Ultrasonic Flow Management

OPERATING INSTRUCTIONS

KATflow 200

Hand-Held Clamp-On Ultrasonic Flowmeter

KATflow 200
Operating Instructions

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1 SAFETY INSTRUCTIONS, LEGAL REQUIREMENTS, WARRANTY, RETURN POLICY

1.1 Symbols

 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 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 setup tip.
ESC Operator key	Operator keys are printed in bold typeface.

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 Katronic for help.

1.3 Warranty

- Any product purchased from Katronic is warranted in accordance with the relevant product documentation and as specified in the sales contract provided. This is subject to the condition that 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 have a problem, it can be returned to Katronic for repair using the Customer Return Note (CRN) attached to the Appendix of this manual. Katronic regret that for health and 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 electromagnetic 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 2012/19/EU) 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. Katronic 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 Katronic.

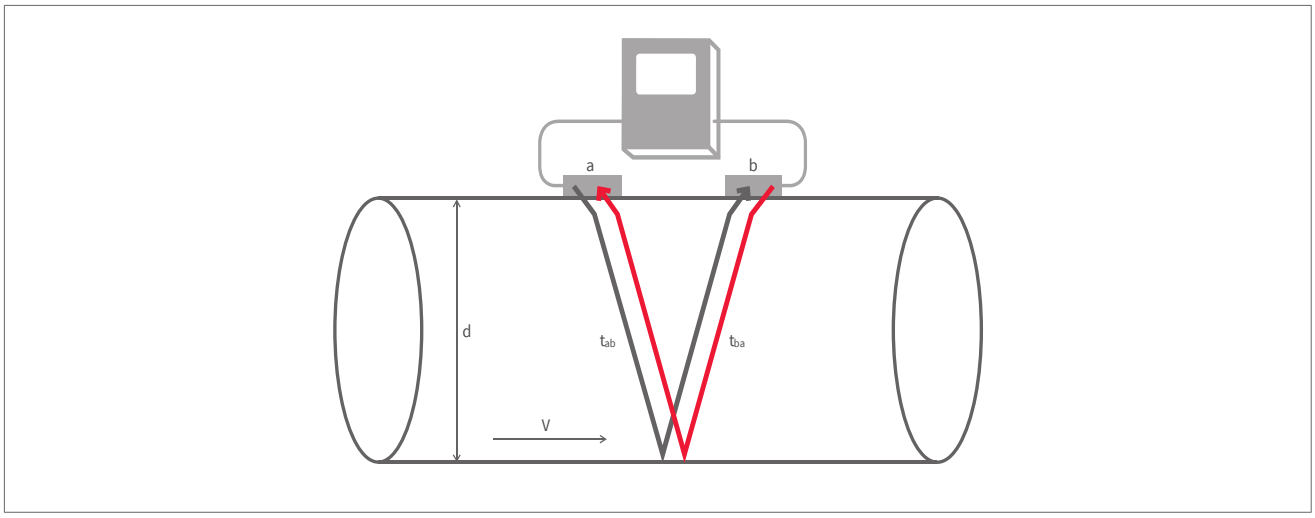
RoHS Directive

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

2 INTRODUCTION

2.1 Clamp-on transit-time flowmeter

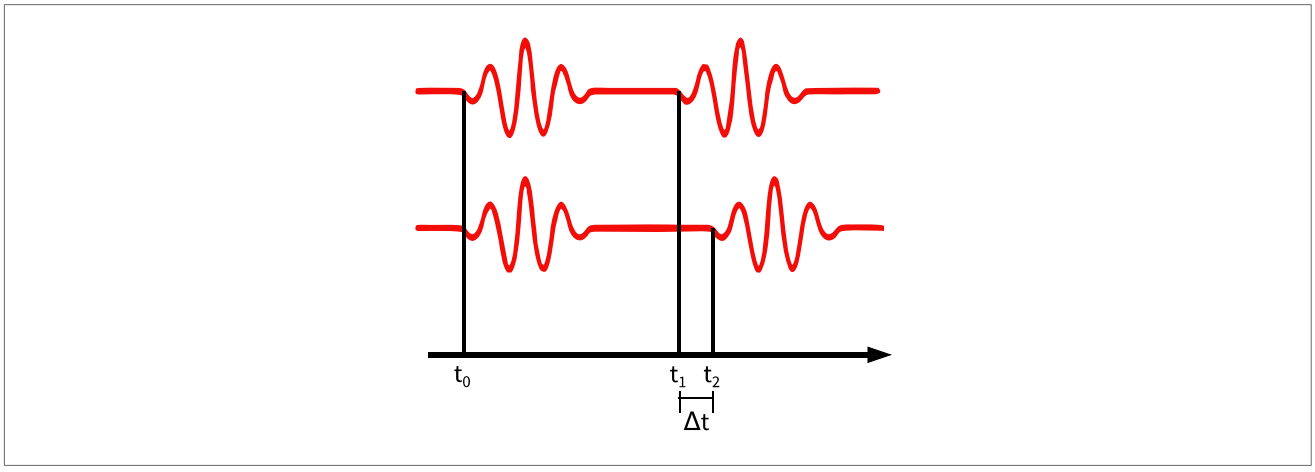
The KATflow 200 is a hand-held, battery operated ultrasonic flowmeter employing clamp-on sensors for the measurement of liquids in full, enclosed pipes. Flow measurements can be undertaken without interruption of the process or interference with the integrity of the pipeline. The clamp-on sensors are attached to the outside of the pipes. The KATflow 200 uses ultrasonic signals for measurement of the flow, employing the transit-time method.



Picture 1: Clamp-on ultrasonic flowmeter configuration

2.2 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.



Picture 2: Transit-time measuring principle

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 and small plastic boxes 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):

- KATflow 200 hand-held flowmeter,
- Clamp-on sensors (usually one or two pairs depending on pipe sizes to be measured),
- Sensor extension cable(s) (optional),
- Sensor mounting accessories,
- Coupling component,
- Measuring tape,
- Operating instructions,
- Wall thickness measurement probe (optional),
- Calibration certificate(s) (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 Section 3.2.1 Acoustic propagation) and in which a rotationally symmetrical flow profile is fully developed (see Section 3.2.2 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 Chapter 9).

3.2.1 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.

3.2.2 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.

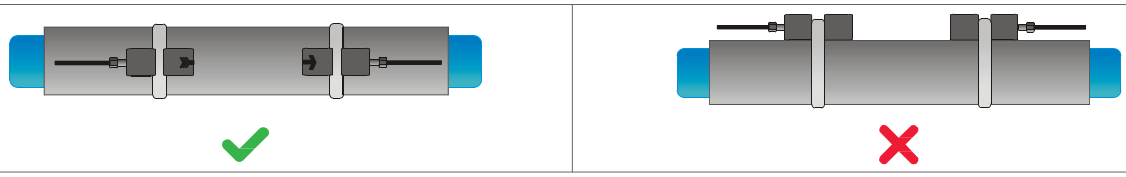
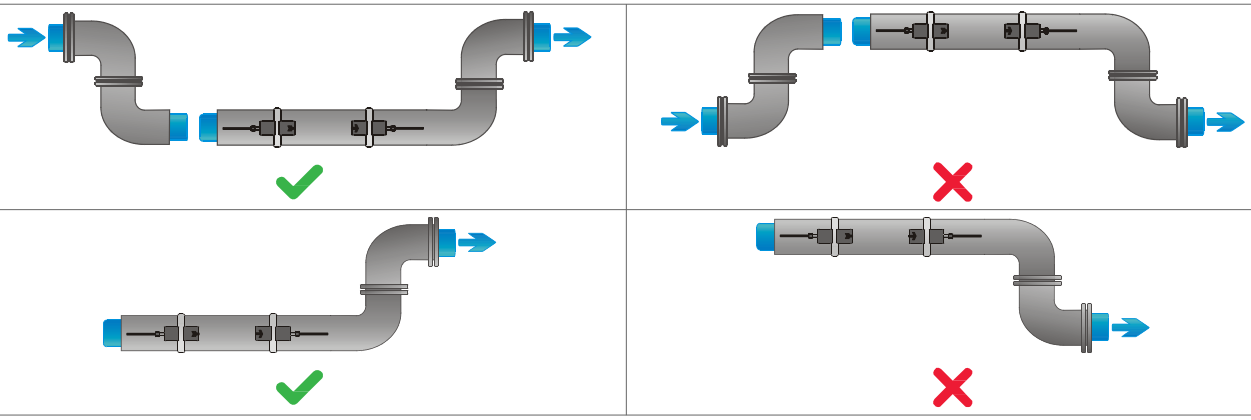
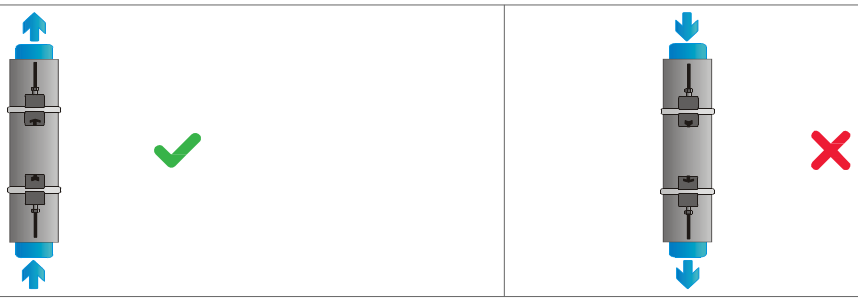
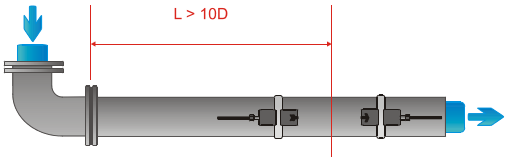
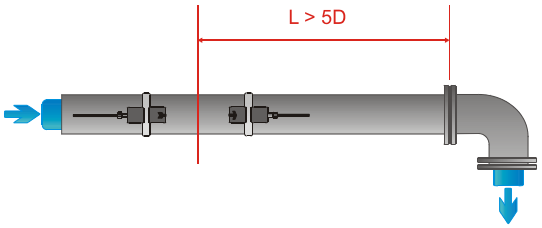
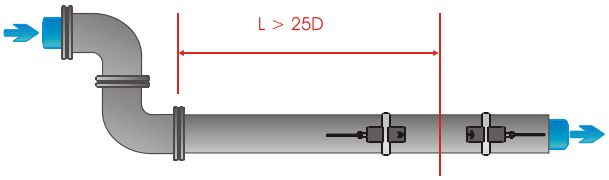
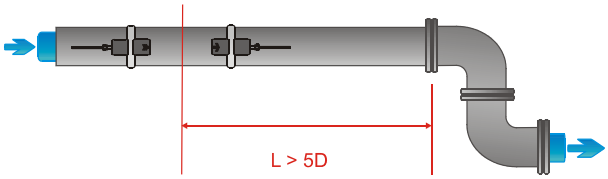
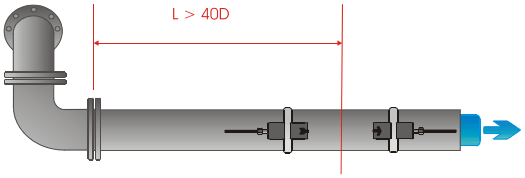
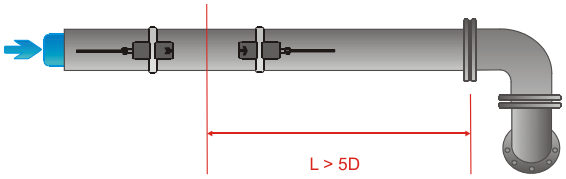
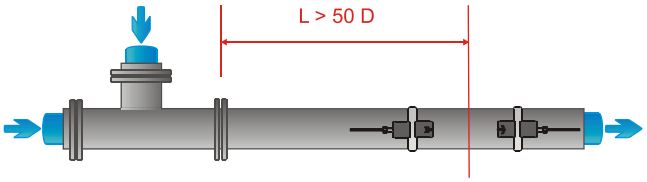
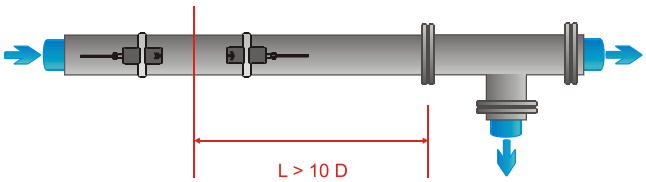
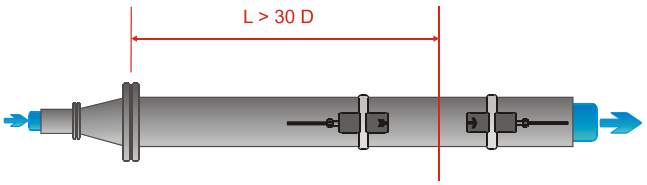
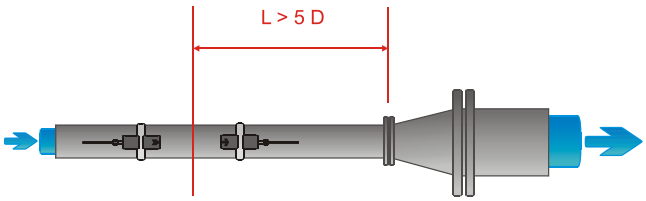
For a horizontal pipe: Select a location where the transducers can be mounted on the side of the pipe, so that the sound waves emitted by the transducers propagate horizontally in the pipe. In this way, the solid particles deposited on the bottom of the pipe and the gas pockets developing at the top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

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

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


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 ≥ 10D	Outlet L ≥ 5D
	
Disturbance source: 2 x 90°-elbow in one plane Inlet L ≥ 25D	Outlet L ≥ 5D
	
Disturbance source: 2 x 90°-elbow in different planes Inlet L ≥ 40D	Outlet L ≥ 5D
	
Disturbance source: T-section Inlet L ≥ 50D	Outlet L ≥ 10D
	
Disturbance source: diffuser Inlet L ≥ 30D	Outlet L ≥ 5D
	

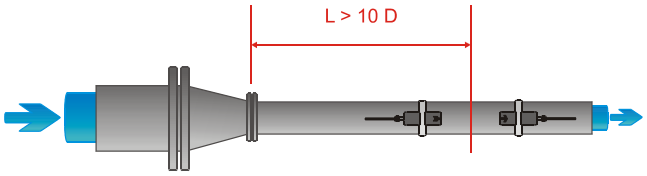
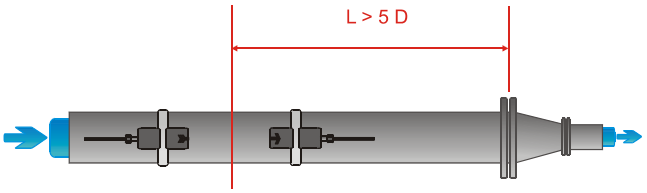
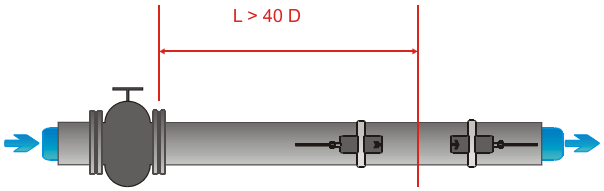
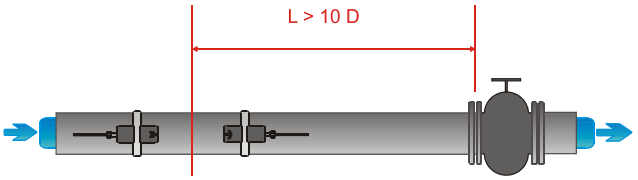
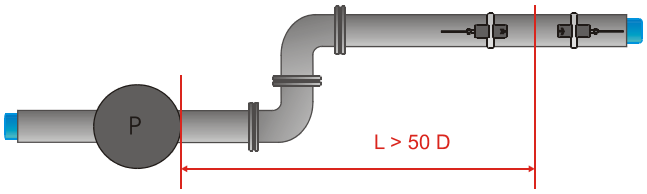
Disturbance source: reducer Inlet L ≥ 10D	Outlet L ≥ 5D
	
Disturbance source: valve Inlet L ≥ 40D	Outlet L ≥ 10D
	
Disturbance source: pump Inlet L ≥ 50D	
	

Table 2: Recommended distances from disturbance sources

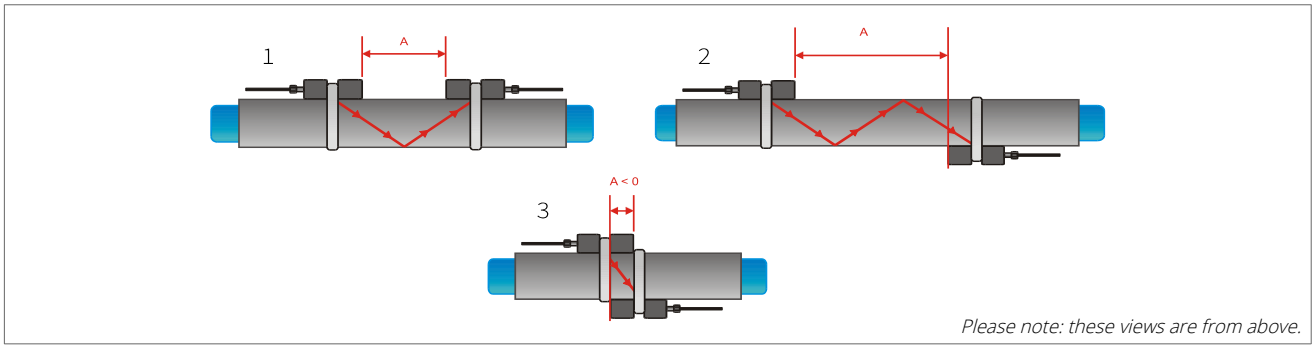
3.4 Pipe preparation

- 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 Sensor mounting configurations and separation distance

3.5.1 Reflection Mode

The most common clamp-on sensor mounting configuration is the Reflection Mode, sometimes known as V-Mode (see Picture 3, sketch 1). Here, the ultrasonic signal passes twice through the medium (two 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.



Picture 3: Clamp-on sensor mounting configurations and sensor spacing

3.5.2 Diagonal Mode

An alternative mounting configuration (see Picture 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 four passes (W-Mode) or three passes (N-Mode) are used (see Picture 3, sketch 2).

3.5.3 Transducer separation distance

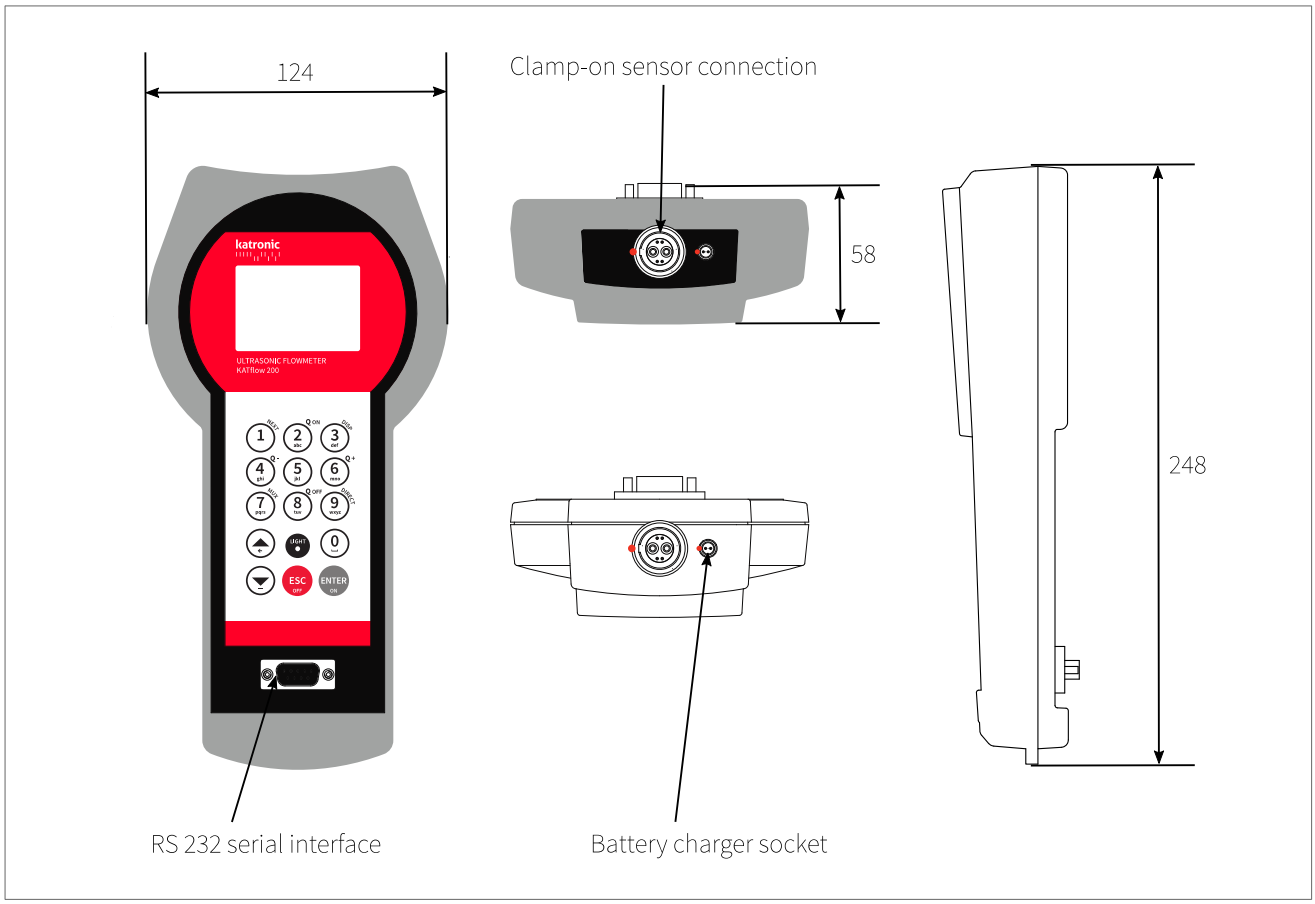
The transducer separation distance A is measured from the inside edges of the sensor heads as shown (see Picture 3). It is automatically calculated by the flowmeter based on the parameter entries for pipe outside diameter, wall thickness, lining material and thickness, medium, process temperature, the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

A negative separation distance A < 0 can occur for mounting configurations on small pipes where Diagonal Mode operation has been selected (see Picture 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.

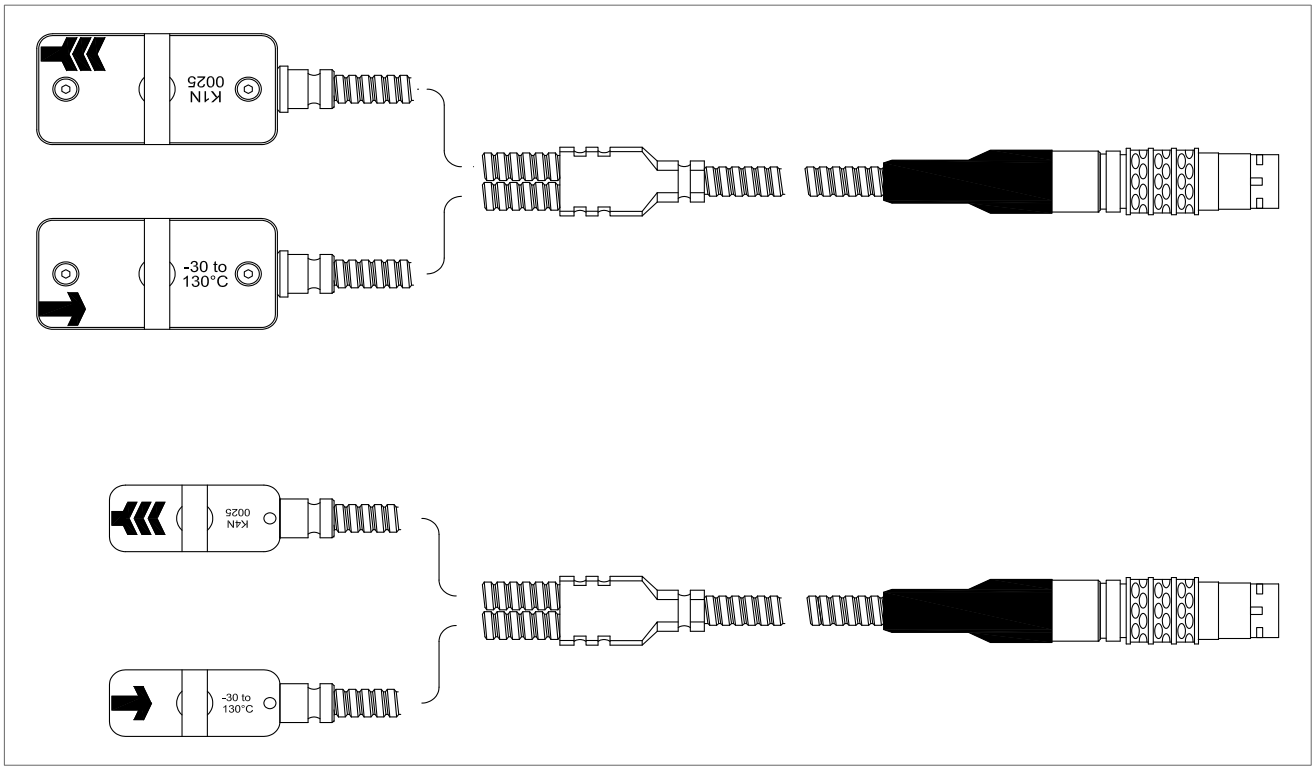
3.6 Flowmeter installation

3.6.1 Outline dimensions

The KATflow 200 is a hand-held, battery operated device with the following outline dimensions (Picture 4).

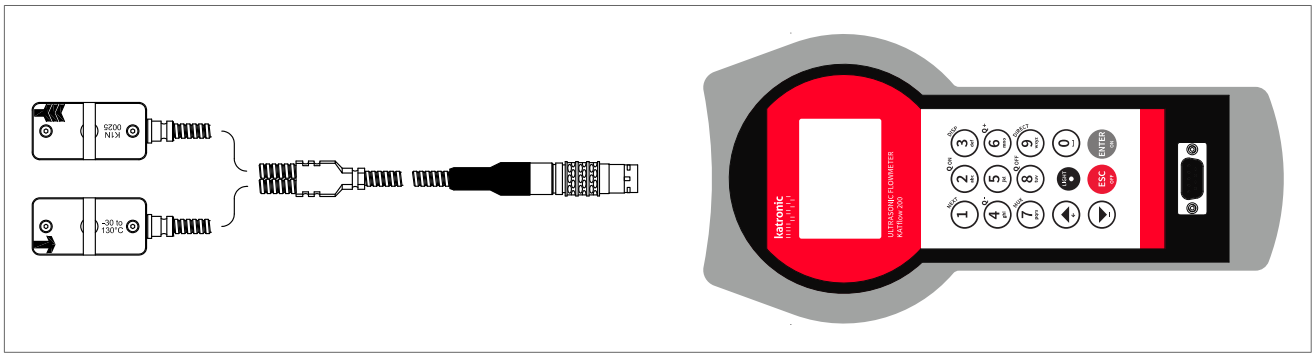


Picture 4: Outline dimensions KATflow 200



Picture 5: K1 and K4 type transducers

3.6.2 Electrical connections



Picture 6: Electrical connection diagram

3.7 Clamp-on sensor mounting

Before the sensors can be mounted

- the installation location should have been determined,
- a sensor mounting method should be chosen,
- the flowmeter batteries must be sufficiently charged,
- the sensors must be connected to the transmitter.

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 (see Section 3.5).

3.7.1 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.

Picture 7: Application of acoustic coupling gel

3.7.2 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 (see Section 3.3).
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. The sensor positioning screen (see Section 4.4) allows fine adjustment of the sensor location.

Picture 8: Correct positioning of the sensors

3.7.3 Sensor mounting with fixtures and chains

- Insert the retaining clip into the groove on the top of the transducer and secure it using the screw knob.
- Apply some acoustic coupling component to the contact surface of the transducer.
- Place the transducer on the side of the pipe or alternatively up to 45 degrees from the horizontal plane through the pipe. This is advisable to establish the best acoustic contact since on top of the pipe air pockets could develop and deposits could accumulate at the bottom of the pipe.
- Take the spring end of the chain in one hand and insert the last ball element in the vertical slot of the retaining clip. Mount the chain around the pipe.
- Pull the chain firmly around the pipe and fasten it in the lateral slot of the retaining clip. There should be no air pockets between the transducer surface and the pipe wall.
- Mount the second transducer the same way.
- Using a measuring tape, adjust the sensor separation distance as suggested by the flowmeter. When the sensor positioning screen is displayed, the middle bar allows fine adjustment of the sensor location.

Picture 9: Sensor mounting with clips and chains

Picture 10: Metallic mounting clip

4 OPERATION

4.1 Switching On/Off

The flowmeter is switched on by holding the **ON** key for more than two seconds continuously. Equally it can be switched off by pressing the **OFF** key for more than two seconds.

When switching on, the flowmeter will perform a hardware and software check, including the data logger space. Progress will be indicated by a series of dashes above and a black bar below.

4.2 Battery charging

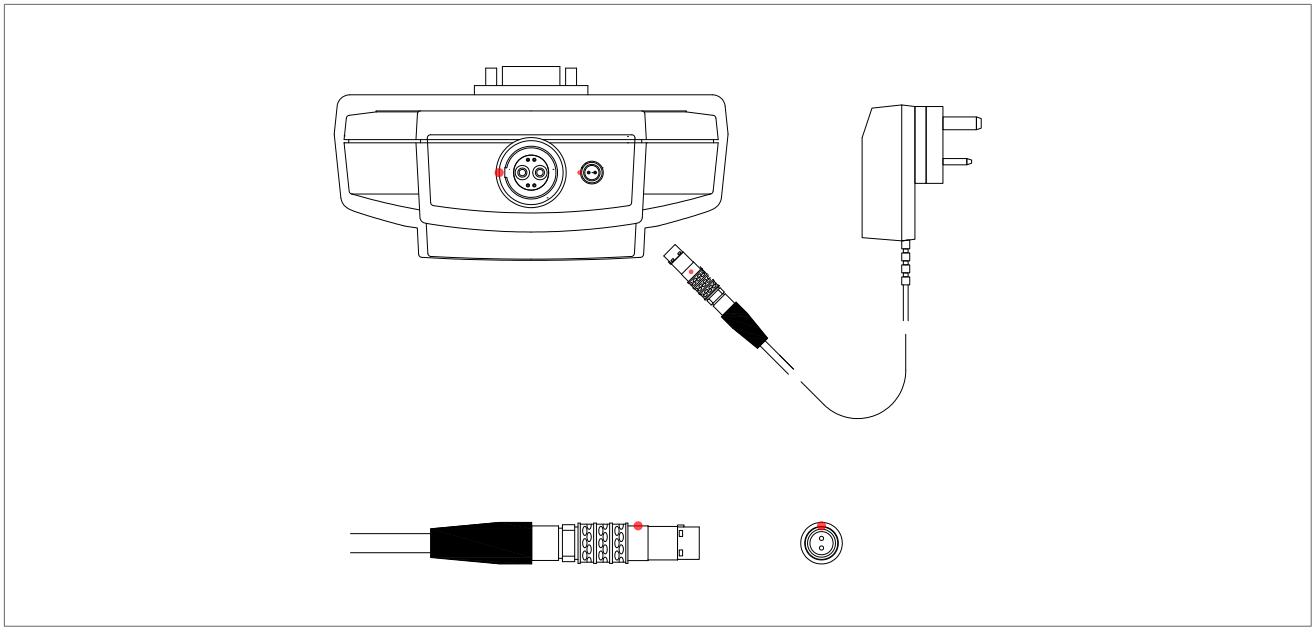
The internal batteries can be recharged with the external battery charger supplied.

Important: Ensure that only Nickel Metal Hydride (NiMH) AA size rechargeable batteries are installed – attempting to recharge other battery types is dangerous and may cause damage.

Connect the battery charger to the charging socket of the flowmeter and to the mains supply 100 ... 240 V AC, 50/60 Hz. The battery charger mains plug is supplied for specific countries as shown in the order code.

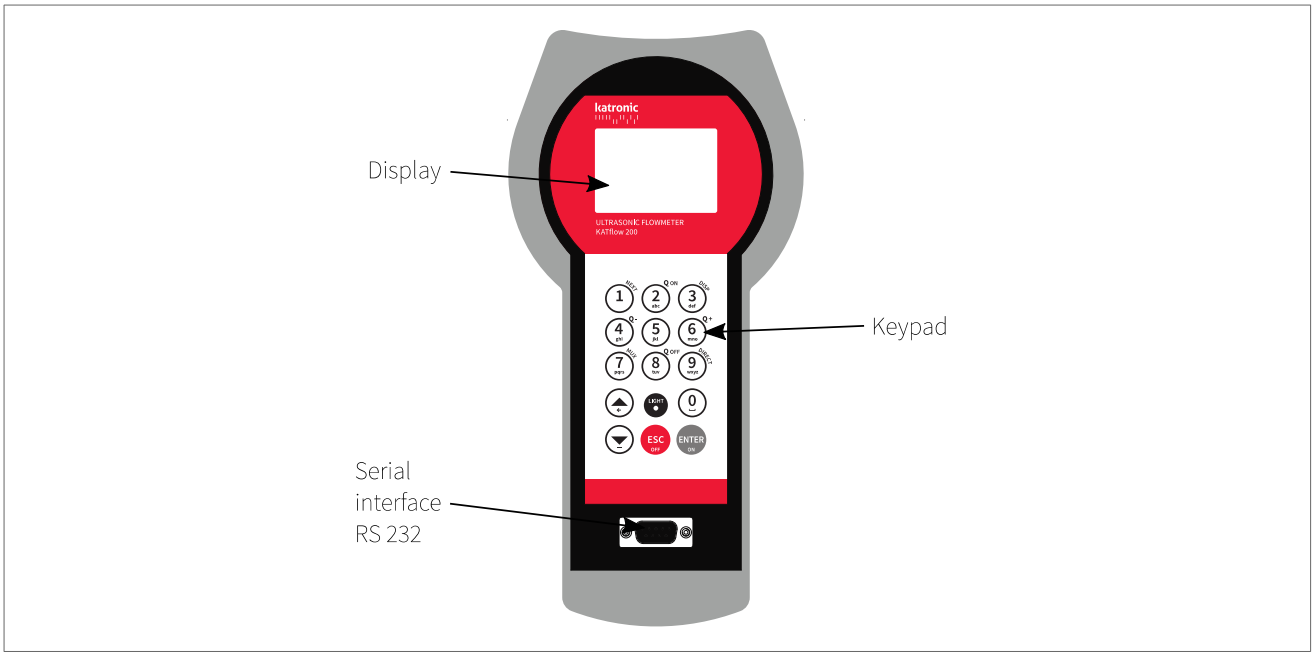
The red mark on the plug aligns with the mark on the socket. Remove plug by sliding the outer casing away from the socket to release the latch.

During the charging process, the battery icon will blink. For a fully charged battery all segments of the battery icon will be filled. Battery charge level is also shown in the diagnostic displays.



Picture 11: Battery charging

4.3 Keypad and display



Picture 12: Keypad and display KATflow 200

Customer-specific settings for data to be displayed can be achieved by using the appropriate menu items.

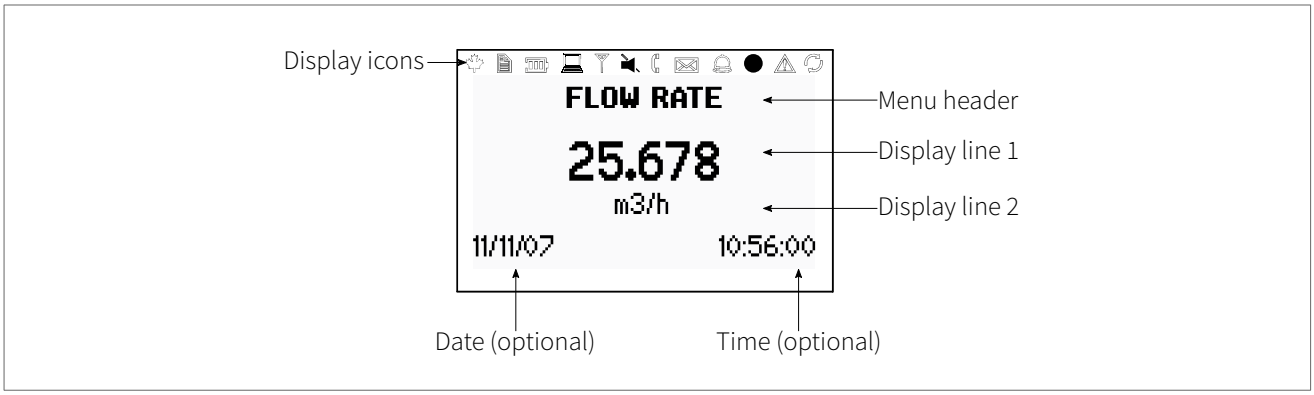
4.3.1 Keypad key functions

Used keys	Main function/Character entry	Secondary function
1 NEXT	1 (1 short key stroke) , (2 short key strokes) . (3 short key strokes) _ (4 short key strokes)	Show **NEXT** available item
2 abc Q_{ON}	A B C 2 /	Q_{ON} = Start/reset totaliser function Adjust screen brightness/contrast (long key stroke)
3 def DISP	D E F 3 ?	Show next **DISP**lay
4 ghi Q_-	G H I 4 <	Q_- = Reset negative total value

Used keys	Main function/Character entry	Secondary function
	J K L 5 >	–
	M N O 6 $	Q_+ = Reset positive total value
	P O R S 7	–
	T U V 8 *	Q_{OFF} = Stop totaliser function
	W X Y Z 9	**DIRECT** access to trend plot
	0 ␣ (Space character) + = #	–
	Move menu/list selection item **UP**	Character entry: ← (backspace) clear
	Move menu/list selection item **DOWN**	Character entry: - (minus sign)
	. (decimal point)	Switch LCD backlight on/off
	**ESC**ape menu item	Abort entry without saving Switches the instrument off if pressed for more than 2 s
	**ENTER** menu item	Confirm entry with saving Switches the instrument on if pressed for more than 2 s

Table 3: Keypad key functions

4.3.2 Display icons and functions



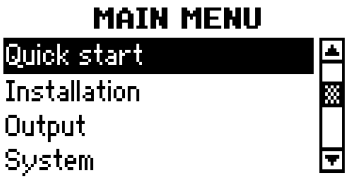
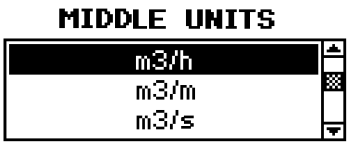
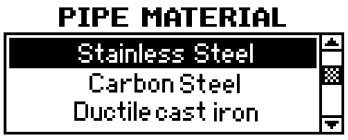
Picture 13: Display overview

Display icon	Function	
		Function not used on KATflow 200
	On Off	Data logger recording Data logger switched off
	On	1 segment = 33 % battery power available
	On	2 segments = 66 % battery power available
	On	3 segments = 100 % battery power available
	Off Outline blinking	< 5 % battery power available Battery charging
	On Off	LCD backlight switched on LCD backlight switched off
		Function not used on KATflow 200
	On Off	Speaker on Speaker off
	On Off	Coupling error Sensor operating correctly
		Function not used on KATflow 200
		Function not used on KATflow 200
	On Off	Time/date set Clock error
	On Off	Error recorded in error log No error detected
	On Off	Serial output RS 232 switched on Serial output RS 232 switched off
L, T or LT		Displays whether flow is **L**aminar, **T**urbulent or **L**aminar-**T**urbulent

Table 4: Display icon functions

4.4 Quick Setup 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:

Used keys	Display screen	Operation
		At first power on and the boot sequence, the “Main Menu“ is displayed. Use the UP ▲ and DOWN ▼ cursor keys to select “Quick Start” and confirm by pressing ENTER.
		Use cursor keys to select “Setup Wizard”. Confirm by pressing ENTER. If the sensors are recognised, the serial number will be shown. If not, the type can be selected.
		Select the main measurement unit using the cursor keys and confirm with ENTER. This unit will be displayed in the middle of the measurement screen. Selecting OFF deactivates the measurement channel.
		Select pipe material using the cursor keys and confirm with ENTER.
		Enter the outer pipe diameter using the alphanumeric keys and confirm with ENTER. Use UP ▲ key as backspace to correct for entry errors. If 0 is entered and confirmed, an additional screen appears that allows entry of the circumference.
		Enter the circumference using the alphanumeric keys. Press ENTER to confirm.
		Enter pipe wall thickness using the alphanumeric keys and confirm with ENTER. Use UP ▲ key as a backspace to correct for entry errors.
		Enter the inner pipe diameter using the alphanumeric keys and confirm by pressing ENTER. The value that appears here will have been calculated from the entered outside diameter (or circumference) and wall thickness. Entering a new value will recalculate the outside diameter.

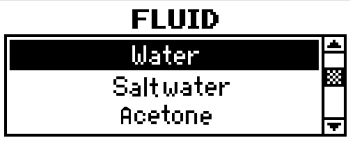
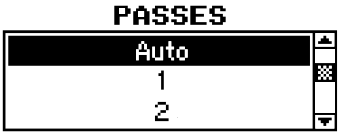
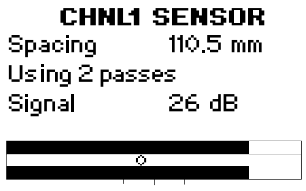
Used keys	Display screen	Operation
		Select the fluid using cursor keys. Confirm by pressing ENTER.
		Enter the fluid temperature using the keypad. Confirm by pressing ENTER. Use UP ▲ key as a backspace to correct for entry errors.
		Select pipe liner material using cursor keys and confirm by pressing ENTER. If a liner material is chosen, an additional screen appears that allows entry of liner thickness.
		Select number of sound passes (sound paths) 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) etc. Confirm with ENTER.
		Select “Start Measurement” and confirm with ENTER to start the sensor positioning procedure.
		Sensor positioning 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. Note: Numbers shown are for indication only.
		Success!

Table 5: Quick Setup Wizard

4.5 Measurement

4.5.1 Main process value display

Measurement is started using “Start Measurement” in the Quick Start Wizard.

The main process value (PV) is the primary measurement data and is usually displayed as the middle unit. User-specific settings for the main process value display can be made using the corresponding options in the menu. The process value can be selected from a list of available values.

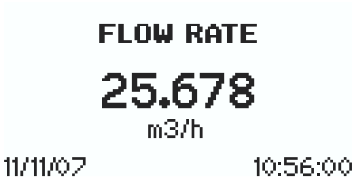
Used keys	Display screen	Operation
		The main process value can be changed in the “Quick Start” or “Installation” menus. Press ESC at any time to return to the “Main Menu”. View totalisers by pressing NEXT. Change to the diagnostic display by pressing DISP.

Table 6: Main process value display

4.5.2 Three-line display

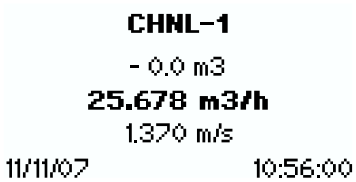
Used keys	Display screen	Operation
		The three-line display screen is configurable to show flow, totalisers and diagnostic functions. Change to diagnostic displays by pressing DISP and to totaliser screens by pressing NEXT. Cycle through display screens using NEXT.

Table 7: Main process value display in three-line display format

4.5.3 Diagnostic display

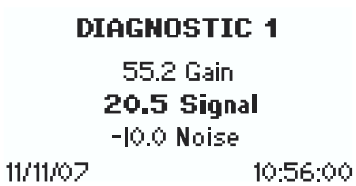
Used keys	Display screen	Operation
		Line 1 shows the amplifier gain. Line 2 displays the signal strength. Line 3 indicates the noise. Change to more diagnostic displays by pressing NEXT. Refer to Customer Support for the meanings of each diagnostic screen.

Table 8: Diagnostic display

Diagnostic displays can be viewed directly during measurement. Other diagnostic functions are available in the menu structure.

4.5.4 Totaliser

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

Used keys	Display screen	Operation
1 NEXT 2 abc Q_{ON}	TOTALISER -1 - 1.3 m3 25.678 m3/h 37.3 m3 11/11/07 10:56:00	The flow totaliser can be started or reset by pressing Q_{ON} when a volume measurement is selected as one of the displayed units. Totaliser screens are viewed by pressing NEXT from the measurement screen. When top and bottom display lines are set to a volume measurement, the first totaliser screen displays cumulative totals and the second screen shows separate positive and negative totals. Pressing NEXT again will return to the main measurement screen.
6 mno Q_+ 4 ghi Q_-		Pressing Q_+ resets the total accumulated flow in the positive flow direction. Pressing Q_- resets the total accumulated flow in the negative flow direction.
8 tuv Q_{OFF}		The totalisers can be stopped by pressing Q_{OFF}.
3 def DISP 1 NEXT		Pressing Q_{ON} again will reset to zero. Change to other displays or revert to the totaliser screen without resetting by pressing DISP or NEXT.

Table 9: Totaliser display

4.5.5 Data logger

- The data logger 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.
- 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 KATdata+ software except when “Wrap Mode” has been enabled.

5 COMMISSIONING

5.1 Menu structure

Main menu	Menu level 1	Menu level 2	Description/settings
Quick Start			
	Setup Wizard		
		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 units (main displayed)	Select from list where available ↑↓ • m/s, ft/s, in/s, m^3/h, m^3/min, m^3/s, l/h, l/min, l/s • USgal/h, USgal/min, USgal/s, bbl/d, bl/h, bbl/min • g/s, t/h, kg/h, kg/min, m^3, l, USgal, bbl, g, t, kg • W, kW, MW, J, kJ, MJ • Signal dB, noise dB, SNR (dB) • SOS in m/s (speed of sound), CU (housing temperature)
		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 speed of sound)
		Pipe c-speed	(Only if user pipe material selected) 500 ... 5 000 m/s
		Outside diameter	6 ... 6 500 mm
		Wall thickness	0.5 ... 75 mm
		Inner diameter	6 ... 6 500 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, Refrigerant R134a, Refrigerant R22, Hydrochloric acid, Sour cream, Sulphuric acid, Toluene, Vinyl chloride • User (kinematic viscosity, density, medium c-speed)
		Kinematic viscosity	(Only if user fluid selected) 0 ... 30 000 mm^2/s
		Density	(Only if user fluid selected) 100 ... 2 000 kg/m^3
		Medium c-speed	(Only if user fluid selected) 800 ... 3 500 m/s
		Temperature	-30 ... +300 °C
		Liner material	Select from list ↑↓ • None • Epoxy, Rubber, PVDF, PP, Glass, Cement • User (liner c-speed)

Main menu	Menu level 1	Menu level 2	Description/settings
		Liner c-speed	(Only if lining material selected) 500 ... 5 000 m/s
		Liner thickness	(Only if lining material selected) 1.0 ... 99.0 mm
		Passes	Select from list ↑↓ Auto, 1 ... 16
	WTG Wizard		
			Reference Thickness (THK)
			Calibration
	Stored setup		"Load", "Save" or "Delete" stored sets of parameters (Names for different measurement points can be entered on "Save" using the keypad)
	Start measure-ment		
		Sensor type	Indication of sensor type and serial number if automatically detec-ted, otherwise select from list ↑↓
		SP1 – Sensor frequency	Only for special, unrecognised sensors
		SP2 – Wedge angle	Only for special, unrecognised sensors
		SP3 – Wedge c-speed 1	Only for special, unrecognised sensors
		SP4 – Wedge c-speed 2	Only for special, unrecognised sensors
		SP5 – Crystal offset	Only for special, unrecognised sensors
		SP6 – Spacing offset	Only for special, unrecognised sensors
		SP7 – Zero flow offset	Only for special, unrecognised sensors
		SP8 – Upstream offset	Only for special, unrecognised sensors
		Sensor K factor	Only for special, unrecognised sensors
Installation			
	Pipe		
		Material	Select from pipe material list ↑↓
		Outside dia	6 ... 6 500 mm (outside diameter)
		Wall thk	0.5 ... 75 mm (wall thickness)
		Inner dia	6 ... 6 500 mm (inner diameter)
		C-speed	600 ... 6 554 m/s (transverse sound speed pipe)
		L-speed	600 ... 8 000 m/s (longitudinal sound speed pipe)
		Circumfer	18.8 ... 20 420 mm (pipe circumference)

Main menu	Menu level 1	Menu level 2	Description/settings
		Roughness	0 ... 10 mm
	Medium		
		Fluid	Select from fluid list ↑↓
		Kinematic viscosity	0 ... 30 000 mm^2/s
		Dynamic viscosity	0 ... 60 $kg\ s^{-1}\ m^{-1}$
		Density	100 ... 2 000 kg/m^3
		C-speed	800 ... 3 500 m/s
		Temperature	-30 ... +300 °C
	Lining		
		Material	Select from material list ↑↓
		Thickness	0.1 ... 99.9 mm
		C-speed	500 ... 6 553 m/s
	Passes		Select from list ↑↓
Output			
	Display		
		Top line	Select unit from list ↑↓
		Middle line	Select unit from list ↑↓
		Bottom line	Select unit from list ↑↓
		Damping	Reduces fluctuations in the display output: 1 ... 255 s
		Metric/Imp.	Use metric or imperial units for entered data
		Auto Seq. Timer	Set automatic change of display
	Data logger		
		Interval	Enter logging interval in seconds: 0 ... 999 s
		Selection	Select from list ↑↓ **ENTER** selects, **0** deselects Up to ten variables may be logged
		Low memory	Warning output 0 ... 100 %
		Log download	Sends all logger data using serial port
		Log erase	Clears the logger
	Serial comms		Serial communication
		Mode	Select from list ↑↓ • None • Printer (output every second of selected values) • Diagnostic • Download (send logger data using serial port) • Cal Test (laboratory calibration, not recommended for field or customer use)

Main menu	Menu level 1	Menu level 2	Description/settings
		Baud	Select from list ↑↓ • 9 600 (default) • 19 200 • 57 600 • 115 200
		Parity	Select from list ↑↓ • None • Even (default) • Odd
System			
	Instrument info		
		Model code	KF200
		Serial number	Example: 20004057
		HW revision	Example: 3.00, 1.70
		SW revision	Example: 4.22-7565, 4.00
	Calculation		
		Low flow cut off	± Low flow velocity cut off: 0 ... 0.10 m/s
		Max. flow cut off	± 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 units
		PV scaling	Calibration process variable gradient scaling: 0 ... 1 000 units
		Zero calibration	Zero calibration settings Adjust: • Zero (Yes/No): Sets current flow as zero (Perform auto zero calibration) • Track (Yes/No): Zero follows output variations • Delta time: Zero flow offset in ns (Zero flow delta time offset in ns, read from sensor PROM or entered directly for special sensors) • Time up: Transit time offset in µs, for delays in special sensors, thermal buffers and cable extensions
	User		
		Identifier	Example: Pump P3A (9 character string possible)
		Tag No	Tag Number: Example: 1FT-3011 (9 character string possible)
		Password	Set 4 character password (default 1111)
	Test		
		Installation	Control system simulation 60 second ramping up of flow velocity in m/s from 0 to programmed Max. flow cut off and subsequent 60 second ramping down All configured outputs will exhibit their programmed behaviour Test Mode: Yes/No
		Display	Display screen test routine
		Keypad	Keypad test routine

Main menu	Menu level 1	Menu level 2	Description/settings
		Memory	Memory test routine Memory erase: Yes/No
		Peripherals	Unit temperature, time, date, clock
		Ultrasonics	Tests ultrasonic board and sensors
	Settings		
		Date	Example: 18/11/2019
		Time	Example: 09:27:00
		Date format	Select from list ↑↓ • dd/mm/yy • mm/dd/yy • yy/mm/dd
		Language	Select from list (as available) ↑↓ English, German, French, Spanish, Russian
		Keypad sound	Yes/No
		Battery	Low warning: Yes/No Auto off timer 1 ... 59 min
	Defaults		Load default settings (except date and time): Yes/No
Diagnostics			
			Shows measured temperature, available logger memory, battery charge level, battery voltage (V), remaining battery capacity (mAh) (cycle using **ENTER**)
Scope			Hidden option that can be selected by pressing **5** in the main menu
			Shows the received acoustic pulse and further data to evaluate the signal quality as an oscilloscope function on channel 1 only (see Section 5.4)

Table 10: Menu structure KATflow 200

5.2 Output settings

5.2.1 Serial interface RS 232

The RS 232 serial interface can be used to transmit data online or to download the integral data logger content. The settings can be found in the “Serial Communication” submenu.

5.3 Wall thickness measurement

Optional sensor probes to measure pipe wall thickness (WTG) are available. The KATflow 200 will recognise a connected probe when entering the Setup or WTG Wizards, the measurement mode or the scope function. Use the Setup Wizard or “Installation” menu to set the pipe material. Select “Start Measurement”.

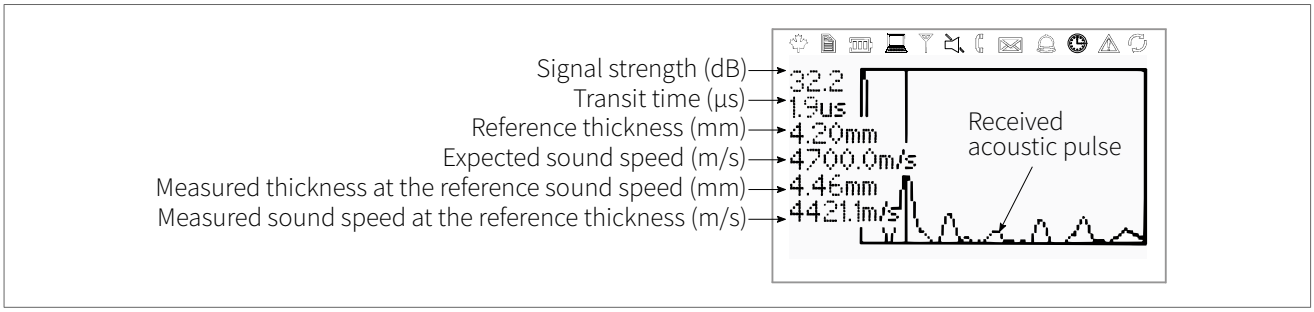
The KATflow 200 will recognise the probe and display the measurement screen. Wall thickness will be shown when the sensor is in good acoustic contact with the pipe.

5.3.1 Wall Thickness Gauge Wizard

To confirm pipe thickness and sound speed, select the “WTG Wizard” from the “ Quick Start” menu. Enter the approximate expected thickness as “Reference THK” and select “Calibrate”.

The screen displays the received acoustic pulse and values for the signal strength, the transit time, the reference thickness, the expected sound speed, the measured thickness at the reference sound speed and the measured sound speed at the reference thickness (top to bottom).

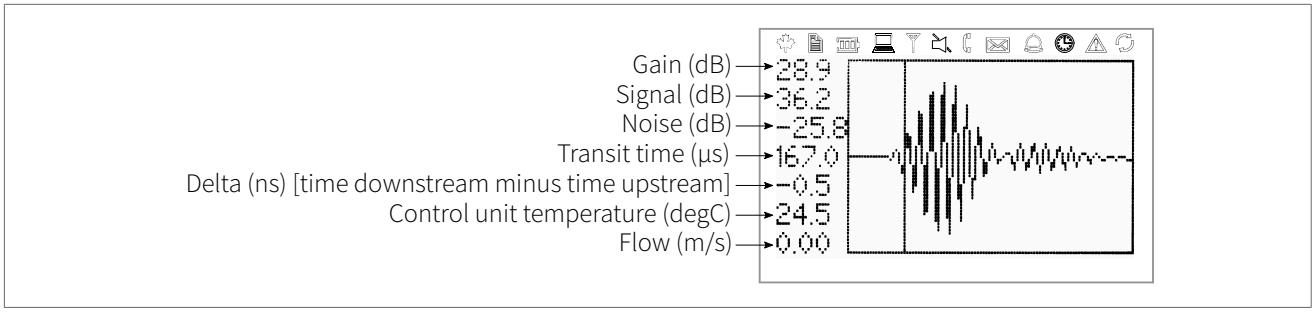
On leaving this screen using the **ESC** key, the flowmeter will ask if you wish to store the recorded value of longitudinal sound speed (“L-Speed” in the “Pipe” menu).



Picture 14: Wall Thickness Gauge (WTG) screen

5.4 Scope function

Katronic 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 data given from top to bottom (see Picture 15).



Picture 15: Scope function display

5.5 KATdata+ software

Software can be provided for downloading the contents of the data logger and communication with the flowmeter.

6 MAINTENANCE

KATflow 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

KATflow 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

7.1 Measurement difficulties and error messages

Most problems with measurement are due to poor signal strength or quality. Initial checks should include:

- Has sufficient acoustic coupling paste been applied?
- Can the number of sound passes be changed? As a general rule, more passes will improve accuracy, fewer passes will give better signal strength.
- Are there any nearby sources of noise or disturbance?
- Can the signal be improved by moving the sensors around the circumference of the pipe?
- Are the application parameters correct?

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 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 from 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 from 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 from 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

Error message	Group	Description	Error handling
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, otherwise call Customer Support

Table 11: Error list

7.2 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 KATdata+ 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”, the KATdata+ software may also be used.

8 TECHNICAL DATA

8.1 Sound speed of selected pipe materials

Material	Sound speed* shear wave (at +25 °C)	
	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

Table 12: Technical data pipe material

*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.

8.2 Technical data of selected fluids

All data given at +25 °C (+77 °F) unless otherwise stated				Sound speed				Change of sound speed per °C		Viscosity (kinematic)			
Substance	Chemical formula	Density $g \cdot cm^{-3}$		$m \cdot s^{-1}$		$ft \cdot s^{-1}$		$m \cdot s^{-1} \cdot °C^{-1}$		$mm^2 \cdot s^{-1}$		$10^{-6} \cdot ft^2 \cdot s^{-1}$	
Acetic acid, anhydride	(CH3CO)2O	1.082	20 °C	1 180.0		3 871.4		2.50		0.769		8.274	
Acetic acid, nitrile	C2H3N	0.783		1 290.0		4 232.3		4.10		0.441		4.745	
Acetic acid, ethyl ester	C4H8O2	0.901		1 085.0		3 559.7		4.40		0.467		5.025	
Acetic acid, methyl ester	C3H6O2	0.934		1 211.0		3 973.1				0.407		4.379	
Acetone	C3H6O	0.791		1 174.0		3 851.7		4.50		0.399		4.293	
Acetylene dichloride	C2H2Cl2	1.260		1 015.0		3 330.1		3.80		0.400		4.304	
Acetylene tetrachloride	C2H2Cl4	1.595		1 147.0		3 763.1		3.80		1.156	15 °C	12.440	15 °C
Alcohol	C2H6O	0.789		1 207.0		3 960.0		4.00		1.396		15.020	
Ammonia	NH3	0.771		1 729.0	-33 °C	5 672.6	-27 °C	6.68		0.292	-33 °C	3.141	-27 °F
Benzene	C6H6	0.879		1 306.0		4 284.8		4.65		0.711		7.650	
Benzol	C6H6	0.879		1 306.0		4 284.8		4.65		0.711		7.650	
Bromine	Br2	2.928		889.0		2 916.7		3.00		0.323		3.475	
n-Butane (2)	C4H10	0.601	0 °C	1 085.0	-5 °C	3 559.7	23 °C	5.80					
2-Butanol	C4H10O	0.810		1 240.0		4 068.2		3.30		3.239		34.851	
sec-Butylalcohol	C4H10O	0.810		1 240.0		4 068.2		3.30		3.239		34.851	
n-Butyl bromide (46)	C4H9Br	1.276	20 °C	1 019.0	20 °C	3 343.2	68 °F			0.490	15 °C	5.272	59 °C
n-Butyl chloride (22,46)	C4H9Cl	0.887		1 140.0		3 740.2		4.57		0.529	15 °C	5.692	59 °F
Carbon tetrachloride	CCl4	1.595	20 °C	926.0		3 038.1		2.48		0.607		6.531	
Carbon tetrafluoride (Freon 14)	CF4	1.750	-150 °C	875.2	-150 °C	2 871.5	-238 °F	6.61					
Chloroform	CHCl3	1.489		979.0		3 211.9		3.40		0.550		5.918	
Dichlorodifluoromethane (Freon 12)	CCl2F2	1.516	40 °C	774.1		2 539.7		4.24					
Ethanol	C2H6O	0.789		1 207.0		3 960.0		4.00		1.390		14.956	
Ethyl acetate	C4H8O2	0.901		1 085.0		3 559.7		4.40		0.489		5.263	
Ethyl alcohol	C2H6O	0.789		1 207.0		3 960.0		4.00		1.396		15.020	
Ethyl benzene	C8H10	0.867	20 °C	1 338.0	20 °C	4 890.8	68 °F			0.797	17 °C	8.575	63 °F
Ether	C4H10O	0.713		985.0		3 389.8		4.87		0.311		3.346	
Ethyl ether	C4H10O	0.713		985.0		3 231.6		4.87		0.311		3.346	
Ethylene bromide	C2H4Br2	2.180		995.0		3 264.4				0.790		8.500	
Ethylene chloride	C2H4Cl2	1.253		1 193.0		3 914.0				0.610		6.563	
Ethylene glycol	C2H6O2	1.113		1 658.0		5 439.6		2.10		17.208	20 °C	185.158	68 °F
Fluorine	F	0.545	-143 °C	403.0	-143 °C	1 322.2	-225 °F	11.31					
Formaldehyde, methyl ester	C2H4O2	0.974		1 127.0		3 697.5		4.02					
Freon R12				774.2		2 540.0		6.61					
Glycol	C2H6O2	1.113		1 658.0		5 439.6		2.10					
50 % Ethylene glycol/ 50 % Water				1 578.0		5 177.0							
Isopropanol	C3H8O	0.785	20 °C	1 170.0	20 °C	3 838.6	68 °F			2.718		29.245	
Isopropyl alcohol (46)	C3H8O	0.785	20 °C	1 170.0	20 °C	3 838.6	68 °F			2.718			

All data given at +25 °C (+77 °F) unless otherwise stated				Sound speed				Change of sound speed per °C		Viscosity (kinematic)			
Substance	Chemical formula	Density $g \cdot cm^{-3}$		$m \cdot s^{-1}$		$ft \cdot s^{-1}$		$m \cdot s^{-1} \cdot °C^{-1}$		$mm^2 \cdot s^{-1}$		$10^{-6} \cdot ft^2 \cdot s^{-1}$	
Kerosene		0.810		1 324.0		4 343.8		3.60					
Methane	CH4	0.162	-89 °C	405.0	-89 °C	1 328.7	-128 °F	17.50					
Methanol	CH4O	0.791	20 °C	1 076.0		3 530.2		292.00		0.695		7.478	
Methyl acetate	C3H6O2	0.934		1 211.0		3 973.1				0.407		4.379	
Methyl alcohol	CH4O	0.791		1 076.0		3 530.2		292.00		0.695		7.478	
Methyl benzene	C7H8	0.867		1 328.0	20 °C	4 357.0	68 °F	4.27		0.644		7.144	
Milk, homogenised				1 548.0		5 080.0							
Naphtha		0.760		1 225.0		4 019.0							
Natural gas		0.316	-103 °C	753.0	-103 °C	2 470.5	-153 °F						
Nitrogen	N2	0.808	-199 °C	962.0	-199 °C	3 156.2	-326 °F			0.217	-199 °C	2.334	-326 °F
Oil, Car (SAE 20a.30)		1.740		870.0		2 854.3				190.000		2 045.093	
Oil, Castor	C11H10O0	0.969		1 477.0		4 845.8		3.60		0.670		7.209	
Oil, Diesel		0.800		1 250.0		4 101.0							
Oil, Fuel AA gravity		0.990		1 485.0		4 872.0		3.70					
Oil (Lubricating X200)				1 530.0		5 019.9							
Oil (Olive)		0.912		1 431.0		4 694.9		2.75		100.000		1 076.365	
Oil (Peanut)		0.936		1 458.0		4 738.5							
Propane (-45 to -130 °C)	C3H8	0.585	-45 °C	1 003.0	-45 °C	3 290.6	-49 °F	5.70					
1-Propanol	C3H8O	0.780	20 °C	1 222.0	20 °C	4 009.2	68 °F						
2-Propanol	C3H8O	0.785	20 °C	1 170.0	20 °C	3 838.6	68 °F			2.718		29.245	
Propene	C3H6	0.563	-13 °C	963.0	13 °C	3 159.4	9 °F	6.32					
n-Propylalcohol	C3H8O	0.780	20 °C	1 222.0	20 °C	4 009.2	68 °F			2.549		27.427	
Propylene	C3H6	0.563	-13 °C	963.0	-13 °C	3 159.4	9 °F	6.32					
Refrigerant 11	CCl3F	1.490		828.3	0 °C	2 717.5	32 °F	3.56				8.500	
Refrigerant 12	CCl2F2	1.516	-40 °C	774.1	-40 °C	2 539.7	-40 °C	4.24					
Refrigerant 14	CF4	1.750	-150 °C	875.2	-150 °C	2 871.6	-268 °F	6.61					
Refrigerant 21	CHCl2F	1.426	0 °C	891.0	0 °C	2 923.2	32 °F	3.97					
Refrigerant 22	CHClF2	1.491	-69 °C	893.9	50 °C	2 923.2	32 °F	4.79					
Refrigerant 113	CCl2F-CClF2	1.563		783.7	0 °C	2 571.2	32 °F	3.44					
Refrigerant 114	CClF2-CClF2	1.455		665.3	-10 °C	2 182.7	14 °F	3.73					
Refrigerant 115	C2ClF5			656.4	-50 °C	2 153.5	-58 °F	4.42					
Refrigerant C318	C4F8	1.620	-20 °C	574.0	-10 °C	1 883.2	14 °F	3.88					
Sodium nitrate	NaNO3	1.884	336 °C	1 763.3	336 °C	5 785.1	637 °F	0.74		1.370	336 °C	14.740	637 °F
Sodium nitrite	NaNO2	1.805	292 °C	1 876.8	292 °C	6 157.5	558 °F						
Sulphur	S			1 177.0	250 °C	3 861.5	482 °F	-1.13					
Sulphuric Acid	H2SO4	1.841		1 257.6		4 126.0		1.43		11.160		120.081	
Tetrachloroethane	C2H2Cl4	1.553	20 °C	1 170.0	20 °C	3 838.6	68 °F			1.190		12.804	
Tetrachloroethene	C2Cl4	1.632		1 036.0		3 399.0							
Tetrachloromethane	CCl4	1.595	20 °C	926.0		3 038.1				0.607		6.531	
Tetrafluoromethane (Freon 14)	CF4	1.750	-150 °C	875.2	-150 °C	2 871.5	-283 °F	6.61					

All data given at +25 °C (+77 °F) unless otherwise stated				Sound speed				Change of sound speed per °C		Viscosity (kinematic)			
Substance	Chemical formula	Density $g \cdot cm^{-3}$		$m \cdot s^{-1}$		$ft \cdot s^{-1}$		$m \cdot s^{-1} \cdot °C^{-1}$		$mm^2 \cdot s^{-1}$		$10^{-6} \cdot ft^2 \cdot s^{-1}$	
Toluene	C7H8	0.867	20 °C	1 328.0	20 °C	4 357.0	68 °F	4.27		0.644		6.929	
Toluol	C7H8	0.866		1 308.0		4 291.3		4.20		0.580		6.240	
Trichlorofluoromethane (Freon 11)	CCl3F	1.490		828.3	0 °C	2 717.5	32 °F	3.56					
Turpentine		0.880		1 255.0		4 117.5				1.400		15.064	
Water, distilled	H2O	0.996		1 498.0		4 914.7		-2.40		1.000		10.760	
Water, heavy	D2O			1 400.0		4 593.0							
Water, sea		1.025		1 531.0		5 023.0		-2.40		1.000		10.760	

Table 13: Technical data of fluids

8.3 Dependence between temperature and sound speed in water

Temperature		Sound speed in water	
°C	°F	m/s	ft/s
0	32.0	1 402	4 600
1	33.8	1 407	4 616
2	35.6	1 412	4 633
3	37.4	1 417	4 649
4	39.2	1 421	4 662
5	41.0	1 426	4 679
6	42.8	1 430	4 692
7	44.6	1 434	4 705
8	46.4	1 439	4 721
9	48.2	1 443	4 734
10	50.0	1 447	4 748
11	51.8	1 451	4 761
12	53.6	1 455	4 774
13	55.4	1 458	4 784
14	57.2	1 462	4 797
15	59.0	1 465	4 807
16	60.8	1 469	4 820
17	62.6	1 472	4 830
18	64.4	1 476	4 843
19	66.2	1 479	4 853
20	68.0	1 482	4 862
21	69.8	1 485	4 872
22	71.6	1 488	4 882
23	73.4	1 491	4 892
24	75.2	1 493	4 899
25	77.0	1 496	4 908
26	78.8	1 499	4 918
27	80.6	1 501	4 925
28	82.4	1 504	4 935
29	84.2	1 506	4 941
30	86.0	1 509	4 951
31	87.8	1 511	4 958
32	89.6	1 513	4 964
33	91.4	1 515	4 971
34	93.2	1 517	4 977
35	95.0	1 519	4 984
36	96.8	1 521	4 984
37	98.6	1 523	4 990
38	100.4	1 525	4 997
39	102.2	1 527	5 010
40	104.0	1 528	5 013
41	105.8	1 530	5 020
42	107.6	1 532	5 026
43	109.4	1 534	5 033
44	111.2	1 535	5 036
45	113.0	1 536	5 040
46	114.8	1 538	5 046
47	116.6	1 538	5 049
48	118.4	1 540	5 053
49	120.2	1 541	5 056
50	122.0	1 543	5 063

Temperature		Sound speed in water	
°C	°F	m/s	ft/s
51	123.8	1 543	5 063
52	125.6	1 544	5 066
53	127.4	1 545	5 069
54	129.2	1 546	5 072
55	131.0	1 547	5 076
56	132.8	1 548	5 079
57	134.6	1 548	5 079
58	136.4	1 548	5 079
59	138.2	1 550	5 086
60	140.0	1 550	5 086
61	141.8	1 551	5 089
62	143.6	1 552	5 092
63	145.4	1 552	5 092
64	147.2	1 553	5 092
65	149.0	1 553	5 095
66	150.8	1 553	5 095
67	152.6	1 554	5 099
68	154.4	1 554	5 099
69	156.2	1 554	5 099
70	158.0	1 554	5 099
71	159.8	1 554	5 099
72	161.6	1 555	5 102
73	163.4	1 555	5 102
74	165.2	1 555	5 102
75	167.0	1 555	5 102
76	167.0	1 555	5 102
77	170.6	1 554	5 099
78	172.4	1 554	5 099
79	174.2	1 554	5 099
80	176.0	1 554	5 099
81	177.8	1 554	5 099
82	179.6	1 553	5 095
83	181.4	1 553	5 095
84	183.2	1 553	5 095
85	185.0	1 552	5 092
86	186.8	1 552	5 092
87	188.6	1 552	5 092
88	190.4	1 551	5 089
89	192.2	1 551	5 089
90	194.0	1 550	5 086
91	195.8	1 549	5 082
92	197.6	1 549	5 082
93	199.4	1 548	5 079
94	201.2	1 547	5 076
95	203.0	1 547	5 076
96	204.8	1 546	5 072
97	206.6	1 545	5 069
98	208.4	1 544	5 066
99	210.2	1 543	5 063
100	212.0	1 543	5 063
104	220.0	1 538	5 046
110	230.0	1 532	5 026
116	240.0	1 524	5 000
121	250.0	1 516	5 007

Temperature		Sound speed in water	
°C	°F	m/s	ft/s
127	260.0	1 507	4 944
132	270.0	1 497	4 912
138	280.0	1 487	4 879
143	290.0	1 476	4 843
149	300.0	1 465	4 807
154	310.0	1 453	4 767
160	320.0	1 440	4 725
166	330.0	1 426	4 679
171	340.0	1 412	4 633
177	350.0	1 398	4 587
182	360.0	1 383	4 538
188	370.0	1 368	4 488
193	380.0	1 353	4 439
199	390.0	1 337	4 387
204	400.0	1 320	4 331
210	410.0	1 302	4 272
216	420.0	1 283	4 210
221	430.0	1 264	4 147
227	440.0	1 244	4 082
232	450.0	1 220	4 003
238	460.0	1 200	3 937
243	470.0	1 180	3 872
249	480.0	1 160	3 806
254	490.0	1 140	3 740
260	500.0	1 110	3 642

Table 14: Temperature and sound speed in water

9 SPECIFICATION

9.1 General

Measuring principle	Ultrasonic time difference correlation principle
Flow velocity range	0.01 ... 25 m/s
Resolution	0.25 mm/s
Repeatability	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 (mean): ±0.5 % of measured value
Turn down ratio	1/100
Gaseous and solid content of liquid media	< 10 % of volume

9.2 Flowmeter

Enclosure type	Hand-held
Degree of protection	IP 65 according EN 60529
Operating temperature	-10 ... +60 °C (+14 ... +140 °F)
Housing material	ABS (UL 94 HB)
Measurement channels	1
Power supply	Internal rechargeable batteries: 4 x NiMH AA 2850 mAh (daily discharge rate approx. 2 % per day, operating range 0 ... +30 °C) or external power supply 9 V DC
Operating time	Up to 24 h with fully charged internal batteries
Display	LCD graphic display, 128 x 64 dots, backlit
Dimensions	228 (h) x 72/124 (w) x 58 (d) mm (without cable glands)
Weight	Approx. 650 g
Power consumption	< 3 W
Signal damping	0 ... 99 s
Transit time measurement rate	100 Hz (standard)
Output update time	1 s, faster rates on application
Operating languages	Czech, Dutch, English, French, German, Italian, Romanian, Russian, Spanish, Turkish (others on request)

9.3 Quantity and units of measurement

Volumetric flow rate	m^3/h, m^3/min, m^3/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, I, gal (US gallons), bbl
Mass	g, kg, t

9.4 Internal data logger

Storage capacity	Approx. 30 000 measurements (each comprising up to 10 selectable measurement units), logger size 5 MB Approx. 100 000 measurements (each comprising up to 10 selectable measurement units), logger size 16 MB
Logging data	All measured and totalised values, parameter sets

9.5 Communication

Serial interface	RS 232
Data	Instantaneous measured value, parameter set and configuration, logged data

9.6 KATdata+ software

Functionality	Download of measured values/parameter sets, graphical presentation, list format, export to third party software, online transfer of measured data
Operating systems	Windows 10, 8, 7, Vista, XP, NT, 2000, Linux, Mac (optional)

9.7 Sensors: K1L, K1N, K1E

Sensor type	K1L	K1N	K1E
Pipe diameter range	50 ... 6 500 mm	50 ... 3 000 mm	50 ... 3 000 mm
Temperature range	-30 ... +80 °C (-22 ... +176 °F)	-30 ... +130 °C (-22 ... +266 °F)	-30 ... +250 °C (-22 ... +482 °F) (for short periods up to +300 °C (+572 °F))
Material of cable conduits	PVC	Stainless steel	Stainless steel
Standard cable lengths	5.0 m	4.0 m	4.0 m
Dimensions of sensor heads	60 (h) x 30 (w) x 34 (d) mm		
Material of sensor heads	Stainless steel		
Degree of protection	IP 66 according to EN 60529 (IP 67 and IP 68 on request)		

9.8 Sensors: K4L, K4N, K4E

Sensor type	K4L	K4N	K4E
Pipe diameter range	10 ... 250 mm	10 ... 250 mm	10 ... 250 mm
Temperature range	-30 ... +80 °C (-22 ... +176 °F)	-30 ... +130 °C (-22 ... +266 °F)	-30 ... +250 °C (-22 ... +482 °F) (for short periods up to +300 °C (+572 °F))
Material of cable conduits	PVC	Stainless steel	Stainless steel
Standard cable lengths	5.0 m	2.5 m	2.5 m
Dimensions of sensor heads	43 (h) x 18 (w) x 22 (d) mm		
Material of sensor heads	Stainless steel		
Degree of protection	IP 66 according to EN 60529 (IP 67 and IP 68 on request)		

10 INDEX

11 APPENDIX A – CERTIFICATE OF CONFORMITY

katronic

CE

Declaration of Conformity

We, Katronic Technologies Ltd., declare under our sole responsibility that the product listed below to which this declaration relates are in conformity with the EU directives:

- EMC Directive 2014/30/EU for Electromagnetic Compatibility
- Low Voltage Directive 2014/35/EU for Electrical Safety

Name of Products	Description
KATflow 100, 150, 200, 210 and 230	Ultrasonic flowmeter with associated Katronic transducers

The mentioned products are in conformity with the following European Standards:

Class	Standard	Description
EMC Directive	BS EN 61326-1:2013	Electrical equipment for measurement, control and laboratory use – EMC requirements
Immunity	BS EN 61326-1:2013	Electrical equipment for continuous unattended use
	BS EN 61000-4-2:2009	Electrostatic discharge
	BS EN 61000-4-3+A2:2006	RF field
	BS EN 61000-4-4:2012	Electric fast transient/burst
	BS EN 61000-4-5+A1:2014	Surge
	BS EN 61000-4-6:2014	RF conducted
	BS EN 61000-4-11+A1:2004	AC mains voltage dips and interruption
Emission	BS EN 61326-1:2013	Electrical equipment Class B
	BS EN 55022:2010	Disturbance voltage Class B
Low Voltage Directive	BS EN 61010-1:2010	Safety requirements for electrical equipment for measurement, control and laboratory use

Coventry, 1 November 2019

For and on behalf of Katronic Technologies Ltd.

Yours sincerely,

Andrew Sutton
Managing Director

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Web www.katronic.com

VAT No. GB 688 0907 89
Registered in England
Number 3298028
Registered office as shown

Cert. No. GB03/5899

12 APPENDIX B – CUSTOMER RETURN NOTE (CRN)

Company	
Name	
Tel. No.	
E-mail	
Address	
Instrument model	
Serial number	
U-F-M contract number (if known)	
Sensor type(s)	
Sensor serial number(s)	

The enclosed instrument has been used in the following environment (please mark):

- ☐ Nuclear radiation
- ☐ Water-endangering
- ☐ Toxic
- ☐ Caustic
- ☐ Biological
- ☐ Other (please specify)

We confirm that (please mark),

- ☐ we have checked the instrument and sensors are free of any contamination,
- ☐ we have neutralised, flushed and decontaminated all parts which have been in contact with hazardous substances and/or environments,
- ☐ there is no risk to man or environment through any residual material.

Date	Signature	Company Stamp