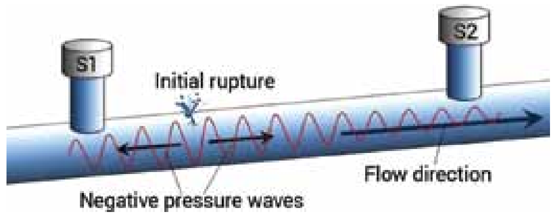
Figure 1. Negative Pressure Waves Diagram



Tips for Leak Detection in Water Systems

Solutions for cutting the costs of water losses

By Eric A. Morris

Compared with high-profile oil and gas pipeline spills, water main leaks receive relatively little attention. But should these comparatively innocuous losses be considered trivial? The answer is no. Various regional authorities across North America have given estimates of water losses due to slow leakage that range from 10% to 45% of total production. This translates into millions of dollars in lost revenue for utilities and may lead to or exacerbate water shortage problems, especially in drought-stricken areas like California and Texas. In some cases, slow leaks that go unnoticed for extended periods can lead to major infrastructure damage. Nowhere has this been more apparent than in Guatemala City, where underground erosion due to leaking sewer pipe has been the primary contributor to the formation of deadly sinkholes up to 100 meters in depth.

This article is intended to provide readers with a general overview of the steps that can be taken to enhance a water utility's leak detection capabilities through the combination of technological advancements with pre-existing techniques and infrastructure. Although implementing the following solutions will require some capital expenditure, the cost of water losses due to leakage over the lifecycle of a particular pipeline more than outweighs the costs of added precautionary measures—particularly if such leakages result in major damage to public infrastructure and/or environmental degradation.

① Continue to make use of existing infrastructure and sensors.

Traditionally, water main leaks were not detected until the problem announced itself in the form of flooded basements or water welling up from cracks in the street. The majority of leaks, however, are not so obvious. Presently, most municipalities are divided into discrete sections for water distribution purposes, with flow sensors installed to measure the amount of water entering each section.

Historical and real-time data from these sensors are available to operators via a SCADA system, allowing changes to be monitored from day to day. A sudden change in the water demand for a particular section over a particular period of time is normally a good indicator that a leak has formed, although small losses often will go completely unnoticed. Even though monitoring water usage section by section narrows down the search considerably, city employees then must painstakingly trace kilometers of pipeline buried under the streets while using special equipment to "listen" from aboveground for the telltale acoustic signs of a rupture. While old-fashioned and time-consuming, this method is both reliable and accurate—leaks can be traced to within approximately one meter by a trained operator.

② Maximize the usefulness of existing sensor nodes with technological retrofits.

Over the past decade, there has been a significant shift toward proactive, rather than reactive, solutions for water main leak detection. Regularly scheduled utilization of an in-line leak tracing technique is an effective way of limiting the maximum length of time leaks may go undetected. Most public utilities, however, are subject to restrictive budgets, limiting the applicability of cutting-edge technologies. Even if it could be made cost-effective to internally probe every section of pipeline within a large city on a frequent basis, leaks may still occur during the time interval between pipe surveys.

For these reasons, operators tend to favor online continuous monitoring techniques that take advantage of existing equipment. SCADA networks are a virtually ubiquitous feature of modern water utilities, and the real-time flow and pressure data obtained from various nodes throughout the distribution network can detect and roughly approximate the location of a leak with the aid of statistical data processing algorithms. This has the benefit of greatly narrowing down the manual search for the leak location, as opposed to having operators scour a large section of piping infrastructure searching for acoustic abnormalities. Such software-based methods are not sensitive enough to detect small leaks, however, unless the existing infrastructure is retrofitted with more sophisticated sensors.

One increasingly common method is known as the negative pressure, or rarefaction, wave method, which takes advantage of negative pressure waves produced during the formation of a pipeline leak. These waves propagate at the speed of sound for long distances—sensors located at nodes upstream and downstream of the leak sample pressure at a much faster rate than conventional SCADA systems, allowing for detection of the pressure waves and determination of the leak location to within tens of meters (see Figure 1). Because negative pressure waves are only produced during the initial pipe rupture, however, the leak will continue unnoticed if environmental interference prevents its immediate detection.

③ Use in-line methods for precise pinpointing of known leaks.

Automated and continuous monitoring techniques such as those described above provide an additional layer of protection that should not be dismissed by water utility managers in an era of ever-increasing public scrutiny. But the accuracy of these methods is dependent on the spacing between sensor nodes, and leaks must be located precisely to avoid unearthing the wrong section of pipeline. Manual tracing using skilled operators with handheld equipment is a reliable way to home in on the problem, but it is time-consuming and prone to missing small leaks.

Fortunately, technological innovations have made the process of leak tracing more efficient. Several companies now offer in-line services capable of detecting and pinpointing the location of even minor leaks from within the pipe itself. These techniques benefit from improved accuracy, less interference from external noise and less labor-intensive operation. Two products currently on the market include Smartball and Sahara. Smartball consists of an acoustic sensor device housed within a foam sphere that is carried along with the water as it flows through a pipeline. The device collects data on pipe conditions for later processing, while receivers placed at various access points track its precise location. Sahara works in a similar fashion, except the acoustic sensor is tethered to the surface by means of a long data transmission cable, allowing for real-time detection and location of leaks. Despite their advantages, these in-line technologies are limited to larger-sized pipeline (6 in. or larger) and can potentially become stuck in pipe sections that are heavily fouled due to inadequate maintenance.

④ Incorporate state-of-the-art sensors during pre-commissioning.

The most effective method of detecting pipeline leaks is installing sensing equipment such as fiber optics along the entire length of pipe to be monitored. The internal refractive index of fiber optics cladding is highly sensitive to perturbations caused by vibrations and temperature changes associated with leaks; therefore, a shift in the time of arrival for a laser signal can be used to pinpoint their locations. The cost associated with installing such devices on existing line is prohibitive for most public utilities, so such an option only becomes realistic for new piping installations.

For the majority of municipal water operators dealing with older infrastructure, the best option is continuous online monitoring by conventional pressure and flow auditing combined with retrofits to allow for a more sensitive technique such as the negative pressure wave method. The aforementioned possibility of missed leak detections by these methods, however, still necessitates periodic pipeline surveys, which are best done with in-line sensing probes. We are sure to see new solutions in the coming years, as leak detection still is an active area of research. w&wd

Eric A. Morris, Ph.D., is research engineer for A.U.G. Signals Ltd. Morris can be reached at eric.morris@augsignals.com or 416.932.4425.