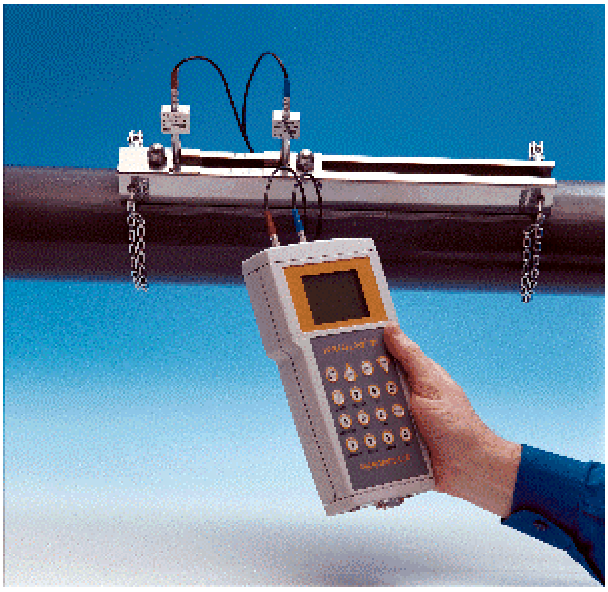
PORTAFLOW 216

Flowmeter

Operating Manual



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CONTENTS

INTRODUCTION

The PORTAFLOW™ 216 is a portable flow meter designed by Micronics for use on liquid flows in full pipes, which utilises Ultrasonic transit-time "Clamp-On" transducer technology.

Easy to operate, the Portaflow 216 features are as follows:

- Large easy to read Graphics Display with backlighting.
- Simple FAST TRACK set up procedure.
- Simple to follow keypad.
- IP55 electronics enclosure.
- Guide rail assembly with chains.
- Pulse Output or 4-20mA (optional)
- 10hr Battery (rechargeable).
- Self-checking diagnostics.
- Continuous signal monitoring.

The instrument displays volumetric flow rate in m^3/hr, m^3/min, m^3/sec, g/min, US g/min, US g/hr, l/min, l/sec and linear velocity in metres and feet per second. The display shows the total volume both positive and negative with up to a maximum of 12 digits.

The following simple guide will enable the user to quickly set up the flow meter to measure flow. Additional data on the facilities available and many useful hints are also contained in this manual.

Fast Track Set up Procedure

Switch on and press **ENTER**.

Select **Quick Start** - Press **ENTER**.
Dimension Units? – Scroll to select units required, press **ENTER**.
Pipe OD – Enter data, press **ENTER**.
Pipe Wall Thickness – Enter data, press **ENTER.**
Pipe Lining Thickness – Enter data, press **ENTER**. **ENTER Zero** if there is no lining on the application.
Select Wall Material – Select using scroll keys, press **ENTER**.
Select Lining Material – This will only be displayed if a lining thickness has been entered. Select using the scroll keys, press **ENTER**.
Select Fluid Type – Select using scroll keys, press **ENTER**.

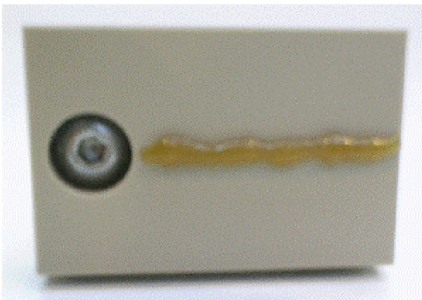
The instrument selects the mode of operation using the data entered and will display the following.

Attach sensor set
in XXXX mode
Approx. max. flow:
XXX m/s
Press ENTER to continue
Or SCROLL to change mode

Fluid Temp? Press Enter to Input the application temperature in the units required °C or °F then press **ENTER.**

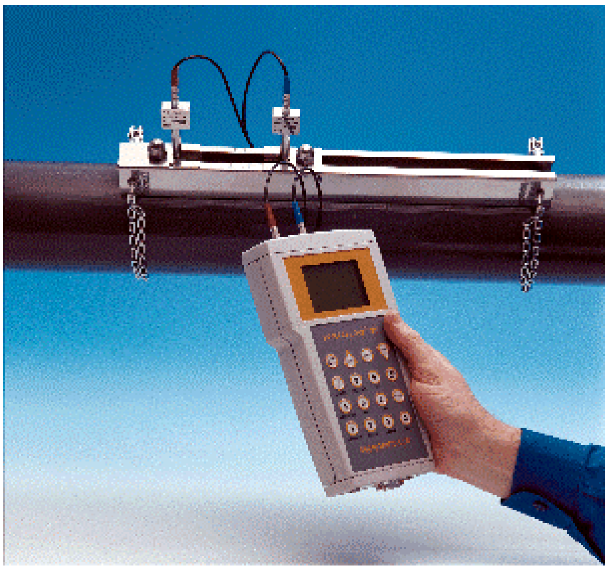
Now retract the sensor blocks back into the guide rail by turning the locking nuts clockwise.
Apply grease to both sensor blocks as shown in **(Figure 1***)*, attach to the pipe using the appropriate mounting hardware in either Reflex or Diagonal Mode. Ensure the Guide rail itself is free of grease

Figure 1:- Inverted view of grease applied to sensor block



Connect the red and blue sensor cables to the electronics and the guide rail assembly. The **RED** cable must be positioned upstream to give a positive flow reading.

Figure 2:- Sensor assembly



For Reflex Mode attach the guide rail **(Figure 3)** to the pipe as shown below. Turn the locking nut on the fixed transducer anti-clockwise, screwing it down on to the pipe surface. Do not over-tighten , causing the guide rail to lift off the pipe.
Set the separation distance **(Figure 3)** by sliding the floating transducer along the scale until the front edge of the block is at the recommended distance displayed by the electronics. Now turn the locking nuts on both the floating and the fixed transducers anti-clockwise, until they make finger tight contact with the pipe surface. To mount the transducers in Diagonal Mode, **(Figure 4) and the instructions** on pages 20-21 of this manual.

Now Press **ENTER** to read flow. Pressing the appropriate key on the keypad can change flow units. An additional key press will change the timescale of the reading - hr/min/sec.

Figure 3*:* - Reflex Mode Operation

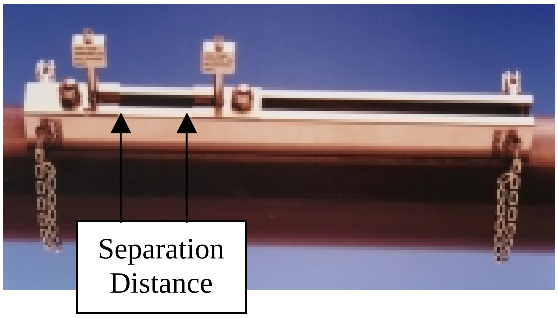
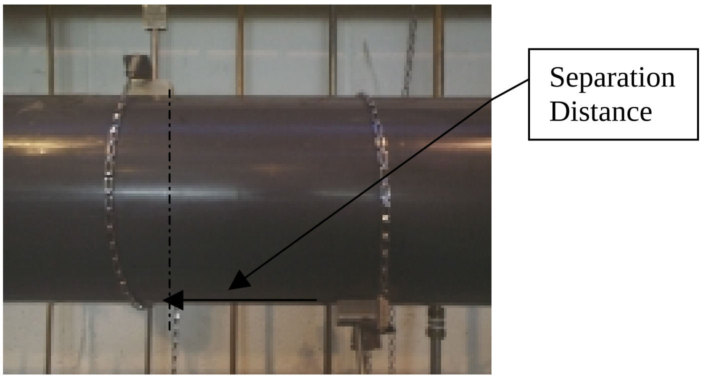


Figure 4:- Diagonal Mode Operation



For Diagonal beam mounting follow the sensor mounting instructions on pages 20 and 21 of this manual.

PARTS AND ACCESSORIES

Connectors

There are four sockets on the electronic housing. Two for the transducer cable assemblies (Blue down/Red up), one for the pulse output, one for the PSU/charger unit and one for the optional 4-20mA output. Please specify 4-20mA output in your order so that it can be configured prior to dispatch.

Pulse Cable Connections

Pulse output – Centre (White) positive, Screen (Silver) negative.

4-20 mA Output connections (optional) only added to software versions 216-3 & 216-2

Charger (Use only the charger supplied.)
The charger is supplied with universal plug-in adaptors. When the instrument is charging, but switched off, the display reads 'CHARGING**'.** It also displays a battery and plug symbol. CHRG is displayed next to the word 'Batt' when in flow mode and the battery charger is connected. When the battery charger is disconnected the display will show a % battery level in the flow mode.

Figure 5:- Battery mains charger. Is supplied with additional plug heads for use Worldwide. The charger is rated 90Vac to 265Vac 47/63mhz @1.1A

Battery Circuit

A battery management circuit controls the battery recharge. The circuit helps to prevent the batteries from being damaged through overcharging. The circuit automatically cuts off the high-level charge current after 4hrs, after which it will provide only a trickle charge. In operating mode a fully charged battery can maintain functionality for up to 8hrs depending upon the demand. A large percentage of the demand taken by the 'Backlighting' and whilst it is continuously enabled the operating life will drop to 4hrs from a fully charged battery.
When in flow measurement mode the battery charge level is continually displayed as a percentage of full charge. When this indication reads approximately 40%, a warning message will appear on the screen. This indicates that there is only 30 minutes use left in the battery. The battery can be charged when the instrument is switched to the ON or OFF state.
See full instructions on charging and discharging the batteries on page 30-31.

Keypad

Programming is via a key tactile membrane keypad.

When measuring flow it is possible, by selecting keys 4, 7, 8, and 9, to change from one unit to another without the need to re-program. Additional key presses will adjust the time scale of the measurements.
Example:

- Press 4 for m/s, press 4 again for f/s
- Press 7 for l/s, press 7 again for l/min
- Press 8 for g/min, press 8 again for USG/min
- Press 9 for m^3/hr, press 9 again for m^3/min, press 9 again for m^3/sec

There are some facilities that require the cursor to be moved from left to right. This can be done using keys 5 (left) and 6 (right).
The pulse output, can only be activated in the flow mode (see page 12 – Pulse output key).
4-20mA(216-3 & 216-2 only)

Transducers

The Portaflow 216 is supplied with one (matched) pair of transducers and a single guiderail to measure flow. The instrument selects the mode of operation (Reflex or Diagonal) dependant on the pipe size and flow velocity.
The instrument can be used over a range from 50mm to 400mm. In Reflex Mode the transducers are positioned in the guide rail to assist correct alignment along the pipe axis, **(Figure 3)**. In Diagonal mode **(Figure 4)** the transducers are removed from the rail and attached to the pipe using the gull-wings and chains. The pipe is then measured and marked up and the transducer blocks are clipped to the pipe wall using a suitable amount of grease applied to the face of each transducer.

Separation Distance
The instrument calculates the separation distance when all parameters have been entered via the keypad. Also the instrument calculates the maximum flow velocity allowed with the standard sensors and indicates whether Reflex or Diagonal mode should be used.

Ultrasonic Couplant
Ultrasonic couplant/grease must be used on the transducer face to interface with the pipe wall.

Fluid Types
Portaflow 216 is capable of measuring clean liquids or oils that have less than 2% by volume of particulate content and air bubbles. During the set up procedure the user is prompted to select from a list of liquids, which include water and oils.
Applications include - river water, seawater, potable water, demin water, treated water, effluent, water/glycol mixes, hydraulic oil, diesel oil and most chemicals.

PROGRAMING-MAIN MENU

Switch 0n…

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PORTAFLOW

216-X V1.00
1 for English
Press Enter to start

X – Option number for the software

Main Menu

Press SCROLL up or down to move cursor to the required option and press **ENTER** to select.

MAIN MENU
Quick start
View/Edit Site Data
Sensor set
Data Logger
Set up RS232
Set up Instrument
Read flow

Main Menu - Quick Start

Selecting quick start offers the user the easiest and quickest option to achieve a flow measurement. If the instrument has already been used, it stores the last application data entered. This allows the user to read flow on the same application without spending time entering new data. Go to ‘Read Flow’ in the main menu.

If **QUICK START** is selected, proceed with the following routine. Use the scroll keys to select, then press **ENTER.**

QUICK START

Dimension units?
mm
Inches

The instrument now asks for the **Pipe outside diameter?** After entering the outside diameter in millimeters press **ENTER**.

```
QUICK START

Dimension units          mm
Pipe O.D.?                58.0
```

Pipe wall thickness now appears on the display. Enter the pipe wall thickness in millimeters, then press **ENTER.**

```
QUICK START

Dimension units          MILLIMETRES
Pipe O.D.?                      58.0
Wall thick?                      4.0
```

Pipe lining thickness now appears on the display. If the pipe you are measuring has a lining, enter the **Pipe lining thickness**. If nothing is entered the instrument automatically assumes there is no lining. Press ENTER to move onr after entering the data.

```
QUICK START

Dimension units            MILLIMETRES
Pipe outside diameter?            58.0
Wall thick?                        4.0
Lining?                            0.0
```

The instrument now displays **Select pipe wall material**. Using the scroll keys it is possible to scroll up or down the options available. Select the required material and press **ENTER.**

```
QUICK START

Select pipe wall material:
Mild Steel
S' less Steel 316
S' less Steel 303

Plastic

Cast Iron
Ductile Iron
Copper
Brass
Concrete
Glass
Other  (m/s)
```

The following will only be displayed at this stage if a lining thickness has been entered. Use the scroll keys to select the required material, then press **ENTER**. If **Other** is selected, enter the sound speed of the lining in metres/sec.

QUICK START

Select pipe lining material:
Steel
Rubber
Glass
Epoxy
Concrete
Other (mps)

Select fluid type now appears on the display.
Use the scroll keys to select the fluid type and press **ENTER**.
If the liquid is not listed select **Other** and enter a liquid sound speed in metres/second. The sound speed information can be found in the back of the manual under **Liquid Sound Speeds.**

QUICK START

Select fluid type:
Water
Glycol/water 50/50
Lubricating oil
Diesel oil
Freon
Other (m/sec)

Attach Sensors

The instrument will now provide the user with details of the mode of operation. It will also give the approximate maximum velocity that can be achieved with the sensors provided. Use the keypad to check the other maximum volumetric flow.
Connect the RED and BLUE sensor cables, between the guide rail and the electronics.

Attach sensors in
REFLEX mode
Approx. max. flow:
7.20 m/s
ENTER to continue
SCROLL changes mode

Select Enter and the display will now show:

Fluid temp?
(°C)

Enter the application temperature and press **Enter.**

The display will now show the sensor seperation distance. Adjust the moveable sensor to the required distance. Press **ENTER** to read flow.

Set sensor Separation to XXX ENTER to continue

READ FLOW now appears on the display.

Batt CHRG Sig 48% (ERROR MESSAGES APPEAR HERE)   m/s

When reading volumetric flow the instrument will display a positive and negative total. Selecting OPTIONS from the keypad can reset these totals (See page 14).

The instrument will continually display the battery and signal levels. Signal levels should be above 40%.
If there is an error with the site data entered or the application, the instrument will display an Error or warning message (See page 15-17), which will appear above the flow reading. If there is more than one message it will scroll between them all.

To stop reading flow press ENTER **ONCE**. The display will read the following.

This will stop all outputs Press ENTER to EXIT SCROLL to return to READ FLOW

Pressing ENTER a second time will stop outputs and return the instrument to **MAIN MENU or** Press the scroll key to return the instrument to **READ FLOW**.

Main Menu - View/Edit Site Data

The **VIEW/EDIT SITE DATA** mode can be accessed from the main menu. It allows the user to enter application details for up to 20 different sites. This facility is useful if a number of sites are being monitored on a regular basis. Application data can be programmed into each site before getting to site.

When scrolling up/down the menu press **ENTER** to select at each prompt.

VIEW/EDIT SITE DATA	
List sites	
Site number	0
Name	QUICK START
Units	MM

Pipe O.D.	58.0
Wall thick	4.0
Lining	0.0
Wall	MILD STEEL
Lining	---------
Fluid	WATER
Read flow	
Exit	

Note:

- Site Zero is always the **QUICK START** data and cannot be changed.
- Changing the data in any site is automatically saved when leaving this menu. Data will have to be re-entered to over ride the old data.

List Sites

Selecting **LIST SITES** allows the user to view the names of up to 20 sites, numbers 1-5 appear first.
Pressing ENTER will display sites from 6-10. Pressing again will display sites 11-15, and again to display 15-20.

1 site not named
2 site not named
3 site not named
4 site not named
5 site not named
Press ENTER to continue

Site Number

Site number allows the user to enter the number of the site data that you wish to be displayed. If the site has not been used then no data would be stored. You can now enter new application data.

Site Name

Site name allows the user to edit or enter a site name. Use the scroll keys to move the cursor to the letter/figure required and press ENTER to select. Press zero, to return the instrument to **VIEW/EDIT SITE DATA**. The new site name will appear on the display.

SCROLL & ENTER select
for space, 0 to end

abcdefghijklmnopqr
stuvwxyz01234567890
>……...............<

Dimension Units

Dimension units allow the user to switch between millimetres and inches. The electronics converts all the application data in a particular site.

Pipe wall/lining thickness and **Pipe wall/lining material** can now be changed as required. Lining material is ignored if a lining thickness has not been entered. A selection of pipe wall/lining materials will be displayed when these options are selected.

Fluid type

Fluid type allows the user to scroll through a selection of fluid types. Select **OTHER** in the **menu if a liquid is not mentioned.**

Select fluid type. When **Other (m/s)** is selected the user must enter the liquid sound speed in m/s. This can be supplied by Micronics or found in the back of the manual under **Liquid Sound Speeds**.

Read Flow

Selecting **Read flow** informs the user of the mode of operation and the approximate maximum flow rate. Press the appropriate key can change the units required.

Attach sensor set
in REFLEX mode
Approx. max. flow:
7.22 m/s
ENTER to continue
SCROLL changes mode

Pressing **ENTER** asks the user to enter a temperature in °C.

Fluid temp? 20.0
(°C)

Now press scroll (up). The instrument will display the separation distance before displaying flow.

Main Menu - Select Sensor mode

When the application information is programmed into the instrument it selects and defaults to the most suitable mode of operation i.e. REFLEX or DIAGONAL.

Sensor Mode

Selecting **Sensor mode** allows the user to choose the appropriate method for clamping the sensors to the pipe. The default would have been displayed on the previous screen and **Sensor mode** can be selected to give the user a choice between Reflex and Diagonal.

SENSOR SET
Mode REFLEX
Read flow
Exit and default

This option is available for two main reasons. Firstly, lets assume that the instrument has selected “mount sensors in DIAGONAL MODE” Your application may not allow you to achieve this mode. Providing the velocity is low enough it is possible to force the sensors into REFLEX mode (See page 4). Changing the sensor mode from Diagonal to Reflex would allow the user to measure the flow. The display may also read, sensor mode invalid for this pipe size.

Cannot READ FLOW
Because pipe
to large/small for sensor

ENTER to continue

Read Flow

Moving the cursor to **Read flow** and pressing **ENTER** informs the user of the mode of operation and the maximum flow capable.
Should the actual flow be higher than the one specified on the instrument, another mode of operation can be selected.
Selecting EXIT will take you back to **MAIN MENU**.

Main Menu - Set Up Instrument

Pulse Output Key

This can only be operated in flow mode.
Use the scroll key to move the cursor up or down the display. To change the flow units press the key required. This will also change the flow units when returning to the flow mode. Changing the flow units will also re-scale the litres per pulse.

PULSE OUTPUT

Flow units
Output OFF
Max. pulse rate1 per sec
Litres per pulse12.76
Exit

Outputs allow the user to select from the following.
Selecting **Off** switches the pulse off and returns to the **PULSE OUTPUT** display.
Selecting the **Forward total** counts the pulses of the forward flow only.
Selecting **Net total** counts the pulses of the sum of the forward total less the reverse total.

OUTPUT

Off
Forward total
Net total

Max. Pulse Rate

This option allows the user to select between fast/slow pulses or large/small pulse width. Select 1 per second for slow pulses and 100 for a fast pulse. The pulse width for 1 per second is 100ms and 5ms for 100 per second.

XXXX per pulse

This will change when the flow units are changed above. When the correct flow units are selected this allows the user to scale the pulses to there own requirements or it can be left in the default setting.

Display backlight

Use the scroll key to select backlight and press **ENTER**. This allows the user to enable or disable the backlight. Enable, means the backlight will stay on for 15secs with every key press. It will stay on permanently with the mains plugged in. Use the scroll key to select and press **ENTER**. The backlight will draw power from the batteries and reduce the operating life of the battery cell. **(follow the application note at the back of the manual)**

Backlight

Enabled
Disabled

Application Options

Use the scroll key to select Application Options and press **ENTER**. Please enter the following password **39502600**. It is a facility that could enhance signal levels on difficult applications, primarily very small or very large pipes. Use enhanced mode when signals are below 800. Below 800 the system may generate noise and therefore the accuracy of the measurement cannot be guaranteed.

Sensor Parameters
This facility is password protected. It stores sensor information used by Micronics and is not available for the user.

WARNING! Sensor
should only be edited
following instruction
from the factory
Enter password

Factory Settings
The facility is used by Micronics in the process of instrument calibration. Press ENTER takes you back to **SETUP INSTRUMENT MENU**.

Exit
Means EXIT and will take you back to the Main Menu.

Main Menu - Read Flow

When choosing the **Read flow** option from the **MAIN MENU** the instrument reverts directly back to the data that was last entered. The instrument will have to be reprogrammed if it is to be used on a new application.

KEYPAD OPTIONS

The output options can only be adjusted/operated in flow mode.

Exit

Delete Key

If anything is entered in error, press the DELETE key and re-enter the information required.

Options Key

This can only be used in flow mode. Scroll down the options then press **ENTER** to select.

OPTIONS	
Cutoff (m/s)	0.05
Set zero	
Total	RUN
Reset + total	
Reset – total	
Damping (sec)	5
Cal Factor	1000
Corr Factor	1000
Diagnostics	
Exit	

Cut Off (m/s)
The instrument has an automatic CUTOFF that is calculated to 0.05 m/s. The maximum flow is calculated when the instrument is programmed and is displayed when sensor set and mode of operation are displayed (See page 9 - Read Flow - Attach sensors). Micronics cannot guarantee measuring flows below this range because of instabilities in measuring system, but it is possible for the user to cancel any cut-off altogether.

Reducing the cutoff to Zero allows the user to see or record any flow that they may not want. For example it may be that the user may not want to measure flows below 50 LPM in a 50mm pipe that is equivalent to 0.42 m/sec, in which case 0.42 m/sec would be entered into the instrument and nothing would be recorded below that level. The maximum **cut off** is 1 m/sec.

Set Zero Flow

On some applications and in some conditions it may be that although there is no flow the instrument may show a small offset due to system noise. The offset can be cancelled out and will increase the accuracy of the instrument. Selecting this option and pressing **ENTER** the display will show the following.

Stop the flow
COMPLETELY and
press ENTER or
SCROLL to cancel

Pressing **ENTER** before the flow has stopped will result in an error message asking if you **are you sure the flow has stopped**. This occurs when the flow is still above 0.25m/sec.

When this facility has already been selected, press **ENTER** to cancel the previous instruction, then it is possible to re-set the Zero balance. The option is not available when error messages E1 and E2 (See page 17) are being displayed.

Total

This option allows the user to disable the positive and negative totalizers. When you select either of these options the totaliser will start or stop functioning. It does not zero the total, this is a separate function described below.

Reset + Total/- Total

The Portaflow 216 has forward and reverse totaliser that can be reset when this facility is selected. Use the scroll keys to select and press **ENTER** to reset. The Total is stored when the unit is switched off or battery goes flat, therefore may need to be reset before each use.

Damping (sec)

This facility is used when the flow readings are unstable due to turbulence caused by obstructions or bends etc. Damping or averaging can be used to make the readings more stable. It can be set to up-date the display, anything between 3 and 100 seconds.

Calibration Factor

If for any reason the instrument goes out of calibration and the readings may be higher or lower than normal then this facility enables the user to correct the reading. If for example the reading is 4% higher than normal then entering 0.96 will reduce the reading by 4%. If the reading is 4% lower than normal then entering 1.04 would increase the reading by 4%.

When the instrument is supplied it will always default to 1.00 and when this is changed it will stay in the memory to whatever it has been changed to, until such time as it needs to be changed again.

Correction Factor

This is a facility that can be used when errors occur due to lack of straight pipe or the sensors have been placed too close to a bend, this could give an incorrect reading to what is expected. The user can set this as a % in the same way as the calibration factor, but it will not be stored in the memory.

Diagnostics

Calculated µs

This is a value the instrument predicts will be the time in µsecs that it should take for the transmitted signal to go across a particular pipe size. This value is ascertained from the data entered by the user. i.e. Pipe size, material, sensor set etc.

Up µs, Dn µs

This is the actual transit time measured by the instrument and will be slightly (5-10µs depending on the pipe size and signal condition) less than the calculated value above.

Measurement µs
A point in the signal transmitted, where the flow measurement is taken from. It is used to see if the signal is being taken from the burst at the correct time to get the strongest signal. It is normally used on smaller pipes when the instrument is being used in double or triple bounce as signals can sometimes interfere with each other. This value is normally a few µs below the **Up µs, Dn µs** value.

Phase up/dn µs
Only valid if **Calculated µs** and **Up µs, Dn µs** are correct. If the reading is zero then there is no signal, which could mean the pipe is empty, or the liquid is contaminated with particles or air.

Phase offset
This value will be between 0 and 15. The exact value is not important and will vary between applications. It should however, be stable when the flow condition is good and velocity is within the range of the transducers being used. As the flow rate increases towards and beyond the maximum, this figure will continuously change. In flow mode the instrument will read unstable or high flow.

Flow (m/s)
This displays flow velocity in m/sec to 3 decimal places.

Signal
This is the average value of **Signal up/dn** and is a value between 800 and 2400 which
Display's the signal strength as a percentage (800=0%, 2400=86%).

Signal up/dn
This value is internal to the electronics and must be greater than 800. There is an option in the **SET UP INSTRUMENT** menu to allow this value to be taken down to 400 in extreme circumstances and is useful on some applications when the signal levels are poor.

Sensor separation
This is a reminder for the user to check for correct sensor separation and sensor mode.

STATUS/ERROR/WARNING MESSAGES
There are three types of message that will appear and they are Status, Error and Warning. These messages appear under the time and date on the display when in flow mode.

Status Messages

S1: INITIALISING
Appears when first entering flow mode to show instrument is starting up.

Error Messages

E1: UNSTABLE OR HIGH FLOW
This error message occurs when either the sensors have been positioned too near to an obstruction or bend causing turbulence, or the instrument is being used outside its normal flow range.

When the instrument is programmed the user is informed of the maximum flow rate that is possible to measure and if this is exceeded then the high flow message occurs.

It may be possible to get round these problems by moving the sensors to a straighter length of pipe or in the case of high flows another set of transducers may be used.

E2: NO FLOW SIGNAL
This message appears when the two transducers cannot send or receive signals, which could happen for various reasons. Firstly check that all cables are connected, transducers are on the pipe correctly with grease on the face.

No flow signal will show if the pipe is empty or partially filled. When the liquid is aerated or when the particulate content of that liquid is too high or if the grease has not been applied to the transducers and the condition of the pipe being measured is poor.

Warning Messages

W1: CHECK SITE DATA
This message occurs when the application information has been entered incorrectly and the wrong sensors have been attached to the wrong pipe size causing the system timing to be in error. The site data needs to be checked and the instrument reprogrammed.

W2: SIGNAL TIMING POOR
Unstable signal timing or differing up/down stream times indicate that the liquid is aerated or pipe surface is of poor quality.

W5: FLOW SIGNALS POOR
This warning appears when there is a signal lower than 25%. This could be due to the application, a poor quality pipe, amongst others.

W6: mA OUT OVERANGE
The mA output is over-range when the flow is higher than the maximum mA range. Once the 4-20mA has been set up and the flow goes above the range set then this message will appear. It is possible to re-scale the 4-20mA to be able to cope with the higher flow.

W7: BATTERY LOW
The battery low warning occurs when battery indication is on 40%. The instrument has approximately 30 minutes usage before it needs recharging. (See application note at the back of this manual)

W8: mA LOAD TO HIGH
The 4-20mA Output is designed to work with a load up to 750Ω. When the load is too high or not connected, the above warning message will be displayed.

Other Messages
The messages below appear mainly when data has been incorrectly entered or the Portaflow 216 is trying to be used on an application that it is not capable of working on.

Pipe OD out of range
The outside diameter of the pipe has been entered and is out of range of the instrument.

Wall thickness out of range
The wall thickness that has been entered is out of range of the instrument.

Lining thickness out of range
The pipe lining thickness has been incorrectly entered.

Site range is 0 - 20
There are only 20 storage sites available with 0 being the QUICK START site.

- CANNOT READ FLOW BECAUSE…
  ….Pipe dimensions are invalid
- CANNOT READ FLOW BECAUSE …materials are invalid
- CANNOT READ FLOW BECAUSE
  …Pipe is too large for sensor set
- CANNOT READ FLOW BECAUSE
  …Pipe is too small for sensor set
- CANNOT READ FLOW BECAUSE
  …Sensor mode is invalid for this pipe size

Temperature range is -20°C to +125°C
The temperature range of the transducers is -20°C to +125°C.

Enter a lining thickness first
This message appears when in **VIEW/EDIT SITE DATA** the user has tried to enter a pipe lining material before entering a thickness.

APPLICATION INFORMATION

The PORTAFLOW 216 is a Transit Time ultrasonic flow meter. It has been designed to work with Clamp On transducers, thus enabling flowing liquid within a closed pipe to be measured accurately without the need for any mechanical parts to be inserted either through the pipe wall or protrude into the flow system.
The meter is controlled by a micro-processor containing a wide range of data which enables the instrument to measure flow in any pipe diameter from 50mm bore up to 400mm, made from any pipe material, over a wide range of operating temperatures.

The system operates as follows:

Figure 6 :- Reflex mode

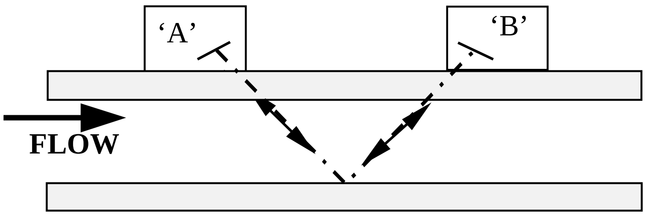
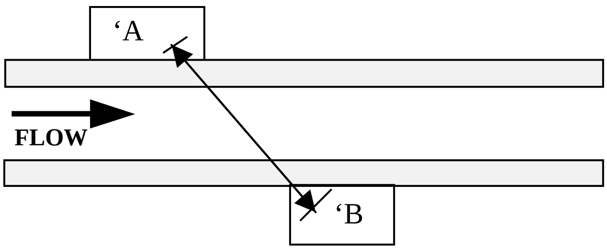


Figure 7:- Diagonal mode



When ultrasound is transmitted from Transducer ‘A’ to Transducer ‘B’ (REFLEX MODE-Figure 6) or Transducer ‘A’ to ‘B’ (DIAGONAL MODE- Figure 7) the speed at which the sound travels through the liquid is accelerated slightly by the velocity of the liquid. If sound is transmitted in the opposite direction from ‘B’ to ‘A’, it is decelerated against the flow of the liquid. The differences in time taken to travel the same distance in opposite directions are directly proportional to the flow velocity of the liquid.

Having measured the flow velocity and knowing the pipe cross-sectional area, the volumetric flow can be easily calculated. The Microprocessor will determine the correct alignment of each transducer.

To measure flow, it is first necessary to obtain detailed information about each application, which is then programmed into the processor via the Key Pad. This information must be accurate otherwise flow measurement errors will occur.

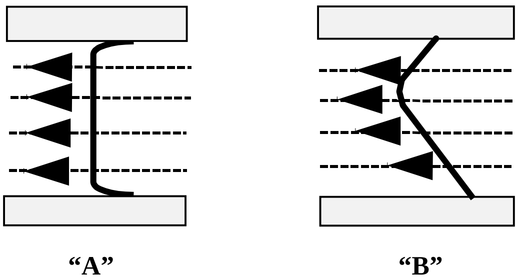
Further, having calculated the precise position at which the transducers must be clamped onto the pipe wall, it is equally important to align and separate the transducers accurately with respect to one another, as failing to do so will again cause errors in measurement.

Finally, to ensure accurate flow measurement it is imperative that the liquid is flowing uniformly within the pipe and that the flow profile has not been distorted by any upstream or downstream obstructions.

To obtain the best results from the Portaflow 216 it is absolutely necessary that the following rules for positioning the transducers and that the condition of the liquid and the pipe wall are suitable to allow transmission of the sound along its predetermined path.

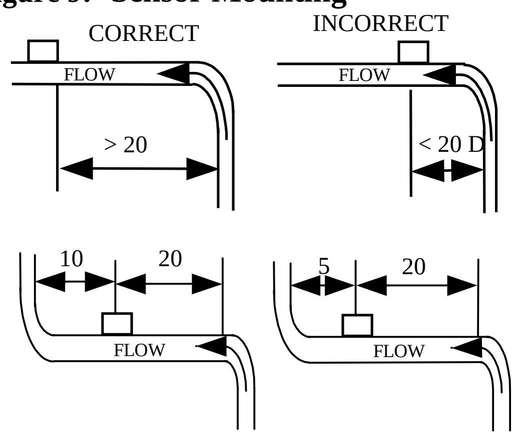
TRANSDUCER POSITIONING
As the transducers for the Portaflow 216 are clamped to the outside surface of the pipe, the meter has no way of determining exactly what is happening to the liquid. The assumption therefore has to be made that the liquid is flowing uniformly along the pipe either under fully turbulent conditions or under laminar flow conditions. Further it is assumed that the flow velocity profile is uniform for 360° around the pipe axis.

Figure 8:- A uniform profile as compared to a distorted profile.



The difference between (a) and (b) is that the Mean Velocity of the flow across the pipe is different and because the Portaflow 216 expects a uniform flow as in (a), the distorted flow as in (b) will give measurement errors which cannot be predicted or be compensated.
Flow profile distortions result from upstream disturbances such as bends, tees, valves, pumps and other similar obstructions. To ensure a uniform profile the transducers must be mounted far enough away from any cause of distortion such that it no longer has an effect.

Figure 9:- Sensor Mounting



The minimum length of upstream straight pipe is 20 Diameters and 10 Diameters downstream that ensures accurate results will be achieved.
Flow measurements can be made on shorter lengths of straight pipe down to 10 Diameters upstream and 5 Diameters downstream, but when the transducers are sighted this close to any obstruction errors can be considerable.

It is not possible to predict the amount of error as this depends entirely upon the type of obstruction and the configuration of the pipe work and flow profile.

The message therefore is clear: Do not expect to obtain accurate results if the transducers are positioned closer than allowed to any obstruction that distorts the uniformity of the flow profile.

MOUNTING THE TRANSDUCERS
It will be impossible to achieve the accuracy of measurement specified for the Portaflow 216 if the transducers are not clamped to the pipe correctly and if the data - I.D. O.D., Pipe Material - are not accurate.

Apart from the correct positioning and alignment of the transducers, of equal importance is the condition of the pipe surface in the area under each of the transducers.

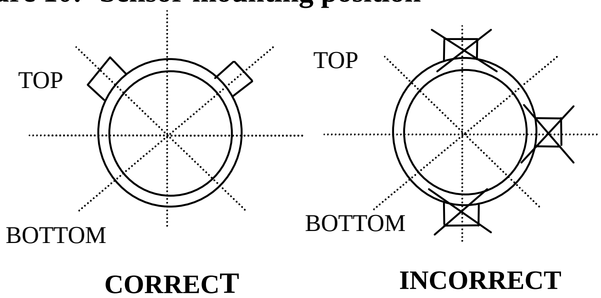
An uneven surface that prevents the transducers from sitting flat on the surface of the pipe can cause Signal Level and Zero Offset problems. The following procedure is offered as a guide to good practice with respect to positioning and mounting the transducers.

1) Select the site following the rules laid down on page 19 - **Transducer Positioning.**

2) Inspect the surface of the pipe to ensure it is free from rust or is not uneven for any reason. Transducers can be mounted directly on painted surfaces as long as the surface is smooth and that the underlying metal surface is free from rust bubbles. On bitumen or rubber coated pipes the coating must be removed in the area under the transducer as it is preferable that the transducers are mounted directly on to the base metal.

3) Transducers can be mounted on both Vertical and Horizontal Pipe Runs.

Figure 10:- Sensor mounting position



4) Apply Interface grease to the face of the transducers. The amount of grease used is extremely important particularly on pipes of less than 89mm bore.

On Stainless Steel Pipes the amount of couplant applied should never exceed the amount indicated in the Example on page 3, For large Plastic and Steel Pipes the amount of grease applied is less critical, however do not use more than is absolutely necessary.

5) Strap the guide rail assembly to the pipe so that it is perfectly parallel to the pipe axis.
6) When screwing the transducers on to the pipe surface use only enough force to ensure that the Transducer is flat against the pipe surface and then lock in position.
7) Clamping the transducers in exactly the correct position is extremely important. The Separation distance is calculated by the Portaflow electronics and the transducers must be positioned and clamped exactly at the distance specified.
8) Always use the sensor grease provided.

LIQUID CONDITIONS
Transit time ultrasonic meters perform best on liquids that are totally free from entrained air and solids. With sufficient air in the system the ultrasound beam can be attenuated totally and therefore prevent the instrument from working.

Often it is possible to tell whether there is air in the system or not. If a flow signal cannot be obtained a simple test to determine whether the flow is aerated involves stopping the flow for a period of 10 - 15 minutes. During this time the air bubbles will rise to the top of the pipe and the flow signal should return.
If the flow signal does return switch on the flow and if sufficient entrained air is locked in the system it will very quickly disperse and kill the signal.

To correct the Portaflow 216 for operation in the laminar flow region, calculate the Reynolds number adjust the **correction factor** as described on Page 15.

PROPAGATION VELOCITY or SOUND SPEED
To make a flow measurement using the Portaflow 216 on any liquid, it is necessary to know the propagation velocity in metres/second. There is a short list of fluids that appear on the display when programming (See page 9), showing water and various other liquids. However if the liquid you wish to measure is not on this list, please revert to the table at the back of this manual or contact Micronics for advice.

REYNOLDS NUMBER
The Portaflow 216 has been calibrated to operate on Turbulent flows with Reynolds Number of approximately 100,000. The calibration of the unit will not be valid if the Reynolds No.is below 4000.

If the Portaflow 216 is to be used on laminar flow applications it will be necessary to calculate the Reynolds No for each application. To calculate the Reynolds No it is necessary to know the Kinematic viscosity in Centistokes; the flow velocity and the pipe inside diameter. Please follow the table below

To calculate R_e use the following formula: -

$$R_e = \frac{dv}{\upsilon^1}(7730) \text{ or } R_e = \frac{d^1\ v^1}{\upsilon^1}(1000)$$

Where

d **= inside pipe diameter in inches**

d^1 **= inside pipe diameter in millimetres**

v **= velocity in feet/second**

v^1 **= velocity in metres/second**

υ^1 **= Kinematic viscosity in centistokes**

MAXIMUM FLOW

The maximum flow is dependent on the velocity and pipe size.

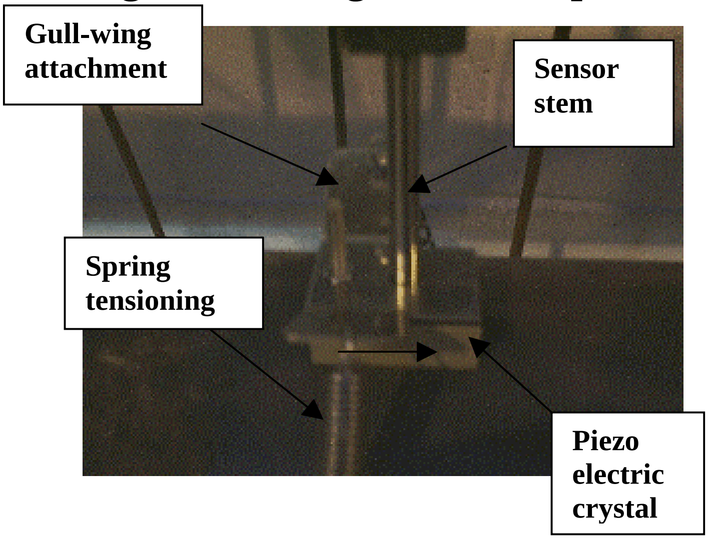
APPLICATION TEMPERATURE

On any application whose operating temperature is either above or below ambient temperature ensure that the transducers reach and are maintained at the application temperature before undertaking a measurement.

When applying the transducers to low temperature applications do not allow the pipe surface to ice up between the transducer and the pipe wall. The ice will force the block away from the pipe wall and consequently you will lose the signal.

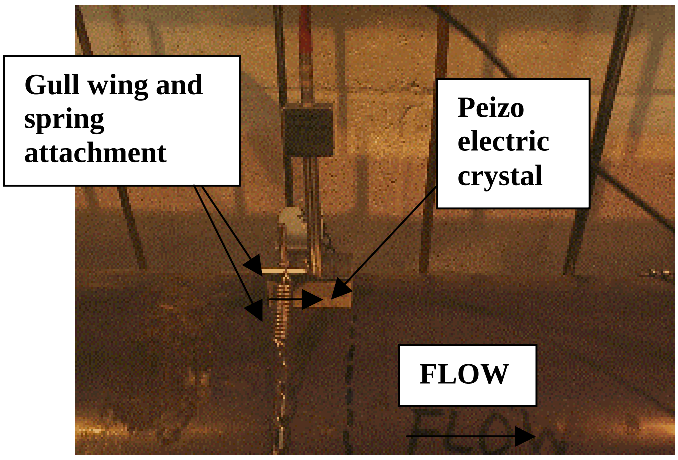
DIAGONAL MODE SETUP

Figure 11: Diagonal Mode parts supplied



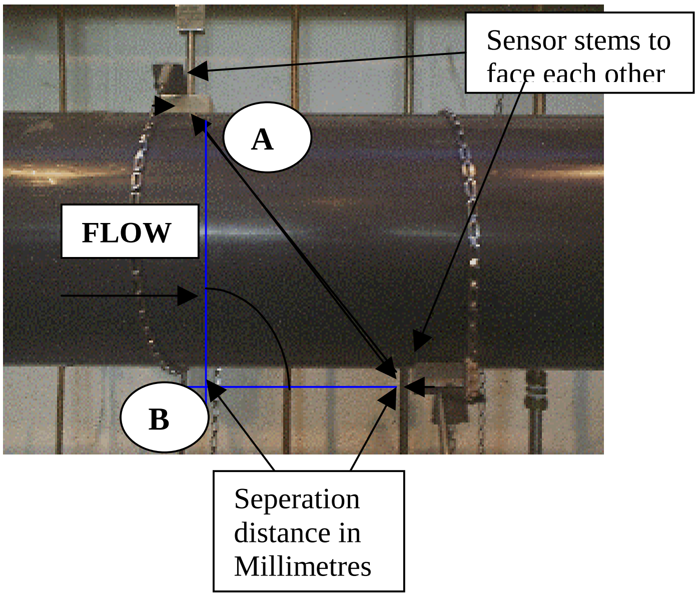
As part of your New Portaflow 216 kit you will find two stainless steel gull wings, two springs and two lengths of chain.
Take the transducers from the reflex guiderail.
Attach the Gull-wing to each transducer using the washer & wing nut provided.
Apply grease to the bottom of the transducer (as shown on page3). Wrap the chain around the pipe as shown. Expand the spring and carefully slide the chain into the slot on the Gull Wing. Plug the red connector into the socket on the upstream sensor. The sensor with the red cable must be positioned up stream. The stem of the sensor must point towards the downstream sensor.

Figure 12: Attaching the sensor to the pipe



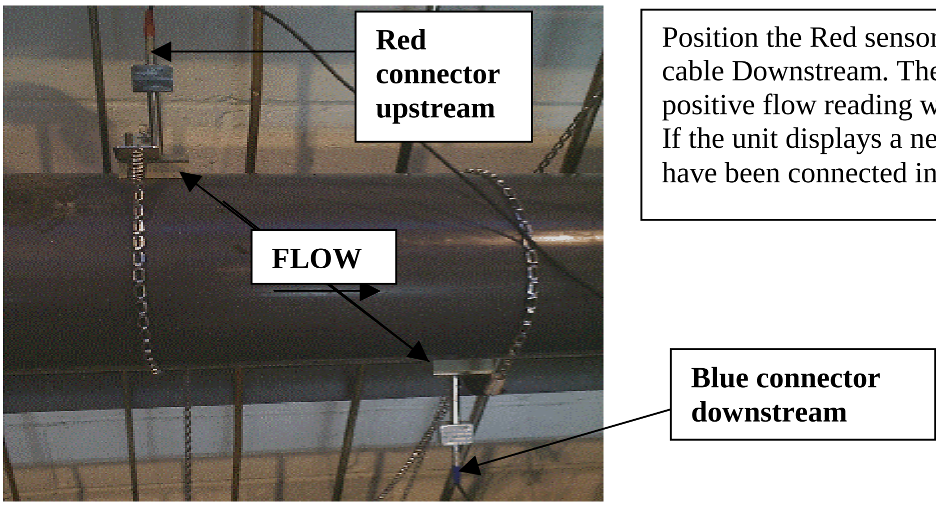
Program the Electronics with the application data to obtain the calculated separation distance.
Measure the circumference of the pipe and mark a position at the halfway point. (Outside Diameter of the pipe times 3.142 divided by 2). Apply grease to the second sensor and plug the blue connector into the top of the sensor. Follow (figure 13) next diagram to set up the sep distance.

Figure 13: Marking the Separation distance



Using a marker pen or a strip of ticket paper mark around the pipe from the front edge of the first sensor "A" till you reach the half way point of the pipe. From "B" measure the separation distance calculated by the electronics. Mount the second transducer as per the first with the stem facing the other transducer.
Press ENTER to view the flow. The signal strength should be greater than 50%. Should you have difficulty getting a signal remove the sensor from the Gull wing re-apply the grease and try to find a signal by moving it with your hand.

Figure 14: Positioning of the sensor cables



Position the Red sensor cable upstream and the Blue cable Downstream. The Electronics will display a positive flow reading with cables in this orientation. If the unit displays a negative reading the cables have been connected into the wrong sensors.

PORTAFLOW™ 216 SPECIFICATION

ENCLOSURE:		
	Protection Class	IP55
	Material	ABS
	Weight	< 1.5 Kg
	Dimensions	235 x 125 x 42 mm
	Display	Graphics LCD display
	Keypad	16 Key Tactile Membrane
	Connections	IP65 Lemo Connectors
	Temperature Range	0°C to +50°C (operating)
		-10° to +60°C (storage)
SUPPLY VOLTAGE:		
Power supply/charger	Input	100-240 VAC ±10% @50/60 Hz
	Max. Power consumption	9 Watts
	Output	9VDC Regulated
BATTERY PACK:		
	5 AA Nickel Metal Hydride	8hrs Operating Time
	Rechargeable	15 hrs Charge Time
		Low Battery Indication
OUTPUTS:		
Display	Volumetric Flow	m^3, litres, gallons (Imperial and US)
	Flow Velocity	metres/sec, feet/sec
	Flow Rate	0.3…12 m/sec to 4 significant figures
	Total Flow	12 Digits (Forward and Reverse)
	Continuous Battery Level Indication	
	Continuous Signal Level Indication	
	ERROR messages	
Analogue	4 - 20mA into 750 Ω	User Definable Scaling
	Resolution	0.1% of full scale
TRANSDUCERS:	Frequency	Velocity Range Reflex (Diagonal Mode)
'B'	50 mm…400mm pipe	0.3 m/sec… 6 m/sec (12 m/sec)
Standard	Temperature range	-20°C to +125°C

REPEATABILITY:

±0.5% with unchanged transducer position

ACCURACY:

± 1-3% of reading within velocity range or ± 0.3 m/sec and under ideal flowing conditions and on a 4" plastic pipe. Micronics cannot guarantee the performance of the Portaflow 216 unless ideal conditions are achieved

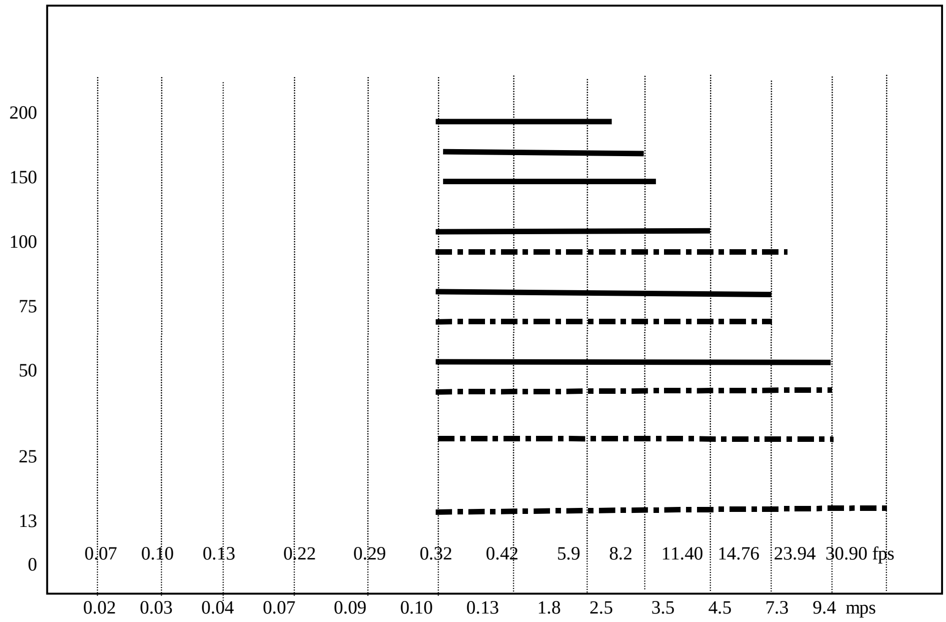
Specification assumes turbulent flow profile with Reynolds numbers above 4000.

PIPE MATERIALS

Any sonic conducting medium such as Carbon Steel, Stainless Steel, Copper, UPVC, PVDF, Concrete, Galvanised Steel, Mild Steel, Glass, Brass. Including Lined Pipes – Epoxy, Rubber, Steel, Plastic.

Micronics reserve the right to alter any specification without notification.

Figure 15:- PORTAFLOW 216 Flow Range



PORTAFLOW 216 FLOW RANGE - DIAGONAL MODE
PORTAFLOW 216 FLOW RANGE – REFLEX MODE

WARRANTY

The material and workmanship of the PORTAFLOW 216 is guaranteed by MICRONICS LTD for one year from the date of purchase provided the equipment has been used for the purpose for which it has been designed, and operated in accordance with the operating manual supplied.

Misuse by the purchaser, or any other person, will immediately revoke any warranty given or implied.

Repair or replacement will be at MICRONICS discretion and will be made without charge at MICRONICS plant during the warranty period. MICRONICS LTD reserve the right, without prior notice, to discontinue manufacture, redesign or modify any of its products. Your statutory rights are not affected by this warranty.
If any problems develop, customers are requested to take the following steps:

Notify MICRONICS LTD or the Distributor/Agent from whom the flowmeter was purchased giving details of the problem. Be sure to include the Model & Serial Number of the instrument. When returning the product to the factory, carefully package and ship freight prepaid. Be sure to include a complete description of the application and problem and identify any hazardous material used with the product. The Warranty of the PORTAFLOW is strictly in accordance with that stated above, and cannot in any way be extended.

CE MARKING

The PORTAFLOW 216 has been tested and found to conform to EN50081 - 1 Emission Standards and EN50082 - 1 Immunity Standards. The tests were conducted by AQL - EMC Ltd, of 16 Cobham Road, Ferndown Industrial Estate, Wimborne, U.K. BH21 7PG. The unit was tested with all cables as supplied of a maximum length of 3m. While the operation of the unit may not be affected by the use of longer cables, MICRONICS can make no statement about conformance to the above standards when these cables are in use.
The PORTAFLOW 216 is supplied with an external battery charging unit. This unit is manufactured by Frieman & Wolf, Geratebau GmbH. P.O. Box 1164 D-48342 Ostbevan, Germany who have CE marked the equipment. MICRONICS have purchased this equipment on the understanding that the manufacturers have tested the unit to the relevant standards prior to CE marking the product. MICRONICS have not tested the charger unit and cannot accept responsibility for any non conformance from the relevant standards.

LIQUID SOUND SPEEDS

Liquid Sound Speeds

Note: All the following sound speeds are calculated at 25°C.

The speed of sound in liquids at temperatures other than 25°C are calculated as follows.

Example:

Substance	**Form Index**	**Specific Gravity**	**Sound Speed**	**Δv/°C - m/s/°C**
Glycol	$C_2H_6O_2$	1.113	1658	2.1
Water, distilled (49,50)	H_2O	0.996	1498	-2.4

For every 1°C higher than 25°C take off the value in the Δv/°C- m/s/°C column.

Glycol at 50°C = 1658 - (2.1 x 25) = 1605.5

For every 1°C less than 25°C add on the value in the Δv/°C- m/s/°C column.

Glycol at 5°C = 1658 + (2.1 x 20) = 1700

If the value has a minus sign in front of it then do the opposite of above.

Distilled Water at 50°C = 1498 - (-2.4 x 25) =1558

Distilled Water at 10°C = 1498 + (-2.4 x 15) = 1462

Substance	Form Index	Specific Gravity	Sound Speed	Δv/°C - m/s/°C
Acetic anhydride (22)	$(CH_3CO)_2O$	1.082 (20°C)	1180	2.5
Acetic acid, anhydride (22)	$(CH_3CO)_2O$	1.082 (20°C)	1180	2.5
Acetic acid, nitrile	C_2H_3N	0.783	1290	4.1
Acetic acid, ethyl ester (33)	$C_4H_8O_2$	0.901	1085	4.4
Acetic acid, methyl ester	$C_3H_6O_2$	0.934	1211	
Acetone	C_3H_6O	0.791	1174	4.5
Acetonitrile	C_2H_3N	0.783	1290	4.1
Acetonylacetone	$C_6H_{10}O_2$	0.729	1399	3.6
Acetylene dichloride	$C_2H_2C_{l2}$	1.26	1015	3.8
Acetylene tetrabromide (47)	$C_2H_2Br_4$	2.966	1027	
Acetylene tetrachloride (47)	$C_2H_2Cl_4$	1.595	1147	
Alcohol	C_2H_6O	0.789	1207	4.0
Alkazene-13	$C_{15}H_{24}$	0.86	1317	3.9
Alkazene-25	$C_{10}H_{12}Cl_2$	1.20	1307	3.4
2-Amino-ethanol	C_2H_7NO	1.018	1724	3.4
2-Aminotolidine (46)	C_7H_9N	0.999 (20°C)	1618	
4-Aminotolidine (46)	C_7H_9N	0.966 (45°C)	1480	
Ammonia (35)	NH_3	0.771	1729	6.68
Amorphous Polyolefin		0.98	962.6	
t-Amyl alcohol	$C_5H_{12}O$	0.81	1204	
Aminobenzene (41)	$C_6H_5NO_2$	1.022	1639	4.0
Aniline (41)	$C_6H_5NO_2$	1.022	1639	4.0
Argon (45)	Ar	1.400 (-188°C)	853	
Azine	C_6H_5N	0.982	1415	4.1
Benzene (29,40,41)	C_6H_6	0.879	1306	4.65
Benzol (29,40,41)	C_6H_6	0.879	1306	4.65
Bromine (21)	Br_2	2.928	889	3.0
Bromo-benzene (46)	C_6H_5Br	1.522	1170	
1-Bromo-butane (46)	C_4H_9Br	1.276 (20°C)	1019	
Bromo-ethane (46)	C_2H_5Br	1.460 (20°C)	900	
Bromoform (46,47)	$CHBr_3$	2.89 (20°C)	918	3.1
n-Butane (2)	C_4H_{10}	0.601 (0°C)	1085	5.8
2-Butanol	$C_4H_{10}O$	0.81	1240	3.3
sec-Butylalcohol	$C_4H_{10}O$	0.81	1240	3.3
n-Butyl bromide (46)	C_4H_9Br	1.276 (20°C)	1019	
n-Butyl chloride (22,46)	C_4H_9Cl	0.887	1140	4.57
tert Butyl chloride	C_4H_9Cl	0.84	984	4.2
Butyl oleate	$C_{22}H_{42}O_2$		1404	3.0
2,3 Butylene glycol	$C_4H_{10}O_2$	1.019	1484	1.51
Cadmium (7)	Cd		2237.7	
Carbinol (40,41)	CH_4O	0.791 (20°C)	1076	2.92
Carbitol	$C_6H_{14}O_3$	0.988	1458	
Carbon dioxide (26)	CO_2	1.101 (-37°C)	839	7.71
Carbon disulphide	CS_2	1.261 (22°C)	1149	
Carbon tetrachloride(33,35,47)	CCl_4	1.595 (20°C)	926	2.48
Carbon tetrafluoride (14)	CF_4	1.75 (-150°C)	875.2	6.61
Cetane (23)	$C_{16}H_{34}$	0.773 (20°C)	1338	3.71
Chloro-benezene	C_6H_5Cl	1.106	1273	3.6
1-Chloro-butane (22,46)	C_4H_9Cl	0.887	1140	4.57
Chloro-diFluoromethane (3) (Freon 22)	$CHClF_2$	1.491 (-69°C)	893.9	4.79
Chloroform (47)	$CHCl_3$	1.489	979	3.4
1-Chloro-propane (47)	C_3H_7Cl	0.892	1058	
Chlorotrifluoromethane (5)	$CClF_3$		724	5.26
Cinnamaldehyde	C_9H_8O	1.112	1554	3.2
Cinnamic aldehyde	C_9H_8O	1.112	1554	3.2
Colamine	C_2H_7NO	1.018	1724	3.4
o-Cresol (46)	C_7H_8O	1.047 (20°C)	1541	
m-Cresol (46)	C_7H_8O	1.034 (20°C)	1500	
Cyanomethane	C_2H_3N	0.783	1290	4.1
Cyclohexane (15)	C_6H_{12}	0.779 (20°C)	1248	5.41

Cyclohexanol	$C_6H_{12}O$	0.962	1454	3.6
Cyclohexanone	$C_6H_{10}O$	0.948	1423	4.0
Decane (46)	$C_{10}H_{22}$	0.730	1252	
1-Decene (27)	$C_{10}H_{20}$	0.746	1235	4.0
n-Decylene (27)	C_{10} H_{20}	0.746	1235	4.0
Diacetyl	$C_4H_6O_2$	0.99	1236	4.6
Diamylamine	$C_{10}H_{23}N$		1256	3.9
1,2 Dibromo-ethane (47)	$C_2H_4Br_2$	2.18	995	
trans-1,2-Dibromoethene(47)	$C_2H_2Br_2$	2.231	935	
Dibutyl phthalate	$C_8H_{22}O_4$		1408	
Dichloro-t-butyl alcohol	$C_4H_8Cl_2O$		1304	3.8
2,3 Dichlorodioxane	$C_2H_6Cl_2O_2$		1391	3.7
Dichlorodifluoromethane (3) (Freon 12)	CCl_2F_2	1.516(-40ºC)	774.1	4.24
1,2 Dichloro ethane (47)	$C_2H_4Cl_2$	1.253	1193	
cis 1,2-Dichloro-Ethene(3,47)	$C_2H_2Cl_2$	1.284	1061	
trans 1,2-Dichloro-ethene(3,47)	$C_2H_2Cl_2$	1.257	1010	
Dichloro-fluoromethane (3) (Freon 21)	$CHCl_2F$	1.426 (0ºC)	891	3.97
1-2-Dichlorohexafluoro cyclobutane (47)	$C_4Cl_2F_6$	1.654	669	
1-3-Dichloro-isobutane	$C_4H_8Cl_2$	1.14	1220	3.4
Dichloro methane (3)	CH_2Cl_2	1.327	1070	3.94
1,1-Dichloro-1,2,2,2 tetra fluoroethane	$CClF_2$-$CClF_2$	1.455	665.3	3.73
Diethyl ether	$C_4H_{10}O$	0.713	985	4.87
Diethylene glycol, monoethyl ether	$C_6H_{14}O_3$	0.988	1458	
Diethylenimide oxide	C_4H_9NO	1.00	1442	3.8
1,2-bis(DiFluoramino) butane (43)	$C_4H_8(NF_2)_2$	1.216	1000	
1,2bis(DiFluoramino)- 2-methylpropane (43)	$C_4H_9(NF_2)_2$	1.213	900	
1,2bis(DiFluoramino) propane (43)	$C_3H_6(NF_2)_2$	1.265	960	
2,2bis(DiFluoramino) propane (43)	$C_3H_6(NF_2)_2$	1.254	890	
2,2-Dihydroxydiethyl ether	$C_4H_{10}O_3$	1.116	1586	2.4
Dihydroxyethane	$C_2H_6O_2$	1.113	1658	2.1
1,3-Dimethyl-benzene (46)	C_8H_{10}	0.868 (15ºC)	1343	
1,2-Dimethyl-benzene(29,46)	C_8H_{10}	0.897 (20ºC)	1331.5	4.I
1,4-Dimethyl-benzene (46)	C_8H_{10}		1334	
2,2-Dimethyl-butane (29,33)	C_6H_{14}	0.649 (20ºC)	1079	
Dimethyl ketone	C_3H_6O	0.791	1174	4.5
Dimethyl pentane (47)	C_7H_{16}	0.674	1063	
Dimethyl phthalate	$C_8H_{10}O_4$	1.2	1463	
Diiodo-methane	CH_2I_2	3.235	980	
Dioxane	$C_4H_8O_2$	1.033	1376	
Dodecane (23)	$C_{12}H_{26}$	0.749	1279	3.85
1,2-Ethanediol	$C_2H_6O_2$	1.113	1658	2.1
Ethanenitrile	C_2H_3N	0.783	1290	
Ethanoic anhydride (22)	$(CH_3CO)_2O$	1.082	1180	
Ethanol	C_2H_6O	0.789	1207	4.0
Ethanol amide	C_2H_7NO	1.018	1724	3.4
Ethoxyethane	$C_4H_{10}O$	0.713	985	4.87
Ethyl acetate (33)	$C_4H_8O_2$	0.901	1085	4.4
Ethyl alcohol	C_2H_6O	0.789	1207	4.0
Ethyl benzene (46)	C_8H_{10}	0.867(20ºC)	1338	
Ethyl bromide (46)	C_2H_5Br	1.461 (20ºC)	900	
Ethyliodide (46)	C_2H_5I	1.950 (20ºC)	876	
Ether	$C_4H_{10}O$	0.713	985	4.87
Ethyl ether	$C_4H_{10}O$	0.713	985	4.87
Ethylene bromide (47)	$C_2H_4Br_2$	2.18	995	
Ethylene chloride (47)	$C_2H_4Cl_2$	1.253	1193	
Ethylene glycol	$C_2H_6O_2$	1.113	1658	2.1
50% Glycol/ 50% H_2O			1578	
d-Fenochone	$C_{10}H_{16}O$	0.947	1320	
d-2-Fenechanone	$C_{10}H_{16}O$	0.947	1320	
Fluorine	F	0.545 (-143ºC)	403	11.31

Fluoro-benzene (46)	C_6H_5F	1.024 (20ºC)	1189	
Formaldehyde, methyl ester	$C_2H_4O_2$	0.974	1127	4.02
Formamide	CH_3NO	1.134 (20ºC)	1622	2.2
Formic acid, amide	CH_3NO	1.134 (20ºC)	1622	
Freon R12			774.2	
Furfural	$C_5H_4O_2$	1.157	1444	
Furfuryl alcohol	$C_5H_6O_2$	1.135	1450	3.4
Fural	$C_5H_4O_2$	1.157	1444	3.7
2-Furaldehyde	$C_5H_4O_2$	1.157	1444	3.7
2-Furancarboxaldehyde	$C_5H_4O_2$	1.157	1444	3.7
2-Furyl-Methanol	$C_5H_6O_2$	1.135	1450	3.4
Gallium	Ga	6.095	2870 (30ºC)	
Glycerin	$C_3H_8O_3$	1.26	1904	2.2
Glycerol	$C_3H_8O_3$	1.26	1904	2.2
Glycol	$C_2H_6O_2$	1.113	1658	2.1
Helium (45)	He_4	0.125(-268.8ºC)	183	
Heptane (22,23)	C_7H_{16}	0.684 (20ºC)	1131	4.25
n-Heptane (29,33)	C_7H_{16}	0.684 (20ºC)	1180	4.0
Hexachloro-Cyclopentadiene(47)	C_5Cl_6	1.7180	1150	
Hexadecane (23)	$C_{16}H_{34}$	0.773 (20ºC)	1338	3.71
Hexalin	$C_6H_{12}O$	0.962	1454	3.6
Hexane (16,22,23)	C_6H_{14}	0.659	1112	2.71
n-Hexane (29,33)	C_6H_{14}	0.649 (20ºC)	1079	4.53
2,5-Hexanedione	$C_6H_{10}O_2$	0.729	1399	3.6
n-Hexanol	$C_6H_{14}O$	0.819	1300	3.8
Hexahydrobenzene (15)	C_6H_{12}	0.779	1248	5.41
Hexahydrophenol	$C_6H_{12}O$	0.962	1454	3.6
Hexamethylene (15)	C_6H_{12}	0.779	1248	5.41
Hydrogen (45)	H_2	0.071 (-256ºC)	1187	
2-Hydroxy-toluene (46)	C_7H_8O	1.047 (20ºC)	1541	
3-Hydroxy-tolune (46)	C_7H_8O	1.034 (20ºC)	1500	
Iodo-benzene (46)	C_6H_5I	1.823	1114	
Iodo-ethane (46)	C_2H_5I	1.950 (20ºC)	876	
Iodo-methane	CH_3I	2.28 (20ºC)	978	
Isobutyl acetate (22)	$C_6H_{12}O$		1180	4.85
Isobutanol	$C_4H_{10}O$	0.81 (20ºC)	1212	
Iso-Butane			1219.8	
Isopentane (36)	C_5H_{12}	0.62 (20ºC)	980	4.8
Isopropanol (46)	C_3H_8O	0.785 (20ºC)	1170	
Isopropyl alcohol (46)	C_3H_8O	0.785 (20ºC)	1170	
Kerosene		0.81	1324	3.6
Ketohexamethylene	$C_6H_{10}O$	0.948	1423	4.0
Lithium fluoride (42)	LiF		2485	1.29
Mercury (45)	Hg	13.594	1449	
Mesityloxide	$C_6H_{16}O$	0.85	1310	
Methane (25,28,38,39)	CH_4	0.162	405(-89.15ºC)	17.5
Methanol (40,41)	CH_4O	0.791 (20ºC)	1076	2.92
Methyl acetate	$C_3H_6O_2$	0.934	1211	
o-Methylaniline (46)	C_7H_9N	0.999 (20ºC)	1618	
4-Methylaniline (46)	C_7H_9N	0.966 (45ºC)	1480	
Methyl alcohol (40,44)	CH_4O	0.791 (20ºC)	1076	2.92
Methyl benzene (16,52)	C_7H_8	0.867	1328	4.27
2-Methyl-butane (36)	C_5H_{12}	0.62 (20ºC)	980	
Methyl carbinol	C_2H_6O	0.789	1207	4.0
Methyl-chloroform (47)	$C_2H_3Cl_3$	1.33	985	
Methyl-cyanide	C_2H_3N	0.783	1290	
3-Methyl cyclohexanol	$C_7H_{14}O$	0.92	1400	
Methylene chloride (3)	CH_2Cl_2	1.327	1070	3.94
Methylene iodide	CH_2I_2	3.235	980	
Methyl formate (22)	$C_2H_4O_2$	0.974 (20ºC)	1127	4.02
Methyl iodide	CH_3I	2.28 (20ºC)	978	
α-Methyl naphthalene	$C_{11}H_{10}$	1.090	1510	3.7

2-Methylphenol (46)	C_7H_8O	1.047 (20ºC)	1541	
3-Methylphenol (46)	C_7H_8O	1.034 (20ºC)	1500	
Milk, homogenized			1548	
Morpholine	C_4H_9NO	1.00	1442	3.8
Naphtha		0.76	1225	
Natural Gas (37)		0.316 (-103ºC)	753	
Neon (45)	Ne	1.207 (-246ºC)	595	
Nitrobenzene (46)	$C_6H_5NO_2$	1.204 (20ºC)	1415	
Nitrogen (45)	N_2	0.808 (-199ºC)	962	
Nitromethane (43)	CH_3NO_2	1.135	1300	4.0
Nonane (23)	C_9H_2O	0.718 (20ºC)	1207	4.04
1-Nonene (27)	C_9H_{18}	0.736 (20ºC)	1207	4.0
Octane (23)	C_8H_{18}	0.703	1172	4.14
n-Octane (29)	C_8H_{18}	0.704 (20ºC)	1212.5	3.50
1-Octene (27)	C_8H_{16}	0.723 (20ºC)	1175.5	4.10
Oil of Camphor Sassafrassy			1390	3.8
Oil, Car (SAE 20a.30)	1.74		870	
Oil, Castor	$C_{11}H_{10}O_{10}$	0.969	1477	3.6
Oil, Diesel		0.80	1250	
Oil, Fuel AA gravity		0.99	1485	3.7
Oil (Lubricating X200)			1530	5019.9
Oil (Olive)		0.912	1431	2.75
Oil (Peanut)		0.936	1458	
Oil (Sperm)		0.88	1440	
Oil, 6			1509	
2,2-Oxydiethanol	$C_4H_{10}O_3$	1.116	1586	2.4
Oxygen (45)	O_2	1.155 (-186ºC)	952	
Pentachloro-ethane (47)	C_2HCl_5	1.687	1082	
Pentalin (47)	C_2HCl_5	1.687	1082	
Pentane (36)	C_5H_{12}	0.626 (20ºC)	1020	
n-Pentane (47)	C_5H_{12}	0.557	1006	
Perchlorocyclopentadiene(47)	C_5Cl_6	1.718	1150	
Perchloro-ethylene (47)	C_2Cl_4	1.632	1036	
Perfluoro-1-Hepten (47)	C_7F_{14}	1.67	583	
Perfluoro-n-Hexane (47)	C_6F_{14}	1.672	508	
Phene (29,40,41)	C_6H_6	0.879	1306	4.65
β-Phenyl acrolein	C_9H_8O	1.112	1554	3.2
Phenylamine (41)	$C_6H_5NO_2$	1.022	1639	4.0
Phenyl bromide (46)	C_6H_5Br	1.522	1170	
Phenyl chloride	C_6H_5Cl	1.106	1273	3.6
Phenyl iodide (46)	C_6H_5I	1.823	1114	
Phenyl methane (16,52)	C_7H_8	0.867 (20ºC)	1328	4.27
3-Phenyl propenal	C_9H_8O	1.112	1554	3.2
Phthalardione	$C_8H_4O_3$		1125	
Phthalic acid, anhydride	$C_8H_4O_3$		1125	
Phthalic anhydride	$C_8H_4O_3$		1125	
Pimelic ketone	$C_6H_{10}O$	0.948	1423	4.0
Plexiglas, Lucite, Acrylic			2651	
Polyterpene Resin		0.77	1099.8	
Potassium bromide (42)	Kbr		1169	0.71
Potassium fluoride (42)	KF		1792	1.03
Potassium iodide (42)	KI		985	0.64
Potassium nitrate (48)	KNO_3	1.859 (352ºC)	1740.1	1.1
Propane (2,13)(-45 to -130ºC)	C_3H_8	0.585 (-45ºC)	1003	5.7
1,2,3-Propanetriol	$C_3H_8O_3$	1.26	1904	2.2
1-Propanol (46)	C_3H_8O	0.78 (20ºC)	1222	
2-Propanol (46)	C_3H_8O	0.785 (20ºC)	1170	
2-Propanone	C_3H_6O	0.791	1174	4.5
Propene (17,18,35)	C_3H_6	0.563 (-13ºC)	963	6.32
n-Propyl acetate (22)	$C_5H_{10}O_2$	1280 (2ºC)	4.63	
n-Propyl alcohol	C_3H_8O	0.78 (20ºC)	1222	
Propylchloride (47)	C_3H_7Cl	0.892	1058	

Propylene (17,18,35)	C_3H_6	0.563 (-13ºC)	963	6.32
Pyridine	C_6H_5N	0.982	1415	4.1
Refrigerant 11 (3,4)	CCl_3F	1.49	828.3	3.56
Refrigerant 12 (3)	CCl_2F_2	1.516 (-40ºC)	774.1	4.24
Refrigerant 14 (14)	CF_4	1.75 (-150ºC)	875.24	6.61
Refrigerant 21 (3)	$CHCl_2F$	1.426 (0ºC)	891	3.97
Refrigerant 22 (3)	$CHClF_2$	1.491 (-69ºC)	893.9	4.79
Refrigerant 113 (3)	$CCl_2F\text{-}CClF_2$	1.563	783.7	3.44
Refrigerant 114 (3)	$CClF_2\text{-}CClF_2$	1.455	665.3	3.73
Refrigerant 115 (3)	C_2ClF_5		656.4	4.42
Refrigerant C318 (3)	C_4F_8	1.62 (-20ºC)	574	3.88
Selenium (8)	Se		1072	0.68
Silicone (30 cp)		0.993	990	
Sodium fluoride (42)	NaF	0.877	2082	1.32
Sodium nitrate (48)	$NaNO_3$	1.884 (336ºC)	1763.3	0.74
Sodium nitrite (48)	$NaNO_2$	1.805 (292ºC)	1876.8	
Solvesso 3		0.877	1370	3.7
Spirit of wine	C_2H_6O	0.789	1207	4.0
Sulphur (7,8,10)	S		1177	-1.13
Sulphuric acid (1)	H_2SO_4	1.841	1257.6	1.43
Tellurium (7)	Te		991	0.73
1,1,2,2-Tetrabromo-ethane(47)	$C_2H_2Br_4$	2.966	1027	
1,1,2,2-Tetrachloro-ethane(67)	$C_2H_2Cl_4$	1.595	1147	
Tetrachloroethane (46)	$C_2H_2Cl_4$	1.553 (20ºC)	1170	
Tetrachloro-ethene (47)	C_2Cl_4	1.632	1036	
Tetrachloro-methane (33,47)	CCl_4	1.595 (20ºC)	926	
Tetradecane (46)	$C_{14}H_3O$	0.763 (20ºC)	1331	
Tetraethylene glycol	$C_8H_{18}O_5$	1.123	1586/5203.4	3.0
Tetrafluoro-methane (14) (Freon 14)	CF_4	1.75 (-150ºC)	875.24	6.61
Tetrahydro-1,4-isoxazine	C_4H_9NO		1442	3.8
Toluene (16,52)	C_7H_8	0.867 (20ºC)	1328	4.27
o-Toluidine (46)	C_7H_9N	0.999 (20ºC)	1618	
p-Toluidine (46)	C_7H_9N	0.966 (45ºC)	1480	
Toluol	C_7H_8	0.866	1308	4.2
Tribromo-methane (46,47)	$CHBr_3$	2.89 (20ºC)	918	
1,1,1-Trichloro-ethane (47)	$C_2H_3Cl_3$	1.33	985	
Trichloro-ethene (47)	C_2HCl_3	1.464	1028	
Trichloro-fluoromethane (3) (Freon 11)	CCl_3F	1.49	828.3	3.56
Trichloro-methane (47)	$CHCl_3$	1.489	979	3.4
1,1,2-Trichloro-1,2,2-Trifluoro-Ethane	$CCl_2F\text{-}CClF_2$	1.563	783.7	
Triethyl-amine (33)	$C_6H_{15}N$	0.726	1123	4.47
Triethylene glycol	$C_6H_{14}O_4$	1.123	1608	3.8
1,1,1-Trifluoro-2-Chloro-2-Bromo-Ethane	$C_2HClBrF_3$	1.869	693	
1,2,2-Trifluorotrichloro- ethane (Freon 113)	$CCl_2F\text{-}CClF_2$	1.563	783.7	3.44
d-1,3,3-Trimethylnor- camphor	$C_{10}H_{16}O$	0.947	1320	
Trinitrotoluene (43)	$C_7H_5(NO_2)_3$	1.64	1610	
Turpentine		0.88	1255	
Unisis 800		0.87	1346	
Water, distilled (49,50)	H_2O	0.996	1498	-2.4
Water, heavy	D^2O		1400	
Water, sea		1.025	1531	-2.4
Wood Alcohol (40,41)	CH_4O	0.791 (20ºC)	1076	2.92
Xenon (45)	Xe		630	
m-Xylene (46)	C_8H_{10}	0.868 (15ºC)	1343	
o-Xylene (29,46)	C_8H_{10}	0.897 (20ºC)	1331.5	4.1
p-Xylene (46)	C_8H_{10}		1334	
Xylene hexafluoride	$C_8H_4F_6$	1.37	879	
Zinc (7)	Zn		3298	

PORTAFLOW 216 Battery Charge circuit Operation.

Charging Controller IC:

A Maxim IC MAX712 or MAX713 controls the Ni-Cd and Ni-Mh battery charger. It has two modes, fast charge and trickle charge; an output indicates the fast-charge status. In both modes it supplies, via a PNP power transistor, a constant current to the battery, by keeping a constant voltage across a current sensing resistor. In fast charge mode it is 250mV, in trickle charge mode 31mV, so the trickle charge current is 1/8 of the fast charge current.

By wiring up input pins on the IC, the number of cells is set to 5, the voltage sampling interval to 168 sec, and the fast-charge time limit to 264 minutes (the maximum). The battery temperature limits are not used.

The IC starts the fast-charge timer when a battery is connected or when power is applied. It terminates the fast charge and returns to trickle charge, either after the 264 min (~4.5 hrs) time limit, or when it senses that the battery voltage remains constant or begins to decrease, meaning that the battery is fully charged.

Charging Voltage:

The voltage available to charge the 6V battery is restricted by the 9V charger input and the two diodes in the input. The S2D silicon diodes had a fwd drop of 0.75V, limiting the available charge voltage to 7.5V, which caused the MAX712 to sense that the battery voltage had stopped rising, and therefore prematurely end the fast charge. With several days of trickle charging the battery could however still reach its full capacity.

In Dec.2000 the S2D diodes were replaced by SS14 Schottky diodes with a fwd drop of 0.35V, thus raising the available charge voltage to 8.3V. At the same time the current was increased.

Instrument differences:

The current sensing resistor consists of either 2 or 4 parallel 1.2Ω resistors, giving about 0.4A or 0.8A fast-charge current.

PF-300 and UFM610P:

Battery Capacity 3.5Ah, or 4.0Ah after Oct.2000

Current 0.4A before, 0.8A after Dec.2000

PF-SE and 216:

Battery Capacity 1.2Ah

Current 0.4A

Software:

The fast-charge status output is not used by the present software (ver.3.06); in a future software update a message will be added, indicating charging status.

Quicker full charge:

The fastest way to fully charge the battery is to charge for 4.5 hrs, then switch the power supply off and on again, thus re-starting the fast charge for another 4.5 hr period, followed by trickle charge.

Warning:

If the battery is getting warm, that would indicate that it is full, and the power supply should not be connected again - overcharging reduces the life of the battery.

Note:

After a recently fully charged battery is connected to the charger, it seems that it takes the MAX712 about 30 min to sense that the battery voltage stops changing, and go to trickle charge.

Examples:

Older PF-300:- A 15 hour charge consists of 4.5 hrs of fast charge (400mA), followed by 10.5 hrs of trickle charge (50mA): 4.5*0.4+10.5*0.05=2.325Ah=3.5Ah*0.66, which fills the battery to 66% of capacity (3.5Ah).

To fill the remaining 34% at 50mA takes 3.5*0.34/0.05=23.8hrs, +15hrs = 39hrs to 100%.

Assuming 20% losses:

(3.5Ah*20%)/50mA=0.7Ah/0.05A=14hrs of

trickle charge to cover losses, +39hrs=53hrs total.

In fact it needs ~9hrs * 0.4A = 3.6Ah to fill the battery from empty to 103% full capacity.

Assuming 20% losses:

(3.5Ah*20%-0.1)/50mA=0.6Ah/0.05A=12hrs of trickle charge to cover losses, +9hrs=21hrs total.

A third session of fast charge would fill the last 17% in 3.5Ah*17%/0.4A=1.5hrs, = 10.5hrs total.

Newer PF-300:-

4.5hrs fast: 0.8A*4.5h=3.6Ah = 90% of 4.0Ah

Slow: 10%= 0.4Ah/0.1A = 4h, total 8.5h to 100%

with 20% losses: 0.8Ah/0.1A = 8h

Total time fast and slow: 16.5hrs to 120%.

Fast only: 4.0Ah/0.8A=5hrs, +20%=6hrs,

that needs 2 sessions: 4.5hrs + 1.5hrs to 120%.

PF-SE & 216:- 1.2Ah/0.4A=3hrs to 100% capacity; with 20% losses 3h+20%=3.6hrs total.

This is well within the first 4.5hrs.

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