

## Distribution

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An effective leak-management program is an important part of asset management. Numerous leak-detection technologies and approaches are available, but a customized program will deliver the best results.

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# LEAK-DETECTION PROGRAMS IDENTIFY AND CONTROL WATER LOSS

***Editor's Note:** This is the last of a three-part series of articles based on a series of AWWA webinars on distribution system issues. The first article, *Biofilm Control: Develop an Effective Strategy to Preserve Quality, Ensure Compliance* (September 2013 issue), described biofilm control strategies. The second article, *Maintenance: Well Asset Management Increases Service Life* (October 2013 issue), reviewed water well rehabilitation technologies. This article covers an array of available leak-detection strategies that can be incorporated into a leak-detection program. For more information, visit [www.awwa.org/webinars](http://www.awwa.org/webinars).*

**L**EAKAGE IS ALWAYS AN ISSUE with underground water conveyance systems. A water utility can control underground leakage only by conducting a painstaking survey of the entire system.

The earliest leak-location method was for an operator to place one end of a listening stick to the ground above a water main and the other end against his or her ear. Water under pressure is a form of potential energy. When the pressure is released to atmospheric pressure, it changes to kinetic energy. Some of the energy is in the form of audible sound. Different types of leaks and leaks in various kinds of pipe materials produce different sounds.

In addition to traditional acoustic leak-detection techniques, utilities are starting to inject helium gas into live water mains to locate leaks. Because helium is four times lighter than air, the helium floats to the surface where it can be measured aboveground with specialized monitoring equipment.



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In the early days, water leak detection was hit or miss. Rudimentary equipment often used long metal rods placed on the surface above a water line. The user would then listen at various points until the loudest noise was found, at which time digging was carried out until the leak was located. Leak surveys were conducted only when a leak was apparent and had to be found. As leak-detection equipment evolved, more utilities began to proactively look for leaks—usually when water losses were high. Still, leak detection was considered a luxury service, conducted only when a utility had extra money in its budget.

Today, leak detection is a cornerstone of most asset-management programs. With aging infrastructure and water resource depletion, leak detection has become one of the most cost-effective ways to save water and money. In fact, many states mandate minimizing leaks and saving water, and many water systems include leak detection in their annual budgets.

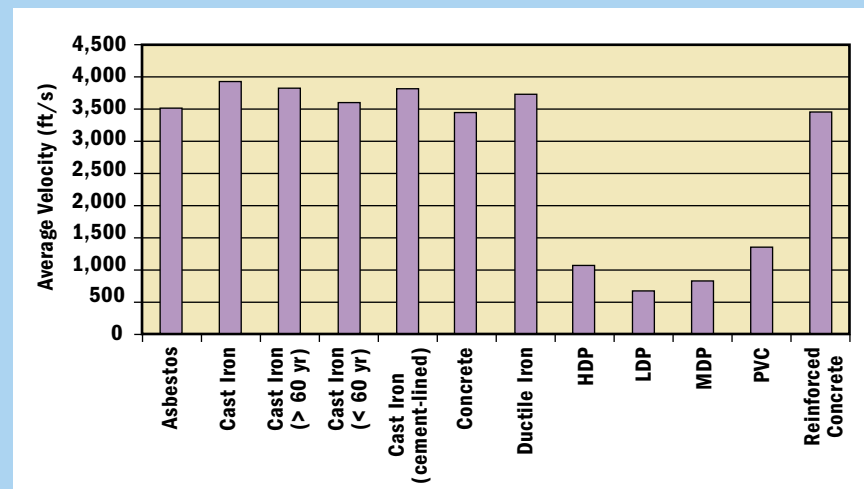
## ACOUSTIC TECHNIQUES

The environment is filled with sounds that mix to create what's commonly referred to as noise. To locate a leak, it's sometimes necessary to disassemble noise into its component parts. This is made easier by using electronics that create notches to listen to specific spectral frequencies and to clip certain amplitudes.

Listening equipment usually consists of points of contact, monitors, or comparative listening. Some typical listening tools include microphones, correlators, and loggers. Because of the nature of water and conveyance networks, no one tool can locate all leaks. Water takes the path of least resistance, and leaks don't always surface, especially if they're small or slowly increasing in volume. Some leaks surface far from the actual point of escape, under streams or highways, or in or around wetlands. Pinpointing a leak can minimize the expense of excavation and restoration.

## Sound Velocity

Water under pressure produces different sounds, depending on pipe size and type.



**Microphones.** The simplest, most essential tools are items such as ground microphones—manual geophones or electronic ground microphones. Such tools are best used on paved surfaces where sound is transmitted equally. When a ground microphone is used, a leak under grass and a leak under concrete, for example, will produce different acoustic signatures. Wind can be disruptive to some units. However, probes can be used if the ground can be penetrated by drilling or spiking.

**Correlation.** Correlation is a more advanced form of leak detection. Vibrations created by leaks travel at known speeds in pipes of specific material and size. To get the best correlation results, it's important to know pipe distance, diameter, and material. Bracketing a suspected leak—placing sensors on each side of a suspected location—is best practice. To correlate the distance to a leak, many correlators rely on software programs that use a fast Fourier transform method to calculate distance to a leak. A laptop or other mobile device can display this information graphically. Correlation helps locate most leaks on distribution pipes, but there are other options for special circumstances.

**Loggers.** Acoustic data loggers can be placed on service lines, valves, or hydrants. Data can be transmitted to the system operator through a variety of methods, and a graphical representation of the data can be provided to the end user. Some device manufacturers use automatic meter reading and advanced metering infrastructure networks for data transmission. Others are storing the data onboard and then retrieving the data by interrogating the logger. The data provided can range from a simple alert that requires field verification to details such as frequency and amplitude data.

Locating nonmetallic pipe leaks is extremely difficult, because the sound energy attenuates rapidly on these materials. There are alternative devices, such as ground-penetrating radar and infrared sensors, but they're more complex and expensive to operate. Other devices can be inserted into a pipe to locate leaks. Some of these devices are carried through the pipe by water flow; others are permanently placed in a pipe, much like fiber-optic cable.

## LEAK-DETECTION STRATEGIES

This article examines only leak surveys and continuous acoustic monitoring.



## Water utilities now have effective tools and methods to promote accountability and efficiency in their supply operations.

However, system operators should be committed to any leak-management program. If equipment will be purchased, operators should learn to use it, know when to use it, and know how to maintain it. If a utility's strategy includes leak surveys, it must determine whether internal or external resources, or a combination, will be used and ensure access to valves and curb stops for proper listening. Survey frequency depends on a costs-benefits analysis for the selected methodology.

A typical leak-detection toolbox includes a listening stick to monitor services, hydrants, and valves; a ground microphone that can filter and amplify sound; and, budget permitting, a leak-noise correlator, especially if your system has leaks that don't readily surface. For some situations, overnight correlators and programmable monitors may be required.

System operators can explore several resources for additional assistance. Outside contractors or manufacturers may provide services and equipment. In addition, fostering working relationships with nearby water utilities can be mutually beneficial, resulting in an exchange of ideas and potentially pooling resources (see sidebar, Utilities Join Forces to Shut Down Leaks). Some larger utilities may offer per-diem services. Also, some vendors are willing to loan equipment for trial, and many rural water associations have rental or loaner programs and knowledgeable staffs.

Some utilities have in-house leak-management programs and leak-detection equipment that may be used regularly or for emergencies. Other utilities have a full suite of equipment and trained crews that survey for leaks regularly, sometimes daily. And some utilities hire consultants to handle their leak-detection program. Leak-detection equipment has become more technologically advanced, more accurate, and less expensive.

**In-House Programs.** The level of leak-detection success increases when a utility's leak-detection program includes the following practices:

### Tools of the Trade

Typical listening tools include microphones, correlators, and loggers.



- Managers should be well-informed, have a written plan that reflects best management practices, and be motivated by leak-detection benefits.
- Personnel should have good hearing, a working knowledge of the water system, and be motivated by leak-detection benefits.
- Equipment should consist of current technology and dedicated tools (including a vehicle and maps) that are in good working order.
- Implementation should consist of internal reporting, good data-management skills, and periodic documentation and reporting to management.

**Service Providers.** When a utility chooses a service provider to develop its leak-detection program, the following criteria are key to getting the job done right:

- Choose a reliable, established company (check references).
- Ensure the company has at least five years' experience.
- Ensure technicians have at least three years' experience and good hearing.
- Verify technicians use current equipment.
- Require clear, concise reports.
- Require that technical assistance be available after the project to re-check missed leaks, etc.

**A Hybrid Approach.** Some utilities will use a combination of in-house and service company services for their leak-detection

programs. This is usually accomplished by utility employees using a basic leak-detection device to survey (or sound) system appurtenances when their workload is minimal (i.e., fall or winter). When a list of noises is compiled, the utility will enlist the services of a consultant to pinpoint the noises. This approach can help utilities limit their costs and technology burdens.

### HELIUM LEAK-DETECTION TECHNOLOGY

An innovative, proven technology that uses helium was developed in Europe and is now being used in the United States to locate leaks in drinking water networks and other pressure lines, such as hot water heating loops. Used in Europe and Asia since 2007, the patented technology is suited for any pipe material. However, the technology's ability to find and locate leaks in nonmetallic and large-diameter pipes sets it apart from other leak-detection technologies.

In polyvinyl chloride (PVC) and polyethylene (PE) pipes, noise doesn't travel readily and is difficult to detect with traditional acoustic leak-detection technologies. Helium is the preferred methodology for leak detection for large-diameter mains, such as transmission mains where there are few or distant listening points and areas of low, intermittent, and high pressure. The helium gas being used is NSF Standard 60-Certified for Drinking Water Treatment Chemicals.

## COOPERATIVE EFFORT

### UTILITIES JOIN FORCES TO SHUT DOWN LEAKS

Small and medium-size utilities with limited staffing and financial resources can coordinate their efforts to cost-effectively address leak detection. Benefits include greater purchasing power for leak-detection services and equipment. Nearby utilities, through an umbrella organization, such as a subsection or allied utilities, can maximize the return on their financial commitments to leak detection.

Initially, the utilities should evaluate leak-detection methods that have proved successful in the ground conditions of their respective service areas. When a preferred method is identified, each utility's commitment level must be determined. Generally, the greater the number of utilities committed to the joint effort, the greater the cost savings. In addition, the utilities can evaluate the willingness of leak-detection service providers and material suppliers to provide group discounts.

Next, a memorandum of agreement (MOA) must be developed and signed by all participating utilities. The MOA must address

- Allocation of initial shared services and equipment costs
- Time allocation for equipment use
- Equipment use schedules
- Check-in and check-out procedures

- Location of shared equipment storage
- Utility scheduling swaps
- Additional utility participants
- Purchase of future equipment and services
- Repair and replacement costs

The Water Cooperative of Pierce County, a group of 21 utilities in Washington, contracted for leak-detection services at a 10 percent discount and negotiated the purchase of 90 shared noise loggers at a 15 percent discount. Individual participating utilities were also allowed to purchase 85 nonshared noise loggers at the group discount.

As a result of the joint and individual utility leak-detection efforts, the utilities collectively reduced nonrevenue water—some by up to 82 percent. The savings have permitted the utilities to address growth without increased production, additional water rights, and additional capital facilities.

Successful coordinated leak-detection programs can provide the foundation for participating utilities to expand their efforts into other cost-saving areas, such as the mutual aid, water quality, regulatory, legislative, and judicial arenas.

The technology uses helium gas as a tracer to locate leaks. As documented in AWWA's Manual of Water Supply Practices M36: *Water Audits and Loss Control Programs*, helium gas is injected into live water mains, with no need to isolate a zone, depressurize, or shut the water system down. The helium mixes with flowing water and travels throughout the pipe network to the desired area(s) to survey for leaks. When the helium-marked water leaves the pipe network through leaks in the pipe wall—through loose connections or at service laterals, meters, or valves—the helium separates from the water. Because helium is four times lighter than air, the helium floats to the surface where it can be measured aboveground with specialized monitoring equipment. Elevated levels of helium detected above a leaking pipeline indicate a leak is nearby.

The technology is quick to implement and easy to deploy. The gas is injected through a standard 3/4-in. corporation stop installed on a water main, pipe, or

appurtenance upstream of an area to be surveyed. There's no need for a launch or retrieval station, which is necessary for other acoustic leak-detection technologies that use smart probes, devices, or balls. Pipeline geometry (connections and turns), pipe-diameter changes, or butterfly valves don't interfere with the technology.

The helium leak-detection process is sensitive enough to identify small leaks. Consequently, "unavoidable leakage" can be reduced to unprecedented levels. For example, a 1.8-gpm leak, which was non-detectable using acoustic technologies, recently was found on a leaking PE pipe in Pennsylvania.

In addition, the helium leak-detection process

- can be deployed in live, fully operable water systems with no effect on operations.
- is effective on all pipe sizes and materials.
- isn't limited by noise or electrical interference, system geometry, or pipe length.

- is less intrusive than other technologies.
- requires only a standard tap for injection.
- won't get stuck or lost traveling through pipe.

#### DEVELOP A LEAK-DETECTION PROGRAM

AWWA's M36 manual should be the starting point for developing a leak-detection program. The manual identifies four major advantages to having such a program:

- Responding more quickly to known leaks
- Replacing or rehabilitating aging and weakened pipe
- Reducing pressure, particularly during low demand
- Finding "hidden" leaks

Water utilities now have effective tools and methods to promote accountability and efficiency in their supply operations. Water utility managers and operators will be called on to assess their inefficiencies and take corrective action. The methods contained in M36 will help them do it. 🌊