arkon flow systems

Operating Instructions

USCX150

Ultrasonic Flowmeter

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Operating Instructions USCX150
Version V20EN140912

USCX150
Operating Instructions

Table of Contents

1 Safety instructions, legal requirements, warranty, return policy

1.1 Symbols used in these operating instructions

Danger
This symbol represents an immediate hazardous situation which could result in **serious injury, death** or **damage to the equipment**. Where this symbol is shown, do not use the equipment further unless you have fully understood the nature of the hazard and have taken the required precautions.

!

Attention
This symbol indicates important instructions which should be respected in order to avoid damaging or destroying the equipment. Follow the the precautions given in these instructions to avoid the hazard. Call our service team if necessary.

Call service
Where this symbol is shown call our service team for advice if necessary.

Note
This symbol indicates a note or detailed set-up tip.

- Information point.

<**BRK**> Operator keys are printed in bold typeface and placed in pointed brackets.

1.2 Safety instructions

- Do not install, operate or maintain this flowmeter without reading, understanding and following these operating instructions, otherwise injury or damage may result.
- Study these operating instructions carefully before the installation of the equipment and keep them for future reference.
- Observe all warnings, notes and instructions as marked on the packaging, on the equipment, and detailed in the operating instructions.
- Do not use the instrument under wet conditions with the battery cover removed or opened.
- Follow the unpacking, storage and preservation instructions to avoid damage to the equipment.
- Install the equipment and cabling securely and safely according to the relevant regulations.
- If the product does not operate normally, please refer to the service and troubleshooting instructions, or contact Arkon for help.

1.3 Warranty

- Any product purchased from Arkon is warranted in accordance with the relevant product documentation and as specified in the sales contract provided it has been used for the purpose for which it has been designed and operated as outlined in these operating instructions. Misuse of the equipment will immediately revoke any warranty given or implied.
- Responsibility for suitability and intended use of this ultrasonic flowmeter rests solely with the user. Improper installation and operation of the flowmeter may lead to a loss of warranty.
- Please note that there are no operator-serviceable parts inside the equipment. Any unauthorised interference with the product will invalidate the warranty.

1.4 Return policy

If the flowmeter has been diagnosed to be faulty, it can be returned to Arkon for repair using the Customer Returns Note (CRN) attached to the Appendix of this manual. Arkon regret that for Health & Safety reasons we cannot accept the return of the equipment unless accompanied by the completed CRN.

1.5 Legislative requirements

CE marking

The flowmeter is designed to meet the safety requirements in accordance with sound engineering practice. It has been tested and has left the factory in a condition in which it is safe to operate. The equipment is in conformity with the statutory requirements of the EC directive and complies with applicable regulations and standards for electrical safety EN 61010 and electro-magnetic compatibility EN 61326. A CE Declaration of Conformity has been issued in that respect, a copy of which can be found in the Appendix of these operating instructions.

WEEE Directive

The Waste Electrical and Electronic Equipment Directive (WEEE Directive) aims to minimise the impact of electrical and electronic goods on the environment by increasing re-use and recycling and by reducing the amount of WEEE going to landfill. It seeks to achieve this by making producers responsible for financing the collection, treatment, and recovery of waste electrical equipment, and by obliging distributors to allow consumers to return their waste equipment free of charge.

Arkon offers its customers the possibility of returning unused and obsolete equipment for correct disposal and recycling. The Dustbin Symbol indicates that when the last user wishes to discard this product, it must be sent to appropriate facilities for recovery and recycling. By not discarding this product along with other household-type waste, the volume of waste sent to incinerators or landfills will be reduced and natural resources will be conserved. Please use the Customer Return Note (CRN) in the Appendix for return to Arkon.

RoHS Directive

All products manufactured by Arkon are compliant with the relevant aspects of the RoHS Directive.

2 Introduction

Clamp-on transit-time flowmeter

The USCX150 is an ultrasonic flowmeter employing clamp-on sensors for the measurement of liquids in full, enclosed pipes. Flow measurements can be undertaken without interruption of the process or interference with the integrity of the pipeline. The clamp-on sensors are attached to the outside of the pipes. The USCX150 uses ultrasonic signals for measurement of the flow, employing the transit-time method.

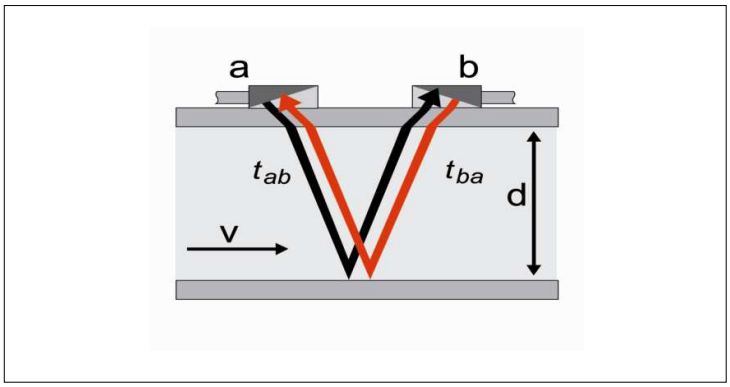


Illustration 1: Clamp-on ultrasonic flowmeter configuration

Measuring principle

Ultrasonic signals are emitted by a transducer installed on a pipe and received by a second transducer. These signals are emitted alternately in the direction of flow and against it. Because the medium is flowing, the transit time of the sound signals propagating in the direction of flow is shorter than the transit time of the signal propagating against the direction of flow. The transit-time difference ΔT is measured and allows the determination of the average flow velocity along the path of acoustic propagation. A profile correction is then performed to obtain the average flow velocity over the cross-sectional area of the pipe, which is proportional to the volumetric flow rate.

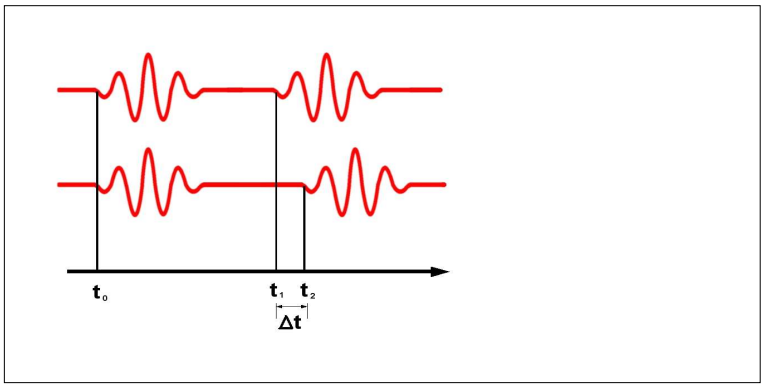


Illustration 2: Transit-time measuring principle

2.1 System configuration

A maximum of 2 sensor pairs can be installed - if two pairs are installed these can be configured either in a 1-pipe dual-path or a 2-pipe single path configuration.

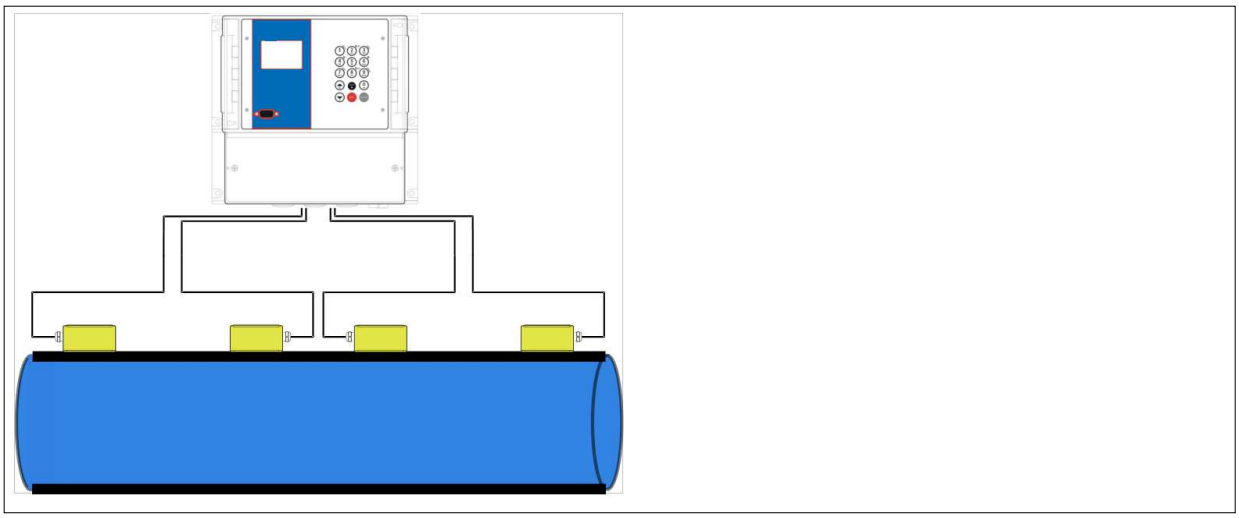


Illustration 3: USCX150 with direct sensor connection in a 1 pipe 2 path configuration

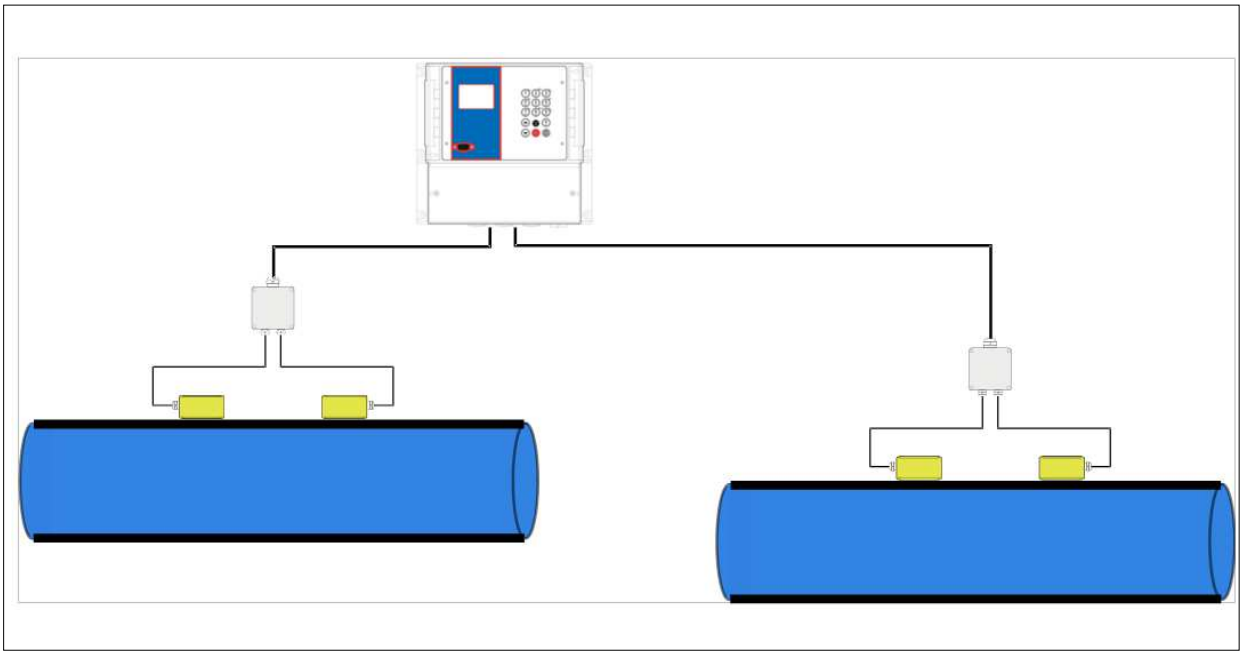


Illustration 4: USCX150 2-pipe 1-path configuration using optional junction boxes

3 Installation

3.1 Unpacking and storage

3.1.1 Unpacking

Care should be taken when opening the box containing the flowmeter, any markings or warnings shown on the packaging should be observed prior to opening. The following steps should then be taken:

- Unpack the flowmeter in a dry area.
- The flowmeter should be handled with care and not left in an area where it could be subject to physical shocks.
- If using a knife to remove packaging care should be taken not to damage the flowmeter or cables.
- The flowmeter package and contents should be checked against the delivery note supplied and any missing items reported immediately.
- The flowmeter package and contents should be checked for signs of damage during transport and any problems reported immediately.
- The vendor accepts no responsibility for damage or injury caused during the unpacking of the instrumentation supplied.
- Excess packing materials should be either recycled or disposed of in a suitable way.

3.1.2 Storage

If storage is necessary, the flowmeter and sensors should be stored:

- in a secure location,
- away from water and harsh environmental conditions,
- in such a way as to avoid damage,
- small items should be kept together in the bags provided to avoid loss.

3.1.3 Identification of components

The following items are typically supplied (please refer to your delivery note for a detailed description):

- USCX150 ultrasonic flowmeter
- Clamp-on sensors (one pair for single channel operation, two pairs for dual channel operation)
- Sensor connection cable(s) if not direct sensor connection
- Sensor mounting accessories
- Coupling component
- Operating instructions
- Project and/or hazardous area documentation (optional)
- Calibration certificate(s) (optional)
- Temperature measurement probes (optional)

3.2 Clamp-on sensor installation

The correct selection of the sensor location is crucial for achieving reliable measurements and high accuracy. Measurement must take place on a pipe in which sound can propagate (see Acoustic propagation) and in which a rotationally symmetrical flow profile is fully developed (see Straight pipe lengths).

The correct positioning of the transducers is an essential condition for error-free measurements. It ensures that the sound signal will be received under optimal conditions and evaluated correctly. Because of the variety of applications and the different factors influencing the measurement, there can be no standard solution for the positioning of the transducers.

The correct position of the transducers will be influenced by the following factors:

- diameter, material, lining, wall thickness and general condition of the pipe,
- the medium flowing in the pipe,
- the presence of gas bubbles and solid particles in the medium.

Check that the temperature at the selected location is within the operating temperature range of the transducers (see Specification).

After the sensor location has been selected, make sure that that supplied cable is long enough to reach the flow transmitter mounting location. Ensure that the temperature at the selected location is within the ambient operating temperature range of the flow transmitter (see Specification).

Acoustic propagation

Acoustic propagation is achieved when the flowmeter is able to receive sufficient signal from the transmitted ultrasonic pulses. The signals are attenuated in the pipe material, the medium and at each of the interfaces and reflections. External and internal pipe corrosion, solid particles and gas content in the medium contribute heavily to signal attenuation.

Straight pipe lengths

Sufficient straight lengths of pipe on the inlet and outlet of the measuring location ensure an axi-symmetrical flow profile in the pipe, which is required for good measurement accuracy. If insufficient straight lengths of pipe are available for your application measurements are still obtainable, but the certainty of the measurement can be reduced.

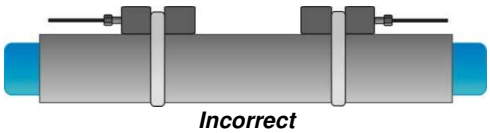
3.3 Installation location

Select an installation location following the recommendations in Table 1 and try to avoid measuring

- in the vicinity of deformations and defects of the pipe,
- near welding seams,
- where deposits could be building up in the pipe.

For a horizontal pipe:
Select a location where the transducers can be mounted on the side of the pipe, so that the sound waves emitted by the transducers propagate horizontally in the pipe. In this way, the solid particles deposited on the bottom of the pipe and the gas pockets developing at the top will not influence the propagation of the signal.

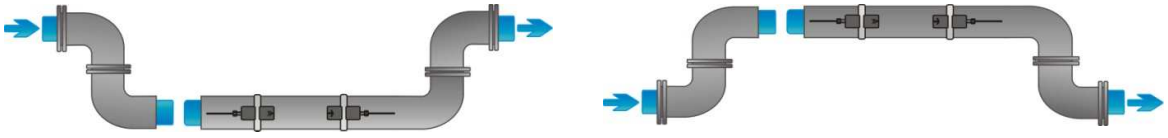
Correct



Incorrect

For a free inlet or outlet pipe section:
Select the measuring point at a location where the pipe cannot run empty.

Correct ***Disadvantageous***



Correct ***Disadvantageous***

For a vertical pipe:
Select the measuring point at a location where the liquid flows upward to ensure that the pipe is completely filled.

Correct ***Incorrect***

Table 1: Recommendations for sensor mounting location

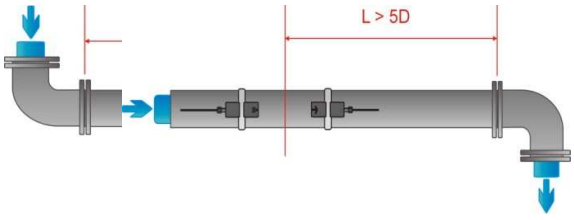
Look for a sensor installation location with sufficient straight pipe to obtain accurate measurements. Please refer to Table 2 as a guideline for recommended distances from disturbance sources.

Disturbance source: 90°-elbow
Inlet

L ≥ 10 D

Outlet

L ≥ 5 D

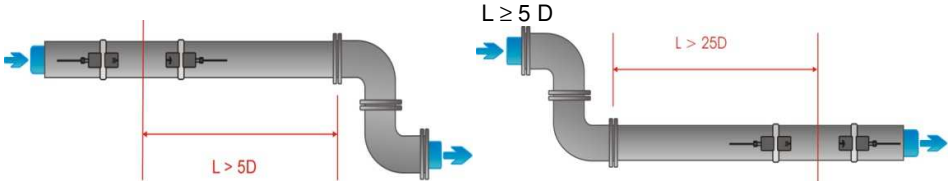


Disturbance source: 2 x 90°-elbows in one plane
Inlet

L ≥ 25 D

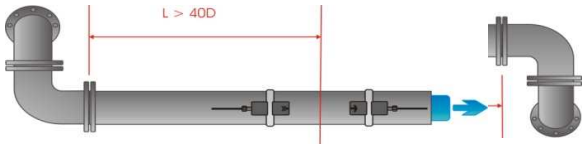
Outlet

L ≥ 5 D



Disturbance source: 2 x 90°-elbows in different planes

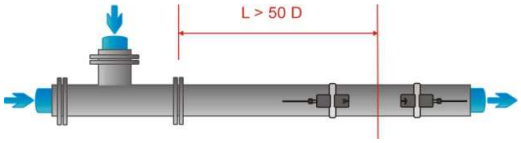
Inlet
L ≥ 40 D



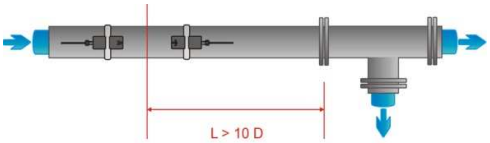
Outlet
L ≥ 5 D

Disturbance source: T-section

Inlet
L ≥ 50 D

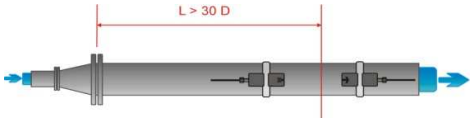


Outlet
L ≥ 10 D

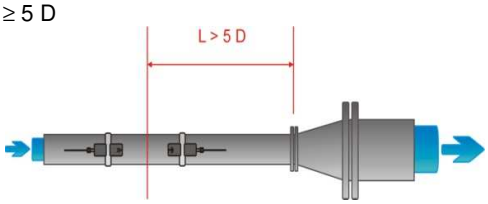


Disturbance source: diffuser

Inlet
L ≥ 30 D

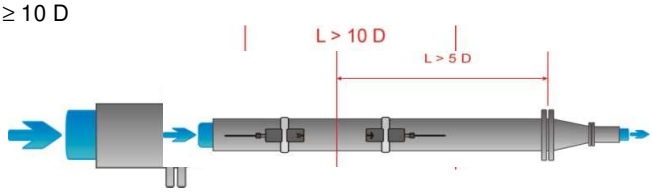


Outlet
L ≥ 5 D



Disturbance source: reducer

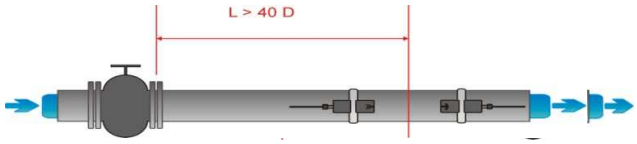
Inlet
L ≥ 10 D



Outlet
L ≥ 5 D

Disturbance source: valve

Inlet
L ≥ 40 D



Outlet
L ≥ 10 D

Disturbance source: pump

Inlet
L ≥ 50 D

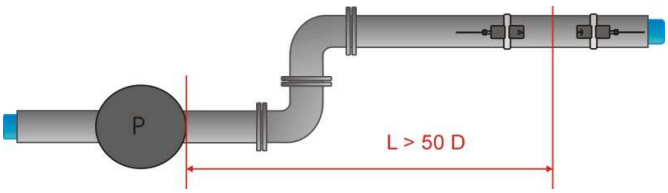


Table 2: Recommended distances from disturbance sources

3.4 Pipe preparation

- Clean dirt and dust from around the area of the pipework where the sensors are to be placed.
- Remove loose paint and rust with a wire brush or file.

Firmly bonded paint does not necessarily need to be removed provided the flowmeter diagnostics indicate sufficient signal strength.

3.5 Clamp-on sensor mounting configurations and separation distance

Reflection Mode

The most common clamp-on sensor mounting configuration is the Reflection Mode, sometimes known as V-Mode (see Illustration 3, sketch (1). Here, the ultrasonic signal passes twice through the medium (2 signal passes). The Reflection Mode is the most convenient mounting method as the transducer separation distance can be measured easily and the sensors can be accurately aligned. This method should be used whenever possible.

Diagonal Mode

An alternative mounting configuration (Illustration 3, sketch (3)) is the Diagonal mode (Z-Mode). The signals travel only once through the pipe. This method is often used for larger pipes where greater signal attenuation might occur.

Further variation of the Reflection and the Diagonal Modes are possible by altering the number of passes through the pipe. Any even number of passes will require mounting the sensors on the same side of the pipe, while with an odd number of passes, the sensors must be mounted on opposite sides of the pipe. Commonly, for very small pipes, sensor mounting configurations such as 4 passes (W-mode) or 3 passes (N-mode) are used (Illustration 3, sketch (2)).

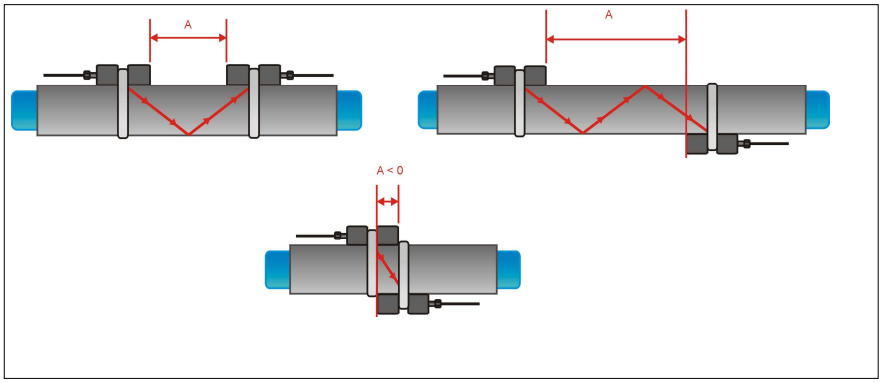


Illustration 5: Clamp-on sensor mounting configurations and sensor spacing

Transducer separation distance

The transducer separation distance A is measured from the inside edges of the sensor heads as shown in illustration 3. It is automatically calculated by the flowmeter based on the parameter entries for pipe outside diameter, wall thickness, lining material and thickness, medium, process temperature, the sensor type and the selected number of signal passes.

Sensor spacing

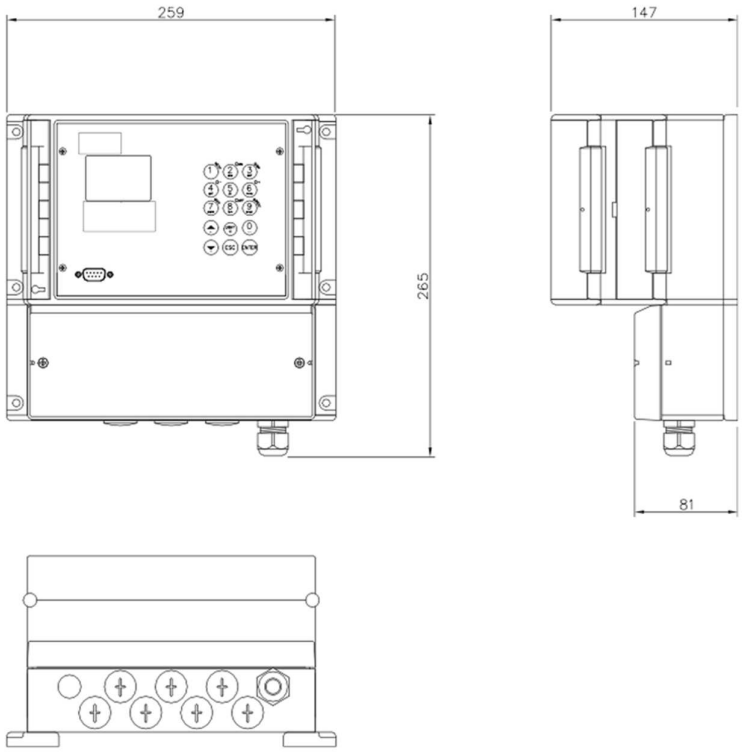
A negative separation distance A < 0 can occur for mounting configurations on small pipes where diagonal mode operation has been selected (see Illustration 3, sketch (3). Negative separation distances may be suggested for reflection mode installations, but are not possible. In these cases, use diagonal mode or a larger number of passes.

3.6 Flowmeter installation

3.6.1 Wall mounting

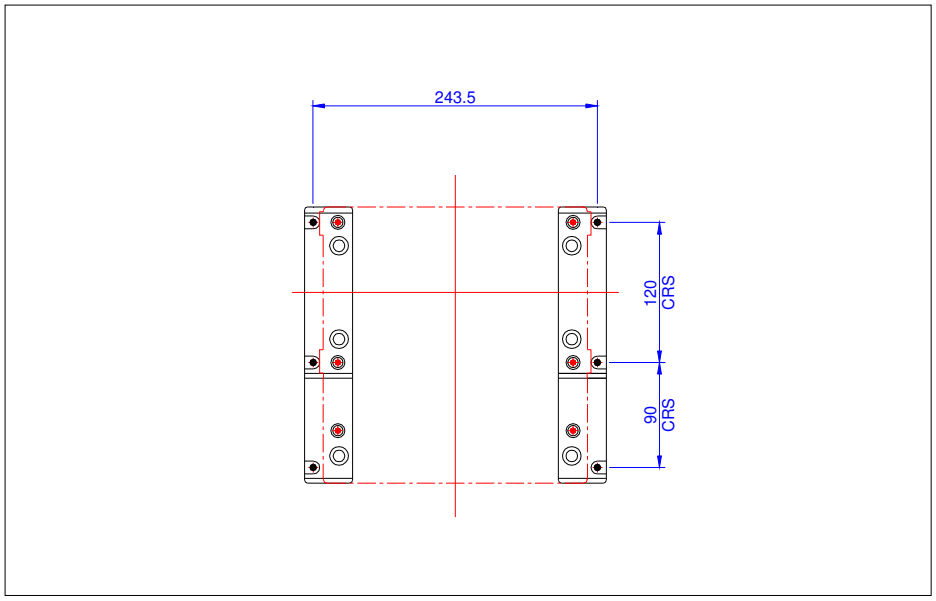
The USCX150 is a wall mounted device and can be installed using suitable screws and wall plugs according to the following drawings.

Flowmeter outline dimensions



Drawing 1: Outline dimensions USCX150 ultrasonic flowmeter

Drilling aid for wall mounting



! Make sure that the ambient temperature is within the -10 ... 60 °C operating temperature range specified for the flowmeter unit.

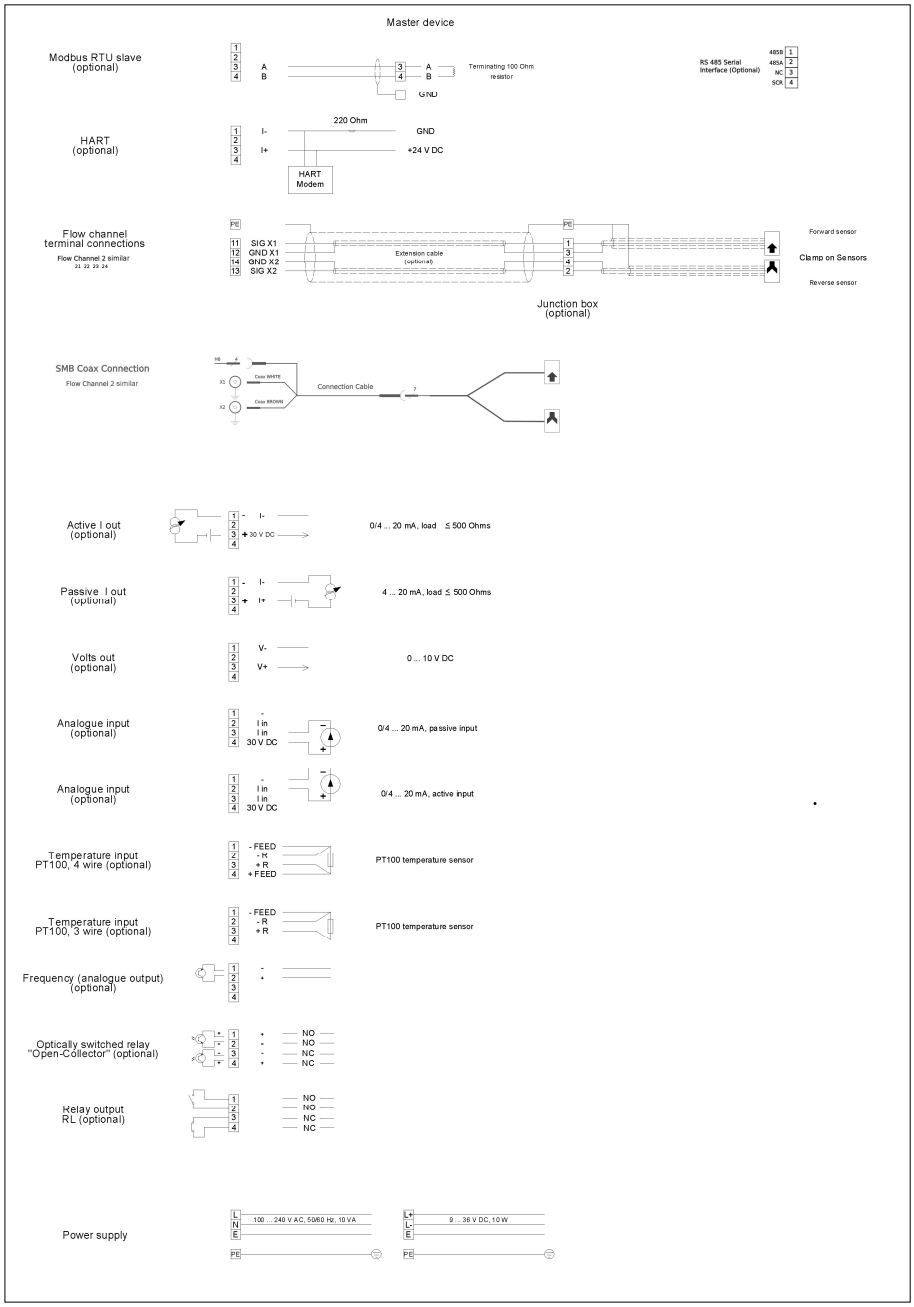
3.6.2 Electrical connections

Electrical wiring

Please note that in order to supply the unit with MAINS POWER, the equipment must be protected by suitably sized switches and circuit breakers.

100 ... 240 V AC, 50/60 Hz	10 W
9 ... 36 V DC	10 W

!



3.7 Clamp-on sensor mounting

Sensor mounting

Before the sensors can be mounted

- the installation location should have been determined,
- a sensor mounting method should be chosen,
- the flowmeter must be mechanically and electrically installed,
- the sensors must be connected to the flowmeter.

Depending on which sensor mounting method is being used, the clamp on sensors are either mounted on the same side of the pipe (Reflection Mode) or on opposite sides of the pipe (Diagonal Mode). The sensor spacing is calculated by the flowmeter from the pipe parameters entered.

3.7.1 Sensor pipe mounting configurations

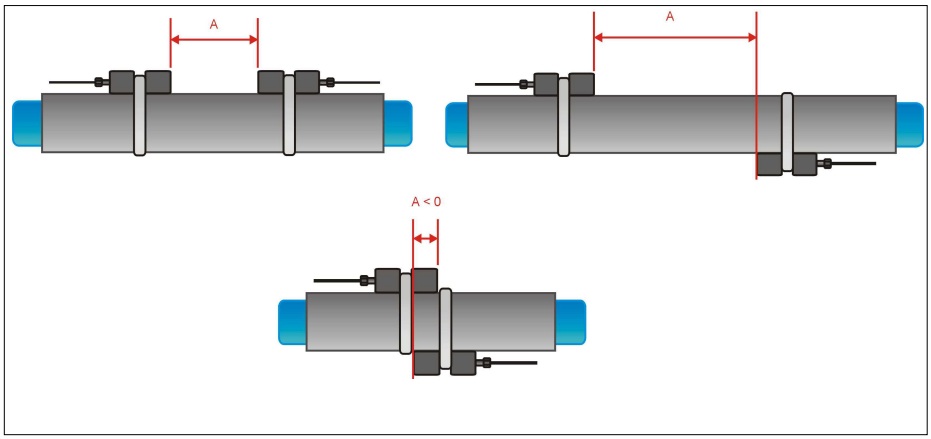


Illustration 6: Sensor pipe mounting configurations

3.7.2 Acoustic coupling gel

In order to obtain acoustical contact between the pipe and the sensors, apply a bead of acoustic coupling gel lengthwise down the centre of the contact area of the sensors.

Illustration 7: Application of acoustic coupling gel

3.7.3 Correct positioning of the sensors

Correct sensor position

Illustration 8: Correct positioning of the sensors

Always mount the transducer pair so that the free front edges of the sensors face each other.

There is a different engraving on the top of each transducer. The transducers are mounted correctly if the engravings on the two transducers form an arrow. The transducer cables should point in opposite directions.

Later, the arrow, in conjunction with the indicated measured value, will help to determine the direction of flow.

The sensor separation distance is automatically calculated by the flowmeter based on the parameter entries for pipe outside diameter, wall thickness, lining material and thickness, medium, process temperature, the sensor type and the selected number of signal passes.

3.7.4 Sensor mounting with tension straps

Illustration 9: Metallic mounting straps

- Cut the tension straps to the appropriate length.
- Pull at least 2 cm of the tension strap through the slot in the clamp and bend the strap back to secure the clamp to the tension strap.
- Guide the other end of the tension strap through the groove on top of the sensor.
- Ensure sensors have adequate acoustic couplant.
- Place the sensor onto the prepared pipe section.
- Hold the clamp on the transducer with one hand and guide the tension

strap around the pipe.

- Pull the tension strap and guide the free end through the clamp so that the clamp hooks engage. Slightly tighten the screw on the clamp.
- Mount the second sensor in the same way.
- Press the sensors firmly to the pipe. There should be no air pockets between the transducer surface and the pipe wall.
- Using a measuring tape, adjust the sensor separation distance as suggested by the flowmeter. When the sensor positioning screen (Section 3.3) is displayed, the middle bar allows fine adjustment of the sensor location.

Illustration 10: Sensor mounting with tension straps and clamps

- Ensure that the narrower side of the clip is above and inside the wider side and that the two sides of the clip do not come into contact while tightening, as this will prevent the strap from being correctly tensioned.

Illustration 11: Clip arrangement for correct tensioning

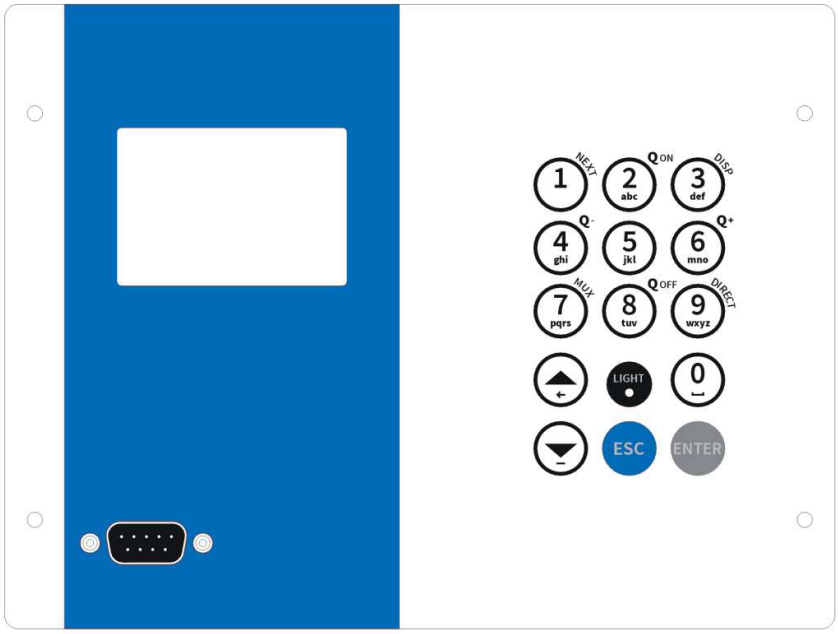
4 Operation

4.1 Switching On/Off

Switching On/Off

The flowmeter is switched on by connecting the power supply to the instrument. Disconnecting the external supply switches off the flowmeter.

4.2 Keypad and display



4.2.1 Keypad key functions

Key	Main function	Secondary function
1 NEXT	Character entry: **1** (1 short key stroke) **,** (2 short key strokes) **.** (3 short key strokes) **_** (4 short key strokes)	Show **NEXT** available item
2 abc QON	Character entry: **A** **B** **C** **2** /	**Q_{ON}** = Start and reset totaliser
3 def DISP	Character entry: **D** **E** **F** **3** **?**	Show next **DISP**lay

	Character entry: **G** **H** **I** **4** **<**	**Q-** = Reset negative total value
	Character entry: **J** **K** **L** **5** **>**	
	Character entry: **M** **N** **O** **6** **$**	**Q+** = Reset positive total value
	Character entry: **P** **Q** **R** **S** **7**	Toggle **MU**ltiple**X**er (where multi-channel functions are provided)
	Character entry: **T** **U** **V** **8** *****	**QOFF** = Stop totaliser function
	Character entry: **W** **X** **Y** **Z** **9**	
	Move menu/list selection item **UP**	Character backspace clear
	Character entry: **.** (decimal point)	Switch LCD backlight on/off
	Character entry: **0** **Space character** **+** **=** **#**	
	Move menu/list selection item **DOWN**	Character entry : **-** (minus sign)
	**ESC**ape menu item	Abort entry without saving

ENTER	**ENTER** menu item	Confirm entry with saving

Table 3: Menu structure

4.2.2 Display functions

Main measurement display

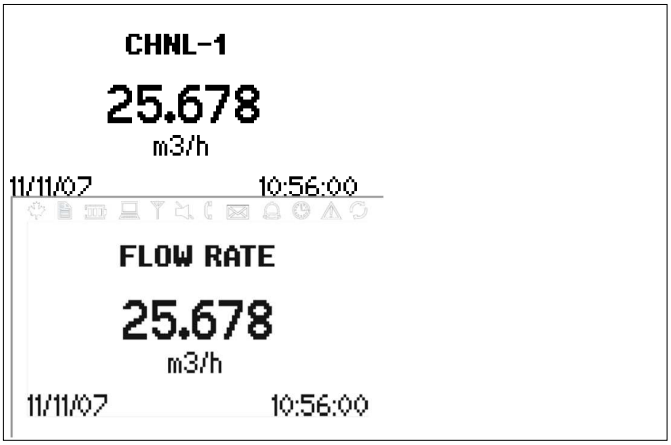


Illustration 12: Main display functions

Display icons

Display icon	Function	
	On **Off**	Not used
	On **Off**	Datalogger recording Datalogger switched off
	On **Off**	Not used
	On **Off**	Backlight switched on Backlight switched off
	On **Off**	I/O processor error I/O processor functioning correctly
	On **Off**	Without strike-through: Speaker on With strike-through: Speaker off
	On **Off**	Poor sensor coupling, low SNR Sensor coupling OK
	On **Off**	Not used

	**On** **Off**	Not used
	**On** **Off**	Time/date set Clock error
	**On** **Off**	Error recorded in error log No error detected
	**On**	Serial communication on (RS232 and/or RS485) **Off** Serial communication off

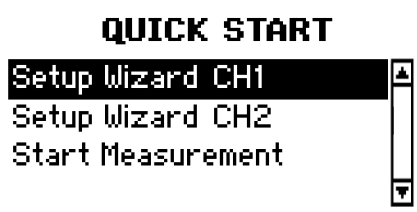
Table 4: Display icons

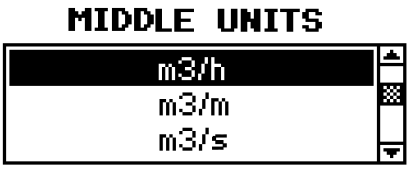
"L", "LT" or "T"	Displays whether flow is laminar, turbulent or mixed

4.3 Quick setup wizard

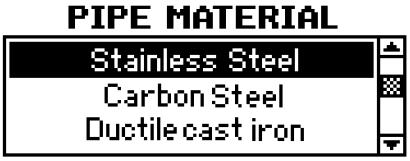
Quick start wizard

The quick setup wizard allows for a speedy setup of the most important parameters in order to achieve successful measurements in the shortest possible time:

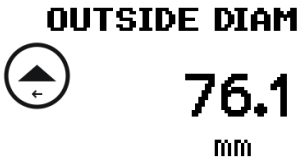
Display screen	**Operation**
	
	The main menu is displayed after first power on and the boot-up sequence.
	Use <**UP**> and <**DOWN**> cursor keys to select **Quick start**. Confirm by pressing <**ENTER**>.
	
	Use cursor keys to select **Setup Wizard**. Confirm by pressing <**ENTER**>. If sensors are recognised, the serial number will be shown. If not recognised or not connected, they may be selected from a list.



Select units of measurement using cursor keys and pressing <**ENTER**>.



Choose pipe material using cursor keys and pressing <**ENTER**>.



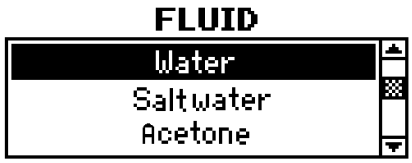
Enter outside pipe diameter using alphanumerical keys and confirm by pressing <**ENTER**>.

Use key <**UP**> as character backspace clear to correct for data entry errors.

If 0 is entered, an additional screen appears that allows entering the pipe circumference.

Enter pipe wall thickness using alphanumerical keys and confirm by pressing <**ENTER**>.

Use key <**UP**> as character backspace clear to correct for data entry errors.



Select fluid using cursor keys.

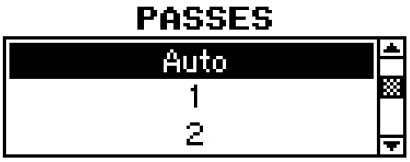
Confirm by pressing <**ENTER**>.

Enter process temperature using alphanumerical keys and confirm by pressing <**ENTER**>.

Use key <**UP**> as character backspace clear to correct for data entry errors.

Select pipe lining material using cursor keys.

Confirm by pressing <**ENTER**>.

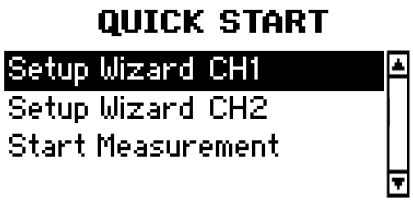


Select transducer configuration (number of passes) using cursor keys.

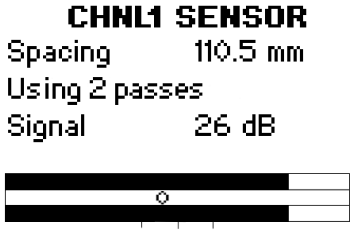
Auto	Automatically
1	1 pass, diagonal mode
2	2 passes, reflection mode
3	3 passes, diagonal mode
4	4 passes, reflection mode
5	5 passes, diagonal mode
6	6 passes, reflection mode

..etc.

Confirm by pressing <**ENTER**>.



Use cursor keys to select **Start Measurement**. Confirm by pressing <**ENTER**>.



Sensor placement screen: Mount transducers with suggested spacing and use middle bar for fine adjustment of position (central position is desired). Observe signal-to-noise (upper bar) and quality (lower bar). These should be of identical length.

Confirm by pressing <**ENTER**> to obtain measurements.

Success!

Table 5: Quick setup wizard

4.4 Measurements

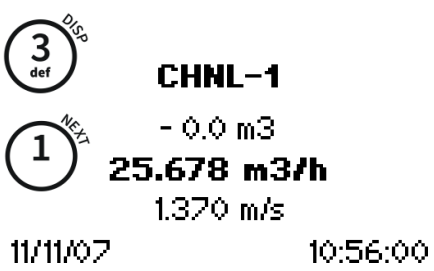
4.4.1 Main process value (PV) display

Measurement screens

Measurement is started using the Quick Setup Wizard. Once all the parameters are programmed, any subsequent power-on sequences will bring up the main PV display immediately.

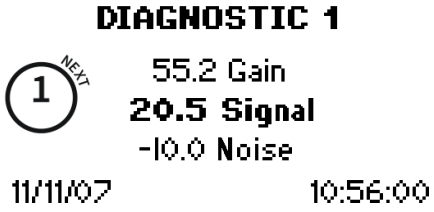
Display screen	Operation
	
CHNL-1 1 NEXT 25.678 m3/h 11/11/07 10:56:00	The main process value can be changed using the menu structure. Press **<ESC>** at any time to access the main menu. Change to other display modes by pressing **<DISP>** or **<NEXT>.**

3-line display format

Display screen	Operation
	
	The three-line display screen is configureable to show flow, totalizers and diagnostic functions. Change to diagnostic displays by pressing **<DISP>** and to totalizer screens by pressing **<NEXT>.** Cycle through display screens using **<NEXT>.** Cycle through available flow channels using **<MUX>.**

4.4.2 Diagnostic displays

Diagnostic screens

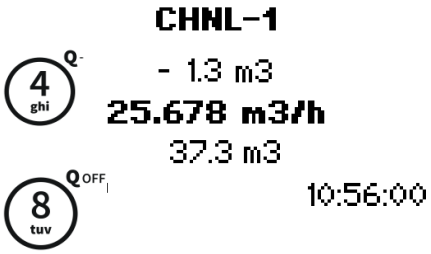
Display screen	Operation
	Line 1 shows the amplifier gain. Line 2 displays the signal strength. Line 3 indicates the noise. Change to more diagnostic displays by pressing **<NEXT>**.

4.4.3 Totalisers

The totaliser displays will only be shown when the totalisers are activated.

Totalisers

Display screen	Operation
	



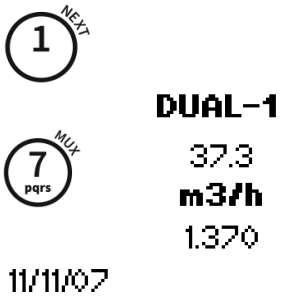
The flow totalizer may be assigned to lines in the three line display, the datalogger or process outputs. They can be started or reset by pressing **<Q_{ON}>**.

Pressing **<Q_{+}>** resets the total accumulated flow in positive flow direction. Pressing **<Q->** resets the total accumulated flow in negative flow direction.

The totalizers can be stopped by activating **<Q_{OFF}>**. Pressing **<Q_{ON}>** again will reset to zero.

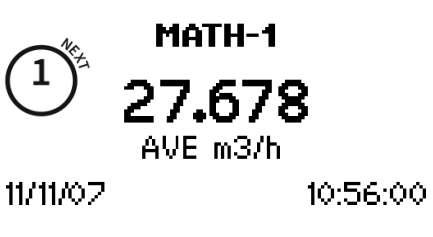
Change to other displays or revert to the three line display screen without resetting by pressing **<DISP>** or **<NEXT>**.

4.4.4 Dual PV display (multi-channel meters)

Display screen	Operation
	Line 1 shows the PV on the selected channel. Line 2 shows the selected units. Line 3 shows the PV on the other channel (in its selected units) Change to diagnostic displays by pressing **<DISP>** and to totalizer and main PV screens by pressing **<NEXT>.** Cycle through available flow channels using **<MUX>.**

4.4.5 "Math" display (when enabled on multi-channel meters)

Display screen	Operation



Displays the "Math" function (when enabled).

Sum, diffierence, average and maximum can be selected in the "Calculation" menu.
"Average" shown in illustration.

Change to diagnostic displays by pressing **<DISP>** and to totalizer, dual and main PV screens by pressing **<NEXT>.**

4.4.6 Datalogger

The datalogger is enabled from the Main Menu, and operates when a non-zero value is entered for the interval.
Items to be logged are selected from the “Selection” screen. “ENTER” selects items, “0” deselects. Up to ten items may be selected.
(Note : If no items are selected the logger will record blank space)
Send logger by serial port to a terminal program by selecting “Log download”.
Clear the logger by selecting “Log Erase”.
Remaining logger space can be seen in the Diagnostic displays.

Logged data can be downloaded, viewed and exported using the Data+ software except when "wrap" mode has been enabled.

5 Commissioning

5.1 Menu structure

Menu structure

Main menu	Menu level 1	Menu level 2	Description/settings
Quick Start			
	Setup Wizard CH1		
		Sensor type	*Indication of sensor type and serial number if automatically detected, otherwise select from list* ↑↓ K1N,K1L,K1E,K1Ex,K1P, K4N,K4L,K4E,K4Ex,K4P, K0, M, Q, Special
		Middle (main displayed) Units	*Select from list where available* ↑↓ m/s, f/s, in/s, m3/h, m3/min, m3/s, l/h, l/min, l/s, USgal/h, USgal/min, USgal/s, bbl/d, bbl/h, bbl/min, g/s, t/h, kg/h, kg/min, m3, l, Usgal, bbl, g, t, kg, W, kW, MW, J, kJ, MJ, Signal dB, noise dB, SNR (dB), C m/s (sound speed), CU (housing temperature), K (correction factor), REY (Reynolds number), SOS, DEN, KIN, SHC (sound speed, density, kinematic viscosity, Specific Heat Capacity from inputs/calculation), TEMP (specified or measured fluid temperature), PRESS (specified or measured fluid pressure), Tin, Tout (inlet and outlet temperature) Other (Assignable input or calculated value), Math (Calculated value – see below).
		Pipe material	*Select from list* ↑↓ Stainless steel, Carbon steel Ductile cast iron, Grey cast iron Copper, Lead PVC, PP, PE, ABS Glass, Cement, User
		Pipe c-speed	*Only if user pipe material selected* 600 ... 6553.5 m/s
		Outside diameter	6 ... 6500 mm
		Wall thickness	0.5 ... 75 mm
		Fluid	*Select from list* ↑↓ Water, Salt water Acetone, Alcohol, Ammonia Carbon Tet (carbon tetrachloride) Ethanol, Ethyl alcohol, Ethyl ether Ethylene glycol, Glycol/water 50% Kerosene, Methanol, Methyl alcohol Milk, Naphtha, Car oil Freon R134a, Freon R22 Hydrochloric acid, Sour cream, Sulphuric acid Toluene, Vinyl chloride User (enter kinematic viscosity, density, medium c-speed)
		Kinematic viscosity	*Only if user fluid selected* 0.001 ... 30000 mm^2/s
		Density	*Only if user fluid selected* 100 ... 2000 kg/m^3
		Medium c-speed	*Only if user fluid selected* 800 ... 3500 m/s
		Temperature	-30 ... 300 °C

		Liner Material	*Select from list* ↑↓ None, Epoxy, Rubber, PVDF, PP, Glass, Cement, User (liner c-speed)
		Liner c-speed	*Only if lining material selected* 600 ... 6553.0 m/s
		Liner thickness	*Only if lining material selected* 1.0 ... 99.0 mm
		Passes	*Select from list* ↑↓ Auto, 1...16
	Setup Wizard CH2		
			As setup wizard for channel 1
	Start Measurement		
		Sensor type	*Indication of sensor type and serial number if automatically detected, otherwise select from list* ↑↓
			As Setup Wizard
		Sensor frequency	*SP1, only for special, unrecognised sensors*
		Wedge angle	*SP2, only for special, unrecognised sensors*
		Wedge c-speed 1	*SP3, only for special, unrecognised sensors*
		Wedge c-speed 2	*SP4, only for special, unrecognised sensors*
		Crystal offset	*SP5, only for special, unrecognised sensors*
		Spacing offset	*SP6, only for special, unrecognised sensors*
		Zero flow offset	*SP7, only for special, unrecognised sensors*
		Upstream offset	*SP8, only for special, unrecognised sensors*
		Sensor placement	Adjust sensor position
Installation			
		Select channel	Channel 1, Channel 2
	Pipe		
		Material	*Select from pipe material list* ↑↓
		Outside diameter	6 ... 6500 mm
		Wall thickness	0.5 ... 75 mm
		C-speed	600 ... 6554 m/s (transverse sound speed)
		Circumference	18.8 ... 20420.4 mm
		Roughness	0.0 ... 10 mm
	Medium		
		Fluid	*Select from fluid list* ↑↓
		Kinematic (viscosity)	0.001 ... 30000 mm^2/s
		Density	100 ... 2000 kg/m^3
		C-speed	100 ... 3500 m/s
		Temperature	-30 ... 300 °C
	Lining		
		Material	*Select from material list* ↑↓
		Thickness	1 ... 99 mm

		C-speed	600 ... 6553.0 m/s
	Passes		
		Passes	*Select from list* ↑↓
Display			
		Select channel	Channel 1, Channel 2
		Select line of display (Top, Middle, Bottom)	*Select from unit list* ↑↓
		Damping	*Reduces fluctuations in the display output* 1 ... 255 s
		Metric/Imp.	Select metric or Imperial units.
In/Output			
	Type		*Select from list* ↑↓
	I Out		**Analogue current output**
		Source	*Select from list* ↑↓ Off, Channel 1, Channel 2, Math 1, Math 2 System, Test
		Units	*Select from unit list* ↑↓
		Min Value	*Min. process variable (PV) value that corresponds to 0/4 mA*
		Max Value	*Max. process variable (PV) value that corresponds to 20 mA*
		Damping	*Additional smoothing of the current output, the higher the damping factor, 1 ... 255 s*
		Span	0-20mA or 4-20mA
		Error	*Defines output behaviour in the event of error* *Select from list* ↑↓ Hold (hold last value, select hold time), 3.8mA, 21.0mA
	Voltage out		
		Source	*Select from list* ↑↓
		Units	*Select from list* ↑↓
		Min Value	*Min. process variable (PV) value that corresponds to 0v*
		Max Value	*Max. process variable (PV) value that corresponds to 10v*
		Damping	*Additional smoothing of the current output, the higher the damping factor, 1 ... 255 s*
		Error	*Defines output behaviour in the event of error* *Select from list* ↑↓
	Frequency out		
		Source	*Select from list* ↑↓
		Units	*Select from list* ↑↓
		Min Value	*Min. process variable (PV) value that corresponds to minimum frequency*
		Max Value	*Max. process variable (PV) value that corresponds to maximum frequency*
		Damping	*Additional smoothing of the current output, the higher the damping factor, 1 ... 255 s*
		Error	*Defines output behaviour in the event of error* *Select from list* ↑↓
	Pulse Out		
		Source	*Select from list* ↑↓

		Units	*Select from unit list* ↑↓
		Mode	*Select from list* ↑↓ Alarm (select on point, off point) Pulse (select value, width) Linear (select min value, max value, damping)
	Relay Out		
		Source	*Select from list* ↑↓
		Units	*Select from unit list* ↑↓
		Mode	*Select from list* ↑↓ Alarm (select on point, off point) Pulse (select value, width) Linear (select min value, max value, damping)
	PT100 4 WIRE		
		Source	*Select from list* ↑↓
		Type	*Select from list* ↑↓ User (Fixed value - enter) PT100 (Measured - select whether inlet, outlet, compensation and enter offset if required)
	Current In		
		Source (channel)	*Select from list* ↑↓ Off, Channel 1, Channel 2, Math 1, Math 2 System, Test
		Source (value)	*Select from list* ↑↓ *Density, Viscosity, Temperature, Other* *Minimum, Maximum, Span settings as on outputs*
	RS 485		[where specified]
	Modbus RTU		[where specified]
	HART®		[where specified]
	Other In/Out types		Refer to Technical Support
System			
	Instrument info		
		Model Code	KF150
		Serial No.	*Example:* 15002013
		HW Revision	*Example:* 2.0, 1.5
		SW Revision	*Example:* 3.1, 2.4
	Calculation		
		Select channel	Channel 1, Channel 2
		Low F Cut	*± Low flow velocity cut off* 0 ... 0.025 m/s
		Max F Cut	*± Maximum flow velocity cut off* 0 ... 30 m/s
		Corrected	*Apply flow velocity profile correction* Yes No
		PV Offset	*Calibration process variable zero offset* -30 ... 30 m/s
		PV Scaling	*Calibration process variable gradient scaling* 0.001... 10 units (based on flow velocity)
		Zero Cal	*Zero calibration settings*
		Zero	*Perform auto zero calibration* Yes No

	Track	*Track zero offset* Yes No
	Delta	*Zero flow delta time offset in ns, read from sensor PROM or entered directly for special sensors*
	Timeup	*Upstream transit-time offset in µs, allows for fixed delays in special sensors, buffer rods and extension leads*
	Math Function	*Select from list* ↑↓ None, Sum, Difference, Average (mean), Max
	Heat Capacity	Specific heat capacity of medium
User		
	Identifier	*Example:* Pump P3A *9 character string*
	Tag No.	*Example:* 1FT-3011 *9 character string*
	Password	Enter a password (Default 1111) See also “Key Lock” below
Test		
	Installation	*Control system simulation: 60 second ramping up of flow velocity in m/s from 0 to programmed Max F Cut and subsequent 60 second ramping down, i.e. the process variable would change over complete possible range. All configured outputs will exhibit their programmed behaviour.* Yes No
	Display	*Display screen test routine*
	Keypad	*Keypad test routine*
	Memory	*Memory test routine, Memory erase yes/no*
	Peripherals	*Unit temperature, time, date, clock, battery meter, charger test routine*
	Ultrasonics	*Tests ultrasonic board and sensors*
	Calibrate PT100s	*Tests measured temperature and resistance*
	Reset PT100s	*Resets temperature inputs*
Settings		
	Date	*Example:* 03/10/07
	Time	*Example:* 09:27:00
	Date Format	*Select from list* ↑↓ dd/mm/yy mm/dd/yy yy/mm/dd
	Language	*Select from list* ↑↓ As installed
	Keypad	*Enable keypad sound* Yes No
Defaults		*Reload factory default settings, except for date and time* Yes No
Key Lock		Locks the keypad until password is entered (four

			number keys followed by “ENTER”). See also “Password” above.
Diagnostics			
		Temperature	*Shows control unit temperature*
		Log Memory	*Percentage of unused datalogger memory, estimated time remaining*
Datalogger			
		Interval	*A value of zero turns the datalogger off, a non-zero value turns the datalogger on and defines the logging interval.* 0 ... 999 s
	Channel 1, Channel 2	Selection	*Select up to 10 items from list* ↑↓ *ENTER to select, 0 to remove* m/s, f/s, in/s, m3/h, m3/min, m3/s, l/h, l/min, l/s, USgall/h, USgall/min, USgall/s, bbl/d, bbl/h, bbl/min, g/s, t/h, kg/h, kg/min, m3, l, Usgall, bbl, g, t, kg, W, kW, MW, J, kJ, MJ, Sig dB (signal), noise dB, SNR, C m/s (sound speed), CU (housing temperature) Tin, Tout (inlet and outlet temperature) TEMP (specified or measured fluid temperature), SOS, DEN. KIN (derived sound speed, density, kinematic viscosity) Math (Calculated value – see below)
		Low Memory	*Warning output: The amount of memory remaining at which the flowmeter begins to give an audible warning.* 0 ... 100 %
		Log Wrap	*Saves "selected" items as a continuous stream without headers (Note : this means files cannot be processed by Data+)* *Yes/No*
		Log Download	*Sends logger content to selected serial communication port.*
		Log Erase	*Erase datalogger* Yes/No
Serial Comms			
		Mode	*Select from list* ↑↓ None Printer, Diagnostic, Log download, Calibration Test (not normally used by user)
		Baud	*Select from list* ↑↓ 9600, 19200, 57600,115200
		Parity	*Select from list* ↑↓ None Even *(Default)* Odd
		Type	*Select from list where fitted*

Table 6: Firmware menu structure

5.2 Diagnostics

Diagnostic screens can be viewed directly during measurement using the **3/DISP** and **1/NEXT** keys, or through the menu structure.

5.3 Display settings

Customer specific settings for data to be displayed can be achieved using the appropriate menu items to select units for the top, middle and bottom lines.

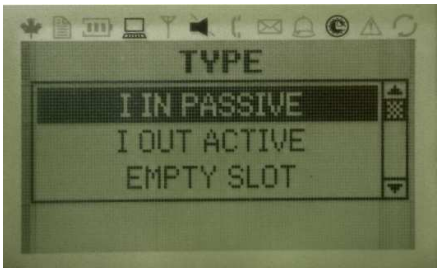
5.3.1 Main PV

The main Process Value (PV) is the primary measurement data, and is usually displayed as the Middle Units.

5.4 Output configuration

The assignment of output slots is detected by the flowmeter, and will be as appears in the table in the "In/Output" menu - first line = Slot 1, second line = Slot 2 etc.

Example with passive current input on slot 1 and active current output on slot 2 shown below :



Serial interfaces

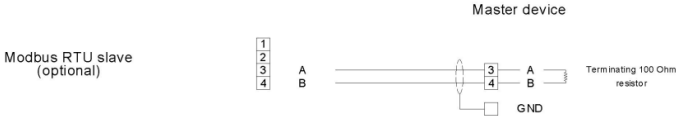
5.4.1 Serial interface RS 232

The RS 232 serial interface can be used to transmit data on-line or to communicate with peripheral equipment and computers.

5.4.2 Serial interface RS 485 / Modbus RTU

The RS 485 interface is used for connecting up to 32 flowmeters to a centralised computer system. Each flowmeter is given an unique address to be able to communicate effectively. The communication protocol used conforms to the conventions of the Modbus RTU protocol, a description of which is given in a separate document. Please refer to customer support for further information.

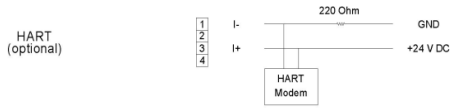
In addition, the ASCII printer output can also directed through the RS 485 interface.

Wiring	
Setup	Please refer to customer support.
Operation	Please refer to customer support.

5.4.3 HART compatible output

The KF100 can also be configured with an optional module which responds to output commands conforming to the HART protocol. Please refer to customer support for further information.

HART® is a registered trademark of the HART Communication Foundation.

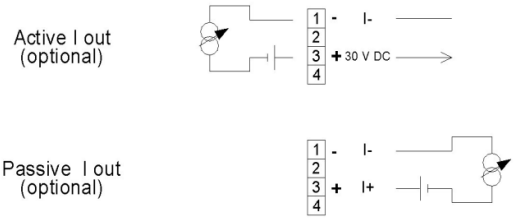
Wiring	
Setup	Please refer to customer support.
Operation	Please refer to customer support.

Analogue outputs

5.4.4 Analogue current output 0/4 ... 20 mA

The analogue current outputs operate in a 4 ... 20 mA or 0 ... 20 mA span.

Current outputs may be assigned to process values in the “mode” section of the output menu. The outputs can be programmed and scaled within the menu structure.

Wiring	
Electrical characteristics	0/4...20 mA active and 4...20 mA passive options. Galvanically isolated from main electronics and from other I/O's. Passive: U=9...30 V, RLoad=50 ohm typical. Resolution: 16 bit, accuracy: 0.1 % of MV. Active: RLoad<500 ohm, U=30 V. Resolution: 16 bit, accuracy: 0.1 % of MV.

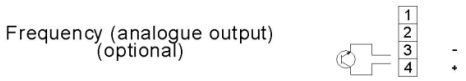
5.4.5 Analogue voltage output 0 – 10 v

Voltage outputs may be assigned to process values in the “mode” section of the output menu. The outputs can be programmed and scaled within the menu structure.

Wiring	
Electrical characteristics	Galvanically isolated from main electronics and from other I/O's. Range 0...10 V. RLoad=1000 ohm. Resolution: 16 bit, accuracy: 0.1% of MV.

5.4.6 Analogue frequency output (passive)

Frequency outputs may be assigned to process values in the “mode” section of the output menu. The outputs can be programmed and scaled within the menu structure.

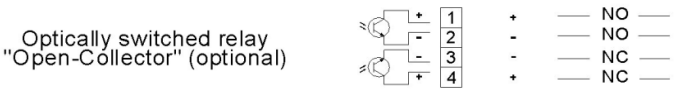
Wiring	
Electrical characteristics	Galvanically isolated from main electronics and from other I/O's. Open-collector: 2...10000 Hz. U=24 V, Imax=4 mA.

Digital outputs

5.4.7 Digital open collector output

Open-Collector outputs may be assigned to process values in the “mode” section of the output menu. The outputs are configured using the menu structure.

The totaliser function is enabled and controlled using the menu structure

Wiring	
Electrical characteristics	Galvanically isolated from main electronics and from other I/O's. Totaliser pulse, value 0.01...1000/unit. Active high and active low available. Width 1...990 ms. U=24 V, Imax=4 mA.

5.4.8 Digital relay output

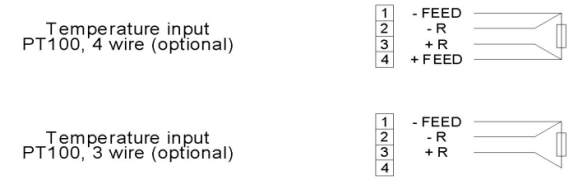
Relay outputs may be assigned to process values in the “mode” section of the output menu. The relay outputs are configured using the menu structure.

Wiring	
Electrical characteristics	Form A (SPDT-NO and NC) contacts Width 3...990 ms. U=48 V, Imax=250 mA.Galvanically isolated from main electronics and from other I/O's. Mode: Alarm, fault, totaliser (programmable). 1 Form A (SPST-NO) contacts. 1 Form A (SPST-NC) contacts. Width 3...990 ms. U=48 V, Imax=250 mA.

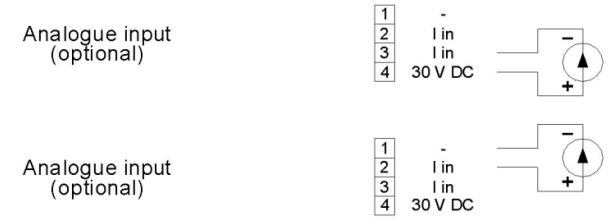
5.5 Input configuration

5.5.1 PT100 inputs

Inputs

Wiring	
Electrical characteristics	3 and 4 wire options. Galvanically isolated from main electronics and from other I/O's. Temperature: Range -50 ... 400 °C. Resolution: 0.01 K. Accuracy: ±0.1 K.

5.5.2 Analogue current input 0/4 ... 20 mA

Wiring	
Electrical characteristics	Active (top) or passive (bottom) variants Measuring range active = 0 ... 20 mA at 30 V Measuring range passive = 4 ... 20 mA Accuracy = 0.1 % of measured value

5.6 Heat quantity measurement (HQM) – [where installed]

If a heat quantity unit is specified for the Process Value, the KF100 will prompt the user for the Specific Heat Capacity of the medium in J/g/K (for example 4.186 J/g/K for water).

This may also be entered in the System\Calculation sub-menu.

The In/Output menu will then allow the user to select the temperature input source; either PT100 temperature sensors or a fixed value for measurement against a known inlet or outlet temperature. Where PT100 sensors are selected, the flowmeter will prompt the user for a temperature offset, which may be useful where the temperature of the medium differs from the temperature of the pipe wall (for example with unlagged pipes). If a fixed value is selected, the meter will ask the user to specify this value.

When heat quantity units are selected, these behave as any other Process Value and may be totalized, or applied to a Process Output.

5.7 Sound velocity measurement (SVM)

The measured sound velocity (SOS) is available as a Process Value and a diagnostic function (where specified) during measurement and may be applied to a Process Output by selecting “C m/s” from the appropriate menu.

5.8 Dual-channel flow calculations (maths functions)

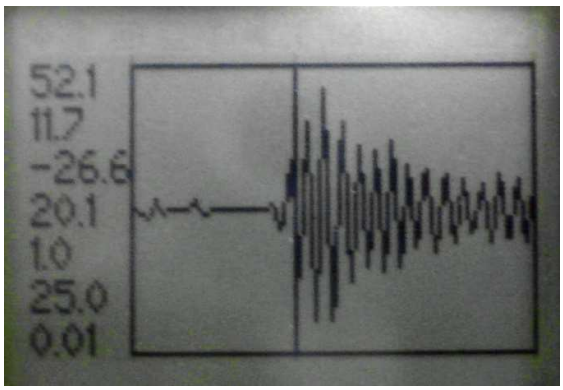
Where suitably equipped, dual channel calculations are available from the System/Calculation/Math menu.

These allow the user to select the sum, difference, average (mean) or maximum of the two flow channels.

This value may be displayed or applied to a Process Output by selecting MATH from the appropriate output menu.

5.9 Scope function

Arkon ultrasonic flowmeters have an additional scope function which shows a representation of the pulse received by the sensors on Channel 1.



In addition to displaying the received pulse, this screen lists the following data (from top to bottom) :

Gain (dB)

Signal (dB)

Noise (dB)

Transit time (us)

Delta (ns) - [time downstream minus time upstream]

Control unit temperature (degC)

Flow (m/s)

6 Maintenance

USCX flowmeters are maintenance free concerning the flow measurement functions. Within the scope of periodic inspections, regular inspection for signs of damage or corrosion is recommended for the transducers, the junction box if installed, and the flowmeter housing.

6.1 Service/Repair

USCX flowmeters have been carefully manufactured and tested. If installed and operated in accordance with the operating instructions, no problems are usually experienced.

Should you nevertheless need to return a device for inspection or repair, please pay attention to the following points:

!

- Due to statutory regulations on environmental protection and safeguarding the health and safety of our personnel, the manufacturer may only handle, test and repair returned devices that have been in contact with products without risk to personnel and environment.
- This means that the manufacturer can only service this device if it is accompanied by a Customer Return Note (CRN) confirming that the device is safe to handle.

If the device has been operated with toxic, caustic, flammable or water-endangering products, you are kindly requested:

!

- to check and ensure, if necessary by rinsing or neutralising, that all cavities are free from such dangerous substances,
- to enclose a certificate with the device confirming that is safe to handle and stating the product used.

7 Troubleshooting

Should there be the need to call customer service, please let us know the following details:

- Model code
- Serial number
- SW, HW revision
- Error log list

Possible error messages may include the following:

Error list

Error message	Group	Description	Error handling
USB INIT FAIL	Hardware	Internal board communication error	Power on/off, otherwise call customer support
NO SERIAL NO.	Hardware	Failed to read from FRAM	Call customer support
NO VERSION NO.	Hardware	Failed to read from FRAM	Call customer support
PARA READ FAIL	Hardware	Failed to read from FRAM	Load defaults, otherwise call customer support
PARA WRITE FAIL	Hardware	Failed to write to FRAM	Load defaults, otherwise call customer support
VAR READ FAIL	Hardware	Failed to read from FRAM	Call customer support
VAR WRITE FAIL	Hardware	Failed to write to FRAM	Call customer support
SYSTEM ERROR	Hardware		Call customer support
VISIBILITY ERR	Hardware	Failed to read from FRAM	Call customer support
FRAM LONG WRITE ERR	Hardware	Failed to write to FRAM	Call customer support
FRAM READ ERR	Hardware	Failed to read from FRAM	Call customer support
RTC ERR	Hardware	Real Time Clock failure	Power on/off, otherwise call customer support
EXTMEM ERR	Hardware	Logger memory failure	Power on/off, otherwise call customer support
SPI ERR	Hardware	SPI bus failure	Power on/off, otherwise call customer support
I2C ERR	Hardware	I2C bus failure	Power on/off, otherwise call customer support
MATH ERR	Software	Internal calculation error	Call customer support
STACK ERR	Software	Internal calculation error	Call customer support
ADDR ERR	Software	Internal calculation error	Call customer support
OSC ERR	Software	Internal calculation error	Call customer support
ADC ERR	Software	Internal calculation error	Call customer support
IO ERR	Software	Internal calculation error	Call customer support
TIMING ERR	Software	Internal calculation error	Call customer support
COMM INIT ERR	Hardware	Internal communication error	Power on/off, otherwise call customer support
COMM START ERR	Hardware	Internal communication error	Power on/off, otherwise call customer support
COMM HS0 ERR	Hardware	Internal communication error	Power on/off, otherwise call customer support

COMM HS1 ERR	Hardware	Internal communication error	Power on/off, otherwise call customer support
COMM READ AVE ERR	Hardware	Internal communication error	Power on/off, otherwise call customer support
COMM READ RAW ERR	Hardware	Internal communication error	Power on/off, otherwise call customer support
COMM READ HISTORY ERR	Hardware	Internal communication error	Power on/off, otherwise call customer support
COMM CRC ERR	Hardware	Internal communication error	Power on/off, otherwise call customer support
SENSOR COUPLING ERR	Application	Weak sensor coupling, low SNR	Recouple sensors, check installation, reduce number of passes, look for other location, then have a cup of tea and call customer support!

Table 7: Error messages

7.1 Data download difficulties

If difficulties are encountered downloading the logger data : -

- Check that the flowmeter is switched on and not in measurement mode.
- Check that the same number COM port is allocated in the “Device Manager” (or equivalent) as is set in the Data+ software.
- Check that the settings (baud, parity, word length, stop bits) are identical.
- Use the supplied connectors – whether connecting to a 9-pin COM port or converting from serial communication to a Universal Serial Bus (USB).
- Is the logger in "Wrap" mode? If "yes", use a terminal program and the "Log download" command. If "No", Data+ software may also be used.

8 Technical data

	Sound Speed* Shear Wave (at 25 ºC)	
Material	**m/s**	**ft/s**
Steel, 1% Carbon, hardened	3,150	10,335
Carbon Steel	3,230	10,598
Mild Steel	3,235	10,614
Steel, 1% Carbon	3,220	10,565
302 Stainless Steel	3,120	10,236
303 Stainless Steel	3,120	10,236
304 Stainless Steel	3,141	10,306
304L Stainless Steel	3,070	10,073
316 Stainless Steel	3,272	10,735
347 Stainless Steel	3,095	10,512
“Duplex” stainless steel	2,791	9,479
Aluminium	3,100	10,171
Aluminium (rolled)	3,040	9,974
Copper	2,260	7,415
Copper (annealed)	2,325	7,628
Copper (rolled)	2,270	7,448
CuNi (70%Cu 30%Ni)	2,540	8,334
CuNi (90%Cu 10%Ni)	2,060	6,759
Brass (Naval)	2,120	6,923
Gold (hard-drawn)	1,200	3,937
Inconel	3,020	9,909
Iron (electrolytic)	3,240	10,630
Iron (Armco)	3,240	10,630
Ductile Iron	3,000	9,843
Cast Iron	2,500	8,203
Monel	2,720	8,924
Nickel	2,960	9,712
Tin (rolled)	1,670	5,479
Titanium	3,125	10,253
Tungsten (annealed)	2,890	9,482
Tungsten (drawn)	2,640	8,661
Tungsten carbide	3,980	13,058
Zinc (rolled)	2,440	8,005
Glass (pyrex)	3,280	10,761
Glass (heavy silicate flint)	2,380	7,808
Glass (light borate crown)	2,840	9,318
Nylon	1,150	3,772
Nylon, 6-6	1,070	3,510
Polyethylene (LD)	540	1,772
PVC, CPVC	1,060	3,477
Acrylic resin	1,430	4,690
PTFE	2,200	7,218

* Please note these values are to be considered nominal. Solids may be inhomogeneous and anisotropic. Actual values depend on exact composition, temperature, and to a lesser extent, on pressure and stress.

All data given at 25 ºC (77 ºF) unless otherwise stated

			Sound Speed		Change v/ºC	Kinematic Viscosity	
Substance	**Chemical Formula**	**Specific Gravity**	**m/s**	**ft/s**	**m/s/ºC**	**mm²/s**	**x10-6 ft²/s**
Acetic anhydride	(CH3CO)2O	1.082 (20 ºC)	1,180	3,871.4	2.5	0.769	8.274
Acetic acid, anhydride	(CH3CO)2O	1.082 (20 ºC)	1,180	3,871.4	2.5	0.769	8.274
Acetic acid, nitrile	C2H3N	0.783	1,290	4,232.3	4.1	0.441	4.745
Acetic acid, ethyl ester	C4H802	0.901	1,085	3,559.7	4.4	0.467	5.025
Acetic acid, methyl ester	C3H6O2	0.934	1,211	3,973.1		0.407	4.379
Acetone	C3H6O	0.791	1,174	3,851.7	4.5	0.399	4.293
Acetylene dichloride	C2H2Cl2	1.26	1,015	3,330.1	3.8	0.400	4.304
Alcohol	C2H6O	0.789	1,207	3,960	4.0	1.396	15.02
Ammonia	NH3	0.771	1,729 (- 33 ºC)	5,672.6 (-27 ºC)	6.68	0.292 (-33 ºC)	3.141 (-27 ºF)
Benzene	C6H6	0.879	1,306	4,284.8	4.65	0.711	7.65
Benzol	C6H6	0.879	1,306	4284.8	4.65	0.711	7.65
Bromine	Br2	2.928	889	2,916.7	3.0	0.323	3.475
n-Butane(2)	C4H10	0.601 (0ºC)	1,085 (- 5º C)	3,559.7 (23 ºC)	5.8		
2-Butanol	C4H10O	0.81	1,240	4,068.2	3.3	3.239	34.851
sec-Butylalcohol	C4H10O	0.81	1,240	4,068.2	3.3	3.239	34.851
n-Butyl bromide (46)	C4H9Br	1.276 (20ºC)	1,019 (20ºC)	3,343.2 (68ºF)		0.49 (15ºC)	5.272 (59ºC)
n-Butyl chloride (22,46)	C4H9Cl	0.887	1,140	3,740.2	4.57	0.529 (15ºC)	5.692 (59ºF)
Carbon tetrachloride	CCl4	1.595 (20ºC)	926	3038.1	2.48	0.607	6.531
Carbon tetrafluoride (Freon 14)	CF4	1.75 (-150 ºC)	875.2 (- 150 ºC)	2,871.5 (-238 ºF)	6.61		
Chloroform	CHCl3	1.489	979	3,211.9	3.4	0.55	5.918
Dichlorodifluoromethane (Freon 12)	CCl2F2	1.516 (40 ºC)	774.1	2,539.7	4.24		
Ethanol	C2H6O	0.789	1,207	3,960	4.0	1.39	14.956
Ethyl acetate	C4H8O2	0.901	1,085	3,559.7	4.4	0.489	5.263
Ethyl alcohol	C2H6O	0.789	1,207	3,960	4.0	1.396	15.020
Ethyl benzene	C8H10	0.867 (20 ºC)	1,338 (20 ºC)	4,.89.8 (68 ºF)		0.797 (17 ºC)	8.575 (63 ºF)
Ether	C4H10O	0.713	985	3231.6	4.87	0.311	3.346
Ethyl ether	C4H10O	0.713	985	3231.6	4.87	0.311	3.346
Ethylene bromide	C2H4Br2	2.18	995	3264.4		0.79	8.5
Ethylene chloride	C2H4Cl2	1.253	1,193	3,914		0.61	6.563
Ethylene glycol	C2H6O2	1.113	1,658	5439.6	2.1	17,208 (20ºC)	185.158 (68ºF)
Fluorine	F	0.545 (-143 ºC)	403 (- 143 ºC)	1322.2 (- 225 ºF)	11.31		
Formaldehyde, methyl ester	C2H4O2	0.974	1,127	3697.5	4.02		
Freon R12			774.2	2540			
Glycol	C2H6O2	1.113	1658	5439.6	2.1		
50% Glycol/50% H2O			1,578	5,177			
Isopropanol	C3H8O	0.785 (20 ºC)	1,170 (20 ºC)	3,838.6 (68 ºF)		2.718	29.245
Isopropyl alcohol (46)	C3H8O	0.785 (20 ºC)	1,170 (20 ºC)	3,838.6 (68 ºF)		2.718	29.245
Kerosene		0.81	1,324	4,343.8	3.6		

Methane	CH4	0.162 (-89 ºC)	405 (-89 ºC)	1,328.7 (-128 ºF)	17.5		
Methanol	CH4O	0.791 (20 ºC)	1,076	3,530.2	292	0.695	7.478
Methyl acetate	C3H6O2	0.934	1,211	3,973.1		0.407	4.379
Methyl alcohol	CH4O	0.791	1,076	3,530.2	292	0.695	7.478
Methyl benzene	C7H8	0.867	1,328 (20 ºC)	4,357 (68 ºF)	4.27	0.644	7.144
Milk, homogenized			1,548	5,080			
Naphtha		0.76	1,225	4,019			
Natural Gas		0.316 (-103 ºC)	753 (-103 ºC)	2,470.5 (-153 ºF)			
Nitrogen	N2	0.808 (-199 ºC)	962 (-199 ºC)	3,156.2 (-326 ºF)		0.217 (-199 ºC)	2.334 (-326 ºF)
Oil, Car (SAE 20a.30)		1.74	870	2,854.3		190	2,045.093
Oil, Castor	C11H10O0	0.969	1,477	4,845.8	3.6	0.670	7.209
Oil, Diesel		0.80	1,250	4,101			
Oil, Fuel AA gravity		0.99	1,485	4,872	3.7		
Oil (Lubricating X200)			1,530	5,019.9			
Oil (Olive)		0.912	1,431	4,694.9	2.75	100	1,076.365
Oil (Peanut)		0.936	1,458	4,738.5			
Propane (-45 to -130 ºC)	C3H8	0.585 (-45 ºC)	1,003 (-45 ºC)	3,290.6 (-49 ºF)	5.7		
1-Propanol	C3H8O	0.78 (20 ºC)	1,222 (20 ºC)	4,009.2 (68 ºF)			
2-Propanol	C3H8O	0.785 (20 ºC)	1,170 (20 ºC)	3,838.6 (68 ºF)		2.718	29.245
Propene	C3H6	0.563 (-13ºC)	963 (-13ºC)	3159.4 (9ºF)	6.32		
n-Propyl-alcohol	C3H8O	0.78 (20 ºC)	1,222 (20 ºC)	4,009.2 (68 ºF)		2.549	27.427
Propylene	C3H6	0.563 (-13 ºC)	963 (-13 ºC)	3159.4 (9 ºF)	6.32		
Refrigerant 11	CCl3F	1.49	828.3 (0 ºC)	2,717.5 (32 ºF)	3.56		
Refrigerant 12	CCl2F2	1.516 (-40 ºC)	774.1 (-40 ºC)	2,539.7 (-40 ºC)	4.24		
Refrigerant 14	CF4	1.75 (-150 ºC)	875.24 (-150 ºC)	2,871.6 (-268 ºF)	6.61		
Refrigerant 21	CHCl2F	1.426 (0 ºC)	891 (0 ºC)	2,923.2 (32 ºF)	3.97		
Refrigerant 22	CHClF2	1.491 (-69 ºC)	893.9 (50 ºC)	2,932.7 (122 ºF)	4.79		
Refrigerant 113	CCl2F-CClF2	1.563	783.7 (0 ºC)	2,571.2 (32 ºF)	3.44		
Refrigerant 114	CClF2-CClF2	1.455	665.3 (10 ºC)	2,182.7 (14 ºF)	3.73		
Refrigerant 115	C2ClF5		656.4 (-50 ºC)	2,153.5 (-58 ºF)	4.42		
Refrigerant C318	C4F8	1.62 (-20 ºC)	574 (-10 ºC)	1,883.2 (14 ºF)	3.88		
Sodium nitrate	NoNO3	1.884 (336 ºC)	1,763.3 (336 ºC)	5,785.1 (637 ºF)	0.74	1.37 (336 ºC)	14.74 (637 ºF)
Sodium nitrite	NoNO2	1.805 (292 ºC)	1876.8 (292 ºC)	6157.5 (558 ºF)			
Sulphur	S		1177 (250 ºC)	3861.5 (482 ºF)	-1.13		
Sulphuric Acid	H2SO4	1.841	1,257.6	4,126	1.43	11.16	120.081

Tetrachloroethane	C2H2Cl4	1553 (20 ºC)	1,170 (20 ºC)	3,838.6 (68 ºF)		1.19	12.804
Tetrachloro-ethene	C2Cl4	1.632	1,036	3,399			
Tetrachloro-Methane	CCl4	1.595 (20 ºC)	926	3,038.1		0.607	6.531
Tetrafluoro-methane (Freon 14)	CF4	1.75 (-150 ºC)	875.24 (-150 ºC)	2,871.5 (-283 ºF)	6.61		
Toluene	C7H8	0.867 (20 ºC)	1,328 (20 ºC)	4,357 (68 ºF)	4.27	0.644	6.929
Toluol	C7H8	0.866	1,308	4,291.3	4.2	0.58	6.24
Trichloro-fluoromethane (Freon 11)	CCl3F	1.49	828.3 (0 ºC)	2,717.5 (32 ºF)	3.56		
Turpentine		0.88	1,255	4,117.5		1.4	15.064
Water, distilled	H2O	0.996	1,498	4,914.7	-2.4	1.00	10.76
Water, heavy	D2O		1,400	4,593			
Water, sea		1.025	1531	5023	-2.4	1.00	10.76

Temperature		**Sound Speed in Water**	
º C	**º F**	**m/s**	**ft/s**
0	32.0	1402	4600
1	33.8	1407	4616
2	35.6	1412	4633
3	37.4	1417	4649
4	39.2	1421	4662
5	41.0	1426	4679
6	42.8	1430	4692
7	44.6	1434	4705
8	46.4	1439	4721
9	48.2	1443	4734
10	50.0	1447	4748
11	51.8	1451	4761
12	53.6	1455	4774
13	55.4	1458	4784
14	57.2	1462	4797
15	59.0	1465	4807
16	60.8	1469	4820
17	62.6	1472	4830
18	64.4	1476	4843
19	66.2	1479	4853
20	68.0	1482	4862
21	69.8	1485	4872
22	71.6	1488	4882
23	73.4	1491	4892
24	75.2	1493	4899
25	77.0	1496	4908
26	78.8	1499	4918
27	80.6	1501	4925
28	82.4	1504	4935
29	84.2	1506	4941
30	86.0	1509	4951
31	87.8	1511	4958
32	89.6	1513	4964
33	91.4	1515	4971

34	93.2	1517	4977
35	95.0	1519	4984
36	96.8	1521	4984
37	98.6	1523	4990
38	100.4	1525	4997
39	102.2	1527	5010
40	104.0	1528	5013
41	105.8	1530	5020
42	107.6	1532	5026
43	109.4	1534	5033
44	111.2	1535	5036
45	113.0	1536	5040
46	114.8	1538	5046
47	116.6	1538	5049
48	118.4	1540	5053
49	120.2	1541	5056
50	122.0	1543	5063
51	123.8	1543	5063
52	125.6	1544	5066
53	127.4	1545	5069
54	129.2	1546	5072
55	131.0	1547	5076
56	132.8	1548	5079
57	134.6	1548	5079
58	136.4	1548	5079
59	138.2	1550	5086
60	140.0	1550	5086
61	141.8	1551	5089
62	143.6	1552	5092
63	145.4	1552	5092
64	147.2	1553	5092
65	149.0	1553	5095
66	150.8	1553	5095
67	152.6	1554	5099
68	154.4	1554	5099
69	156.2	1554	5099
70	158.0	1554	5099
71	159.8	1554	5099
72	161.6	1555	5102
73	163.4	1555	5102
74	165.2	1555	5102
75	167.0	1555	5102
76	167.0	1555	5102
77	170.6	1554	5099
78	172.4	1554	5099
79	174.2	1554	5099
80	176.0	1554	5099
81	177.8	1554	5099
82	179.6	1553	5095
83	181.4	1553	5095
84	183.2	1553	5095
85	185.0	1552	5092
86	186.8	1552	5092

87	188.6	1552	5092
88	190.4	1551	5089
89	192.2	1551	5089
90	194.0	1550	5086
91	195.8	1549	5082
92	197.6	1549	5082
93	199.4	1548	5079
94	201.2	1547	5076
95	203.0	1547	5076
96	204.8	1546	5072
97	206.6	1545	5069
98	208.4	1544	5066
99	210.2	1543	5063
100	212.0	1543	5063
104	220.0	1538	5046
110	230.0	1532	5026
116	240.0	1524	5000
121	250.0	1516	5007
127	260.0	1507	4944
132	270.0	1497	4912
138	280.0	1487	4879
143	290.0	1476	4843
149	300.0	1465	4807
154	310.0	1453	4767
160	320.0	1440	4725
166	330.0	1426	4679
171	340.0	1412	4633
177	350.0	1398	4587
182	360.0	1383	4538
188	370.0	1368	4488
193	380.0	1353	4439
199	390.0	1337	4387
204	400.0	1320	4331
210	410.0	1302	4272
216	420.0	1283	4210
221	430.0	1264	4147
227	440.0	1244	4082
232	450.0	1220	4003
238	460.0	1200	3937
243	470.0	1180	3872
249	480.0	1160	3806
254	490.0	1140	3740
260	500.0	1110	3642

Specific Heat Capacity

Medium	**SHC (KJ/Kg.K)**
Ethanol @ 0 deg C	2.30
Ethylene Glycol	2.36
Freon R12 @ 5 deg C	0.88
Light oil @ 15 deg C	1.80
Mineral Oil	1.67
Paraffin	2.13

Propane @ 0 deg C	2.40
Water	4.18
Water (salt)	3.93

9 Specification

General

Measuring principle : Ultrasonic time difference correlation principle
Flow velocity range : 0.01 ... 25 m/s
Resolution : 0.25 mm/s
Repeatibility : 0.15 % of measured value ±0.015 m/s
Accuracy :
Volume flow
± 1 ... 3 % of measured value depending on application,
± 0.5 % of measured value with process calibration
Flow velocity
± 0.5 % of measured value
Turn down ratio : 1/100
Gaseous and solid content of liquid media : < 10 % of volume

Flowmeter

Enclosure : Wall mounted housing
Degree of protection : IP 66 according EN 60529
Operating temperature : -10 ... 60 °C (14 ... 140 °F)
Housing material : Polycarbonate
Flow channels : 1 or 2
Power supply : 100 ... 240 V AC 50/60 Hz,
9 ... 36 V DC, special versions on request
Display : LCD graphic display, 128 x 64 dots, backlit
Dimensions : H 237 x W 258 x D 146 mm without cable glands
Weight : Approx. 2.3 kg
Power consumption : < 10 W
Signal damping : 0 ... 99 s
Measurement rate : 1Hz standard, higher rates on application
Operating languages : English, 2 other (as requested and subject to availability)
Response time : 1 s, faster rates upon request
Calculation functions : Average/difference/sum

Quantity and units of measurement

Volumetric flow rate : m3/h, m3/min, m3/s, l/h, l/min, l/s, USgal/h (US gallons per hour), USgal/min, USgal/s, bbl/d (barrels per day), bbl/h, bbl/min, bbl/s.
Flow velocity : m/s, ft/s, inch/s
Mass flow rate : g/s, t/h, kg/h, kg/min
Volume : m_3, l, gal (US gallons), bbl
Mass : g, kg, t
Heat flow : W, kW, MW (only with heat quantity measurement option)
Heat quantity : J, kJ, MJ (only with heat quantity measurement option)

Sig dB (signal), noise dB, SNR,
C m/s (sound speed), CU (housing temperature)
Tin, Tout (inlet and outlet temperature)

Internal data logger

Storage capacity : In excess of 1 million data points (16MB)
Logging data : Up to ten selected variables

Communication

Serial interface : RS 232, RS 485 (optional)
Data : Instantaneous measured value, parameter set and configuration, logged data

Data+ Software

Functionality : Downloading of measured values/parameter sets, graphical presentation, list format, export to third party software, on-line transfer of measured data
Operating systems : Windows 2000, NT, XP, Vista, 7; Linux; Mac (optional)

Process inputs / Process Outputs (maximum of ten per instrument)

Inputs
Temperature : PT 100, three or four-wire circuit, measuring range - 50 ... 400 °C, resolution 0.1K, accuracy ±0.2 K
Current : 0 ... 20 mA active or 4 ... 20 mA passive, U = 30 V, R_i = 50 Ohm, accuracy 0.1 % of MV

Outputs
Current : 0/4 ... 20 mA, active (R_{Load} < 500 Ohm), 16 bit resolution, U = 30 V, accuracy = 0.1 %
Voltage : On request, 0 ... 10 V, R_i =500 Ohm
Frequency : On request
Digital (Optical - Open Collector) : U = 24 V, I_{max} = 4 mA
Digital (relay) : Form C (SPDT-CO) contacts, U = 48 V, I_{max} = 250 mA

Clamp-on sensors

Type K1L, K1N, K1E
Diameter range : 50 ... 3000 mm
Dimensions : 60 x 30 x 34 mm
Material : Stainless steel
Temperature range :
Type K1N: -30 ... 130 °C (-22 ... 266 °F)
Type K1E: -30 ... 200 °C (-22 ... 392 °F), for short periods up to 300 °C (572 °F)
Degree of protection : IP 66 acc. EN 60529, IP 67 and IP 68 optional

Type K4L, K4N, K4E
Diameter range : 10 ... 250 mm
Dimensions : 43 x 18 x 22 mm
Material : Stainless steel
Temperature range :
Type K4N: -30 ... 130 °C (-22 ... 266 °F)
Type K4E: -30 ... 200 °C (-22 ... 392 °F), for short periods up to 300 °C (572 °F)
Degree of protection : IP 66 acc. EN 60529, IP 67 and IP 68 optional

Type K1Ex, K4Ex
(for use in hazardous areas Zone 1 or 2)
Diameter range :
Type K4Ex: 10 ... 250 mm
Type K1Ex: 50 ... 3000 mm
Dimensions : 60 x 30 x 34 mm
Material : Stainless steel
Temperature range : -20 ... 120 °C
Degree of protection : IP 66 acc. EN 60529
Protection concept : Encapsulation
Certification code : Ex mb IIC T4 - T6
The sensors are suitable for use in hazardous areas classified as Zone 1 and 2. The transmitter unit must be placed in the safe area or suitable enclosure.

10 Index

Appendix A

Certificate of Conformity

The USCX150 is manufactured conform CE requirements.