Advances in Acoustic Methods for Locating Leaks in Plastic Pipe and Trunk Mains

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ABSTRACT

Acoustic devices are the most common type of equipment used to locate leaks in municipal water pipes. These include simple listening devices such as ground microphones and listening sticks. Acoustic devices also include leak noise correlators, which were first developed more than two decades ago and have significantly improved the accuracy of locating leaks. It is generally accepted that the effectiveness of existing correlators is limited on plastic pipe and larger diameter trunk mains.[1,2]

This paper will go over the physics of leak noise in plastic and larger diameter trunk mains, sound. The frequency and wavelength of the sound waves will be reviewed in relation to the field procedures required to measure the physical acoustic waves of leaks on plastic pipe and trunk mains.

Case studies will then be provided to illustrate best practices for conducting leak detection on plastic pipe and trunk mains. Leak studies of actual leaks on both plastic pipes and trunk mains will be reviewed to demonstrate the field methods that were successfully implemented, as well as the leak noise frequencies of the successful detects.

INTRODUCTION

It has been generally accepted that leak noise correlators are consistently effective only on pipe diameters up to 12 inches. As a result, trunk main leak detection has evolved into primarily insertion-based technologies whereby a tool is inserted, and is carried with the flow of water down the pipe. While these technologies have proved to be highly effective in detecting small leaks in truck mains, there are a number of drawbacks, which can limit the use of these technologies. These include the requirement for a 2 inch port to insert the tool into the pipe, requirement for a minimum flow rate, in some cases a requirement that service laterals be shut down, and limitations on the number of 90° bends that the tool can navigate.

There are a number of factors that limit the effectiveness of acoustic correlators on trunk mains:

- The low-frequency nature of the acoustic signals within the trunk main.
- The ability of the radio to transmit long distances, as the access for sensors on trunk mains are quite far apart.
- Lack of advanced signal processing, which can appropriately handle the low-frequency signals.
- Suitably designed sensors which are tuned specifically to the low-frequency acoustic signals in large diameter pipe

BACKGROUND

The background theory for the cross correlation method is a simple time of flight as shown in figure 1. Essentially, the leak makes noise, and it will take longer for the acoustic wave from the leak to reach point 1 than it will point 2.

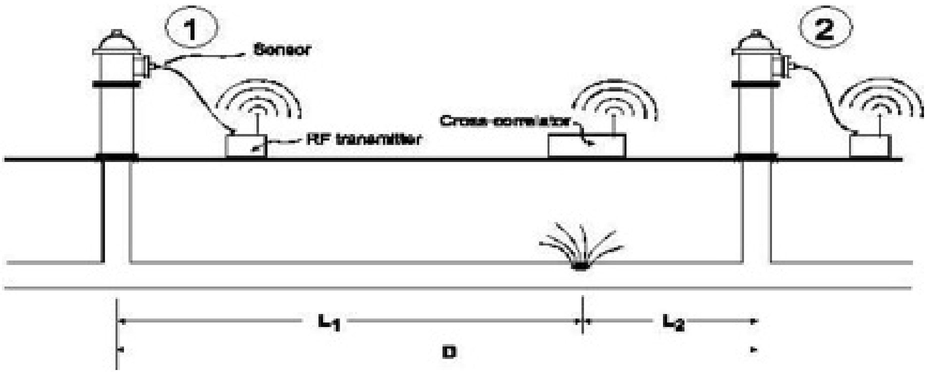

Figure 1: Correlation Background

As the distance between the sensors at point 1 and point 2 increases, the frequency of acoustic wave will modulate from a relatively high frequency close to the leak, to a lower and lower frequency as the distance increases. This modulation is caused simply by attenuation of the higher frequency signals due to their shorter wavelength. As attenuation of acoustic waves is based on the number of site goals that the wave will go through as it propagates, a longer wavelength signal goes through less cycles and therefore it takes longer to attenuate.

If the technical challenges can be overcome there are several distinct advantages to using the correlation method on large dam under trunk mains:

- There is no need for specialized appurtenances, as usually existing access points on the pipe can be used such as fire hydrants, pitot taps, and air valves.

- There is no requirement to shut down laterals off the main trunk unless they have noise sources associated with them such as PRVs.

- There is no requirement for a minimum flow in the pipe.

- It is possible to successfully correlate leaks around multiple 90° bends, therefore these are not a major factor in planning a link detection program.

- Perhaps the largest advantage is that the technology will find the leaks with the largest energy production first. In our experience these have tended to be very large leaks. In some cases the technology has detected leaks kilometers away from the measurement location, and they have subsequently been tracked down.

CASE STUDY 1: LAS VEGAS VALLEY WATER DISTRICT: 16" SCCP

As part of a contract with LVVWD, Echologics surveyed the CO6 pipe that runs the length of the strip in Las Vegas. The diameter of this pipe ranges from 16 inches up to 24 inches. This type has had several catastrophic failures and a survey was conducted to determine both the condition of the pipe and any leakage on it. During the course of our survey a leak was detected on the CO6 pipe

Figure 2 shows the site plan of the area where the leak was located on Las Vegas Boulevard. Once the correlation was obtained, it was clear that there was obvious dipping of the pavement in the area as shown in Figure 3.

An initial excavation of the leak ended up in a 'dry hole', which found only a service lateral that appeared not to be leaking. Upon further investigation it was determined that there was a 2 inch copper service off the main service that had been excavated, and the leak is shown in Figure 4. A diagram of the sound path of the lake is shown in figure 5, as is quite instructive as a case study. The correlator initially identified a six-inch service line off the trunk main as the leak location.

A review of the sound path will indicate that the correlator correctly identified the leak location however the sound was coming from a remote location on the 2 inch copper service. There was a distinct advantage of using the correlator technology, as the area was investigated several times before the leak could be found. The ability to go back and double-check and reshoot the leaks several times and was instrumental in LVVWD finally being able to locate it.

Figure 2: Site Location, Las Vegas Boulevard.

Figure 3: Southbound Las Vegas Blvd., looking north

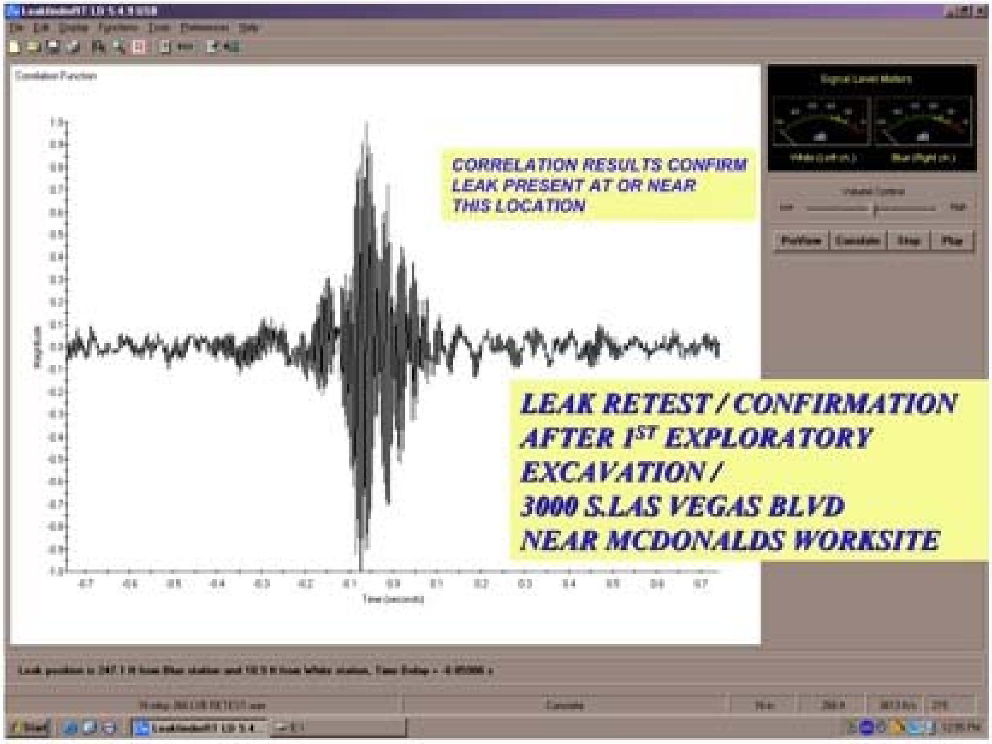

Figure 4: Leak Correlation plot, showing clear leak peak

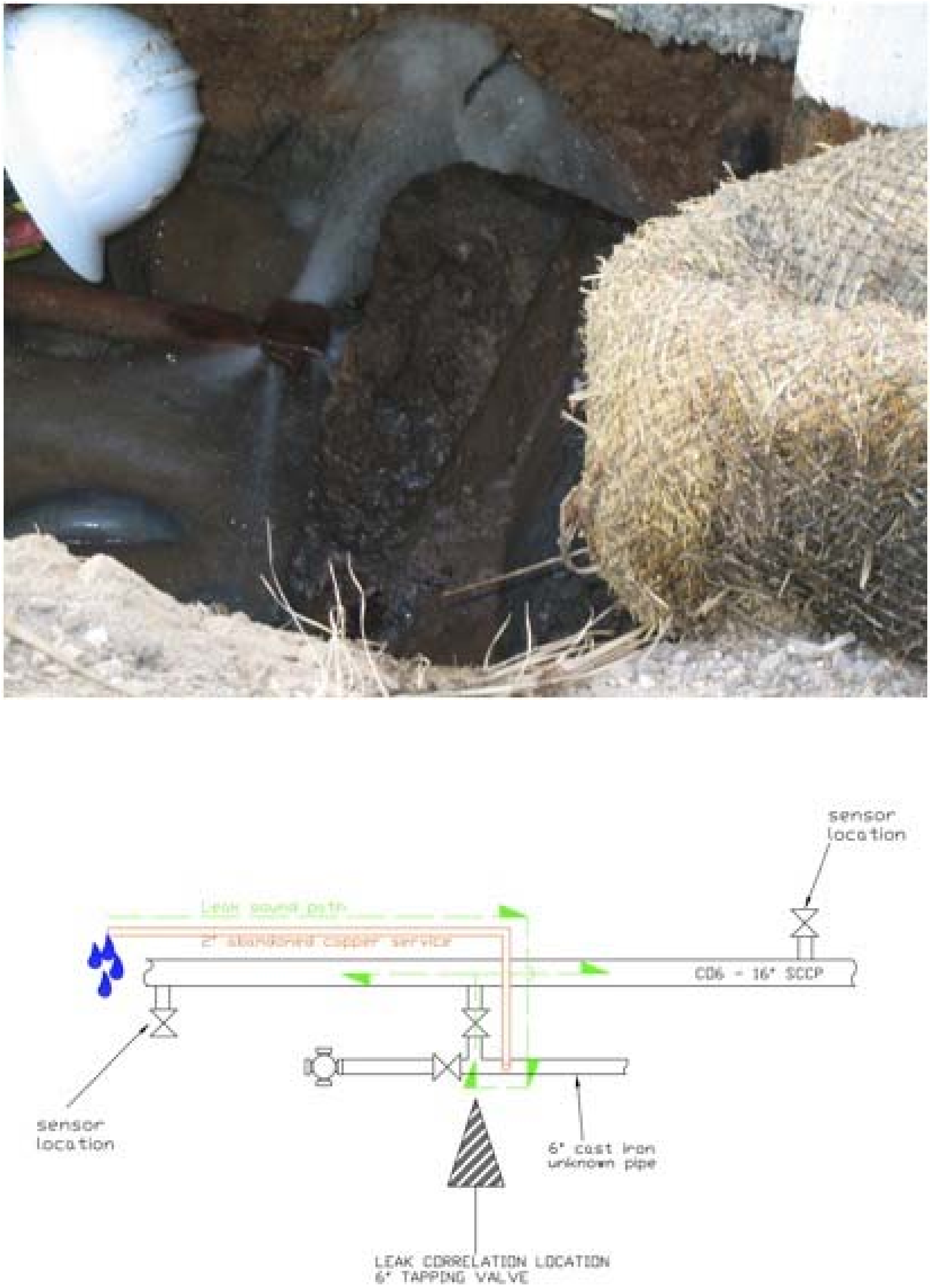

Figure 5: Sound path and photo of the leak on Las Vegas Valley Boulevard

CASE STUDY 2: THAMES WATER 30” Cast Iron

As part of our ongoing contract work with Thames water, Echologics detected a leak on a 30-inch cast-iron main on Milbank road near the British Parliament. There was a seepage in an underground parking garage that has been ongoing for many years. Figure 6 provides the site plan showing the Thames River and the Parliament buildings at the top photograph.

Figure 6: Millbank Site, 30” Cast Iron Main

The leak correlation can be seen as a prominent peak in figure 7, and the location of the leak when investigated was in the vicinity of prominent subsidence of the road. Subsequent excavation confirmed the link location to be accurate, and a photograph of it is shown in Figure 10.

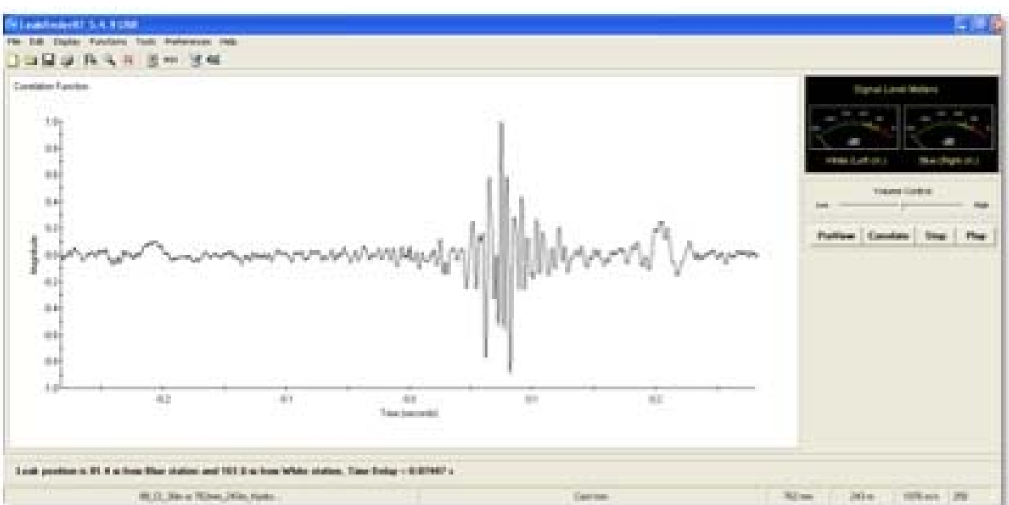

Figure 7: Correlation showing the leak location on a 30 inch cast iron main

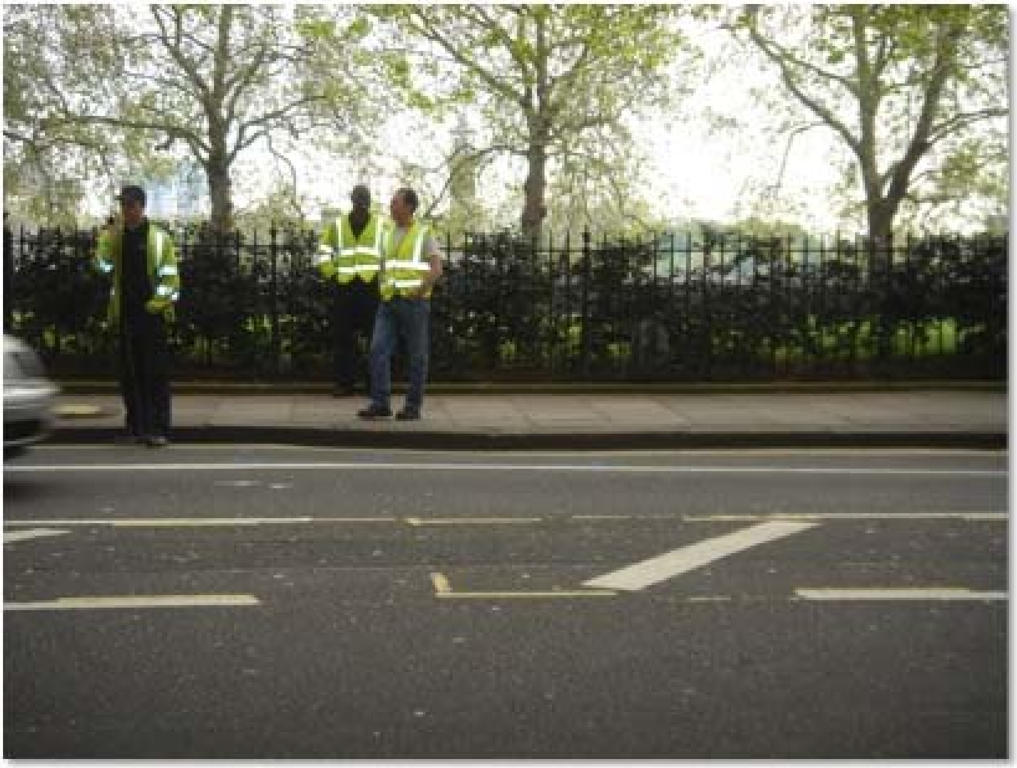

Figure 8: Leak location showing how prominent road dip in the bus lane

Figure 9: Photograph of the leak after excavation

CASE STUDY 3: THAMES WATER 24 INCH CAST IRON MAIN

Another noteworthy leak detection was performed for Thames water on a 24 inch cast-iron main. This leak was first identified as a distance of approximately 3 km from where it was eventually found. It first appeared as an out of bracket leak, meaning that the noise from the leak appeared from outside the area spanned by the two sensors. When finally tracked down, the leak was asked made it at 1.5 mega liters per day, or approximately 400,000 gallons per day. This leak was caused by two corrosion holes approximately one inch in diameter each.

Figure 10 shows the correlation peak measured over a distance of approximately 300 m. Figure 11 shows the eventual repair of the leak, which involved a welding sockets to fill the corrosion holes.

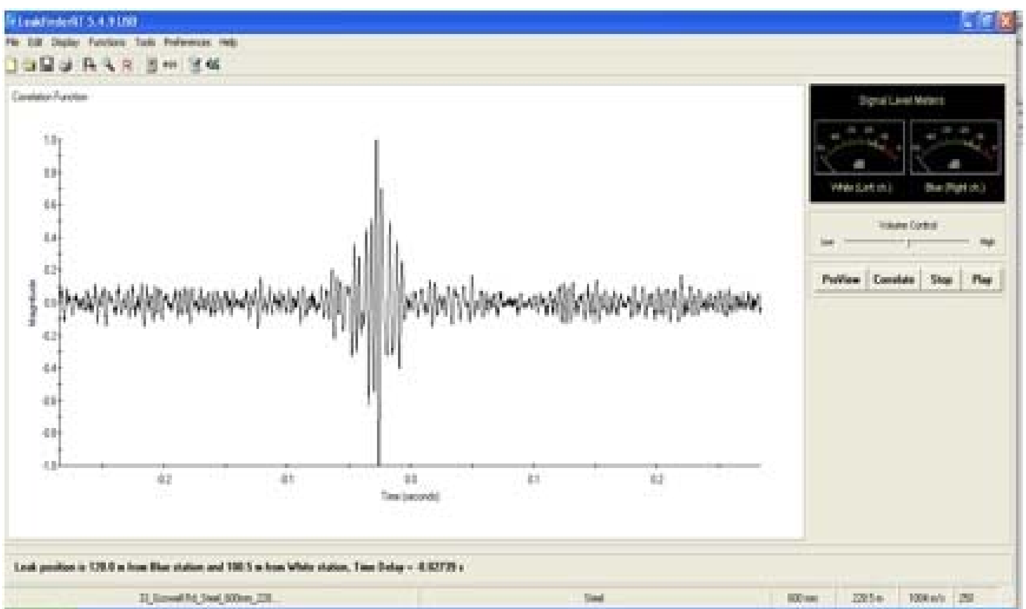

Figure 10: Correlation of Burdett Road Leak

Figure 11: Repair of Burdett Road Leak, note two sockets welded to pipe

CASE STUDY 4: COLUMBUS 36" PCCP

Echologics was retained by Columbus Ohio to investigate a potential leak on a 36 inch PCCP main. One week relating to a old corporation tap had been repaired, however the pipe would still not pass a pressure test. Initial correlations pointed to one end of the pipe as an outer brackets signal, however as the valve was closed at this end further investigation was done. A leak was pinpointed on and asbestos cement bypass, which was allowing water to escape during the pressure test.

Figure 12 shows the site plan of the 36 inch main, which crosses a river. The location and the correlation of the leak location are shown in Figures 13 and 14 for reference. This is a case where it would have been difficult to troubleshoot this leak with an insertion based technology, as the leak would likely have been beyond the insertion point for the tool due to the pipe geometry.

Figure 12: site plan of the 36 inch PCCP Main

Figure 13: Location of week on the 4 inch asbestos cement bypass