User Guide: Touch Pro series correlators.

(Touch Pro, Touch Pro TM, Tri-Corr Touch).

Warning:	This manual contains important safety and operating information. Please read, understand, and follow the instructions in the manual and also any safety / approvals documents shipped with the device.

TABLE OF CONTENTS

1 INTRODUCTION AND PREPARATION FOR USE

Thank you for choosing a HWM system. We trust it will provide you with many years of service.

The Touch Pro series are correlator systems. They are designed to detect leaks within a pressurised water pipe network. More precisely, they are used for detecting the most probable location of a water leak. (i.e., To *pin-point* the leak location).

1.1 DOCUMENTATION AND SUPPORT OF PRODUCT

This user-guide covers the following model families:

Model Number(s)	Description
MCT - *	Touch Pro correlator system
HYDKITMCT *	Hydrophone kit (for correlators)
S16S / 1 / *	Hydrophone 2 sensor.

This includes the following systems:

- Touch Pro
- Touch Pro TM
- Tri-Corr Touch.

This user guide gives detailed information for the use of the correlator system to pinpoint the most probable location of a water-leak from a pressurised water pipe.

The user guide covers use of various parts of the system and its sensor options.

The user-guide should be read in conjunction with the user-guide(s) of the equipment it is being used with. Read any Safety Warnings and Approvals Information supplied.

For use with the Hydrophone 2 sensors, also read any appropriate sections of:

- MAN-165-0001 User-Guide – Hydrophone 2.

Note: HWM periodically updates software to include new features and any required changes, thus you may observe slight changes from the diagrams and features shown in this manual.

HWM provides support by means of our customer support webpages:

https://www.hwmglobal.com/help-and-downloads/

Should you have any questions that are not covered by this manual or the system's online help, please contact the HWM Technical Support team on +44 (0) 1633 489479, or email cservice@hwm-water.com

Acknowledgements:

USB interface:

The Outstation USB driver, although developed and tested by HWM-Water, is based on code examples generated by Atmel Corporation. To satisfy Atmel copyright licensing requirements, HWM-Water must display the following Atmel disclaimer:

1.2 SAFETY CONSIDERATIONS

Safety Note:

Before continuing, carefully read and follow the information in the "**Safety Warnings and Approvals Information**" document supplied with the product.
This provides general safety information.

Safety Procedures:

Working with water and other fluids under pressure can be hazardous. Recommended safety procedures for working conditions must be followed at all times, and operational procedures described in this manual should not take precedence over local safe working practices or company procedures. If in doubt, ask your local safety officer.

The use of Touch Pro equipment Hydrophone 2 sensor option with the water supply is subject to the hygiene procedures applicable to any objects coming into contact with drinking water supplies. Hydrophone sensors and adaptors should be appropriately sterilised prior to use and applicable procedures should be followed during their installation.

Use of Touch Pro with other liquids or gases should follow national and company safety procedures for operation in proximity with these substances.

DO NOT use your hands for installing the sensors in valve/hydrant chambers or meter boxes without checking for foreign objects. Sharp objects can easily pierce gloves. If any excavation is required, use suitable tools.

Electrical Safety:

Water pipes are frequently used as the connection for electrical earth. Danger of electric shock exists with metal pipes when disconnecting meters, etc. An earthing strap should be fitted between the two ends of the pipe before disconnection.

Sensor Magnet:

The Touch Pro Sensors are equipped with a Neodymium Magnet. This feature allows the sensor to be connected to any ferrous valve, and to remain stable. This magnet has been chosen due to its magnetic strength and small size.

The Touch Pro outstations are equipped with a Neodymium Magnet. This feature allows the outstation to be connected to a ferrous pit lid, and to remain stable even under high-wind conditions. This magnet has been chosen due to its magnetic strength and small size.

1.3 Operating Temperature

Refer to the equipment datasheet or your sales representative for guidance on the storage and operating temperature range of the device. Ensure the equipment is within its operating temperature range prior to and during use.

1.4 Battery Installation and Charging

Due to shipping regulations, the Touch Pro Base Unit and Outstations are dispatched with the battery packs packaged separately. All batteries supplied are rechargeable lithium-ion. The batteries are identical and are interchangeable.

Warning: Do not short-circuit the batteries. Any misuse may result in explosion or fire. They must not be used in any other application or used with any other equipment. Only batteries/battery-packs supplied by HWM-Water Ltd must be used. The sealed battery packs contain circuitry to prevent overcharging and over discharging.

When delivered, the internal batteries required for the Base Unit and Outstations will only have a nominal charge and should be fully charged before mobile operations are undertaken.

To charge the batteries they must first be installed in the equipment.

Tools required: No. 1 Posi bit,
Torque driver set to 0.8 – 1.0 Nm
Flat head screwdriver

Note: Sensors are powered from the equipment they are fitted to, and do not contain batteries.

1.4.1 Base Unit – Battery pack installation

Loosen / remove the Velcro hand straps from the rear of the unit.

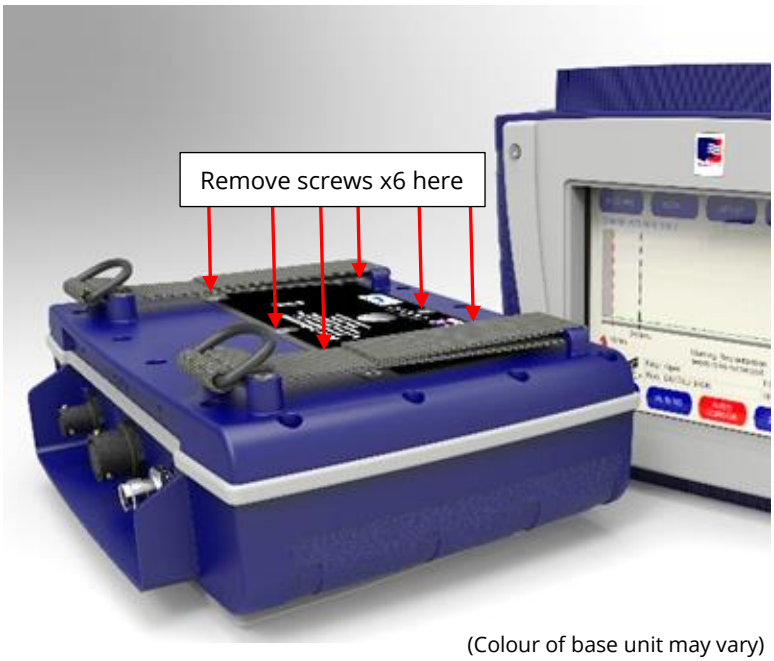
Remove 6 off M3 x 10 Posi countersunk screws as indicated using a
No. 1 Posi bit.

Remove the battery cover.

Install and connect the battery.

Replace the battery cover and secure with 6 off M3x10 Posi countersunk screws, using a No.1 Posi bit and tighten to 0.8 – 1.0 Nm.

Replace / tighten the Velcro hand straps.



(Colour of base unit may vary)

1.4.2 Outstation Units – Battery pack installation

Remove the 2 off ¼ turn fasteners from the base of the unit, as indicated, using a flat head screwdriver.

Remove the battery cover assembly.

Install and connect the battery.

Replace the battery cover assembly.

Tighten the 2 off ¼ turn fasteners on the base of the unit, using a flat head screwdriver.

(Repeat the steps above with the second outstation).

1.4.3 Battery charging and storage

Following the battery fitting procedure, the units will require a full charge before use.

All batteries may be charged simultaneously while the components are stored in the Touch Pro case. The units will charge regardless of their on/off status.

Charging for all batteries takes up to 6 hours from flat, although an overnight charge is recommended for maximum performance.

When the batteries are fully discharged, they should be recharged within 24 hours.

Provided the above instructions are followed carefully maximum battery life should be maintained.

Note: If the system is going to be stored for any length of time, to ensure long life of the batteries it is recommended that they are charged to approx. 1/4 of capacity. The batteries should be removed from the units during extensive periods of storage.

Plugging a charger into an outstation that is switched on will automatically switch off the outstation. This is to prevent the outstation being left on when charging in the case. To use an outstation while it is charging, please depress the on/off button for 2 seconds to switch the outstation back on. An outstation will always charge when a charger is connected and the battery is not full, regardless of whether the outstation is on or off.

Note: When replacing the Outstation battery, please ensure that no USB is connected. No damage will be done to the unit, but it will cause the outstation to run a bootloader program.
(This feature is for factory use or maintenance purposes only).

2 OVERVIEW

2.1 INTRODUCTION

The Touch Pro is a high-speed leak location system which employs:

- Class-leading sensors.
- A large full-colour touch screen.
- An integrated noise filtering, analysis, and management software.

The equipment package combines to produce accurate survey data using cross correlation techniques.

Leak correlation is used to find the exact location of a leak on a pipe. Highly sensitive acoustic sensors are placed at intervals on the pipe. These listen to the sound made by the leak. The data is transmitted wirelessly from 'outstation units' to a handheld 'base unit', which processes the information to identify the leak sound, and then applies mathematical algorithms to pinpoint the leak position.

This latest model retains all the key features of earlier Touch Pro systems and provides many new benefits which ensure greater operating flexibility and faster operating speed.

The Touch Pro system is fully menu driven and is operated by touch screen, making it much easier to input data and also maximising the visible screen area to display results more clearly than has ever been possible before.

The Touch Pro has sensitive transducers built into its sensor. This enables it to perform well even in traditionally difficult conditions, such as on plastic and large diameter pipes. This can be further extended with the use of the Hydrophone-2 sensor option.

The Touch Pro features a high visibility full colour VGA touch screen to greatly improve data entry and the quality of data presentation. The touch-sensitive user interface eases and simplifies leak-finding without compromising on functionality or precision and enables the unit to be operated with the minimum number of key presses. The large screen, with anti-glare screen protection, clearly displays correlation results and supportive information even in bright sunshine, effectively combining outstanding performance with excellent ease of use.

The system is equipped with an innovative multi-filter correlation option which can simultaneously perform three correlations at different filter settings. This is particularly useful when the pipe material is uncertain.

The outstation is compact with high-quality long-range radio transmission; it also features a magnet to secure onto metallic street furniture.

The purpose designed robust case not only carries and protects all components but charges them via mains or vehicle supply. The charge level for all items can be shown at the touch of a button.

2.2 THE CORRELATION PRINCIPLE

The prime function of the sophisticated correlator built into Touch Pro is to measure the time difference between the leak noise signals arriving at each sensor. Touch Pro determines the leak position by relating this difference in propagation (travel) time to the velocity of sound along the pipe and to the measured distance (pipe length) between the sensors.

In the "classic" correlation process, two sensors are deployed on pipe fittings.

“Dry” connections require one type of sensor; these are attached to the outside of pipes or fittings. “Wet” connections require a different type of sensor; these are in direct contact with the water; they are attached using a suitable fitting (e.g., a hydrant) which provides and access point to the water.

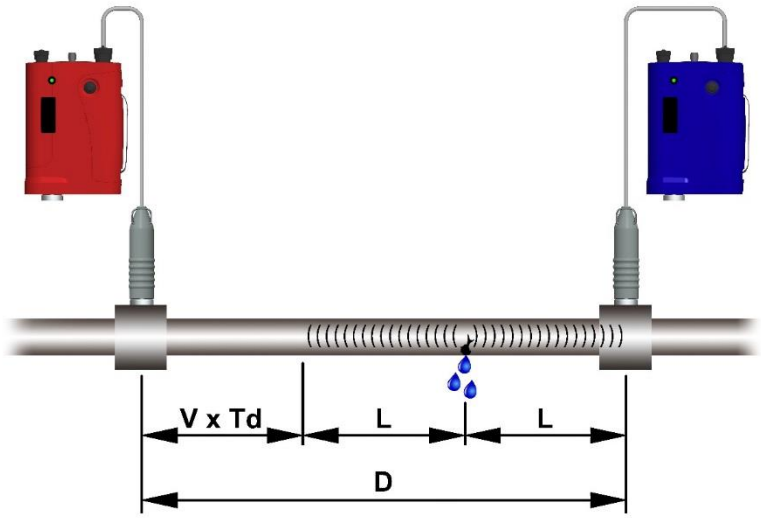
The sensors are positioned either side of the suspected leak position. Noise is created as pressurised water escapes from the pipe through the leak.

This noise is conducted in both directions away from the leak through the pipe wall (as minute vibrations). It is also conducted through the water column (as a pressure wave).

The leak noise travels at a constant velocity (V), which depends on the material and diameter of the pipe. It arrives first at the sensor nearer the leak.

The sounds arriving at each sensor are compared. The time difference (Td) between the two sound arrival times, combined with knowledge of the sound velocity, which is provided by the pipe type and length, allows the leak position to be calculated by the correlator.

The principle of correlation can be defined by: L = ½ (D - (V x Td)) and is shown graphically below:



Further details of correlation can be found in section 14.

2.3 System Overview

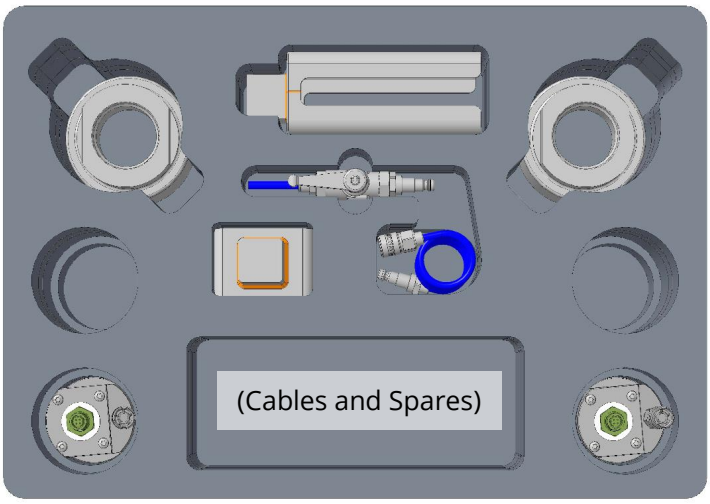
Touch Pro is generally supplied in the following basic kit form, which is the minimum system configuration specified for effective leak location operations:

- One Touch Pro Base Unit
- Two Accelerometer Sensors with protective shrouds and leads
- Two Outstations (Red and Blue)
- Headphones
- Carry case

The carry case enables in-case charging of all components from a mains or a 12V vehicle supply.
It also includes the facility to indicate the status of charge for all components.

The Touch Pro TM system adds:

- Two Hydrophone 2 type sensors
- Cables for connection of Hydrophone 2
- Bleed valve accessory kit.
- Adaptor Options and tools (These must first be discussed with your HWM representative, to confirm availability. Adaptors required vary according to local needs).
- Consumable items (various)



The additional equipment is usually supplied within an additional carry-case.
(Note: Contents and layout may vary according to kit supplied).

In addition, the following optional extras are available:

- Vehicle Mounted Aerials
- Hydrophone 2 Sensor installation tool
- Soft Carry Case
- 12V Vehicle Supply Cable
- Mains Charge Cable
- Consumable items (various)

A standard Touch Pro system can be upgraded to the Touch Pro TM system by the purchase of the additional Hydrophone-2 kit and other items. Discuss any upgrade requirements with your HWM representative.

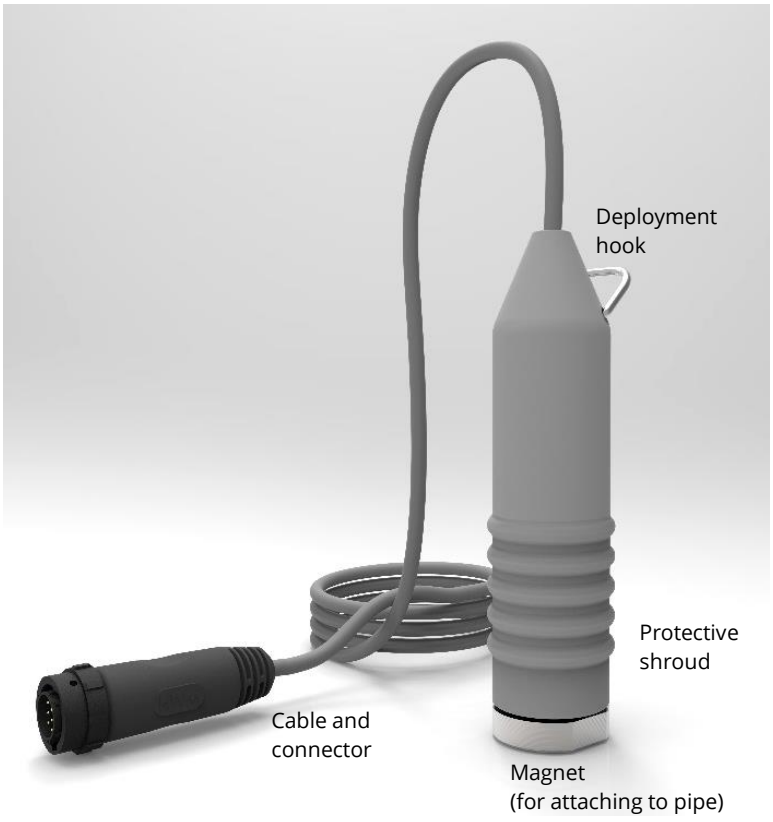
2.3.1 Accelerometer sensors

Accelerometers are suitable for a very wide range of leak detection operations on pipes or fittings.

The two accelerometer sensors supplied with the Touch Pro system detect the noise signals travelling along the body of the pipe from the leak point.
These signals are then fed into the correlator unit for measurement and analysis.

An accelerometer is positioned on either end of the pipe work under investigation and connected either to an outstation or directly to the base unit.

The normal operation is to have two outstations (red and blue) operating remotely and linked via radio to the base unit.



The radio inside each outstation, which transmits data to the base unit automatically, switches on whenever a sensor is connected. The radio frequencies used by the outstations are matched to the frequencies used by the base unit. To ensure correct operation, do not mix equipment from different kits.

Caution: Operators should note that **all sensors can be damaged** by sudden shock impact and should be handled with care.
Do not drop sensors onto the ground and ensure they do not bang

against the pipeline during fitting or removal.
Ensure the connectors of the sensors and other equipment are kept clean, dry, and free of debris.
Do not clean the connectors with water-based cleaning fluids.

2.3.2 Hydrophone-2 sensors

The Hydrophone sensors are suitable for leak detection operations where the sensor can be mounted onto a fitting that provides access to the water column; the sensor must be in direct contact with the pressurised water.

The two Hydrophone-2 sensors supplied with the Touch Pro TM system detect the noise signals travelling within the water column itself, from the leak point. These signals are then fed into the correlator unit for measurement and analysis.

A Hydrophone is positioned on either end of the pipe work under investigation and connected either to an outstation or directly to the base unit.

The normal operation is to have two outstations (red and blue) operating remotely and linked via radio to the base unit.

Thread
(for attaching to a water access point).
Note: Thread adaptor(s) may also be required.

The radio inside each outstation, which transmits data to the base unit automatically, switches on whenever a sensor is connected. The radio frequencies used by the outstations are matched to the frequencies used by the base unit. To ensure correct operation, do not mix equipment from different kits.

Caution: Operators should note that **all sensors can be damaged** by sudden shock impact and should be handled with care.
Do not drop sensors onto the ground and ensure they do not bang against the pipeline during fitting or removal.
Ensure the connectors of the sensors and other equipment are kept clean, dry, and free of debris.
Do not clean the connectors with water-based cleaning fluids.
Do not damage threads and seals of the unit ; return to the carry-case when not in use in order to protect them.

Note: Current systems are supplied with the Hydrophone-2 version, shown above.
Earlier systems may have been supplied with Hydrophone (1).
(Refer to the note within section 2.7 for further information on Hydrophone (1)).

2.3.3 Base Unit

Touch Pro is a totally self-contained electronic unit which performs the leak noise correlation calculations accurately and very quickly. The system features a MS Windows-CE embedded software driven operating system with several intuitive menus, which guide and prompt the operator throughout all data input and processing phases.

The system is designed primarily for rapid Leak Position and Velocity Measurement operations, but it also incorporates excellent Listening mode and Surveying mode facilities.

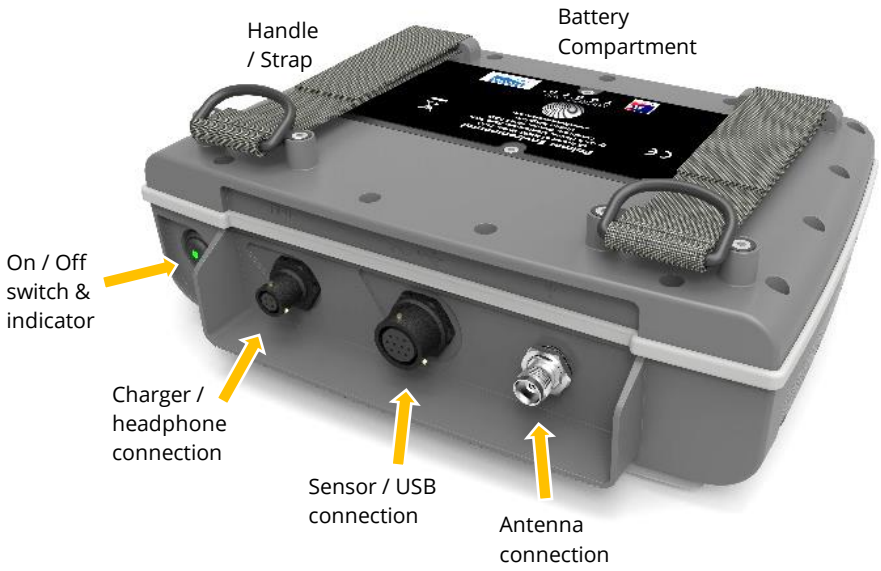
The intuitive menu driven touch screen enables the operator to navigate the set-up procedure by simply tapping the appropriate virtual buttons on the high visibility full colour VGA display screen.

A range of language options are selectable via the menu screen.

A key feature of Touch Pro is its Windows compatible software and USB to PC software-enabled printing.

The Touch Pro base unit can be connected to a personal computer via the USB port. Windows will recognize the unit when it is connected and will display a folder containing all data files without the need for any external software. This enables easy navigation of the data via the PC.

The required cable for USB connection is CABA7605 (CA-068-0008).



2.3.4 Outstations

Touch Pro is supplied with two outstations which are coded 'Red' and 'Blue' for ease of identification during operations.

They are identical in operation (but with different transmission frequencies - each matched to its appropriate receiver built into the Touch Pro Base Unit).

The basic Touch Pro kit includes a Red outstation which is connected to the remote sensor.
The outstation captures the leak noise from the sensor and transmits the signals at U.H.F. to the Base Unit.

The addition of the optional Blue outstation with a secondary radio link provides greater operational flexibility and speeds up many aspects of on-site work.

Radio links also increase operator safety by allowing the sensors to be deployed remotely in busy streets or other work areas with heavy traffic flows.

A base magnet at the bottom of each outstation allows the unit to be securely held in an upright position on metallic street furniture during use.

The outstations are powered by a lithium-ion battery. The battery is recharged within the outstation. The charging may be done in either the Touch Pro carry case (using the cable harness), or with a supplied power lead, or 12V supply cable.

With both sensors plugged into outstations the Touch Pro base unit can be located anywhere within radio signal range or mounted in a vehicle for fully mobile operations.

The sensor connection on the outstation can either be used with two different sensor types – an accelerometer (default) or a Hydrophone (e.g., Hydrophone-2 ; The unit is also compatible with the Hydrophone version 1).

2.3.5 Headphones

The Touch Pro operator monitors the noise from the sensors with stereo headphones. These can confirm instantly that the sensor pick up and signal transmission part of the system is functioning correctly. This important procedure also enables experienced operators to determine if the leak signals are suitable for effective correlation and to check for the presence of background interference in the pipework under test.

The studio quality stereo headphones supplied have earpieces labelled 'Right' and 'Left' and should be worn accordingly for effective operations. Headphones are supplied to enable the user to listen to the leak noise either from red, blue or both outstations. The Base Unit gives the operator full control over the source into the headphones.

The headphones can also be plugged directly into each outstation connected to a remote sensor on the pipe to monitor a monaural signal. This technique aids sensor installation and set up by allowing the operator to confirm leak noise and interference levels quickly at each sensor position before completing the correlation.

HWM-Water Ltd supplies an optional choice of quality headphones which include the following (or similar) models:

David Clark Model 10S-DC 	**David Clark Model 10S-DC (Optional)** Stereo Noise Attenuating Headset. Newest Undercut, Comfort Gel Ear Seals. Double-Foam Head pad. Dual volume controls. Lightweight, 5ft. straight cord. Earphone elements are hi-fidelity, dynamic with a range of 10-20,000 Hz. NRR 23dB.
Fame Headphones 	**Fame Headphones (Standard)** Spatial sound image. Outstanding wearing comfort for long listening sessions. Excellent attenuation of ambient noise. Ear cup is rotatable for one-ear listening. Convenient protective pouch included. Extremely rugged. Single-sided coiled cable, detachable. Comfortable headband and ear pads.

2.3.6 Charging case

The Touch Pro carry case enables all components to be stored and charged simultaneously (FIG A).

A single recessed charging connector on the side of the case charges the two outstations and the base unit when they are in storage. A display panel inside the charging case (FIG B) enables the operator to view the charging status of each component at the touch of a button without needing to remove them from the case.

In-case charging can take place through mains power (using the supplied mains adapter) or a 12V vehicle supply.

FIG A

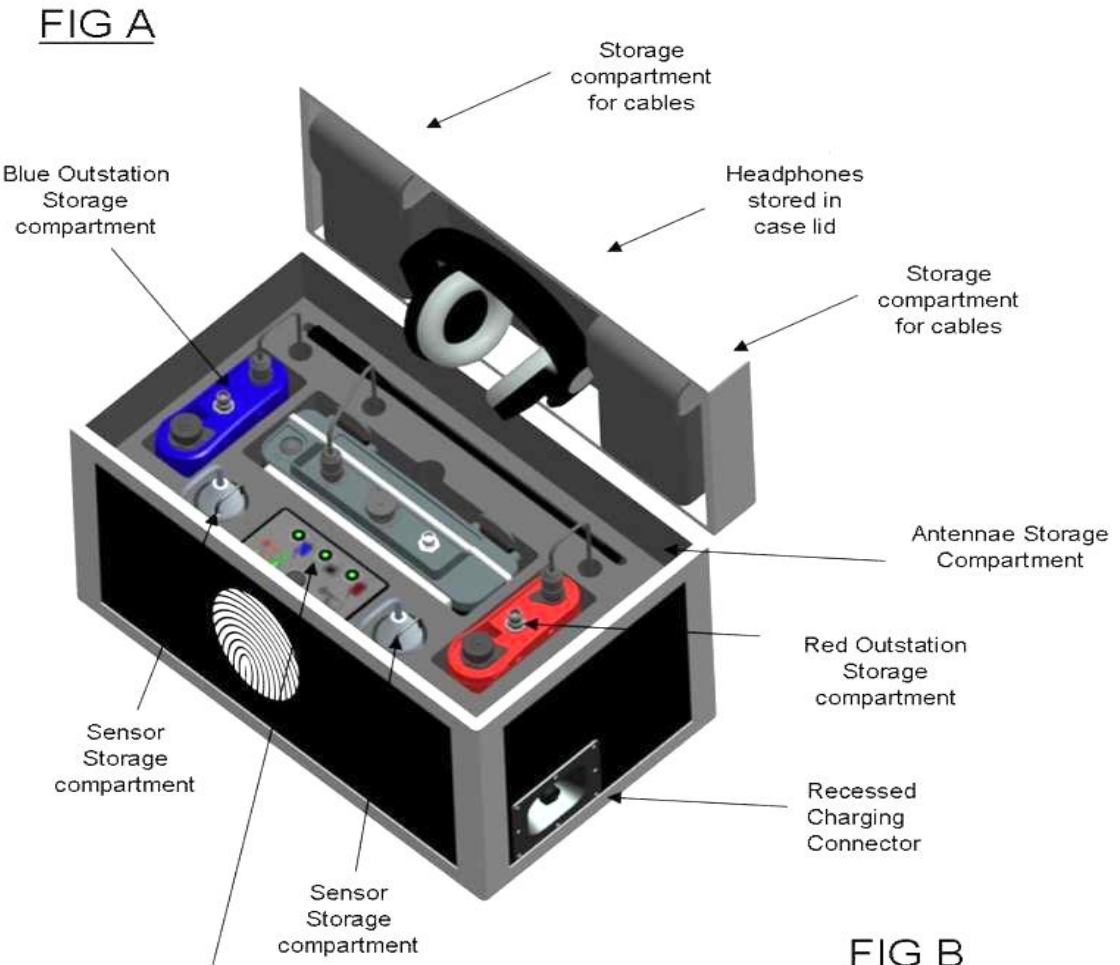
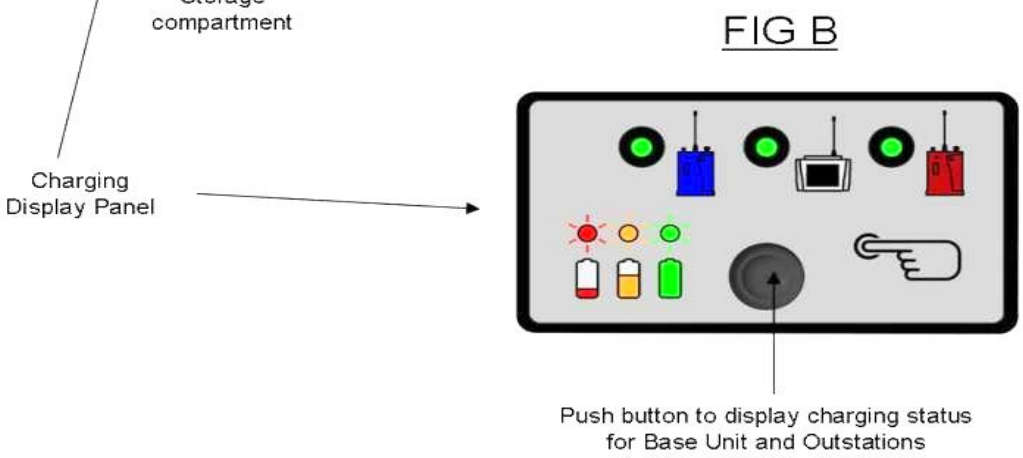


FIG B



The internal battery of the Touch Pro system will run continuously for approximately eight hours without re-charging.

The system draws very little current and can also be operated from a vehicle's 12-volt battery for long-term site operations.

The lithium-ion rechargeable batteries employed are interchangeable with those of the outstations.

Units can be stowed with accelerometer type sensors still connected for fast deployment.

The battery display panel inside the case (FIG B) is used to show the battery status of each connected outstation and base units without having to physically switch on each unit.

An LED displays the battery status of each individual unit connected. To operate, simply push the button to activate the LEDs. The LED colour displayed will either be green, amber, or red to show the battery level for each unit connected. The LED will remain lit for 5 seconds after the button is pressed before switching off. Any LED that does not light when the push button is pressed indicates that individual unit is not connected or faulty.

12-volt power cable

When the charging adapter is connected, any unit connected to the case charger will be charged. Units may be disconnected or re-connected to the case charger whilst charging at any time. Whilst each unit is charging, an LED on that unit will slowly flash green. When charging is completed, the LED will stop flashing.

Pushing the button whilst charging to display the battery status will temporarily stop the charging in order to allow an accurate reading to be taken. When the 5 seconds has expired the lights on the display panel will switch off and charging will resume automatically.

When the charging adapter is initially connected to the connector on the outside of the case, the LEDs will light to show the battery levels of the connected units. After 5 seconds the lights will switch off and the charging will begin. This automatic process can be used to check that the units have been connected to the charger successfully and will charge when power is applied.

2.4 OPTIONAL EQUIPMENT

HWM-Water Ltd can provide the following optional equipment which expands the overall capability of Touch Pro even further and improves operating flexibility in difficult situations.

2.4.1 Vehicle mounted aerials

An extension aerial is required for effective receiver operation when Touch Pro is mounted in a vehicle and operating over extended ranges.

The standard Touch Pro receiver aerial is simply unscrewed, and the coaxial cable of the extension aerial is connected instead. The extension aerial has a magnetic base for fixing to the vehicle's roof. Alternatively mounts for non-ferrous roofs are available.

2.4.2 Hydrophone-2 (sensor kit)

Hydrophones are available as optional equipment (or included in Touch Pro TM systems).

Because accelerometers are attached to the external surfaces of pipe systems, weak noise signals may sometimes be degraded by mechanical filtering or high background interference effects. In these instances, and if suitable pipe fittings are available, Hydrophone sensors can be used instead of accelerometers. Hydrophones may provide better leak noise signals in difficult operating conditions.

If two suitable pipe fittings are not available, operators may use one hydrophone and one accelerometer. It should be noted, however, that this technique is not generally recommended because the although the hydrophone has a greater sensitivity and working range, the system as a whole will be restricted by the accelerometer sensor performance.

Hydrophone sensors are mounted for direct contact with the water at hydrant, air valve or flowmeter points. The Hydrophone may have to use adaptor(s) to convert to the thread appropriate for the fitting it is being connected to. A selection of adapters for various pipe fittings is available from HWM; discuss your requirements with your HWM representative for further details.

Leak noise propagates very efficiently along the water core, which gives hydrophones a greater working range than the accelerometer type sensors. Hydrophones are also far more sensitive to low pressure waves (signals) and they are particularly effective in locating leaks in large diameter trunk lines.

Hydrophones generally give good results in all types of plastic pipe systems and the signal information from hydrophones often increases operator confidence where any soft or non-metallic pipe materials are encountered.

2.4.3 Hydrophone Thread adapters

When the Touch Pro used with a Hydrophone-2, thread adaptors may be required to attach the sensor to the water network.

Thread adapters available for Hydrophone-2 include:

- Hydrophone-2 to London Round Thread adapter.
- Hydrophone-2 to Belfast adapter.
- Hydrophone-2 to Euro adapter.

For information on the availability of other adapters, please discuss with your HWM representative.

2.5 OPERATING RANGES (ACCELEROMETER & HYDROPHONE)

Using hydrophones, the operating range between outstations can be very high particularly during a quiet period of the day. For example, distances over 4km of 4" iron can be achieved from leak to sensor.

Note: Increasing the operating distance always decreases the chance of correlating successfully. Radio power may also be a limiting factor at extreme distances.

Actual operating ranges are influenced by a number of variables. The results will vary, being dependent, for example, on:

- pipe wall thickness,
- ground conditions,
- size and shape of the leak,
- background noise and other noises in the pipe system.

Successful correlation distances in excess of 2,000 meters have been achieved on 8" PVC pipe using hydrophones.

The following table gives a general indication of maximum working distances.
It is stressed that the actual range achieved may be better or worse than indicated depending on the site conditions.

General reliable maximum Pipe Materials working distances for pressures above 2 Bar:

Urban Network		
Pipe Material	**Accelerometers**	**Hydrophones**
Iron, Steel, Copper	400 metres	800 - 1200 metres
Lead, A/C, Concrete	300 metres	600 - 800 metres
Plastic	50 - 100 metres	400 - 500 metres

Trunk Mains		
Pipe Material	**Accelerometers**	**Hydrophones**
Iron, Steel	500 - 800 metres	2000 - 3000 + metres
A/C, Concrete	400 - 600 metres	1000 - 2500 + metres
Plastic	100 - 200 metres	500 - 1500 + metres

2.6 Installation of Accelerometer Sensor

The accelerometer makes a dry connection with the pipe network. (i.e., There is no contact with the water column). The sensor has a strong magnet that will enable it to remain in position on steel/iron fittings.

The magnetic sensor must ideally be mounted vertically on top of the water pipe or tap where possible. Mounting the sensor horizontally, on the side of the tap, may affect the sensor sensitivity.

Prior to fitting the sensor, the surface should be prepared by cleaning with a wire brush to ensure any dirt, debris, or corrosion is removed. This allows the sensor and magnet to make good contact with the water pipe.

Ensure sufficient slack is in the cable to avoid disturbing the sensor position when other equipment is moves around during use.

2.7 INSTALLATION OF HYDROPHONE SENSOR

The Hydrophone 2 makes a wet connection with the water pipe network (i.e., The sensor is in direct contact with the water column).

(The picture opposite shows Hydrophone 2 being used without any adaptor within a thread-compatible boundary box).

Where the thread of the Hydrophone 2 is unsuitable for the fitting, adaptors (1 stage or multi-stage) will be required to match the thread to the fitting.

(The picture opposite shows Hydrophone 2 with a single-stage London Round Thread adaptor, being installed on fire hydrant).

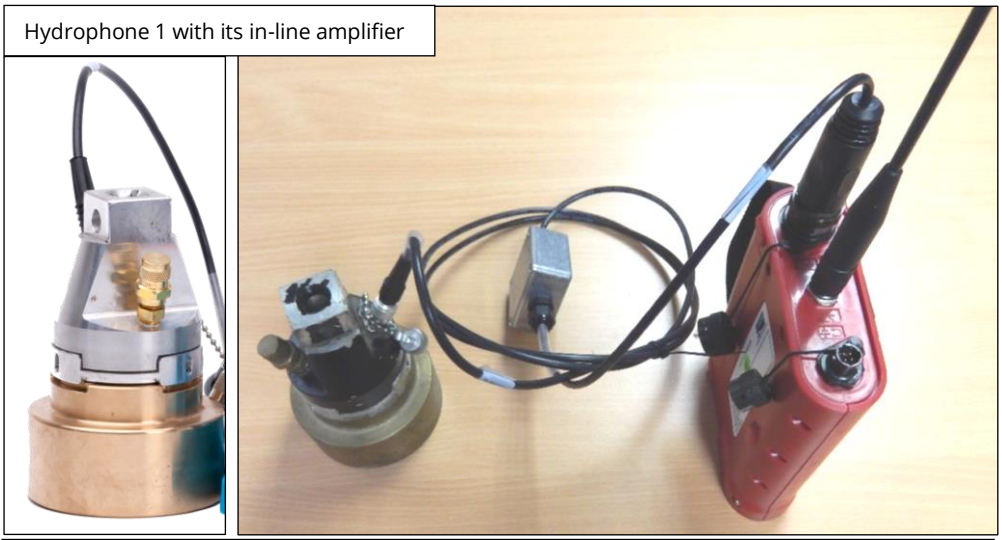
Further details of connection of the Hydrophone 2 to a fitting, including safety precautions, can be found within the Hydrophone 2 User-guide (MAN-165-0001).

Be sure to follow any additional measures for safety and hygiene required by your company or safety officer.

Note: When fitting the Hydrophone-2 horizontally (e.g., to a Fire hydrant with side connections), try to ensure that the bleed hole is at the top when fitted. This will allow effective removal of trapped air when bleeding the air from the water column after fitting and turning on the water feed to the hydrant outlets.

Note: Hydrophone 2 is an updated version of an earlier Hydrophone sensor design from HWM, now known as Hydrophone 1.
The earlier version has different electrical and mechanical connections.
It required different cables and an in-line amplifier box (see pictures below).

Hydrophone 1 with its in-line amplifier



(Outstation and thread adaptor also shown in this picture ; these are additional items).

Adaptors for the earlier version of the Hydrophone are not compatible with the Hydrophone 2 unit. (An adapter would be required).

For details of the earlier version of Hydrophone, including adapters and how

To connect it to a fitting, refer to the earlier version (issue 'K') of this user-guide, (i.e., MAN-068-0001-K).

Whilst its construction and installation are different, use of Hydrophone-1 with the Touch Pro system is identical to Hydrophone-2.

2.8 THE HYDROPHONE 2 KIT (HYDROPHONE PAIR AND CARRY-CASE)

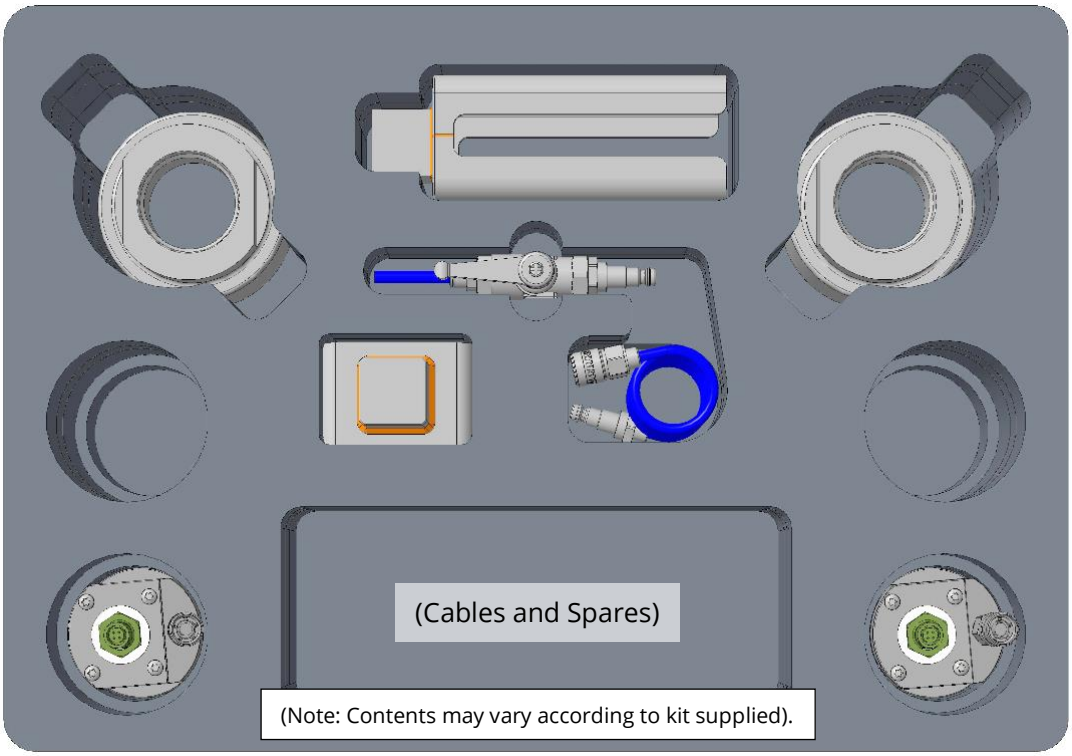
The Hydrophone 2 kit is an upgrade option for HWM correlator systems ; these are normally supplied with just a pair of accelerometer type sensors (with a magnetic base coupling). However, certain correlator systems (e.g., the Touch Pro TM) also include the Hydrophone kit as standard.

The Hydrophone 2 kit for Touch Pro typically comprises:

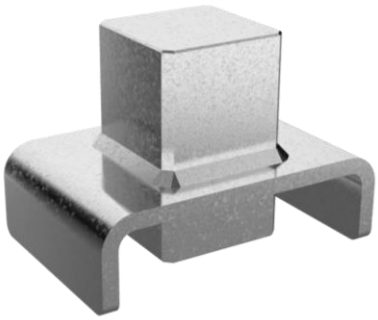
- 1 x carry case
- 2 x Hydrophones
- 2 x Hydrophone to correlator connection cable
- 1 x Hydrophone fitting tool ; 1 x adaptor fitting tool.
  (The tools are for use with a 1.25” square hydrant key).
- Consumable items (e.g., Silicone grease, PTFE tape)
- Spares (e.g., O-rings / gaskets)
- (optional) 2 x Hydrophone to Hydrant adapters / other valve adapters.
  (Depending on your local needs / discussion with your HWM representative).
  Note: May be supplied as a single-stage or a multi-stage adaptor.

Refer to section 2.7 for additional details.

A plastic case is supplied, with foam cut-outs that can securely and safely store the pair of Hydrophone 2 sensors and accessory equipment. There are compartments for some couplers, a bleed kit, cables, a fitting tool, and spares / consumables.



A fitting tool is available to assist in tightening and releasing certain adaptors that are required to be fitted first in order to make the valve thread compatible with Hydrophone 2.



A fitting tool is available to assist in tightening and releasing the Hydrophone.

It adapts a 1-1/4 inch square peg (suitable for a 1-1/4 inch hydrant key) to a 50mm wide U-shaped end (suitable for engaging with the Hydrophone 2 body).

When using the tool, ensure it is correctly positioned (as shown) so that it does not cause damage to the Hydrophone-2 connectors or bleed valve or any attached cables.

3 EQUIPMENT: CONNECTORS, CONTROLS, INDICATORS, DEPLOYMENT

This section covers Touch Pro operating procedures and describes the functions and effects of the various keys and controls.

Important: Always press the keys on the touch screen with a touch screen stylus or using fingernails. Do not use sharp objects.

The Touch Pro features an intuitive user interface designed to perform accurate correlation with the minimum number of key presses. In this manual, we will show you some of the key screens that will be used during a correlation.

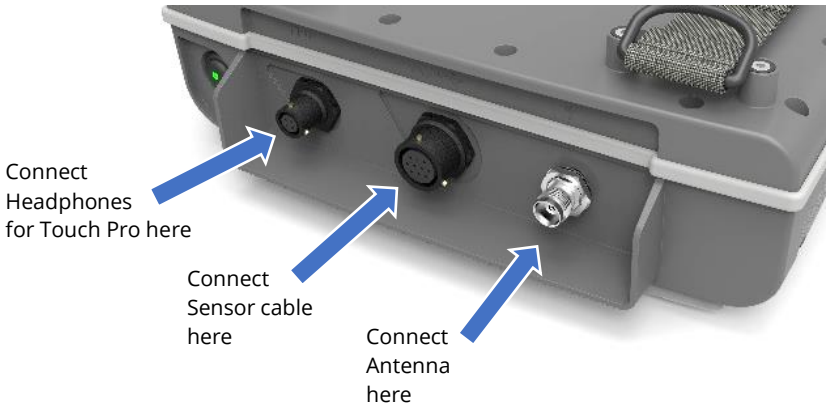
Prior to commencing use, ensure batteries have been charged and correctly installed in the base unit and outstation units (refer to section 1.4).

All connectors should be kept dry and free of dirt and debris at all times.

3.1 BASE UNIT – CONNECTING UP AND SWITCHING ON

Once the batteries have been installed and charged in the Base Unit:

- Connect the antenna to the connector shown.
- If the base unit is being used with a sensor, connect the sensor (via its cable) to the connector shown.
- The wired headphones option can also be connected, whenever required.

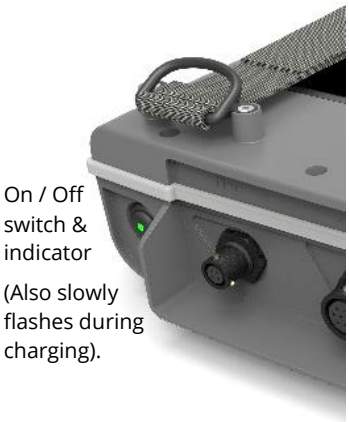


The Base unit may now be switched on. The position of the On/Off power is shown opposite.
(Prior to switching on, confirm the antenna is connected).

Switch the Base Unit on by pressing the On / Off button for at least 2 seconds.

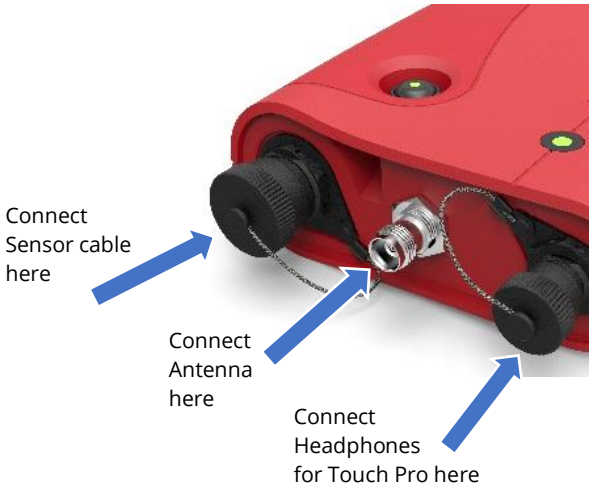
A number of system tests and calibrations are carried out on power up to ensure the unit is fully functional. After a few seconds the main Correlation screen will appear on the display.

Note: If the sensors being used have swapped between accelerometer and hydrophone, be sure to also change the setting in the Base unit when in use (see section 7.1).



3.2 OUTSTATION UNITS

3.2.1 Connecting up



Once the batteries have been installed and charged in the Outstations:

- Connect the antenna to the connector shown.
- Connect the sensor (via its cable) to the connector shown.
- The wired headphones option can be connected to the connector shown (if required).

3.2.2 Switching on / Setting the Transmit Power

The position of the On/Off power is shown opposite.
(Prior to switching on, confirm the antenna is connected).

An outstation can be **switched on** by pressing the On/Off button for at least 2 seconds. (Transmit power is high).

To set the outstation **transmit power** to **low**,
press the On/Off button a second time for at least 2 seconds.

To **switch off** the outstation, press the On/Off button for a third time for at least 2 seconds.

Note: If operating the Base Unit within 20m of an outstation, it is recommended that the Outstation is set to low transmit power, to ensure that the more distant Outstation radio signal is received.
If both outstations are closer than 20m to the base station, ensure that both are operating in low power mode.

3.2.3 Deployment

Ensure any safety precautions are in place prior to deployment or during use of the equipment (e.g., Protection from road traffic).

Prior to deployment of a sensor, it may be checked to confirm it is working, if desired.

To check that a sensor is working correctly, connect the headphones to the Outstation (or Base unit) and listen while running your finger over the sensor magnet (for an accelerometer type sensor), or gently tapping the sensor body with your finger (for a Hydrometer type sensor). A clear crisp noise should be heard.

Deploy each sensor on a water pipe fitting either side of the suspected leak position.

- To install accelerometer type sensors, follow the directions given in section 2.6.
- To install Hydrophone type sensors, follow the directions given in section 2.7.

When both sensors have been installed, the equipment should be powered up. Set the transmit power of the outstations according to their distance from the base unit. The equipment is now ready for use (see section 4.3 and subsequent sections).

3.2.4 LEDs – operation and meaning:

The Outstation incorporates a green LED in the On/Off button which indicates the transmit power level.

<u>LED within On/Off button:</u> (transmit power level)

- Green = Transmit power high.

- Off= Transmit power low.

Tri-colour LED

A separate tri-colour LED is also on the outstation, which produces short flashes when the unit is on, and simultaneously shows the battery charge level.

<u>Tri-colour LED:</u> (indicates battery level)

When the unit is on and functioning normally, the battery level LED flashes briefly once a second. To indicate the battery status the LED will change from Green to Yellow and Red.

- Green (short flash) = Unit on ; Battery OK.
- Yellow (short flash) = Unit on ; Battery is Mid-Level.
- Red (short flash) = Unit on ; Battery is Low.
- Green (long flash) = Unit being charged.

The LED will show green for most of its battery life and turn yellow when the battery is starting to run down. A Red flashing LED indicates the battery requires immediate charging.

HWM-Water Ltd recommends that no correlations are attempted when the outstation requires charging, as this may interfere with the quality of the correlation result.

When the outstation is initially connected to a sensor the LED should flash 10 times quickly. This indicates that the sensor has been registered, the radio has been switched on, and the relevant audio filters have been setup.

When charging voltage is applied to the outstation the battery level LED will begin flashing green to indicate charging. If the outstation is switched on, then it will automatically switch off when power is applied. When the battery is fully charged then the LED on the unit will switch off.

If the outstation is being charged whilst it is switched on the Tri-colour LED will flash 10 times faster than normal, and will only show green. When charging completes the LED will return to its normal flashing rate.

The case charger automatically stops charging temporarily when the case button is pressed.

4 BASE UNIT OPERATION

4.1 INTRODUCTION

The mechanical features of the base unit are described in sections 2.3.3 and 3.1. This section (and subsequent ones) deal with the operation of the base unit, driven by its touch-sensitive LCD screen. The base unit is also called "the console".

The console is driven mainly by means of buttons which appear on the screen. Occasionally the user will also have to tap on the graph area to set up parameters or drag edges to adjust.

There is a top-level screen, which we will refer to as the "main screen". Other screens can be reached from the main screen by pressing a sequence of buttons. This manual will sometimes show the sequence of buttons required as follows:

(Main screen) → Button1 → Button 2 … (substituting the description of Button1, 2, etc).

The basic principles of leak localisation by correlation were described in sections 2.2 and are further described in section 14. To position the leak, the base unit requires information about **distance** between sensors (following the path of the pipe network), the **speed** of sound within the pipe material, and the **time** difference between a leak sound reaching its two sensors.

The base employs a database which stores *the speed of sound* within various pipe types (differing pipe materials and diameters). It also allows the user to add to the database for up to 4 new pipe materials, or additional pipe diameters. It includes a useful tool to obtain the speed of sound from a pipe by experiment ; the user can enter the results into the definition of a custom pipe material if desired. The materials database can therefore be set up for new materials, or existing materials adjusted, via the console.

The pipe length is also required for the correlation process to localise the leak position. This information has to be entered by the user, who must first obtain it by the use of a map of the pipe network and a measuring wheel, or similar means.

The time difference between the leak sound reaching the two sensors is estimated by the unit by means of a considerable amount of calculations; these sometimes produce a set of results (likely positions and an estimate of a confidence level of the leak being

located at each of the positions). The user can investigate each position further (e.g., by using a ground microphone) before considering excavation and remedial works.

The correlator also includes a headset option for the user to listen to the sounds being picked up by the sensors ; this can often verify if the pipe includes sounds similar to a leak noise, or if some other type of repetitive noise source is present.

The pipe materials can distort various sounds, and other noises from moving water will be present. It can be helpful to remove some of the background noise when undergoing the correlation process. The base unit includes a comprehensive set of filter features to accomplish this. These can be tuned manually by expert users, or selection can be automated by the unit to find an appropriate filter.

The unit has the facility to store correlation results for examining later within the unit, using various “file” functions. The unit can also produce snapshots of the current graph and display the snapshot and live correlation results (by splitting the screen area).

4.2 LANGUAGE SELECTION

The base unit supports many languages, which can be selected by the user.
To select the language, use the screen:

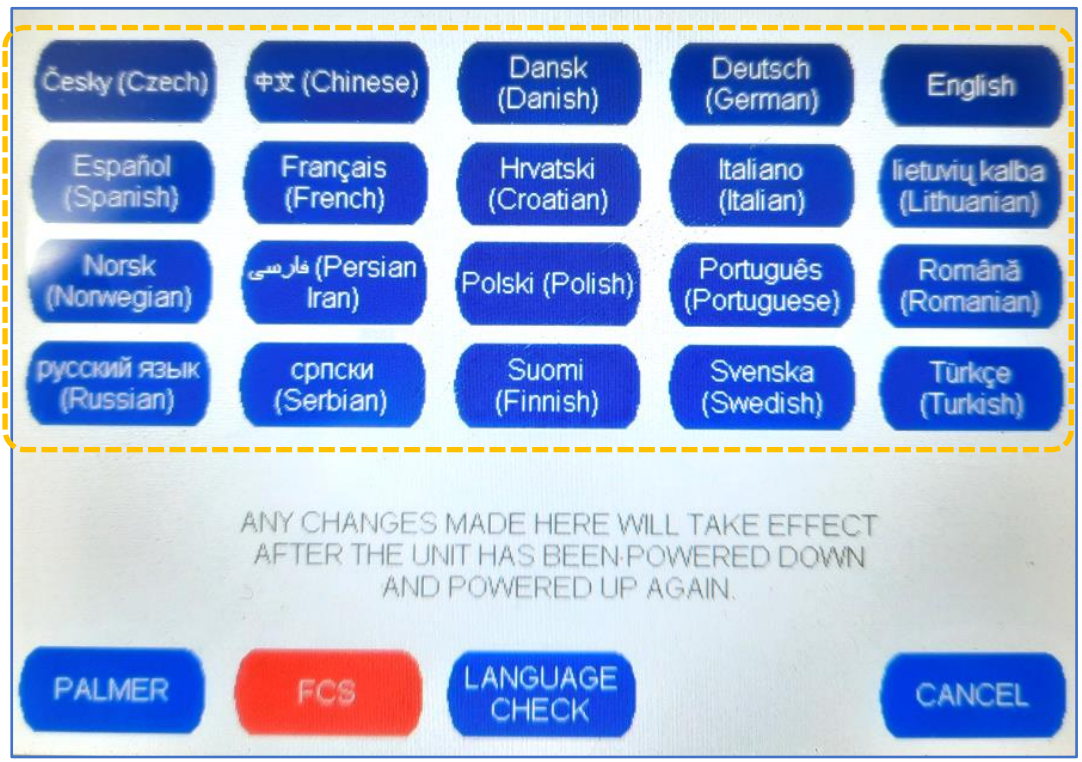
(Main screen) → Setup → Advanced → Set Language

The tap on your preferred language to select it.

The unit will appear to shut down but does not re-start on its own.

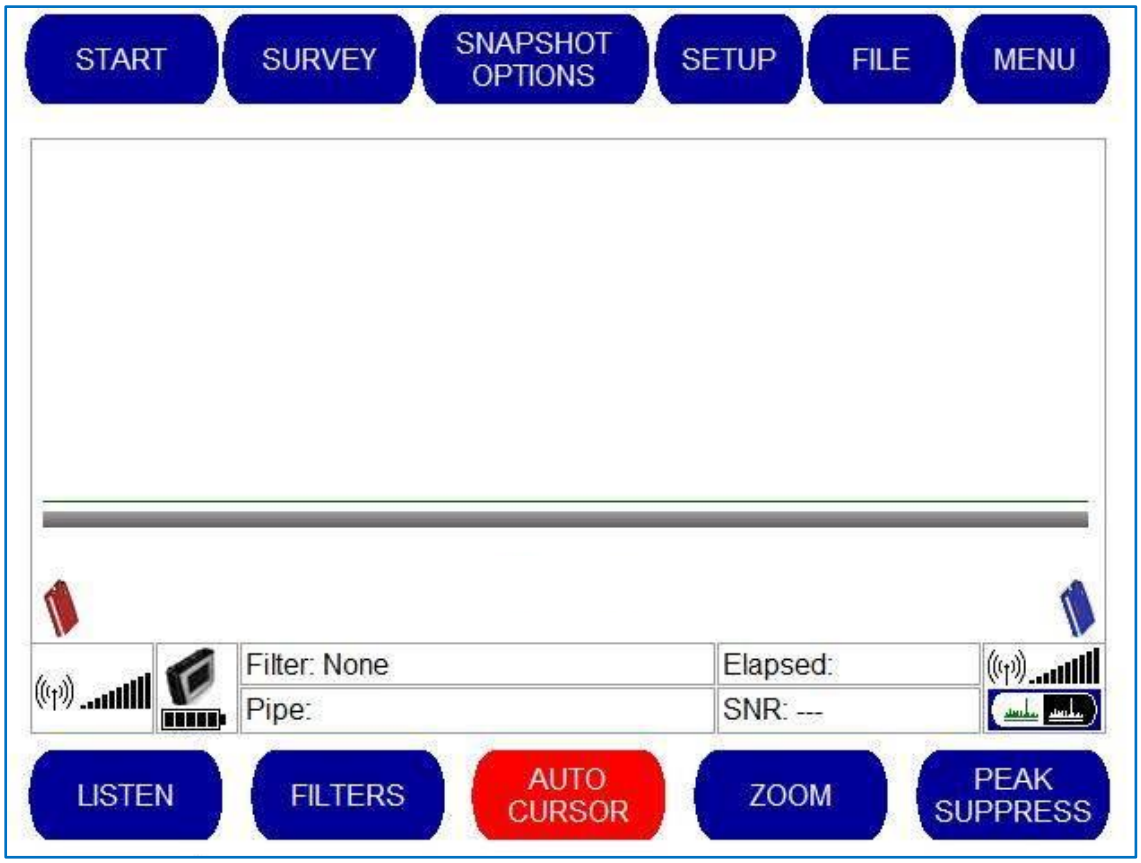
Power-down the unit using the push button. Then turn the unit back on.

The unit will change to use your chosen language.

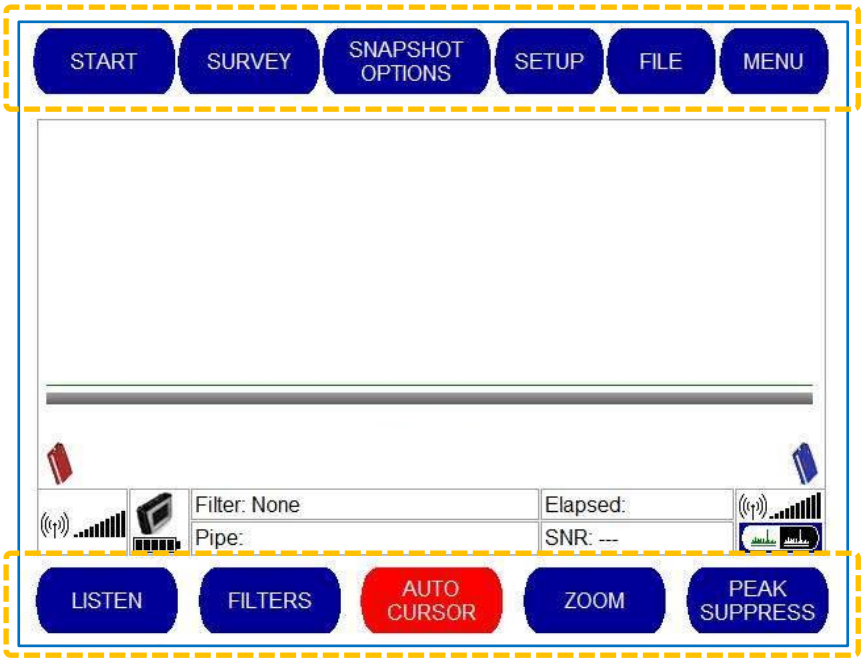


4.3 MAIN SCREEN (A QUICK TOUR)

After powering the unit, some initial splash screens are displayed, followed by the main screen (shown below). The main screen is the top of any menu selections.



The buttons at the top and bottom of the screen sometimes start operations; at other times they behave like a menu selection and lead to sub-menus.



A button's colour gives an indication of the availability of its function:

- A greyed-out button indicates the function is not currently selectable (usually incompatible with the current operation of the unit).

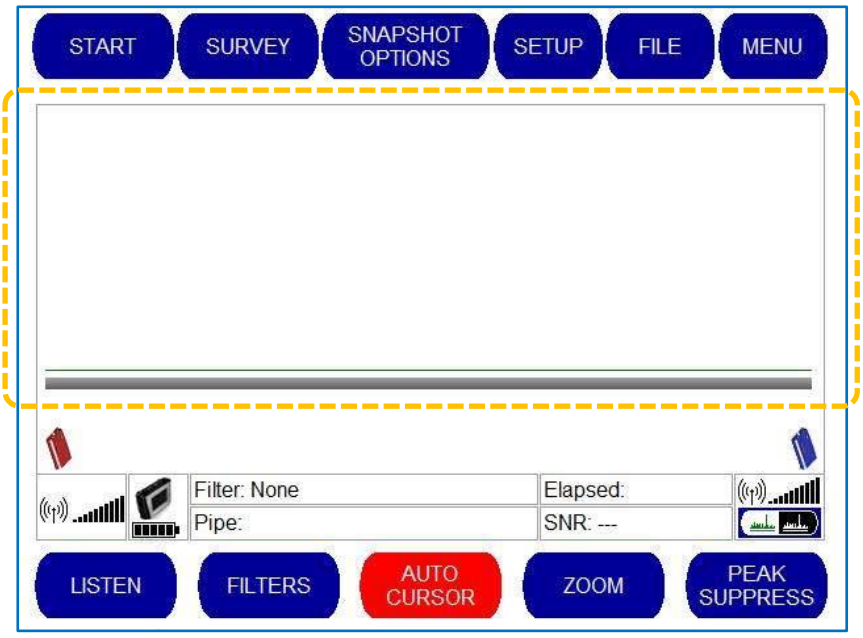
- A blue button indicates the function is available to be selected.

- A red button indicates that a feature has been selected, and that it is currently still active. (The feature can be de-activated by tapping the red button ; the feature can be toggled between being on or off).

- A red button can alternatively be used to indicate a current selection, where one of a group of similar options is available, but where only one can be active.
  Tapping an alternative selection will make the current selection inactive (its button returns to blue) and the new selection active (its button turns red).

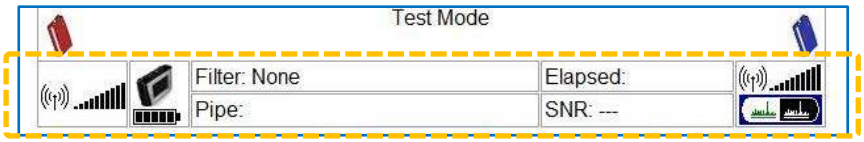
The center of the main screen (see dashed area, opposite) is used for displaying graphs.

Just below the graph area there is a thick line, which represents the pipe network between the 2 sensors.
The line also represents the total distance between the sensors (the sum of pipe sections, where a pipe is made of more than one section).



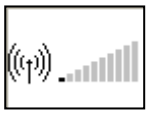
The outstation symbols (or a base symbol) that appear on the display are coloured to represent the red or blue outstations.

Below the red and blue outstation symbols there is an information panel.



The radio inside each outstation, which transmits data to the base unit automatically, switches on when a sensor is connected. The user can switch between high and low power transmission, as appropriate to its position relative to the base unit.

The signal bars below an outstation symbol shows the received radio signal strength from it, arriving at the base unit. Each bar indicates a higher signal strength.

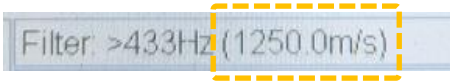


The battery level for the base unit is shown. Each bar indicates more charge.
When the battery level is critically low battery icon will turn red.
We advise that no correlations be performed when the battery charge is critically low as this can have an adverse result on the correlation result.

The additional data at the lower part of the screen is related to any correlation process, and is summarised as follows:

Filter: This reading shows the audio filter settings that have been used to obtain the correlation result.

It also shows the sound velocity chosen for the leak localisation.



Pipe: This reading shows the selected pipe material selection.

It also shows the total length of pipe that has been input for this correlation.

Elapsed: This displays the time that the unit has been correlating. The longer the correlation the more data is used to calculate the precise leak location.

SNR: The SNR figure (Signal to Noise Ratio, here shown as 4 : 1) displays the confidence in the highest peak.

- The unit provides a confidence factor by measuring the ratio between the highest peak and the next highest peak(s).

(The peak under consideration is first selected, with the selection being indicated by a dotted line).

- A high peak (i.e., an SNR of 20:1 or more) will be a strong clearly defined peak which equates to a good correlation.

A coloured light (large dot) is displayed next to the SNR result, indicating a judgement of the confidence for the correlation.

- A green light indicates that confidence is high.
- An amber light indicates that confidence is medium, will be shown when there is a less well-defined peak (e.g., an SNR figure of 8 : 1).
- A red light indicates that confidence is low on a result. This will be when there is no clearly define single peak (e.g., an SNR figure of 3 : 1).

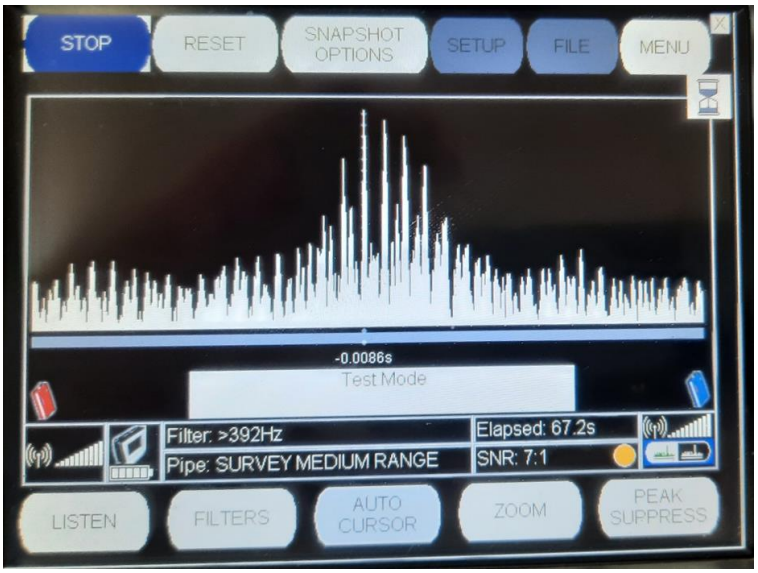
A SNR result of 99:1 indicates either a problem with the system or a failure to be able to correlate.

The Touch Pro can be switched between normal display colours and a high-contrast mode. The high contrast mode is useful when using Touch Pro in bright sunshine.

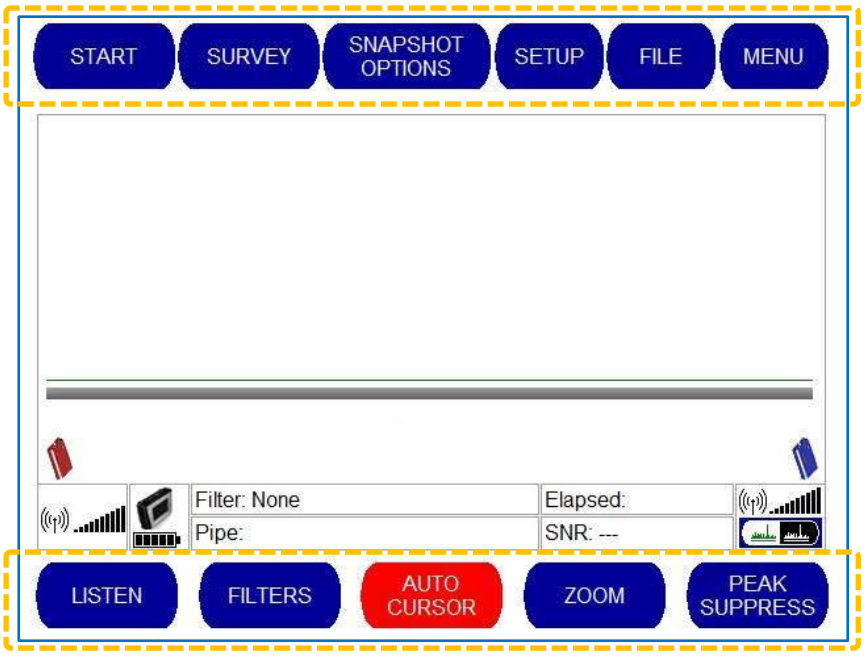
To switch between the two modes, tap on the High Contrast icon (shown opposite).

When in high-contrast mode, most of the colour is removed from the screen and a monochrome display is produced that is easier to view in direct sunlight.

Note: Certain parts of the image will remain displayed in colour when High Contrast mode is activated.
e.g., The icons for the red and blue outstations, the coloured light for indicating confidence in the SNR result.



There are buttons displayed on each of the screens the unit displays.



Whilst some buttons are common across most screens, the buttons can also vary according to the screen being viewed.

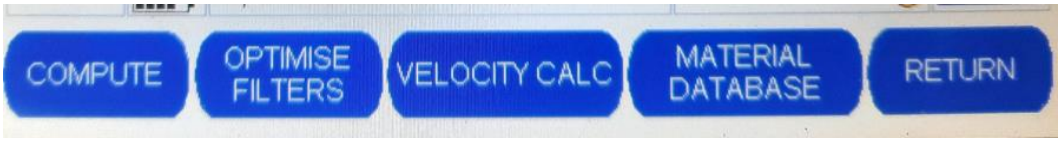
The various screens are organised in a hierarchical structure for navigation purposes.
Certain buttons will cause the unit to change to a lower-level screen. Certain other buttons cause the unit to exit the current screen and go up a level to the previous screen. The upwards navigation process ends at the top level, which is the main screen (as shown above).

Each button's text (and function) can potentially change during operation and when navigating through the screens ; the button use is re-assigned to be relevant to driving the unit, or to the next screen.
For example, "Start" (to start the correlation process in the above screen), will change to "Stop" (to pause the correlation process and allow the screen to stabilise).

To keep the number of buttons limited, to avoid cluttering up the display, certain buttons at the top of the main screen ('Menu' and 'Snapshot Options') will change the buttons shown at the bottom of the screen (without having to stop the current correlation process, if running).

Regular buttons:

Buttons when Menu is selected (red):



Buttons when Snapshot Options is selected (red):

Certain buttons on the top of the main screen are used to start sound processing by the correlator unit (alternatively, the unit could be paused from such activities).
(e.g. The 'Start' button or the 'Survey' button ; these are mutually exclusive selections of operation ; only one of these can be active at a given time).

START – This begins the correlation process. (See section 7).

SURVEY – This helps the user to identify whether there is a leak on the pipe. (See section 5).

Certain buttons on the top of the main screen ('Setup' and 'File') can only be used when there is no currently active sound processing.

SETUP – This enables the operator to change the configuration settings on the unit.
(See section 11 ; also discussed within various other sections).

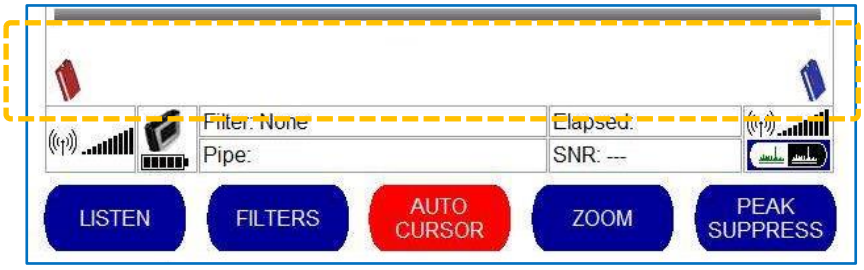
FILE – This allows you to save a correlation result or load a previously saved result. (See section 7.3).

These menu options (buttons) will be explained in more detail in the relevant section of this manual. Likewise, an explanation for the buttons on the lower part of the display will also be given.

4.4 SELECTION OF SENSOR INPUTS

The system can have up to three sensors connected; one at each of two outstations and one directly connected to the base unit. Correlation can only be between two units, so the inputs being used must be selected first.

The current selections are shown on the main display. (here it is the red and blue outstations).



(The base unit may alternatively be shown, if selected).

If the selection is not correct or the user wishes to change it, this can be done via the Setup screen.

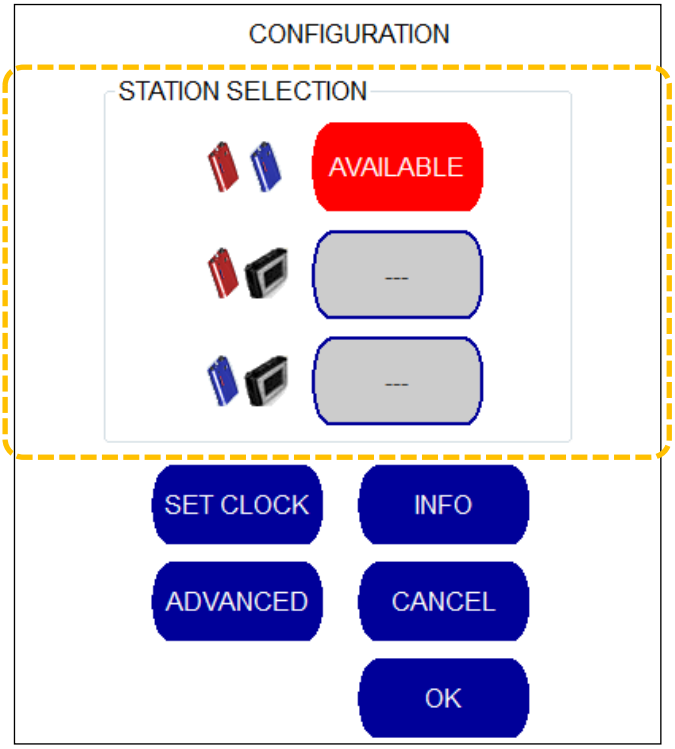
(Main screen) → Setup → (make choice on this screen).

The "Station Selection" panel contains buttons enabling you to specify which two units you are correlating between.

- Red and blue,
- Red and base station, or
- Blue and base station.

Tap on one of the buttons to select the station combination being used for configuration.

Then tap on the OK button ; you will return to the main screen.



5 SURVEY MODE (QUICKLY CHECK FOR LEAKS)

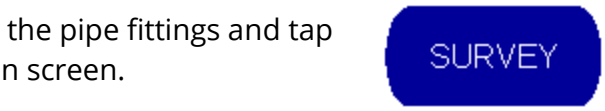
5.1 OPERATION

Survey Mode provides a simplified correlation display that enables you to check large distances rapidly for the presence of leaks. (No pipe material settings are required as all of the filters can be set to 'open').

The survey mode helps the user to identify whether there is a leak on the pipe ; it does not try to locate the leak.

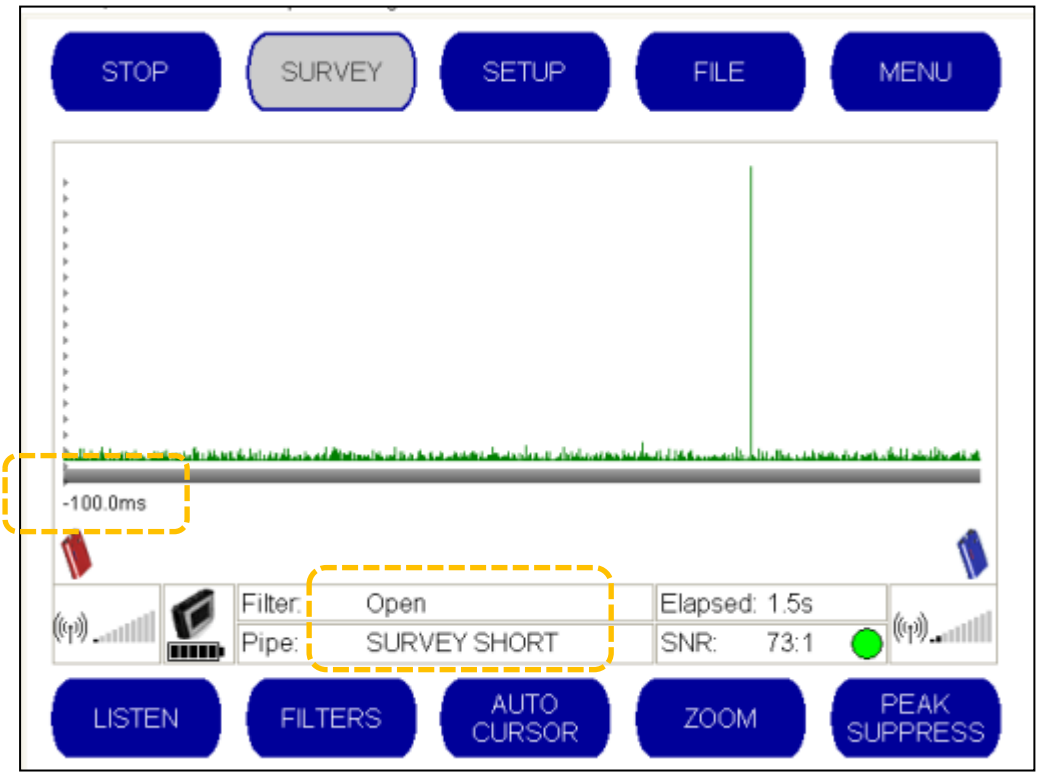
Accelerometers are the most practical signal sensors for quick operation and the distance between sensors should be kept reasonably short; generally, up to 400 metres for metal pipes and 50-60 meters for plastic is a good maximum for accelerometers in this mode of operation.

To activate the Survey mode, attach the sensors to the pipe fittings and tap on the 'Survey' button that is shown within the main screen.



Upon pressing the button, a graph appears.

If a distinct peak is shown on the graph this is an indication that a leak exists between the two sensors. The Sound to Noise ratio (SNR) is displayed to indicate the unit's confidence in a leak having been identified.



No distance information is provided, but the graph but a timespan is. This corresponds to a selection shown in the 'Pipe' information box.

The 'Filter' information box also contains a selection (here set to 'Open').

5.2 Settings for Survey Mode (range and filters)

There are two settings for survey mode:

- Range selection (timespan required for the correlation software).
- Filter selection (to remove unwanted frequencies).

The settings can be made from the “Rapid Survey Configuration” screen, accessed as follows:

(Main screen) → Setup → Advanced → Survey Settings.

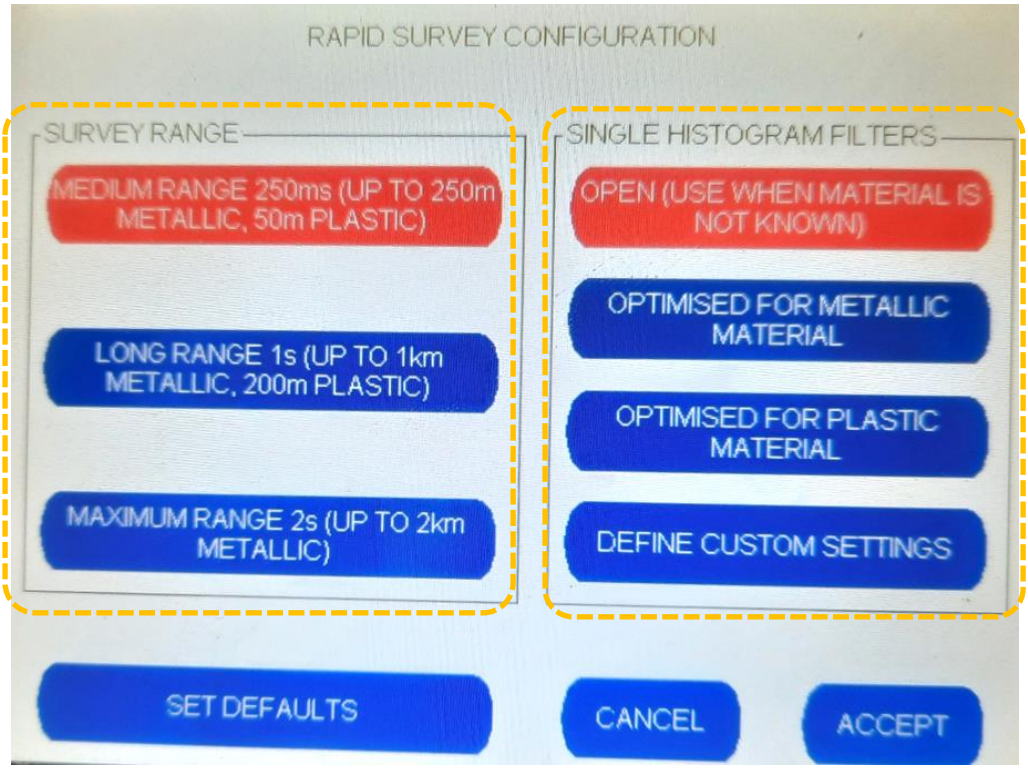
The “Rapid Survey Configuration” screen is displayed.

Current selections are shown in red. To change settings, first make your selection and then tap on Accept.

The ‘Survey Range’ panel selection determines the duration of the audio sample required by the correlation engine for various lengths of pipe materials.

(If in doubt about the pipe material, select the maximum range you may require).

Medium, Long and Maximum range settings can be selected.



The audio filter to be used can also be selected (within the ‘Single Histogram Filters’ panel). The filters used during sound processing can be optimised for metallic, plastic, or unknown pipe materials.

Expert users can define a custom audio filter setting using the ‘Define Custom settings’ button. This button uses the same custom filter settings screen as used for the correlation process. (Refer to section 7.2.5).

The operator has the option to return to pre-set filter defaults by selecting the “Set Defaults” button.

6 USING HEADPHONES

The operator can work with the correlator using the display only. However, the correlator console has a useful headphone output and is normally supplied with headphones.

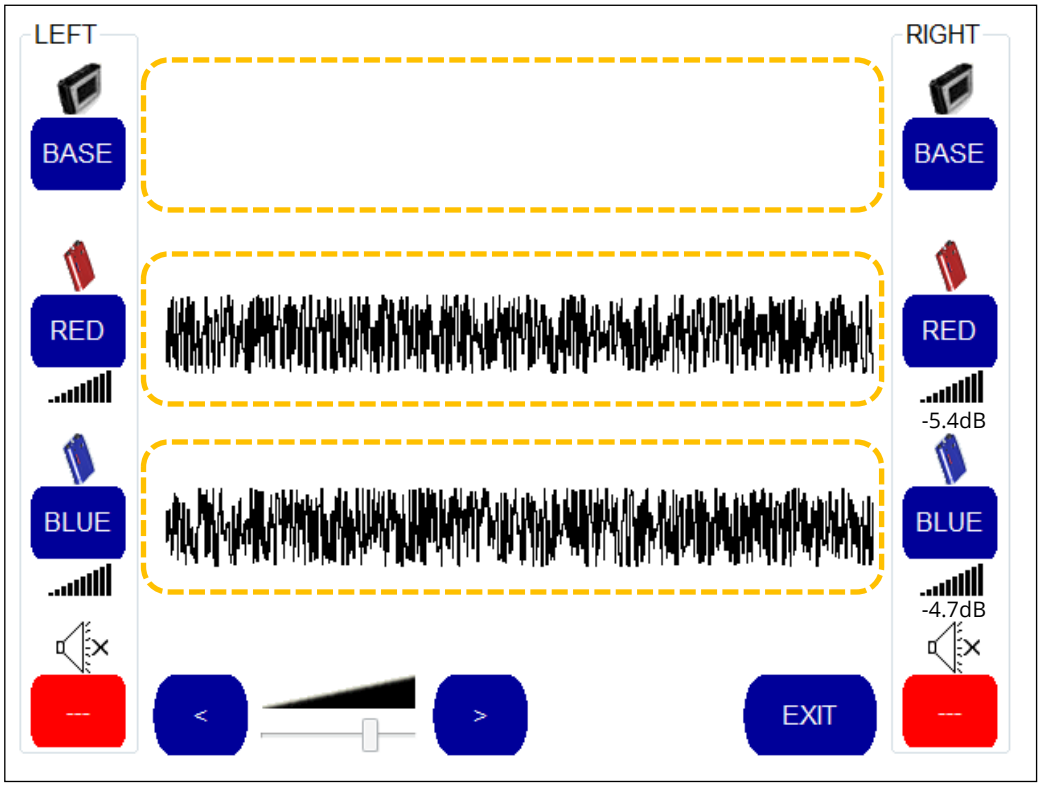
Refer to section 2.3.5 and 2.3.3 for typical headphone options and also the connector used on the console for attachment ; the headphone connector is custom made for the correlator.

When the headphones are plugged in, the audio will continue to be available for use during survey or correlation modes. This is a useful feature for confirming that noise is being successfully transmitted and received. However, there is a separate screen dedicated to the audio controls, which can be accessed as follows:

(Main screen) → Listen.

After pressing the "LISTEN" button, the following screen is displayed.

The graph area of the screen is split into three panels.

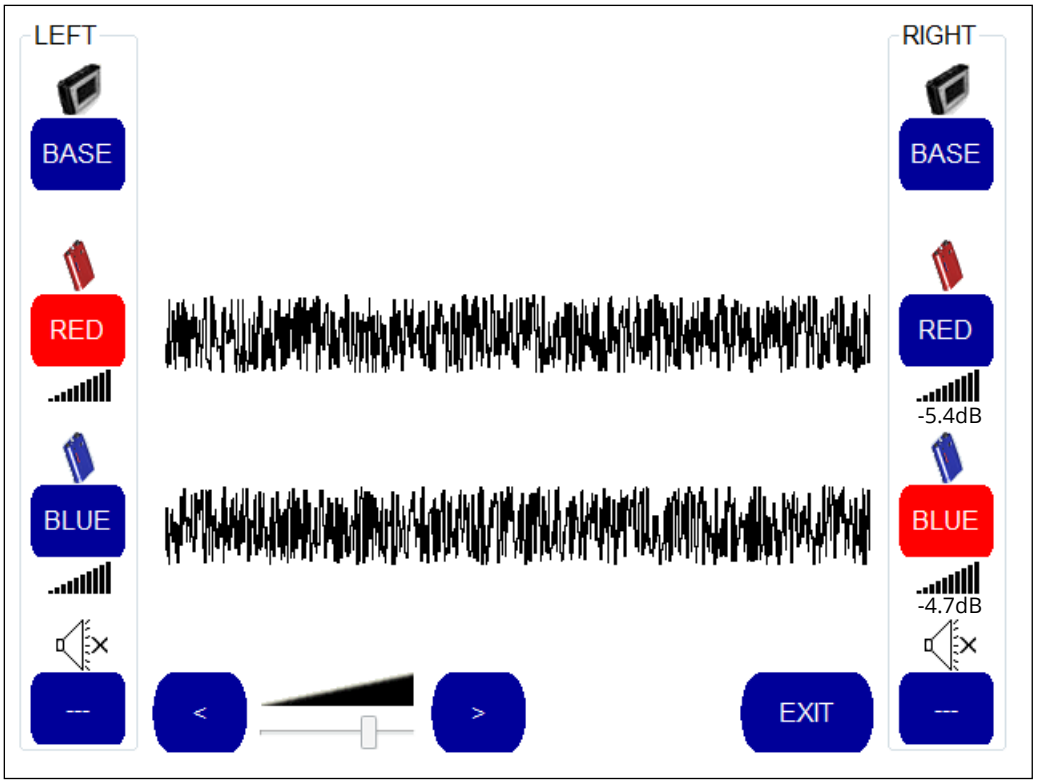


- If a sensor has been connected directly to the Base Unit, the audio signal waveform from that sensor is reproduced and displayed graphically in the top panel.
- If a sensor has been connected to the Red Outstation, the audio signal waveform from that sensor is reproduced and displayed graphically in the middle panel.
- If a sensor has been connected to the Blue Outstation, the audio signal waveform from that sensor is reproduced and displayed graphically in the bottom panel.

In the above example, the operator can clearly ***see*** that sound is being received from both the red and blue outstations. There is no audio, however, because both left and right channels have been muted (the Left and Right selections are set to 'audio off').

The operator can now use the buttons on the screen to select the sound that is heard through the left and right speakers on the headphones.

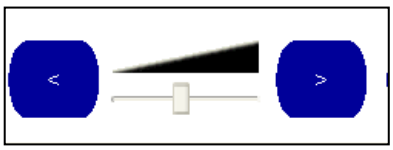
For example, if the operator wished to listen to the sound from the red outstation through his left ear and the sound from the blue outstation through his right ear, he would select the following configuration:



(A button turns red when it is selected, to show the operator what is being heard through each speaker).

If the operator wished to hear only the noise transmitted from the blue outstation, he could select the blue outstation for both the left and the right speakers.

Audio volume into the headphones can be controlled using the " < " and " > " buttons shown on the volume control.



The "EXIT" button returns the operator to the main correlation screen.

7 CORRELATION (LEAK LOCALISATION)

7.1 CORRELATION USING THE TOUCH PRO

Before beginning a correlation, ensure that each sensor is positioned at either end of the pipework under investigation, and has been connected either to an outstation or to the main base unit. When a sensor is connected to an outstation it automatically transmits its signal. The operator can check to see whether the radio signal is being received by examining the signal bars on either side of the main correlation screen.

Selecting the 'Start' button from the main screen activates the Correlation mode and begins the correlation process proper.

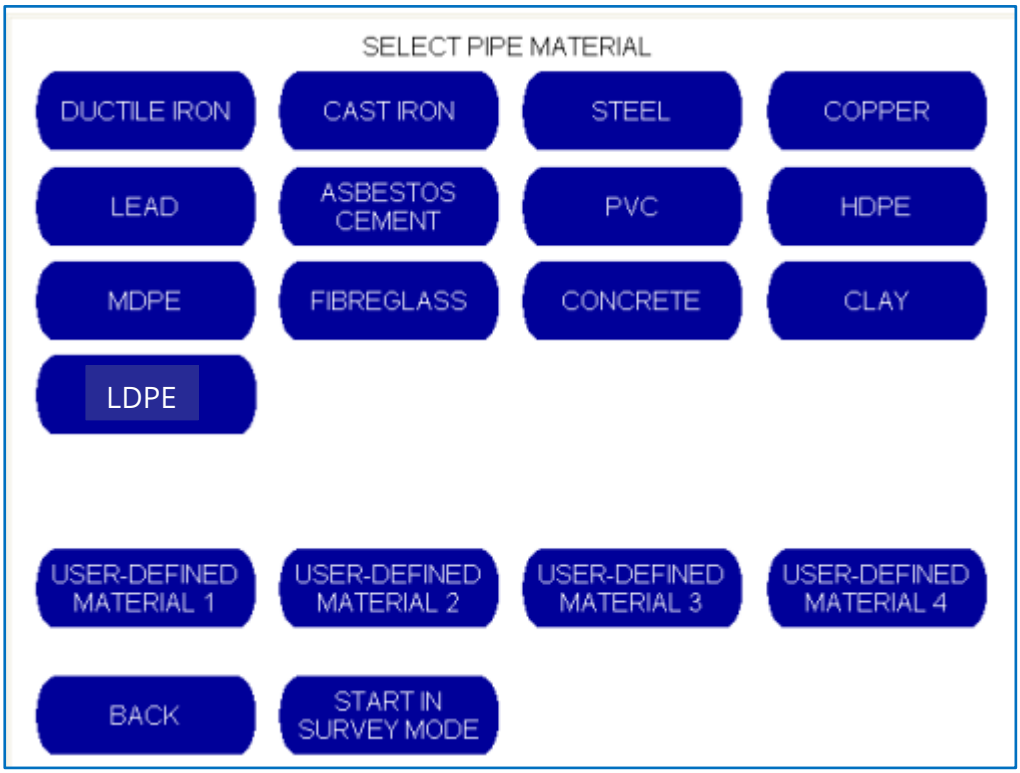
The correlation process refers to a Materials Database within the memory of the console unit. Initial stages are for the correlator to build a picture of the pipe structure between the sensors by the operator picking the relevant pipe material(s) and size(s). The Touch Pro correlator can support single pipes or pipes built up from a mixture of materials, diameters, and sizes.

Once the correlator has the relevant pipe structure information it can calculate the length (time) of audio it needs to obtain for correlation purposes. It is also aware of the speed of sound in each section of the pipe.

After the Start button is tapped, the operator will be presented with the Pipe Material Select screen.

This screen shows a list of pipe materials that the operator can select from.

Additionally, there are buttons for up to four user defined materials.



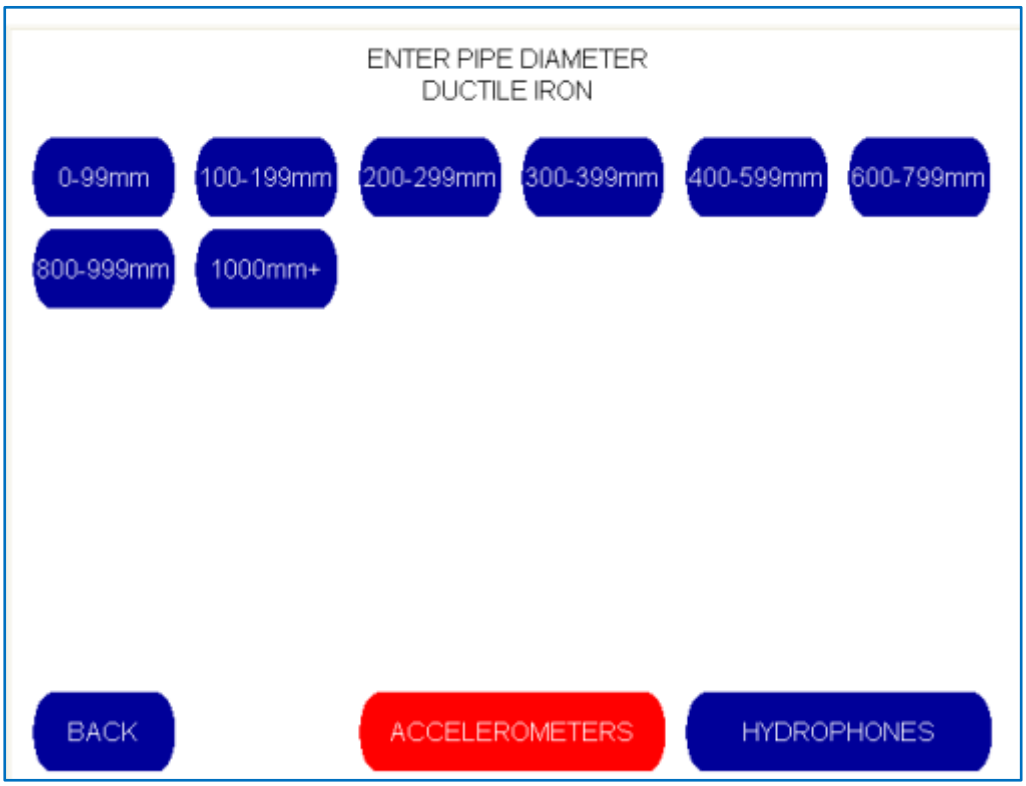
The Touch Pro is preconfigured with the sound velocities and default filter settings for the various pipe materials.

Note: If the pipe is built of multiple sections of different types of material or size, enter the first one.

After selecting the required pipe material, the operator is automatically taken to another screen; This is the Pipe Diameter Selection for the chosen pipe material.

A range of pipe diameters is displayed automatically to suit the material selected.

The operator should input the diameter (range) of the pipe.



Note: **Sensor selection.**

Selection of the correct sensor type is important for accurate correlation results. It is also important for correct filter selections during operation.

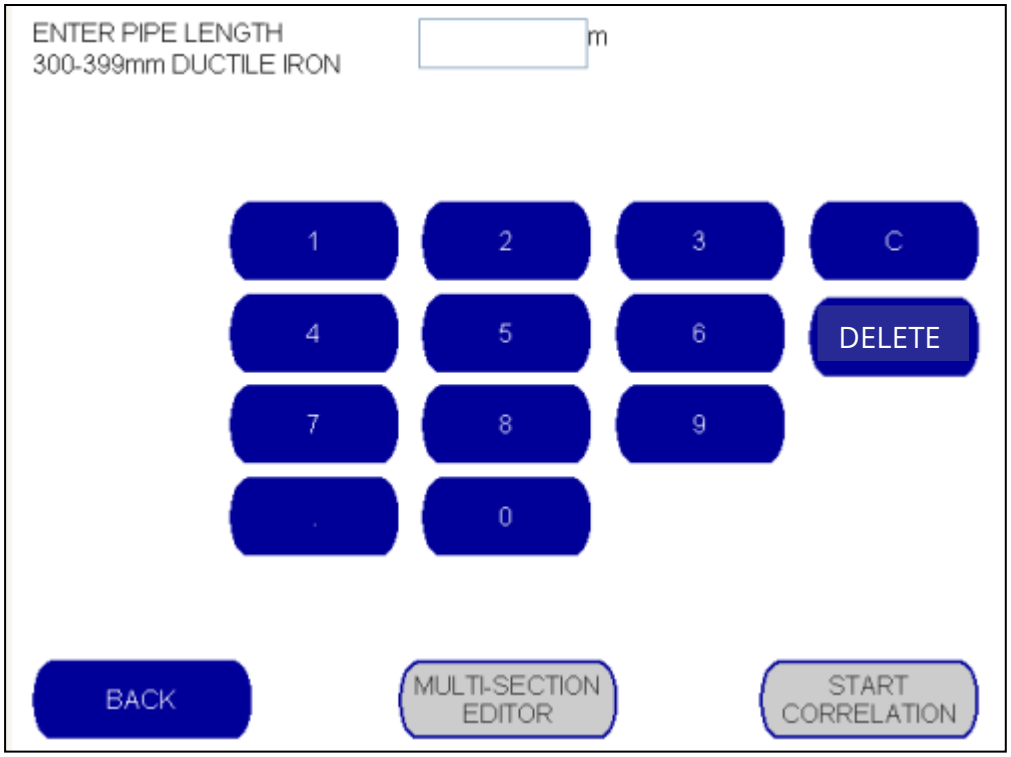
The sensor type is set to Accelerometers by default.

If using Hydrophone Sensors (Hydrophone 1 or Hydrophone 2), the operator must notify the Base Unit at this point.

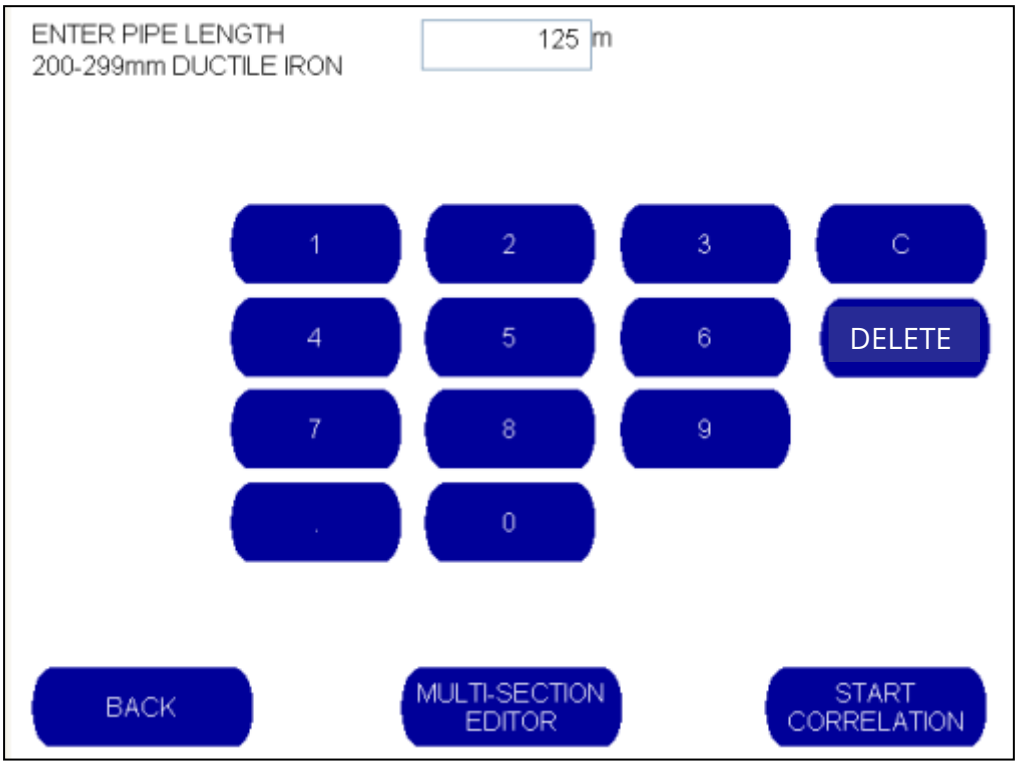
The button of the currently active sensor selection is displayed as red.

The operator is then taken to the Pipe Length Input Screen.

Input the length of the current section of pipe using an on-screen keypad, as shown opposite.



When the pipe length has been input, the buttons "Multi-Section Editor" and "Start Correlation" buttons turn from grey to blue, enabling them to be selected.



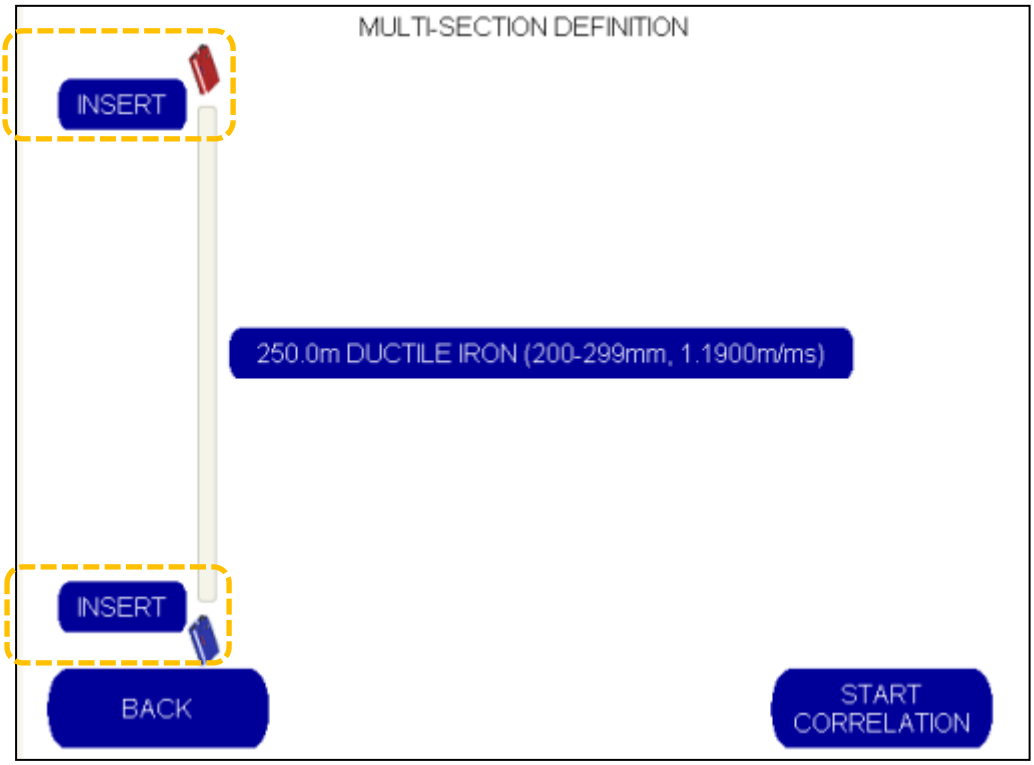
If the full length of pipe uses the same material, tap on the "Start Correlation" button … You will be returned to the main correlation screen, and the correlation process begins.
However, If the pipe has been constructed using different materials and / or diameters, these should be input ; tap on the "Multi Section Editor" button.

The Multi Section Editor button produces a ‘Multi-Section Definition’ screen.

This displays the details of the first length of pipe input.

In the example shown opposite, 250m of Ductile iron pipe has been entered.

Additional parameters including the speed of sound through the audio path are also shown.

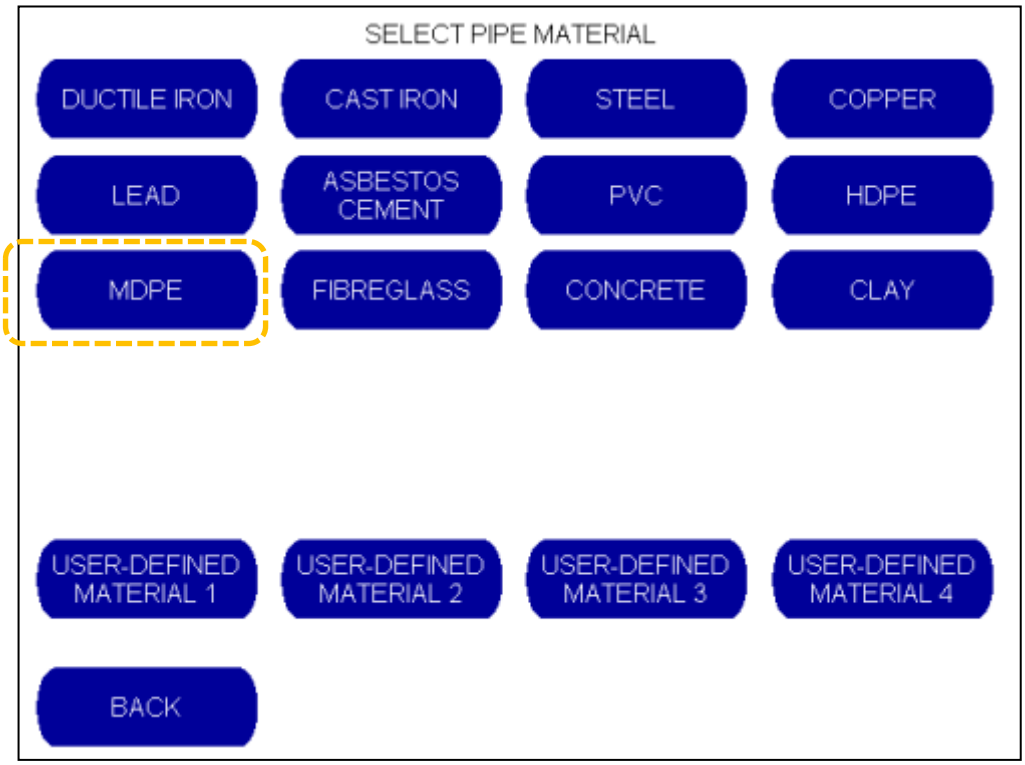


The operator can then select *where* to insert an additional section of pipe by using one of the two “INSERT” buttons.

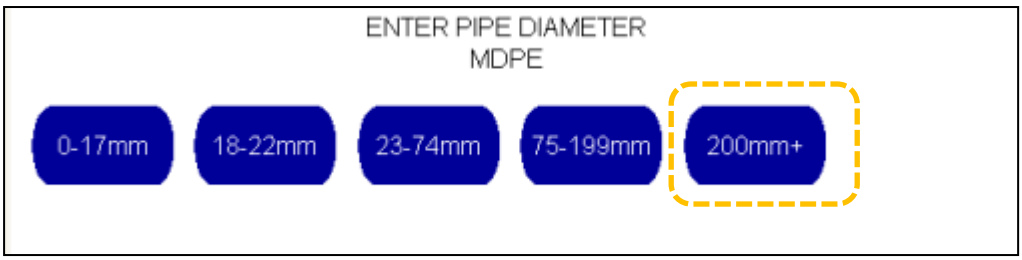
For example, if the operator wishes to add a short 25m section of MDPE pipe, located 250m from the Red Outstation…

… Select the “INSERT” button closest to the Blue Outstation…

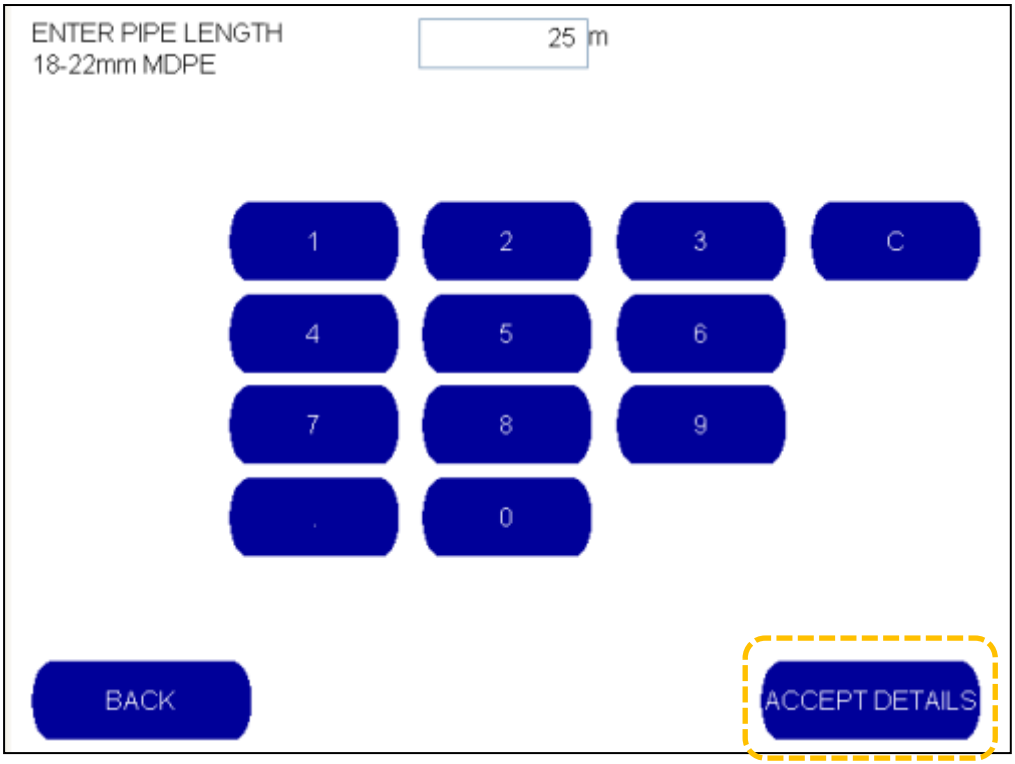
… and then input the required pipe material.



Then input the pipe diameter.

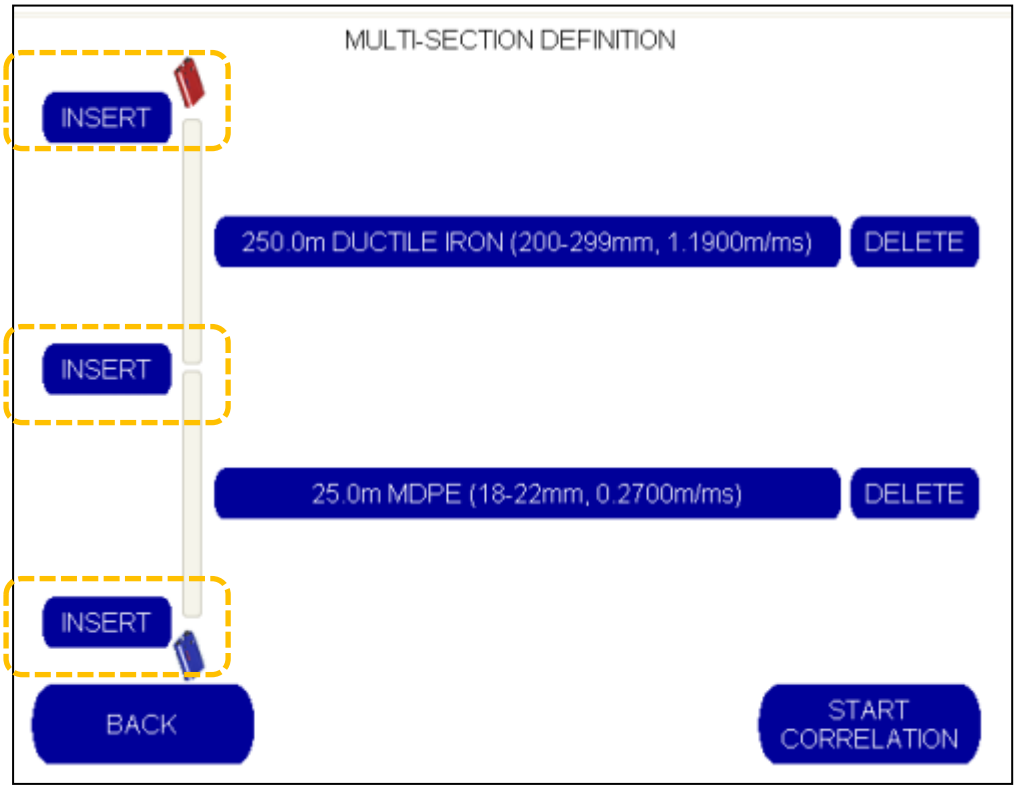


Finally, input the pipe length and tap on the “Accept Details” button.



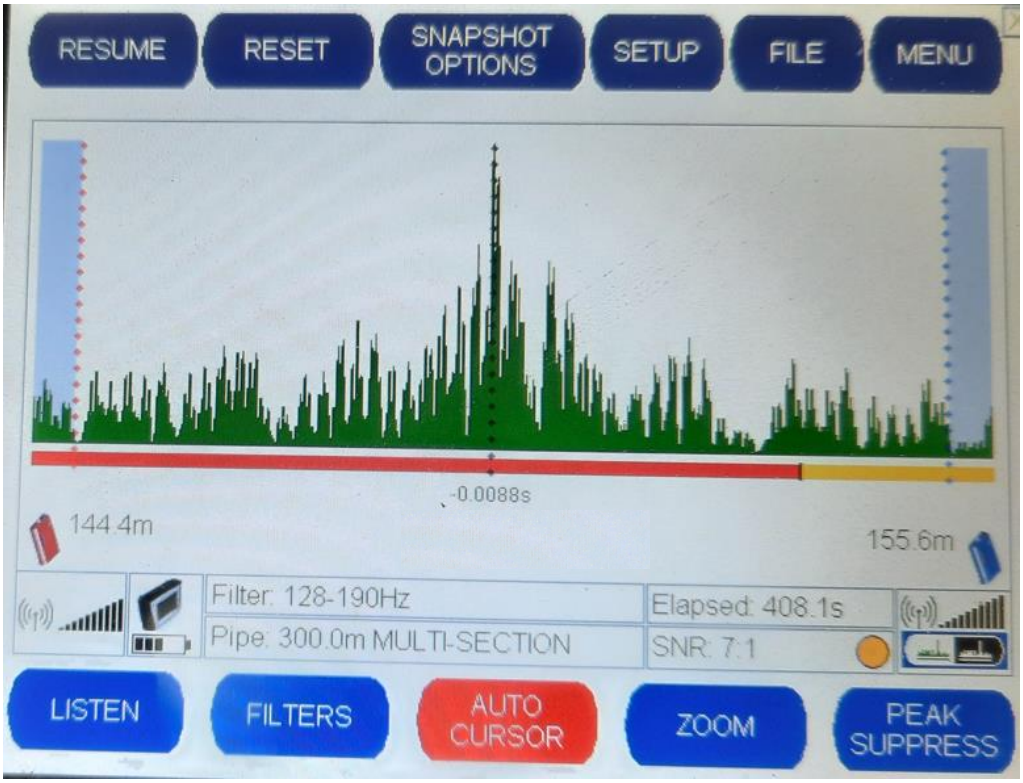
The unit returns to the Multi-Section Definition screen, which now displays the two different pipe materials and lengths (and now 3 possible insert locations).

If an error has been made, a pipe length can be adjusted by tapping on the pipe section or deleted using the relevant “Delete” button.



Additional sections of pipe material can be added by selecting the “Inset” button until the full length of pipe located between the two outstations has been input.
Then select the “Start Correlation” button to proceed.

The pipe lengths are shown below the graph area, colour coded according to material types selected.



The correlation results are shown as a histogram (set of vertical lines) ; after some time, a distinct peak may appear (which is a good indicator of the leak position having been located).

There are various vertical markers on the screen:

- Red dots indicate the position of the red outstation.
- Blue dots indicate the position of the blue outstation.
- The greyed-out areas between the edge of the graph and the red / blue outstations indicate an “out of bracket” area ; it is outside of the zone between the sensors and as such the position of any leak cannot be determined.
- Black dots indicate the position of a cursor.

The cursor position is important …

- Below the cursor is a (numeric) time-difference ; it indicates the time difference at the current cursor position.
- The time difference is used to calculate the position of the leak on the pipe network.
- The leak positions are shown next to the outstations on the display.
  (In the image above, the cursor is placed on the peak of the histogram. The time difference corresponds to the leak being estimated to be most likely at a distance of 144.4m from the red outstation sensor or 155.6m from the blue outstation sensor).

Helpful Note:

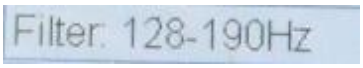
If, following a correlation, the operator wishes to perform a new correlation, the Pipe Material screen will give the operator the option of selecting "Use Existing Definition" to select the pipe materials used in the previous correlation.

Note that the 'Start' and 'Survey' buttons will change whilst the user is driving a correlation or survey (see below for an example):

- The 'Survey' button cancels any existing correlation and starts the survey mode.
- The 'Start' button cancels any existing survey and starts the correlation mode.
- The 'Stop' button pauses any existing correlation or survey.
- The 'Resume' button un-pauses any existing correlation or survey.
- The 'Reset' button cancels any existing correlation or survey and clears the screen (i.e., no graph content).

It should be noted that correlation is not always as straight-forward as the previous description. In particular, note that:

- The correlation required the selection of a filter.
  This can be done manually, but Touch Pro includes some automation tools.



- The cursor had to be accurately positioned on the peak.
  This can be done manually, but precision is needed.
  Touch Pro include some helpful tools and / or automation.

7.2 TOOLS TO ASSIST CORRELATION

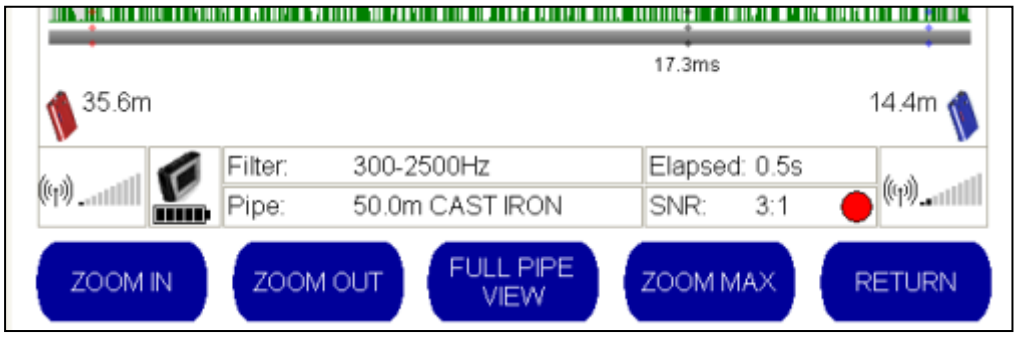
7.2.1 Zoom feature

The cursor can be re-positioned manually, by tapping the screen in the desired new location.

To improve the resolution, you can first tap on the 'Zoom' button, which is usually located at the bottom of the main screen.

The zoom function centres on the cursor position. The cursor position can be changed prior to activating the zoom function simply by tapping the area of the graph that you wish to magnify.

Selecting Zoom will modify the buttons on the lower part of the screen.



Tap 'Return' when finished to go back to showing the regular buttons.

The 'Zoom-In' button zooms in to the area surrounding the current cursor position. The zoom-in function can be used a maximum of twice, which gives maximum resolution.

Using the zoom function changes the scale and gives improved leak position resolution (control over where the cursor is re-positioned), which is particularly useful when the sensors are far apart.

The 'Zoom-Out' button similarly zooms one stage out from the current zoom level.

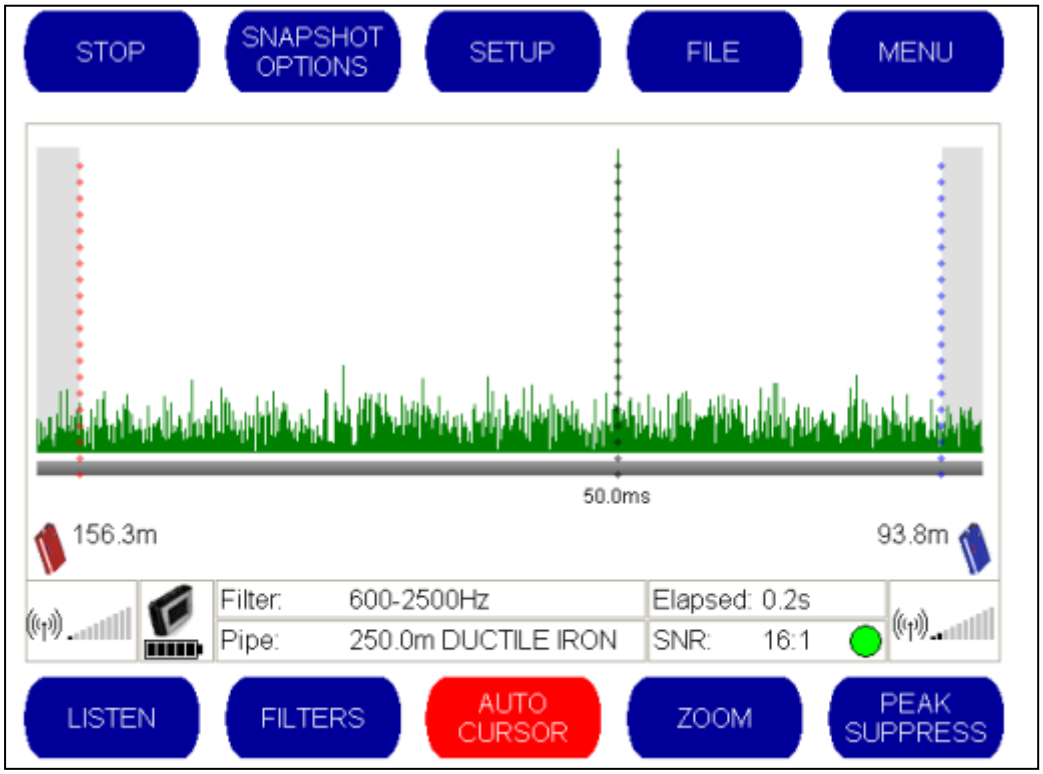
The 'Full Pipe View" button automatically displays the full correlation graph.

The 'Zoom Max' button automatically zooms to the maximum level.

7.2.2 Auto-Cursor feature

To assist in positioning the cursor onto the peak, you can tap on the 'Auto Cursor' button, which is usually located at the bottom of the main screen. When active (displayed as red), cursor positioning will no longer be manual. The Auto Cursor can be turned off at any time by tapping the button again.

When switched on, the auto cursor will always locate itself onto the highest peak, allowing the operator to automatically pinpoint exactly where the highest peak is.



In the above example (which has a very sharp peak), the Auto Cursor is automatically positioned over the highest peak. The distance from the highest peak to the red outstation is displayed (156.3m), and the distance from the highest peak to the blue outstation is also displayed (93.8m). The Signal to Noise Ratio (SNR) is 16:1 and displaying a green light, indicating that that confidence is high for this particular correlation.

Should the operator wish to move the cursor to another point on the graph, this can be achieved simply by touching the screen at the required point. The Auto Cursor is immediately switched off and the screen displays the distance from the outstations to the selected position.

To move the cursor back to the highest peak, press the Auto Cursor button again.

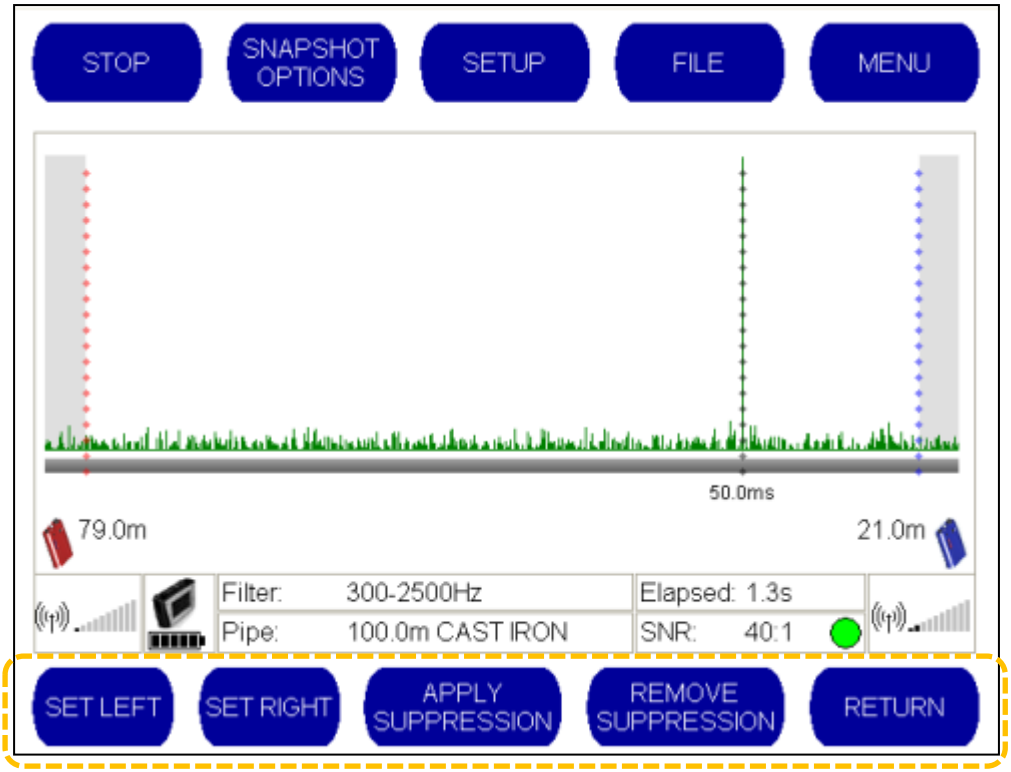
Please note that the position of the cursor may take several seconds to steady during a correlation depending on how well defined the correlation peak is.

7.2.3 Peak Suppress feature

Peak suppression allows the operator to remove an unwanted peak from the correlation result. This is useful when the source of that peak has been identified as a non-leak. By suppressing this, the unit will correlate ignoring the sound levels being produced at this location on the pipe.

To navigate to the Peak Suppress features, tap on the 'Peak Suppress' button, which is usually located at the bottom of the main screen.

When the "Peak Suppress" button has been selected, the following buttons appear at the bottom of the screen.



There are two ways to select the area of the graph to be suppressed.

The first method to use the "Set Left" and "Set Right" buttons to mark the area to be suppressed. To do this, tap the "Set Left" button and then touch the screen to mark the point to the left of the peak to be suppressed. Then, tap the "Set Right" button and then touch the screen to mark the point to the right of the peak to be suppressed.
The background area in between the two settings will then turn grey to indicate that this selected area will be removed from the correlation.

Once the first method is used, the area for suppression will be shown on the screen. The operator can now use the second method, which is to drag the area to be suppressed with a finger on the touch screen. The dragged area will then turn grey indicating that this area will be removed from the correlation.

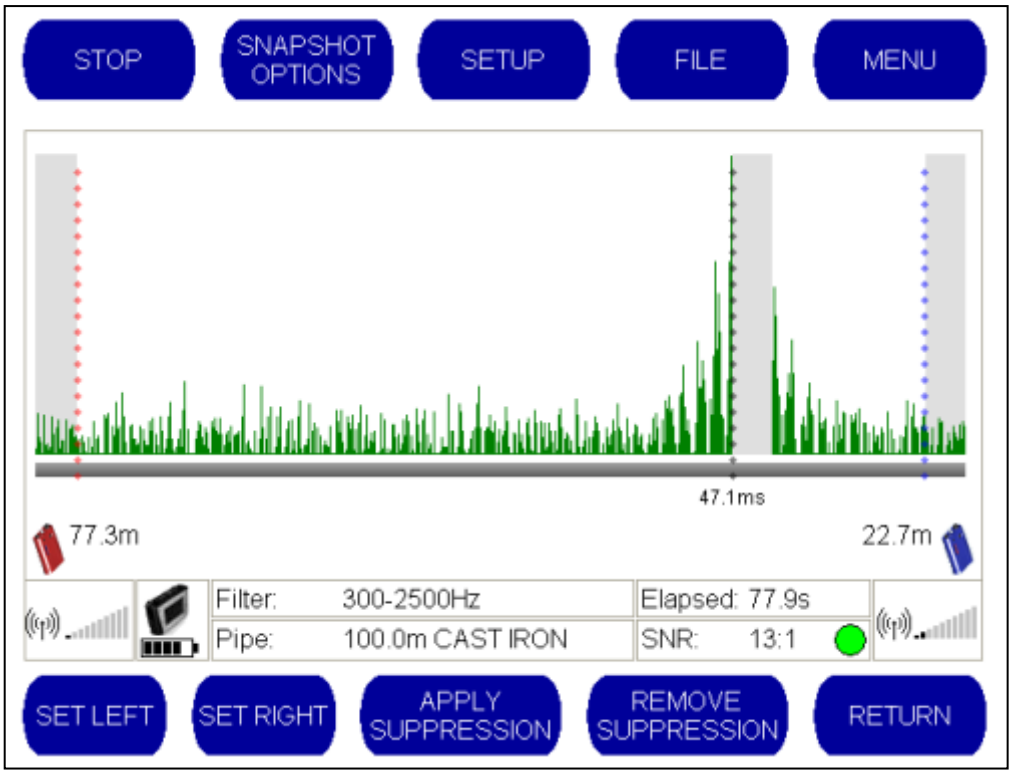
Note that removing a peak also causes the graph to re-scale, based on the new highest peak.

In the example shown below, the grey area shows the original peak (at 50ms) is suppressed.

If Auto-Cursor is enabled, it will jump to the new peak, which is outside of the suppressed area.

... The distance results (from red and blue outstations) have been updated based on the new peak.

The graph has also been re-scaled, also based on the new peak.



To view the correlation graph without the suppression, tap the “Remove Suppression” button. To re-view the correlation with the suppression, tap the “Apply Suppression” button ; this restores the previous suppression settings.

When finished, tap on the ‘Return’ button.

7.2.4 AFIS (Filter Optimization) feature

Touch Pro provides default filter settings for a wide range of different pipe materials and sizes. However, due to the number of unknown variables that can change the frequency of leak noise, default filter settings can never be optimised for every leak situation. Experienced users can manually change the filter settings to find the leak, but this is often a time-consuming process involving multiple correlations. Even then, it can be “hit or miss” to successfully locate the leak.

To assist the operator, Touch Pro incorporates a unique
Automated **F**iltering **I**ntelligence **S**ystem (AFIS),
which effectively builds an ‘expert user’ into the unit.

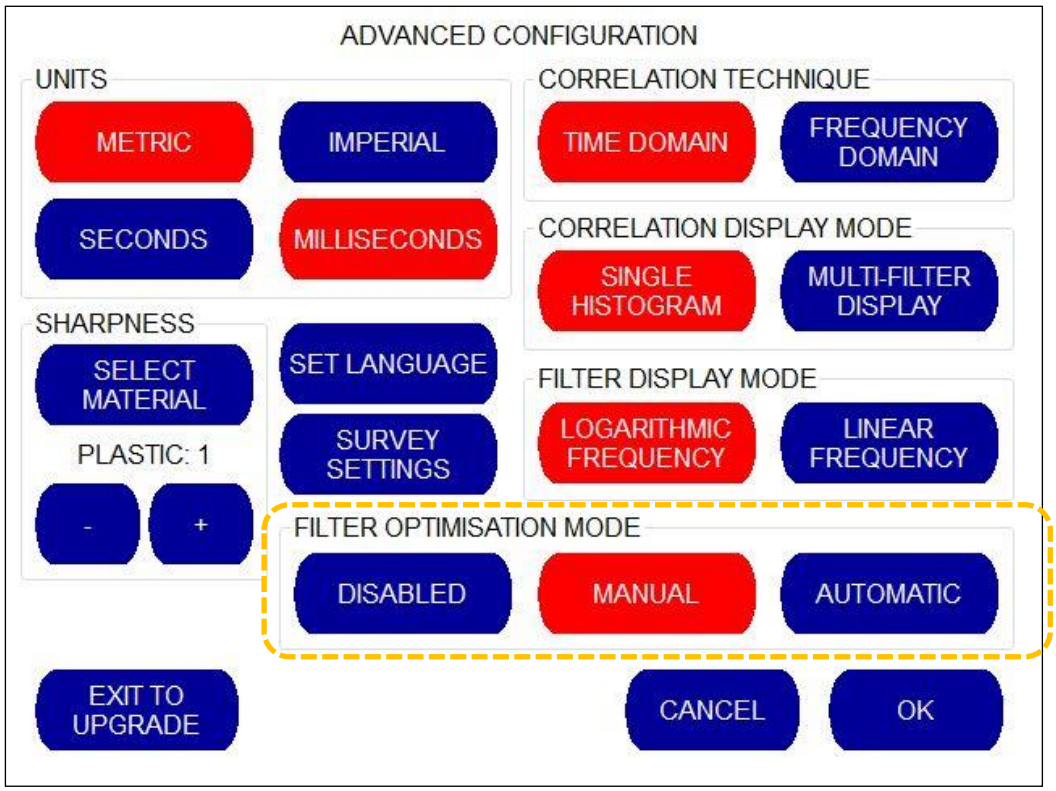
AFIS works by automatically applying multiple filter settings to determine the best possible correlation result during the correlation.

Touch Pro runs up to 55 different filter combinations on the correlation data, checking the quality of the result and optimising the filter settings as required, until the clearest and most accurate result can be presented.

Setup options for the running of the AFIS feature can be accessed within the Advanced Configuration screen (see below).
To access this screen (from the main screen) tap the following buttons:

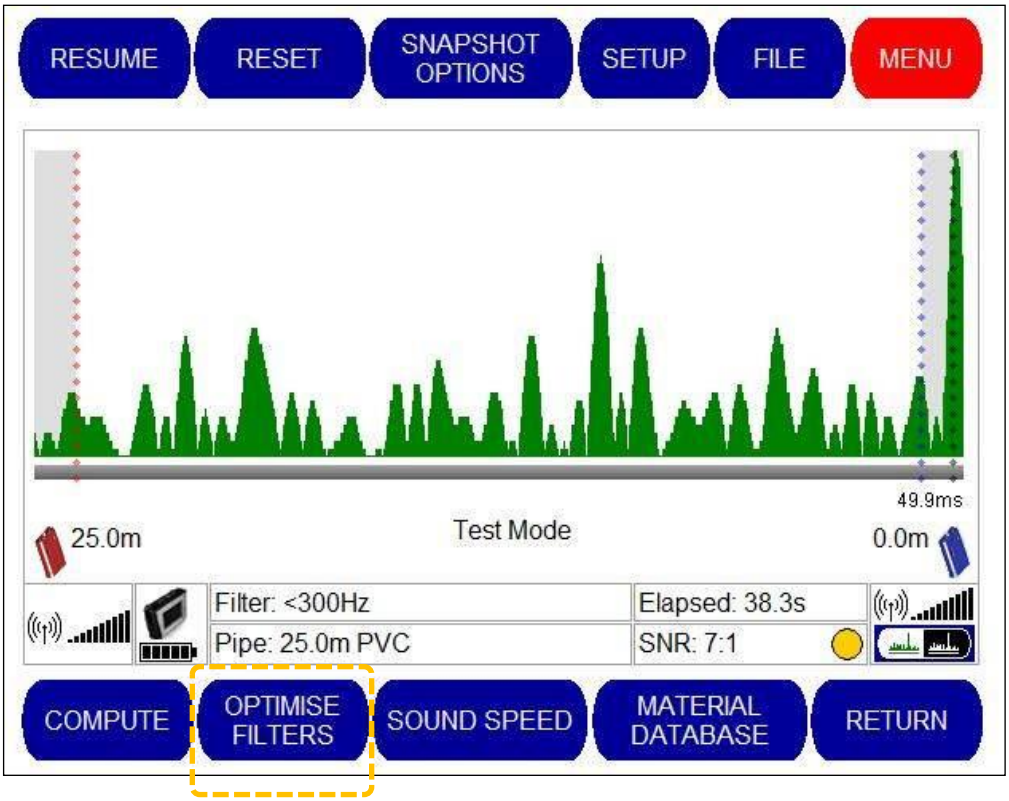
(Main screen) → Setup → Advanced Setup

(The setup options for running the AFIS feature are shown opposite).



The settings (above) are related to the 'Optimise Filters' button, which is shown opposite.

The button is displayed from the main screen after the 'menu' button has been activated.

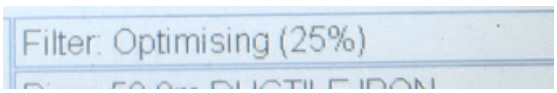


When Filter Optimisation Mode setting is set to:

- 'Disabled':
  The Optimise Filters button is 'greyed out' and has no function.
- 'Manual':
  The Optimise Filters button is blue in colour and allows the user to decide if and when the AFIS feature is put to use.
  Tapping on the Optimise Filters button allows the AFIS to run just once.
  AFIS will run once every time the button is tapped.
- 'Automatic':
  The AFIS is run automatically to optimise the filters during correlation whenever the existing filter settings are not effective in producing an accurate correlation.
  The feature is re-run periodically (approx. every 30s) to re-assess the most recent sound information, until a filter selection producing a correlation result with the highest confidence level is found.

  The user can also start the AFIS feature by tapping on the 'Optimise Filters' button.

Whilst AFIS is running, the 'Filter' information box shows its progress, as shown opposite.



7.2.5 Filter Settings – Manual Adjustment

Helpful Note:

This section is for expert users only…

Touch Pro uses a unique Automated Filtering Intelligence System (AFIS) which automatically runs up to 55 different filter combinations on the correlation, checking the quality of the result and optimizing the filters until the best result is obtained.
AFIS works with both live and saved data and is designed to make manual filter setting a thing of the past by effectively building an "expert user" into the unit.

AFIS Filter Optimization may be set to be "always on" enabling it to work whenever a correlation fails to produce an accurate result.

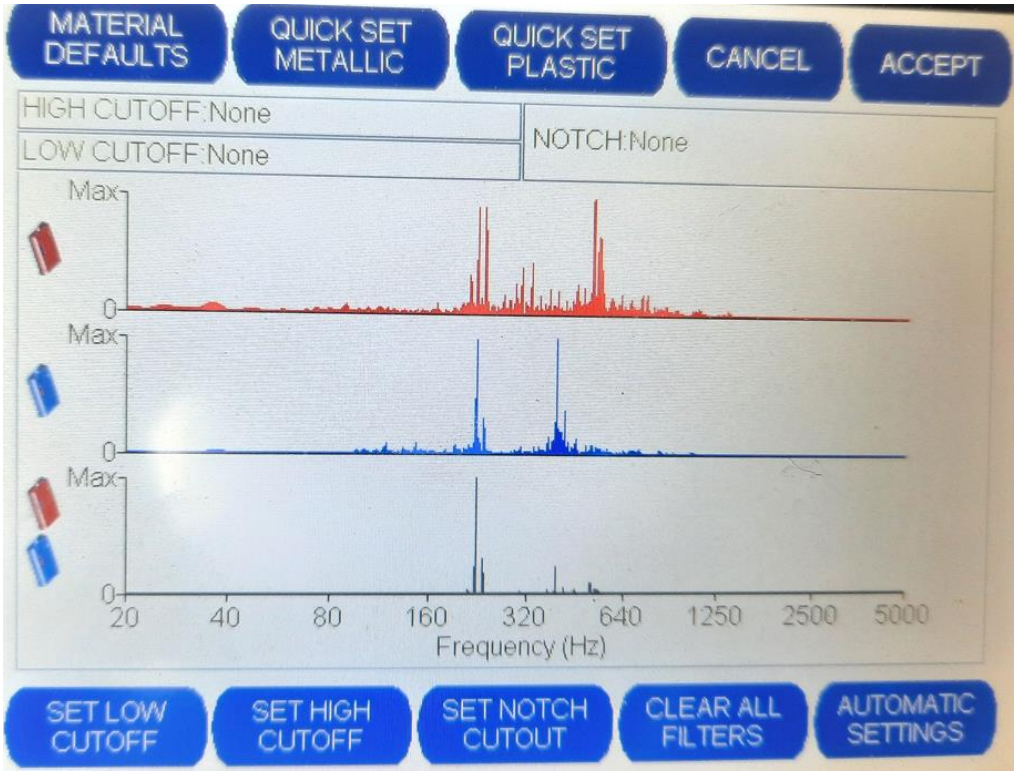
We recommend that the Filter Optimization mode is first used to automatically optimize filter settings during the correlation before deciding whether any manual filter adjustments are required.

Note: Before making any manual adjustments to filter settings, the AFIS running settings have to be switched to 'Disabled' or 'Manual'.
If left in 'Automatic' mode, AFIS is very likely to begin to run and override the manual filter settings; they will no longer be in use.

The comprehensive audio filters in Touch Pro cover the frequency range up to 5000 Hz and are designed to be used to eliminate background noise and to thereby enhance the leak noise signals.
Adjustment may be made to maximise the similarity between the two sound channels, to compensate for the modification of the leak noise by the pipe material. The filter settings below 20Hz are lower than human hearing can notice, although Touch Pro can analyse and correlate at these subsonic frequencies.

The filter settings screen can be navigated to by tapping on the 'Filters' button that normally appears on the main page.

The following screen is displayed:



This screen shows the frequency spectrum of the noise being received. The range is 0-5 kHz.

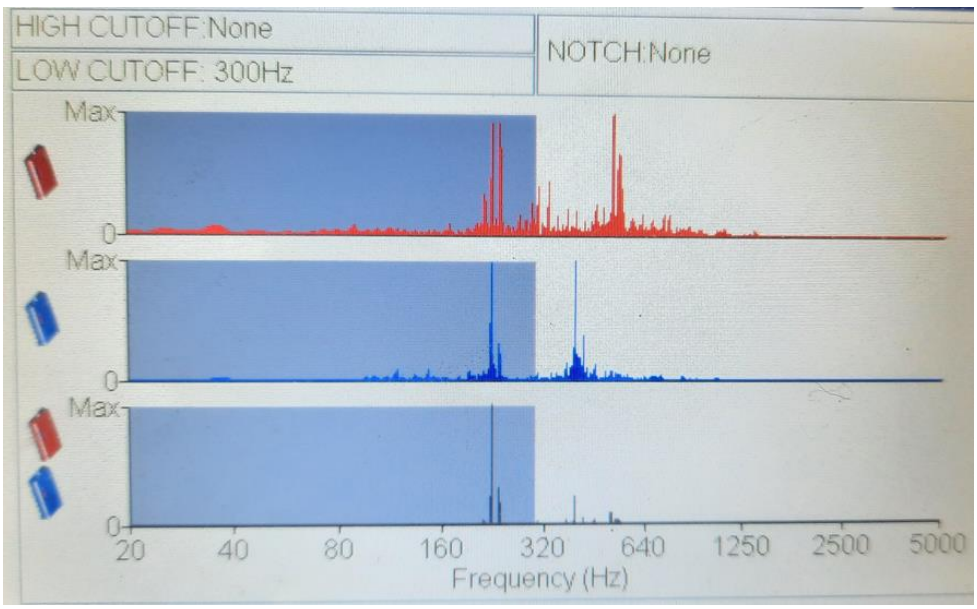
Three graphs are displayed:

- The top graph shows the noise being received from the red outstation. Noise data is displayed in red.
- The middle graph shows noise being received from the blue outstation. Noise data is displayed in blue.
- The bottom graph shows the noise being received from a combination of the red and blue outstations. This is known as the Coherence Graph. Noise data is displayed in black.

In the example shown above, no filters have been selected because the whole spectrum of noise is displayed against a white background.

When filters are applied, the frequencies being filtered out are displayed against a grey background.

This makes it easy for the operator to see which filters have been applied, as shown in the example opposite:



The only the sound frequencies in the being displayed within the white background area are used to perform the correlation.

To reject low frequencies:

Press the “Set Low Cut-off” button and then touch the screen at the point on the graph that the cut off is to be applied up to. The area immediately to the left of this point will be filtered out and displayed graphically on a grey background.

To reject high frequencies:

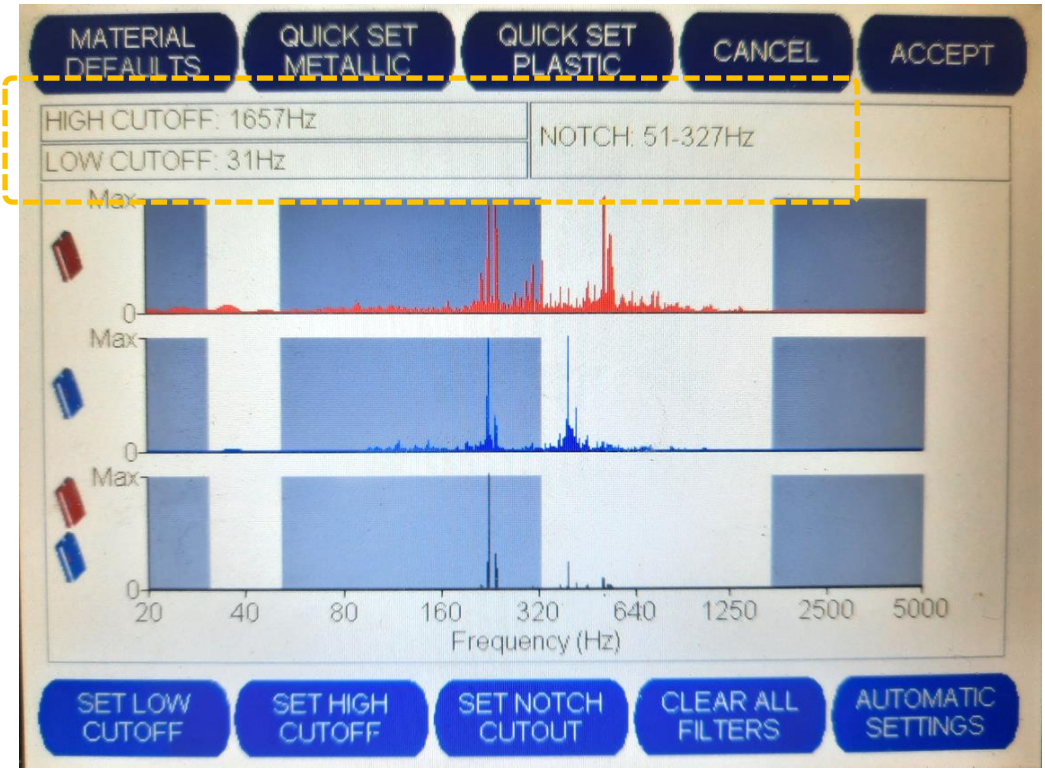
Press the “Set High Cut-off” button and then touch the screen at the point on the graph that the cut off is to be applied up to. The area immediately to the right of this point will be filtered out and displayed graphically on a grey background.

To reject a band (notch) of middle frequencies:

Press the “Set Notch Cut-out” button and then touch the screen graph at points either side of the middle frequencies that are to be filtered out. The area in-between the two selected points will be displayed graphically on a grey background and the sound frequencies filtered out.

Combinations of all 3 filter types can be applied.

Details of each filter applied are shown in the information area above the graphs.



Using the touch screen, the filter bands can be moved simply by dragging a finger to the left or right of the graph to widen or narrow the white nonfiltered area.

Once finished, tap on “Accept” to apply the settings to the correlation.

The function of the remaining buttons is as follows:

- The “Cancel” button cancels the settings and returns you to the main correlation screen.
- The “Clear all Filters” button removes all of the grey filtered areas.
- The “Automatic Settings” button looks at the black coherence graph and sets the filters so that it only allows the area that contains the most dominant sound frequencies to pass through. This allows the specific noise to be correlated and removes some of the additional background noise.
- The “Material Defaults” button configures the filters to the settings specified by the pipe material (as previously selected during setup of the correlation).
- The “Quick Set Metallic” button is recommended if a pipe is known to be metal, but the specific type of metal is uncertain.
  This automatically cuts out the lower frequencies and uses only the higher frequencies (i.e., above 300Hz) to identify the leak noise.
- The “Quick Set Plastic” button is recommended for non-metallic pipes if the specific pipe material is uncertain.
  This automatically cuts out the higher frequencies and uses only the lower frequencies (i.e., up to 200Hz) to identify the leak noise.

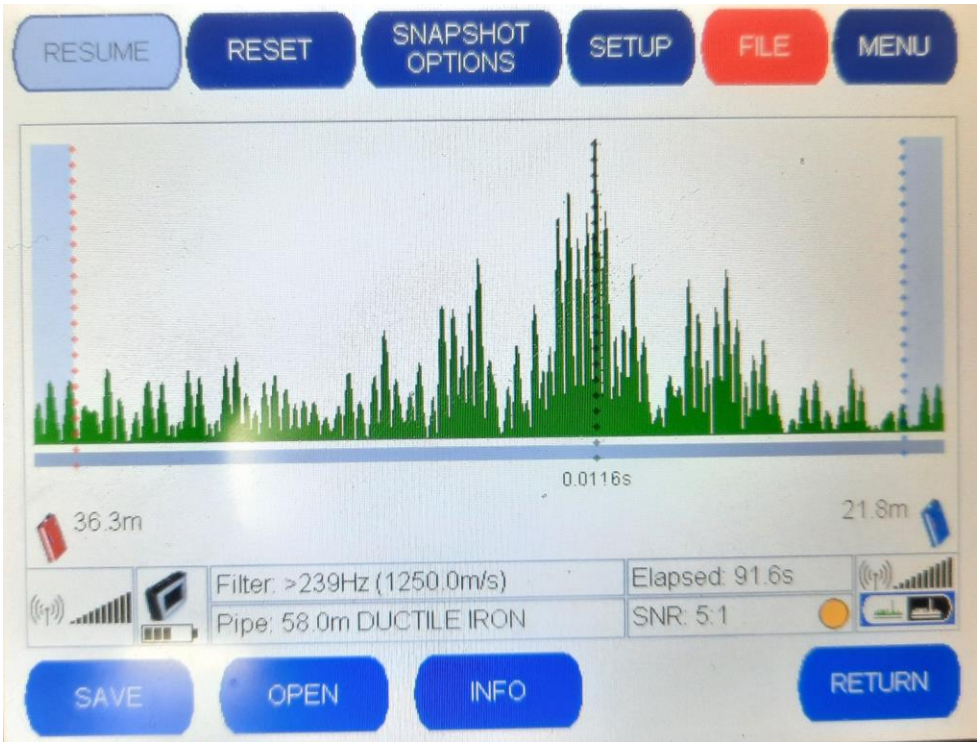
Note: When a new correlation is performed, the filter settings will revert back to the standard filter settings for the selected material, diameter, and pipe length.

7.3 FILE FUNCTIONS: SAVING AND RE-OPENING A CORRELATION

The Touch Pro includes a file system, allowing information to be saved as data files. This includes the ability to be able to save and re-open correlations. This can be used to re-examine the correlation later in time or it can also be used as an input to the Touch Pro 'Compute Mode' feature (see section 7.4).

The file system functions can be opened by tapping on the 'File' button which appears on the main screen.

When selected (File button is red), the buttons on the bottom line change, as shown.



The buttons function as follows:

- The 'Save' button saves the current data and graph(s). It allows you to enter information and name the file.

- The 'Open' button allows the operator to select and load a previously saved graph into the correlation screen.

- The 'Info' button allows the operator to input (or edit) information about the correlation for future reference. (Five lines of text are available).

- The 'Return' button returns the operator to the main correlation screen .

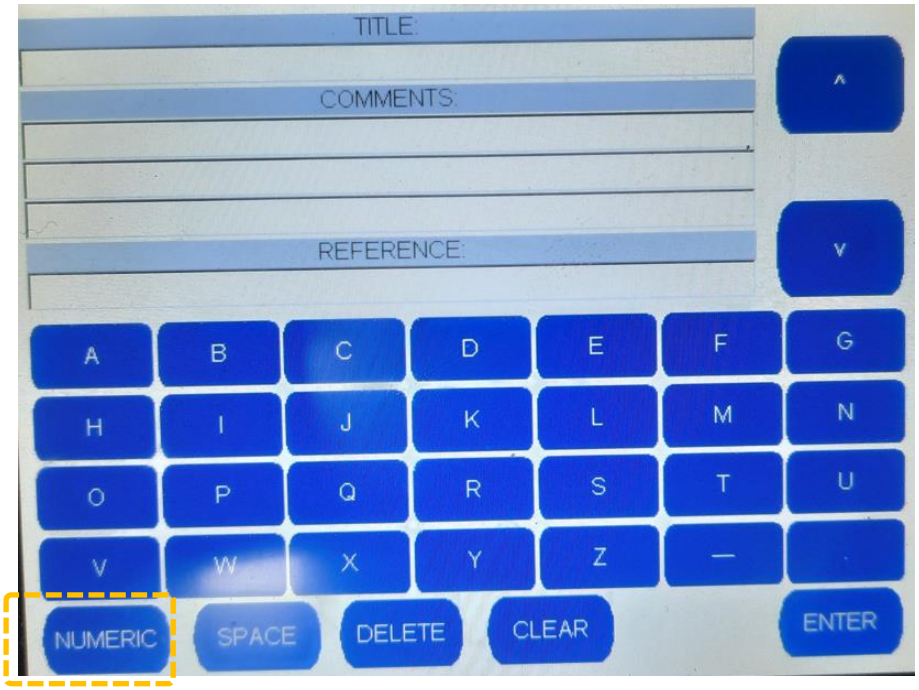
7.3.1 Saving a Correlation Result

Tap the “Save” button.

Enter information about the correlation (e.g., location, date, etc).

The operator can toggle between numbers and letters by selecting the “ALPHA” or “NUMERIC” buttons that appear at the bottom left of the screen.

Tap the ‘Enter’ button to finish.

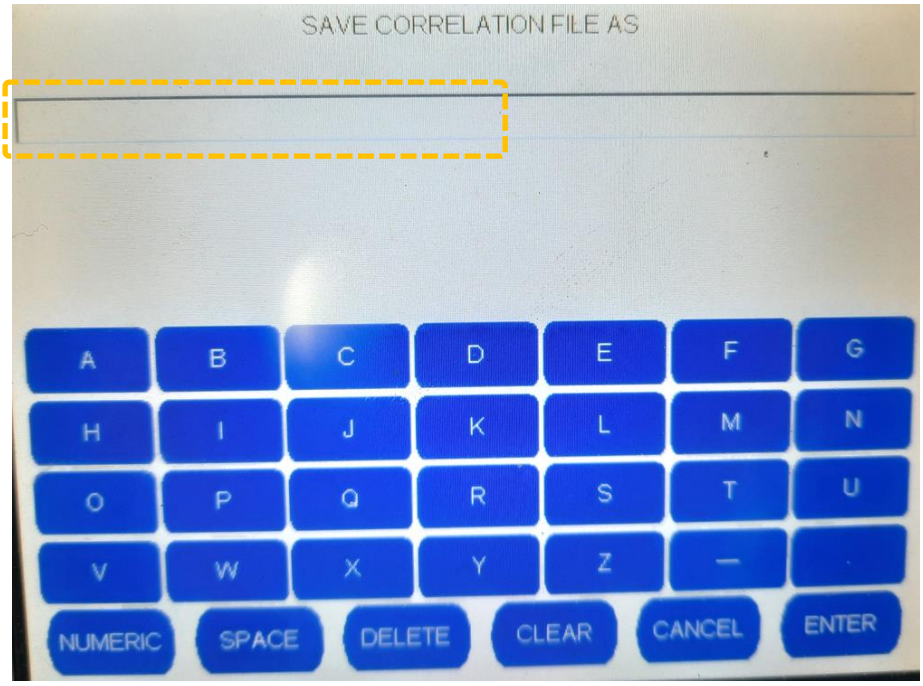


Then enter a name for the file.

(The name can be a combination of numbers and letters)

Tap the ‘Enter’ button to finish.

(The correlation data is then saved).



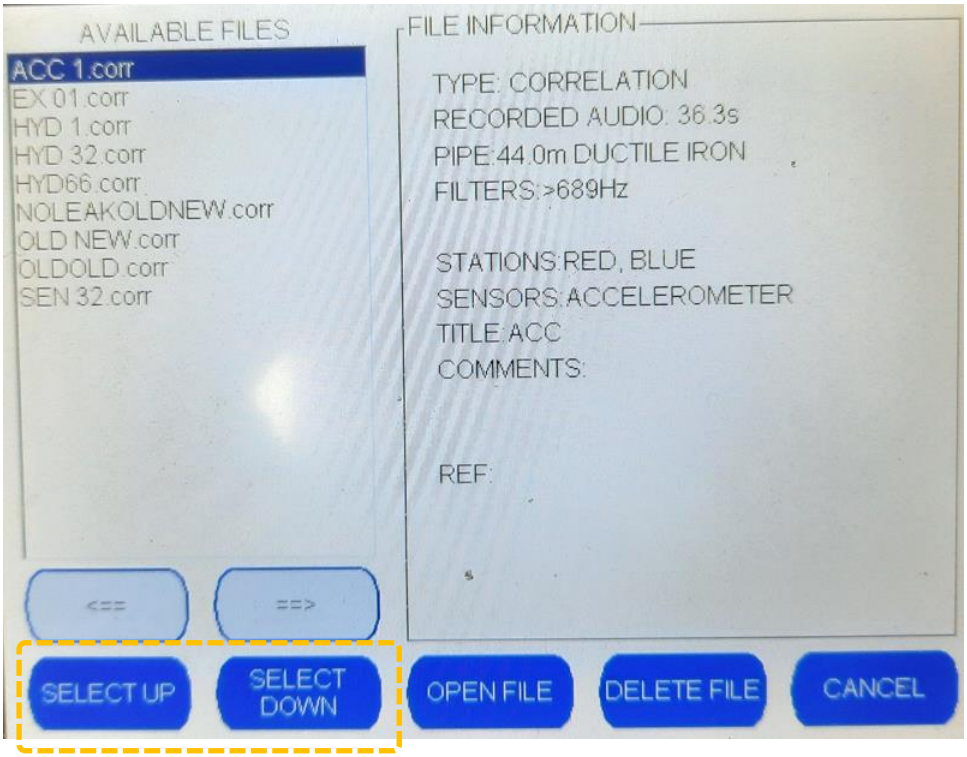
7.3.2 Opening a Previously Saved Correlation Result

Tap the “Open” button.

The unit displays a list of saved correlation results (in the left-hand panel).

The operator can now select a file to open by using the ‘Select Up’ and ‘Select Down’ buttons to choose.

A summary of the file information is shown in the right-hand panel.



When the file has been selected, press the ‘Open File’ button to view this correlation result.

Alternatively, the operator can choose to delete the currently selected correlation result file from the system by pressing the ‘Delete File’ button.

To cancel the operation, select ‘Cancel’. This will you return to the File Menu.

How many correlations can be stored in the memory?

The Base Unit is supplied with approximately 200Mb of free space which can be used to store correlation results. A correlation that uses one minute of data will create 2.4Mb of audio data, enabling about 80 of these correlations to be stored in the base unit at any one time. Saving a result stores a maximum of 1 minute of audio samples.

However, most correlations will require substantially less data; thereby enabling a much larger number of correlations to be stored in between downloads to the PC.

7.4 COMPUTE MODE – IMPROVING LEAK LOCATION ACCURACY

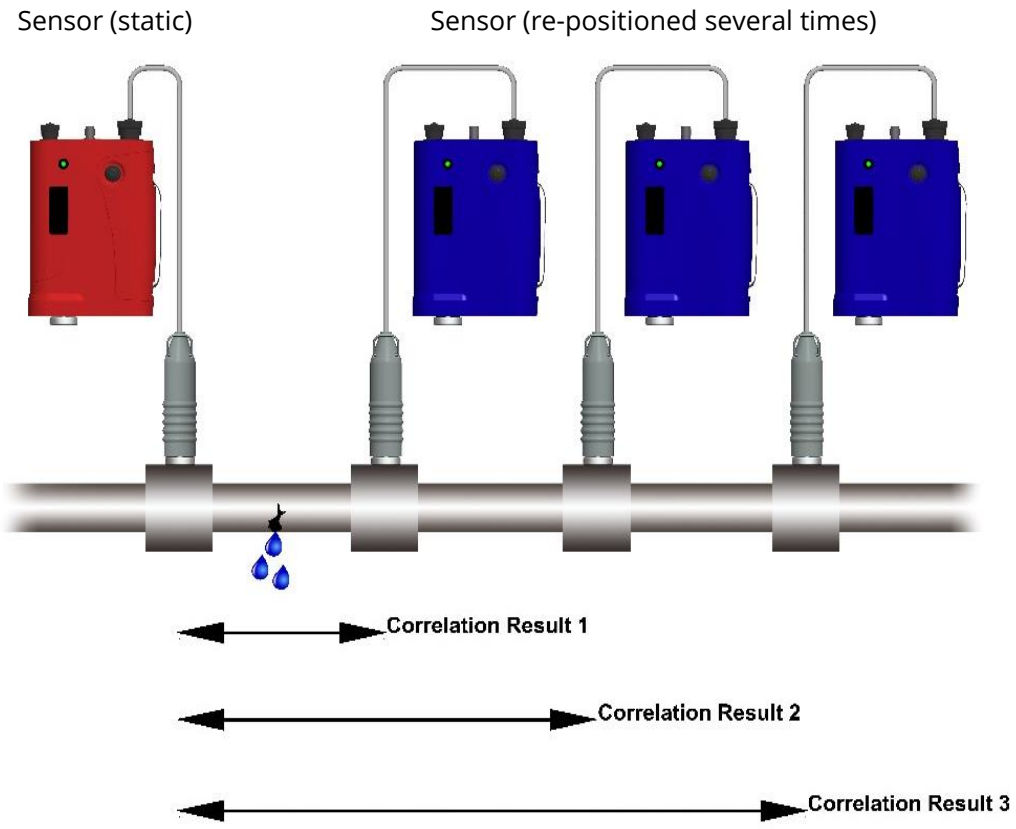
7.4.1 Purpose /Overview

It should be noted that the leak position measurements described so far could be based on an *estimated* velocity of sound within the pipe (especially when the structure of the pipe network is unknown). Greater confidence in the result is achieved if two or more correlation runs are conducted for the same leak.

Compute mode provides an additional way of pinpointing leak positions by using a set of correlation results, rather than a single correlation result. This also provides a useful way of obtaining a more accurate calculation of the sound velocity.

Where the same pipe material and diameter are used within the network, the time delay / distance relationship of the correlation is theoretically linear. Therefore, as the distance between a sensor and the leak noise increases, the time taken for the sound to reach the sensor increases proportionally with the distance. (e.g., if you move the sensor twice as far away, the sound will take twice as long to reach it).

It is this linear relationship that makes it possible to determine the sound speed (and therefore the leak point) automatically, when using a set of correlation results.



In **Compute mode** the base unit will give you the leak position from the ***static sensor***, based on multiple correlations taken when ***moving the other sensor*** to several different access points away from the leak.

To use compute mode, several correlations need to be produced (3 or more is recommended). Each correlation needs to be saved (see section 7.3). One sensor should be kept static (fixed) on a selected pipe fitting and the other is moved from fitting-to-fitting, each time making a new correlation run (and saving it).

Compute mode enables the operator to utilize a set of previously stored leak position files to compile a computed result. Care must be taken to ensure that all correlation files used in Compute mode are taken from the same leak site and that one sensor remained on the same fitting for all of the selected runs; It does not matter which of the sensors remains static. Simply enter the set of relevant files to produce the computed calculation and graphical plot.

The compute function calculates the sound velocity based on the sum of correlation graphs previously entered, thereby giving you a more accurate overall correlation result. At the end of the compute function, a graph is displayed showing all correlation results pinpointed. An average line is drawn through each correlation in order to pinpoint the leak position.

7.4.2 Using Compute mode

To use compute mode, follow the normal procedure for a standard leak correlation.

- Select Pipe Material.
- Select Diameter.
- Enter the Pipe length (i.e., the distance between sensors).
- Correlate and obtain a definite peak.
  (Adjust filter settings as required to obtain a good correlation peak).
- Select the “FILE” menu and save the correlation result.

Then, move one outstation and repeat the correlation procedure, inputting the new pipe length and saving the new correlation result.

HWM-Water Ltd recommends at least three separate correlations be conducted in this manner. The more times this correlation process is repeated, the more data is available to improve the overall accuracy of the combined correlation graph.

Once the set of correlation files have been prepared (as above), the operator is now ready to commence the compute operation…

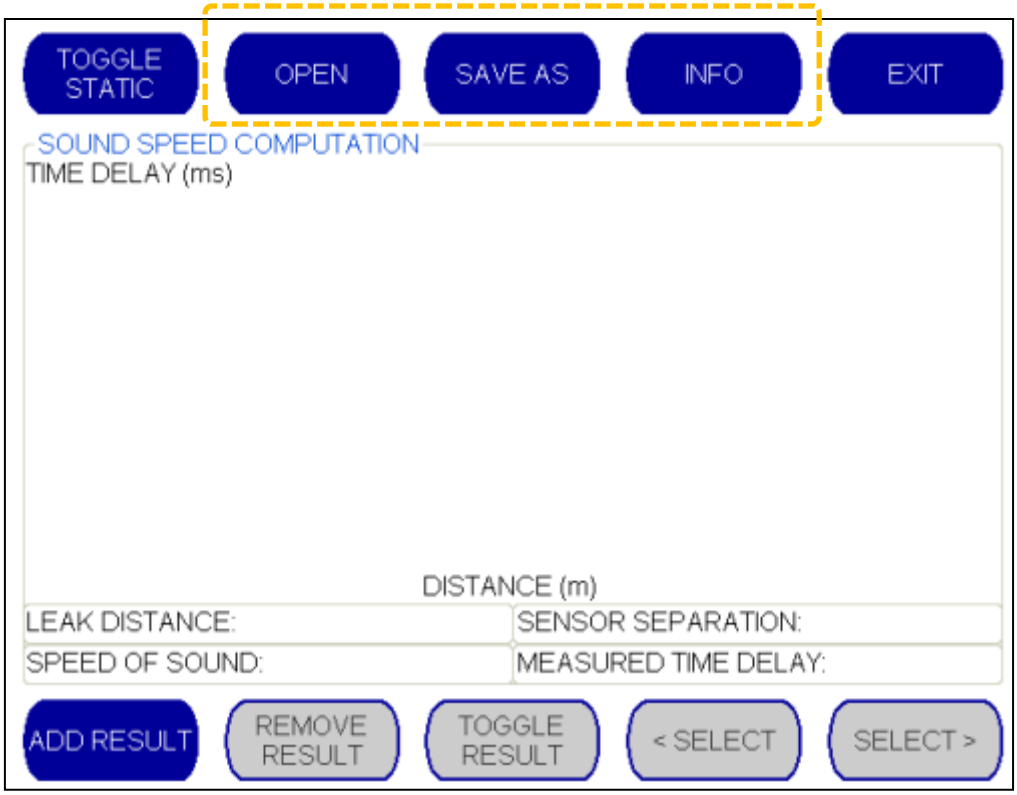
The Compute Mode is accessed as follows:

(main screen) → Menu → Compute

When ‘Compute’ is selected, the ‘Sound Speed Computation’ screen will be displayed.

It initially looks as shown opposite.

The screen includes a set of buttons that can be used to drive the file system of the Touch Pro. These operate in a similar manner to that described in section 7.3, and will not be described in any detail here. However, please note that they apply to Compute Mode data in this context (i.e., for saving and opening Compute graph results).

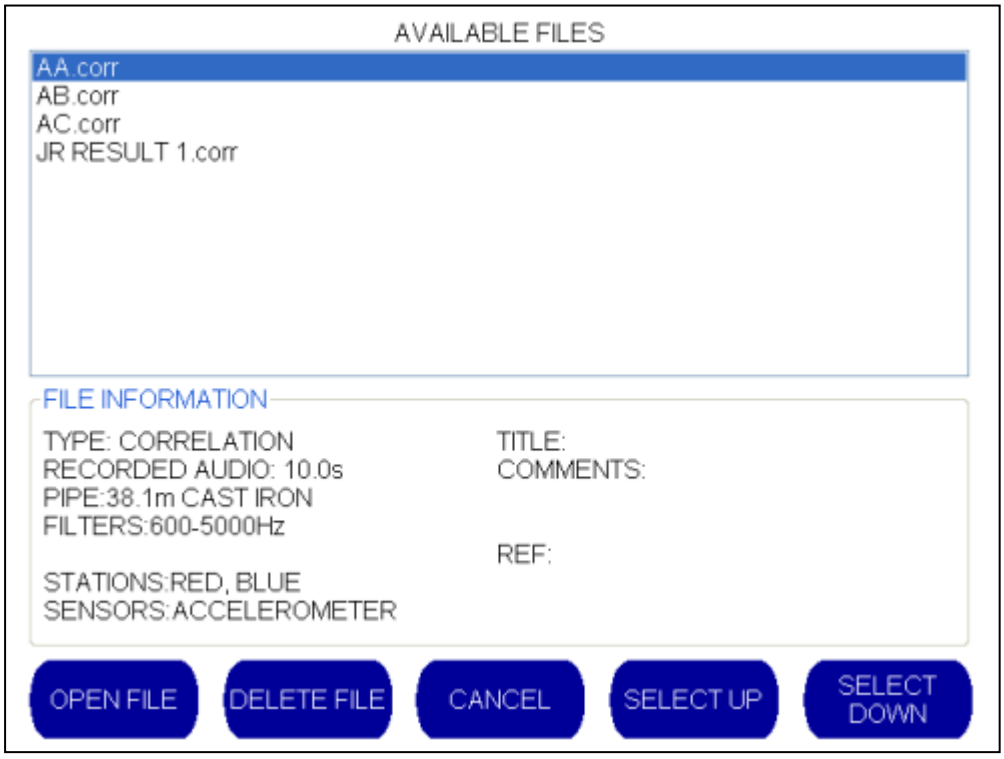


To proceed with the Compute mode, the operator must add the set of previously saved correlations to the computation screen (shown above).

Tap on the “Add Result” button.

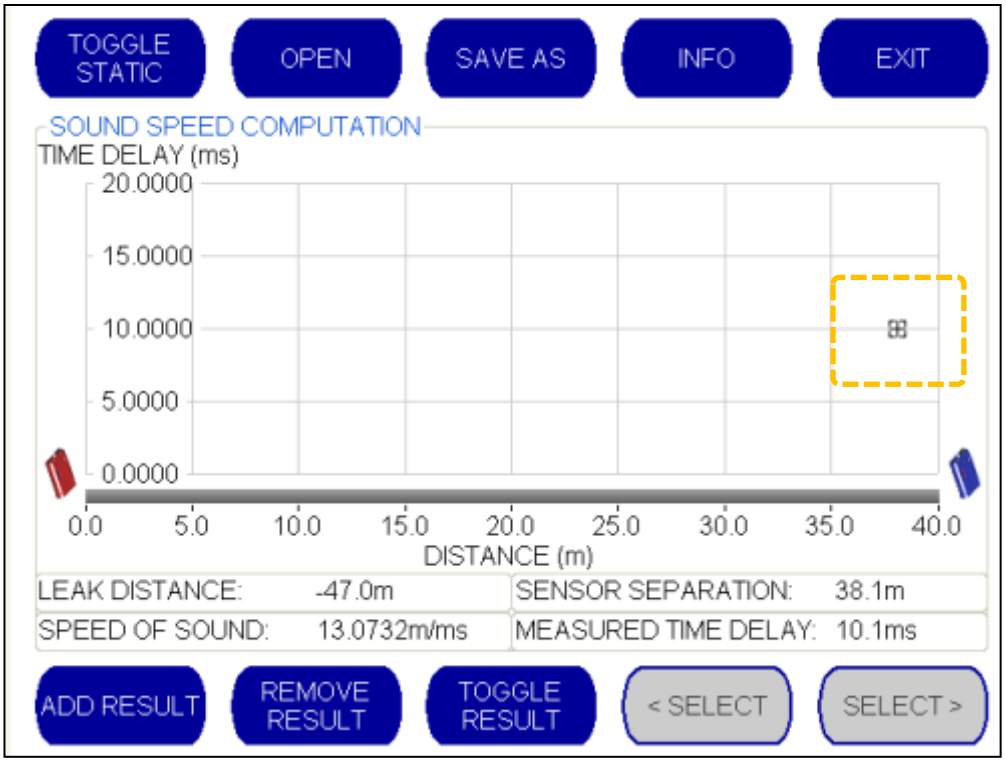
Then select one of the saved correlations.

(Note that all selected correlation must have been conducted with the stationary sensor remaining in position; The correlations must vary only by re-positioning the moving sensor to different locations along the pipe).



Then select “Open File” to load this correlation result into the Compute graph.

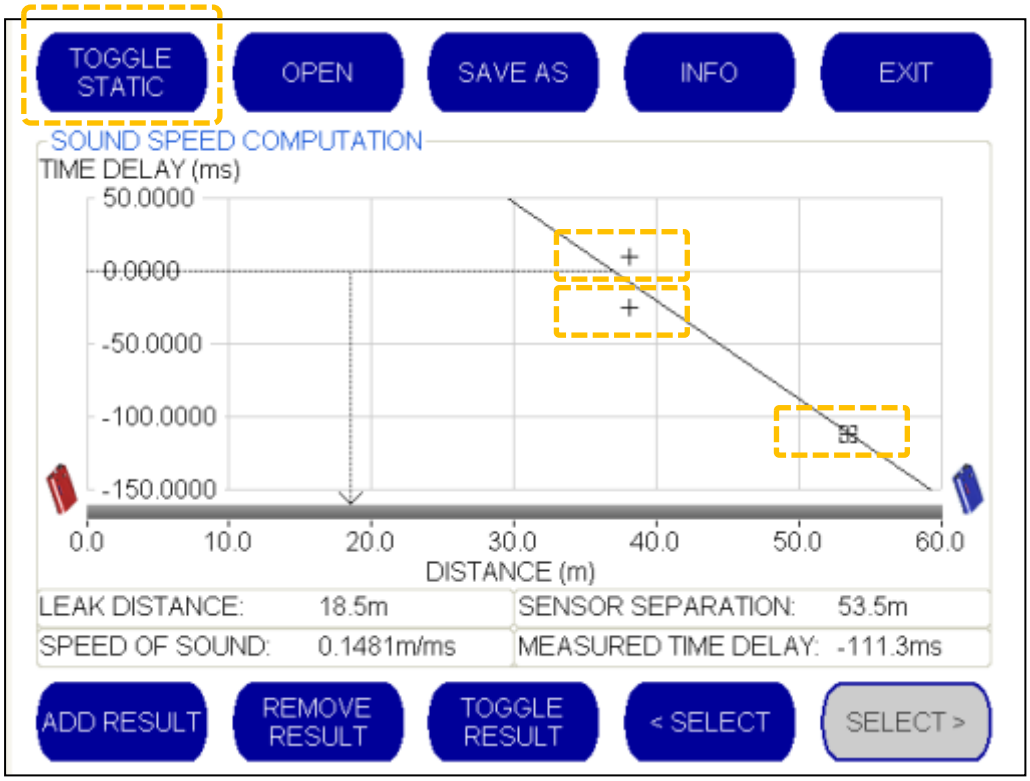
The selected correlation result will now appear as a cross hair on the Sound Speed Computation screen, as shown in the example opposite.



Repeat this procedure to add all of the correlation results conducted on the pipe into the Sound Speed Computation screen.

In the example opposite, three correlation results have been plotted onto the Compute graph.

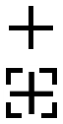
The base station, by default, assumes that the red outstation has remained static during the different correlations.
If this is not correct, press the "Toggle Static" button to swap.



Note: The static correlator must always be displayed on the left-hand side of the graph.

The markers for the correlation results should give a good approximation to points on a straight line when plotted on the graph (the more points available on the graph, the better it will be to see where the line should be drawn). However, if there are some “outlying” results these should be removed from the graph…

Correlation results are shown as a “ + “ or “[+]” symbol on the graph.



The “[+]” symbol is also a cursor, identifying the “currently selected correlation”.

To move between the different correlation results displayed on the Compute graph, use the “ < SELECT ” and “ SELECT > ” buttons.

Any Correlation results which are considered by the operator to be significantly 'off-the-line' and therefore skewing the leak position can be excluded from the computed results.

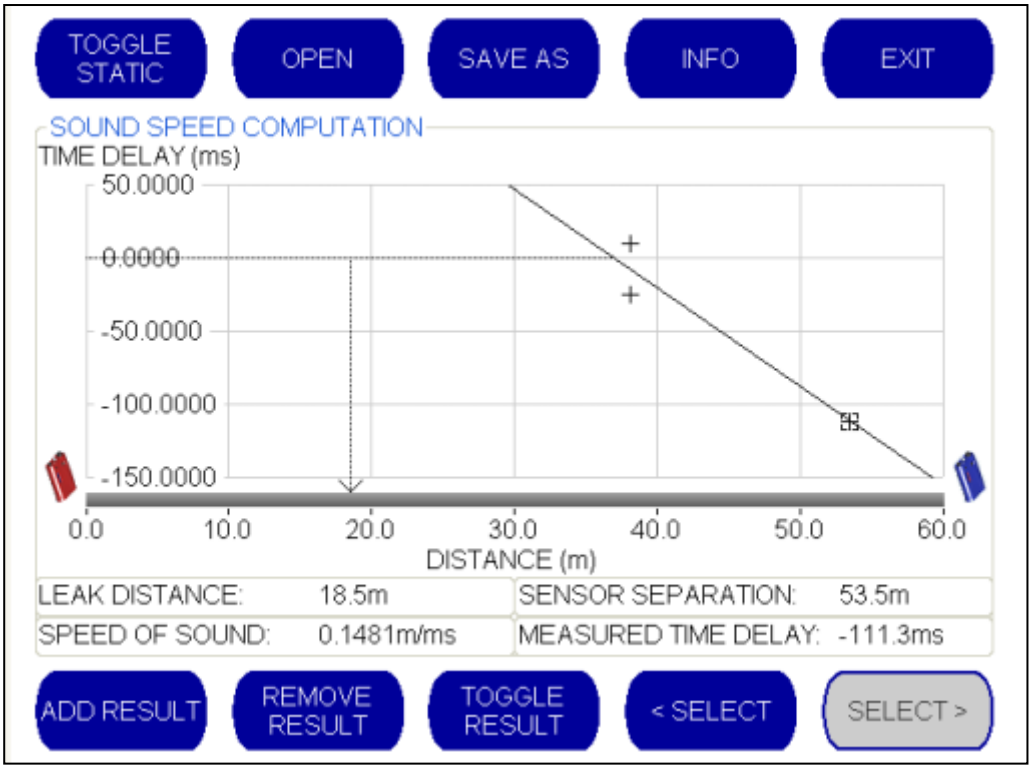
Move the cursor over the erroneous correlation result.

The “Toggle Result” button can be used to temporarily exclude this specific result from the computed results. The correlation result remains on the screen but does not influence the plotting of the compute position until the “Toggle Result” button is pressed again.

Alternatively, a correlation result can be permanently removed from the Compute graph completely by moving the cursor over the result and selecting the “REMOVE RESULT” button.

The greater the number of correlations used, the more easily an erroneous result can be spotted.

7.4.3 Understanding the Data Produced from a Computation



Since the correlations had sensors placed at different distances between them, the results will also show different time delays. The graph has to accommodate all correlation results. Therefore ...

- The X-axis of the graph shows distance
  (scaled to allow all of the selected correlation files to be included).
- The Y-axis of the graph shows time delay,
  (scaled to allow all of the selected correlation files to be included).

The correlator draws a straight line through the points (correlation results) in order for the operator to spot any significantly outlying points ; the effect of these should be removed from the results.

The information panel on the screen should be considered a two separate panels ; the one on the left shows the over-all result of the computation ; the one on the right shows information relevant to the single correlation identified by the cursor position.

- Sensor Separation – This displays the distance between the non-static sensor and the static sensor for the *selected* correlation.
- Measured Time Delay – This is the time delay for the *selected* correlation
- Leak Distance (& vertical arrow) – This displays the result of the Compute graph, giving the distance between the identified leak position and the stationary outstation.
- Speed of Sound – This displays the speed of the sound traveling through the pipe that has been calculated by the Compute graph.

8 MATERIAL DATABASE (EDIT / DEFINE PIPE MATERIALS)

The Touch Pro base unit has a built-in database of pipes of differing material types and diameters. Each pipe material type and pipe diameter is pre-programmed with the expected speed of sound traveling through it. This data enables the correlator to obtain a good estimate for the speed sound in a pipe network when doing correlations, allowing it to pinpoint the distance from the sensors to the leak (when the correct pipe material(s) and diameter(s) are identified).

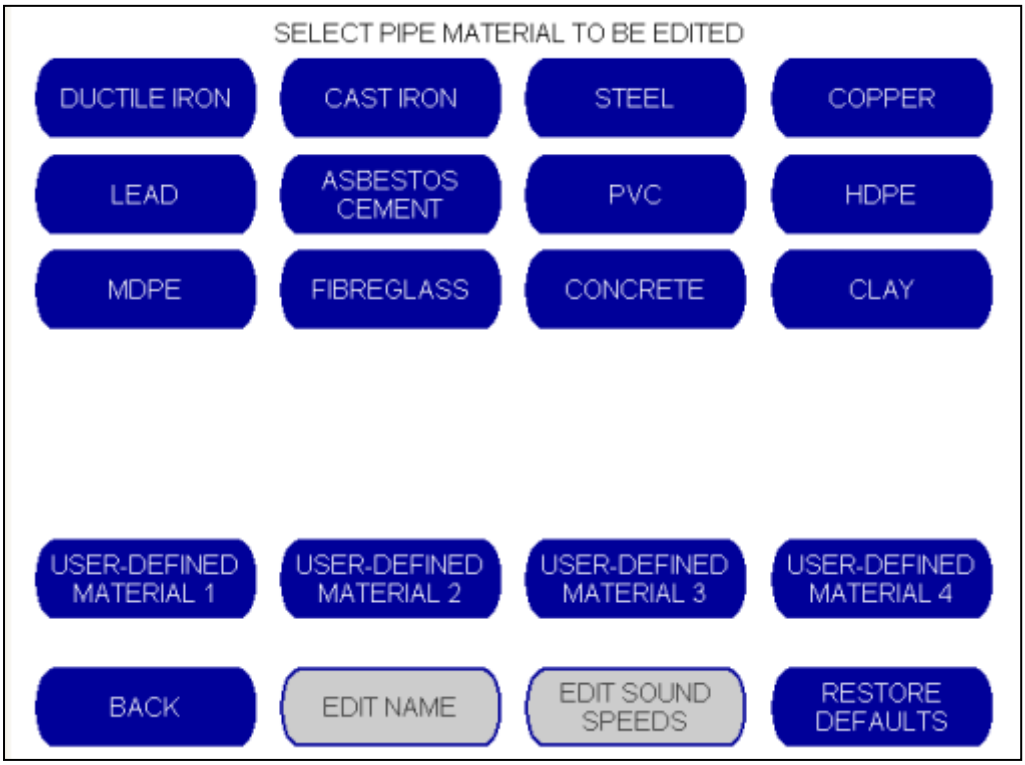
The Material Database screen is accessed as follows:

(Main screen) → Menu → Material Database ; (Its title is "Select Pipe Material to be Edited).

The Material Database screen allows the operator to edit the name and sound speeds of the pre-programmed pipe materials stored in the Base Unit. It also allows up to four additional user-defined materials to be stored.

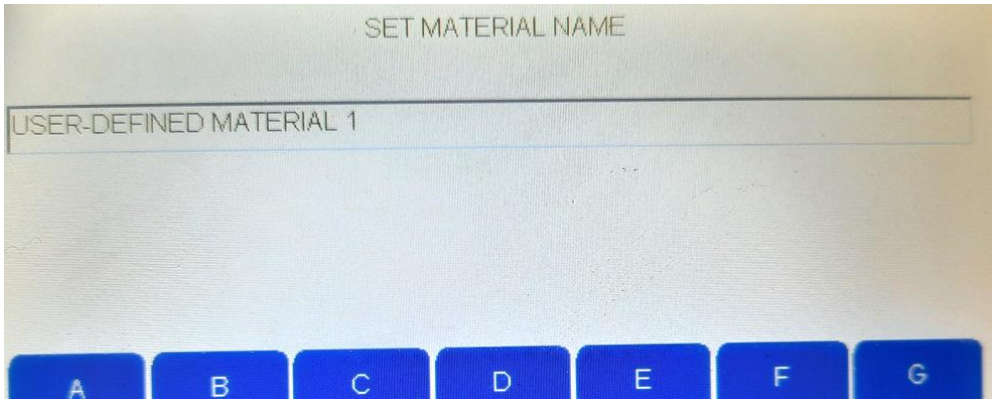
To edit the name of a pipe material:

Select the pipe material to be edited (tap on a material button ; it will turn red) and then tap on "Edit Name".



Use the virtual keyboard to input the new name or to edit an existing one.

Tap on "Enter" to accept.

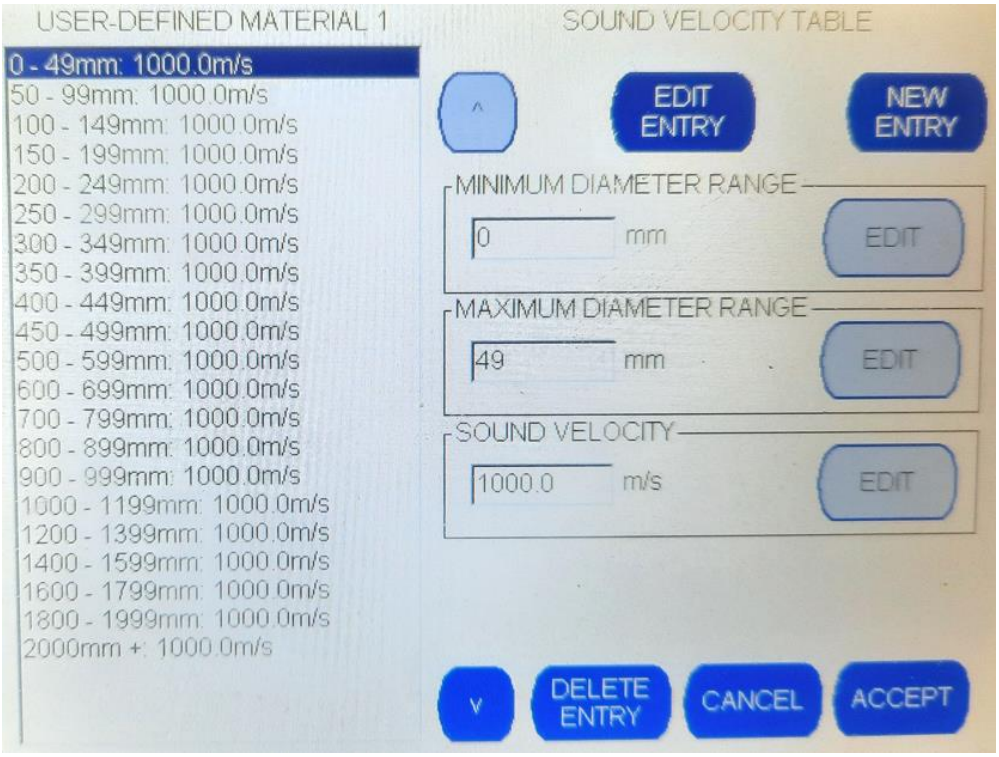


You will be returned to the Materials Database, where the new name will be displayed.

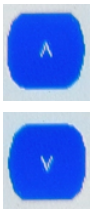
To edit the Sound speeds for a pipe material:

Select the pipe material to be edited (tap on a material button ; it will turn red) and then tap on "Edit Sound Speeds".

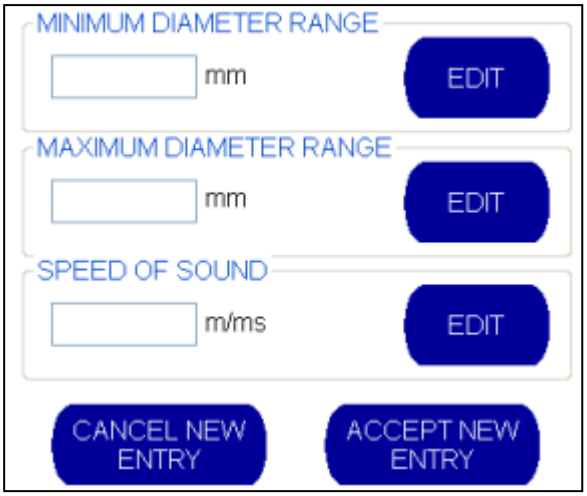
The "Sound Velocity Table" screen is displayed, complete with a table showing the database contents for the selected pipe material. Check each sound velocity (speed) value (see also section 10).



The operator can use arrowed buttons to scroll up and down the sound table displayed on the left-hand side of the screen.
This will automatically populate the fields, enabling the operator to edit only the field(s) that require changing.
Lines can also be inserted (New Entry button) or can be deleted (Delete Entry button).



Tap on "Edit Entry" button to enable editing of the specific line ; this activates the edit options. A numeric keypad pops up ; Edit the value and then tap on "Enter"



When the table line is complete, tap on "Accept New Entry".

When the table editing is finished, tap on the "Accept" button to end the editing of the material table.

9 MULTI-GRAPH MODES

9.1 CORRELATION DISPLAY (1 HISTOGRAM / 3 HISTOGRAM)

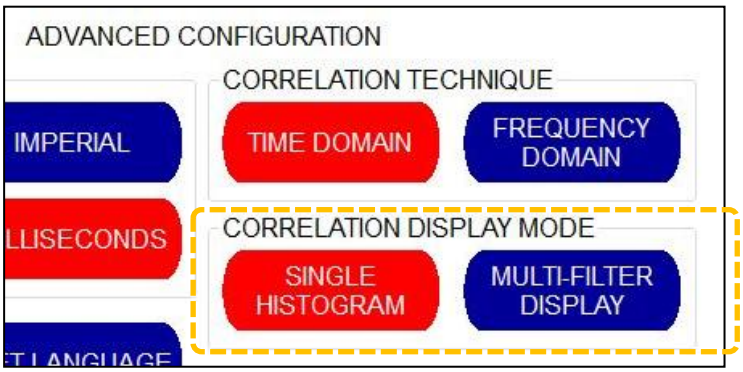
The default setting is to display a Single Histogram graph during the correlation. For a single graph, with AFIS disabled, only one set of audio filter settings can be applied. It is however possible for the Touch-Pro to display three separate graphs, with each using its own manual filter settings.

The setting for this is in the Advance Configuration screen, accessed as follows:

(Main screen) → Setup → Advanced Setup

The currently selected option for correlation display mode is shown in red. ('Single Histogram' display).

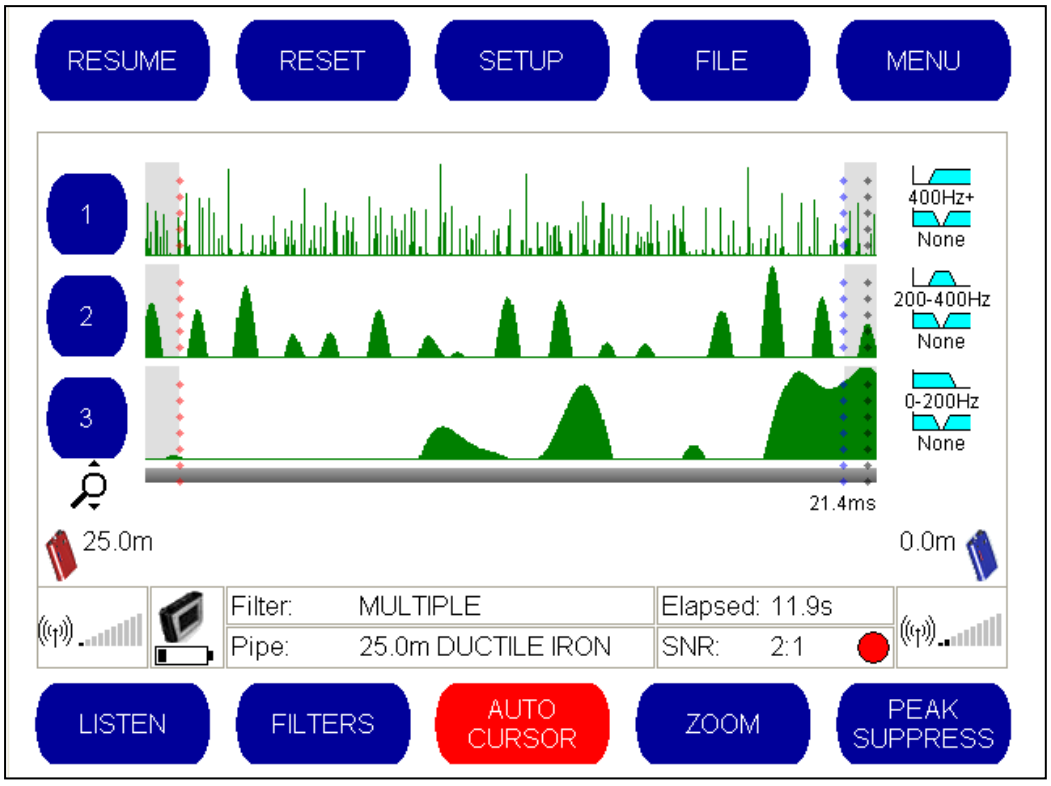
This can be toggled to the 'Multi-Filter display' if required.



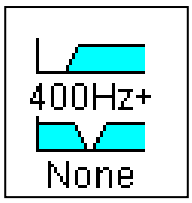
When the Multi-Filter Display option is selected, the main correlation screen changes to simultaneously, display three correlation graphs, as shown below.

This setup allows the operator to perform *three* different correlations *simultaneously* at the leak site.

Each graph has different filter settings applied, thereby enabling the operator to choose (at a glance) the best out of the correlation results that are on display.

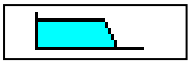


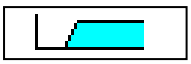
Next to each graph there is a ‘filter icon’, which also behaves as a button.

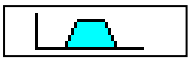


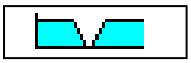
The images displayed on the icon will vary, according to what filters are set.
The filter type images are spread across 2 lines and includes frequency details.

The images represent the following:

 Low-pass filter

 High pass filter

 Band pass filter

 Band stop filter.

Note: The white areas in the above icons signify a stop band.
The cyan (light blue) shaded areas indicate a pass band.

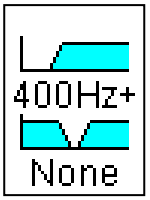
This is the opposite way around to the filter setting screen, where white areas signify a pass band and shaded areas (grey) signifies the stop band.

Be careful to remember this when adjusting filter settings.

The filter settings can be adjusted.

To edit the settings, tap on the filters icon of the relevant line.

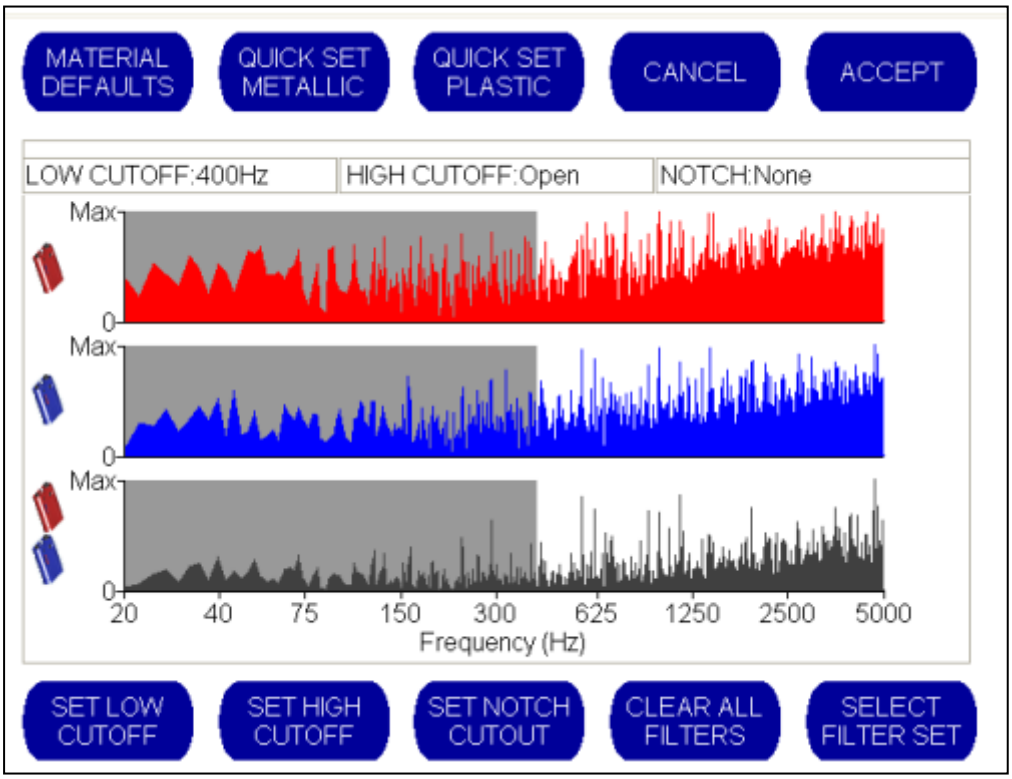
You will be taken to a filter setting screen (similar to that described in section 7.2.5 ; each of the 3 graphs will have its own settings).



The filter settings can now be changed.

When filter settings have been changed, select “Accept” to return to the main correlation screen.

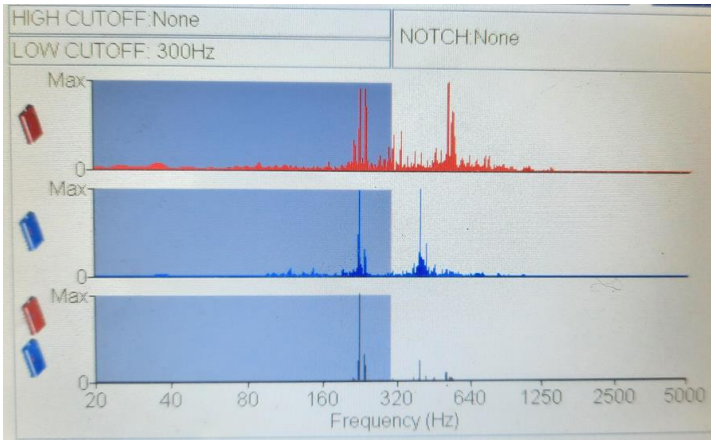
Repeat the process for the other filter settings if required.



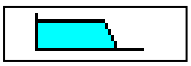
An example of a setup for a High pass filter response is shown opposite.

High-pass filter 

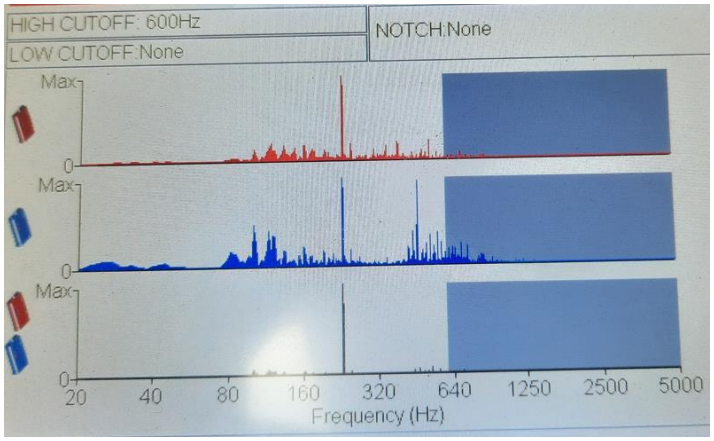
(Implemented by ‘set low cutoff’ button)



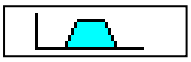
An example of a setup for a Low pass filter response is shown opposite.

 Low-pass filter

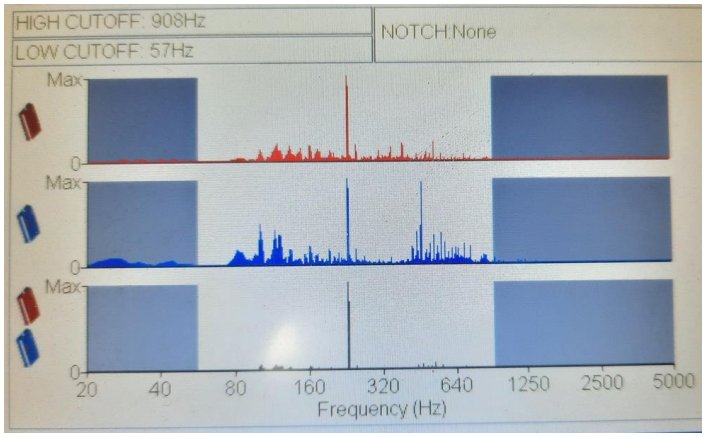
(Implemented by ‘set high cutoff’ button)



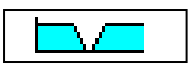
An example of a setup for a Band pass filter response is shown opposite.

 Band-pass filter

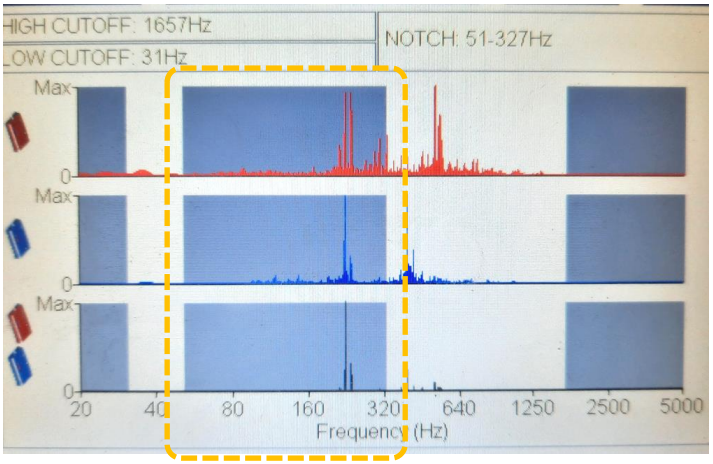
(Implemented by both ‘set low cutoff’ button and also the ‘set high cutoff’ button)



An example of a setup for a Band stop filter response is shown opposite.

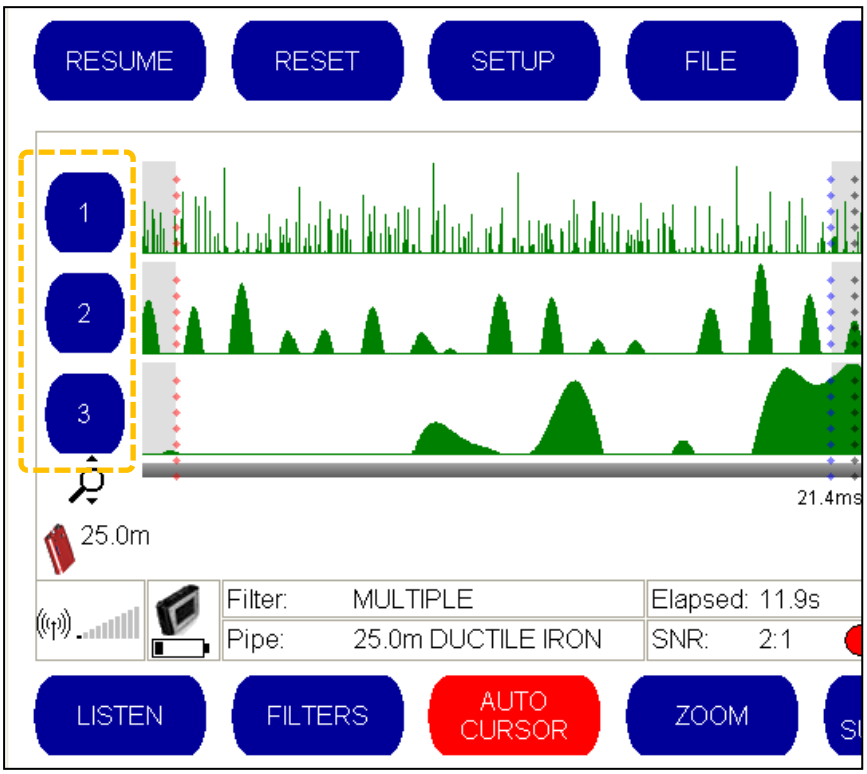
 Band stop filter.

(Implemented by ‘set notch cutout’ button)



For convenience, each correlation graph is numbered 1, 2 and 3.

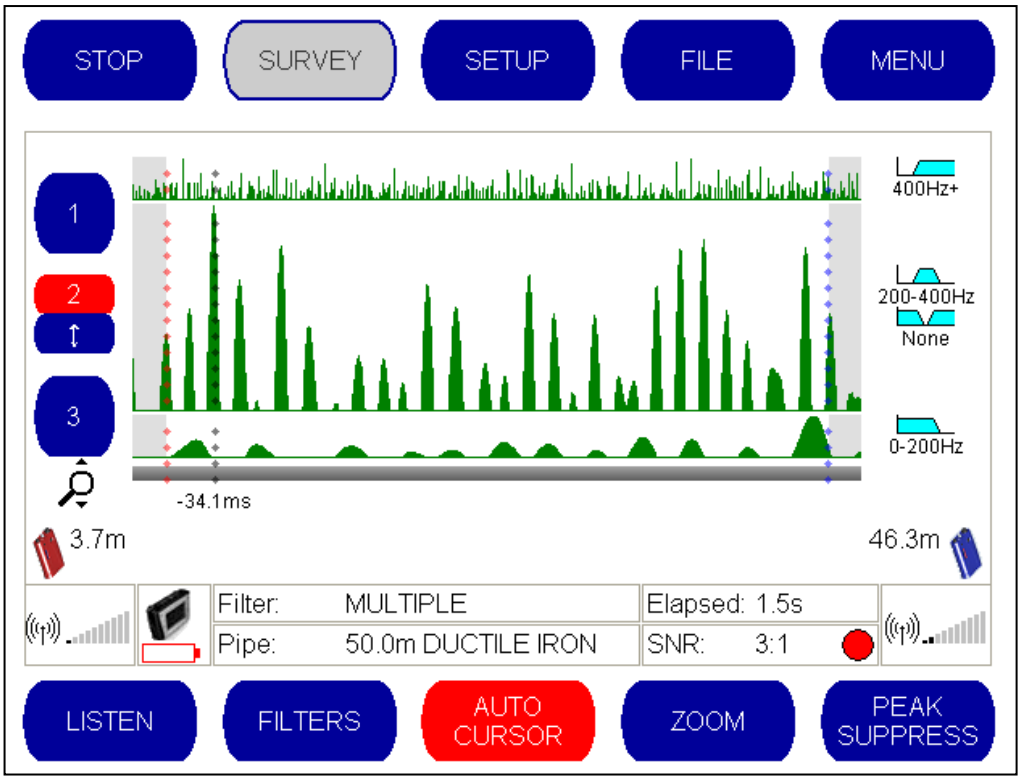
Pressing one of these numbers will expand that particular graph. Other graphs shown on the screen will be reduced in size.



For example, if the middle graph were required, pressing the blue button labelled “2”, shown to the left of the graph, will change the display as shown below:

If the operator wishes to select the filter settings used to generate Graph Number 2, tap the small blue arrow button underneath the number.

This will apply these filter settings and return the operator to a single histogram view showing the correlation produced with these filter settings.



This feature (3 graph display) is particularly useful when pipe material is uncertain or when performing a survey to identify whether (or not) a leak is present on the pipe.

9.2 SNAPSHOT OPTIONS (GRAPH COPY)

The Snapshot feature enables the operator to record (for comparison purposes) a still image of the correlation graph at any time during a real-time correlation. This is useful for highlighting temporary noises such as a flushing toilet or sudden traffic noise that might interfere with the correlation result.

Note: In order to use the Snapshot Options features, the current graph must first be frozen (paused by tapping on the 'Stop' button).

(Note that whilst the Snapshot Options features are being described here for use with the Correlation mode, the feature operates similarly during the Survey mode).

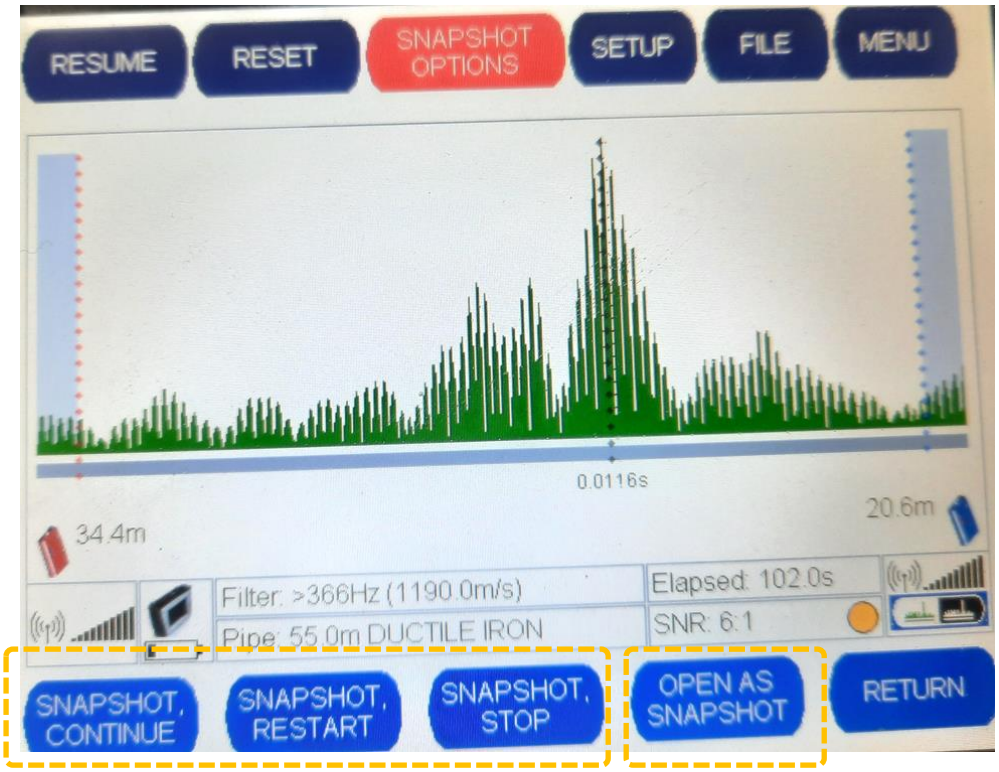
The Snapshot Options features are accessed as follows:

(Main screen) → Menu → Snapshot Options

The Snapshot button turns red when selected. (The option can be cancelled by tapping on the 'Return' button).

The bottom row of buttons are re-assigned new functions for allowing a snapshot of the current graph to be taken.

Also, there is a button related to the file system.



Tapping on one of the blue 'Snapshot …' buttons will cause the screen area to be split to support an additional graph. The live correlation is shown within the lower graph area. The snapshot of the correlation is shown immediately above it.

The choice of which button to press is related to the correlation (which is currently paused):

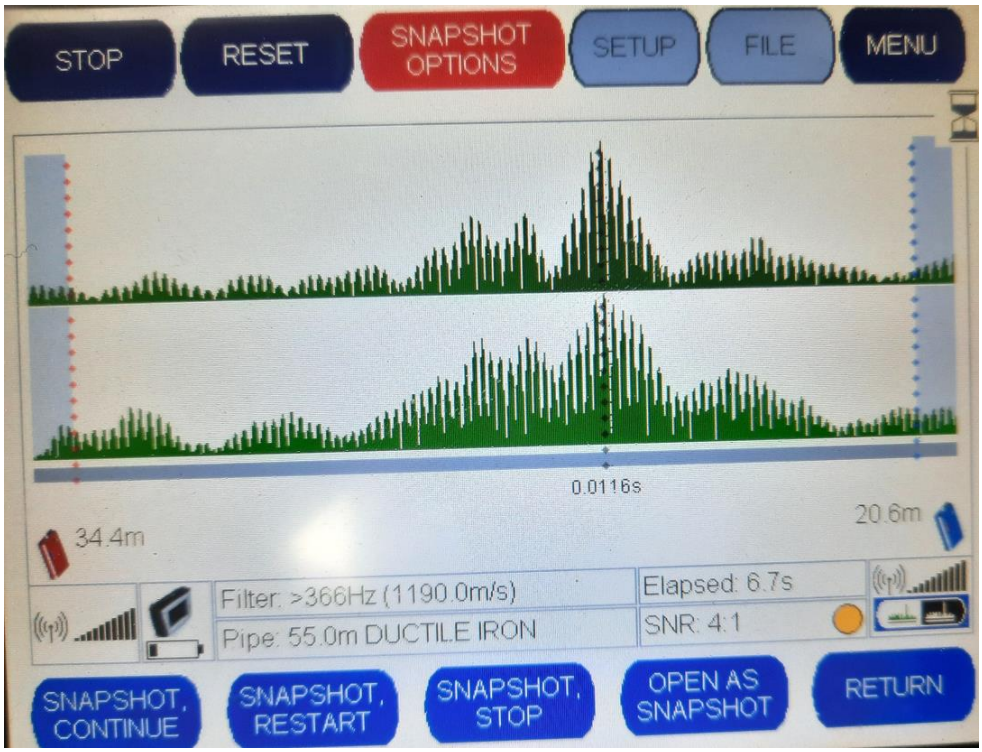
- The "Snapshot, Stop" button makes a copy of the current result, and the correlation remains paused.
- The "Snapshot, Continue" button makes a copy of the current result and allows the current correlation to continue (it is resumed).

- The “Snapshot, Restart” button makes a copy of the current result and then starts a new correlation (displayed on the on the lower graph area).

The Snapshot feature effectively enables the operator to compare noise levels at different points during the correlation process. When the “”Snapshot. Continue” or “Snapshot. Restart” buttons are selected, the static snapshot image appears towards the top of the screen, while the real time correlation continues to run underneath.

An example of the ‘Snapshot. Continue” button press is shown opposite.

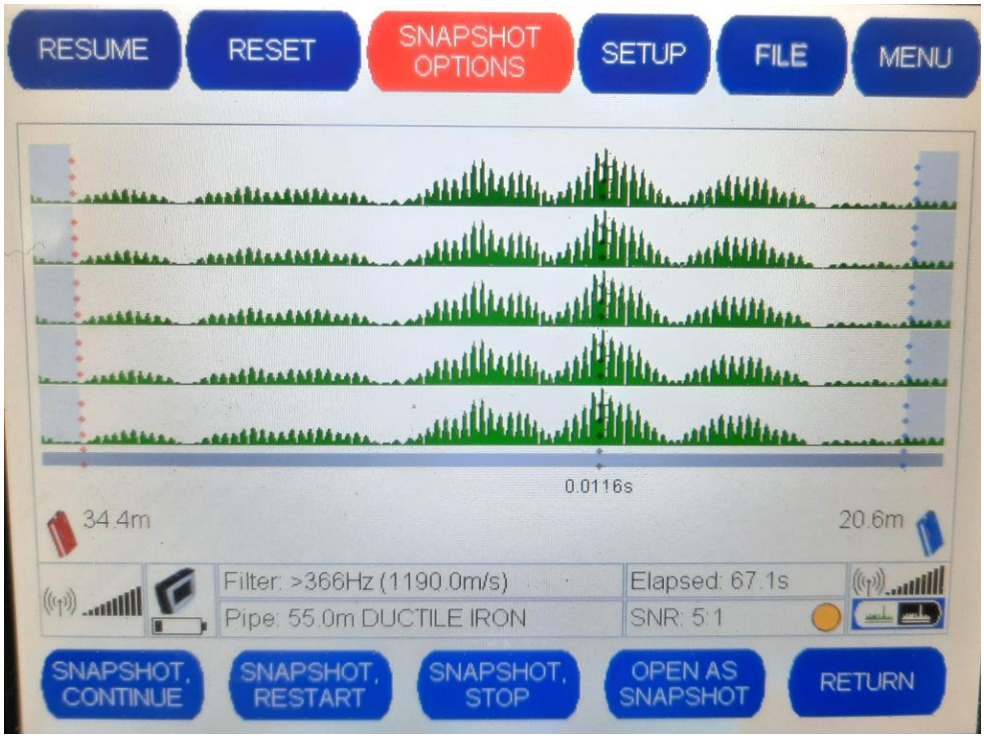
In this example, the original graph contents now occupy the upper graph area whilst the live correlation (which is running) occupies the lowest graph area (and the graph shape has moved on from the snapshot image).



The Snapshot process can be repeated, with up to 4 snapshots being taken.

The graph size reduces each time to accommodate the new image (as shown opposite).

(The live correlation is always the lowest graph).



- The “Open as Snapshot” button opens an existing correlation as a snapshot.

10 VELOCITY CALCULATION (SOUND SPEED CALCULATOR TOOL)

The Touch Pro correlator contains a handy tool for calculating the speed of sound within a pipe or pipe network. It has various pre-conditions:

- The length of the pipe must be known.
  The pipe details must have been entered as part of a correlation.
- The leak (or another sound source) can be in-bracket or out of bracket.
  If the leak (or another sound source) is in-bracket, its position (distance from one of the sensors) must be already known.
- A correlation must be in progress.

The tool has various uses:

- The current speed of sound (from the material table) can be substituted by the calculated value.
- New pipe materials can be characterised and stored as a user-defined material (for future use).

The sound speed Calculation tool is accessed as follows:

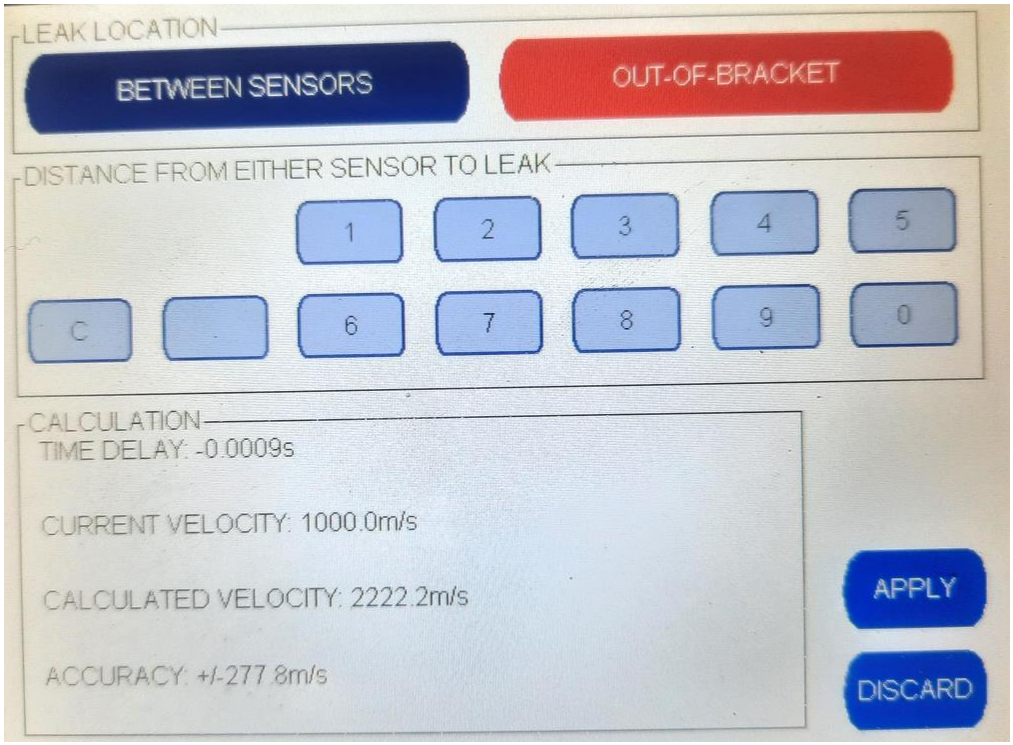
(Main screen) → Menu → Velocity calc

The user must select one of the buttons on the "Leak Location" panel.

If the sound source is out-of-bracket, select that button.

If the sound source is in-bracket, choose the 'Between Sensors' button.

(See the discussion of in-bracket vs out-of-bracket in section 14 for an explanation of these terms).



10.1 Out-of-bracket calculations

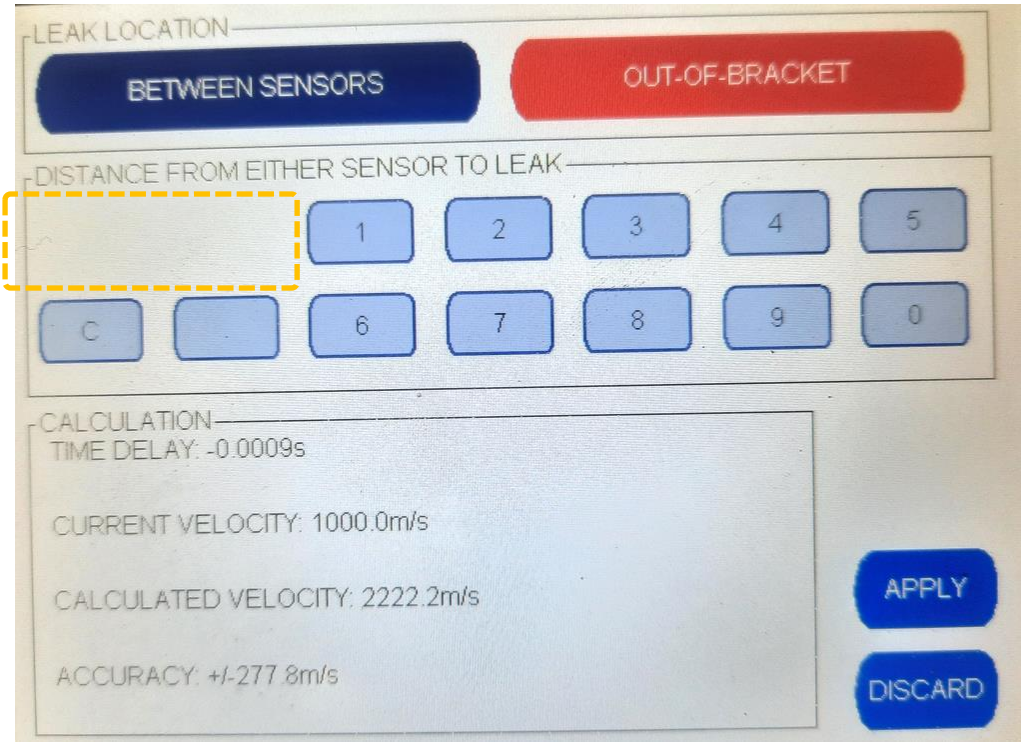
The out-of-bracket sound calculation is the easiest to understand.

If the sound source is outside of the space between the connectors, it reaches one sensor first (the near sensor). It then travels the full length of the pipe between sensors and is picked up by the other sensor (the far sensor).

In this situation, the pipe length (between sensors) is known. Also, the time-difference is the time the sound took to travel down the known length.

Since Speed = Distance / Time … the speed of the sound can be easily calculated.

In this situation, the keyboard shown on the screen does not get used ; there is therefore no field available to enter a value.



The calculation results are shown in the Calculation panel.

10.2 In-bracket calculations

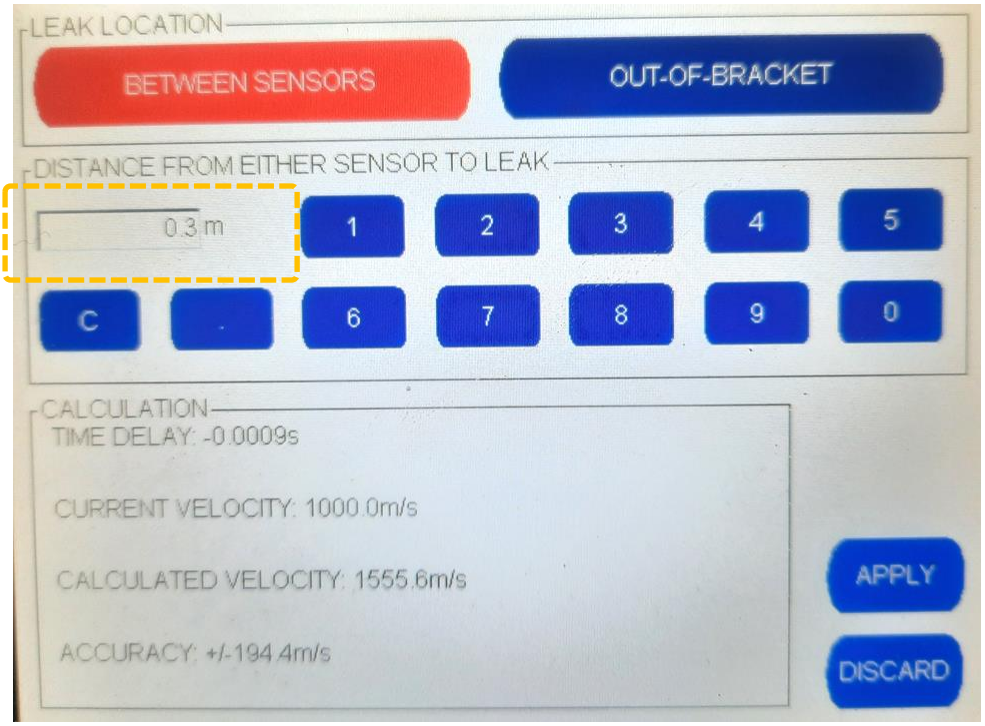
In-bracket sound speed require the leak position (distance from any one of the sensors) to be already known ; this is input into the calculation screen.

The correlator requires the shortest distance to a sensor. Since the total pipe length is also known it is easy to determine whether the input distance value is for the sensor nearest the leak (the distance is less than half the pipe length) or the sensor furthest from the leak. The correlator measures the time difference between the sound arrival at the two sensors. From this it can calculate the speed of sound through the pipe.

Speed = distance / time … = (total length – (2 x shortest distance to sensor)) / time

The user must input the distance to one of the sensors using the keypad.

The results are calculated immediately and shown in the Calculation panel.



10.3 USING THE VELOCITY CALCULATION RESULT

A calculated velocity can either be discarded or used.

Tap on the 'Discard' button or the 'Apply' button respectively.

When 'Apply' is selected, you are returned to the correlation screen, but the sound speed being used for correlation is updated.

The velocity should be noted if characterising the pipe as a new user-defined material ; it has to be entered manually in the definition of any new material.

For an out-of-bracket calculation, the calculated velocity reading will be useful in the next correlation, when the outstation has been moved so that the suspected leak position now falls between the two outstations. This will bring the leak within the bracket to get a correlation result.

The operator can choose whether to use the velocity calculation from the out-of-bracket attempted correlation to generate a user defined material or to continue using the default material velocities. Note that if generating a user-defined material, the user will have to enter the velocity value on the relevant line of the material table (i.e., for the correct pipe diameter range).

11 STATUS AND SETTING OPTIONS

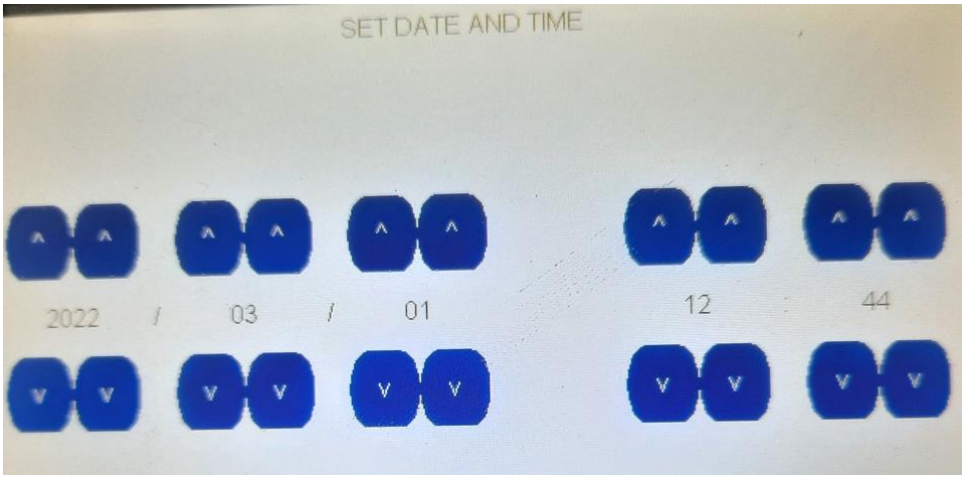
11.1 SETTING THE DATE AND TIME

The date and time can be set on the “Set Date and Time” Screen, which is accessed as follows:

(Main screen) → Setup → Advanced → Set Clock

The date and time can be adjusted by using the relevant up and down buttons.

Then tap on “OK”.



11.2 DISPLAYING THE SOFTWARE VERSION

The software version of the Touch Pro can be viewed as follows:

(Main screen) → Setup → Info

The software version is shown.

11.3 Displaying Radio details and battery information

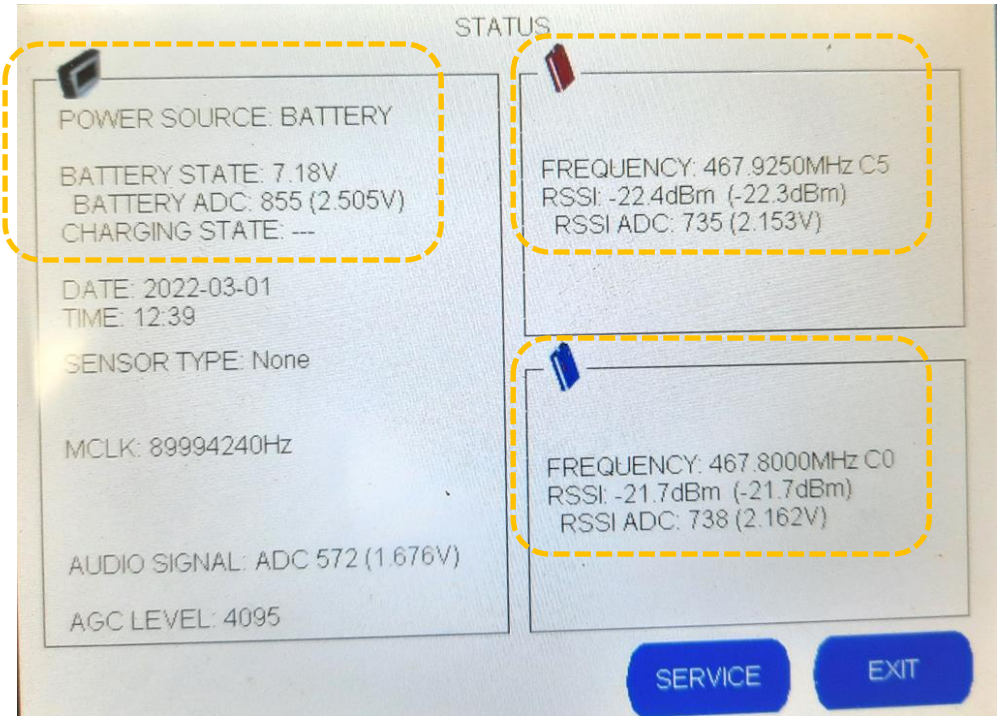
The Status screen gives details of the dual radio channels used by the Touch Pro correlator system.

The Status screen can be viewed as follows:

(Main screen) → Setup → Info → Status

Status information includes battery and charging status of the base unit.

The radio frequencies and received power levels (RSSI ; Received Signal Strength Indication) from the two outstations are shown in the right-hand display panel.



The current power source for the base and voltage level of the internal battery is shown in the left-hand panel.

The RSSI level can be a useful diagnostic tool to check that the signal is being received OK from the outstations.

Pressing the “Exit” button will return you to the Setup screen.

Note: The product name may vary according to market region.

Note: The “Service” button is for use only by HWM-Water Ltd engineering personnel.

11.4 Setting Units of measure

The units of measure used by the Touch Pro console are set within a panel within the Advanced Configuration screen.

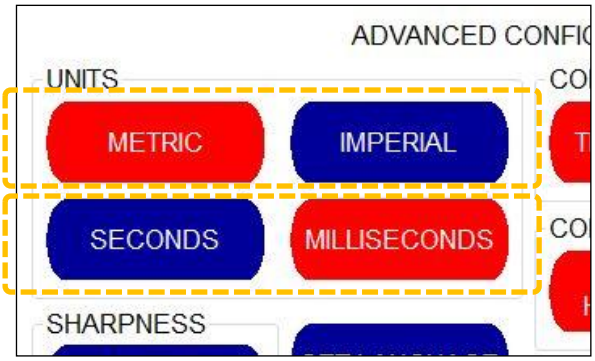
The Advanced Configuration screen can be viewed as follows:

(Main screen) → Setup → Advanced

The operator can toggle between metric or imperial units being used for distance measurements.

Simply press the button to select the unit of measurement required.

(The selected option is displayed in red).



Units used for displaying the time delay can similarly be toggled between seconds or milliseconds.

11.5 Setting Correlation Technique (Time or Frequency Domain)

The correlation technique used by the Touch Pro console is set within a panel within the Advanced Configuration screen.

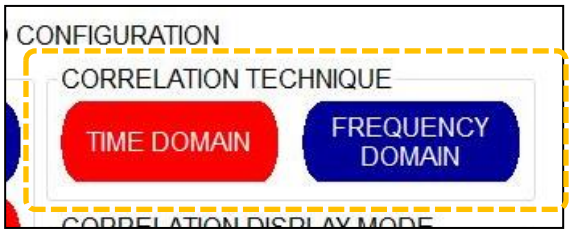
The Advanced Configuration screen can be viewed as follows:

(Main screen) → Setup → Advanced

The Advanced Configuration screen enables the operator to toggle between "Time Domain" and "Frequency Domain", as shown opposite.

These refer to different mathematical processes used to calculate the correlation result.

Tap a button to make a selection.
The selected option is displayed in red.



Note: This setting is for advanced user only.
HWM-Water Ltd recommends that the pre-set time domain correlation technique be used.
However, it should be noted that Frequency Domain may speed up correlations in long pipe situations.

11.6 Sharpness Settings

The Touch Pro incorporates a sharpening function to help pinpoint leaks where the correlation data has broad rounded peaks, as commonly happens with plastic materials.

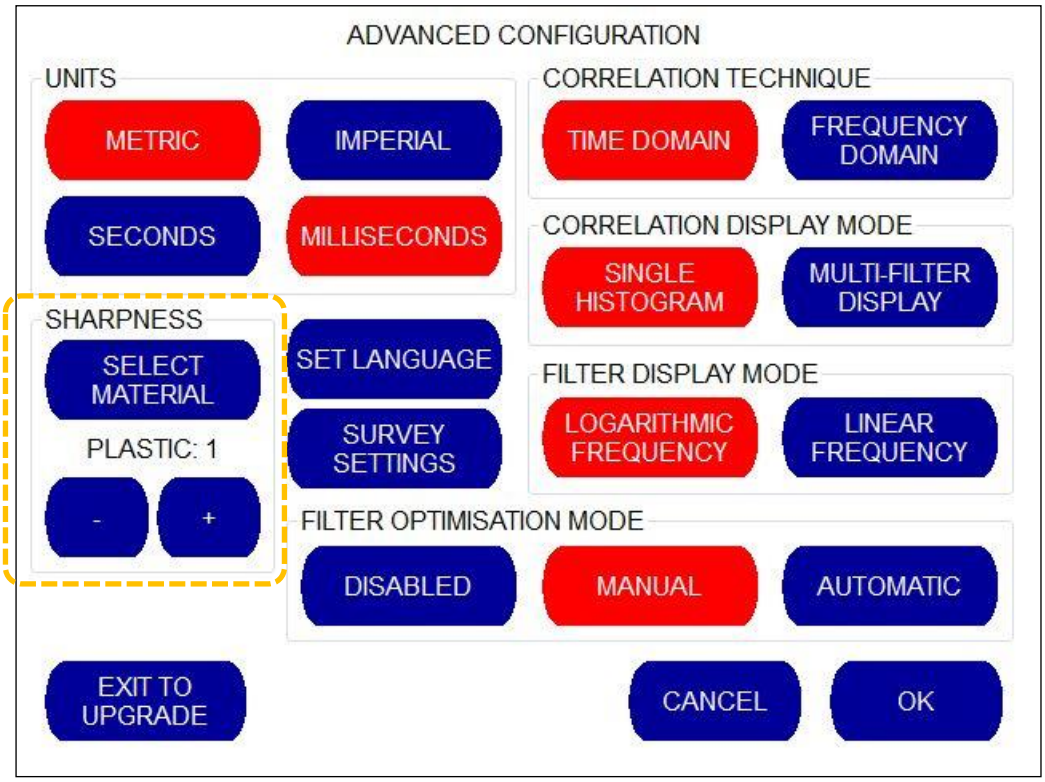
There are two sharpness values, one used for plastic pipes and one for all other materials.

A value of 0 represents no sharpening. Values in the range of 1-15 represent increasing degrees of sharpness.

Plastic pipes normally require a higher value. The default values are 2 for plastic and 0 for other materials.

Use the 'Select Material' button to determine which value to change; the material is shown below the button.

Then use the + and – buttons to adjust the value.



12 TROUBLESHOOTING

Problem: There is no RF Signal being received from the Outstations.

Recommended Actions …

- Check that the outstations are switched on.
- Check that the antenna is connected, and that the RF connector is clean.
- Check that the outstation is registering the connected sensor (LED Flashes).
- Check the Outstation and Base Unit battery levels.
- On the Base Unit, check that you have the correct stations selected (e.g., correlate between RED–BLUE not RED-BASE)

- On the Base Unit check in the display screen that the outstation frequency is correct and that the RSSI should approximately -80dBm or less.
  Check the battery level shown for the base is at a minimum 7.2V.
- If standing close to one of the outstations and receiving no RF signal from the other check that the nearest outstation is set to low transmit power.

Problem: The RF Signal is being received but it is very weak.

Recommended Actions …

- Check the battery levels on all units.
- Check that the antennas are not damaged.
  (e.g., The outstation antennas can be swapped to see if the problem follows the antenna).
- There may be interference from another RF system operating in that area on the same frequency.
- Check that the outstations are at least 2m away from the Base Unit.
- To improve signal strength, try using a mag-mount antenna on the base unit.

Problem: Audio being received but the correlation peak is poor.

Recommended Actions …

- Check for leak noise signal at both outstations through the headphones to ensure leak noise can be heard as clearly as possible
- Check that both sensors are working correctly (sensor test mentioned above).
- Check that both Outstation signals are being received over the RF clearly at the Base Unit through headphones.
- Adjust the filters on the Base Unit to take out any unwanted ambient noise.
- Try correlating at a different time of day/night in case there are pumps or other external noise sources interfering with the correlation result.
- Check sensor cables and connectors for damage.
- If using an accelerometer type sensor, try to improve the leak noise audio signal level from the sensor:
  - Ensure that the accelerometer mounting point is on the pipe where the suspected leak is located. Confirm this with a map of the network.
  - Check that the sensor contact on the pipe is clean from debris.
  - Try different contact points on the fitting, if possible, to get the best leak noise (metal surfaces are preferred).
    Always check leak noise at the Outstation with headphones first.
  - Ensure that the accelerometer is mounted vertically where possible.
  - If there is ambient noise, try correlating using hydrophones.

Note: Don't stand too close to sensor when listening through headphones to avoid audio feedback.

Problem: The Main Correlation Screen displays the warning message "Correlation out of bracket".

Recommended Actions …

- This message means that a possible leak has been found, but it is outside of the area in-between the outstations.
  The Touch Pro will not give a position on an out of bracket leak so the outstations will need to be re-positioned so that the suspected leak is in between the outstations.
  Out of bracket leaks can, however, be used to measure the speed of sound for the pipe.

Problem: The Main Correlation Screen displays the warning message "Centre correlation".

Recommended Actions …

- This message means that a correlation peak has occurred exactly at the midpoint between the two sensors.
  This may not be a leak at all. A non-leak noise heard on the pipe could also produce this effect. Therefore, caution is advised.
  Move one outstation to the next convenient point, to ensure the leak position is well away from the center point, and then perform the correlation again to ensure that the result is genuine.

Problem: The Main Correlation Screen shows good peak, but no leak can be heard at that location.

Recommended Actions …

- Check the audio signals at the Base Unit *through headphones* to ensure that the leak noise can be heard as clearly as possible.
- Check that the pipe length entered is as accurate as possible and that the pipe material is correct. Confirm this with a network map if necessary.
- Check on the Filters screen that noise levels are included in the filter pass band (the white area).
- Perform a velocity check on the pipe. This can be done in 3 ways:
  - Use an Out of Bracket leak and obtain the velocity using the sound speed screen.

    - Open a tap on the pipe network and use the velocity check facility on the Touch Pro. Perform the correlation using this velocity reading
    - Use Compute mode on the Touch Pro to give both velocity reading and a leak position based on more than one correlation.
- Use the Peak Suppression facility to eliminate any unwanted peak. The graph will rescale at the next highest peak.
- Check that the batteries on all units are not low.
- Check that the sensors are not damaged.
- Check that there is no RF interference.

Note: It is recommended that all leak positions from the correlation results be confirmed with a listening device, such as a Ground Microphone.

Problem: Windows ActiveSync or Windows Mobile Device Center will not connect to the Base Unit.

Recommended Actions …

- Try using a different USB port in the PC.
- Check any virus scans are not preventing the connection.
- Check the active sync is configured to start when a connection is detected.
- Check the USB cable for damage.

Problem: Cannot connect to the outstation using the USB port

Recommended Actions …

- Check that the Outstation is turned on.
  After a successful upgrade the outstation will always automatically switch off.
- Check the LED when ON/OFF button is pressed. The LED should continually flash once a second when valid application firmware is running.

Problem: The units will not charge.

Recommended Actions …

- The lithium-ion batteries may not be charged at temperatures below 0°C and there is a safety cut out to stop this from happening.
- Try swapping the batteries from the other units to identify whether the battery is defective.
- Check that power is being applied to the units by plugging in the charger and checking that the light on the charging adapter is lit.
- If the charging adapter is not lit, check that the fuse in the plug is working correctly.

- When power is applied to the case charger, the LED should initially light up to give the current battery level of any connected units. After 5 seconds the LEDs will go out and the charging will begin.
  If a unit is connected and the LED doesn't light this means that either the battery is defective, or the connection is faulty for that unit.
- Check the Amphenol connectors and cables for damage.
- Note that whilst a unit is charging, a green LED will flash slowly on the unit. When charging is completed, the LED will be extinguished.

Problem: When trying to switch on the outstation the LED flashes 10 times quickly and then switches off. The outstation will not operate at all

Recommended Actions …

- The outstation bootloader is running.
  If the USB lead is connected then please disconnect the USB lead and then switch the outstation off and then back on.
- If the 10 LED flashes still show, when the ON/OFF button is pressed, then please reconnect the USB and perform and upgrade using the Touch Pro PC software provided.

Problem: All units are connected for in-case charging, but 1 or more of the LEDs do not light when pushing the button.

Recommended Actions …

- Check that the unit indicated by the un-lit LED has been connected to the case correctly.
- Ensure that the unit will switch on.
  If the battery is too low to switch the unit on, ensure that the battery is connected inside the unit correctly.
- The battery level may be too low to register on the display panel of the charging case.
  Charge the unit for approximately 30 minutes and then check again.
- Check to see whether a defective battery is causing the problem by swapping batteries with another unit. See if the corresponding LED will now light.
- Check to see whether the case charger circuit and connection is defective by attaching the unit to another connector and to see whether the corresponding LED will light when the button is pressed.

13 MAINTENANCE, SERVICE AND REPAIR

Unauthorised servicing will void the warranty and any potential liability for HWM-Water Ltd.

There are no user serviceable parts inside Touch Pro, except for replacing the battery Do not attempt to disassemble any of the units since it may become damaged (e.g., by static discharge), which will not be covered by warranty.

Caution: Please be extra careful with items of the system which are connected to mains electricity supplies as the high voltage currents involved can be lethal. If the Touch Pro mains adapter fails to operate, get a qualified electrician to check the power circuits and the cables to the equipment.

13.1 ROUTINE CARE AND MAINTENANCE

The following care and maintenance procedures are designed to keep your Touch Pro system in good general working order. If any part of your Touch Pro system does not work correctly, please contact the Service Team at HWM-Water Ltd or your local Touch Pro distributor.

CLEANING

Touch Pro and its accessories must not be cleaned with any solvent or abrasive type cleaners as these may damage the equipment. For safety, ensure that all items are disconnected from the mains electricity supplies before you start cleaning.

Touch Pro equipment should be cleaned with a soft cloth which has been lightly moistened with water and a mild household detergent. Use only light hand pressure when cleaning all items and be particularly careful when cleaning the Touch Pro display screen to avoid scratching the surface.

All electrical connectors should be cleaned with a 'no deposit' type electrical cleaner.

ACCELEROMETERS

The accelerometers supplied with Touch Pro are sensitive to sudden shock or impact. These sensors should be handled with care at all times. Ensure the connectors are kept clean and dry. Do not clean the sockets with any water-based solvents.

Check the accelerometers daily before conducting any field operations:

- Connect one of the accelerometers to an outstation and monitor the signals on the headphones as you gently stroke the base of the sensor with your fingers.
- Plug in the other accelerometer and repeat the test.
- If there is a large difference in the signal levels from the accelerometers, please contact the Service Team at HWM-Water Ltd or your local Touch Pro Distributor.

To preserve the strength of the magnets they should always be stored with their 'keeper' plates fitted. The magnets on the accelerometers may effect or even damage magnetically sensitive equipment if placed too near.

The system can be further checked by placing both sensors together on a desk (or fitting) and correlating whilst "scratching" the surface of the desk or fitting. A rapid centre correlation should be produced.

When a sensor is connected to an outstation, the LED on the outstation will flash quickly ten times to show that it is transmitting the signal.

HYDROPHONES

Before use check that the rubber sealing washer is undamaged and lubricate the washer with silicone grease provided to ensure you obtain a good watertight seal.

Check the washer regularly during use and apply a little silicone grease at frequent intervals during the daily operations. This simple maintenance will ensure good watertight seals and will reduce wear on the seals themselves.

Always chlorinate the hydrophones before bringing into contact with the drinking water supply to ensure they are sanitised.

BATTERIES

The lithium-ion batteries fitted to the Touch Pro and outstations are interchangeable between units. Recharge only with the supplied Touch Pro charger.

To ensure long battery life:

- Do not discharge completely.
- Recharge battery immediately after use.
- Do not invert the battery during recharging. (see opposite for the recommended equipment orientation during charging; it is the same as when in the carrycase).

Note: Regular overcharging will reduce the battery life.
The batteries may not be charged below 0°C and there is a safety cut out to stop this from happening.

To prevent deterioration or damage to the battery:

- Do not drop or subject to strong physical shock.
- Batteries should only be charged using a Touch Pro charger supplied by HWM

- Do not use below 0°C (32°F) or above +55°C (131°F).
  There is no built-in safety device to stop any operations outside these temperatures. However, the battery does have internal circuitry to protect just the battery from damage.

Important SAFETY considerations:

- Do not incinerate.
- Do not directly connect the positive and negative terminals.
- Do not use other than the specified battery charger.
- When handling the batteries or equipment containing batteries, observe any additional warnings and caution points found in the Safety Warnings document supplied with the product.

Environment:

- Touch Pro outstations and accelerometers are waterproof, but care should be taken to keep water off them where possible.
  Always dry the equipment carefully before storing it away.
- The Touch Pro outstation operates effectively between 0 and 55° Celsius.
  At temperatures below 0 and above 55° Celsius performance may become erratic and extreme temperatures will eventually damage the system.
- Do not leave Touch Pro behind glass in direct sunlight as temperatures above 55° Celsius may be exceeded even in the U.K.
- In very hot climates the battery charge capacity may be reduced, and you will have to recharge the units more frequently.

13.2 REPLACEABLE PARTS

Batteries

- Only batteries with the correct specification and type must be used.
  These are available from HWM-Water Ltd should replacements be required.

Gaskets / Seals / O-Rings

- Check condition of any gaskets, O-rings, or other seals on the Hydrophone 2 or any supplied adaptors prior to use. Do not use if damaged.
- Only use replacement parts recommended and provided by HWM.

Adaptors

- Check condition of threads on any adaptors provided for use with Hydrophone. Do not use an adaptor or Hydrophone 2 with a damaged thread.
- Only use replacement parts recommended and provided by HWM.

Silicon Grease

- Only use replacement parts recommended and provided by HWM.

Hydrophone 2 Installation Tool

- Only use a replacement tool provided by HWM.

Carry Case

- Contact your HWM representative to check for availability of a carry case for Hydrophone 2.

13.3 Return of product for Service or Repair

When returning product for investigation or repair, be sure to follow the instructions of your distributor to document why the product is being returned and provide contact details.

If returning to HWM, this can be done by completing the on-line RMA form: https://www.hwmglobal.com/hwm-rma/

If soiled, ensure the unit is cleaned with a mild cleaning solution and soft brush, disinfected, and dried prior to shipment.

13.4 Upgrading the Outstation Firmware

Each outstation has a bootloader firmware (program) installed. During normal operation the bootloader is disabled and will not be seen by the user.

The bootloader firmware program is used to interface with the PC software when upgrading the software of the outstation. The bootloader will run automatically if either a problem is found with the normal application firmware or when the PC software is used to upgrade the outstation.

When the bootloader is running pressing the on/off button will result in 10 Red LED flashes after which the outstation will switch off. If the bootloader is running when the USB is connected, then disconnect the USB and try and switch on the outstation.

If the application firmware is OK, then the outstation will switch on and can be used as normal.

If the bootloader continues to run, then please reconnect the USB and perform an upgrade.

14 APPENDIX 1 …

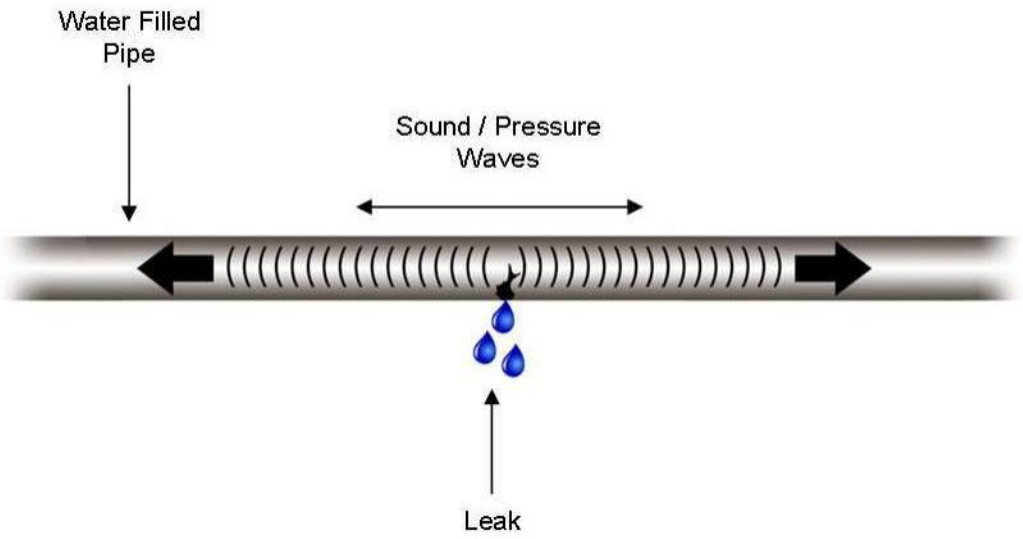
THE PRINCIPLES OF LEAK LOCATION USING NOISE CORRELATION

This Appendix section of the Touch Pro Operating Manual provides an overview of the basic theory and principles of leak location using leak noise correlation techniques.

LEAK NOISE

When a liquid under pressure escapes from a pipeline it creates a sound pressure wave (leak noise) which travels along the pipe from the exit point (see Diagram 1).
The velocity (speed) at which the sound travels within the pipe depends mainly on the pipe diameter and material.

Diagram 1



The Touch Pro system detects these leak noise sound signals with two sensors which are attached to the pipe on either side of the leak point. The sensors can be attached to pipe valves, hydrants or stop taps, etc.

TIME DIFFERENCE

Diagram 2 shows the Red and Blue colour-coded sensors which are attached to the pipe on either side of the leak. The sensors detect the sound wave signals and transmit this information to Touch Pro Base Unit by radio.

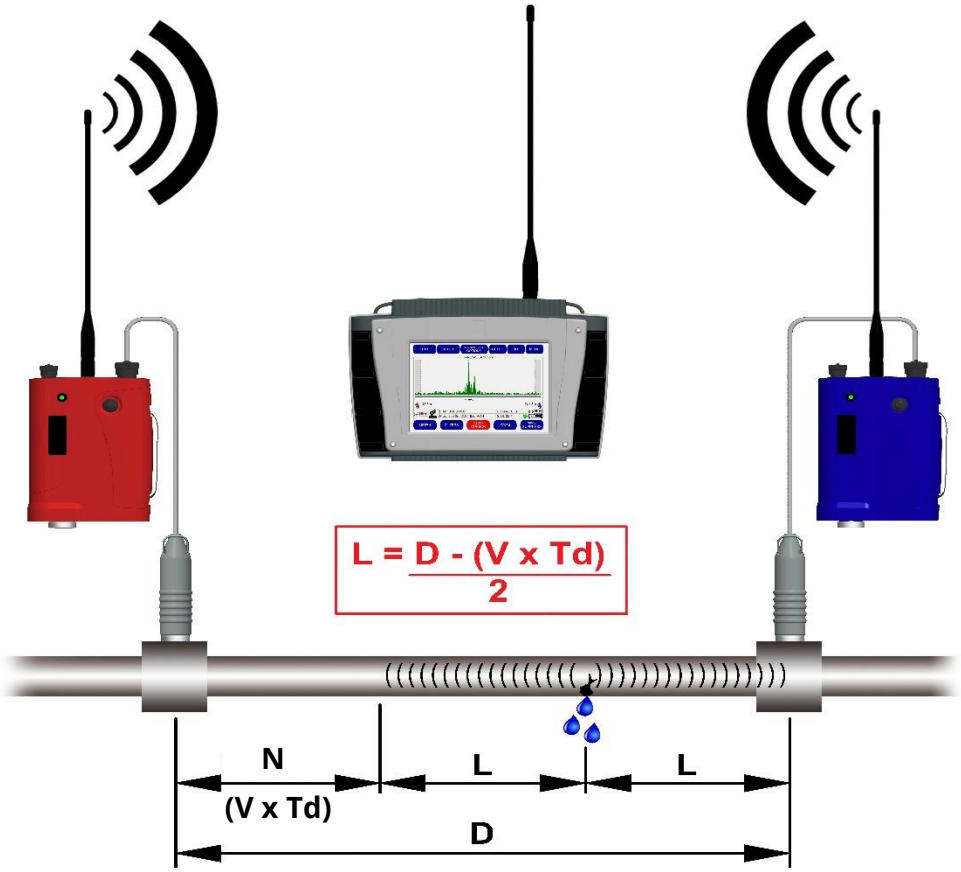
In our illustration the leak is situated at distance 'L' from the Blue sensor.

If the leak was exactly in the middle of the two sensor positions the sound pressure wave would reach each sensor at precisely the same time. In this theoretical situation we should say there was zero time- difference between the two signals.

Diagram 2 shows the leak closer to the Blue sensor, so the sound wave reaches this sensor first. At the same time, of course, the sound wave has also travelled the same

distance ‘L’ towards the Red sensor but has some distance yet to travel (‘N’). This extra travel time creates a time-difference between the signals arriving at the Red and Blue sensors. The time-difference is referred to as Td.

Diagram 2



Touch Pro compares the two sound signals from the outstations and determines the extra time taken for the sound wave to travel the extra distance, ‘N’, to reach the Red sensor. (i.e., Touch Pro seeks to determine Td).

VELOCITY-TIME-DISTANCE

As the velocity of sound ‘V’ for various liquids and pipe systems is known, we can now determine distance by applying the formula:

Distance = Velocity x Time (D = V x T).

If the time-difference (Td) between sensor signals is known, and the velocity of sound within the pipe (V’) is known, then the distance N can be determined simply from:

N = V x Td.

The total distance between the Red and Blue sensors is given by:

D = (2 x L) + N

As we wish to find L, which is the distance between the Blue sensor and the leak point, we can rearrange the equation to:

$$L = \frac{D - N}{2} \qquad \text{or} \qquad L = \frac{D - (V \times Td)}{2}$$

So, we can measure the distance D between the sensors (following the pipe network) and can estimate the velocity V from our knowledge of the pipe size and material. We then measure the time-difference Td between the sound waves reaching each sensor and apply all these data to calculate L which gives us the actual leak location.

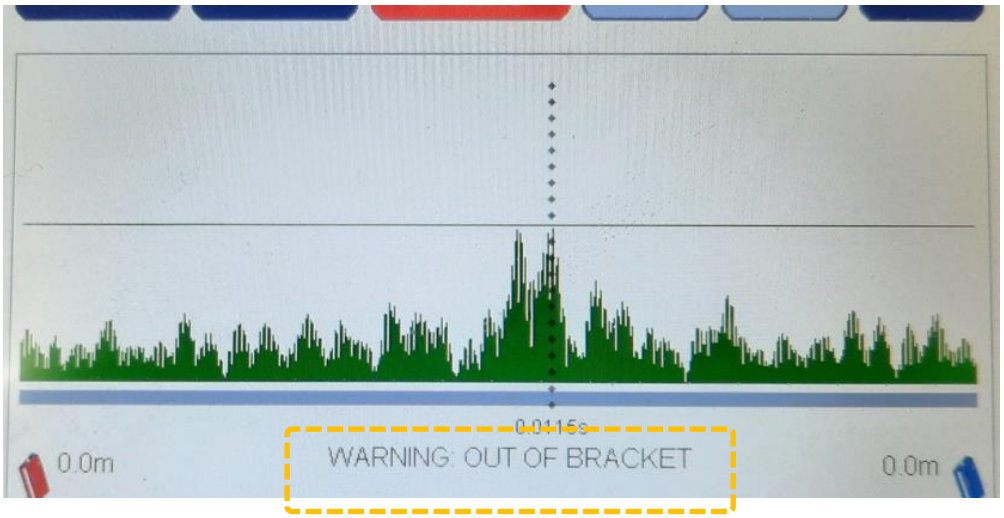
In practice, Touch Pro performs all of the time measurements and calculations for you.

In diagram 2 the leak point was shown nearer to the Blue sensor. In fact, it doesn't actually matter if the leak point is nearer the Red sensor as Touch Pro automatically deals with either situation.

SENSOR BRACKETS (In-bracket vs Out-of-bracket conditions)

In order to locate leaks precisely the two sensors must 'bracket' the leak point. This means that the leak should be between the Red and Blue sensors ; this is referred to as an “in-bracket” leak condition. Conversely, if the leak is not between the Red and Blue sensors, the leak position cannot be detected ; this is referred to as an “out of bracket” or “non-bracket” leak condition.

If the sensors are incorrectly positioned, Touch Pro will detect the 'non-bracket' condition and warn you by displaying a warning message on the screen.



Touch Pro will also indicate which sensor is nearest to the leak, so you know which one to move (further away) ; the nearest sensor is indicated by a 0.0m distance from the leak.

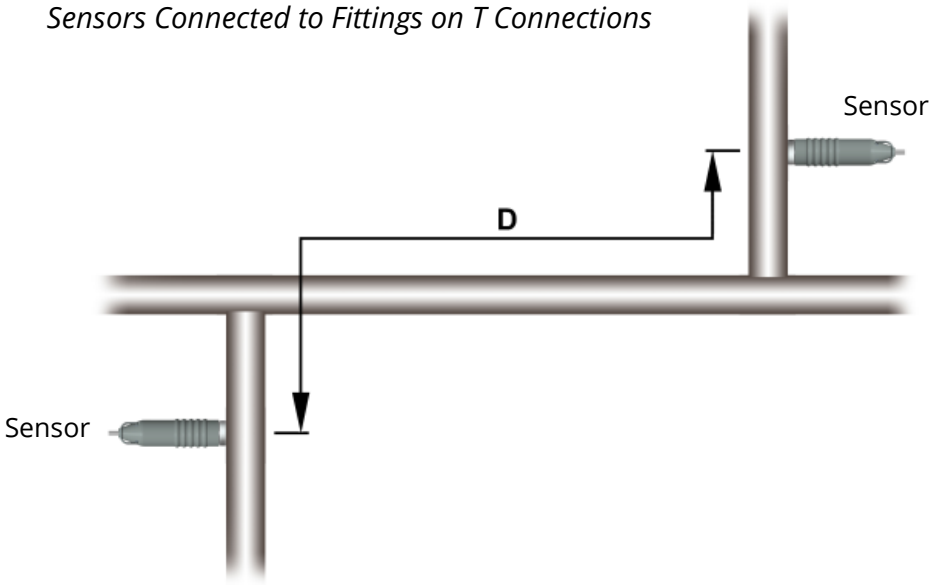
If the leak is shown fairly near to one sensor it is good operating practice to also treat this as a non-bracket condition. In these instances, you should move the near sensor away from the indicated leak position and re-correlate.

'T' CONNECTIONS

The distance D which you have to key-in to Touch Pro refers to the total length of pipe between the sensors. If the sensors are attached to T connections, then the length of the T network must be included in D.

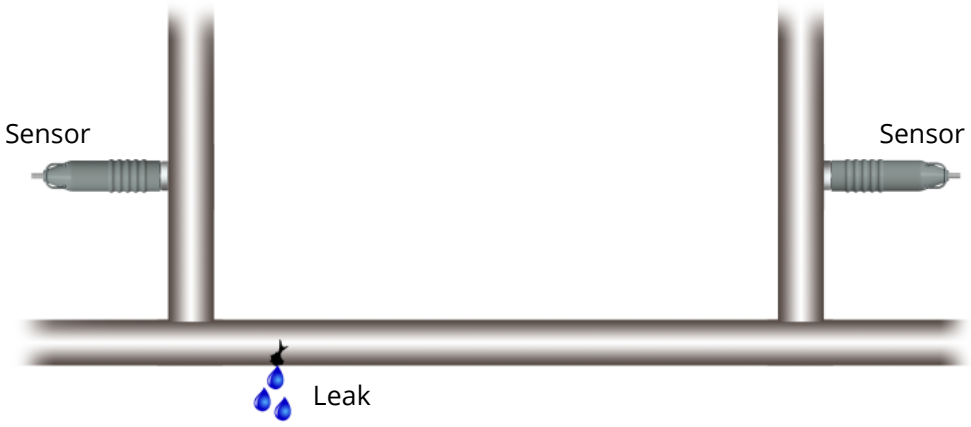
Diagram 3

Sensors Connected to Fittings on T Connections



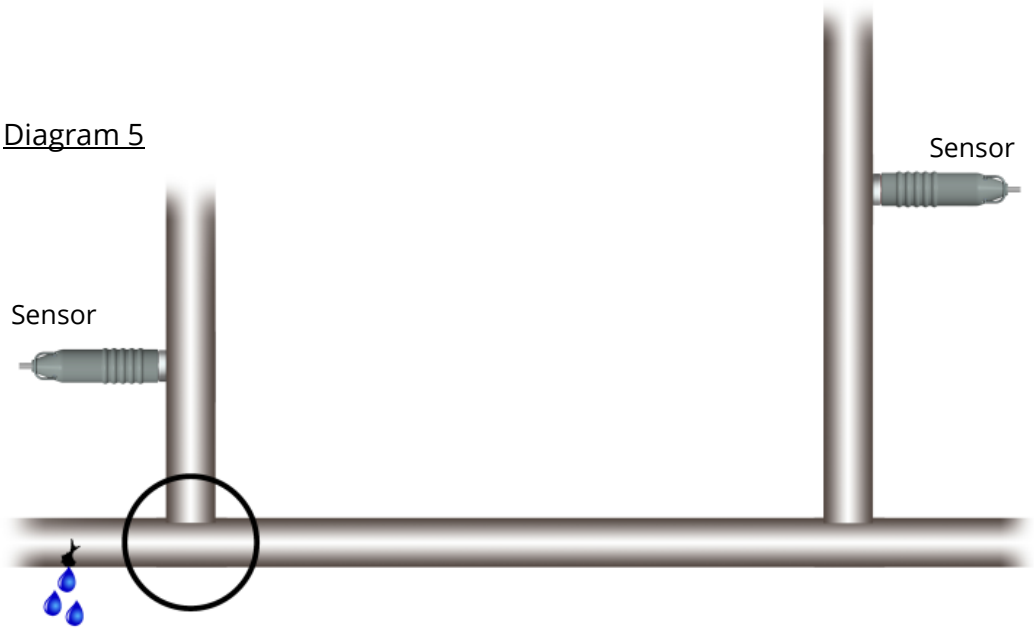
Care is required when interpreting the results from T connection surveys. The following illustrations demonstrate predicted results for various pipe-work layouts and shows recommended actions.

Diagram 4



The Leak (shown in Diagram 4) will be indicated correctly.

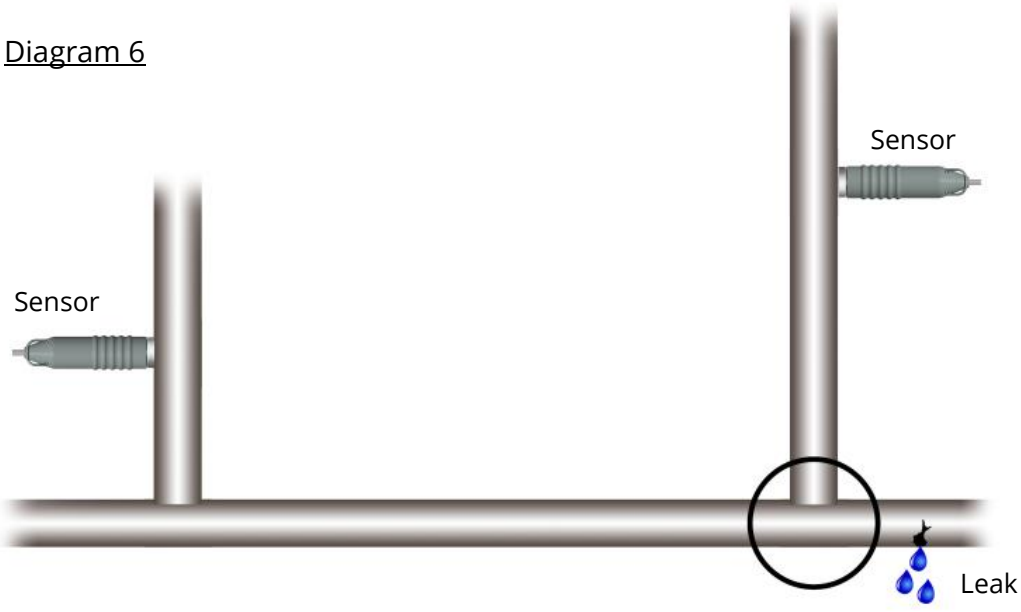
Diagram 5



The Leak (shown in Diagram 5) will be indicated at the left T connection that is circled.

Action: Move the left-hand sensor further to the left and try again.

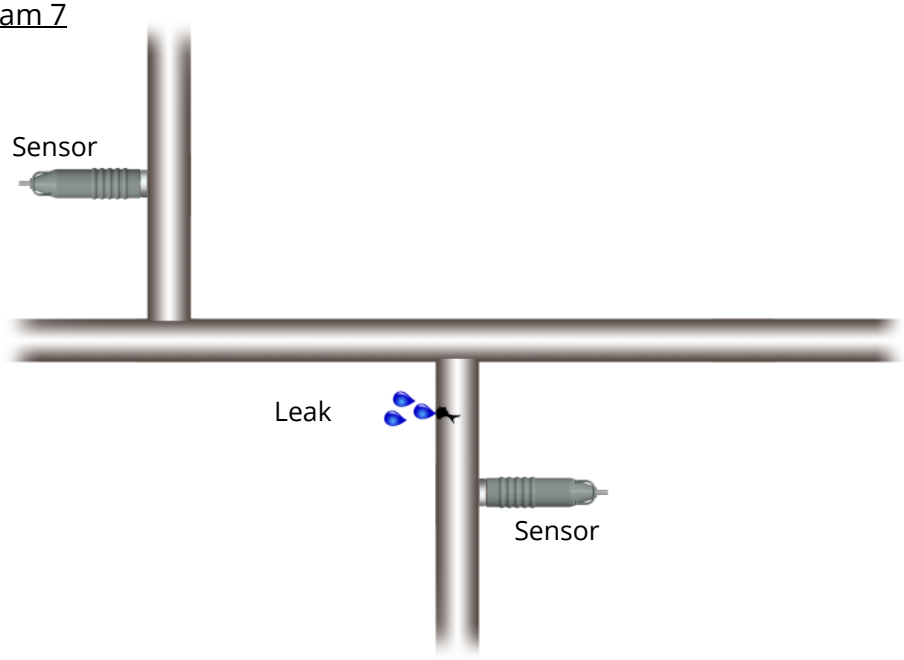
Diagram 6



The leak (shown in diagram 6) will be indicated at the right-hand T connection that is circled.

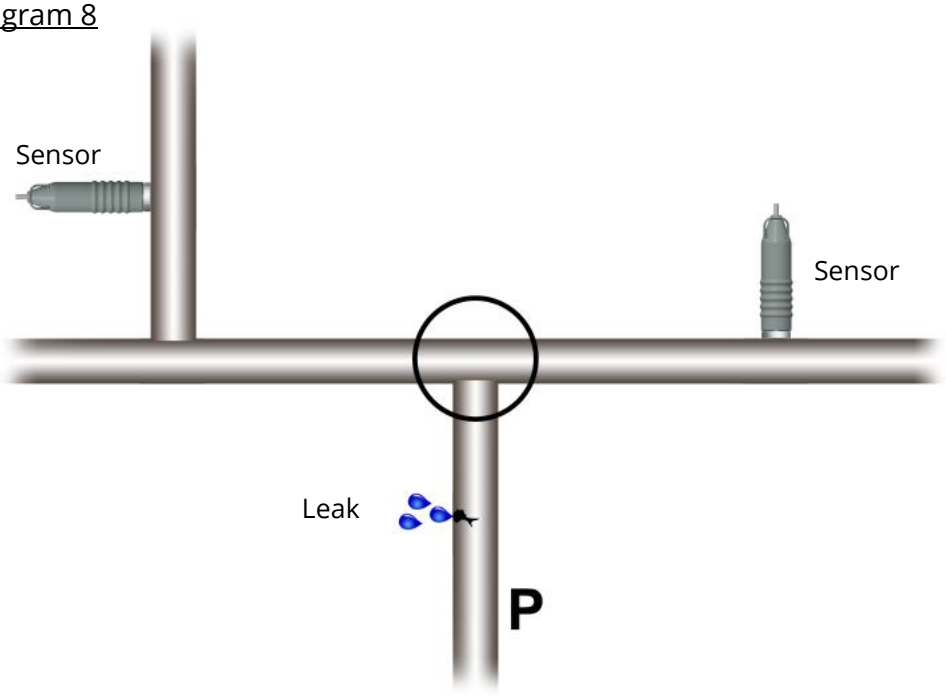
Action: Move the right-hand sensor further to the right and try again.

Diagram 7



The Leak (shown in Diagram 7) will be indicated correctly.

Diagram 8

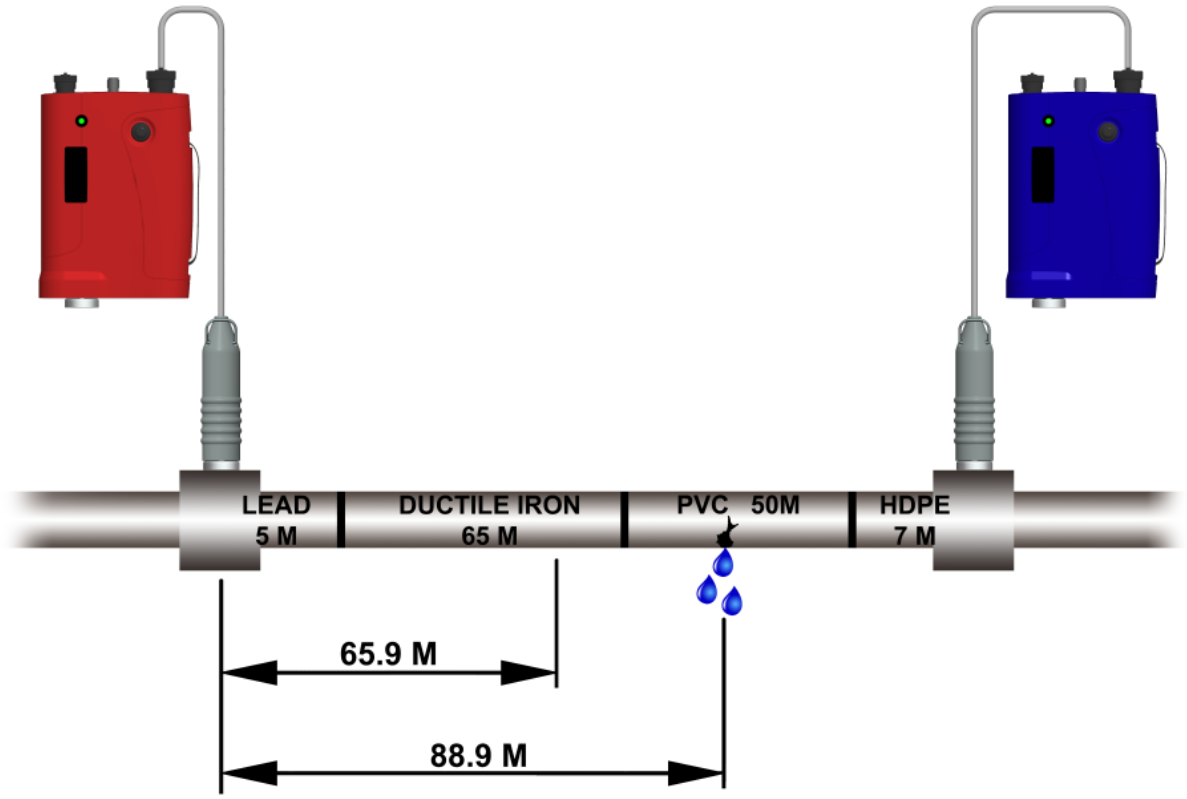


The Leak (shown in Diagram 8) will be indicated at T connection that is circled..

Action: Move either sensor to a fitting down the T connection (e.g., to P) and try again.

Mixed pipes

Diagram 9



The speed or velocity at which leak noise travels is greatly dependent on pipe material.

Different pipe materials give different velocities.

To locate a leak in a pipe run made up of mixed materials, the velocities applicable to each material, and the length of each pipe must be used. This is not the same as using an average velocity.

e.g., Using an average sound velocity for the materials, a leak would be indicated at 65.9 metres from the Red sensor. In fact, Touch Pro in Mixed Pipe Material Mode under identical conditions calculated the true leak position at 88.9 metres from the Red sensor.

COMPUTE MODE THEORY

Compute Mode is a special Touch Pro operating feature which can improve the overall accuracy of correlation surveys.

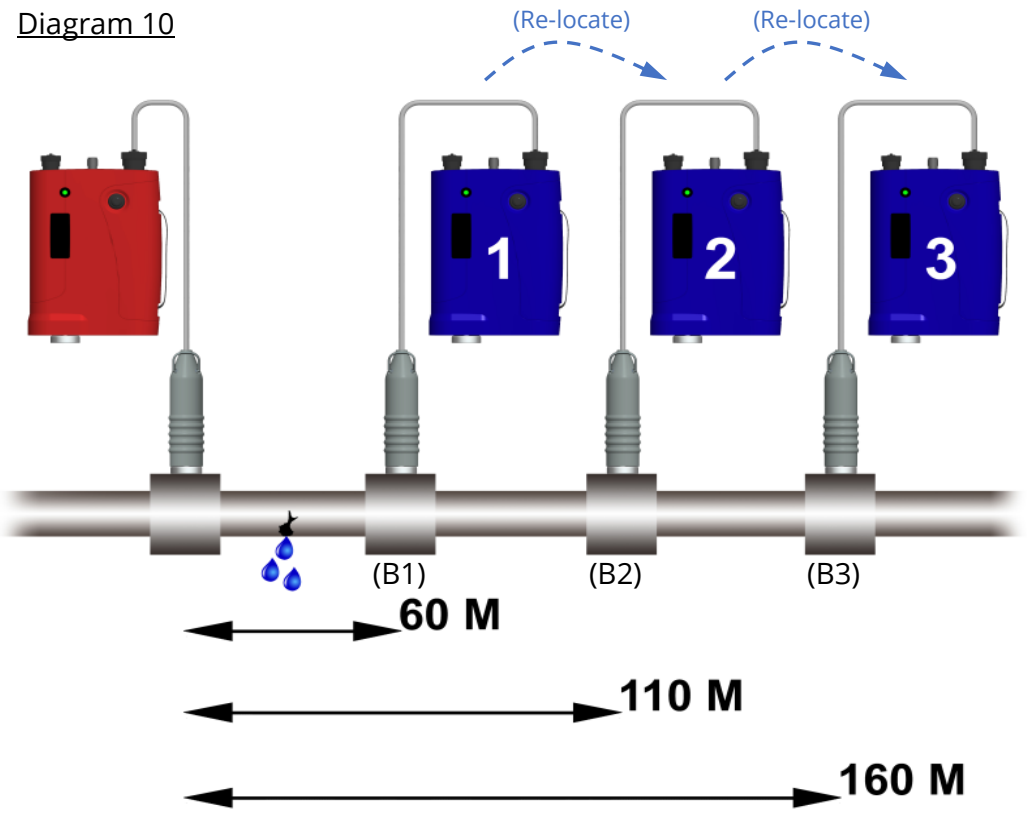
In Compute Mode the data from two (or more) correlation runs are combined to produce a result which is totally independent on the velocity of sound V. The effect of any error in the measurement of the distance D between sensors is also significantly reduced. In practice at least three results are needed.

Touch Pro takes the basic equation D = (2 x L) + (V x Td) and solves the equation for two or more values of D and Td.

The additional values for D and Td are obtained by keeping (in this example) the Red sensor on one fitting while the Blue sensor is moved from fitting to fitting (B1, B2, B3).

In practice either sensor can be selected to remain fixed as the reference sensor. The sensors must bracket the leak for the Compute Mode runs to be valid. The new values of D and Td generate a very accurate figure for V which is then used to calculate the leak position from the fixed sensor.

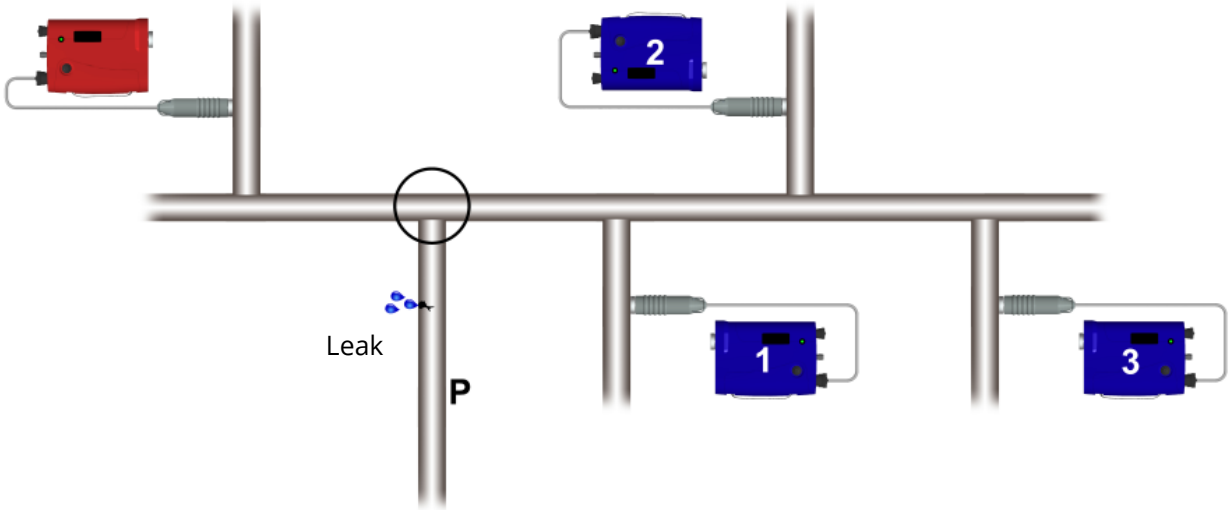
Diagram 10



Indicated leak position	R - B1 : 52.8M	)		
(Distance from the Red)	R - B2 : 48.4M	)	Average position	47.8m
	R - B3 : 42.4M	)	Computed position	49.0m

Particular care should be taken when using Compute Mode with T connection pipework. If a leak is indicated near to a T connection, it is quite possible that the leak is actually down the T (as shown in Diagram 11).

Diagram 11



If this situation occurs the Red sensor should be moved to a fitting down the T connection (P) and a complete re-run in Compute Mode should be carried out.

HWM-Water Ltd.
Ty Coch House
Llantarnam Park Way
Cwmbran
NP44 3AW
United Kingdom
+44 (0)1633 489479
www.hwmglobal.com

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