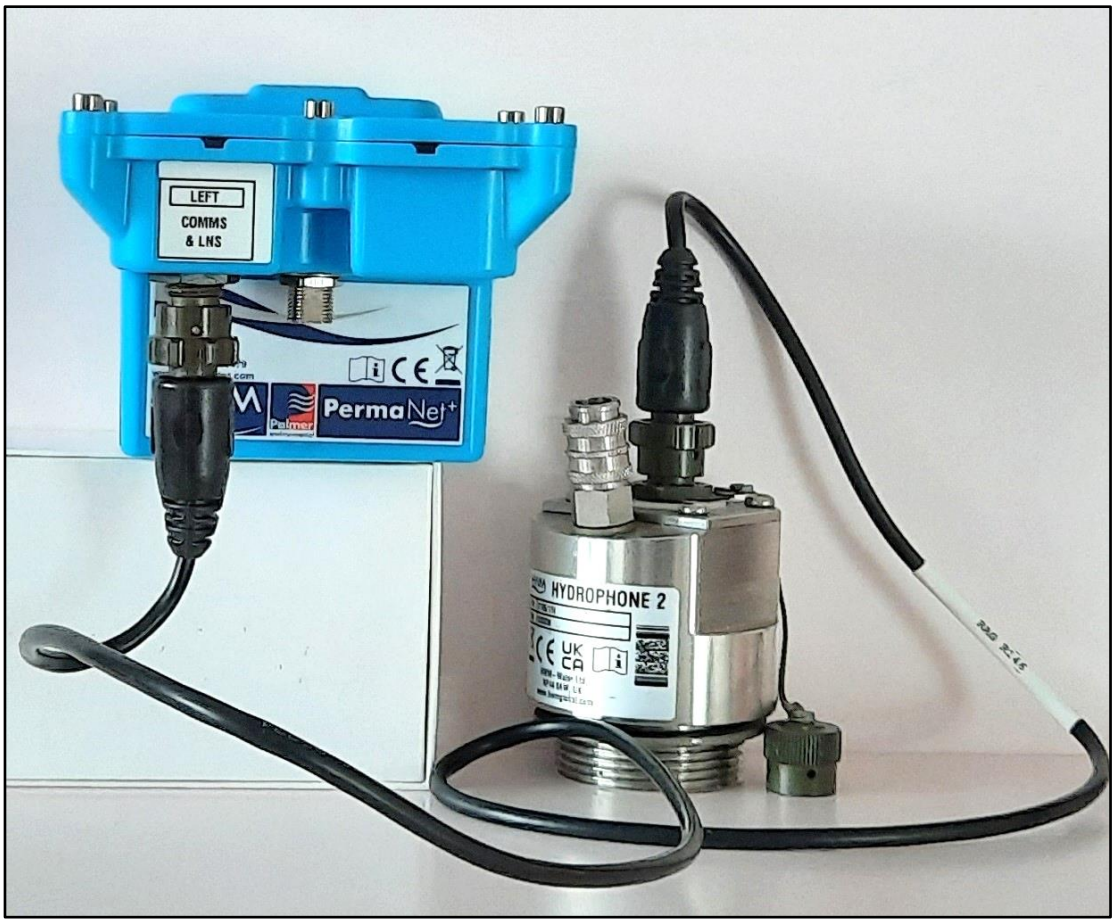
User Guide: PermaNet+ with Hydrophone-2. Installation and Setup.



Warning: This manual contains important safety and operating information. Please read, understand, and follow the instructions in the manual.

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1 INTRODUCTION, BACKGROUND AND SUPPORT OF PRODUCT

1.1 INTRODUCTION

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

Pipeline leaks are a constant burden to water industries, which can affect the efficiency of the individual company's performance. Leakage loss reduces the amount of water actually being delivered, thus affecting the financial side of the business. The longer the leak is left, the larger the economic, and potentially environmental, consequences. It is therefore more beneficial and safer to detect a leak early and make repairs to the pipes before significant damage to the business is caused.

At HWM, we pride ourselves in designing the best leak detection equipment at an affordable price for the benefit of water companies.

1.2 ABOUT PERMANET+ WITH HYDROPHONE

PermaNET+ is a powerful leak detection system that allows the user to deploy a fleet of data loggers around a water network that are permanently installed to listen for leaking pipes. The data logger units are called PermaNet+ devices.

The Hydrophone-2 is a very sensitive sensor device, which listens to noises within the water network. Typically, leak noise travels greater distances through the pressurised water inside the pipe than through the pipe wall and fittings. Low frequency noise also travels best through water; hydrophone sensors are particularly sensitive to this low frequency noise.

The PermaNET+ logger can operate in one of two distinct modes:
(1) Daily leak evaluation or (2) Trunk Main mode (frequent leak evaluation).

In Daily leak evaluation mode:

The logger's highly sensitive Hydrophone sensor switches on at night, at a time specified by the user, and takes samples of the noise it hears on the pipes. This is presented as 2 figures, Level and Spread and also a leak judgement. The level figure represents the sound level that occurs most often during the sample period and the spread is how much the sound varies during this time. A large, consistent Level and small Spread is typical of a leak, whereas a small level and large spread is typical of a background noise.

If the logger judges that there may be a leak, then it takes another set of samples after a definable period, to confirm the first result. If leaking water noises are suspected, the logger can be set to automatically make a short recording (typically 10 seconds). This allows the user to play back the recording to decide for themselves if the recording sounds like a water leak.

The PermaNET+ system will also perform noise analysis and present the data as Histograms that help to visualise the noise into patterns that can be identified as leaks.

The logger sends this data once a day to a central server.

In Trunk Main mode:

The logger's highly sensitive Hydrophone sensor switches on frequently and takes samples of the noise it hears on the pipes. This is also presented as 2 figures, Level and Spread and also a raw leak judgement indication. The data produced by the logger should be monitored for a period of time to characterise the typical noise levels of the network. The logger can then be set to produce an alarm if there is any persistent change from the expected noise levels, which could indicate a new leak is present.

The logger can be set to automatically make a short recording (typically 10 seconds) shortly after an alarm condition has occurred. This allows the user to play back the recording to decide for themselves if the noise sounds like a water leak.

The logger sends this data to a central server at the programmed call-in times, or earlier if an alarm occurs.

The Hydrphone-2 sensor unit connects to 'wet' fittings that allow access through them into the water column, (e.g., hydrants, washouts, or meter points). The Hydrophone sensor itself is an extremely sensitive marine sensor, which listens within the water column. The Hydrophone-2 can fit directly to certain fittings. Where this is not possible, a range of adapter options will allow easy connection to many other fittings. A bleed valve is available on the unit, through which air can be removed from the sensor chamber to ensure the best quality sound.

1.3 DOCUMENTATION AND SUPPORT OF PRODUCT

This user-guide covers the following model families:

Model Number(s)	Description
PN/*/*/*	PermaNet+ (Leak detection logger device), with a
S165 / 1 / *	Hydrophone 2 sensor.

It gives detailed information for the installation and use of Hydrophone 2 with PermaNET+ loggers for detection of possible water-leaks in a water pipe.

The user-guide should be read in conjunction with any appropriate sections of:

MAN-130-0017	User Guide: IDT (PC version) – Logger User Interface
MAN-072-0001	Antenna Installation Guide

The IDT (PC version) user-guide contains guidance on common features of HWM loggers, including how to confirm common settings or modify the set-up of your equipment.

Read any Safety Warnings and Approvals Information supplied.

Retain all documents supplied with the equipment for future reference.

To view your data a viewing tool is required; refer to any user-guide or training materials relevant to the tool you will be using (see also section 7).

Note: The system periodically has new features and changes released, 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

1.4 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.

Use of Hydrophone equipment 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.

1.5 Operating Temperature

Refer to the PermaNet+ Datasheet and Hydrophone-2 Datasheet or your sales representative for guidance on the storage and operating temperature range of the device. Ensure the unit is within the operating temperature range prior to installation.

1.6 UNPACKING

As you unpack your new PermaNet+ logger and Hydrophone, please confirm that you have the following parts:

- PermaNet+ data logger.
- Hydrophone-2 unit.
- Cable for connecting the Hydrophone-2 to the PermaNet+ logger.
- An Antenna (various types are available).

If there are any omissions, please contact our sales team to rectify or supply the missing parts.

Please dispose of your waste packaging responsibly.

2 Description, Overview, and Preparation for use

2.1 Hydrophone 2 Description

The Hydrophone-2 sensor is shown opposite.

The Hydrophone will typically connect to the interface labelled “LNS” or “Comms and LNS” (or similar).

The upper part of the sensor contains an electrical connector and an auxiliary connection point to the water column.

The auxiliary access will accept a series 21 quick coupling.

A cover (plastic transit cap or Mil-spec cap) should be used to keep the electrical connector clean when not in use.

The body of the sensor has flats that will accept a 50mm spanner, or alternatively a custom tool (available from HWM) for installation where access space is limited.

View showing cable and bleed-valve connections.

The lower part of the sensor contains a small chamber, which provides some protection to the sensing element of the device. It also has an aperture to give access to the pressurised water column.

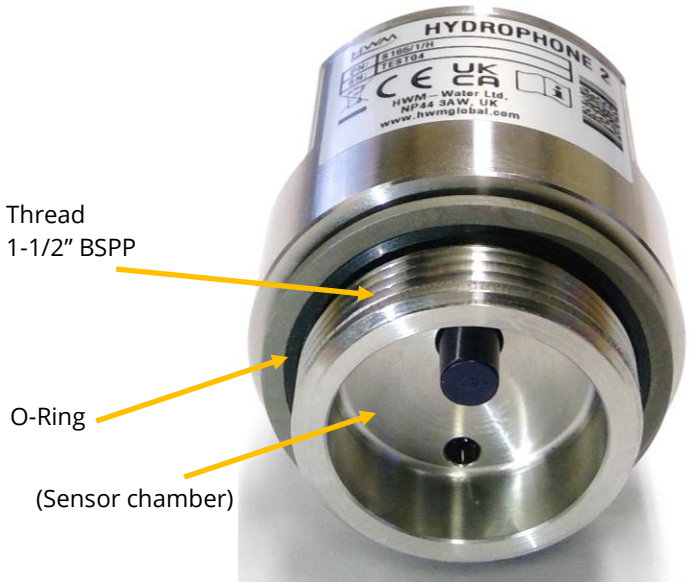
Remove any thread protection covering prior to use.

View showing sensing element and vent aperture

The outer ring of the chamber is threaded, 1.5 inches BSPP.

The Hydrophone 2 is supplied with an O-ring which is used to seal the surface between the hydrophone and an adaptor. The O-ring is surrounded by a washer to prevent distortions and leaks when under high pressure.

Check the seal to ensure it is in a good condition prior to use.



Various adaptors (options) can be fitted to the Hydrophone-2. Select a suitable one for use with the asset (valve, hydrant, etc) to which the Hydrophone is going to be connected.

An example of an adaptor is shown opposite.
(This is the 1.5-inch BSPP to 2.5-inch London Round Thread Adaptor).

Refer to your HWM representative for latest information regarding available adaptors.

The electrical connector is a waterproof 4-pin mil-spec connector.

A suitable cable is required to connect the Hydrophone 2 to the logger unit (See section **3.10.1**). A variety of lengths are available.

When ordering the logger and sensor, ensure an interconnecting cable is also ordered ; this must be of a suitable length to reach where the logger is going to be mounted.

In addition, consider any adaptors that may be required to join the Hydrophone 2 to the pipe network.

2.2 INSTALLATION ACCESSORIES

When fitting the Hydrophone 2, the installer will require certain tools and accessories, available from HWM: (These can be re-used for many Hydrophone-2 installations).

- A quick-fit bleed kit for Hydrophone 2.
- An installation tool (for use where there is no space to use a spanner / wrench).
- A USB logger programming cable.
  (A cable used temporarily for programming the PermaNet+ with a PC. See also section 2.2.3).

2.2.1 Quick-fit bleed kit

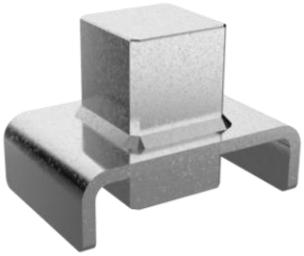
A selection of quick-fit bleed kits is available from HWM.
(The standard version is shown. Another version includes a hose and tap).

The kit allows for a temporary connection to the quick-release connector on Hydrophone 2 in order to bleed air from the chamber and thereby allowing the sensor element to have good contact with the water column.

Note: The user must ensure that water is discharged safely when using this kit.

2.2.2 Installation Tool (sockets)

A 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.



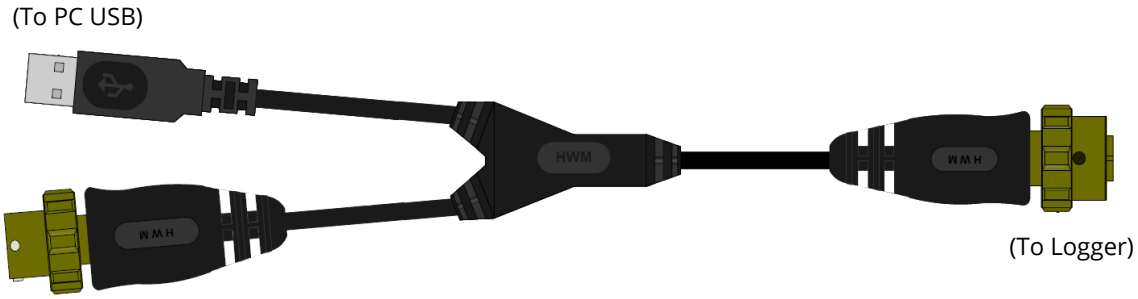
A tool is also available to assist in tightening and releasing the Hydrophone-2.

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.

2.2.3 Programming cable (Y adaptor)

PermaNET+ family of loggers require a Y- shaped programming cable in order to both program the logger and to test the Hydrophone-2 sensor is functioning whilst on-site.



The cable part-number is CABA9349/P. (See also section 3.10.2).

2.3 PermaNET+ Logger – Physical Description

The PermaNet+ logger device is shown below.

Connector for: Hydrophone-2, Comms to PC (for setup)

Connector for: Antenna

The logger should be mounted in the orientation shown for best battery life.
A mounting bracket is available.

The device has a connector for attaching the antenna. (This connector is unlabelled).

The device has an interface labelled “LNS” or “Comms and LNS” (or similar). This is a dual-purpose connector; its regular use is to connect the Hydrophone-2 to the unit via a cable. However, when it is required to communicate with the logger, the connector is used for that purpose also. (See section 2.2.3)

The optional mounting bracket acts as a wall-mount hook.

It locates in a slot at the rear of the unit.

Fix the bracket to the wall of the chamber before hanging the logger on it.

The PermaNET+ logger is primarily designed for leak detection and includes a "LNS" interface to drive the Hydrophone-2 sensor. However, certain models include an additional interface to frequently measure (and log) other physical parameters, such as the flow of water (used in conjunction with a water meter) ; This requires a 'Flow' interface to be built into the unit. For details of how to set up the logger for a Flow interface, please refer to the IDT (PC version) user-guide ; This user-guide deals only with the setup of the LNS interface.

2.4 PermaNet+ Logger – Device Overview

The PermaNet+ loggers are fitted with an interface for the Hydrophone-2 sensor. They are (when the antenna and sensor are attached) of a waterproof construction, being designed to be permanently installed around a water network, listening for leaking pipes. The devices accomplish this by means of a specialised microphone (the Hydrophone) that can detect the sounds that occur within a pressurised network; In particular, they are listening for the presence of sounds emitted from a pipe leak.

Note: The logger regards the Hydrophone-2 as a type of Leak-Noise sensor (or 'LNS' sensor device).

A micro-controller, built into the logger unit, measures the noise levels at certain times during the day and then performs a statistical analysis to generate further data, which includes a leak-judgement. The results are saved in memory for upload to the server at a later time. Where the Trunk Main type operation is in use, the logger can provide a more urgent alert to a possible leak condition by sending an alarm indication.

The logger will operate its leak-detection function in one of two distinct leak evaluation modes:

- A daily leak-evaluation mode, or
- A frequent leak-evaluation mode (this is known as the “Trunk Main” mode).

Two different algorithms are employed to produce and analyse the data, depending on which of the modes is in use. The modes are further discussed in sections 2.4.1 and 2.5.

In addition, the logger handles many repetitive tasks, such as the regular logging of data for other channels (if an option is fitted) and also communications to the server.

2.4.1 Measurement data types

The ‘leak evaluation’ data produced by the logger depends on whether it is operating in the standard (daily leak-evaluation) mode or the Trunk Main (frequent leak evaluation) mode.

Daily leak evaluation mode:

The saved data could be in the form of:

- A “noise histogram”.
  This provides a detailed indication of how consistent the noise measurement is and can be used for more advanced analysis. Histograms can also help to visualise the noise into patterns that can be identified as leaks.
  (Noise histograms do not occupy any regular logging channels of the logger, but are supplied to the server as a supplementary data package).
- LNS Level and LNS Spread (numeric indications).
  These two figures are a numeric summary of the noise histogram.
  - The “Level” figure represents the sound level that occurs most often during the sample period.
  - The “Spread” figure is how much the sound level varies during the above time.

  (A large consistent Level and small Spread is typical of a leak, whereas a small Level and large Spread is typical of background noise within a pipe).
- A “leak / no-leak” status.
  This gives a simple indication of whether results indicate a probable leak.
- Sound recording files.
  (Sound recordings do not occupy any regular logging channels of the logger, but are supplied to the server as a supplementary data package).

Trunk Main evaluation mode:

The saved data could be in the form of:

- LNS Level (minimum, average, or maximum),
  and LNS Spread; (these are numeric indications).
  These figures are regularly logged datapoints that provide an ongoing numeric indication of the noise within the water pipe.
  The "Level" figure represents the sound power level within the water pipe.
  The "Spread" figure is how much the sound power level varies during the time between log periods (i.e., maximum – minimum power).
  (A large consistent Level and small Spread is typical of a leak, whereas a small Level and large Spread is typical of background noise within a pipe).
- A "leak / no leak" indication (status).
  Note: This is a series of judgements made at the time when each log period (sample acquisition) ends.
  This gives a simple indication of whether results indicate a probable leak.
  (Since the evaluation is made frequently, at the log intervals, there can be some instability in this result ; It will require further filtering by the logger to stabilise).
- Sound recording files.
  (Sound recordings do not occupy any regular logging channels of the logger, but are supplied to the server as a supplementary data package).

2.4.2 Battery / lifetime

The PermaNet+ logger is powered by non-rechargeable Lithium batteries. The Hydrophone-2 itself contains no batteries ; it is powered by the logger whenever the sensor is needed. The logger is designed to minimise the battery use and thus increase the life expectancy of the unit (e.g., the loggers become active when needed; most of the time they are in standby). The battery life is also affected by user-programable settings. The user should therefore set the logger with the view of preserving the battery power. (e.g., Use the longest intervals between sampling that can still produce the required data and results).

2.4.3 Cellular communications and SIM-card

The PermaNet+ logger includes an interface to the cellular communications network, which provides access to the internet. The data stored within the loggers can be sent automatically over internet using the mobile communications network. The normal destination of the data is the HWM DataGate server. Communication is 2-way between the logger and server, by means of a proprietary protocol using UDP packets.

A SIM card is normally fitted within the logger.

When it is time to upload the data over the mobile network, the logger switches on its cellular radio circuits and sends its data. Once completed, it puts them back into standby mode.

2.4.4 Serial Communications (for setup using a Laptop computer)

The logger includes a serial communications interface. This enables the user to communicate with the logger during installation for the purpose of setup and to make on-site tests including test of the Hydrophone 2 sensor. Communication requires the attachment of a HWM communications cable and also the HWM "IDT (PC version)" software. (See section 4.1).

2.5 LOGGER OPERATION - REPETITIVE FUNCTIONS & LEAK DETECTION MODES

The logger is normally shipped from the factory in a minimally active state, to extend battery life whilst in storage (e.g., no measurements are made or logged). This mode is designed for periods of storage or shipping of the device, with the logger referred to as being in "shipping mode", or "sleeping". Once activated (see section 2.9), the logger no longer sleeps, but begins its repetitive daily tasks.

Whenever possible it saves power by putting circuits it does not currently need into a "standby" condition (e.g., Hydrophone-2). However, the logger will become highly active at the time it is required to make any sound measurements, complete its leak evaluation, and store the results within its memory. The logger will then go into standby until the next programmed event is due or a sensor reading is required.

Operation with standard Daily leak evaluation mode setting:

The logger's primary task is a leak-sensing program, which runs once daily. The Leak-state evaluation program is extensive, taking up to 2 hours to complete. It takes place between 2-4am (although it can be changed). Typically, it is made during a time of low water use to reduce the possibility of consumer water use being incorrectly judged as a leak. During this time, the logger makes an initial evaluation. if the logger determines a change of leak-state (a potential new leak), it waits for some time and then carries out a second confirmation evaluation (double check); This reduces the possibility of temporary noises being mistaken for a leak indication.

If the logger determines that a new leak is likely to be present near-by, it can (if so set) automatically make a sound recording when the new leak is first detected. The sound recording is by default 10 seconds in duration.

The logger therefore produces one leak-status determination per day. It waits until its scheduled call-in time and uploads its data to the server.

Office staff can evaluate the leak status of an individual site (results from a single logger) or look at the leak status of several sites on an area of the pipe network (the results from many loggers) using the appropriate data viewing tool (via a website).

Note: Loggers using this mode can also support regular repetitive logging tasks; other types of sensor interfaces can also be fitted to the logger. (These can only be fitted during logger production).
The LNS driver navigates around other regular sensor sampling activities. However, ensure call-in times do not collide with any sound recording activities.

Operation with Trunk Main evaluation mode setting:

The logger uses a much shorter leak-sensing program, which takes only a fraction of a second to complete and runs repeatedly throughout the day. The Leak-state evaluation therefore produces a continuous stream of results, rather than a single daily judgement.

Note: Since the leak evaluation can be made in a short time, loggers using this mode can also support regular repetitive logging tasks; other types of sensor interfaces can also be fitted to the logger. (These can only be fitted during logger production).
The LNS driver navigates around other regular sensor sampling activities. However, ensure call-in times do not collide with any sound recording activities.

The Trunk Main mode is designed to provide a rapid alert when leaks are detected. This is accomplished by setting the logger to call-in with an alarm indication upon detecting a probable leak. This requires an alarm to be programmed with the logger settings.

Because the leak status indication is a continuous stream of datapoints, it is possible that the raw data may occasionally "flap" (rapidly change between leak and no-leak indications). When setting the alarm trigger conditions, it is possible to filter this out and only send an alarm when there are definite indications of a leak. At this time the logger can also (if so set) automatically make a sound recording. The sound recording is by default 10 seconds in duration. After making any sound recording, the logger then makes a call-in to send the alert and upload its data to the server.

(Note: The automatic sound recording becomes scheduled when *any* alarm condition becomes active, not just the one created for the leak detection).

Office staff can evaluate which sites are indicating a leak status using the appropriate data viewing tool (typically a website). An area containing multiple sites (with loggers) can be interrogated for those that have an active alarm for a leak condition.

Note: Making and transmitting sound recordings can use a lot of data and also drain the battery significantly if too many are made. In order to preserve battery life and reduce data costs, the recording system is restricted to 7 recordings a month. If you have a specific requirement for more than this limit, then please contact HWM customer service for assistance.

When available, sound recording files can be used to confirm whether the sound within a pipe does resemble the sound produced by a leak.

If several sites in the area have loggers that have produced sound recordings at precisely the same time, the approximate location of the suspect leak can often be found, using a process called Leak Localisation / Correlation.
(Availability depends on data viewer being used).

Note: Always use a ground microphone to confirm a leak location prior to commencing repair works.

2.6 BACKGROUND INFORMATION

Prior to considering installation and setup of the Hydrophone 2 with your logger, some background information is provided …

2.6.1 System Overview

The loggers (with Hydrophone 2 sensor) form only a part of a functioning system. A typical system will comprise of:

- A fleet of loggers (with Hydrophone-2, or other type of Leak Noise Sensor).
  These are set to evaluate the sounds within a pipe to determine if a leak could be present nearby.
- A Laptop PC (with Microsoft Windows).
  The laptop PC can (with HWM software installed and a suitable comms cable) provide a Graphical User Interface for the logger, giving the installer access to set up and test the logger.
- HWM IDT software tool:
  "IDT (PC version)" application software (installed on the PC).
  A software tool (**I**nstallation and **D**iagnostic **T**ool) is used to check or modify logger setup and to put the logger into various modes in order to test it within an installation.
- A server, set up to receive logger messages and data. This is typically the HWM Datagate server. The server acts as a data warehouse, safety storing the logger data and also providing it to the authorised viewing platform.
- A User-account and password for the HWM DataGate system (for administration purposes).
- A User-account and password for the chosen data viewing website (for viewing your data / leak determination results, possibly along with some results from other sensors).
  - When using the standard daily leak evaluation mode, the HWM PermaNETWeb website is often used.
  - When using the Trunk Main evaluation mode, the HWM DataView website may be used.

  Refer to your HWM representative regarding the selection of a data viewer website most appropriate to your needs. This discussion should include any other sensor data that the logger may be producing.

  Note: Other technologies (e.g., PC-based software) exist for viewing data, but the latest offering from HWM is the use of secure webpages. Discuss with your HWM representative for further information, if required.

Note: The term "DataGate" is used throughout this manual.
An alternative name may be used by the server in your location (e.g., OmniColl).

2.6.2 DataGate – Terminology and Summary

This section *introduces the terminology* that is used by DataGate and the IDT…

The destination of PermaNet+ logger data is usually the DataGate system, provided by HWM. DataGate and PermaNETWeb webpages are the main administration and viewing portals for logger and site data.

An overview of the scheme is summarised here…

HWM **logger devices** produce several forms of measurement data, each of which can be considered as a data **channel**. The data represents a measurement made by a logger deployed on the pipe network. Access to the pipe network is often available through various chambers that house valves or hydrants, connected to the water pipes. A chamber can be used as an installation **site** for a logger. A site may be one of many in an area of inter-connected pipework (which may be known by various names (e.g., zone, district, suburb, area); some areas of the water network may include a water meter to monitor water use, which DataGate can refer to as a District Metered Area (DMA). Sites in a certain area may therefore be collected together in a group, often referred to as a **DMA**. DMAs, in turn may be collected together in a group, referred to as an **account** (or Zone). Each of these separate entities may be represented on a database, such as one used by the **DataGate** system, which links some of them to a **User** of the system.

Or, put in reverse order…

- **DataGate** contains a database.
- A **User** of Datagate can be linked with an account.
- An **accoun**t can be a group of multiple DMAs.
- Each **DMA** can contain multiple sites.
- Each **site** can have one logger device installed at any given time (or none).
- Each **logger device** can produce multiple **channels** of measurement data.
- The **data** of a channel may consist of multiple samples that are obtained at different times. It is linked to the site on which the logger is deployed.

The data produced by each logger is uploaded to DataGate. DataGate links the measurement data of each logger to the correct site.

2.6.3 Ways to set the Logger Configuration

The PermaNet+ holds many setting parameters that affect its operation.

Example settings are:

- When to make the Leak detection.
- Whether to automatically make a sound recording of a suspected leak.
- Scheduled measurements (a manually set temporary additional task).
- When to call-in with the data.
- Mobile-network settings (e.g., telephone number, network to use).

The logger settings can be adjusted at various times…

- Initial settings are made within the factory, prior to shipping.
  Default settings are used, plus some settings being customer-defined. These will be suitable for most installations.
- The IDT software gives the user access to adjust some settings. The user has to be near the logger to make the changes over the serial communications cable.
- After installation, some additional settings can be modified remotely, via the unit receiving commands from the DataGate system.

2.7 IDT – SETUP AND TEST TOOL

HWM provides a setup and test tool (called 'IDT') for the equipment. (See section 4.1).

The user of the IDT software can instruct the logger to do various maintenance tasks, such as communications tests. This is particularly useful when done on-site since communications are affected by the (often below-ground) location of installation, local signal strength of the mobile network and the radio leakage properties of the chamber.

e.g., The IDT app can help by making test calls or show signal levels to find the best position for an antenna.

2.8 OVERVIEW OF THE INSTALLATION PROCESS (LOGGER & HYDROPHONE)

The deployment process depends on the strategy employed by the water company.

An example of Installation may consist of the following steps…

- DataGate must be prepared to receive data from the logger; this is an administration process.
- Installation sites must be selected. These should have a description and a reference number to identify them on DataGate.
- Equipment must be available at the installation site to complete the installation. This will include:
  - The PermaNet+ logger.
  - The Hydrophone-2 sensor and cable.
  - Any adaptors or couplings required to connect between the Hydrophone-2 and the water network valve.
  - An antenna.
    (It is possible that several antenna configurations may need to be tried in order to get a good result. It may also be useful to have a variety of antenna types to try).
- The installer must activate the logger to take it out of shipping mode.
- The user connects a communications cable between the PC and logger. IDT can be used to read current settings from the logger into the computer memory.

- The user should check and (if required) adjust the settings of the logger for the Hydrophone-2 use and the leak determination process settings.
- (Optional) Test the Hydrophone-2 using the IDT tool prior to installing.
- Prepare the Hydrophone-2 and couplings for connection to the water valve. Ensure they are suitably clean and sterile.
- Ensure the valve to which the Hydrophone is being attached is suitably clean and sterile.
- If required, occasionally lubricate the threads and other connecting surfaces to ensure they do not become permanently bonded.
- Fit the Hydrophone-2 to the water valve whilst ensuring any health and safety requirements or work practices for undertaking work on pressurised water pipes are followed. Undertake a risk assessment prior to commencing work.
- Bleed the air from the Hydrophone-2 sensor chamber using a bleed kit.
- The user should check and (if required) adjust the generic settings of the logger. (Call-in schedules, etc).
- The antenna is connected to the logger. The antenna is placed in its initial location within the installation chamber (this may need to be adjusted later; it is a trial-and-error process).
- (Optional). The user can (whilst the chamber lid is off) make a Call Test to DataGate to verify internet connectivity settings are OK and that data can be sent.
- The lid of the chamber is closed (unfortunately, this degrades the radio signal with the cellular network), and the power-level received (typically using the CSQ level) is checked. If inadequate, adjustments need to be made to the antenna position, or the type of antenna used, to find the best CSQ level.
- With the lid of the chamber closed (and positions finalised), a further Test Call is made to confirm the logger can send and receive data.
- Remove any temporarily used cables from the logger (e.g., the programming cable) and re-connect the permanent cables.
- Close the lid of the chamber.
- The HWM logger goes to into standby until it needs to make leak determination measurements or send in measurement data. Periodically it completes these tasks.

2.9 Logger activation process (for First-time use)

When shipped from the factory, the unit is often deactivated.

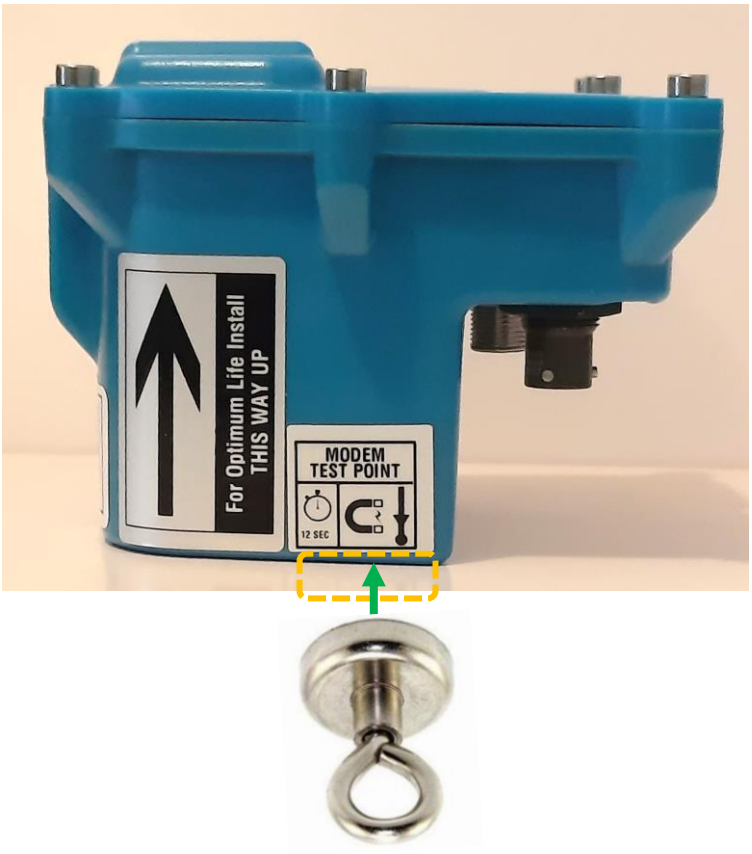
This mode is designed to preserve its battery life whilst being shipped or in long term storage; this is often called “shipping mode” or “sleep mode”.

The PermaNet+ logger frequently checks if an installer is trying to use it.

To use the logger, it must first be *activated*. The equipment will then start running its regular program for leak determination.

On the side of the logger there is a label showing a magnet symbol. A magnetic field sensor is located under this label.

A strong magnet must be constantly held against the coloured dot on the base of the unit (near the magnet label) for **12 seconds** to start the logger.



3 FITTING / REMOVING THE HYDROPHONE 2

3.1 SAFETY / HYGIENE

Warning: When fitting or removing the Hydrophone 2 to an asset (water valve, Hydrant, etc) be aware that very high pressures are likely to exist which can present a hazard of injury to the installer.

Only use adaptors that are approved by HWM.

Working with water and other fluids under pressure can be hazardous. Make a risk assessment before proceeding and ensure adequate safety measures are in place. Wear any Personal Protective Equipment required during any fitting and removal processes.

Ensure any required safety or water hygiene practices are being followed.

3.2 ELECTRICAL CONNECTIONS – PROTECTION DURING INSTALLATION

The electrical connection to the hydrophone should be kept dry and clean of dirt and debris.

It is recommended to attach the hydrophone side of the cable to the Hydrophone-2 prior to fitting, to prevent contamination of the connector with water or dirt, especially if access is restricted due to limited space. Similarly, it is recommended to keep the cable attached when removing the Hydrophone-2, until the risk of water or debris contamination is negligible. However, do not lift or carry the Hydrophone-2 by any attached cable or hose ; This can cause damage to the equipment or the cable.

3.3 HYDROPHONE-2 PRE-INSTALLATION TEST

Prior to installing the Hydrophone-2, it is recommended that a pre-installation test is made to confirm the unit is functioning correctly.

Temporarily connect the Hydrophone-2 and use the test procedures described in section 5.1.3 to confirm the hardware is functioning correctly. This confidence test can prevent the need of extra work required to remove the Hydrophone-2 from a fitting if a problem should be discovered later on in the installation process.

Note: In order to complete the tests, the user should be familiar with the contents of the whole of this user guide; communications with and setup of the logger for Hydrophone-2 use are described in later sections.

3.4 REQUIRED PARTS AND TOOLS

Before commencing, ensure that you have the following equipment to install:

- A Hydrophone-2 sensor.
- A PermaNet+ logger.
- A cable to interconnect the Hydrophone-2 to the logger. (e.g., CABA2715).
- A set of suitable couplings (and seals) to connect the Hydrophone-2 to the fitting being used on the installation site.
- An antenna for the logger unit.
- (Any other mounting accessories, sensors or options that are required to be installed at the site).

The following tools and consumables may also be required:

- Silicone grease (suitable for use with fittings for potable water).
- Seals (various types, depending on fitting and adaptors selected)
  (These are required to seal the Hydrophone-2 to certain adaptors, between any mid-stage adaptors, between adaptors and fitting).
- A bleed kit for Hydrophone-2.
- Hydrophone-2 Installation tool (and a hydrant valve key to drive the tool).
  (Also an additional installation tool for fitting certain thread adaptors may be required).
- A laptop PC with IDT pre-loaded.
- A PC to logger communications cable (a Y-cable) ; refer to section 2.2.3).
- 50mm and 60mm spanners (wrench) if sufficient space is available to use.
- PTFE tape.

3.5 Preparing the water access chamber

Prior to fitting the Hydrophone 2 assembly to an asset, the water access chamber should be prepared by clearing of any debris. If required, excavate the chamber to ensure the valve can be easily accessed.

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

The Hydrophone-2 must be installed within a chamber that is free of water. Pump any water from the chamber as and when required prior to and during installation.

3.6 Preparing the Hydrophone

Prior to fitting the Hydrophone 2 to an asset, it must be prepared for assembly with whatever adaptors are required to match coupling point of the asset.

Ensure the parts are hygienically clean prior to assembling.

Ensure the O-ring is fitted and in good condition.

Whenever required, apply a light coat of silicon grease to the thread area of the hydrophone and also the O-ring, to ease assembly (and later disassembly).

Ensure any silicon grease present does not contain trapped dirt or debris ; If contaminated, thoroughly clean the surfaces and re-apply fresh grease.

3.7 SELECTING AND PREPARING ADAPTERS

Connection of Hydrophone-2 to an asset (hydrant, valve, etc) will sometimes be direct, but it will often require the use of adaptors in order to change the Hydrophone-2 thread connection into the required thread (and seal) to use on the asset.

Due to the large number of hydrant connections in use globally, adaptor kits are tailored to the needs of the local market. Contact your HWM representative regarding your specific adaptor needs to check for availability and its construction.

For some connections, a single stage adaptor may be available. Sometimes multiple adapter stages may be used in order to reach the desired connector type.

(No adaptor required).

(Connection on Asset)

(Single-stage adaptor).

(Connection on Asset)

(Multi-stage adaptor).

(Connection on Asset)

Note: Adaptor images are for illustration purposes only, and may vary from the adaptors supplied or installed.

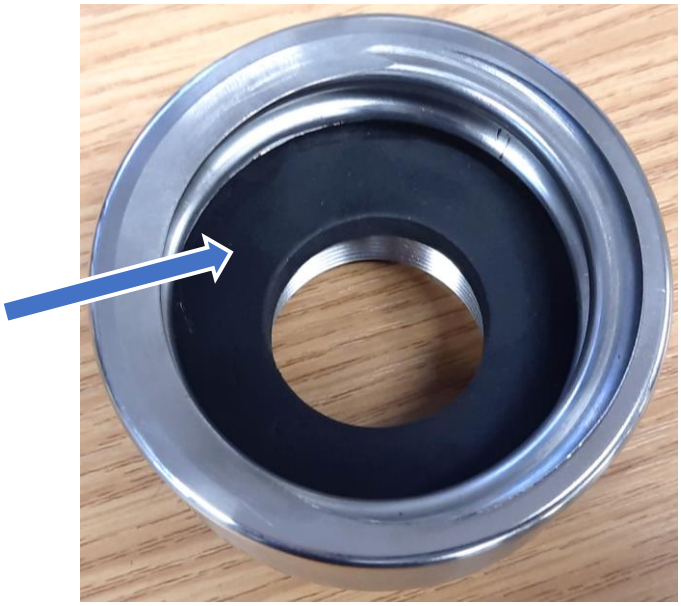
Ensure the upper and lower circular surfaces of any adapters
are clean and free of debris; The surface may form part of a high pressure water seal when it comes into contact with another adaptor or the O-ring of the Hydrophone 2.

Ensure any required seals for the adapter are fitted.

Ensure any seals of the adaptor are clean and free of debris.

Ensure the seals are in good condition. (Replace if required).

Lightly coat any rubber seals with silicone grease along any surface that will come into contact with another surface.



Apply a light coat of silicone grease to lubricate the two screw threads of the adaptor (internal or external threads).

Prior to fitting the adaptors and Hydrophone assembly to the connection point of the asset, plan how to assemble the parts together.

Sometimes the Hydrophone may need to be assembled to the adaptor first (outside of the chamber), due to space restrictions not permitting the use of tools to tighten the assembly. The whole assembly may then be fitted to the asset. At other times, it may be possible to begin assembly at the asset connection end and build the adaptors up from that.

Ensure no threads are damaged by cross-threading or trapped debris during assembly.

Ensure the asset (valve) to which you are making a connection is turned off prior to beginning installation and whenever fitting or removing equipment.

3.7.1 Connecting to a boundary box / ATPLAS connection

The Hydrophone-2 has a male thread of 1.5-inch BSPP, and is designed to be fitted directly to an ATPLAS / Boundary box with a female thread of 1.5-inch BSPP.

The Hydrophone-2 should be prepared for use (as per section 3.6) prior to fitting.

No adaptors are usually required, but an extension device to raise any existing water meter connection is available from HWM (if required).

The riser device also permits the one-way valve to stay in place.

When fitting Hydrophone-2:

Remove any debris from the boundary box and ensure it is clean.

Close the water valve and then remove any existing apparatus from the connection point.

Gently open the valve to flush out dirt and debris. Close the valve and inspect for cleanliness.

The Hydrophone-2 may then be fitted to the Boundary Box, tightening by hand initially. If using the Hydrophone 2 installation tool, be sure not to over-tighten as this could damage the boundary-box thread.

3.7.2 Connecting to a London Round Thread connection

The Hydrophone-2 has a male thread of 1.5-inch BSPP.
HWM can supply a single-stage adapter to convert the Hydrophone-2 thread to 2.5-inch female London Round Thread.

If using the Hydrophone 2 with the London Round Thread adaptor, the Hydrophone 2, it must be first prepared (as per section 3.6).

The adapter can be pre-assembled to the Hydrophone-2 prior to use. Ensure no cross-thread damage occurs when connecting the two items together. It should first be fitted hand tight. Then tighten by a further 1/4-turn using 60mm and 50mm spanners on the flats, or HWM-supplied adaptor tools.

Do not attempt to seal the threads between the Hydrophone sensor and the London round thread adaptor with PTFE tape or any other sealing material.
The seal is made by the O-ring of the Hydrophone 2.

When fitting Hydrophone-2:

Remove any debris from around the valve connection and ensure it is clean.

Gently open the valve to flush out dirt and debris. Close the valve and inspect for cleanliness.

The hydrophone assembly can now be screwed onto the valve connection.
Ensure no cross-thread damage occurs when connecting the two items together.

The assembly should be hand tight initially.
Then use two the Hydrophone 2 installation tool to complete the tightening process.

Be sure not to over-tighten as this could make disassembly difficult.

3.7.3 Connecting to other types of valve connection

Globally, there are many other types of connection standards for equipment connection to the water pipe network. They are too numerous to mention here. Some countries may have many connection types in use.

For connection to other types of valve connection, follow the guidelines given in section 3.7, as appropriate.

3.8 BLEEDING THE HYDROPHONE

The Hydrophone 2 should be in direct contact with water and no local leaks should exist at the installation site ; the noise from local leaks can prevent the detection of leaks further into the pipe network.

Remove trapped air by attaching a bleed valve tool to the auxiliary connection point of Hydrophone 2. (HWM can supply a suitable re-usable bleed kit if required).

Ensure the bleed tool is so positioned that its outlet is facing away from any people (including the user) or equipment, so that any water discharged will not cause injury or damage. Water should be discharged to an area away from the chamber so as to not cause flooding.

Slightly open the valve of the hydrant to allow water to pass into the Hydrophone chamber. Then insert the bleed tool to allow water to flow and for any trapped air to escape.

Remove the bleed tool (using the Quick Release connector) once a steady stream of water (with no air bubbles) is present ; this indicates the air is completely expelled.

Then fit the quick release valve protector cap.

Open Hydrant valve fully to allow water into the hydrophone. A fully open hydrant valve will give the best noise transmission to the Hydrophone.

3.9 REMOVING THE HYDROPHONE 2 FROM AN ASSET

If it is required to remove the Hydrophone 2 from an asset, the following steps should be followed:

Ensure the valve is turned off before removing or fitting any equipment.
Use the bleed valve to confirm the system is de-pressurised prior to removal.

Ensure the surface of any apparatus that will replace the hydrophone (water meter, hydrant cover, etc) is suitably clean and sterile.

If flooded, drain the access chamber using a pump.

Clear any debris from the chamber, allowing good access to the Hydrophone and the asset.

Remove the Hydrophone 2 and any adaptors from the asset connection.
Keep them in a safe place so as to not get damaged and also where they can be kept clean.

Gently open the valve to flush out any dirt and debris. Close the valve and inspect for cleanliness.
Apply silicon grease onto the thread of the apparatus (hydrant cover / water meter, etc) that is to be replace the Hydrophone 2. Then fit it to the asset, ensuring threads are not damaged. Tighten as appropriate for the attached equipment.

The Hydrophone 2 should be cleaned, disassembled from any adaptors, and re-packed into its original container or carry-case. It should be made hygienically clean prior to its next use.

3.10 CONNECTING THE HYDROPHONE 2 TO YOUR LOGGER

3.10.1 During normal use

During normal use, the Hydrophone 2 will be connected to the logger by a 4-pin cable (e.g., part number CABA2715), shown below.

(To logger)

(To Hydrophone-2)

One connector has pins ; connect this to the Hydrophone 2, as shown opposite.

One connector has sockets ; connect this to the logger.

The logger connection will be labelled “LNS” or “LNS & Comms”, (or similar).

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

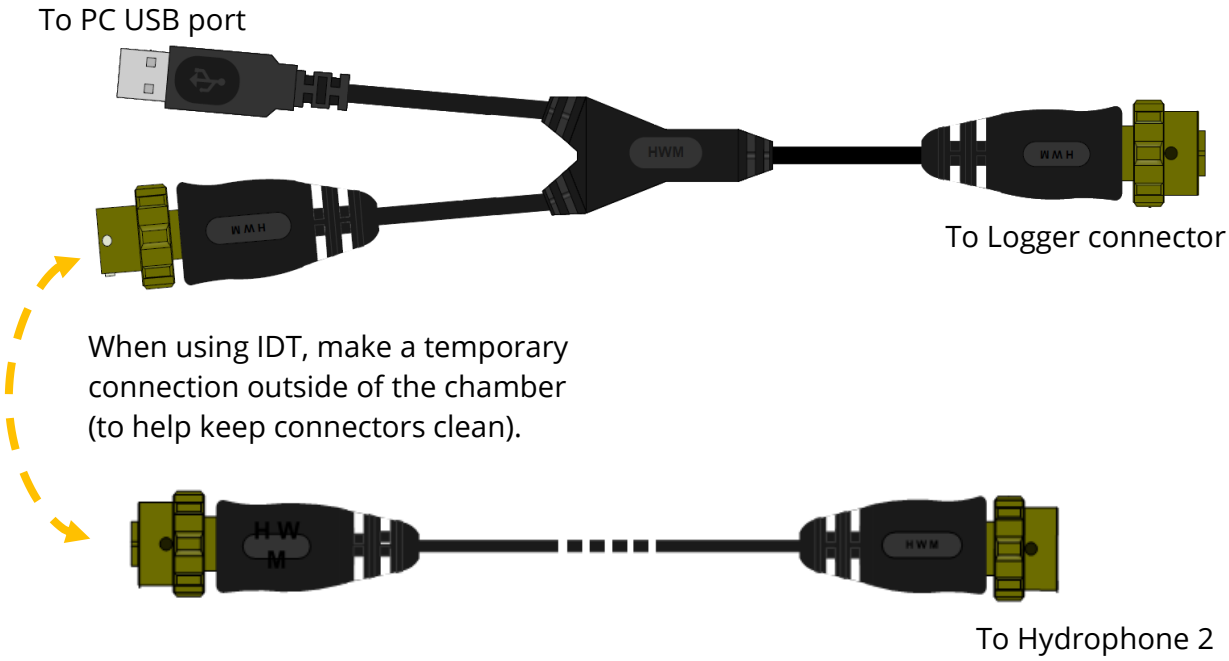
When attaching the cable, ensure the connector is correctly closed (twist to seal); It will then become a waterproof connection.

Note: The connector for the hydrophone is shared with the serial communications interface used for setup of the logger. (See section 3.10.2).

3.10.2 During programming

When programming the PermaNet+ logger, the PC requires a programming cable. The logger shares the same connector for both the interface for Hydrophone-2 and the interface for the programming cable. The programming cable therefore takes the form of a Y-adaptor. The programming Y- cable splits the logger connections into 2 paths (logger to Hydrophone ; logger to USB communications interface).

The connection path is shown below:



Once any programming and tests have been completed (including test calls to the server), remove the temporary Y-cable, and re-attach the Hydrophone-2 to the logger with the regular cable.

4 COMMUNICATING WITH THE LOGGER

To communicate with the logger (for local programming and test purposes), a PC is required, along with a HWM software utility called "**I**nstallation and **D**iagnostic **T**ool", or more commonly known as IDT (PC version).

Note: There is another version of IDT, the IDT (mobile app version).
The mobile app version of IDT is not for use with PermaNet+ loggers.

4.1 INSTALLING IDT (PC VERSION)

IDT (PC version) and its user-guide can be downloaded from the HWM Customer Support website, or from the following webpage:

https://www.hwmglobal.com/idt-support/

(Note: The user has to be registered by HWM and have a password to gain access).

Refer to the IDT User-guide for information on how to install and use the tool.

IDT can be set to different operational user-level "views" (which set the user-interface and available options). The "basic" or "advanced" view is sufficient for checking the setup, installation purposes, and the testing the Hydrophone 2.

4.2 CONNECTING THE COMMS CABLE / INTERFACE

To communicate with the unit a communications cable is temporarily required.

The cable is in the form of a "Y-cable" (3 connectors), which allows the Hydrophone-2 to continue to be connected to the logger whilst undertaking programming and test.

- One connector is for the temporary connection of the Hydrophone-2.
  (Detach the Hydrophone-2 cable at the logger side and connect it to the Y-cable).
- One connector is for the logger (plugs into the "LNS & Comms" interface).
- One connector is for the PC's USB port.

(Refer to section 3.10.2 for an illustration and further details).

Launch IDT.

Connect your PC to the logger's Comms interface using the Y-cable; the Hydrophone-2 should continue to be connected to the logger.

There will be a short delay before the PC recognises the connection of the logger; This is normal.

If your PC has sound enabled, you will hear a sound when the logger connects.

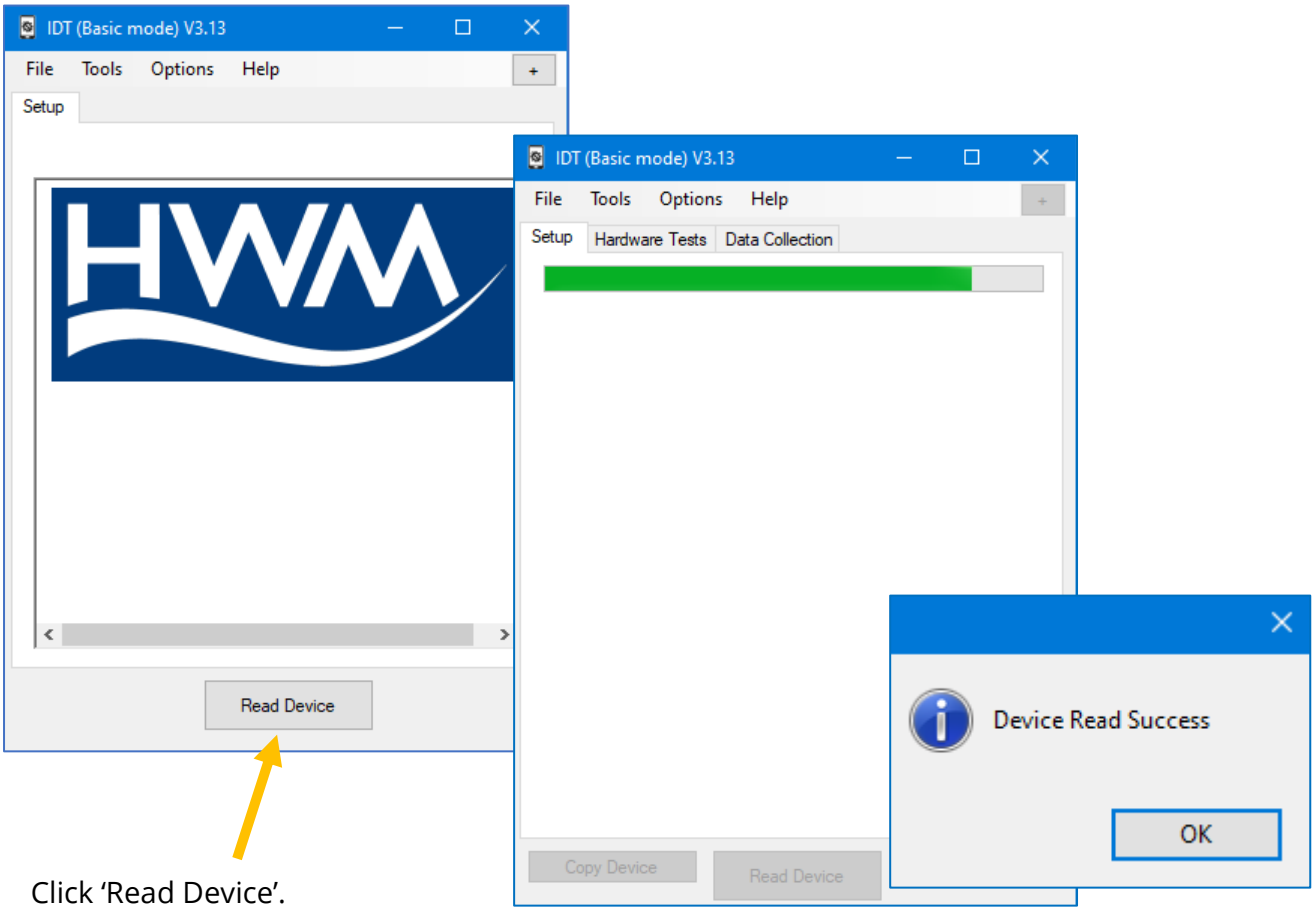
Note: The first time you connect your PermaNet+ to a new USB port, Windows will configure the driver; Wait until this process is completed before proceeding.

The communications circuit of the logger is normally on standby, to preserve the unit's battery. The logger occasionally checks the communications link to see if a user wishes to communicate with it; If so, it opens the link. This link remains open for

communication for approximately 2 minutes, waiting for instructions. If there is no interaction from the user during this time, the logger puts the communications link back into standby. If the user begins using the link, the logger completes any tasks the user gives to it and then keeps the link open for 10 minutes after it was last used. It then puts the link into standby.

If the link is in standby, unplug the USB cable for a few seconds and then re-connect it to re-establish communications.

4.2.1 Loading Logger settings into IDT (PC)

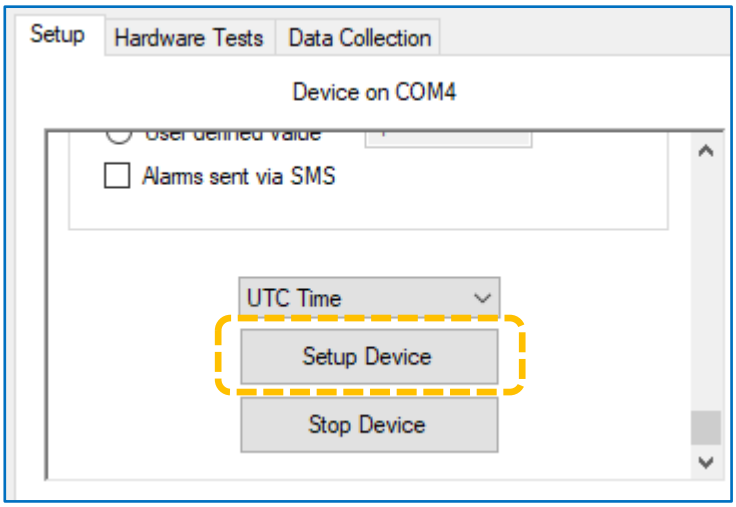


Click 'Read Device'.

A progress bar will show across the top of the page. When completed, an information box will appear stating 'Device Read Success'. Click "OK" to clear the box.

The IDT-PC program has now read a copy of the unit's program (settings) into the "current program" memory area.

The settings can be changed within IDT but note that the logger itself is not updated with any of the program changes unless the user later saves the settings stored in IDT back into the logger by clicking on the "Setup Device" button.



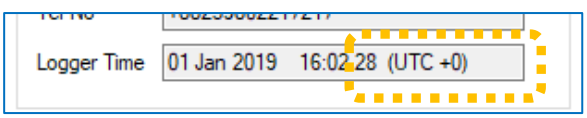
Note: The logger will usually have settings pre-programmed by the factory prior to shipping. However, **the installer has responsibility** for confirming the settings are appropriate for use at the installed site.
If you have specific requirements this can be discussed with your HWM sales representative at the time of ordering the loggers.

Note: Please also refer to the IDT (PC version) user-guide.
The IDT user-guide is written primarily for a generic multi-purpose data logger, however many of the IDT functions and settings are common to the PermaNet+ device. Where this is so, they will only be mentioned briefly in this guide.

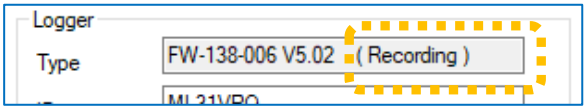
The logger can operate in several modes (see section 2.5).
For certain modes it operates in a similar way to a general-purpose data logger, whilst in other mode it may operate using a specialised leak determination program. This user-guide will provide details of the program operation in each mode and the relevant additional settings for it.

Note: When IDT starts it checks whether a new version is available; If so, it is recommended to download it to keep the software up to date with any new features or bugfixes.
Similarly, when IDT reads the PermaNet+ logger details it may advise that a new version of software is available for the logger itself. If so, it is recommended to update it before commencing.
Refer to the IDT user-guide (if required).

Before proceeding with setup, confirm the logger is set to use your local time-zone.



Check that the logging status is set to "Recording". (Refer to the IDT guide for guidance). It is also important to confirm the logger is in a "Recording" running state before leaving the installation site.



5 CONFIGURING THE PERMANET+ LOGGER

The PermaNet+ loggers have standard settings for operation programmed into them prior to shipping from the factory, with some variations according to customer requirements.

Note: The installer may check or be required to adjust certain settings to suit the particular installation site.

5.1 CHECK / SETUP OF CHANNELS FOR USE WITH HYDROPHONE-2

5.1.1 Check of existing settings / adjustment

When shipped from the factory, the logger will usually have some pre-configured (or partially pre-configured) channels, including those required to generate data for the hydrophone sensor. If this is not the case, the channels must be added in order to be able to drive the sensor to obtain data.

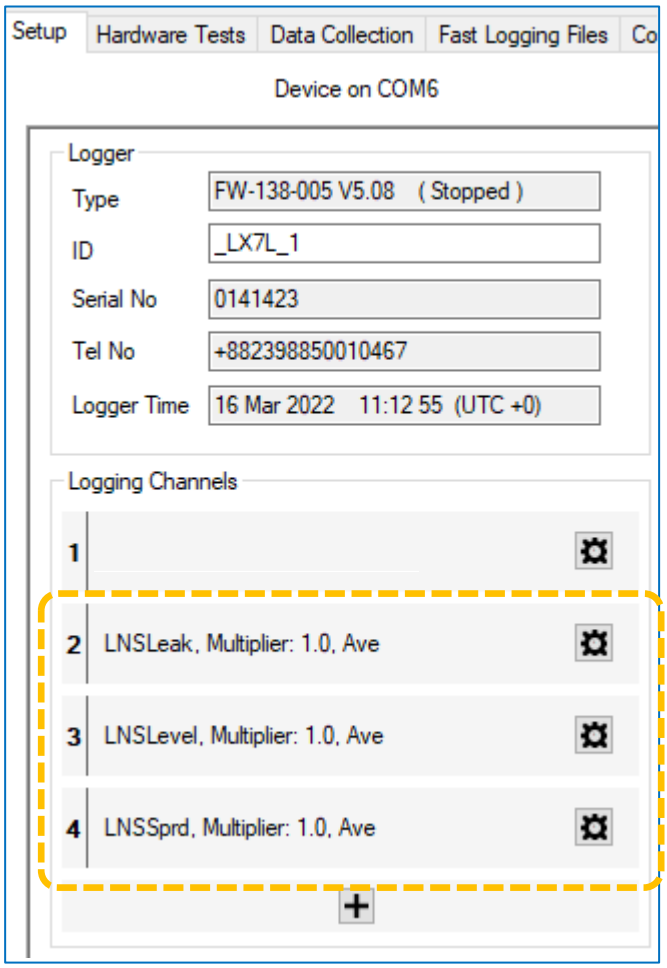
Note: The channels may be partially set up to ensure that the channel numbering of the data streams will marry-up with those that have been set up for the logger on the DataGate server.

The channel types required for Hydrophone 2 are:

- LNS-Leak
- LNS-Level
- LNS-Spread

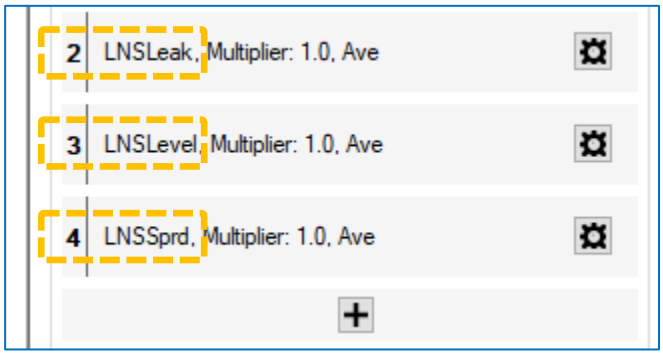
To check if the channels already exist:

After reading the logger configuration, select the Setup tab and locate the "Logging Channels" panel; this shows any channels that already have some configuration for data-logging.

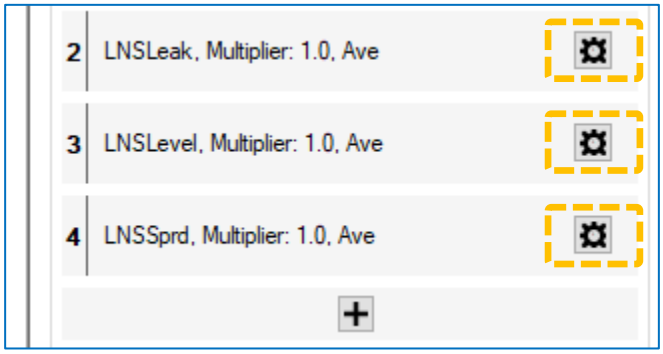


If channels for the Hydrophone-2 have already been created, they will be listed (along with any other channels). A summary of its settings is also shown.

Make a note of the channel numbers assigned for each channel type, in case it is needed later (e.g., For the programming of alarms).



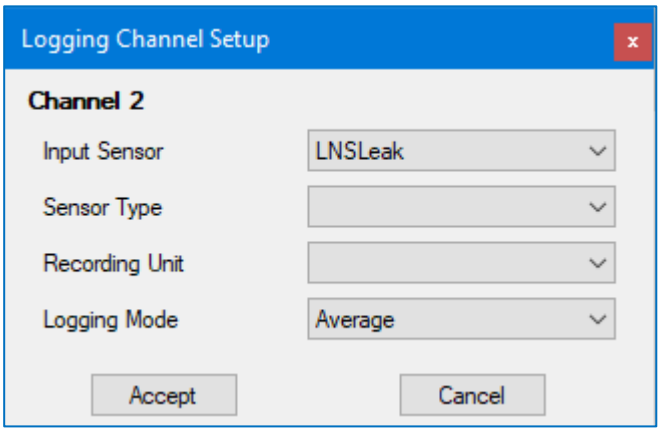
For each channel, tap on the 'setup cog' button to check the settings.



An example of *incomplete settings* is shown opposite:

(e.g., Some fields are missing).

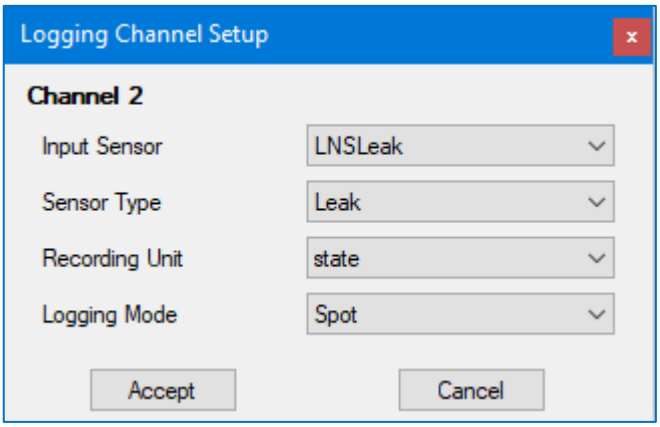
If any settings are incomplete, the missing settings should be completed.



For Daily leak determination mode, set the LNS-Leak channel up as shown opposite.

For Trunk Main mode, set the channel up in an identical manner.

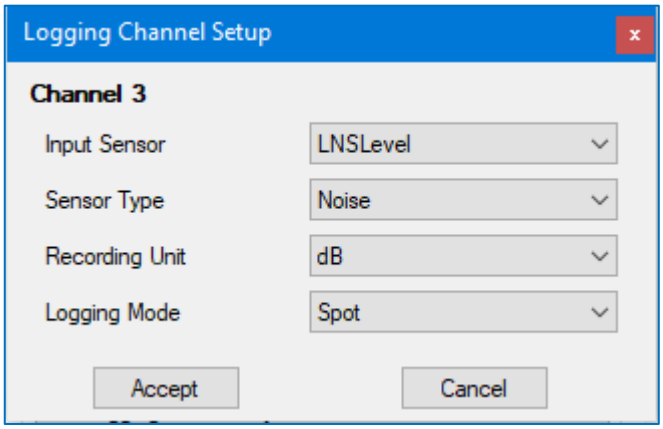
Tap on the Accept button when complete.



For Daily leak determination mode, set the LNS-Level channel up as shown opposite.

For Trunk Main mode, set the channel up in a similar manner, but with a logging mode of your choice (minimum, average, maximum).

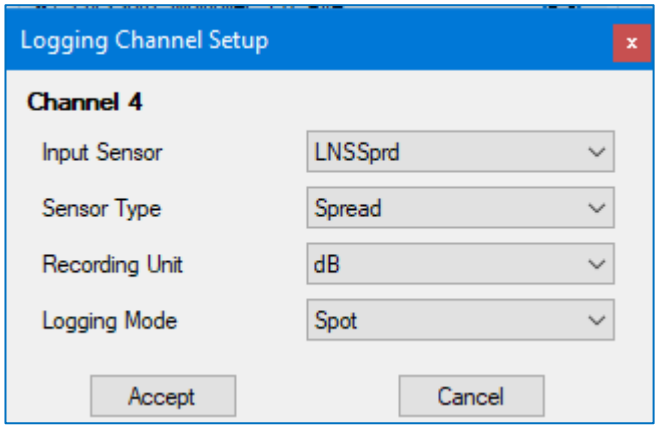
Tap on the Accept button when complete.



For Daily leak determination mode, set the LNS-Sprd channel up as shown opposite.

For Trunk Main mode, set the channel up in an identical manner.

Tap on the Accept button when complete.



Note: For the Daily leak determination mode, no datapoints will be produced at the logging rate, as the regular logging activity becomes deactivated by other settings (see section 5.2) ; the logger's use of the above settings is to some degree ignored.

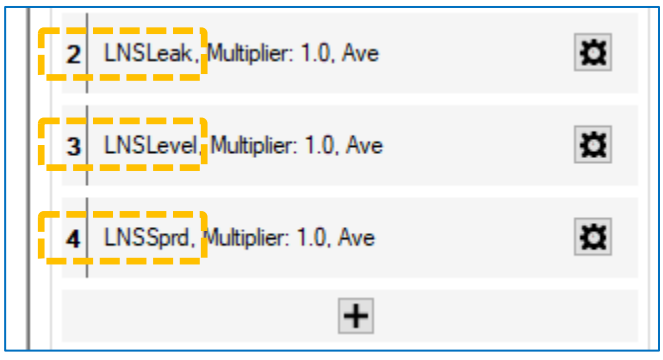
Note: For the Trunk Main leak determination mode, datapoints will be produced at the logging rate, as normal. The settings for leak determination (see section 5.4) to some degree ignore the above settings, which are used for logging purposes only.

5.1.2 Setup of non-existing channels

If the channels (shown opposite) do not exist, they need to be added by tapping on the ' + ' button.

(Refer to the IDT user guide for details on adding a channel to a logger).

Add the channels such that the resultant setup is as detailed in section 5.1.1.



5.1.3 Hydrophone-2 functional tests

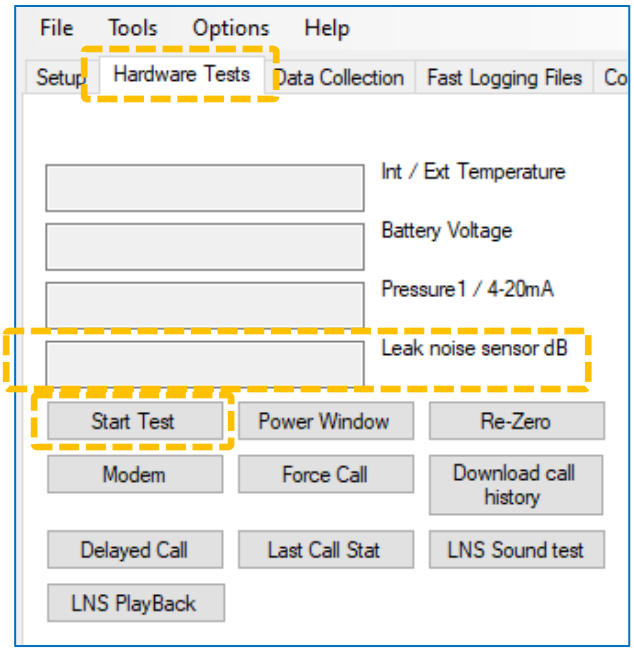
The Hydrophone-2 unit can be tested using the IDT tool.

Save any existing changes to the logger setup prior to test.

Check the Hydrophone-2 is connected prior to starting the test.

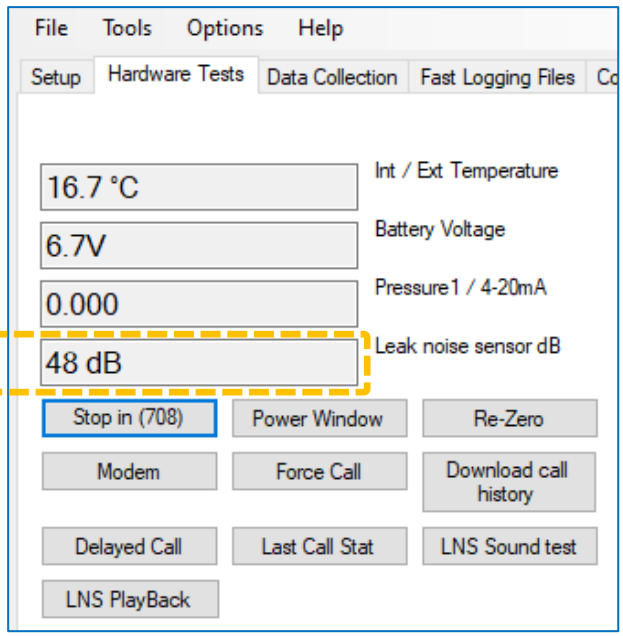
Select the 'Hardware Test' tab.

Confirm the Hydrophone-2 channel appears amongst the list of result fields ; It will appear as a 'Leak noise sensor'.



Click on the 'Start Test' button.

The Hydrophone-2 sound level (ambient noise) is measured by the logger every few seconds and is shown in the Leak noise sensor results window.

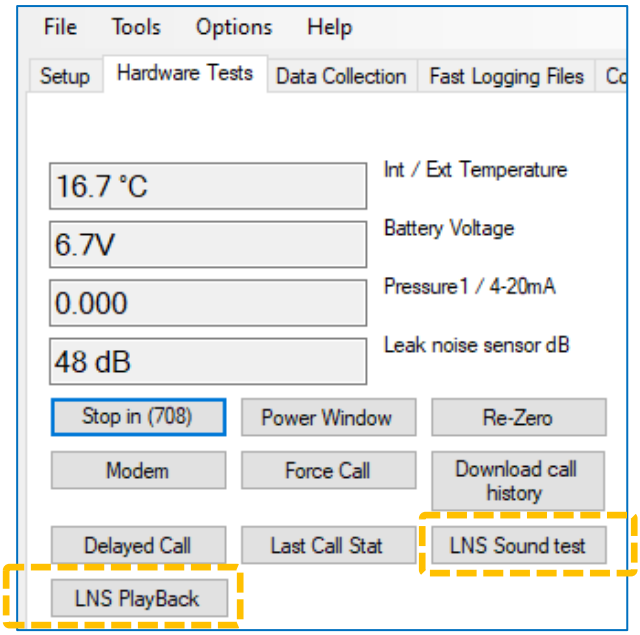


When installed into the water column, the sound level value represents the ambient sound in the pipe network.

If a pre-installation test is being made, the sound level value represents the ambient sound in air. Lightly scratching the metal side of the Hydrophone-2 will cause the measured level to change, thus confirming it is operating OK.

Keep test time to a minimum to preserve the logger battery life. When you are satisfied that the unit is operating OK, click on the 'Stop in' button to halt the test.

Further confirmation of the Hydrophone-2 audio can be made by making a sound recording from the Hydrophone-2. When completed, the sound recording can be uploaded to the PC and played back (through headphones connected to the PC, etc).



To start producing the sound recording, click the 'LNS sound test' button.

... Initially a count-down will be shown on the button.

... then it will show as 'recording'.

When the recording is complete, click on the 'LNS Playback' button.
IDT will first upload the audio to the PC (which takes approx. 30 seconds).
IDT will then play the audio back through the PC speakers (or a pair of headphones, if attached to the PC).

5.2 CONFIGURING LEAK DETECTION (SELECTING THE EVALUATION MODE)

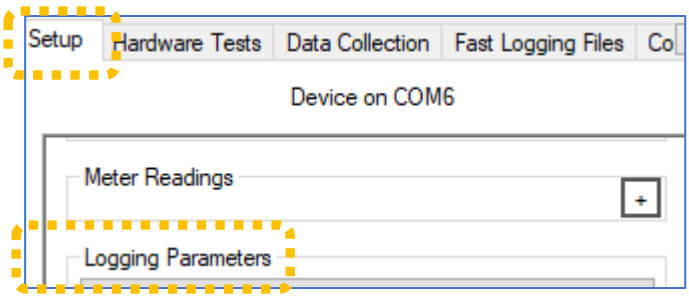
The logger interface must first be set up to drive the Hydrophone sensor to obtain audio samples, as detailed in section 5.1

Note: The IDT display is adaptive in behaviour and shows information and controls which change depending on previous selections / de-selections.

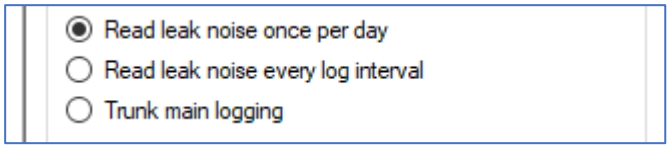
To configure the logger, first select the Setup tab in IDT.

The Setup tab is divided into panels of related settings.

The controls for the leak determination program cycle, and other relevant settings are found in the Logging Parameters" panel.

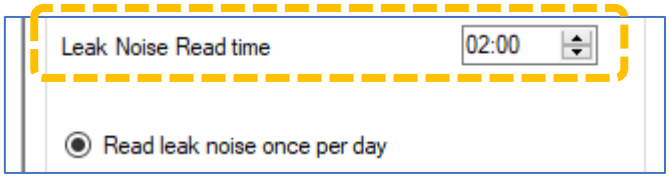


The leak evaluation mode is selected using the 'radio button' style controls, shown opposite.



- For the logger to use daily leak evaluation mode,
  select "Read leak noise once a day".
  The Hydrophone-2 sensor is then excluded from being activated at the sample rate (which is used for most sensors).
- For the logger to use Trunk Main leak evaluation mode,
  select "Trunk main logging".
  The Hydrophone-2 sensor is included amongst the sensors that are activated at the sample rate.
- **Do not** select the "Read leak noise every log interval" setting.
  This setting the is for HWM use only, and never for general use.
  (If set, the logger will run the daily leak noise program many times a day and will soon exhaust the battery).

5.3 CONFIGURING LEAK DETECTION (DAILY EVALUATION MODE)



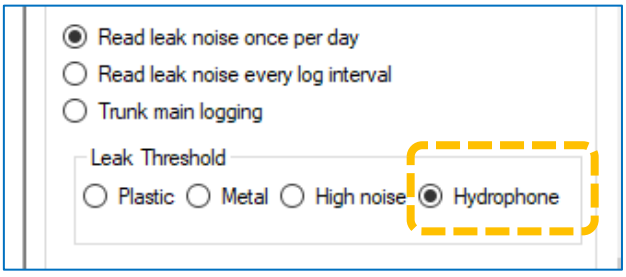
With the 'Read Leak noise once a day' selection set, a "Leak Noise Read Time" field becomes visible.

The "Leak Noise Read time" field controls the time (using a 24-hour clock) when the leak determination program is to be run with the Hydrophone.

It is usual to set this to a time when the water network has minimal noise, such as when it is in minimal use (usually in the early hours of the morning).

Note: The entire system should have timings set to work in a co-ordinated manner. Leak determination by the logger should occur close to the optimum (quiet) evaluation time. Sufficient time should however be allowed for any confirmation checks by the unit, which must occur before data is sent into the server. The server, in turn, should have received data from the loggers prior to the typical start of the working day, so that a recent evaluation of the leak status of each of the sites being monitored by the fleet of loggers is available for users (of the PermaNET+ data viewer) early in the day.

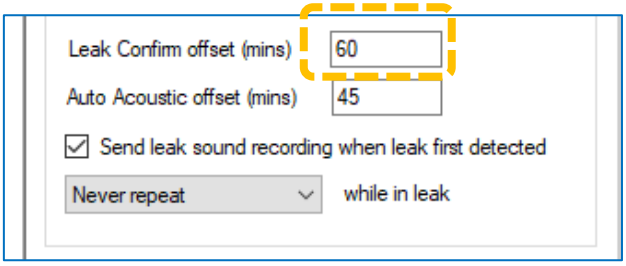
One section of the Logging Parameters panel is a "Leak Threshold" selection.



This is a sensitivity control which determines which threshold is being used as the judgement of a leak / no-leak condition during leak determination.

For use with the Hydrophone 2, select the 'hydrophone' setting.
(The other selections are for use with a different type of leak noise sensor).

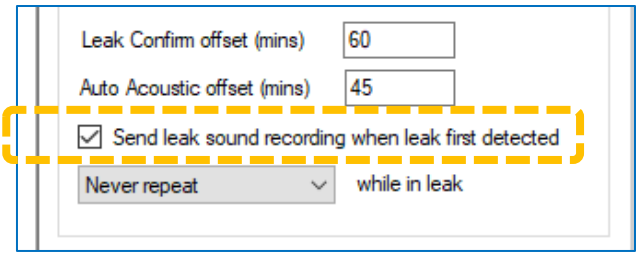
To avoid giving false leak indications, the leak detection program is run a second time, which produces the final judgement. This confirmation run avoids leak indications being generated for temporary noises within the environments (engine noises from a parked lorry, etc).



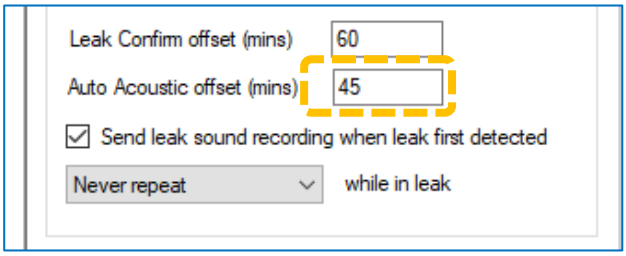
The time-delay for the confirmation run is set in the field shown. As well as allowing the environmental noise to disappear, a short break will also give some time for the battery to recover.

The "send leak sound recording when leak first detected" control will (when set) cause the PermaNet+ unit to make a short recording of the pipe noise if it judges that a new leak is present.

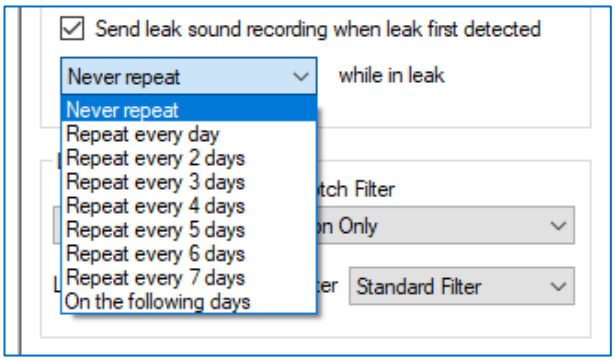
The recording lasts typically for 10 seconds.



The Auto Acoustic offset control sets the time delay (after the confirmation run) for when the audio recording (if enabled) is to be made.



There are options regarding repeating the audio recording whilst the logger continues to show a leak condition.



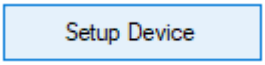
The audio recording(s) are stored in the logger and will be uploaded to the server at next logger call-in. A user can then listen to the noise (played back from the server) to form an opinion as to whether it sounds like a leak.

For daily leak determination, *a single datapoint is produced each day* for the following channels, each being associated with the Hydrophone-2 leak-noise-sensor.

- Level
- Spread
- Leak indication (judgement)

(The selections of Logging mode, etc, as detailed in section 5.1.1, for producing sensor datapoints are disregarded and over-ridden).

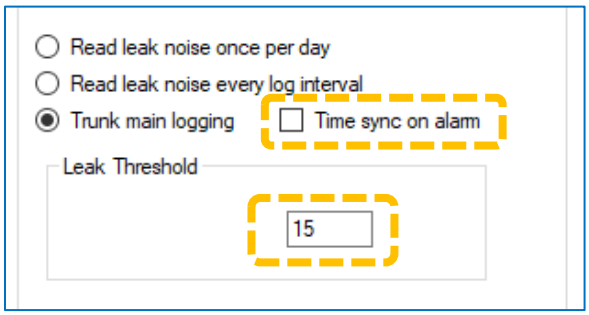
The IDT-PC program stores the new settings in the PC memory.
To save then into the PermaNet+ unit, click on the "Setup Device" button in IDT.
(This is located towards the bottom of the Setup tab).



5.4 CONFIGURING LEAK DETECTION (TRUNK MODE)

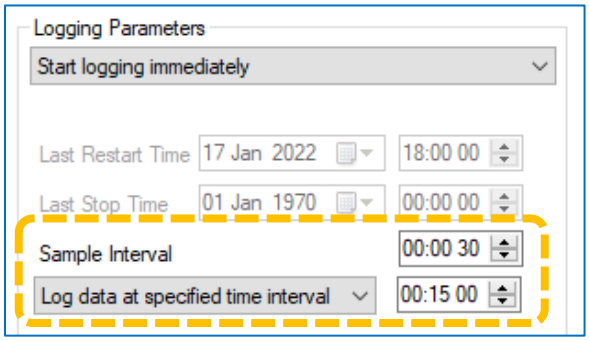
With the 'Trunk main logging' selection set, a "Time sync on alarm" control also becomes visible (refer to section 5.4.3).

In addition, the Leak Threshold changes to be able to set a numeric value (no longer a limited choice based on a material or sensor selection).



The Trunk Main mode runs frequently, and therefore requires the setup of the timing parameters.
(Setup is identical to that of a standard HWM logger that logs sensor measurements; refer to the IDT user guide).

For Trunk Main mode, the selector should be set to "log data at specified time interval", as shown.



e.g., Here the sample interval is 30 seconds, and the log interval is 15 minutes.
The logger listens to a short (approx. 150mS) sample of the audio from the Hydrophone-2 every 30 seconds and calculates the sound power level.
A set of data (the results of the measurement samples) are temporarily stored in order to produce datapoints (at the log data time intervals).

For Trunk Mode leak determination, a continuous stream of datapoints are produced for the following channels, each being associated with the Hydrophone-2 leak-noise-sensor.

- Level — The channel can be set to a logging mode of minimum, average, or maximum ; Logged datapoints will conform to the selection.
  For the purpose of leak determination, the channel setting is disregarded, and the Average value of the set of samples is used.
- Spread — The channel must use a logging mode of spot.
  For the purpose of leak determination (and the production of Datapoint values), the spread is always evaluated as the (maximum level – minimum level) from the set of available samples.
- Leak indication (judgement) — The channel must use a logging mode of spot.
  For the purpose of leak determination (and the production of Datapoint values), the leak indication is always judged using the following:
  Is (Level – Spread) greater than Leak Threshold?

The purpose of trunk main logging is to provide an alarm as early as possible in the event of a burst in order to reduce the impact on consumers and the massive loss of water and potential flooding that can occur. This requires the logger to be set up with alarm conditions. When the alarm condition is met, the logger generates an alarm message for sending to the DataGate server. The server then distributes the alarm to any interested parties.

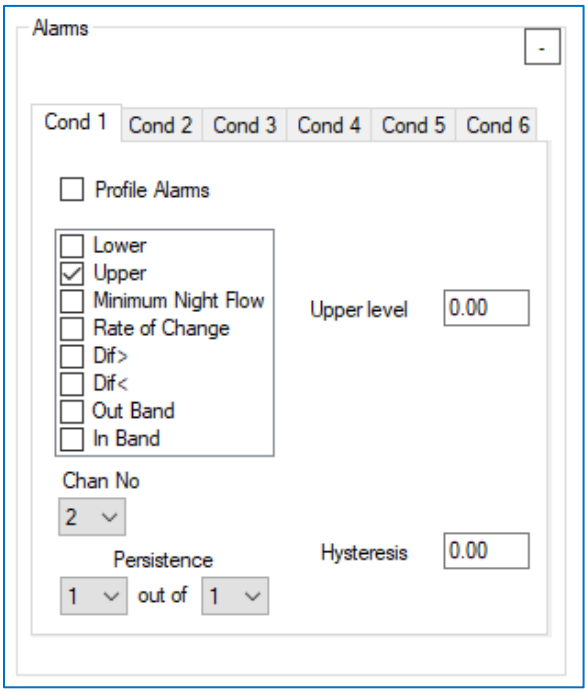
5.4.1 Use of the Leak Threshold for triggering Alarms

One method of producing an alarm is to use the LNS-Leak indication.

The leak indication is based on the difference between level and spread values, this being compared with the set Leak Threshold value.

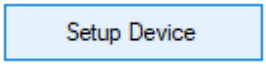
It is recommended that before an actual alarm is programmed into the logger, it is run at the site for a while and that the leak threshold (initially set low) is slowly adjusted (higher) to a point where the LNS-Leak indication is not showing any false indications of a leak being present.

Once the correct leak threshold value for the site has been found, then set an Upper-level alarm (as shown opposite), monitoring the LNS-Leak channel. This will send an alert if the Leak Threshold is crossed.



If you still get false alarms, you can adjust the sensitivity by changing the Persistence setting. (e.g., Set 6 out of 9 to only set the alarm if 6 thresholds out of 9 consecutive ones are crossed). However, use of persistence will increase the time between a suspected burst and the alarm being triggered so careful choice of logger interval vs persistence should be made.

The IDT-PC program stores the new settings in the PC memory.
To save then into the PermaNet+ unit, click on the ”Setup Device” button in IDT.
(This is located towards the bottom of the Setup tab).



5.4.2 Use of level (profile alarm) for triggering Alarms

One method of producing an alarm is to use the LNS-Level value.

This is based on the assumption that a leak caused by a burst mains will raise the noise level produced from the pipe to a higher-than-normal level.

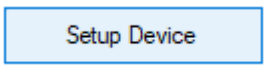
The noise from the pipe network should be studied for some time to determine if it does follow some regular pattern of behaviour, with predictable noise levels. If not, this method is unsuitable.

A profile alarm can then be created, monitoring the LNS-Noise channel, with an upper threshold being set at a level above what is normally expected at various times of the day.

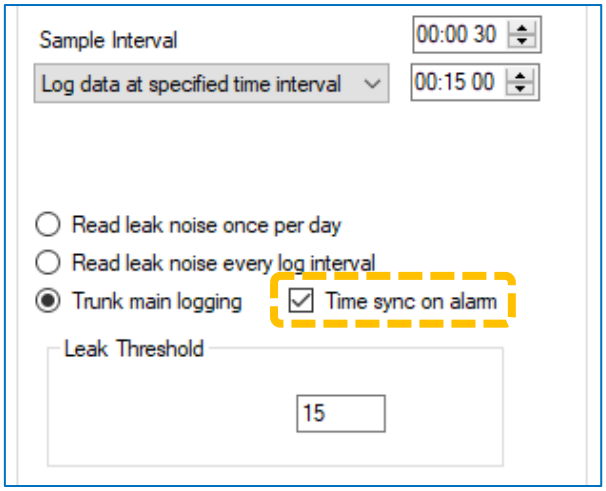
(For details of how to set up a Profile Alarm, please refer to the user guide for IDT).

It may be useful to add an additional channel (set to LNS-Level, maximum) in order to make an assessment of the noise values that the pipe network produces ; this will include the maximum from all the data sampled, some of which could otherwise be missed.

The IDT-PC program stores the new settings in the PC memory.
To save then into the PermaNet+ unit, click on the ”Setup Device” button in IDT.
(This is located towards the bottom of the Setup tab).



5.4.3 Use of an alarm to trigger an audio recording



When in Trunk Main mode, an alarm trigger also has to be set up. An alarm will start the process of informing interested parties that there is a potential issue (leak). (See sections 5.4.1 and 5.4.2).

If the "Time sync on alarm" is selected, additional activities are put into motion within the logger itself whenever *any* alarm is triggered.

- The logger is set to make a call-in which now will include the additional task of very accurately synchronising the logger's clock with the network.
- The logger is set to make an audio recording on the next available log boundary (15 minutes later in the above example).

The purpose of the time-sync is to give the server the option of using the sound files from two or more loggers (if they simultaneously detect the leak) for correlation purposes, to try to locate the leak position.

The logger uploads the audio file to the server at the next call-in time.

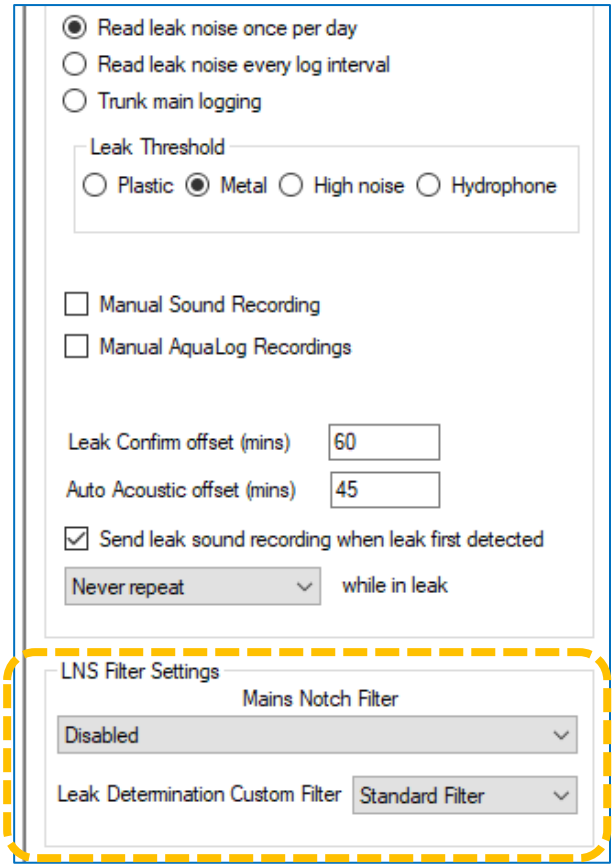
5.5 Configuring leak detection (alongside regular Logging)

The loggers can carry out leak detection activities (in both Daily leak determination and Trunk Mode leak determination) whilst simultaneously running the tasks required for the logging the data from any other sensors.

e.g., If an interface and sensor for monitoring water flow are installed, this can also be set up for regular logging activities.

(For guidance on the setup of other interfaces, please refer to the IDT user-guide).

5.6 Configuring Audio filters for Hydrophone-2



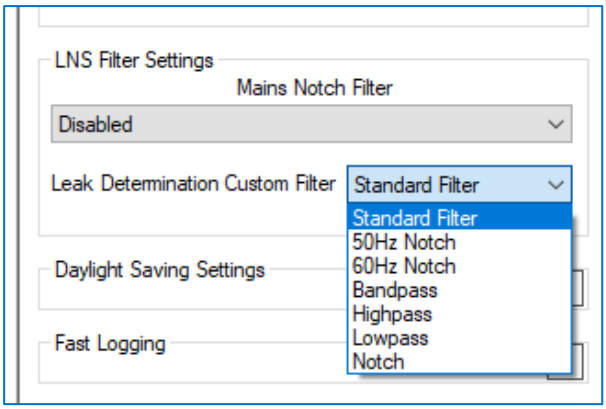
The Hydrophone-2 (and logger) will pick up a wide range of sound frequencies from the water column. However, not all are desirable for the purpose of leak detection. The noises could include mains hum, water pumps, or other temporary noise sources, such as traffic.

The logger has a comprehensive set of filters available for use in order to discard some of the unwanted noises and to focus its attention on noises that could be leaks.

The settings can be found in the 'LNS Filter Settings' panel.

There are 2 selectors.

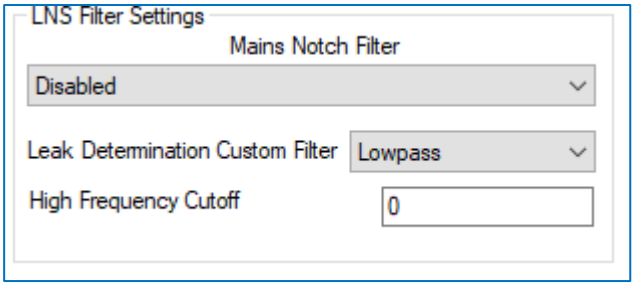
The top selector, labelled 'Mains Notch Filter', is the main control; it decides how the lower filter, labelled 'Leak determination Filter' is to be applied (or indeed, switched off).



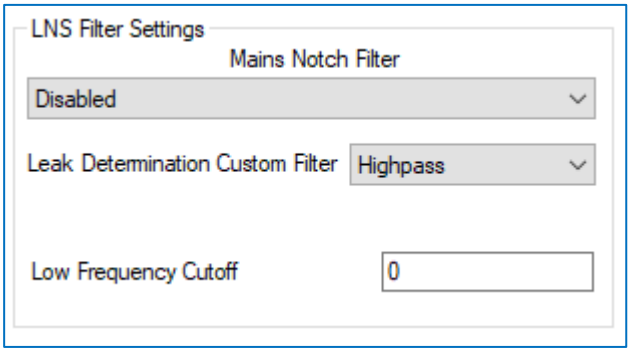
The following filter types are available:

- Standard Filter.
  This is a wide-band mains frequencies suppression filter.
- 50Hz Notch.
  This is a narrow-band mains frequency suppression filter, tailored to 50Hz mains.
- 60Hz Notch.
  This is a narrow-band mains frequency suppression filter, tailored to 60Hz mains.
- Low-pass can be used to reject high frequencies.
- High-pass can be used to reject low frequencies.
- Band-pass can be used to reject both high and low frequencies but accept mid-frequencies.
- Notch can be used to reject a specific band of frequencies, but allow others to pass through.

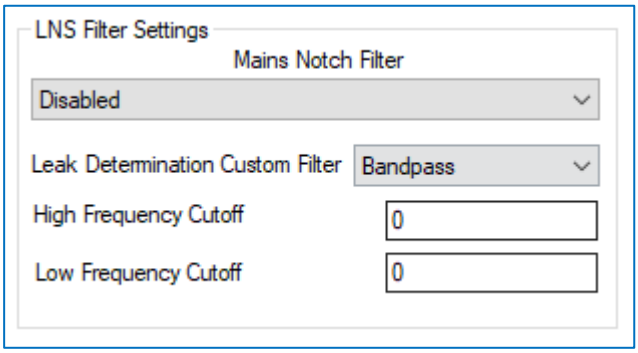
The Low-pass filter, when selected, has an appropriate field to set the cut-off frequency.



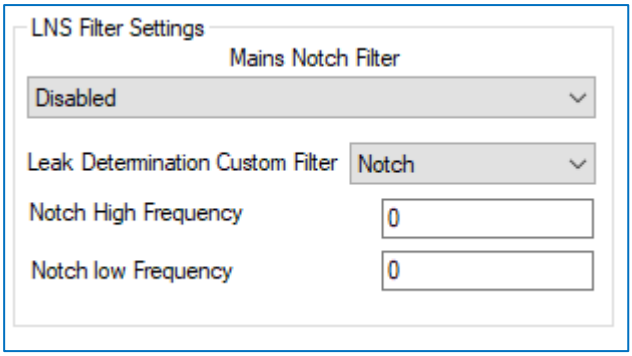
The High-pass filter, when selected, has an appropriate field to set the cut-off frequency.



The Band-pass filter, when selected, has appropriate fields to set the lower and upper cut-off frequencies.

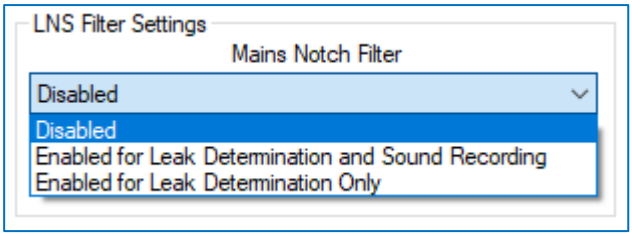


The Notch filter, when selected, has appropriate fields to set the lower and upper cut-off frequencies.

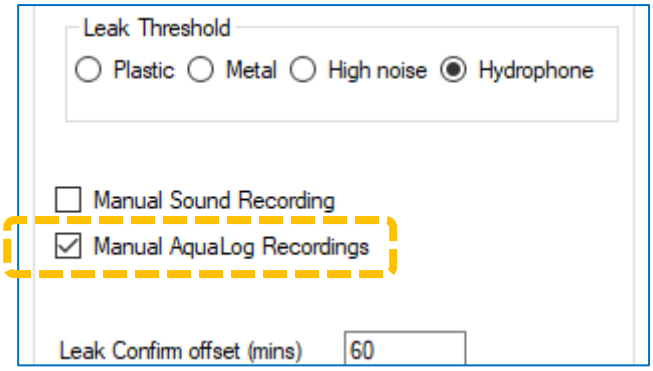


The 'Mains Notch Filter' selector can either:

- Disable the selected filter.
- Apply it for leak determination purposes only.
- Apply it for both leak determination and also sound recording purposes.

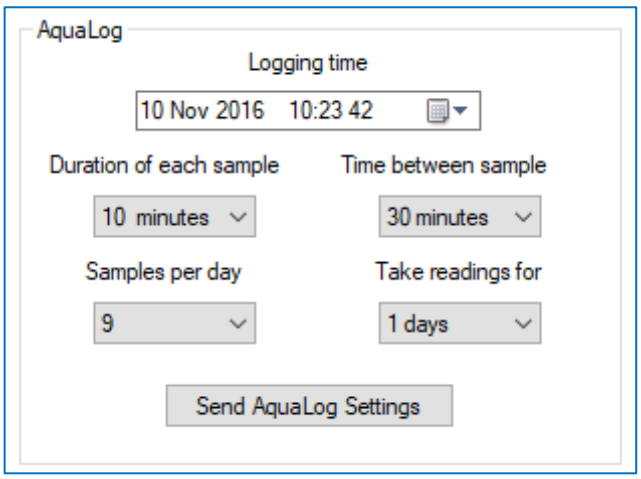


5.7 ADDITIONAL DATA FROM A 1-TIME PROGRAM – AQUALOGS



The "Manual Aqualog Recordings" control will (when set) cause the PermaNet+ logger to produce Aqualog data.

Aqualog production is a temporary addition to the logger's regular task of leak determination.



When Aqualogs are enabled, IDT shows another panel for the Aqualog settings.

An Aqualog produces data for a histogram of the noise levels that appear on the water network. More precisely, it can produce several sets of data for histograms, collected at different times.

The start time (and date) is selected using the "logging time" control; enter a date and time to commence.

The "Duration of each sample" sets the length of the Aqualog data collection cycle.

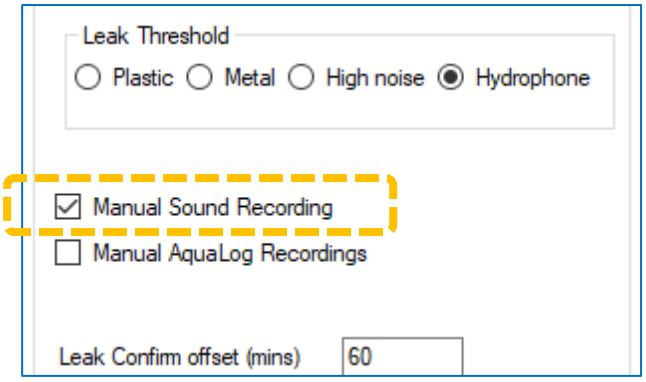
The "Time between samples" is the pause time before beginning the next Aqualog data collection cycle (if any are still pending for the current day)

The "Samples per day" sets the number of times the Aqualog data collection cycle should be run during each day.

The "Take readings for" control sets the number of days the daily cycle should be repeated.

When the Aqualog panel settings are complete, click the "Send Aqualog Settings" button. This will upload the temporary additional logging task to the unit. The Aqualog data will be uploaded to the server and can be viewed once the data has been produced and stored.

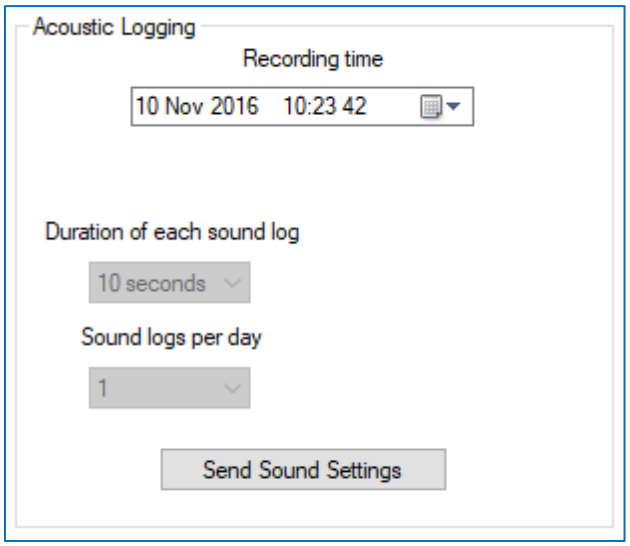
5.8 Additional data from a 1-time program – Sound Recordings



The "Manual Sound Recording" control will (when set) cause the logger to produce additional sound recordings.

The production of these sound recordings is a temporary addition to the logger's regular task of leak determination.

The recordings will be made independent of any leak judgement (i.e., whether a potential leak is detected or not).



When Manual Sound Recordings are enabled, IDT shows another panel (Acoustic Logging) for the settings. This has controls for setting a temporary program cycle for obtaining the additional Sound recordings.

The start time (and date) is selected using the "Recording time" control; enter a date and time to commence.

The "Duration of sound log" sets the length of the audio recording.

The "Sound logs per day" sets the number of times the logger must make a sound recording during each day.

When the Acoustic Logging panel settings are complete, click the "Send Sound Settings" button.
This will upload the temporary additional logging task to the unit. The Sound recordings will be uploaded to the server and can be played back from the server once they have been produced and stored.

5.9 OTHER REQUIRED LOGGER SETTINGS

5.9.1 Setup of data destination and logger call-in times

The PermaNET+ logger has to be set up for the regular delivery of its data (typically to a server). There are settings for:

- Where to send the data
- Delivery method and protocol
- Time(s) to send the data (usually by call-in to a server)

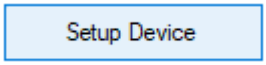
For the above settings, the PermaNet+ logger behaves as the generic logger device described within the IDT (PC version) manual; These settings are common to many HWM products. Please refer to the IDT (PC version) manual for guidance on these settings.

Note: The device must have these settings correctly programmed in order to send its data into the server. Ensure the call-in destination is correct and that suitable call-in times have been set.

Note: When daily leak evaluation mode is being used:
The entire system should have timings set to work in a co-ordinated manner. Leak determination by the logger should occur close to the optimum (quiet) evaluation time. Sufficient time should however be allowed for any confirmation checks by the unit, which must occur before data is sent into the server.
The server, in turn, should have received data from the loggers prior to the typical start of the working day, so that a recent evaluation of the leak status of each of the sites being monitored by the fleet of loggers is available for users (of the PermaNet+ data viewer) early in the day.

Note: Before leaving site, be sure to save the settings to the logger:

The IDT-PC program stores the new settings in the PC memory.
To save then into the PermaNet+ unit, click on the "Setup Device" button in IDT.
(This is located towards the bottom of the Setup tab).



6 INSTALLATION

Every site installation is unique with various types of connections, positioning or environmental conditions possible. The following recommendations will assist in a reliable installation...

6.1 LOGGER INSTALLATION

Diagrams of typical installations of a logger with Hydrophone-2 are shown (opposite and below).

Note: Diagrams are for illustration purposes only. The diagrams show a generic logger rather than the PermaNET+. In addition, the antenna is missing from the diagrams.

The logger should be installed in the correct orientation (see section 2.3) for optimum battery performance.

The logger unit must be mounted in a suitable location where the Hydrophone-2 cable can reach its intended installation point.

(Note: Additional sensors may be in use but are not shown in the diagrams).

Position the equipment and antenna away from sources of electrical interference such and motors or pumps.

Ensure the antenna (not shown) can be mounted in a suitable location where the radio signal will be of sufficient strength to call into the cellular network.

Cables should be positioned so as to not cause any hazards. The cables should be neatly arranged. Do not allow any equipment to rest on cables or connectors as crush damage can result.

Next install the antenna.
(See section 6.2).

Where the antenna is held in place by a magnet, ensure the weight of any cables does not excessively load the magnet so as to detach it from the installed location.

Do not pull the logger, antenna, or any sensor by any cable as this can cause damage.

Note: If fitting the Hydrophone-2 to a hot water pipe, ensure the equipment does not exceed its specified maximum temperature rating.

Complete any further setup and tests of the logger including a test of communications to the server. This will require the use of the communications Y-cable, which should be left connected during this process.

Before leaving site, disconnect the communications Y-cable and then re-connect the Hydrophone-2 cable directly to the logger.

Ensure the connector is correctly seated, so it is water-tight.

6.2 ANTENNA INSTALLATION

6.2.1 Options

HWM offers a variety of antenna alternatives that can be used with the PermaNet+ logger. The selection choice will need to be based on the construction of the chamber and the quality of radio service (signal strength, etc) at the particular installation site. The selection includes:

- Monopole antenna.
- Dipole antenna
- T-bar antenna
- I-bar antenna
- Button antenna
- Puck antenna
- Magpot antenna
- Hanging antenna
- Magmount antenna
- (Various installation brackets)

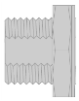
Only use HWM-provided antenna for the logger, to ensure the radio interface meets approvals requirements (i.e., safety).

Details of the various antenna types, their suitability to various types of installation site, and installation guidelines are not detailed here. Refer instead to the “Antenna Installation Guide” document, MAN-072-0001 ; This is available on the HWM website (Support → Help & Downloads → Antenna).

The antenna is usually located towards the top of the installation chamber, which implies the logger should be installed first. When deciding on where to position the logger, keep in mind that space must also be available for the antenna.

6.2.2 Installation

The PermaNet+ unit has a metal “FME” style connector for connection of an antenna.



FME

An antenna with the appropriate connector should be selected and attached, tightening to finger-tight only. Always comply with any installation restrictions as per warnings in the documentation supplied. If possible, avoid locations where the antenna could be adversely affected (e.g., by an occasional flood condition).

- No sharp bends should exist in the cable routing of the antenna.
- Never bend the radiating element of the antenna.
- Do not allow any equipment to rest on the antenna, antenna cable, or antenna connector as crush damage can result.

The selection of an appropriate antenna will depend on the conditions at the site, including signal strength, communication test results, and the available space. It can sometimes be a trial-and-error process to find the most suitable solution, although some guidance regarding antenna decisions is given in the Antenna Installation Guide document.

It is recommended to test the cellular communications of the installed equipment prior to leaving site.

6.2.3 Testing cellular communications

IDT should be used to check that the logger can connect to the cellular network and that the antenna is suitable for use and in the best location before finalising its position.

- Choose a suitable antenna for the installation (see section 6.2.1) and decide on its initial position.
- Determine the network technology being used and the appropriate signal quality limits that should be used (refer to the IDT user-guide).
- Perform Network Signal tests to confirm the logger connects to the mobile network and find the best location of the antenna.
  (The tests should be made with the chamber lid closed).
- Perform test calls to confirm the logger can communicate with the DataGate server via the internet and (if required) SMS.
- If the test results are inadequate, re-position the antenna (or select another type of antenna).

Note: Details of use of IDT for making these tests are within in the IDT (PC version) user-guide.

Trouble-shoot a test-call failure if required, using the advice in the IDT (PC version) user-guide. Further information is also available in the HWM Antenna Installation Guide (MAN-072-0001), and on the webpage https://www.hwmglobal.com/antennas-support/

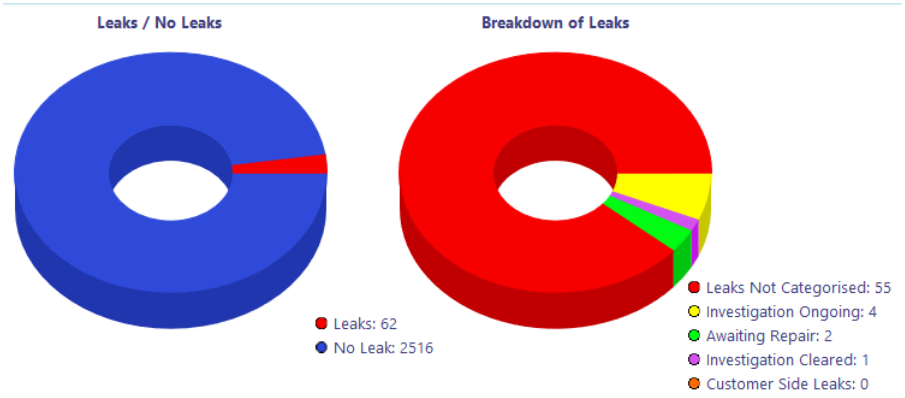
7 VIEWING YOUR DATA

Each logger calls into a server, where its data can be stored. The data is linked to the site on which the logger is deployed. The server therefore stores the current status (and historic data) for an entire fleet of loggers, linked to the sites on which they are deployed.

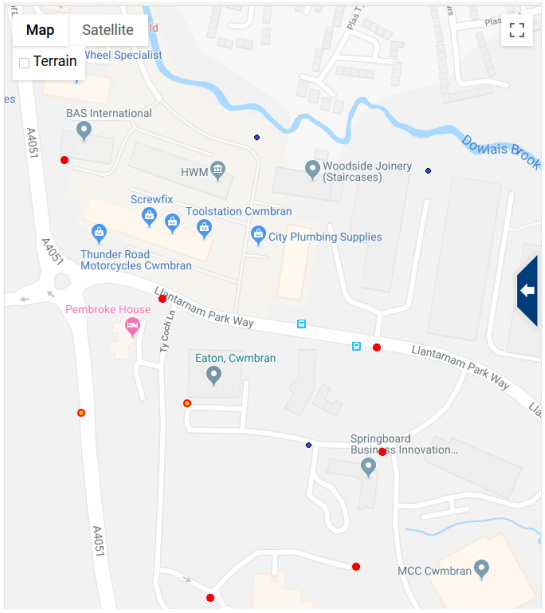
Site data is best viewed with an appropriate viewing tool (usually a website).
An example viewing tool for use with PermaNet+ devices is the HWM PermaNETWeb website.

PermaNETWeb can display the status of *multiple* devices (sites) simultaneously, thus allowing the leak-state of an area of a utility network to be easily visualised.

This can be shown as a "dashboard" graphical status (see opposite).



Alternatively, the state of an area of a utility network can be visualised by showing each site as a coloured dot or icon on a background map (or satellite view) and the current leak determination status for the site (or the logger call-in status); see below.



Refer to the appropriate manual or training provided for your viewing tool for further guidance.

8 INTERPRETATION OF LEAK DATA

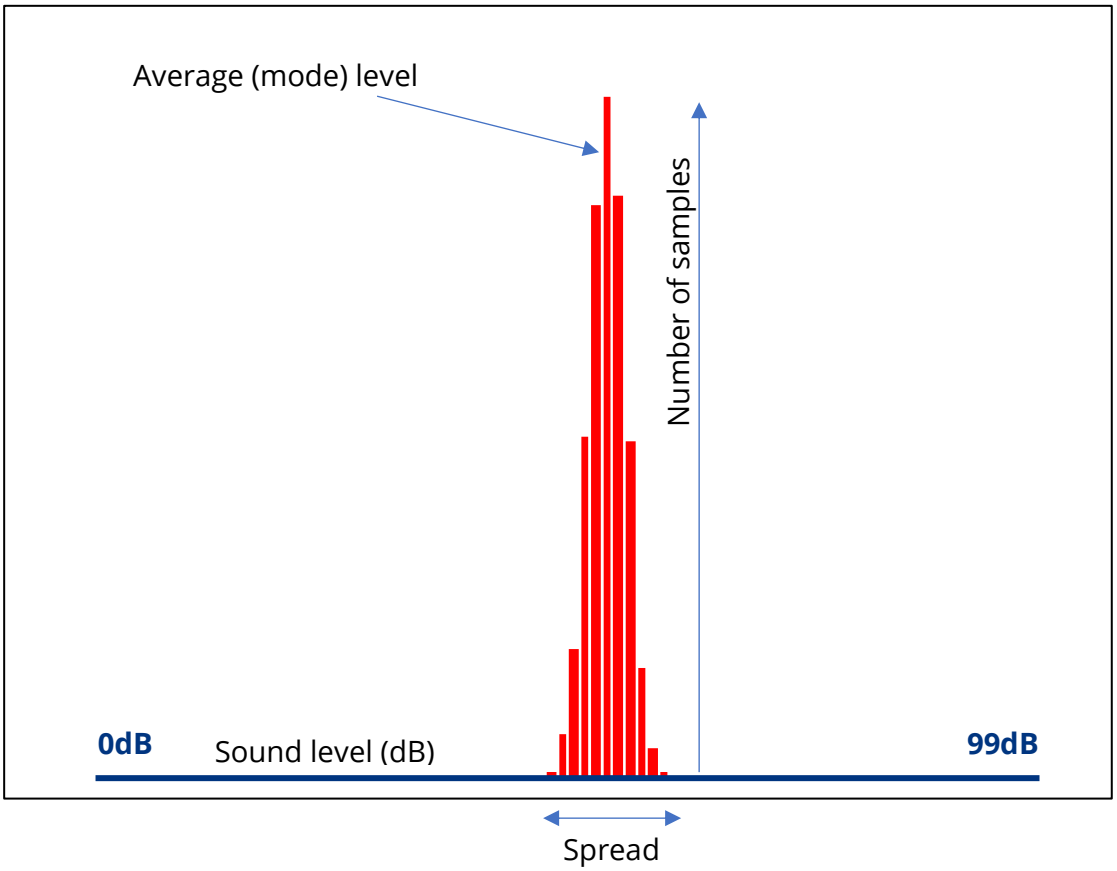
The following illustrations of level and spread results are based on loggers that are set to make an extensive single daily evaluation. The concept will be similar for other logger algorithms (e.g., Trunk main), but some differences exist (not detailed here).

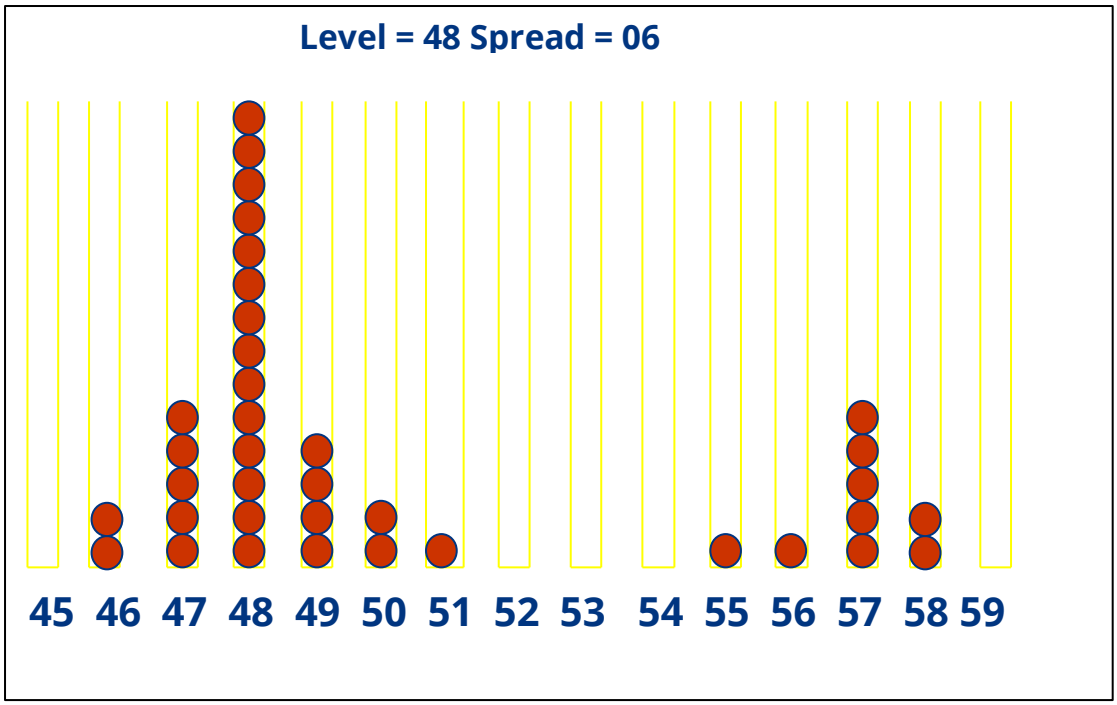
8.1 LEVEL AND SPREAD RESULTS (USING SINGLE DAILY EVALUATION)

The raw sound level is measured on a scale between 0dB and 99dB.

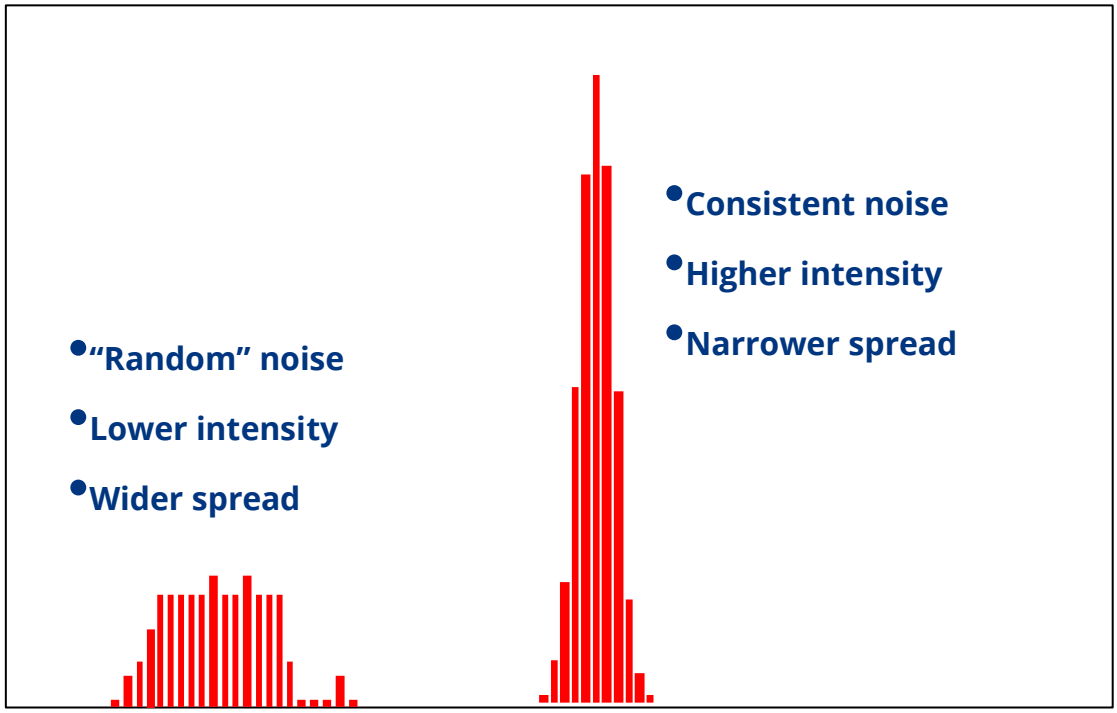
The signal **Level** (in decibels) is the point on the dB scale where there is a clearly identifiable peak.

The **Spread** is the width (number of dB values) that can be considered to be included within the over-all shape of the biggest peak.





Each test will provide different results depending on the ambient noise conditions at any given deployment. A leak will be indicated by a consistent noise generated at a higher intensity than any random background noise, so the best indication of a leak is a high peak with a very narrow spread, see example on the right below. The noise on the left is a probably not a leak as it is low intensity and broad spread.



8.2 LEVEL AND SPREAD RESULTS (USING TRUNK MODE)

The raw sound level is measured on a scale between 0dB and 99dB.

The algorithm for obtaining level and spread figures is less elaborate than the extensive daily leak evaluation method (see 8.1). This is due to the logger making frequent assessments. These have to be kept short in duration (to conserve battery use), which results in less data being used for each assessment.

The level and spread figures are produced as datapoints (at the log period) and are based on the audio power measurements that are produced (and temporarily stored) at the sample rate, in between log periods. The level used for leak evaluation purposes is taken as the average value, and spread is the difference between maximum and minimum value.

Leak judgements (datapoints) are made at the log rate. However, the judgement is not considered “final” as the alert of a leak involves the setting of a logger alarm. The alarm triggering conditions filters the stream of leak-judgement data, monitoring the raw leak indication until it becomes suitably stable; the alarm is triggered ; Interested parties are alerted to consider investigating the possible leak.

A leak will be indicated by a consistent noise generated at a higher intensity than the regular random background noise. When a leak occurs, the average sound level will increase, and that increase will be persistent, causing the alarm set to alert users to trigger.

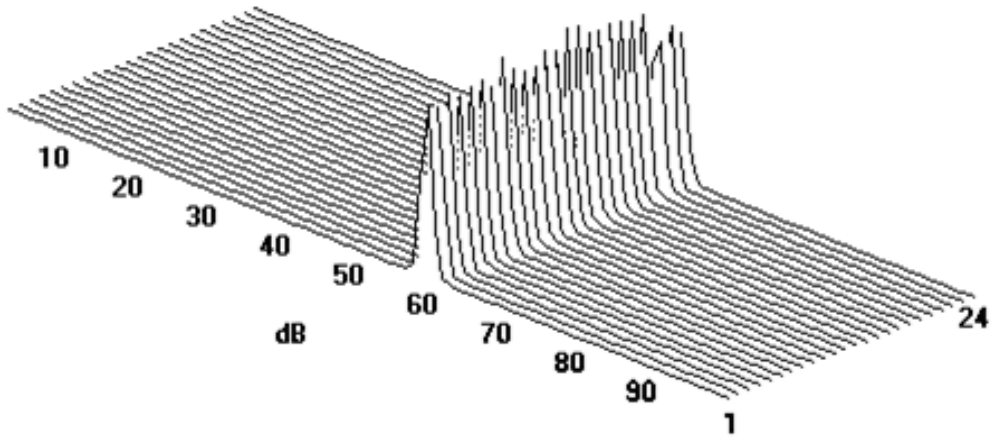
8.3 AQUALOG / HISTOGRAM RESULTS - EXAMPLES

The following section discusses how to read Histograms.

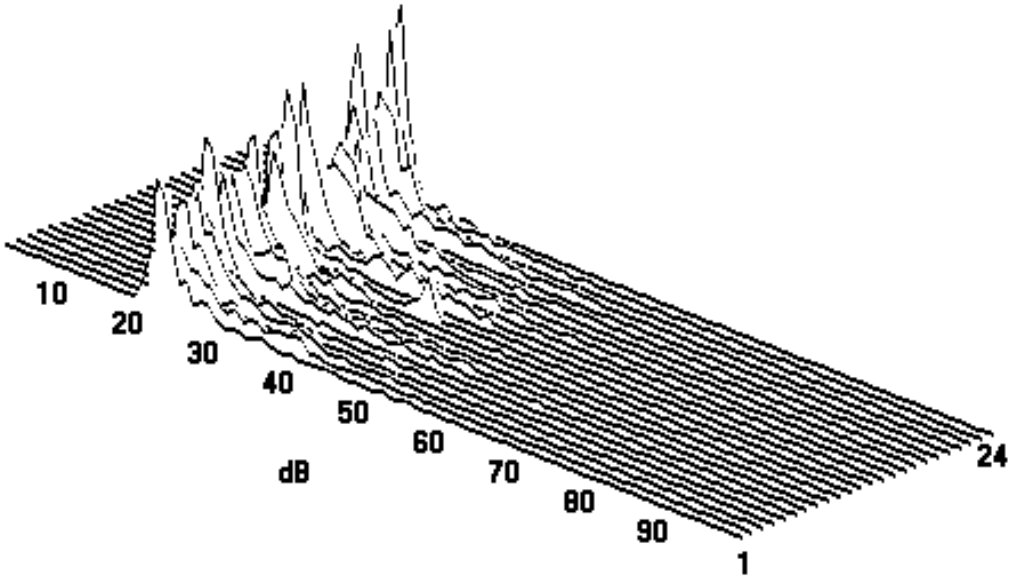
Note: A standard histogram is amongst the data received from the logger once per day. An 'Aqualog' is the same as a 'Histogram' but is manually triggered and has customisable timings.

Examples:

In the below example of a 'good leak indication,' measured over 24 days there is an average **Spread** of 5dB and **Level** of 58dB at the peak.
This shows a high repeatability of the leak noise.
Average Level = 58
Average Spread = 5



In the below example of a 'poor leak indication' again measured over 24 days, there is an average Spread of 27dB and Level of 21dB at the peak. This shows a poor repeatability of the leak noise.
Average Level = 21
Average Spread = 27

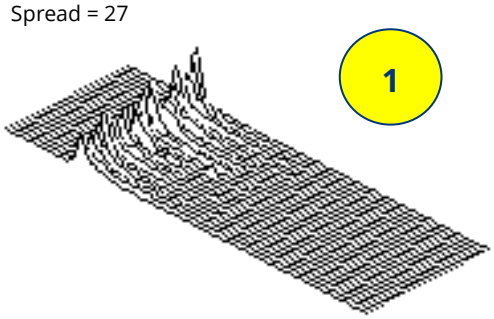


In the below set of examples the strongest leak indication is No 3 – a narrow spread (5dB) and a strong level (60dB).

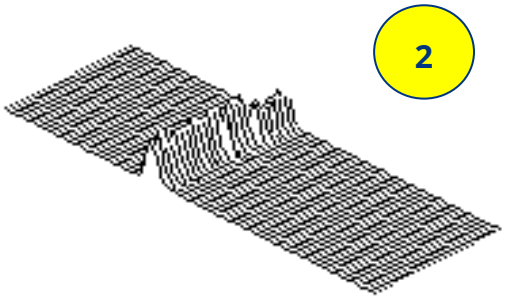
The others do not offer good indications of leaks:

No 1 … Big spread / poorly defined peak,
No 2 … Good spread but poor peak,
No 4 … Big spread / inconsistent peak.

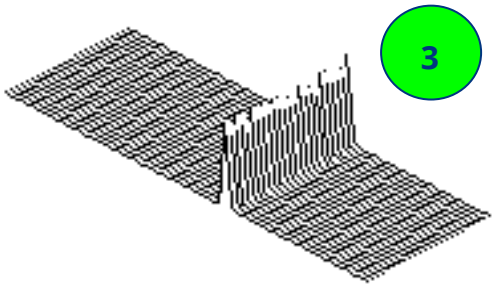
Average Level = 21
Spread = 27



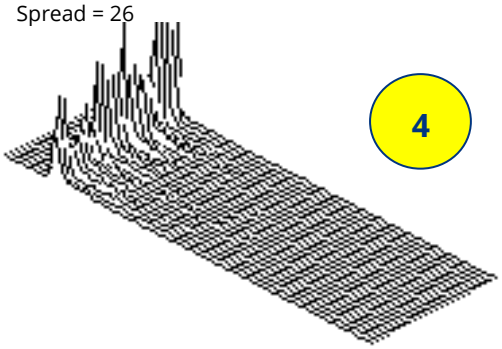
Average Level = 24
Spread = 9



Average Level =60
Spread = 4



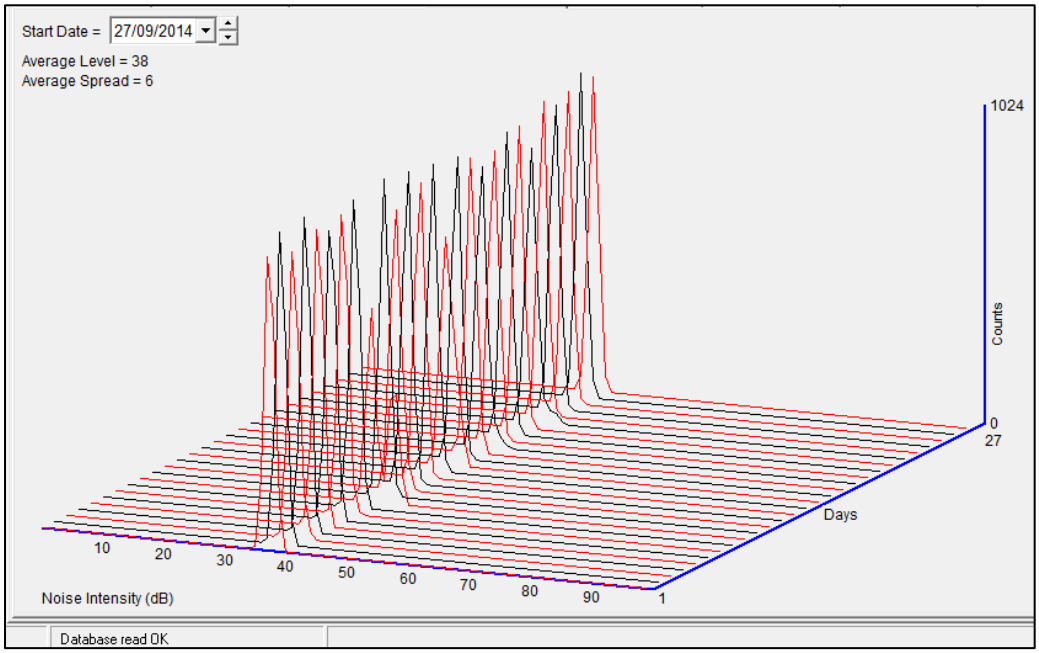
Average Level = 29
Spread = 26



In summary:

The best indication of a leak is with the highest consistent peak (noise) with the narrowest spread and the highest number of samples in it.

See below a typical PermaNet+ Aqualog screen shot showing a good example of a leak.



Note: Aqualogs and Histograms are not available on all loggers
(e.g. They are not provided on loggers operating in Trunk Main mode)

9 TROUBLESHOOTING

The data from the logger does not appear on the server:

- Check the settings for the SIM card to access the mobile data network.
- Ensure the logger uses the correct data destination URL and port-number for your server.
- Check call-in times have been set.
- Check antenna is attached and in an OK condition.
  Check signal quality and strength parameters are suitable. Re-locate the antenna, if required, or try an alternative type of antenna.
- Make a Call Test and confirm OK.
- Ensure your server is correctly configured to receive and present the data.
  The channel numbers used by the logger and the DataGate server must match.

10 MAINTENANCE, SERVICE AND REPAIR

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

The Hydrophone-2 is a sealed unit and has no user-serviceable parts. Do not attempt to disassemble the unit since it may become damaged, which will invalidate the warranty. Furthermore, during production it is subjected to high pressure testing to ensure the integrity of seals ; Disassembly by the user can cause risk of injury during any subsequent attempt to use the Hydrophone.

The PermaNet+ logger is also a sealed unit and has no user-serviceable parts.

10.1 REPLACEABLE PARTS

Antenna

- Only use antenna recommended and provided by HWM.

For details of antenna options and part-numbers to order, refer to the following link: https://www.hwmglobal.com/antennas-support/

Batteries

- Only use batteries and parts recommended and provided by HWM.
- Batteries are only replaceable by a HWM approved service centre or relevantly trained technician. Contact your HWM representative for more details if required. A battery swap must be accompanied by a reset of power-use counters for the logger to perform normally.
- Batteries can be returned to HWM for disposal. To arrange the return, complete the on-line RMA form: https://www.hwmglobal.com/hwm-rma/
  Refer to the Safety Warnings and Approvals Information for guidelines of the packing requirements.

SIM-card

- SIM-cards are replaceable by a HWM approved service centre or relevantly trained technician.
- Only use consumable parts recommended and provided by HWM.

O-Rings and seals

- Check condition of any 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 Tools

- HWM provides custom tools (sockets) for the fitting and removal of the Hydrophone-2 in tight places. For these, only use a replacement part provided by HWM.
  Other tools (open-ended spanners / wrenches) are available from most tool stores.

Carry Case

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

Cables

- Only use a replacement part provided by HWM.

10.2 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/

Prior to shipping, put the equipment into Shipping mode (refer to the IDT app user-guide for instructions). Refer to the Safety Warnings and Approvals Information for guidelines of the packing requirements.

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

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