Keywords : Leakage Sensing Pipe, TDR, Leakage Sensing Monitoring System, Leakage Detection

Abstract
In modern society, the social demand for continuous water supply and stable water quality is rising. It is getting harder and harder to refine water sources due to the shortage of water and the deterioration of water quality. Current leakage-sensing methods are limited, making it difficult to detect leaks and find the exact leakage points of origin. Hence, a real-time system to assess and monitor leakage must be put in place to reduce the loss of water resources. In this paper, written for the purpose of real-time sensing leakages over wide areas, suggests a TDR, which uses a leakage sensing pipe (LSP) to detect leaks and breakdown locations by measuring distances, a leakage sensing monitoring system (LSMS) using a LSP for detection and a simulation that uses a pilot system for validation.

1. Introduction
Waterworks pipe network is an important component of water supply plant. Currently, it is difficult to detect effectively the abnormal status of a pipe due to the superannuation of a pipe network or an accident, since pipe networks are laid under the ground. Similarly, more time, manpower, and funds are required for the maintenance of the underground pipes, in addition to development of a leakage detection system. In this paper discusses the development of a LSP by inserting a wire that can be measured by TDR and suggests a LSMS using TDR[1].

2. Related Technology
Current leakage detection methods include the night smallest flux measurement, noise detection, correlation using sensor, gas injection, etc. They cannot guarantee the exact locations and may produce costly yet unsatisfactory results. It is also difficult to establish a remote sensing and warning system over the Internet.

2.1 Leakage and Breakage
Leakage means water flowing out of pipe equipment due to unintentional breakage or
cracks. Causes for such leaks include superannuation, load of a vehicle and the ground, separation of connecting parts, and carelessness in construction[2].

3. Leakage-Sensing using TDR

3.1 Development of LSP

In this paper demonstrates a waterworks pipe (Polyethylene, Steel, Cast-iron pipe etc.) network by inserting wires in waterworks pipes and installing exclusive connecting equipment. The leakage and breakage are detected by the installed TDR (Time Domain Reflectometer) at regular intervals, which then sends information to the main monitoring center. Figure 1 shows structure of LSP. The LSP has sensing wires inserted inside the pipe. The sensing wires are generally made of coated copper to transmit electricity[3].

![Fig 1. The Structure of a LSP](image)

3.2 TDR's Principle and Application

The TDR is used to measure the distance of the breakdown, a cable disconnection, a short circuit and a breakdown and failure point by transmitting pulse signals and measuring its reflections. The real-time information on the leakages, the exact location of the underground waterworks pipe, the cause of breakage due to another construction, and the location of the leakage can be exactly obtained and identified through the overlapping inspection of each TDR[4]. (Error : about 0.3m/1Km)

![Fig 1. Central LSMS Configuration](image)

3.3 Development of LSMS

This LSMS is a superstructure, composed of equipment for transmitting pipe information to the monitoring center over the Internet or CDMA, system for detection, understructure composed of LSP, connection parts, network routers for connectivity, and control panel for access inspection and connection above the ground. Figure 2
shows central LSMS configuration. For the purpose of monitoring the status of the leakage, the breakage point of a LSP and its status can be displayed by analyzing the information from a TDR and the LSP in the pipe network[5].

4. Pilot System Simulation

Constructed virtual environment using pilot system for simulation. Data such as the length of each pipe and information from reported damages can be gathered by accessing the TDR of the system. The experiments were done using the prototype steel pipe (300 polyethylene steel pipe). The location of the leakage and breakage was identified through the wavelength analysis of the LSMS[6].

Fig 2. Result of LSMS and TDR Screen

5. Conclusions

In this paper, we proposed and simulated to LSMS using TDR. With this system and its capability for accurate leakage detection, the convenience of the residents will be enhanced with stable water supply through the reduction of leakage incidents, along with the reduction of personal. In addition, new technology, new construction methods, and technical manpower can be obtained with the development of the LSP. The suggested LSMS can be applied not only to waterworks but also to underground sewer pipes. Moreover, wide wireless Internet connection, 3D GIS modeling and development and improvement of constructing LSP are thought to be required.

Reference