Outer Perimeter** Enter the pipe outer perimeter. If the diameter of the know, enter it in window M11.	Pipe Outer Perimeter 439.194 mm
Menu 1 1 **Pipe Outer Diameter** Enter the pipe outside diameter, The pipe outside diameter must range from 10mm to 6000mm.	Pipe Outer Diameter 139.8 mm
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.	Pipe Wall Thickness 7.5 mm
Menu 1 3 **Pipe Inner Diameter** Enter the pipe inside diameter. If the pipe outside diameter and pipe wall thickness has been entered, press DN to skip this window. Note: Enter either pipe wall thickness or pipe inside diameter.	Pipe Inner Diameter 124.8 mm

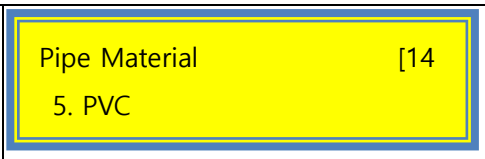
Menu 1 4

Pipe Material

Enter pipe material. The following options are available (by UP,DN 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

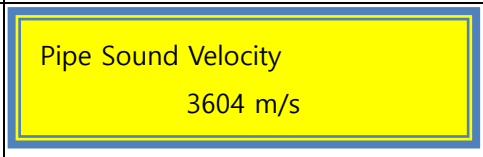
Refer to item 9 “Other”; it is possible to enter other materials, which are not included in previous eight items. Once item 9 is selected, the relevant pipe sound velocity must be entered in Window M15.



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.



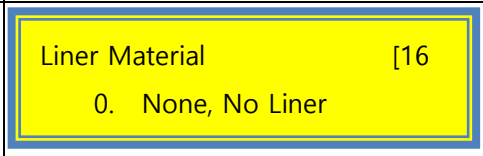
Menu 1 6

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

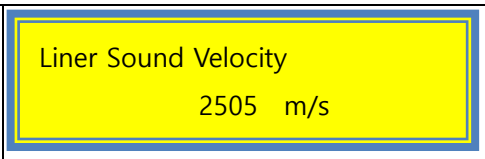
Item 11 “Other” is available to enter other materials that are not included in previous ten items. Once the “Other” is selected, the relevant liner sound velocity must be entered in Window M17.



Menu 1 7

Liner Sound Velocity

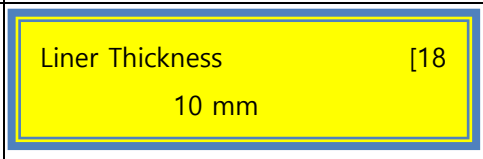
Enter liner sound velocity. It only can be visited when item " Other" in Window M16 is selected.



Menu 1 8

Liner Thickness

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



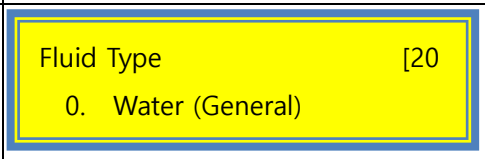
Menu 2 0

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 (-45C)	7. Butane (0C)
8. Other Liquid	9. Diesel Oil
10. Castor Oil	11. Peanut Oil
12. Gasoline #90	13. Gasoline #93
14. Alcohol	15. Water (125C)

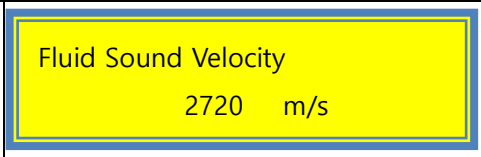
"Other" refers to any fluid. The relevant sound velocity must be entered in Window M21.



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”.

0. Standard-M	1. Insertion Type C
2. Standard-S	3. User Type
4. Standard-B	5. Insertion B(45)
6. Standard-L	7. JH-Polysonics
8. Standard-HS	9. Standard-HM
10. Standard-M1	11. Standard-S1
12. Standard-L1	13. PI-Type
14. FS410(FUJI)	15. FS510(FUJI)
16. Clamp-On TM-1	17. Insertion TC-1
18. Clamp-On TS-1	19. Clamp-On TS-2
20. Clamp-On TL-1	21. Insertion TLC-2
22. Clamp-On M2	23. Clamp-On L2

Transducer Type [23
≥ 23. Clamp-On L2

Menu 2 4

Transducer Mounting

Four mounting methods are available:

0. V (sound wave bounces 2 times)
1. Z(sound wave bounces once. The most commonly use method)
2. N (small pipe, sound wave bounces 3 times.)
3. W (small pipe, sound wave bounces 4times.)

Transducer Mounting
0. V

Menu 2 5

Transducer Spacing (this value is Calculated by the flow meter) 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.

Transducer Spacing
281.871 mm

Menu 2 6

Parameters’ Save & Load

Several types piping and specifications can be input.
This method doesn`t input severe piping separately, and can be selected from the M26 and measured.

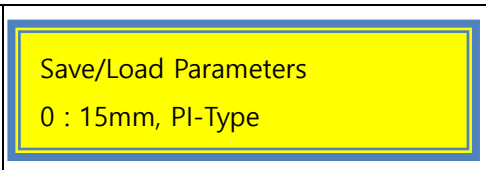
0. Use RAM Setting
1. Solidify Setting

Default Settings [26
≥ 1. Solidify Setting

Menu 2 7

The area of current fluid in pipe interior is represented.

0. 15mm, PI-Type
1. 110mm, V, PVC
2. 12.83mm, PI-Type
3. 219mm, Z, Carbon St
4. 259mm, Z, Carbon St
5. 325mm, V, PVC
6. 80mm, V, Carbon Ste
7. 25mm, V, Stainless
8. 400mm, V, PVC



Menu 2 8

Holding with Poor Sig

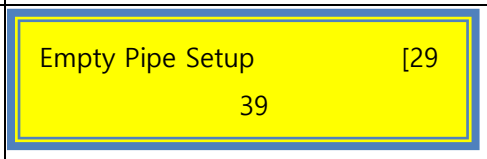
Select “Yes” to hold last good flow signal displayed if the flow meter experiences a poor signal condition.

This function will allow continued data calculation without interruption.

Menu 2 9

Empty Pipe Setup

This value is used to solve problem of empty pipe.
When pipe is empty, flowmeter shows transmission signal as “normal working” in pipe wall.
This function is for protect against the action of flowmeter, when pipe is empty.
For the protection, enter 30~40 in window.



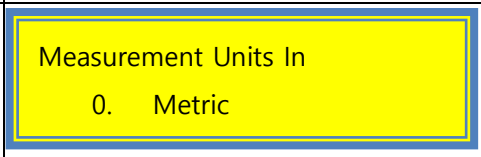
Menu 3 0

Measurement Units Options

Select the measurement unit as follows:

0. Metric
1. English

Factory default is metric.

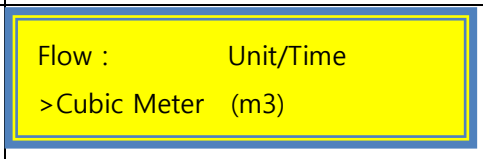


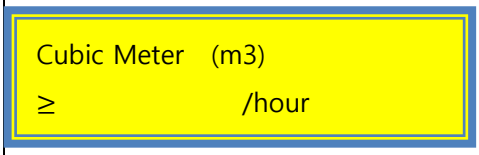
Menu 3 1

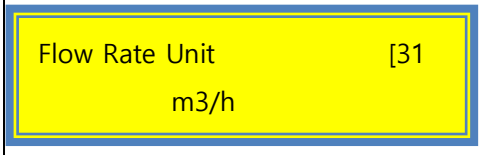
Flow Rate Units Options

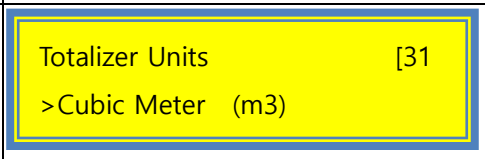
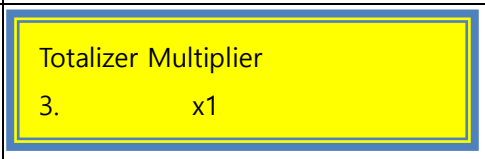
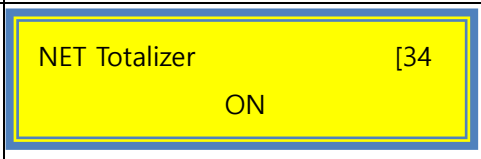
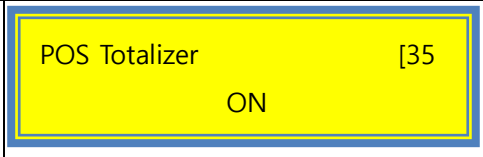
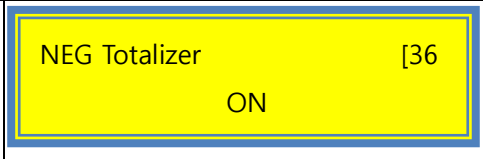
The following flow rates units are available:

0. Cubic Meters (m3)
1. Liters (l)
2. USA Gallons (Gal)
3. UK Gallons (IGL)
4. Million US Gallons (mg)
5. Cubic Feet (cf)
6. USA Oil Barrels (OB)
7. UK Oil Barrels (IB)

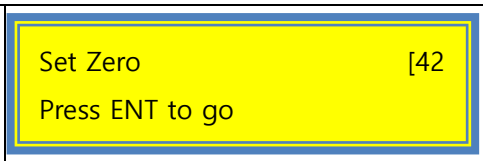
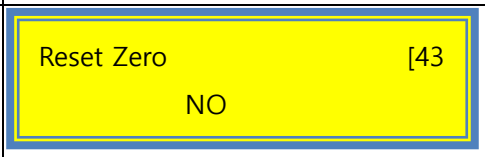
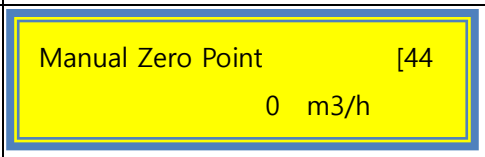
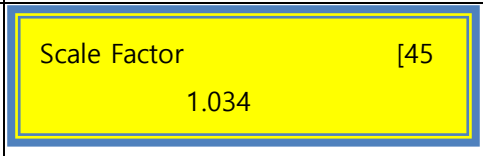


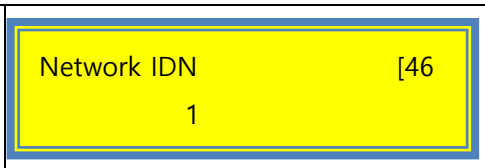
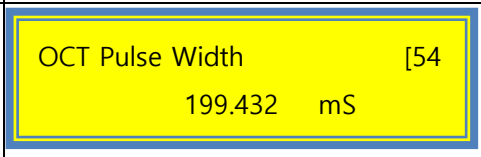
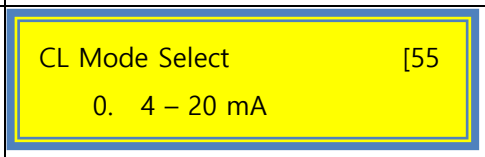
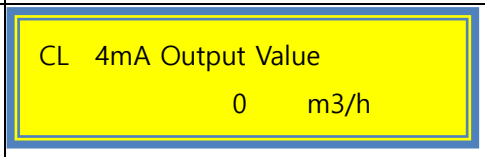
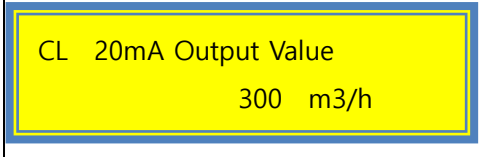




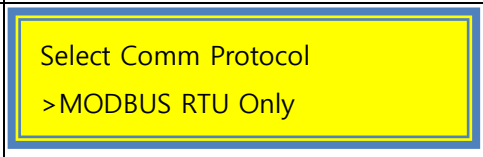
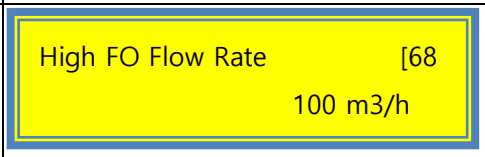
The following time units are available: / Day / Hour / Min / Sec Factory default is Cubic Meters/hour	
Menu 3 2 **Totalizer Units Options** Select totalizer units. The available unit options are as same as those found in Window M31. The user can select units as their required. Factory default is Cubic 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” 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 will make all parameters are reset. Press ENT ; move UP or DN 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.	Totalizer Reset? [37 Selection
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.	Manual Totalizer [38 Press ENT When Ready
Menu 4 0 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. indicates no damping; 999 indicate the maximum damping. Usually a damping factor of 3 to 10 is recommend in applications.	Damping [40 3 sec
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 flow meter 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	Low Flow Cutoff Val. 0.03 m/s

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 flow meter, the difference is going to be added into the actual flow values and measurement differences will occur in the flow meter. 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 locations 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 6 **Network IDN** Input system identifying code, these numbers can be selected from 0～65535 except that 13 (0DH ENTER), 10 (0AH Newline), 42 (2AH＊) and 38 (26H&) are reserved. System IDN is used to identify the flow meter to a network.	
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 54 **OCT Pulse Width** Max. 500 mS	
Menu 5 5 **Current Loop Mode Select** Select the current loop mode. The following options are available: 0. 4-20 mA 5. 0-4-20 mA 1. 0-20 mA 6. 20-0-20 mA 2. 0-20mA Via RS232 7. 4-20mA vs, Vel. 3. 4-20 mA vs. Sound 8. 4-20mA vs, Energy 4. 20-4-20 mA	
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 same as that found in Window M31.	

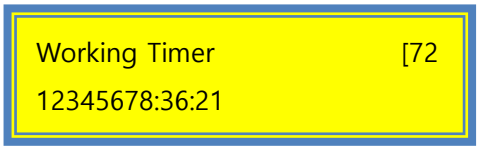
Menu 5 8 **CL Check Verification** Check if the current loop has been calibrated before leaving the factory. Press ENT move UP or DN separately to display 0mA, 4mA till 24mA, and at the same time, check with an ammeter to verify that CL output terminals M31 and 32 agree with the displayed values. It is necessary to re-calibrate the CL if over the permitted tolerance. For more information, refer to “Analog Outputs Calibration”. “0”, “4”, “8”, “12”, “16”, “20” mA	CL Checkup (mA) [58 Press ENT When Ready CL Checkup (mA) [58 ➢ 4
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.	CL Current Output [59 4.000 mA
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.	YY-MM-DD HH:MM:SS 13-06-22 12:06:40
Menu 6 1 **ESN** Display electronic Model and 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.	FUM-1000 Ver18.42 S/N=18217291
Menu 6 2 **COM Setup** COM Setup is the window used to set serial port; the Serial port for communications and other equipment. Its connection with the equipment of its serial port set of parameters must match. Window the first choice of data that baud rate, 9600,19200,38400,56000,57600,115200 choice. The second option that in check, None.	RS-485/RS-232 Setup 9600, None, 8,1

Data length fixed to eight; Stop bit for a fixed length; Factory serial port parameters for the default "9600，8，None，1".	
Menu 6 3 **Select Comm Protocol** **MODBUS ASCII+TDS7** **MODBUS RTU Only**	
Menu 6 7 **Set FO Frequency Range** Set up low FO Frequency and high FO frequency range. It must be higher than the low FO frequency. Ranges from 1-999Hz. Factory default is 1000Hz. **NOTE:** The frequency output is transmitted through OCT Serial Port; therefore the OCT must be set to the frequency output mode.	
Menu 6 8 **Low FO Flow Rate** Set up low FO flow rate, i.e. the corresponding flow value when output signal frequency is at the lowest FO frequency. For example, when the low FO frequency is 1000Hz, low FO flow rate is 100m3/h (when the frequency output is 1000Hz, then the low flow at this moment measured by the flow meter is 100m3/h.	
Menu 6 9 **High FO Flow Rate** Enter the high FO flow rate, i.e. the corresponding flow value when frequency output signal is at highest FO frequency.	
Menu 7 0 **LCD Backlit Option** Select LCD backlit controls. For example, If the user enter "10", the backlighting will keep on for "10" seconds then turn off automatically.	

Menu 7 2

Working Timer

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



Menu 7 8

OCT Output Setup

The OCT output in the flow meter is a kind of isolated collector open circuit output with programmable open and close qualifications. The user can program the open and close functions under the following conditions: the system alarm signals are being activated or the totalizer pulse is being transmitted.

The frequency output signal is also transmitted from the OCT. When it functions as the frequency output, other functions are unavailable The following signal options are available:

0. No Signal	1. Poor Signal
2. Not Ready (No*R)	3. Reverse Flow
4. AO Over 100%	5. FO Over 120%
6. Alarm #1	7. Reverse Alarm #2
8. Batch Controller	9. POS Int Pulse
10. NEG Int Pulse	11. NET Int Pulse
12. Energy POS Pulse	13. Energy NEG Pulse
14. Energy NEG Pulse	15. MediaVel=>Thresh
16. MediaVel<Thresh	17. ON/OFF via RS485
18. Timer(M51 Daily)	19. Timed Alarm #1
20. Timed Alarm #2	21. Batch Total Full
22. Timer by M51	23. Batch 90% Full
24. Flow Rate Pulse	25. Disable OCT

Menu 7 9

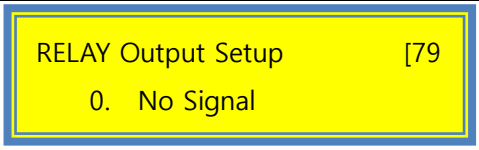
Relay Output Setup

The relay output in the flow meter is programmable.

The user can program the open and close functions under the following conditions: the system alarm signals are activated or the totalizer pulse is transmitting. The relay is single-pole and constant-on for external instrument controls.

The following options are available:

1. No Signal	2. Poor Signal
3. Not Ready (No*R)	4. Reverse Flow
5. AO Over 100%	6. Alarm #1
7. Reverse Alarm #2	8. Batch Controller
9. POS Int Pulse	10. NEG Int Pulse
11. NET Int Pulse	12. Energy POS Pulse
13. Energy NEG Pulse	14. Energy NEG Pulse
15. MediaVel=>Thresh	16. MediaVel<Thresh
17. ON/OFF via RS485	18. Timer(M51 Daily)
19. Timed Alarm #1	20. Timed Alarm #2
21. Batch Total Full	22. Timer by M51
23. Batch 90% Full	24. Disable Relay

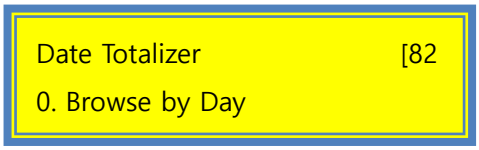
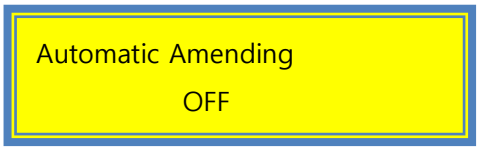


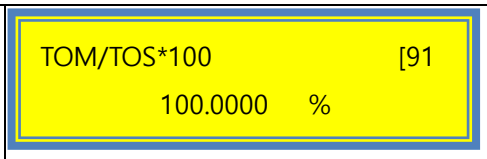
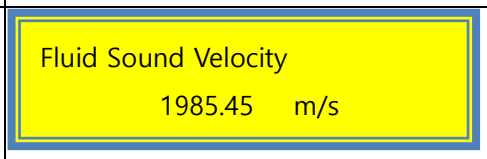
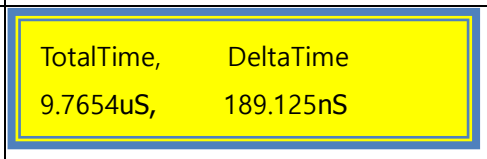
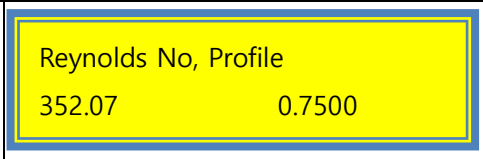
Menu 8 0

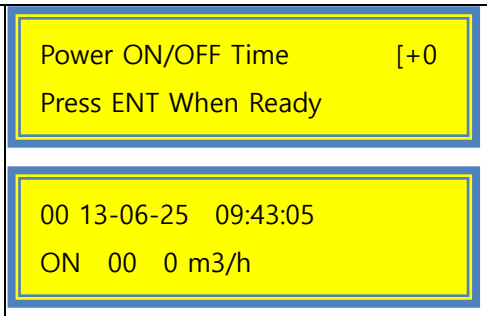
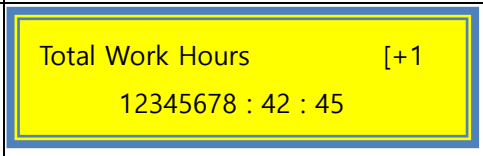
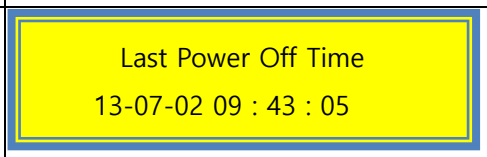
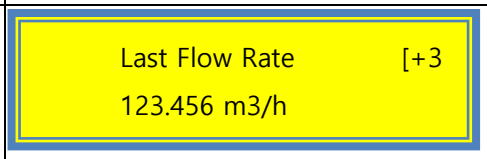
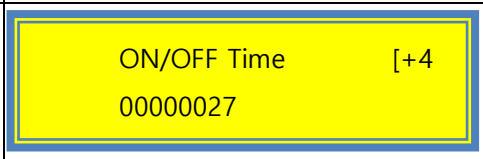
Flow Batch CTRL

The choice of quantitative window of the launch control signal controller. The following options are available:

0. Key Pressing	1. Serial Port
2. AI3 Rising Edge	3. AI3 Falling Edge
4. AI4 Rising Edge	5. AI4 Falling Edge
6. AI5 Rising Edge	7. AI5 Falling Edge
8. Timer-Periodical	9. Timer-daily

Menu 8 1 **Flow Batch Controller** The internal batch controller in the flow meter is able to control the input signals through keypad or analog input Serial Port. Output signals can be transmitted through OCT or relay. The flow batch value can be modified in this window. The screen will enter the batch control display as soon as the modification completed.	
Menu 8 2 **Date Totalizer** 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. 0. Browse by Day 1. Browse by Month 2. Browse by Year	
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 flow meter 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 flow meter and the factor that is set currently by the flow meter. Normally this scaling factor is the average of the line and surface velocity factor inside the pipe.	

Menu UP 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 UP 1 **Total Working Hours** With this function, it is possible to view the total working hours since the flow meter left the factory. The figure on the right indicates that the total working hours since the flow meter left the factory is 12345678 hours 42 minutes 45 seconds.	
Menu UP 2 **Last Power Off Time** Display the last power off time.	
Menu UP 3 **Last Flow Rate** Displays the last flow rate.	
Menu UP 4 **Total ON/OFF Times** Display total on/off times since the flow meter left the factory.	

7. Error Diagnoses

The ultrasonic flow meter 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 each time the flow meter is powered on. Some errors can be detected during normal operation. Undetectable errors caused by incorrect settings and unsuitable measurement conditions will 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 flow meter are divided into two categories:

Table 1 is for errors displayed during self-diagnostics upon powering on the flow meter. "* 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	MO8 DISPLAY	CAUSE	SOLUTION
* R	System Normal	Systemnormal	No errors
* J	Sub CPU Fatal Error	Sub CPU defect	Connect 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	Signal strength is low	Solve as the upper
* H	Poor Signal Quality	Signal quality is poor Including all above reasons	Use corresponding solve
* Q	Frequency output over	Adjust actual flow as frequency output 120%.	Re-check the frequency output settings (refers to M66-M69 specifications) or confirm whether the actual flow quantity is too large.
* E	Current Loop Over	The value error between neighbor two measurement is over 120% , this is normal phenomenon when the flow is very small or near zero point	Re-check the settings (refers to M56 specifications) or confirm whether the actual flow quantity is too large.
* F	Refers to table1	find troubles when power is on and self-monitoring eternal hardware obstacle	Try to turn the power on again, and observe the displayed information and deal with it according to the last table. Please contact the manufacture if it still has the trouble. Contact the manufacture
* G	ADJ GAIN= > S1 ADJ GAIN= > S2 ADJ GAIN= > S3 ADJ GAIN= > S4	The setting is that adjusting did increase. If instrument stops or switch at S1, S2, the it will have signal wavelength of too low or poor.	Try concerned solution.
*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 the CL output abnormal?

Answer: Check to see if the desired current output mode is set in Window M55. Also, 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 M59.

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: The FUM-1000 flow meter is designed to work with high reliability under such conditions. It is provided with an intelligent signal conditioning circuit and internal correction circuitry. FUM-1000 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 FUM-1000 is a state-of-the-art universal transit-time flow meter designed using SLSI technology and low voltage broadband pulse transmission. While principally designed for clean liquid applications, the instrument is tolerant of liquids with small amounts of air bubbles or suspended solids found in most industrial environments.

8.2. Features of FUM-1000 Dedicated

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

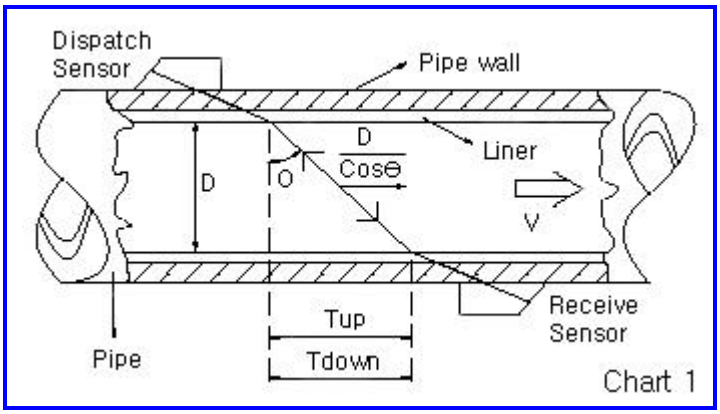
- Low consumption power, high reliability, anti-jamming and outstanding applicability.
- Clear, user-friendly menu selections make flow meter simple and convenient to use.
- U.S., British and Metric measurement units are available. Meanwhile, almost all-universal measurement units worldwide may be selected 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.
- Power on/off function: allows the viewing of time and flow rate as power is switched on and off 64 times. Also, the flow meter 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.
- Internally configured batch controller makes batch control convenient.

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.

$$T_{UP} = \frac{MD / COS\theta}{Co + VSIN\theta} \qquad (1)$$

$$T_{DOWN} = \frac{MD / COS\theta}{Co - VSIN\theta} \qquad (2)$$



M - Spreading times
D - inner diameter
θ - Sending in angle
C_0 - Fluid static sound velocity
T_{UP} - positive spreading time
T_{DOWN} - negative spreading time
△T - spreading time difference (=T_{UP} - T_{DOWN})
The average velocity is gotten in pipe, when (1) and (2) are equal.

$$V = \frac{MD}{Sin2\theta} \cdot \frac{\triangle T}{T_{UP} \times T_{DOWN}}$$

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

ITEM		CONTENTS
Pipe	Material	Steel , Stainless steel, Cast iron, Harden plastic (concrete and lining pipe need discuss)
	Inner diameter	25 ~ 6000mm
	Vertical pipe length	Confirmed straight pipe of upper stream 10D, downstream 5D Pump outlet side needs straight pipe of 30D. (reference page 13 and 14)
Fluid	Sort	Most liquid measure: Water, seawater, oil, chemical and etc
	Turbidity	Clear liquid with no air bubbles (less than 10000ppm (mg/l))
	Temperature	-20℃ ~ +80℃, (the liquid without freezing, brine)
Sensor	Velocity	0m/s ~±30m/s
	Sorts of sensor	Clamp-On S, Clamp-On M2, Clamp-On L2 Insertion Type B
	Installation method	"V" method : in general, suitable for small pipe diameters D≤350mm; "Z" method : in general, suitable for small pipe diameters D≥350mm; "W" method : D≤50mm
	Cable length	Standard: 10m, Max: 200m. Wire resistance: 75Ω
Body	Display	Digital backlight LCD of character numeric (2×20)
	Keyboard	4×4 keyboard
	Installation method	on-wall mounting in gauge room or gauge box
	Output	4 ~ 20mA or 0 ~ 20mA current loop, precision 0.1% RS-485 Output frequency range of programs : 1 ~ 9,999Hz (OCT output) Relay output
	Power supply	FUM-1000 wall-mounting type: 110VAC, 220VAC ±10% or 8~36VDC
	Power	2 Watts
	Size	FUM-1000 installation type : 251×92×80mm;
	Weight	FUM-1000 : 3.1 Kg,
Environ-ment	Temperature	Body：-20 ~ 50℃ Sensor：-20 ~ 80℃
	Humidity	Body：85% RH（40℃） Sensor：98% RH（40℃）, (submersible measurement until underwater 2m depth)
Accuracy		±1.0% after Calibration Reproducibility: ±0.2%~0.5% at 0 ~ ±30m/s Linearity 0.5% Data output cycle：500ms
Driving Time		Subsequently

9. Appendix1 - Flow Application Data

9.1 Fluid Sound Velocity and Viscosity

Unit：m/s

Fluid type	Sound velocity	Viscosity	Fluid type	Sound velocity	Viscosity
Water 20℃	1482	1.0	Glycerin	1923	1180
Water 50℃	1543	0.55	Gasoline	1250	0.80
Water 75℃	1554	0.39	66# gasoline	1171	
Water100℃	1543	0.29	80# gasoline	1139	
Water 125℃	1511	0.25	0# diesel oil	1385	
Water 150℃	1466	0.21	Benzene	1330	
Water 175℃	1401	0.18	Ethylbenzene	1340	
Water 200℃	1333	0.15	Toluene	1170	0.69
Water 225℃	1249	0.14	Carbon tetrachloride	938	
Water 250℃	1156	0.12	Coal oil	1420	2.3
Acetone	1190		Petroleum	1290	
Acrbinor	1121		Pine oil	1280	
Ethanol	1168		Trichloroethylene	1050	0.82
Alcohol	1440	1.5	Peanut oil	1472	
Acetophenone	1310		Eastor oil	1502	
Acetaldehyde	1180				
Glycol	1620				

9. 2 Sound Velocity in Liquids

Temperature and purity matter the sound velocity greatly, to pay more attention in fact.

The follow is sound velocity in liquids 20℃ purity 100% :

1200m/s	Methanol, Ethanol, Octane, Ethanoic acid, Proponent, Ethyl ether
1400m/s	Light oil, Transformer oil, Spindle oil, O-dim ethyl benzene
1600m/s	Aniline, Diethyl alcohol.
1800m/s	Glycerin

9. 3 Fluid Sound Velocity and Viscosity

Substance	Form Index	Temp. (℃)	Sound Vel. (m/s)	Kinematics Viscosity ($m^2/s\ 10^{-6}$)	Substance	Form Index	Temp. (℃)	Sound Vel. (m/s)	Kinematics Viscosity ($m^2/s\ 10^{-6}$)
Acetic acid	CH_3COOH	20	1159		Cinnamaldehyde	C_9H_8O	25	1554	
Acetic anhydride	$(CH_3CO)_2O$	20	1180	0.769	Cinnamic aldehyde	C_9H_8O	25	1554	
Acetic acid, anhydride	$(CH_3CO)_2O$	20	1180	0.769	Colamine	C_2H_7NO	25	1724	
Acetonitrile	C_2H_3N	25	1290	0.441	o-cresol	C_7H_8O	20	1541	4.29 (40℃)
Ethyl acetate	$C_4H_8O_2$	25	1085	0.467	m-cresol	C_7H_8O	20	1500	5.979 (40℃)
Methyl acetate	$C_3H_6O_2$	25	1211	0.407	Cyanomethane	C_2H_3N	25	1290	0.441
Acetone	C_3H_6O	20	1190	0.407	Cyclohexane	C_6H_{12}	20	1284	1.31 (17℃)
Acetonitrile	C_2H_3N	25	1290	0.441	Cyclohexanol	$C_6H_{12}O$	25	1454	0.071 (17℃)
Acetonylacetone	$C_6H_{10}O_2$	25	1399		Cyclohexanone	$C_6H_{10}O$	25	1423	
Acetylen dichloride	$C_2H_2Cl_2$	25	1015	0.400	Decane	$C_{10}H_{22}$	25	1252	1.26 (20℃)
Acetylene tetrabromide	$C_2H_2Br_4$	25	1027		1-decene	$C_{10}H_{20}$	25	1235	
Acetylene tetracloride	$C_2H_2Cl_4$	25	1147	1.156 (15℃)	n-decylene	$C_{10}H_{20}$	25	1235	
Ethyl alcohol	C_2H_6O	25	1207	1.396	Diacetyl	$C_4H_6O_2$	25	1236	
Alkazene-13	$C_{15}H_{24}$	25	1317		Diamylamine	$C_{10}H_{23}N$	25	1256	
Alkazene-25	$C_{10}H_{12}Cl_2$	25	1307		1, 2-dibromo-ethane	$C_2H_4Br_2$	25	995	0.79 (20℃)
2-amino-ethanol	C_2H_7NO	25	1724		trans-1, 2-dibromoethene	$C_2H_2Br_2$	25	935	
2-aminotolidine	C_7H_9N	25	1618	4.394 (20℃)	Dibutyl phthalate	$C_6H_{22}O_4$	25	1408	
4-aminotolidine	C_7H_9N	25	1480	1.863 (50℃)	Dichloro-t-butyl alcohol	$C_4H_8Cl_2O$	25	1304	
Ammonia	NH_3	-33	1729	0.292	2, 3-dichlorodixane	$C_2H_6Cl_2O_2$	25	1391	
t-amyl alcohol	$C_5H_{12}O$	25	1204	4.374	dichlorodifluoromethane (Freon 12)	CCl_2F_2	25	774.1	
Aminobenzene	$C_6H_5NO_2$	25	1639	3.63					
Aniline	$C_6H_5NO_2$	20	1659	1.762	1, 2-dichloro ethane	$C_2H_4Cl_2$	25	1193	0.61
Azine	C_6H_5N	25	1415	0.992	cis1, 2-dichloro-ethane	$C_2H_2Cl_2$	25	1061	
Benzene	C_6H_6	25	1306	0.711	trans 1, 2-dichloro-ethane	$C_2H_2Cl_2$	25	1010	
Benzol	C_6H_6	25	1306	0.711	Dichlorofluoro-methane (Freon21)	$CHCl_2F$	0	891	
Bromine	Br_2	25	889	0.323					
Bromobenzene	C_6H_5Br	25	1170	0.693	1-2-dichlorohexa-fluorocyclobutane	$C_4Cl_2F_6$	25	669	
1-bromo-butane	C_4H_9Br	20	1019	0.49 (15℃)					
Bromoethane	C_2H_5Br	20	900	0.275	1-3-dichloro-isobutane	$C_4H_8Cl_2$	25	1220	
Bromoform	$CHBr_3$	20	918	0.654	Dichloro methane	CH_2Cl_2	25	1070	0.31
n-butane	C_4H_{10}	-5	1085		1, 1-dichloro-1, 2, 2, 2 -tetra fluoroethane	$CClF_2$-$CClF_2$	25	665.3	
2-butanol	$C_4H_{10}O$	25	1240	3.239					
sec-butylalcohol	$C_4H_{10}O$	25	1240	3.239	Diethyl ether	$C_4H_{10}O$	25	985	0.311
n-butyl bromide	C_4H_9Br	20	1019	0.49 (15℃)	Diethylene glycol	$C_4H_{10}O_3$	25	1586	
n-butyl chloride	C_4H_9Cl	25	1140	0.529	Diethylene glycol, monoethyl ether	$C_6H_{14}O_3$	25	1458	
tert butyl chloride	C_4H_9Cl	25	984	0.646					
Butyl oleate	$C_{22}H_{42}O_2$	25	1404	0.529	Diethylenimide oxide	C_4H_9NO	25	1442	
2,3 butylene glycol	$C_4H_{10}O_2$	25	1484		1, 2-bis (difluoramino) butane	$C_4H_8(NF_2)_2$	25	1000	
Carbinol	CH_4O	25	1076	0.695					
Carbitol	$C_6H_{14}O_3$	25	1458		1, 2-bis (difluoramino)-2-methylpropane	$C_4H_9(NF_2)_2$	25	900	
Carbon dioxide	CO_2	-37	839	0.137					
Carbon disulphide	CS_2	20	1158	0.290	1, 2-bis (difluoramino) propane	$C_3H_6(NF_2)_2$	25	960	
Carbon tetrachloride	CCl_4	20	938	0.608					
Cetane	$C_{16}H_{34}$	20	1338	4.32	2, 2-bis (difluoramino) propane	$C_3H_6(NF_2)_2$	25	890	
Chlorobenezene	C_6H_5Cl	20	1289	0.722 (25℃)					

1-Chlorobutane	C_4H_9Cl	25	1140	0.529	2, 2-dihydroxy-dilethyrther	$C_4H_{10}O_3$	25	1586	
Chloroform	$CHCl_3$	20	931	0.383					
1-chloropropane	C_3H_7Cl	25	1058	0.378	Dihdroxyethane	$C_2H_6O_2$	25	1658	
1, 3-dimethyl-benzene	C_8H_{10}	20	1343	0.749 (15℃)	Hexadecane	$C_{16}H_{34}$	25	1338	4.32(20℃)
1, 2-dimethyl-benzene	C_8H_{10}	25	1331.5	0.903 (20℃)	Hexalin	$C_{16}H_{12}$	25	1454	70.69(17℃)
1, 4-dimethyl-benzene	C_8H_{10}	20	1334	0.662	Hexane	C_6H_{14}	25	1112	0.446
2,2-dimethyl-butane	C_6H_{14}	25	1079		n-hexane	C_6H_{14}	20	1083	0.489
Dimethyl ketone	C_3H_6O	25	1174	0.399	2, 5-hexanedione	$C_6H_{10}O_2$	25	1399	
Dimethyl pentane(47)	C_7H_{16}	25	1063		n-hexanol	$C_6H_{14}O$	25	1300	
Dimethyl phthalate	$C_8H_{10}O_4$	25	1463		Hexahydrobenzene	C_6H_{12}	25	1248	1.31(17℃)
Diiodo-methane	CH_2I_2	25	980		Hexahydrophenol	$C_6H_{12}O$	25	1454	
Dioxane	$C_4H_8O_2$	25	1376		Hexamethylene	C_6H_{12}	25	1248	1.31
Dodecane (23)	$C_{12}H_{26}$	25	1279	1.80	2-hydroxy-toluene	C_7H_8O	20	1541	4.29 (40℃)
1, 2-ethanediol	$C_2H_6O_2$	25	1658		3-hydroxy-toluene	C_7H_8O	20	1500	5.979 (40℃)
Ethanenitrile	C_2H_3N	25	1290	0.441	Iodo-benzene	C_6H_5I	20	1114	0.954
Ethanoic anhydride(22)	$(CH_3CO)_2O$	25	1180	0.769	Iodo-ethane	C_2H_5I	20	876	0.29
Ethanol	C_2H_6O	25	1207	1.39	Iodo-methane	CH_3I	25	978	0.211
Ethanol amide	C_2H_7NO	25	1724		Isobutyl acetate	$C_6H_{12}O$	27	1180	
Ethoxyethane	$C_4H_{10}O$	25	985	0.311	Isobutanol	$C_4H_{10}O$	25	1212	
Ethyl acetate	$C_4H_8O_2$	20	1164	0.499	Iso-butane		25	1219.8	0.34
Ethyl alcohol	C_2H_6O	25	1207	1.396	Isopentane	C_5H_{12}	25	980	0.34
Ethyl benzene	C_8H_{10}	20	1338	0.797(17℃)	Isopropanol (46)	C_3H_8O	20	1170	2.718
Ethyl Bromide	C_2H_5Br	20	900	0.275	Isopropyl alcohol	C_3H_8O	20	1170	2.718
Ethyliodide	C_2H_5I	20	876	0.29	Kerosene		25	1324	
Ether	$C_4H_{10}O$	20	1006	0.336	Ketohexamethylene	$C_6H_{10}O$	25	1423	
Ethyl ether	$C_4H_{10}O$	25	985	0.311	Mercury	Hg	20	1451	0.114
Ethylene bromide	$C_2H_4Br_2$	25	995	0.79	Mesityloxide	$C_6H_{16}O$	25	1310	
Ethylene chloride	$C_2H_4Cl_2$	25	1193	0.61	Methanol	CH_4O	25	1076	0.695
Ethylene glycol	$C_2H_6O_2$	20	1666	21.112	Methyl acetate	$C_3H_6O_2$	20	1181	0.411
50% glycol/50% H_2O		25	1578		o-methylaniline	C_7H_9N	25	1618	4.394 (20℃)
d-fenochone	$C_{10}H_{16}O$	25	1320	0.22	4-methylaniline	C_7H_9N	25	1480	1.863 (50℃)
d-2- fenochone	$C_{10}H_{16}O$	25	1320	0.22	Methyl alcohol	CH_4O	25	1076	0.695
Fluoro-benzene (46)	C_6H_5F	25	1189	0.584	Methyl benzene	C_7H_8	20	1328	0.644
Formaldehyde, methylester	$C_2H_4O_2$	25	1127		2-methyl-butane	C_5H_{12}	25	980	0.34
					Methyl carbinol	C_2H_6O	25	1207	1.396
Formamide	CH_3NO	25	1622	2.91	Methyl-chloroform	$C_2H_3Cl_3$	25	985	0.902 (20℃)
Formic asid, amide	CH_3NO	25	1622	2.91	Methyl-cyanide	C_2H_3N	25	1290	0.441
Freon R12		25	774.2		3-methyl cyclohexanol	$C_7H_{14}O$	25	1400	
Furfural	$C_5H_4O_2$	25	1444		Methylene chloride	CH_2Cl_2	25	1070	0.31
Furfuryl alcohol	$C_5H_6O_2$	25	1450		Methylene iodide	CH_2I_2	25	980	
Fural	$C_5H_4O_2$	25	1444		Methyl formate	$C_2H_4O_2$	25	1127	
2-furaldehyde	$C_5H_4O_2$	25	1444		Methyl iodide	CH_3I	25	978	0.211
2-furancarboxalde-hyde	$C_5H_4O_2$	25	1444		α-methyl napthalene	$C_{11}H_{10}$	25	1510	
2-furyl-methanol	$C_5H_6O_2$	25	1450		2-methylphenol	C_7H_8O	20	1541	4.29 (40℃)
Gallium	Ga	30	2870		3-methylphenol	C_7H_8O	20	1500	5.979 (40℃)
Glicerin	$C_3H_8O_3$	20	1923	1188.5	Milk, homogenized		25	1548	
Glycerol	$C_3H_8O_3$	25	1904	757.1	Morpholine	C_4H_9NO	25	1442	
Glycol	$C_2H_6O_2$	25	1658		Naphtha		25	1225	

Heptane	C_7H_{16}	25	1131	0.598(20℃)	Nitrobenzene	$C_6H_5NO_2$	20	1473	1.665
n-heptane	C_7H16	25	1180		Nitromethane	CH_3NO_2	25	1300	0.549
Hexachloro-cyclopentadiene	C_5C_{l6}	25	1150		Nonane	C_9H_2O	25	1207	0.99(20℃)
					1-nonene	C_9H_{18}	25	1207	
Octane	C_8H_{18}	25	1172	0.73	Refrigerant 21	$CHCl_2F$	0	891	
n-octane	C_8H_{18}	20	1192	0.737(25℃)	Refrigerant 22	$CHClF_2$	50	893.9	
1-octene	C_8H_{16}	25	1175.5		Refrigerant 113	CCl_2F-$CClF_2$	0	783.7	
Oil of camphor Sassafrassy		25	1390		Refrigerant 114	$CClF_2$-$CClF_2$	-10	665.3	
					Refrigerant 115	C_2ClF_5	-50	656.4	
Oil, car(SAE 20a.30)		25	870	190	Refrigerant C318	C_4F_8	-10	574	
Oil, castor	$C_{11}H_{10}O_{10}$	25	1477	0.670	Silicone (30cp)		25	990	30
Oil, diesel		25	1250		Solvesso #3		25	1370	
Oil, fuel AA gravity		25	1485		Spirit of wine	C_2H_6O	25	1207	1.396
Oil (Lubricating X200)		25	1530		Sulfuric Acid	H_2SO_4	25	1257.6	11.16
Oil (olive)		25	1431	100	1, 1, 2, 2-tetrabromo-ethane	$C_2H_2Br_4$	25	1027	
Oil (peanut)		25	1458		1, 1, 2, 2-tetrachloro-ethane	$C_2H_2Cl_4$	25	1147	1.156 (15℃)
Oil (sperm)		25	1440		Tetrachloroethane	$C_2H_2Cl_4$	20	1170	1.19
Oil, 6		22	1509		Tetrachloroethene	C_2Cl_4	25	1036	
2, 2-oxydiethanol	$C_4H_{10}O_3$	25	1586		Tetrachloro-Methane	CCl_4	25	926	0.607
Pentachloroethane	C_2HCl_5	25	1082		Tetradecane	$C_{14}H_3O$	20	1331	2.86
Pentalin	C_2HCl_5	25	1082		Tetraethylene glycol	$C_8H_{18}O_5$	25	1586	
Pentane	C_5H1_2	25	1020	0.363	Tetrahydro-1, 4-isoxazine	C_4H_9NO	25	1442	
n-pentane	C_5H1_2	20	1032	0.366	Toluene	C_7H_8	20	1328	0.644
Perchlorocyclo-pentadiene	C_5Cl_6	25	1150		o-toluidine	C_7H_9N	25	1618	4.394 (20℃)
					p-toluidine	C_7H_9N	25	1480	1.863 (50℃)
Perchloroethylene	C_2Cl_4	25	1036		Toluol	C_7H_8	25	1308	0.58
Perchloro-1-hepten	C_7F_{14}	25	583		Tribromomethane	$CHBr_3$	25	918	0.654
Perfluoro-n-hexane	C_6F_{14}	25	508		1, 1, 1-trichloro-ethane	$C_2H_3Cl_3$	25	985	0.902 (20℃)
Phene	C_6H_6	25	1306	0.711	Trichloro-ethene	C_2HCl_3	25	1028	
β-phenyl acrolein	C_9H_8O	25	1554		Trichloro-fluoromethane (Freon 11)	CCl_3F	0	828.3	
Phenyl amine	$C_6H_5NO_2$	25	1639	3.63					
Phenyl bromide	C_6H_5Br	20	1170	0.693	Trichloro-methane	$CHCl_3$	25	979	0.55
Phenyl chloride	C_6H_5Cl	25	1273	0.722	1, 1, 2-trichloro-1, 2, 2-trifluoro-etham	CCl_2F-$CClF_2$	0	783.7	
Phenyl iodide	C_6H_5I	20	1114	0.954(15℃)					
Phenyl methane	C_7H_8	20	1328	0.644	Triethylamine	$C_6H_{15}N$	25	1123	
3-Phenyl propenal	C_9H_8O	25	1554		Triethylene glycol	$C_6H_{14}O_4$	25	1608	
Phthalardione	$C_8H_4O_3$	152	1125		1, 1, 1-trifluoro-2-chloro-2-bromo-ethane	$C_2HClBrF_3$	25	693	
Pimelic ketone	$C_6H_{10}O$	25	1423						
Plexiglas, lucite, acrylic		25	2651		1, 2, 2-trifluorotrichlo-ethane (Freon 113)	CCl_2F-$CClF_2$	0	783.7	
Refrigerant 11	CCl_3F	0	828.3						
Propane	C_3H_8	-45	1003		d-1,3,3-trimethylnorcamphor	$C_{10}H_{16}O$	25	1320	0.22
1, 2, 3-propanetriol	$C_3H_8O_3$	25	1904	$0.757x10^{-3}$	Trinitrotoluene	$C_7H_5(NO_2)_3$	81	1610	
1-propanol	C_3H_8O	20	1222		Turpentine		25	1255	1.4
2-propanol	C_3H_8O	20	1170	2.718	Unisis 800		25	1346	
2-propanone	C_3H_6O	25	1174	0.399	Water, distilled	H_2O	20	1482	1.00
Propene	C_3H_6	-13	963		Water, heavy	D_2O	20	1388	1.129
n-propyl acetate	$C_5H_{10}O_2$	2	1280		Water, sea		20	1520	1.00
n-propyl alcohol	C_3H_8O	20	1225	2.549	Wood alcohol	CH_4O	25	1076	0.695
Propylchloride	C_3H_7Cl	25	1058	0.378	m-xylene	C_8H_{10}	20	1343	0.749 (15℃)

Propylene	C_3H_6	-13	963		o-xylene	C_8H_{10}	25	1331.5	0.903 (20℃)
Pyridine	C_6H_5N	25	1415	0.992(20℃)	p-xylene	C_8H_{10}	20	1334	0.662
Refrigerant 11	CCl_3F	0	828.3		Xylene hexafluoride	$C_8H_4F_6$	25	879	0.613
Refrigerant 12	CCl_2F_2	-40	774.1						

9. 4 Material Sound Velocity(at 25℃)

Unit : Velocity (m/s)

Pipe material	Sound velocity	Pipe material	Sound velocity	Pipe material	Sound velocity
Steel 1% Carbon,hardened	**3150**	CuNi (90%Cu 10%Ni)	**2060**	Zinc, rolled	**2440**
Carbon Steel	**3206**	Brass (Naval)	**2270(2050)**	Glass, Pyrex	**3276(3280)**
Mild Steel	**3235**	Gold(hard-brawn)	**1200**	Glass, heavy silicate flint	**2380**
Steel 1% Carbon	**3220**	Inconel	**3020**	Glass,light borate crown	**2840**
Stainless Steel 302	**3120**	Iron (electrolytic)	**3240**	Nylon	**2400**
Stainless Steel 303	**3120**	Cast Iron	**2460(3230)**	Nylon,6-6	**1070**
Stainless Steel 304	**3206**	Lead	**2170**	Polyelathylene	**1950**
Stainless Steel 316	**3175**	Teflon	**1225(1240)**	Polyethylene(HD)	**2310**
Stainless Steel 347	**3100**	Iron(Armco)	**3230**	Polyethylene(LD)	**1940**
Stainless Steel 410	**2990**	Ductile Iron	**3000**	PVC, CPVC	**2540(2400)**
Stainless Steel 430	**3360**	Monel	**2720**	Acrylic	**2730**
Aluminum	**3048(3080)**	Nickel	**2960**	Asbestos Cement	**2200**
Aluminum (rolled)	**3040**	Tin, rolled	**1670**	Cement	**4190**
Copper	**2260**	Titanium	**3150(3125)**	Mortar	**2500**
Copper (annealed)	**2325**	Tungsten,annealed	**2890**	Rubber	**1600(1900)**
Copper (rolled)	**2270**	Tungsten, drawn	**2640**	FRP	**2505**
CuNi (70%Cu 30%Ni)	**2540**	Tungsten, carbide	**3980**	Teflon 1	**1450**
Tar Epoxy	**2000**	Plastic	**2280**	ABS	**2286**

9. 5 Sound Velocity in Water（St.Pres 1.01325bar）

Unit：Temp. (℃), Velocity (m/s)

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

9.6 Pipe Schedules & Nominal Pipe Diameters – ANSI B36.10

NOR. OD	S/N	OUTDIAMETER		WALL THICKNESS		INNER DIAMETER		NOR. OD	S/N	OUTDIAMETER		WALL THICKNESS		INNER DIAMETER	
		INCH	mm	INCH	mm	INCH	mm			INCH	mm	INCH	mm	INCH	mm
1/8	10S	0.405	10.287	0.049	1.245	0.307	7.798	3	5S	3.500	88.900	0.083	2.108	3.334	84.684
	40/Std/40S			0.068	1.727	0.269	6.833		10S			0.120	3.048	3.260	82.804
	80/XS/80S			0.095	2.413	0.215	5.461		40/Std/40S			0.216	5.486	3.068	77.927
1/4	10S	0.540	13.716	0.065	1.651	0.410	10.414		80/XS/80S			0.300	7.620	2.900	73.660
	40/Std/40S			0.088	2.235	0.364	9.246		160			0.438	11.125	2.624	66.650
	80/XS/80S			0.119	3.023	0.302	7.671		XXS			0.600	15.240	2.300	58.420
3/8	10S	0.675	17.145	0.065	1.651	0.545	13.843	3 1/2	5S	4.000	101.600	0.083	2.108	3.834	97.384
	40/Std/40S			0.091	2.311	0.493	12.522		10S			0.120	3.048	3.760	95.504
	80/XS/80S			0.126	3.200	0.423	10.744		40/Std/40S			0.226	5.740	3.548	90.119
1/2	10S	0.840	21.336	0.083	2.108	0.674	17.120		80/XS/80S			0.318	8.077	3.364	85.446
	40/Std/40S			0.109	2.769	0.622	15.799	4	5S	4.500	114.300	0.083	2.108	4.334	110.084
	80/XS/80S			0.147	3.734	0.546	13.868		10S			0.120	3.048	4.260	108.204
	160			0.188	4.775	0.464	11.786		40/Std/40S			0.237	6.020	4.026	102.260
	XXS			0.294	7.468	0.252	6.401		80/XS/80S			0.337	8.560	3.826	97.180
3/4	5S	1.050	26.670	0.065	1.651	0.920	23.368		120			0.438	11.125	3.624	92.050
	10S			0.083	2.108	0.884	22.454		160			0.531	13.487	3.438	87.325
	40/Std/40S			0.113	2.870	0.824	20.930		XXS			0.674	17.120	3.152	80.061
	80/XS/80S			0.154	3.912	0.742	18.847	5	5S	5.563	141.300	0.109	2.769	5.345	135.763
	160			0.219	5.563	0.612	15.545		10S			0.134	3.404	5.295	134.493
	XXS			0.308	7.823	0.434	11.024		40/Std/40S			0.258	6.553	5.047	128.194
1	5S	1.315	33.401	0.065	1.651	1.185	30.099		80/XS/80S			0.375	9.525	4.813	122.250
	10S			0.109	2.769	1.097	27.864		120			0.500	12.700	4.563	115.900
	40/Std/40S			0.133	3.378	1.049	26.645		160			0.625	15.875	4.313	109.550
	80/XS/80S			0.179	4.547	0.957	24.308		XXS			0.750	19.050	4.063	103.200
	160			0.250	6.350	0.815	20.701	6	5S	6.625	168.275	0.109	2.769	6.407	162.738
	XXS			0.358	9.093	0.599	15.215		10S			0.134	3.404	6.357	161.468
1 1/4	5S	1.660	42.164	0.065	1.651	1.530	38.862		40/Std/40S			0.280	7.112	6.065	154.051
	10S			0.109	2.769	1.442	36.627		80/XS/80S			0.432	10.973	5.761	146.329
	40/Std/40S			0.140	3.556	1.380	35.052		120			0.562	14.275	5.501	139.725
	80/XS/80S			0.191	4.851	1.278	32.461		160			0.719	18.263	5.187	131.750
	160			0.250	6.350	1.160	29.464		XXS			0.864	21.946	4.897	124.384
	XXS			0.382	9.703	0.896	22.758	8	5S	8.625	219.075	0.109	2.769	8.407	213.538
1 1/2	5S	1.900	48.260	0.065	1.651	1.770	44.958		10S			0.148	3.759	8.329	211.557
	10S			0.109	2.769	1.682	42.723		20			0.250	6.350	8.125	206.375
	40/Std/40S			0.145	3.683	1.610	40.894		30			0.277	7.036	8.071	205.003
	80/XS/80S			0.200	5.080	1.500	38.100		40/Std/40S			0.322	8.179	7.981	202.717
	160			0.281	7.137	1.338	33.985		60			0.406	10.312	7.813	198.450
	XXS			0.400	10.160	1.100	27.940		80/XS/80S			0.500	12.700	7.625	193.675
2	5S	2.375	60.325	0.065	1.651	2.245	57.023		100			0.594	15.088	7.437	188.900
	10S			0.109	2.769	2.157	54.788		120			0.719	18.263	7.187	182.550
	40/Std/40S			0.154	3.912	2.067	52.502	8	140	8.625	219.075	0.812	20.625	7.001	177.825
	80/XS/80S			0.218	5.537	1.939	49.251		XXS			0.875	22.225	6.875	174.625
	160			0.344	8.738	1.687	42.850		160			0.906	23.012	6.813	173.050
	XXS			0.436	11.074	1.503	38.176	10	5S	10.750	273.050	0.134	3.404	10.482	266.243
2 1/2	5S	2.875	73.025	0.083	2.108	2.709	68.809		10S			0.165	4.191	10.420	264.668
	10S			0.120	3.048	2.635	66.929		20			0.250	6.350	10.250	260.350
	40/Std/40S			0.203	5.156	2.469	62.713					0.279	7.087	10.192	258.877
	80/XS/80S			0.276	7.010	2.323	59.004		30			0.307	7.798	10.136	257.454
	160			0.375	9.525	2.125	53.975		40/Std/40S			0.365	9.271	10.020	254.508
	XXS			0.552	14.021	1.771	44.983		60/XS/80S			0.500	12.700	9.750	247.650

NOR. OD	S/N	OUTDIAMETER		WALL THICKNESS		INNER DIAMETER		NOR. OD	S/N	OUTDIAMETER		WALL THICKNESS		INNER DIAMETER	
		INCH	mm	INCH	mm	INCH	mm			INCH	mm	INCH	mm	INCH	mm
10	80	10.750	273.050	0.594	15.088	9.562	242.875	18	10	18.000	457.200	0.250	6.350	17.500	444.500
	100			0.719	18.263	9.312	236.525		20			0.312	7.925	17.376	441.350
	120			0.844	21.438	9.062	230.175		Std			0.375	9.525	17.250	438.150
	140			1.000	25.400	8.750	222.250		30			0.438	11.125	17.124	434.950
	160			1.125	28.575	8.500	215.900		XS			0.500	12.700	17.000	431.800
12	5S	12.750	323.850	0.165	4.191	12.420	315.468		40			0.562	14.275	16.876	428.650
	10S			0.180	4.572	12.390	314.706					0.625	15.875	16.750	425.450
	20			0.250	6.350	12.250	311.150					0.688	17.475	16.624	422.250
	30			0.330	8.382	12.090	307.086		60			0.750	19.050	16.500	419.100
	Std/40S			0.375	9.525	12.000	304.800					0.875	22.225	16.250	412.750
	40			0.406	10.312	11.938	303.225		80			0.938	23.825	16.124	409.550
	XS/80S			0.500	12.700	11.750	298.450		100			1.156	29.362	15.688	398.475
	60			0.562	14.275	11.626	295.300		120			1.375	34.925	15.250	387.350
	80			0.688	17.475	11.374	288.900		140			1.562	39.675	14.876	377.850
	100			0.844	21.438	11.062	280.975		160			1.781	45.237	14.438	366.725
	120			1.000	25.400	10.750	273.050	20	10	20.000	508.000	0.250	6.350	19.500	495.300
	140			1.125	28.575	10.500	266.700					0.312	7.925	19.376	492.150
	160			1.312	33.325	10.126	257.200		20/Std			0.375	9.525	19.250	488.950
14	10	14.000	355.600	0.250	6.350	13.500	342.900					0.438	11.125	19.124	485.750
	20			0.312	7.925	13.376	339.750		30/XS			0.500	12.700	19.000	482.600
	30/Std			0.375	9.525	13.250	336.550					0.562	14.275	18.876	479.450
	40			0.438	11.125	13.124	333.350		40			0.594	15.088	18.812	477.825
	XS			0.500	12.700	13.000	330.200					0.625	15.875	18.750	476.250
				0.562	14.275	12.876	327.050					0.688	17.475	18.624	473.050
	60			0.594	15.088	12.812	325.425					0.750	19.050	18.500	469.900
				0.625	15.875	12.750	323.850		60			0.812	20.625	18.376	466.750
				0.688	17.475	12.624	320.650					0.875	22.225	18.250	463.550
	80			0.750	19.050	12.500	317.500		80			1.031	26.187	17.938	455.625
				0.875	22.225	12.250	311.150		100			1.281	32.537	17.438	442.925
	100			0.938	23.825	12.124	307.950		120			1.500	38.100	17.000	431.800
	120			1.094	27.788	11.812	300.025		140			1.750	44.450	16.500	419.100
	140			1.250	31.750	11.500	292.100		160			1.969	50.013	16.062	407.975
	160			1.406	35.712	11.188	284.175	24	10	24.000	609.600	0.250	6.350	23.500	596.900
16	10	16.000	406.400	0.250	6.350	15.500	393.700					0.312	7.925	23.376	593.750
	20			0.312	7.925	15.376	390.550		20/Std			0.375	9.525	23.250	590.550
	30/Std			0.375	9.525	15.250	387.350					0.438	11.125	23.124	587.350
				0.438	11.125	15.124	384.150		XS			0.500	12.700	23.000	584.200
	40/XS			0.500	12.700	15.000	381.000		30			0.562	14.275	22.876	581.050
				0.562	14.275	14.876	377.850					0.625	15.875	22.750	577.850
				0.625	15.875	14.750	374.650		40			0.688	17.475	22.624	574.650
	60			0.656	16.662	14.688	373.075					0.750	19.050	22.500	571.500
				0.688	17.475	14.624	371.450		60			0.969	24.613	22.062	560.375
				0.750	19.050	14.500	368.300		80			1.219	30.963	21.562	547.675
	80			0.844	21.438	14.312	363.525		100			1.531	38.887	20.938	531.825
				0.875	22.225	14.250	361.950		120			1.812	46.025	20.376	517.550
	100			1.031	26.187	13.938	354.025		140			2.062	52.375	19.876	504.850
	120			1.219	30.963	13.562	344.475		160			2.344	59.538	19.312	490.525
	140			1.438	36.525	13.124	333.350	30	10	30.000	762.000	0.312	7.925	29.376	746.150
	160			1.594	40.488	12.812	325.425		20			0.500	12.700	29.000	736.600
									30			0.625	15.875	28.750	730.250