ALIASONIC

Portable Transit-Time Ultrasonic Flowmeter

Model AUF610 Series

Operation Manual

CE

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1. Introduction

1.1 Preface

Welcome to the Alia AUF610 (Version 8.xx) series ultrasonic flow meter. The AUF610 is manufactured using patented technologies and is equipped with more functions and advanced performance than ever.

The latest Version 8.xx Series Ultrasonic Flow Meter is an upgrade of the Version 7.xx Series Ultrasonic Flow Meter. The new Version 8.xx retains all the excellent features and functions in previous versions including the sonic pulsed measurement technology, the ultrasonic triggering and signal receiving circuits' ability to reliably process low input signals. The main improvements affect the battery supply circuit and the transmitting circuits. These improvements have been integrated into this new version to allow us to deliver a more advanced measurement technologies and reliable ultrasonic flow meter.

The AUF610 Series flow meter incorporates the latest ICs manufactured from the famous semiconductor manufacturers like Philips and TI. The hardware is easy to use and features intuitive operation, high accuracy and outstanding reliability. The system's feature rich software provides a user friendly interface that provides the operator with access to more information for accurately monitoring and analyzing pipe flows. The AUF610 uses a patented balanced low voltage, multi-pulse, triggering circuit. This increases signal to noise ratio within the signal processing unit resulting in a meter that performs superbly in demanding industrial environments. Even in electrically noisy locations with VFD's and high voltage in close proximity the Alia AUF-610 provides superior performance.

Other outstanding features:

- The signal receiving circuits feature self-adapting performance so as to ensure that the user can easily operate the instrument without any adjustment.
- The built-in rechargeable Ni-H battery can work continuously for more than 10 hours without recharge.
- User-friendly dual language software interface (English & Chinese)

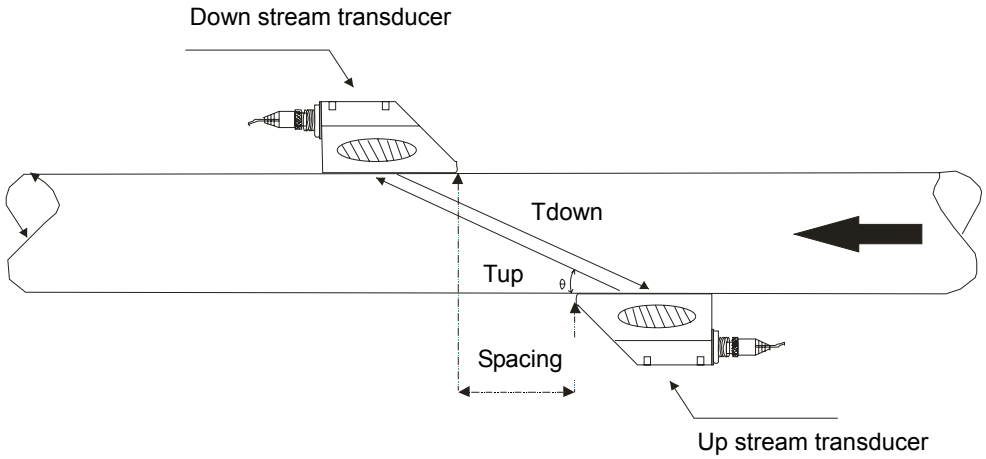
1.2 Features

* Accuracy: +/- 1.0% of velocity and +/-2% value of reading (0.5 to 30m/s) NOTE (1)
* Repeatability: 0.2% of reading
* Dual Language Display (Chinese and English)
* 4 flow totalizers
* Patent balanced low-voltage multi-pulse measuring technology
* Built-in date totalizers
* Ultrasonic triggering
* Built-in data-logger
* High Signal to noise ensures signal integrity in electrically & acoustically noisy environments
* 0.5 second totalizing period
* 100 Pico-second resolution of time measurement

1.3 Principle of Measurement

The AUF610 ultrasonic flow meter is designed to measure the fluid velocity of clean homogeneous liquids in a closed conduit. The transducers are the 'outside the pipe', non-contacting, clamp-on type. This ensures non-fouling operation and a simple, easy installation.

The AUF610 transit time flow meter utilizes two ultra-sonic transducers. Each one is both a transmitter and a receiver. The transducers are clamped on the outside of a closed pipe in a pre-determined distance from each other. The pipe size, pipe material and process (liquid) characteristics dictate where and how far apart the transducers are mounted. If sound crosses the pipe once it is called the Z-method. If the sound transverses the pipe twice it is called the V-method. If the sound transverses the pipe four times then it is known as the W-method. The flow meter operates by alternately transmitting and receiving frequency modulated bursts of sound energy between the two transducers. Once upstream and once downstream and then accurately determining the time difference between the two sonic beams and the time difference is a linear, accurate and repeatable measurement of the process velocity within the pipe. Calculating the pipe's internal area and integrating the velocity measurement over time results in the flow rate. (see.Figure)



$$v = \frac{M * D}{SIN\ 2\theta} \times \frac{\triangle T}{Tup * Tdown}$$

Figure

NOTES:

Θ = the angle to the flow direction

M = the transit time of the ultrasonic beam

D = the pipe diameter

Tup = the downstream transit time

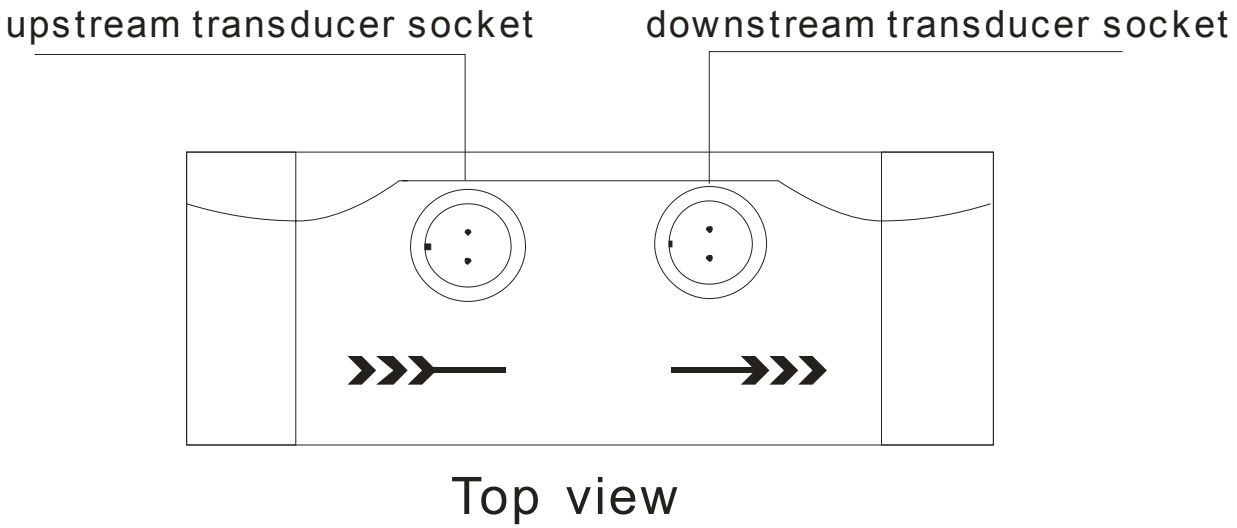
Tdown = the upstream transit time

△ T = Tup -Tdown

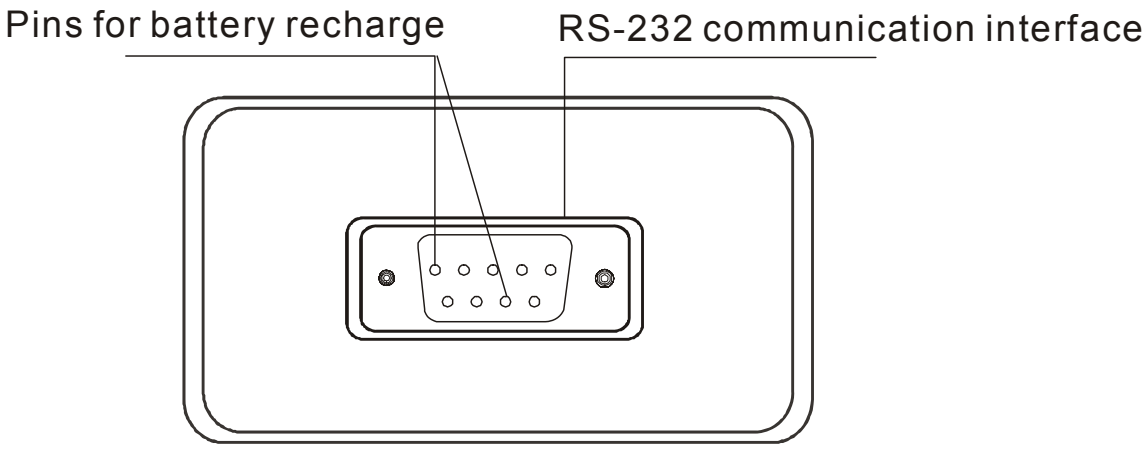
1.4 Product identification

Each AUF610 Series flow meter has a unique product identification or ESN# written in the software and can only be accessed by the manufacturer. In the case of an equipment failure, this number, located on 0menu window M61, MUST be provided when contacting the manufacturer.

1.5 Parts Identification

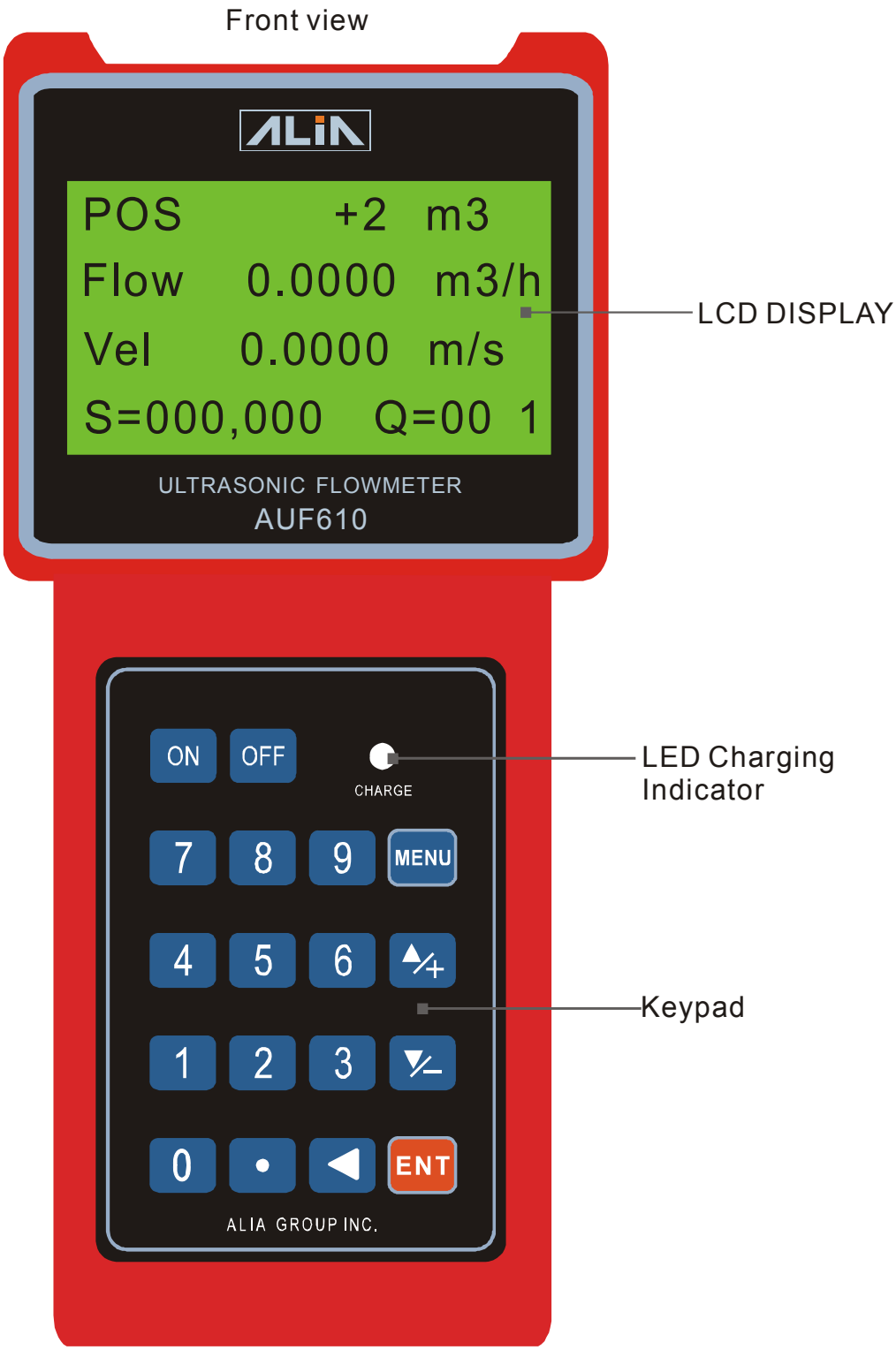


Top view

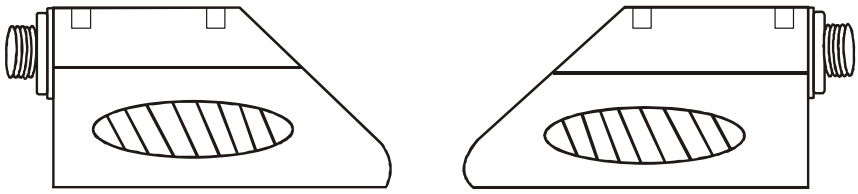


bottom view

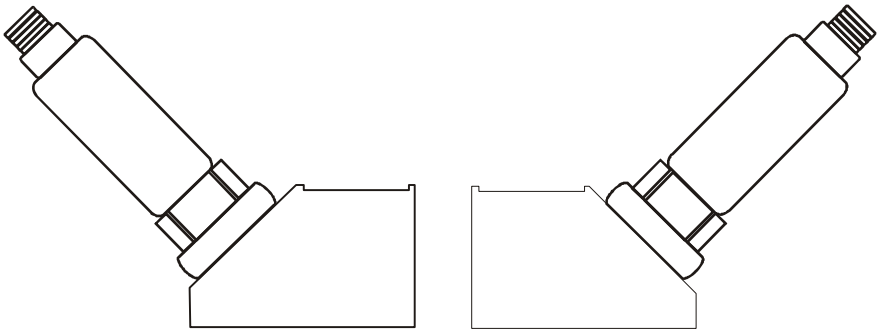
AUF 610 HANDHELD



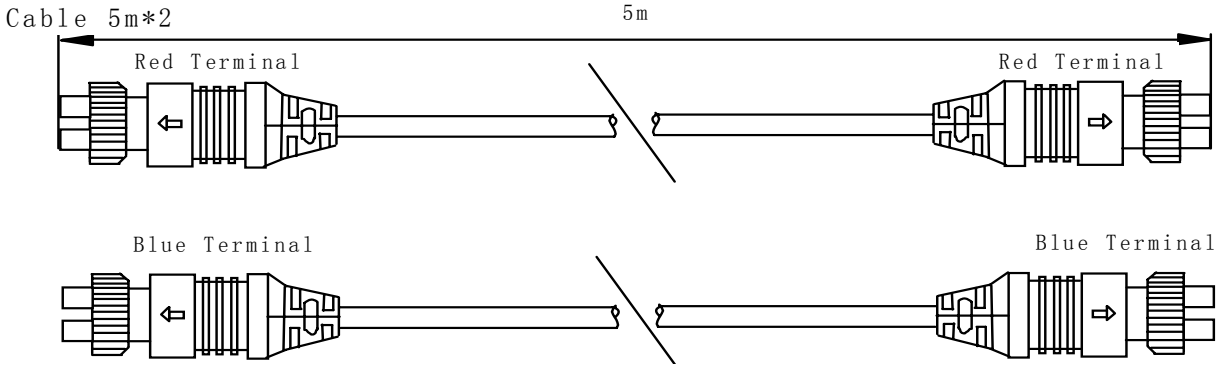
Standard Type Temperature Sensor (15mm~6000mm)



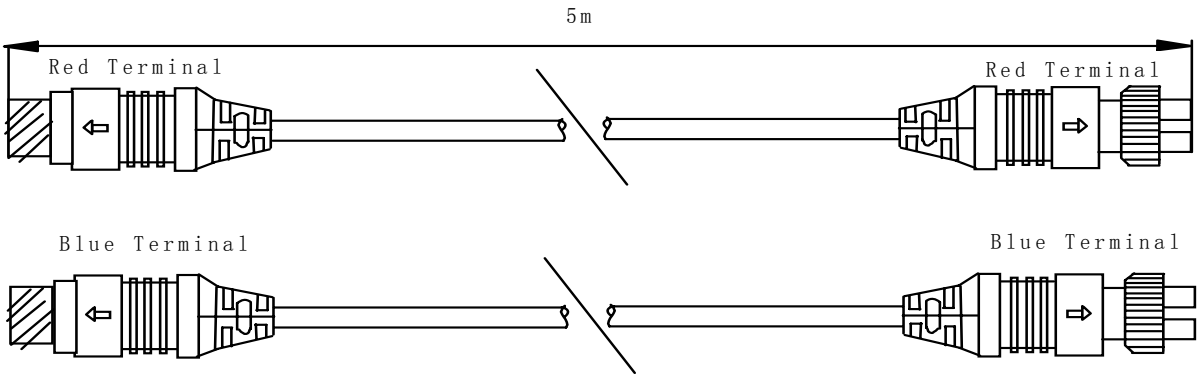
High Temperature Type Sensor (15mm~1000mm)



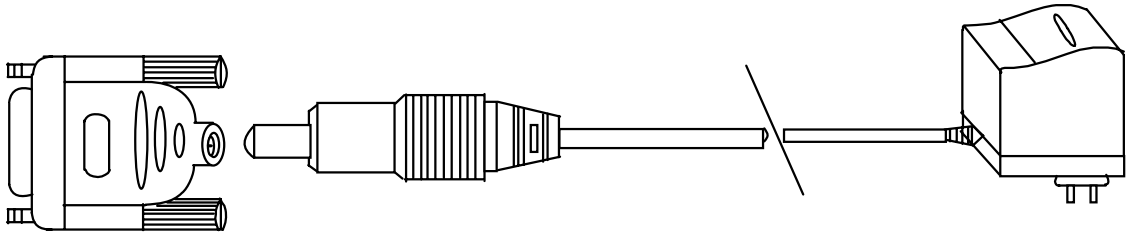
Transducer Standard Cables : 5M



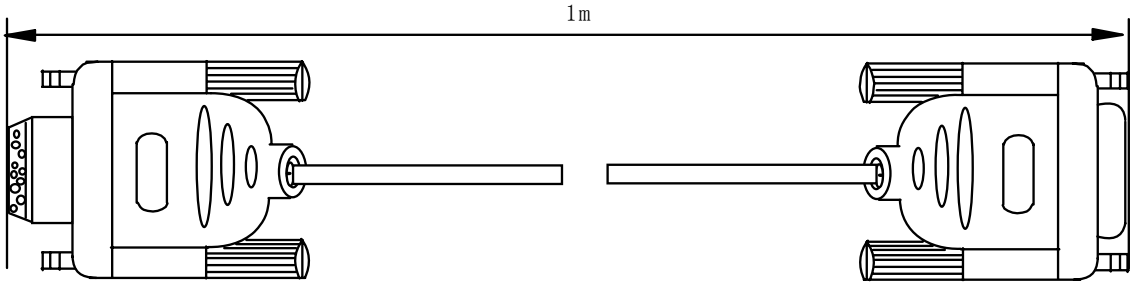
Transducer Expansion Cables : 5M



HandHeld Power Supply Cable



HandHeld RS-232 Interface



1.6 Typical Applications

The AUF610 flow meter can be applied to a wide range of measurements. The measured pipe ranges 15~6000 mm [1/2”~240”]. The AUF610 will measure a broad range of clean homogeneous liquid processes including ultra-pure liquids, potable water, chemicals, reclaimed water, cooling water, river water, plant effluent, etc. The instrument transducers are mounted outside the pipe and are therefore not in contact with the process and have no moving parts. The flow meter is not affected by system pressure, fouling or wear as would an orifice plate. The High Temperature Type AUF610 transducers are rated to 160℃. Higher temperature ratings can be achieved by using special transducers. Please contact your Alia representative for further details and assistance.

1.7 Data Integrity and Built-in Time-Keeper

All user-configured values are retained in non-volatile flash memory that will retain its memory for over 100 years regardless of power status. Password protection is provided to avoid inadvertent configuration changes or totalizer resets.

A time-keeper is integrated in the flow meter for the indexing of date totalizing. It also works as the time base for the of flow totalizer. It keeps operating as long as the battery's terminal voltage is over 1.5V. In case of total battery failure, the time-keeper will not keep running and it will lose the correct time. The user must re-enter the proper time in these instances. An improper actual time has no other affect but date indexing.

1.8 Specifications

Linearity	0.5%
Repeatability	0.2% value of Reading
Accuracy	±1% (R) +/- 2% value of reading (0.5 to 30 m/sec)
Response Time	0-999 seconds, user-configurable
Velocity	±32m/s
Pipe Size	15mm-6000mm
Rate Units	Meter, Feet, Cubic Meter, Liter, Cubic Feet, USA Gallon, Imperial Gallon, Oil Barrel, USA Liquid Barrel, Imperial Liquid Barrel, Million USA Gallons. User configurable.
Totalizer	7-digit totals for net, positive and negative flow
Liquid Types	Clean , homogeneous liquids
Security	Setup values Modification Lockout. Access code needs unlocking
Display	4*8 Chinese characters or 4*16 English letters
Communication Interface	RS-232C, Baud-rate: from 75 to 57600. Manufacturer's protocol Same as FUJI ultrasonic flow meter. Driver data available on demand, User protocols can be made on enquiry.
Transducers	Model M1 for standard, other 3 models for optional
Transducer Cord Length	Standard 2*5 meters, optional 2*10 meters
Power Supply	3 AAA Ni-H built-in batteries. When fully recharged it will last over 10 hours of operation. 100V~240VAC for the charger
Data Logger	Built-in data logger can store over 2000 lines of data
Manual Totalizer	7-digit press-key-to-go totalizer for calibration
Housing Material	ABS
Case Size	100*66*20MM
Handset Weight	514(1.2 lbs) with batteries

2. Making a Measurement

2.1 Built-in Battery

The instrument can operate either from the built-in Ni-H rechargeable battery, which will last over 10 hours of continuous operation when fully recharged, or from an external AC/power supply from the battery charger. The battery charging circuitry utilizes both constant-current and constant-voltage. This allows fast charging initially and then reverting to trickle charge when the battery nears the full recharge. Generally, when the green LED starts to turn on, the battery is nearly 95% charged. When the red LED is off, the battery will be 98% recharged.

Trickle charging ensures that over-recharging is never a concern. The charger can if fact remain connected to the handset for tests or monitoring situations requiring more time than the standard battery life.

A fully charged battery will show an internal battery terminal voltage of approximately 4.25V. The terminal voltage and an approximate battery time remaining are displayed on window M07. Please note that the estimator is not an exact indication of time remaining but only estimation. Use the Mains power supply for long term testing. It is NOT advisable to run the system below a 3.0V level at the terminals.

2.2 Power Up Self-Check

Press the ON key to switch on the instrument and press the OFF to turn off the power. Once the flow meter is switched on, it will run a self diagnostic program, checking first the hardware and then the software integrity. If there are any issues, an error message will appear on the display. Table 3 in Section 5 on Troubleshooting will explain any errors and advise of corrective action.

Following the startup self-diagnostics, the flow meter will display Menu Window Number 01 (M01). This windows displays the Process Velocity, the calculated Flow Rate, the Positive Totalizer (+), Signal Strength and Signal Quality. All these values are based on the application parameters last configured in the AUF610 handheld.

The flow measurement program always operates in the background of the user interface.

2.3 Keypad

The keypad for the operation of the flow meter has 18 keys, as shown by the diagram below. Keys 0 to 9 and the . key are for entering numerical values.
The ▲/+ and ▼/- keys move the screen cursor up & down the menu window. They also acts as the+/-keys when entering numerical values. The ◄ key is for backspacing or when there wants to move left or backspace the character that is located to the left of the cursor. The ENT key is used to ENTER data or inputting any selections.
The MENU key (referred to as the M key) allows direct access to all the menu items listed later in this manual. Pressing the MENU button followed by a two digit number will cause the user to be immediately directed to that menu item. The ON key is for power on. The OFF key is for power off.

2.4 Key Board Entry

The flow measurement (and totalizers) will continue to run no matter what user menu window is being browsed or viewed. The flow measurement will only change when the user enters new application parameters. Whenever a modification to the flow metering system is made that affects the sound path the meter will automatically determine the threshold of transmitted signal and adjust the gain on the receiving signal amplifiers. An internal counter monitors the progress of this operation. The progress is shown on the right lower corner of the LCD display. Examples are new pipe parameters, the power is switched on or the transducers have been adjusted on the pipe. All user entered configuration values are retained in NVRAM of the flow meter, until modified by the user. Frequently used configurations can be stored in one of up to 18 memory locations for rapid recall and setup. (Use menu location M27)

2.5 Menu Item Organization

M00~M09 items display REAL_TIME DATA including: flow rate, process velocity, date/ time, totalizers, battery voltage and estimated working hours for the battery.

M10~M29 items relate to entering pipe parameters.

M30~M38 items permit flow rate unit and totalizer unit set up.

M40~M49 items allow adjust the meter for process dynamics including response time, zeroing, calibration and modification password setup.

M50~M53 items are for the built-in logger.

M60~M78 items are for time-keeper initialization, version and ESN information viewing and alarms.

M82 is for viewing date totalizer.

M90~M94 items are diagnostic values used to optimize or confirm the meter's operation.

M97~M99 are commands used to force the output of internal data.

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

There are three types of menu windows:

(1) Numerical entry windows (i.e. M11 for the entering of pipe OD)

(2) An entry window for selecting options. (i.e.M14 for the selection of pipe materials)

(3) Display windows (i.e. M01 displays process conditions)

2.6 Menu Windows

The user interface of this flow meter comprises about 100 different menu windows that are numbered by M00, M01, M02…M99.

There are 2 methods to enter menu windows:

(1) Directly going/entering. The user can press the MENU key plus two-digit number Keys. For example, the menu window M11 is for the entering of pipe outer diameter. The display will go to the M11 menu window after the user presses MENU 1 1, then press the ENT key and enter a value. Pressing the ENT key again will enter the value.

(2) Pressing ▲/+ and ▼/- keys. Each time the ▼/- key is pressed the menus will advance to the next item in order. For example, if the current window is on M12, the display will go to the number M13 window after pressing the ▼/- key.

2.7 SET UP (Quick Start)

To begin, select the system of measurement (US or Metric) in MENU Item 30.

The user must supply any two of the following four items of pipe information. The meter will calculate the rest. *(There are tables in the appendices at the end of this manual for reference)*

- Pipe circumference (M10)
- Pipe OD (M11)
- Pipe wall thickness (M12)
- Pipe ID (M13)

Enter the following pipe data and process data in the appropriate Menu locations:

- Pipe Material (M14)
- Lined Pipe (M16)
- Process Liquid (M20)
- Transducer type (M23)
  * For Alia select either **#11** (Standard-TS) or **#12** (Standard-TM)
- Transducer Mounting Configuration (M24)

The selections on M23 & M24 are is pipe size dependent. The diagrams on pages 9, 17 & 18 will guide the user.

Handheld Menu Item 25 describes the transducer spacing that the Handheld has calculated as required for your application. It is always a good idea to scroll back through the menu items to confirm that the correct data was entered as the spacing / distance between the transducers is based on this information and is critical. *See Section 2.8 for correct transducer installation*

Now proceed to configure the units of measurement (flow rate) and the totalizer units. This is done as follows:

- Flow Rate / Time Units (M31)
- Totalizer Units (M32)
- Totalizer Multiplier (M33)
- Turn OFF or ON Totalizers (M34,35,36)
  Positive, Negative, Net Totalizers
- Totalizer reset (see Item M37 page 22)

Now, if the transducers are installed correctly and the above is done, the meter is ready to measure. Press M01. At the bottom of the window the S value and the Q value should be in the 700,000 to 800,000 and >60% respectively. This may take a few seconds as the meter adjusts its gain for the new installation.

Finally, determine if any signal is being generated at zero flow. This will show up as flow rate or flow velocity when there is NO FLOW. This can occur in environmentally noisy locations with pipe vibration. If there is a flow reading when there is no flow then the meter must be zeroed. Go to M42, Press ENTER then follow the on-screen instructions. (There is a counter to monitor progress) ENSURE THERE IS NO FLOW.

You should now be making an accurate measurement. If this is a common measurement it might be advantageous to SAVE it to a memory location (M26) for future use. Cont' next page…

Cont'… The following will facilitate the operation of this instrument:

(1) When the window display is between M00 and M09 it is only necessary to press a single digit number key to access other windows between M00 & M09.

(2) When the window display is between M00 and M09 it is only necessary to press a single digit number key to access other windows between M00 & M09.

(3) When the window display is between M00 and M09, repeated pressing the ENT key will cycle between M00 and M90.

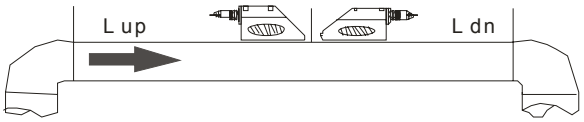
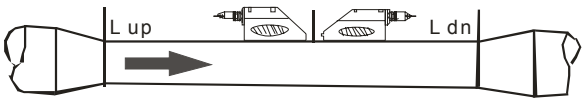
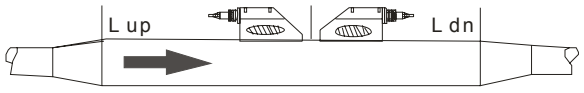
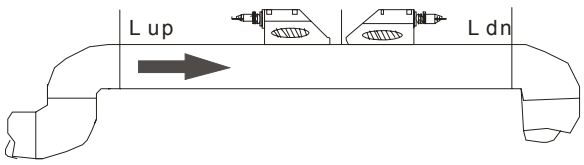
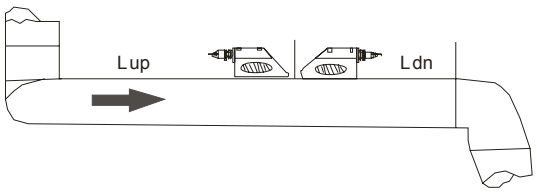
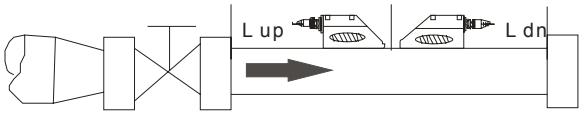
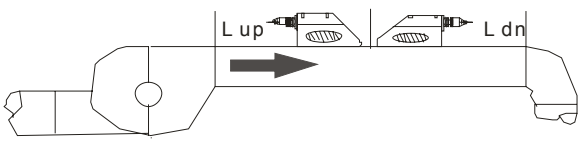
(4) When the window display is M25, press ENT key to go to M01.

2.8 Transducers Mounting / Location

The first step in the installation process is the selection of an optimum location in order to obtain better signal quality, which ensures a more reliable and more accurate measurement. For this to be completed effectively, it is best to have a basic knowledge of the hydraulic system about to be measured.

The optimum location will be length of straight pipe that is always full of process and has no bubbles. The piping can be in vertical (flow going up) or horizontal position but should have the following recommended straight lengths of pipe both upstream and downstream as defined in diameters.

TABLE 1

Piping Configuration and Transducer Position	Upstream Dimension L up x Diameters	Downstream Dimension L dn X Diameters
	10D	5D
	10D	5D
	10D	5D
	12D	5D
	20D	5D
	20D	5D
	30D	5D

Examples of optimum locations:

Guidelines for selection of optimum mounting locations:

(1) Install the transducers on a longer length of the straight pipe.

(2) Make sure that the temperature at the selected location does not exceed the range of the transducers. Generally speaking, the closer to the room temperature, the better.

(3) Consider the possibility that the pipe has coated over time.

(4) Select a straight length of a relatively newer pipe. If the conditions are not optimum, consider the coating as part of the liner for a better result.

(5) Some pipes are dual walled with a plastic line or with air in between. The system may not work in the latter case. Also the thickness between the outer pipe and the liner may vary. This can prevent or disrupt ultrasonic wave propagation. Avoid this kind of pipe. Alternately, consider permanently installed through the pipe, hot tap type transducers as available from Alia.

2.9 Transducers Installation

The transducers used by the AUF610 series ultrasonic flow meter are made of piezoelectric crystals both for transmitting and receiving ultrasonic signals. Measuring the traveling time difference of the upstream verses downstream ultrasonic signals travelling in the pipe makes the measurement. Since the measured time difference is very small, the spacing, alignment and acoustic coupling of the transducers are factors critical for the specified measurement performance of the system. Great care should be taken when installing the transducers.

Here are some guidelines:

- Locate an optimum position where the straight pipe length is sufficient, and where pipes are in a favorable condition, e.g., newer pipes with no rust and ease of operation.
- Clean any dust and rust. For a better result, polishing the pipe with a sander is recommended.
- Apply adequate coupling grease to the spot where the transducers are to be installed and leave no gap between the pipe surface and the transducers.
- Extra care should be taken to avoid any sand or dust particles left between the pipe outer surface and the transducers.
- To avoid gas bubbles inside the upper part of the pipe, the transducers should be installed on the side of the pipe at the 2:00/10:00, 3:00/9:00 or 4:00/8:00 o'clock positions.

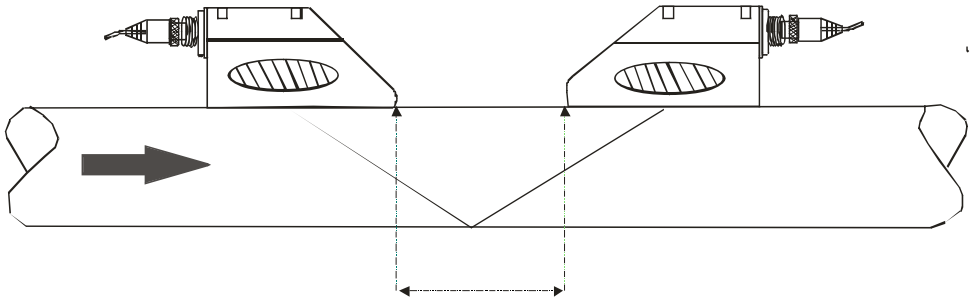
2.9.1 Transducers Spacing

The spacing value shown on menu window M25 refers to the distance of inner spacing between the transducers. It is calculated based on the preliminary pipe data, sonic path info (see 2.9.2 below) and process information entered by the user in the previous menu items. If the spacing does not sound right (i.e. spacing of 2" on a 10" pipe then checks the setup figures. Data can get entered incorrectly especially with inexperienced users. The spacing is important，and should be measured from the indicator which is an integral part of each transducer assembly.

As important as the Transducer spacing is the 'bounce pattern' of the Ultra sonic signal. This is described below.

2.9.2 V-method Installation

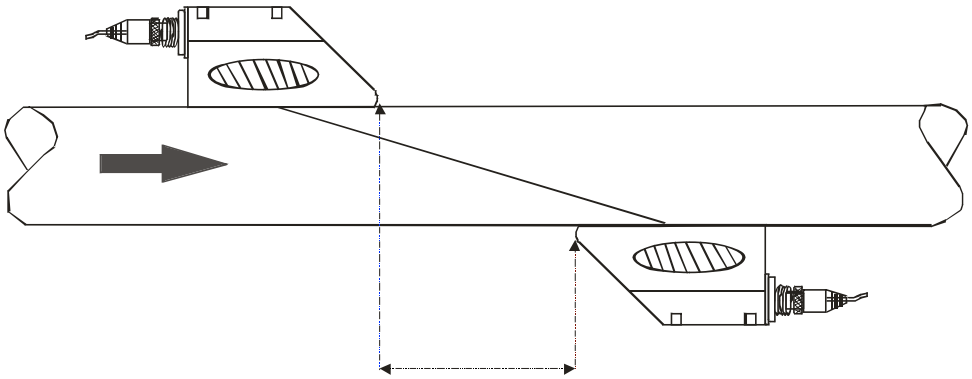
V-method installation is the most commonly used mode. It is used most frequently on pipes with ID's ranging from 15 millimeter to 400 millimeter. It is also called reflective mode or single bounce method.



TOP VIEW OF PIPE
sensors spacing

2.9.3 Z-method Installation

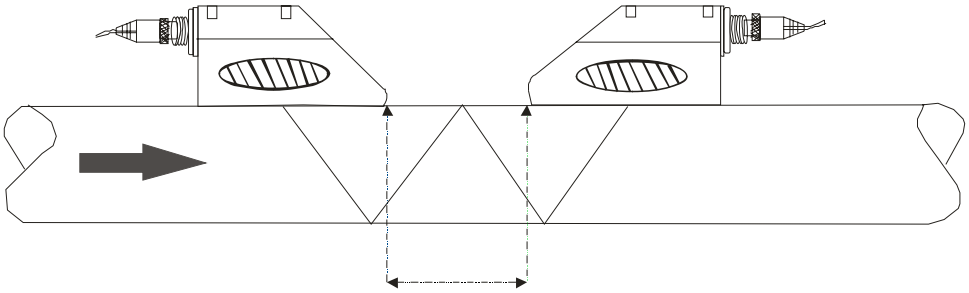
Z-method is commonly used when the pipe diameter is between200millimeters and 6000 millimeters.



TOP VIEW OF PIPE
sensors spacing

2.9.4 W-method Installation (not used as often but has its' applications)

W-method is usually used on plastic pipes with a diameter from 15 millimeters to 50 millimeters



TOP VIEW OF PIPE
sensors spacing

2.10 Installation Verification

During the process of the installation, one can: check the receiving signal strength, the signal quality Q value, the transit time differential of the signals, the estimated speed of sound in the process, the measured traveling time of the signals and the calculated traveling time ratio. Therefore, optimum measurement results and successful results can be achieved.

2.10.1 Signal Strength

Signal strength indicates the amplitude of the received ultrasonic signals in the form of an arbitrary 3-digit number. “000” is no signal detected and 999 indicates that the maximum signal strength available has been received.

The instrument will provide a reliable measurement if the signal strength ranges from 500 to 999, however the stronger the signal the better. The instrument continually updates the flow reading by time averaging the received velocity signal. Therefore a stronger signal ensures fewer situations a signal path is compromised possibly affecting the overall flow rate and total. The following methods help optimize signals:

(1) Relocate a more favorable location, if the current location is not good enough for a stable and reliable flow reading, or if the signal strength is lower than 700.

(2) Try to polish the outer surface of the pipe, and apply more ‘grease’ coupler to increase the signal strength.

(3) Adjust the transducers both vertically and horizontally while checking the varying signal strength, stop at the highest position, and then check the transducers spacing to make sure the transducers spacing is the same as what the M25 shows.

2.10.2 Signal Quality

Signal quality is indicated on the lower right-hand side of the display and denoted as ‘Q’. The higher a Q value the better the guarantee of a reliable measurement. Under normal pipe condition, the Q value is in the range 60-90%. Causes for a lower Q value could be:

(1) Interference of other instruments and devices such as high powered electrical equipment working nearby. Relocate the flow meter to a new place where the interference will be reduced.

(2) Bad sonic coupling for the transducers with the pipe. Try to apply more coupler or clean the surface, etc

(3)Pipe location is bad. Relocation is recommended.

2.10.3 Total Transit Time and Delta Time

The numbers displayed on menu window M93 are called total transit time and delta time respectively. They are the raw data the instrument uses to calculate the flow velocity inside the pipe. The flow velocity / rate indication is a function of the total time and delta time. The total transit time should remain stable or vary little. If the delta time fluctuates higher than 20%, it means there are probably issues with the transducer installation.

2.10.4 Time Ratio between the Measured Total Transit Time and the Calculated Time

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

(1) If the pipe parameters are correctly entered.

(2) If the actual spacing of the transducers is right and the same as what the window M25 shows.

(3) If the transducers are installed properly in the right directions.

(4) If the mounting location is good and if the pipe has changed shape or if there is too much fouling inside the pipes.

(5) Other issues or conditions not conducive to Ultra sonic measurement..

3. How to Use

3.1 How to determine if the instrument is working properly?

When ‘R’ is displayed in the lowest right corner of LCD display, the instrument is working properly, generally speaking.

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

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

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

3.2 How to judge the liquid flowing direction?

(1) Make sure that the instrument works properly

(2) Check the flow rate for the indication. If the displayed value is POSITIVE, the direction of the flow will be from the RED transducers to the BLUE transducers; if the displayed value is NEGATIVE, the direction will be from the BLUE transducers to the RED transducers;

3.3 How to change between units systems?

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

3.4 How to select a required flow rate unit?

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

3.5 How to use the totalizer multiplier?

Use window M33 to select a proper totalizer. Make sure that the totalizer pulse rate is appropriate for the application, the receiving instrument yet still output the resolution necessary to properly characterize the flow.

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

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

3.6 How to open or shut the totalizers?

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

3.7 How to reset the totalizers?

Use M37 to reset each respective totalizer.

3.8 How to restore factory default setting?

Use M37, when the ‘selection’ message is displayed. Press the dot key first and the message ‘Master Erase’ will display, then press the backspace ◀ key. The master erase step will erase all the parameters entered by the user and setup the instrument with default values.

3.9 How to use the damper?

The damper acts as a filter for a stable reading. If ‘0’ is entered in window M40 that means there is no damping. A larger number slows down the instrument’s response causing it to appear more stable. However remember that a larger setting will prevent a quick response in a dynamic situation..

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

3.10 How to use the zero-cutoff function?

The number displayed in window M41 is called the low-flow cutoff value. The flow meter will replace these any flow rate below this value with zero. This is used in situation where hydraulic or ambient noise is causing a flow reading in a pipe where there is no flow. This ensures that the flow meter will not totalize false value.

3.11 How to setup a zero point?

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

Make sure that the flow is absolutely stopped, then run the function in window M42 by pressing the ENT key.

3.12 How to get a scale factor for calibration?

A scale factor is the ratio between the 'actual flow rate' and the indicated value by the flow meter. Knowledgeable plant personnel should only use this as properly set up the meter is accurate.

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

3.13 How to use the operation locker?

The system locker provides a means of preventing inadvertent configuration changes or totalizer resets. When the system is locked, menu window browsing can be done without affecting any change, but any modifications are prohibited.

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

3.14 How to use the built-in data logger?

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

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

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

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

Logging data can be redirected to the RS-232C interface without being stored into the logger buffer.

Use M53 to view the data in the logger buffer.

Dumping the logging data through the RS-232C interface and the clearing of the buffer can be operated with a function in window M52.

3.15 How to use the Frequency Output?

There is a Frequency Output in all AUF610 series flow meters. This frequency output signal, which represents the flow rate, is intended to connect with other instruments.

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

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

Enter the frequency range in window M67.

For example, assume that the flow rate varies in a range 0m3/h to 3000m3/h, and an output signal is at a maximum frequency of 200Hz is going to be required for other instrumentation. The user should enter 0 in M68 AND 3000IN M69, and enter 200 and 1000 in window M67.

Please note that the user has to make the selection with OCT setups in window M78 by selecting the 13 option reading like 'FO output' to direct the frequency output to the OCT OUTPUT hardware device.

3.16 How to use the Totalizer Pulse Output?

The totalizer output will produce a pulse output with every unit flow of the totalizer .

Refer 3.4 and 3.5 for the setups of the totalizer units and multiplier.

The totalizer pulse output can only be realized by mapping the pulse output to the OCT or BUZZER hardware devices.

For example, assume that the POS totalizer pulse output is needed, and every pulse should represent 0.1 cubic meter of liquid flow; the pulse output will be mapped to the internal Buzzer, so that with every 0.1 cubic meter of flow the BUZZER will beep for a while.

The following setups should be taken/performed:

(1) Select the unit Cubic Meter under window M32.

(2) Select the Multiplier as '2. x0.1' under window M33.

(3) Select the output option '9. POS INT Pulse' under window M77. (INT stands for totalized)

3.17 How to produce an alarm signal?

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

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

(1) Alarms on when there is no receiving signal

(2) Alarms on when there is poor signal received.

(3) Alarms on when the flow meter is not in normal measurement modes.

(4) Alarms on reverse flow.

(5) Alarms on the overflow of the Frequency Output.

(6) Alarms on when the flow is out of a designated range set by the user.

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

For example, assume that the Buzzer should start beeping when the flow rate is less than 300m3/h and greater than 2000m3/h, the following steps for setups would be recommended.

(1) Enter 300 under M73 for #1 alarm low flow rate.

(2) Enter 2000 under M74 for #1 alarm high flow rate.

(3) Select the item reading like '6. Alarm #1' under M77.

3.18 How to use the built-in Buzzer?

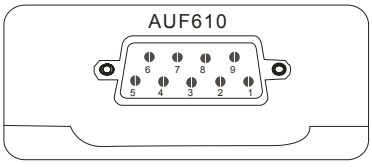
The built-in buzzer is user-configurable. It can be used as an alarm. Use M77 for setups.

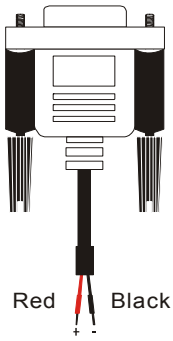
3.19 How to use the OCT output?

The OCT output is user-configurable, which can be performed by selecting the proper input source such as pulse output. Use M78 for the setups.

Please make sure that the Frequency Output shares the OCT.

The OCT output shares pins with the RS-232C interface, and the terminal is at Pin **6** and the ground is at Pin **5.**





Max. Outer pressure V: 24VDC

3.20 How to modify the built-in calendar?

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

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

3.21 How to adjust the LCD contrast?

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

3.22 How to use the R232 serial interface?

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

3.23 How to view the Date Totalizers?

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

3.24 How to use the Working Timer?

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

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

3.25 How to use the manual totalizer?

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

3.26 How to check the ESN and other details?

Every set of the AUF610 series flow meter utilizes a unique ESN to identify the meter. The ESN is an 8-digit number that provides the information of version and manufacturing date.

The user can also employ the ESN for instrumentation management.

The ESN is displayed in window M61.

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

3.27 How to know how long the battery will last?

Use M07 to check how long the battery will last. Also please refer to 2.1

3.28 How to charge the built-in battery?

Refer to 2.1

4. Menu Window Details (Table 2)

TABLE 2

MENU #.	FUNCTION DETAIL
M00	Display three positive negative net totalizers, signal strength, signal quality and working status.
M01	Display POS totalizer, flow rate, velocity, signal strength, signal quality and working status
M02	Display. NEG totalizer, flow rate, velocity, signal strength, signal quality and working status
M03	Display NET totalizer, flow rate, velocity signal strength, signal quality and working status
M04	Display date and time, flow rate, signal strength, signal quality and working status
M05	Display date and time, velocity, signal strength, signal quality and working status
M06	Display the wave shape of the receiving signal
M07	Display the battery terminal voltage and its estimated lasting time
M08	Display the all the detailed working status, signal strength, signal quality
M09	Display today's total flow, velocity, signal strength, signal quality and working status
M10	Window for entering the outer perimeter of the pipe
M11	Window for entering the outer diameter of the pipe 0 to 6000mm is the allowed range of the value
M12	Window for entering pipe wall thickness
M13	Window for entering the inner diameter of the pipe
M14	Window for selecting pipe material Standard pipe materials (that the user need not know the speed) include: carbon steel (1) stainless steel (2) cast iron (3) ductile iron (4) copper (5) PVC (6) aluminum (7)asbestos (8) fiberglass
M15	Window for entering the pipe material speed only for non-standard pipe materials
M16	Window for selecting the liner material, select none for pipes without any liner Standard liner materials that the user need not know the speed include: (1) Tar Epoxy (2)Rubber (3)Mortar (4) Polypropylene (5) Polystryol (6)Polystyrene (7)Polyester (8)Polyethylene (9)Ebonite (10)Teflon
M17	Window for entering the liner material speed only for non-standard liner materials
M18	Window for entering the liner thickness, there is a liner
M19	Window for entering the ABS thickness of the inside wall of the pipe
M20	Window for selecting fluid type For standard liquids that the user need not know the liquid speed include: (0) Water (1) Sea Water (2) Kerosene (3) Gasoline (4) Fuel oil (5) Crude Oil (6) Propane at –45C (7) Butane at 0C (8) Other liquids (9) Diesel Oil (10) Caster Oil (11) Peanut Oil (12) #90 Gasoline (13) #93 Gasoline (14) Alcohol (15) Hot water at 125C
M21	Window for entering the fluid sonic velocity only for non-standard liquids

<table>
<tr><td>M22</td><td>Window for entering the viscosity of the non-standard liquids</td></tr>
<tr><td>M23</td><td>Window for selecting the proper transducers
There are 14 different types of transducers for selection.
If the user-type-transducers are used, 4 user type wedge parameters, which will be prompted by the software, should be entered following.
If the π type transducers are used, 3 π type transducers and pipe parameters should be entered following.
<table>
<tr><td>Model</td><td>S</td><td>M</td><td>L</td><td>HS</td><td>HM</td></tr>
<tr><td>Transducer Type</td><td>7 Clamp-on TS-1</td><td>7.Clamp-on TM-1</td><td>15. Clamp-on TL-1</td><td>12 Standard-S1</td><td>8 Standard-M1</td></tr>
</table></td></tr>
<tr><td>M24</td><td>Window for selecting the transducer mounting methods, Four methods can be selected:
(0) V - Method (1) Z - Method (2) N - Method (3) W - Method</td></tr>
<tr><td>M25</td><td>Display the transducer mounting spacing</td></tr>
<tr><td>M26</td><td>Entry to store the parameter configuration into the internal NVRAM</td></tr>
<tr><td>M27</td><td>Entry to load one set of saved parameters</td></tr>
<tr><td>M28</td><td>Select YES or NO for the instrument to determine whether or not to hold (or to keep) the last correct value when poor signal condition occurs. YES is the default setup</td></tr>
<tr><td>M29</td><td>Enter a value ranging from 000 to 999. 0 is the default value</td></tr>
<tr><td>M30</td><td>Window for selecting unit system. Default value is ‘Metric’. The change from English to Metric or vice versa will not affect the unit for totalizers.</td></tr>
<tr><td>M31</td><td>Window for selecting flow rate that will be used by the instrument afterward. Flow rate can be in.
0.Cubic (m3) 5.Cubic feet (cf)
1.Liter (l) 6.USA liquid barrel (bal)
2.USA gallon (gal) 7.Imperial Liquid barrel (ib)
3.Imperial Gallon (igl) 8.Oil barrel (ob)
4.Million USA gallon (mgl)
The flow unit time base can be per day, per hour, per minute or per second</td></tr>
<tr><td>M32</td><td>Window for selecting the totalizer’ working unit</td></tr>
<tr><td>M33</td><td>Select totalizer multiplier</td></tr>
<tr><td>M34</td><td>Turn on or turn off the NET totalizer</td></tr>
<tr><td>M35</td><td>Turn on or turn off the POS totalizer</td></tr>
<tr><td>M36</td><td>Turn on or turn off the NEG totalizer</td></tr>
<tr><td>M37</td><td>Totalizer reset
Restore the instrument to the default parameters as the manufacturer did by pressing the dot key followed by the backspace key. CAUTION: Please note the current parameters before doing restoration as this cannot be undone.</td></tr>
<tr><td>M38</td><td>Press-key-to-run or to stop totalizer for easier calibration</td></tr>
<tr><td>M39</td><td>Operational interface language selection in Chinese and English. This selection makes it possible that more than 2 billions of people on the word can read the menu.</td></tr>
<tr><td>M40</td><td>Flow rate damper for a stable value. The input range is 0 to 999 seconds.</td></tr>
<tr><td>M41</td><td>Lower flow rate cut-off to avoid invalid accumulation.</td></tr>
<tr><td>M42</td><td>Zero point setup under the condition when there is no liquid running inside the pipe.</td></tr>
</table>

M43	Clear the zero point set by the user, and restore the zero point set by the manufacturer
M44	Set up a manual flow bias. Generally this value should be 0.
M45	Scale factor for the instrument. The default value is '1'.
M46	Network environment Identification Number. Any integer can be entered except 13(0DH, carriage return), 10 (0AH, line feeding), 42 (2AH), 38, 65535. Every set of the instrument in a network environment should have a unique IDN. Please refer to the chapter for communication.
M47	System lock-out to avoid inadvertent modification of the parameters
M48	Not used
M49	Window for Network Communication Testing
M50	"Window to set up schedule for time based data saving. Selects items to be saved.
M51	Time setup for the data logger
M52	Data logging direction control. If 'To RS-232' is selected, all the data produced by data logger will be transmitted out through the RS-232 interface If 'To buffer 'is selected, the data will be stored into the built-in logger memory Buffer transferring and buffer clearing
M53	Logger buffer viewer. It functions as a file editor. Use Dot, backspace UP and DN keys to browse the buffer.
M54	Not used
M55	Nod used
M56	Not used
M57	Not used
M58	Not used
M59	Not used
M60	Settable 99-year calendar and Clock. Press ENT for modification. Use the dot key to skip the digits that need no adjusting
M61	Display Version information and Electronic Serial Number (ESN) that are unique for each AUF610 series flow mater.
M62	RS-232 setup. Baud rate & Parity – Adjustable from 75 to 115200 bps
M63	Not used
M64	Not used
M65	Not used
M66	Not used
M67	Input the frequency range for the frequency output. The biggest range is 0Hz-9999Hz. Default
M68	Enter a flow rate value that corresponds to lower frequency
M69	Enter a flow Rate value that corresponds to higher frequency
M70	LCD display backlight control. The entered value indicates how many seconds the backlight will be on with each key stroke.
M71	LCD contrast control. The LCD will become darker when a small value is entered.
M72	Working timer. It can be cleared by pressing ENT key, and then select YES.
M73	Alarm #1 Low Flow Rate Threshold value. There are two available alarm indications in the system. Either an Open Collector or a buzzer. Select in menu items M78 and M77
M74	Enter the higher flow rate value that will trigger the #1 Alarm.

M75	Enter the lower flow rate value that will trigger the #2 Alarm.
M76	Enter the higher flow rate value that will trigger the #2 Alarm.
M77	Buzzer setup. When selected the buzzer will beep when a trigger event occurs
M78	OCT (Open Collect Transistor Output) setup
M79	Not used
M80	Work as a keypad and display for another handhold set by RS-232 connected with the handset
M81	Not used
M82	View Totals by User selectable Date
M83	Not used
M84	Not used
M85	Not used
M86	Not used
M87	Not used
M88	Not used
M89	Not used
M90	Display signal strength, signal quality, time ratio on the upper right corner.
M91	Displays the Time Ratio between the Measured Total Transit Time and the Calculated time. If the pipe parameters are entered correctly and the transducers are properly installed, the ratio value should be in the range of 100±3%. Otherwise the entered parameters and the transducer installation should be checked.
M92	Displays the estimated fluid sound velocity. If this value has an obvious difference with the actual fluid sound speed, the pipe parameters entered and the transducer, then installation should be checked again.
M93	Displays total transit time and delta time (transit time difference)
M94	Displays the Reynolds number and the pipe factor used by the flow rate program.
M95	Not used
M96	Not used
M97	Command to record the pipe parameters entered by the user either to the built-in data logger or to RS-232C serial interface
M98	Command to record the diagnostic information either to the built-in data logger or to RS-232C serial interface
M99	Command to copy the current display either to the built-in data logger or to RS-232C serial interface
M+0	Browse the most recent 64 recorded instrument power-on and power-off dates and times and flow rates at each time
M+1	Displays the total working time of the instrument
M+2	Displays the last power-off date and time
M+3	Displays the last power-off flow rate
M+4	Displays the times of instrument powered on (the instrument has been powered on
M+5	A simple four operation calculator is available for field use
M+6	Not used
M+7	Not used
M+8	Not used
M+9	Not used
M-0	Entry to hardware adjusting windows only for the manufacturer

5. Troubleshooting

5.1 Power-on Error Displays and Corrective Actions

The AUF610 series ultrasonic flow meter provides an automatic power-on diagnosis for the hardware problems. When any message (with the power on) in the following table displays, counter-measures should be taken.

TABLE 3

ERROR MESSAGE	INTERPRETATION	CORRECTIVE ACTION
ROM Testing Error Segment Test Error	Internal software issue	Power on again, if this message appears again, contact the factory
Stored Data Error	The internal memory has cleared and user entered parameters	When this message displays, the user should press ENT key, and all the configuration will be restored to the
Clock Loses Time Error	Problem with the Time-keeper or the crystal oscillator.	Power on again, if this message appears again, contact the factory.
Date Time Error	Number entry error in the calendar	Initialize the calendar at MENU window M61
Reboots repetitively	Hardware problems	Contact the factory

5.2 Operational Error Codes and Corrective Actions

The AUF610 series ultrasonic flow meter will display a Code in the lower right corner with a single letter like I, R etc. on menu windows M00, M01, M02, M03, M90 and M08.

Table 4 explains the Error Codes when in operating mode and suggested corrective action.

TABLE 4

ERROR CODE	CORRESPONDING M08 MESSAGE	INTERPRETATION	CORRECTIVE ACTION
R	System Normal	No error	
I	Detect No Signal	(1)No Signals detected (2)Transducers installed improperly (3)Too much fouling (4)Pipe liners are too thick. (5)Transducer cords are not properly connected	(1) Relocate measuring location (2) Clean the spot (3) Check the cords
J	Hardware Error	Hardware problem	Contact the factory
H	PoorSig Detected	(1)Poor signal detected (2)Transducers installed improperly (3) Too much fouling (4) The pipe liners are too thick (5) Problem with transducers cords	(1)Relocate measuring place (2))Clean the spot (3) Check the cords (4) Check the coupler
Q	Frequ Output Over	The actual frequency for the Frequency Output is out of the range set by the user	Check the value entered at M66, M67, M68 and M69, and try to enter a larger value on M69

F	System RAM Error Date Time Error CPU or IRQ Error ROM Parity Error	(1)Temporary problems with RAM, RTC (2)Permanent problems with hardware	(1)power on again (2) contact factory
1 **2** **3**	Adjusting Gain	Instrument is in the progress of adjusting the gain for the signal, and the number indicates the progressive steps	
K	Empty pipe	(1)No liquid inside pipe (2)Setup error on M29	(1)Relocate where the pipe is full of liquid (2)Enter 0 on M29

5.3 Other Trouble Shooting Tips

- When the actual flow inside the pipe is flowing, but the instrument displays 0.0000 for the flow rate. The display shows 'R' (all systems A-OK) and the signal quality, the 'Q' value, is a satisfactory value?
  Check the 'Low Flow Cutoff and the 'Set Zero' function. Either setting may have been inadvertently set incorrectly. To solve this problem, either lower the 'Low Flow Cutoff' value or use the 'Reset Zero' function on menu window M43.
- The displayed flow rate is much lower or much higher than the actual flow rate in the pipe under normal working conditions.
  Possible Zero Offset value incorrectly entered in M44. Enter '0' in M44.
- Problem with transducer installation.
  There is a 'Zero Point'. Try to 'zero' the instrument by using M42 and make sure that the flow inside the pipe should be standstill.
- The battery can not work as long as the time period as indicated by M07
  Battery should be replaced due to the end of the service life.
  The battery has not been fully recharged or the recharge has been stopped too many times halfway.
- Newly changed battery does not work with the battery estimating software.
  Customizing the battery with the software should be taken. Please contact the factory.
- There is a time difference between the actual working time and the estimated one, when the terminal voltage is in the range 3.70 and 3.90 volt.
  Please refer to battery voltage for a closer estimated working time.
- If the delta time fluctuates higher than 20% (M93), it means there maybe issues with the transducer installation
  Re-locate the transducers
- If there is poor signal strength, then the signal received /transmitted ratio (M92) should be checked. This ratio should be in the range of 100±3. If this range is exceeded, the user should check the transducer installation parameters & mounting:

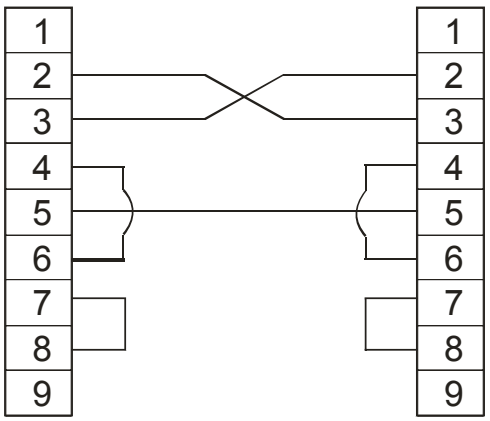
For issues NOT listed here please contact ALIA

6. Communication Protocol & Remote Operation

The AUF610 series ultrasonic flow meter integrates a standard RS-232C communication interface and a complete set of communication protocols.

6.1 Interface Pin-out Definition

1	for battery recharge, positive input
2	RXD
3	TXD
4	Not used
5	GND
6	OCT output
7	Not used
8	For battery recharge, negative input
9	RING input for connecting a MODEM



Rs232 WIRNG DIAGRAM

6.2 Communication Protocol Registers

The protocol is comprised of a set of basic commands that is a string in ASCII format, ending with a carriage (CR) and line feed (LF). Commonly used commands are listed in table 5.

TABLE 5

Command	Function	Data Format
DQD (CR)	Return flow rate per day	±d.dddddE±dd (CR) (LF) *
DQH (CR)	Return flow rate per hour	±d.dddddE±dd (CR) (LF)
DQM (CR)	Return flow rate per minute	±d.dddddE±dd (CR) (LF)
DQS (CR)	Return flow rate per second	±d.dddddE±dd (CR) (LF)
DV (CR)	Return flow velocity	±d.dddddE±dd (CR) (LF)
DI+ (CR)	Return POS totalizer	±ddddddE±d (CR) (LF)**
DI- (CR)	Return NEG totalizer	±ddddddE±d (CR) (LF)
DIN (CR)	Return NET totalizer	±ddddddE±d (CR) (LF)
DID (CR)	Return Identification Number	ddddd (CR) (LF)
DL (CR)	Return signal strength and quality	S=ddd,ddd Q=dd (CR) (LF)
DT (CR)	Return date and time	yy-mm-dd hh:mm:ss (CR) (LF)
M @ (CR)***	Send a key value as if a pressed	
LCD (CR)	Return the current window display	
FOdddd (CR)	Force the FO output with a frequency in dddd Hz	
ESN (CR)	Return the ESN for the instrument	Dddddddd (CR) (LF)
RING (CR)	Handshaking Request by a MODEM	
OK (CR)	Response from a MODEM	No action
GA	Command for GSM messaging	Please contact factory for detail
GB	Command for GSM messaging	
GC	Command for GSM messaging	
DUMP (CR)	Return the buffer content	In ASCII string format

DUMP0 (CR)	Clear the whole buffer	In ASCII string format
DUMP1 (CR)	Return the whole buffer content	In ASCII string Format, 24KB in length
W	Prefix before an Identification Number in a network environment. The IDN is a word ranging 0-65534.	
N	Prefix before an Identification Number in a network environment. The IDN is a single byte value, ranging 00-255.	
P	Prefix before any command	
&	Command connector to make a longer command by combining up to 6 commands	

Notes:

1. CR stands for Carriage Return and LF for Line Feed.
2. 'd' stands for the 0~9 digit numbers.
3. @ stands for the key value, e.g., 30H for the '0' key.

6.3 Protocol Prefix Usage

Prefix P - The prefix P can be added before any command in the above table to have the returning data followed with two bytes of CRC check sum, which is the adding sum of the original character string.
Take the DI+(CR) command as an example. Assume that DI+(CR) would return +1234567E+0m3(CR) (LF) (the string in hexadecimal is 2BH, 31H, 32H, 33H, 34H, 35H, 36H, 37H, 45H, 2BH, 6DH, 33H, 20H, 0DH, 0AH), then PDI (CR) would return +1234567E+0m3!F7 (CR) (LF). '!' acts as the starter of check sum which is yielded by adding up the string 2BH, 31H, 32H, 33H, 34H, 35H, 36H, 37H, 45H, 2BH, 30H, 6DH, 33H, 20H. Please note that there will be SPACES (20H) before '!'.
Prefix W - The prefix W should be used in the network environment. The usage format is W+ digit string which stands for the IDH + basic command. The digit string should have a value between 0 and 65534 except 13 (0DH), 10(0AH), 42 (2AH,*), 38 (26H, &). For example, if the IDN=12345 instrument is addressed and returning the velocity of that instrument is requested, the command will be W12345DV (CR).
Prefix N - The prefix N is a single byte IDN network prefix, not recommended in a new design. It is reserved only for the purpose of the compatibility with the former versions Command Connector &
The & command connector can connect up to 6 basic commands to form a longer command so that it will make the programming much easier. For example, assume that the measurement of an instrument with IDN=4321 are going to be returned, and (then) all the following 3 values--- (1) flow rate (2) velocity (3) POS totalizer---will be returned simultaneously. The combined command would be W4321DQD&DV&DI+(CR), and the result would be:
+1.234567E+12m3/d (CR)
+3.1235926E+00m/s (CR)
+1234567E+0m3 (CR)

6.4 Keypad Coding

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

KEYPAD KEY	HEX CODE KEY	DECIMAL CODE KEY	ASCII CODE
0	30H	48	0
1	31H	49	1
2	32H	50	2
3	33H	51	3
4	34H	52	4
5	35H	53	5
6	36H	54	6
7	37H	55	7
8	38H	56	8
9	39H	57	9
.	3AH	58	:
◀	3BH, 0CH	59	;
MENU	3CH, 0DH	60	<
ENT	3DH, 0DH	61	=
▲/+	3EH	62	>
▼/-	3FH	63	?

7. Warranty and Service

7.1 Warranty

ALIA responsible for 18 monthes guarantee period of all products since ex-factory date(except man-made sabotage),If there occurs quality problems with our products during this period,user only need to assume the one-way freight.(Note:Please inform our ALIA representative before product sent back.)

7.2 Service

For operational issues we recommend contacting your Alia rep by phone, fax or email. These issues can usually be resolved this way. Installation assistance for our customers is available at standard Alia service rates.

7.3 Software Upgrade Service

We provide free-of-charge software upgrade services. Please contact the factory for more information regarding availability of revisions or updates.

7.4 Product identification

Each AUF610 Series flow meter has a unique product identification or ESN# written in the software and can only be accessed by the manufacturer. In the case of an equipment failure, this number, located on menu window number M61, MUST be provided when contacting the manufacturer.

APPENDIX I

Glossary of Terms

Calibration – Calibration refers to the process of determining the relation between the output of a measuring instrument and the value of its input quantity a measurement standard. In non-specialized use, calibration is often regarded as including the process of adjusting the output or indication on a measurement instrument to agree with value of the applied standard,

Measurement Uncertainty – Measurement uncertainty is the statistical calculation of the total error exhibited by a measuring instrument as a result of a series of measurements taken and compared to a known standard. The result of a physical measurement comprises two parts: an estimate of the true value of the measurand and the uncertainty of this estimate.

Laminar Flow - Laminar flow, sometimes known as streamline flow, is when a fluid flows in parallel layers, with no disruption between the layers. In fluid dynamics, laminar flow is a flow regime characterized by high momentum diffusion, low momentum convection, pressure and velocity independent from time. It is the opposite of turbulent flow and is generally characterized by a Reynolds number less than 3000.

Random Error – (also known as Precision Error) The random error is the component of a measurement uncertainty analysis that characterizes the inherent error of the instrument based its fundamental measurement technology and the stability of the inherent parts.

Reynolds Number – The Reynolds Number is a dimensionless number in fluid mechanics that characterizes the ratio of inertial or driving forces to the restrictive or viscous force within a process.. It is used with other dimensionless numbers, to provide a criterion for determining the hydraulic flow profile and predict flow geometry within a pipe.

Systematic Error – (also known as Bias error) The systematic error is the component of a measurement uncertainty analysis that characterizes the error of the instrument caused by environmental, installation or human factors. This can often be minimized with careful installation and maintenance.

Transitional Flow – Transitional flow is the region of flow when laminar becomes turbulent and vice versa. Hydraulic characteristics are very hard to predict in this regime. A Reynolds number between-3000 – 8000 usually characterizes it.

Turbulent Flow - Turbulent flow is the flow regime characterized by chaotic, stochastic property changes. This includes low momentum diffusion, high momentum convection with rapid variations in pressure and vector velocity in space and time. A flow with a calculated Reynolds number above 6000 will be turbulent.

Turndown Ratio – Is the ratio of the maximum to minimum measured process variable between which the instrument performs to its published specification. Example: If a flow meter has an uncertainty of better than 2.0% (R) when it measures from 10 USGPM to 150USGPM the actual turndown is 15:1.

APPENDIX II

Understanding Measurement Uncertainty

As we can see from this manual the Ultra Sonic flow Meter can be a very powerful instrument. It can install on the outside of most pipes and will in most cases, measure the flow inside, sight unseen, with an uncertainly of better than 2.0 % (R). However, like all instrumentation the resultant reading is only as good as the configuration data used to set the instrument up and the transducer installation. There are many potential variables that can negatively impact the integrity of the measurement. Fortunately, with a little planning and care most outside influences can be mitigated. Further more the instrument has many troubleshooting features and measurements that allows the user to track down issues that may be affecting optimum performance.

Pointers to Be Aware of:

- Accurately determine the pipe dimensions. Is the pipe indeed round? Have assumptions that were made about the pipe size, diameter and wall thickness correct? Is the pipe perfectly circular? Plastic pipe has been know to go out of round.
- Be sure of the pipe material.
- Be sure of the process. Know the process composition, viscosity and temperature in advance or be able to determine it at site. Is it what you expected?
- Observe environmental factors. Hot Sun, vibration in the pipe, flow characteristics, electrical noise.
- Observe the system dynamics, including the pump, its position and the location of other flow disturbance inducing obstructions.
- What is the flow profile? Reynolds Number?

Measurement Uncertainty analysis is both a science and an art, but primarily a science. It consists of two error components, the random error and the systematic error. The random error is the error inherent to the basic instrument's measuring technology. The systematic error is the error added by the installation. As an example, in perfect conditions, just out of the box, an instrument's measurement accuracy (measurement uncertainty) specifications cannot exceed the values listed on the published specification data sheet. If it is incorrectly installed those values will degrade from the above described optimum situation specification. Understanding the complete system (including the hydraulics of the process, the flow meter, the receiving instrument for the flow meter & the customer's expectations etc.) will go a long way to ensuring a successful installation.

APPENDIX III (PVC Pipe Dimensions)

PVC and CPVC Pipes - Schedule 40					
Nominal	Outside	Minimum	Nominal	Weight	
Pipe Size	Diameter	Wall	Inside	(lb/100 ft)	
(inches)	(inches)	Thickness	Diameter	PVC	CPVC
		(inches)	(inches)		
1/2	0.84	0.109	0.622	16	17
3/4	1.05	0.113	0.824	21	23
1	1.315	0.133	1.049	32	34
1 1/4	1.66	0.14	1.38	43	46
1 1/2	1.9	0.145	1.61	51	55
2	2.375	0.154	2.067	68	74
2 1/2	2.875	0.203	2.469	107	118
3	3.5	0.216	3.068	141	154
4	4.5	0.237	4.026	201	220
5	5.563	0.258	5.047	273	
6	6.625	0.28	6.065	353	386
8	8.625	0.322	7.981	539	581
10	10.75	0.365	10.02	755	824
12	12.75	0.406	11.938	1001	1089
14	14	0.438	13.124	1180	
16	16	0.5	15	1543	
PVC and CPVC Pipes - Schedule 80					
Nominal		Minimum	Nominal	Weight	
Pipe Size	Outside	Wall	Inside	(lb/100 ft)	
(inches)	Diameter	Thickness	Diameter	PVC	CPVC
	(inches)	(inches)	(inches)		
1/2	0.84	0.147	0.546	20	22
3/4	1.05	0.154	0.742	27	30
1	1.315	0.179	0.957	41	44
1 1/4	1.66	0.191	1.278	52	61
1 1/2	1.9	0.2	1.5	67	74
2	2.375	0.218	1.939	95	102
2 1/2	2.875	0.276	2.323	145	156
3	3.5	0.3	2.9	194	209
4	4.5	0.337	3.826	275	305
5	5.563	0.375	4.813	387	
6	6.625	0.432	5.761	542	582
8	8.625	0.5	7.625	805	883
10	10.75	0.593	9.564	1200	1309
12	12.75	0.687	11376	1650	180
14	14	0.75	12.5	1930	
16	16	0.843	14.314	2544	

APPENDIX IV (Steel Pipe Dimensions - Schedule as noted)

Pipe Size	Outside Diameter	Identification			Wall Thickness	Inside Diameter
(inches)	*(inches)*	Steel		Stainless Steel Schedule No.	*- t -*	*- d -*
		Iron Pipe Size	Schedule No.		*(inches)*	*(inches)*
1	1.315	.	.	5S	0.065	1.185
		.	.	10S	0.109	1.097
		STD	40	40S	0.133	1.049
		XS	80	80S	0.179	0.957
		.	160	.	0.25	0.815
		XXS	.	.	0.358	0.599
1 1/4	1.66	.	.	5S	0.065	1.53
		.	.	10S	0.109	1.442
		STD	40	40S	0.14	1.38
		XS	80	80S	0.191	1.278
		.	160	.	0.25	1.16
		XXS	.	.	0.382	0.896
1 1/2	1.9	.	.	5S	0.065	1.77
		.	.	10S	0.109	1.682
		STD	40	40S	0.145	1.61
		XS	80	80S	0.2	1.5
		.	160	.	0.281	1.338
		XXS	.	.	0.4	1.1
2	2.375	.	.	5S	0.065	2.245
		.	.	10S	0.109	2.157
		STD	40	40S	0.154	2.067
		XS	80	80S	0.218	1.939
		.	160	.	0.344	1.687
		XXS	.	.	0.436	1.503
2 1/2	2.875	.	.	5S	0.083	2.709
		.	.	10S	0.12	2.635
		STD	40	40S	0.203	2.469
		XS	80	80S	0.276	2.323
		.	160	.	0.375	2.125
		XXS	.	.	0.552	1.771
3	3.5	.	.	5S	0.083	3.334
		.	.	10S	0.12	3.26
		STD	40	40S	0.216	3.068
		XS	80	80S	0.3	2.9
		.	160	.	0.438	2.624
		XXS	.	.	0.6	2.3

Pipe Size	Outside Diameter	Identification			Wall Thickness	Inside Diameter
(inches)	*(inches)*	Steel		Stainless Steel Schedule No.	*- t -*	*- d -*
		Iron Pipe Size	Schedule No.		*(inches)*	*(inches)*
3 1/2	4	.	.	5S	0.083	3.834
		.	.	10S	0.12	3.76
		STD	40	40S	0.226	3.548
		XS	80	80S	0.318	3.364
4	4.5	.	.	5S	0.083	4.334
		.	.	10S	0.12	4.26
		STD	40	40S	0.237	4.026
		XS	80	80S	0.337	3.826
		.	120	.	0.438	3.624
		.	160	.	0.531	3.438
		XXS	.	.	0.674	3.152
5	5.563	.	.	5S	0.109	5.345
		.	.	10S	0.134	5.295
		STD	40	40S	0.258	5.047
		XS	80	80S	0.375	4.813
		.	120	.	0.5	4.563
		.	160	.	0.625	4.313
		XXS	.	.	0.75	4.063
6	6.625	.	.	5S	0.109	6.407
		.	.	10S	0.134	6.357
		STD	40	40S	0.28	6.065
		XS	80	80S	0.432	5.761
		.	120	.	0.562	5.501
		.	160	.	0.718	5.187
		XXS	.	.	0.864	4.897
8	8.625	.	.	5S	0.109	8.407
		.	.	10S	0.148	8.329
		.	20	.	0.25	8.125
		.	30	.	0.277	8.071
		STD	40	40S	0.322	7.981
		.	60	.	0.406	7.813
		XS	80	80S	0.5	7.625
		.	100	.	0.594	7.437
		.	120	.	0.719	7.187
		.	140	.	0.812	7.001
		XXS	.	.	0.875	6.875
		.	160	.	0.906	6.813

Pipe Size	Outside Diameter	Identification			Wall Thickness	Inside Diameter
(inches)	*(inches)*	Steel		Stainless Steel Schedule No.	*- t -*	*- d -*
		Iron Pipe Size	Schedule No.		*(inches)*	*(inches)*
10	10.75	.	.	5S	0.134	10.482
		.	.	10S	0.165	10.42
		.	20	.	0.25	10.25
		.	30	.	0.307	10.136
		STD	40	40S	0.365	10.02
		XS	60	80S	0.5	9.75
		.	80	.	0.594	9.562
		.	100	.	0.719	9.312
		.	120	.	0.844	9.062
		.	140	.	1	8.75
		.	160	.	1.125	8.5
12	12.75	.	.	5S	0.156	12.438
		.	.	10S	0.18	12.39
		.	20	.	0.25	12.25
		.	30	.	0.33	12.09
		STD	.	40S	0.375	12
		.	40	.	0.406	11.938
		XS	.	80S	0.5	11.75
		.	60	.	0.562	11.626
		.	80	.	0.688	11.374
		.	100	.	0.844	11.062
		.	120	.	1	10.75
		.	140	.	1.125	10.5
		.	160	.	1.312	10.126
14	14	.	.	5S	156	13.688
		.	.	10S	0.188	13.624
		.	10	.	0.25	13.5
		.	20	.	0.312	13.376
		STD	30	.	0.375	13.25
		.	40	.	0.438	13.124
		XS	.	.	0.5	13
		.	60	.	0.594	12.812
		.	80	.	0.75	12.5
		.	100	.	0.938	12.124
		.	120	.	1.094	11.812
		.	140	.	1.25	11.5
		..	160	.	1.406	11.188

APPENDIX V (Speed of sound)

Speed of sound in normal air is *343 m/s.* The velocities of sound in some common liquids are indicated in the table below.

Liquid	Sound Velocity [1)] (m/s)
Acetic acid	1584
Acetone	1174
Alcohol, ethyl (ethanol)	1144
Alcohol, propyl	1205
Benzene	1298
Carbon disulfide	1149
Carbon tetrachloride	926
Castor oil	1474
Chloroform	995
Ether	985
Ethylene glycol	1644
Glycerol (glycerine)	1904
Heptane	1138
Hexane	1203
Kerosene	1324
Mercury	1450
Methyl alcohol (methanol)	1143
Methyl alcohol, 0°C (methanol)	1130
Octane	1171
Phenol	1274
Toluene	1275
Turpentine	1240
Water	1493
Water, 0°C	1402
Water, 20°C	1482
Water, sea with 3.5% salinity	1533
Water, sea with 3.5% salinity, 20°C	1522

Based on temperature 25°C.

- *(1 m/s) = (3.6 km/h) = (196.85 ft/min) = (3.28 ft/s) = (2.237 mph)*