WATER AUDITING AND LEAK DETECTION TECHNIQUES

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ABSTRACT

Water loss in water distribution system is an important issue in India. Up to 50% to 60% of treated and pumped water is lost during transit from source to consumers end. Unwanted water leaky pipelines are almost always pertaining in drinking water supply networks. Since the supply networks are usually underground this problem becomes more challenging. To resolve such problem, this paper studies the possibilities of leak detection of unwanted leaks in the water distribution pipelines from the surface using acoustic systems. The acoustic equipment uses audio and vibration noise produced during leakage of water from the pipeline. However, the techniques and methodologies that are currently used for the individuation of leaks, despite being universally accepted are extremely, time- consuming and requires highly- experienced persons. This paper gives an overview of techniques and equipment used for water audit and leaks in water distribution systems. Furthermore, a strategy for reducing water loss is addressed.

Keyword: *Non- revenue water, water audit, leak detection, equipments.*

1. INTRODUCTION

World's water resources are limited but exist on our planet with a constantly growing population. The development of water resources to human's benefit has been a basic factor for better changes of cities and people throughout history. Pollution, climate change and construction of cities in dry regions are some of the factors increasing supply/demand imbalances. Many inventive technologies have been developed in recent times to benefit the efficient supply and demand of drinking water. Water audits provide analytical, scientific framework that categorizes all water use in your system. It is a tool to overcome drought related problem, water shortage, leakage and losses. Water loss i.e. non-revenue water from water distribution systems is an important issue in India. Non- revenue water is water that has been produced and is lost before it reaches the customers. Losses can be the real loss or apparent losses. NRW is typically measured as the volume Of water lost as a share of net water produced. It is sometimes expressed as the volume of water lost per km of water distribution network per day.

The global volume of NRW or water loss is staggering. Each year more than 32 billion m^3 of treated water are lost through leakages from distribution networks. Controlling water loss has, therefore, become a priority for water utilities around the world.To deal with losses in an effective manner particularly from networks in water scares areas, water utility managers are turning the technologies to reduce costs, increase efficiency and improve reliability. Leak detection and repair is one of the components of controlling water loss. Methodologies for achieving good results to reduce water losses are continuously evolving. The choice of particular leak detection technology depends on the operational conditions and construction material of pipes.

Many of the techniques currently used for leak detection involves acoustic equipment. Some techniques are able to approximate to localize the position of a leak while others can find exact locations. The techniques involved

are Manual Listening Stick, Electronic Amplified Listening Devices (Ground Microphones), Leak Noise Correlators, Correlators using Hydrophones, Noise Loggers, etc.

1.1 Water audit

Water audit determines the water loss in the water distribution system through leakages, theft, storage overflow and meter inaccuracy. It determines where the water ends up and how much of it is got there. All water distribution systems lose some amount of water for different reasons and have no accurate statistics for how much water is lost. Water auditing serves as an important step towards improved water conservation and, works for water loss reduction plan, can save money and time for water system.
Elements of water audit include:

- Determine system input volume
- Determine the authorized consumption
- Estimate apparent losses
- Calculate the current annual real losses (CARL)

Step 1: The Water Use Inventory

It is essential that experts develop an understanding of exactly how and where their system uses water. To do this, a checklist of all water use points in the system with flow rates must be developed.

Start with identifying every point and facility in which water is used. For purpose such as toilets and faucets, etc. the list should include the item, its location, its operation period and its flow rate. If the system has low-flow fixtures or if flow control devices have been installed, identify them in the checklist.

Mechanical systems account for approximately 25 percent of the total water use in an average building. The list should include the type of systems installed, its location, its capacity, and the rate at which it uses water. In some cases, the owner will manually identify the water flow rate. However, it may be necessary to use a stopwatch and a bucket to determine the actual water flow rate. Irrigation (gardening) systems can also be a significant water user. The inventory should include number of systems, number of sprinkler heads attached to each system, flow rate of the systems and types of controls installed. Reducing water use in applications that use hot or treated water will produce savings that go beyond solely the cost of the water.

While completing the checklist, one should pay attention for any unexplained water flow. As piping systems are modified over the years, it may be difficult to know the loss of water which is invisible.

Step 2: Metering

Unfortunately, most of the facilities consist of single master water meter. Readings from master meters will provide an indication of how a system compares to other system, but it will not show where water use can be reduced, particularly if the area is large. To narrow down the water use areas, it is possible to provide sub meters in small areas.

Where and how sub meters are to be installed depends on the design of the water distribution system of the facility. Equipment with high water use rates should have separate sub meters. Each meter should be read at least monthly. If there are views that the readings for a particular meter are high, or if the readings for a meter suddenly increase, it will be necessary to read that meter more frequently; even on a daily or twice-daily basis. While all the systems are off and the water distribution system is closed it is one way to identify the search for leaks and losses in the distribution network. All meter readings should be reviewed on a regular basis for unexplained changes. Tracking water meter readings will provide a baseline of water use for the facility. For example, in hotels, use can be tracked on a per-occupied-room basis. For canteen, it could be on a use per-meal-served basis. Office facilities may use per-building-occupant basis. The key to gain useful information from sub meters is to have the meters read on a regular basis, and as frequently as possible. Frequent readings help to quickly identify and locate leaks or the easiest option for water audit can be using a measuring bucket and the flow rate of taps in each room of the building. Calculating the water consumption on the basis of operation period of tap and its flow rate can give appropriate detail of the water consumed every day.

Step 3: The Water Efficiency Plan

Once information has been estimated on how water is being used in the facility, an action plan can be established for reducing water use. The plan should be made certain that each individual has the authority and

support needed to implement the plan. The plan should have a specific water use reduction goal for the facility. Those goals must be measurable, achievable and realistic. The plan must also identify a mechanism for a periodic review of the program success in meeting those goals.

The water audit should identify the number of areas in which water saving can be achieved. The water efficiency plan should set priorities for implementation based on costs, benefits and available manpower.

1.2 Leak-detection

1.2.1 Leakage control programs

Economic constraints, over public health risk, and the need to conserve water is motivate widely. Two components in any leakage control program are water audits and leak detection surveys. Water audits account for water flow input and output of the distribution system and this helps to identify the parts of distribution systems that have excessive leakage. However, they do not locate leaks that require leak detection surveys, usually using acoustic equipment.

1.2.2 The survey

The areas that have been identified with excessive leakage, leaks are commonly pinpointed using acoustic devices. Acoustic devices detect the sound or the vibrations induced by water leaking from pressurized pipe. Leak sounds are transmitted through the pipe over a significant distance, and through the surrounding soil in the area of the leak. Initially, leak detection crew roughly categorizes the leaks in water-distribution systems by listening on all accessible audible points with the distribution system such as fire hydrants and valves. Suspected leaks are then pinpointed by listening on the ground surface directly above the pipe at a very close interval (about 1 m). Alternatively, suspected leaks can be pinpointed automatically by using Leak Noise Correlators, Ground Microphones, and Listening Stick which have become popular in recent years. Normally, leak noise correlators are more efficient and more accurate than other listening devices. Leakages could also be detected using several non-acoustic techniques such as tracer gas, infrared imaging, and ground-penetrating radar. The use of these techniques for the purpose is still very limited and their effectiveness is not as well established as that of acoustic methods.

1.2.3 Leak detection equipment

Acoustic equipments are the principal type of devices used by the water industry to locate leaks in distribution systems. These include leak-noise correlators, ground microphones and simple listening sticks to listen the sound induced by water as it travels from pipes under pressure.

1.2.4 Listening Stick

The stethoscope or listening stick has an earpiece and is used to hear leaks on fittings and to pinpoint the location of a leak. The material of the listening stick can be metal or wooden with an earpiece attached to amplify sounds. The technique is dependent on the experience of the engineer to hear the leak. The technique best suits for metallic pipelines between 75mm and 250mm diameter and pressure above 10m. The material or size of pipe do not prevent the listening stick from being pinpointed from the surface, but it is the type of leak, ground backfill material, water pressure, background noise and ability of the engineer that affects.

Figure 1. listening stick

1.2.5 Ground Microphone

The ground microphone electronically amplifies the sound of a leak. Pinpointing leak position using an electronic amplified listening device involves the process of comparing a number of leak noises. To begin with, the operator must select the most suitable sensor device; the elephant foot for rough surface or the elephant foot for smooth surface, or the pinpointing stick for open pipeline.

Figure 2: Ground Microphone

To operate the ground microphone safely and effectively, the operator must adjust the headphone volume control to a comfortable listening level. Once the noise has been heard, the headphones re to be muted before moving the elephant foot and hand probe to the next test position.

The sequence is to be repeated to listen to each of the test locations as moving through the pipe route where signal strength increases. The loudest leak noise will then indicate the location of the leak in pipeline.

1.2.6 Leak Noise Correlates

LNC's are the portable micro-processor based devices that pinpoint leaks automatically based on the cross-correlation method. Leak signals are transmitted from the sensors to the wireless correlators. Rather than locating a leak based on the noise level, this instrument uses the velocity of sound made by the leak as they travel along the pipe toward each of two microphones placed on the fittings either side of the suspected leak. If the leak is not equidistant then the sensors will detect the same noise at different times- the difference in arrival time is measured by the correlation process.

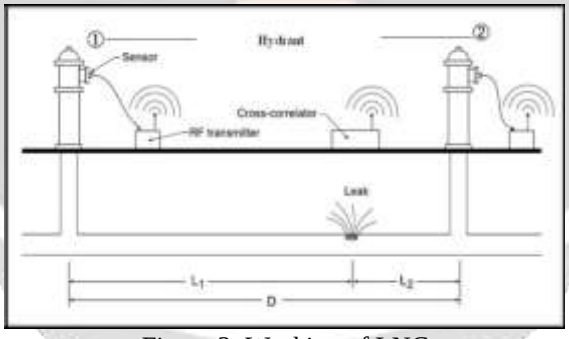

Figure 3: Working of LNC

Arrival time of signal 1, T1 = L1/V,
Arrival time of signal 2, T2 = L2/V,
Time lag between the signals 1 and 2, $\Delta T = T2 - T1 = (L2 - L1)/V$,

$L2 = D - L1$,
$\Delta T = (D - 2L1)/V$,
$L1 = (D - V\Delta T)/2$

Where, V – sound propagation velocity in pipe.

The location of the leak is calculated based on an algebraic relationship between the time lag, the sensor-to-sensor distance, and the propagation velocity of sound waves in the pipe. The distance between sensors is measured on site or read from distribution system maps. Propagation velocities for various pipe types and sizes are usually available in most commercial devices, or they can be measured easily on site.

2 Merits and demerits

Merits

a. Water auditing improves knowledge and documentation for water distribution system.
b. Identifies the area of risk for excess water use/water consumption
c. Leak detection can reduce property damage
d. Can save operational and maintenance cost
e. Can reduce energy for treatment and pumping
f. Can help in supplying regular water to the customers.

Demerits

a. Improper material for water distribution system can increase financial operational cost.
b. Excess pressure can cause damage to pipeline
c. If leaks occur, it may cause drinking water quality, and there might be risk to public health.
d. Water audit and leak detection needs a experienced person for operation of equipments

3 Summary

Leaks are usually the major cause of water loss in water-distribution system. To minimize public health risk, economic loss and to conserve water, utilities a regular audit of the distribution system is to be conducted as leak-detection surveys. Water audits provide an overall view of water losses and identify the areas of distribution system having excessive leakages. Leak-detection survey determines the exact location of leaks by using acoustic listening devices and leak noise correlates. Acoustic equipments are effective for metal pipes but could be problematic for plastic pipes. The use of non acoustic techniques is still very limited and their effectiveness is not as well established as that of acoustic methods. To reduce leakages some strategies according to the area of risk are to be established.

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