A Study for Leak Location Detection with Characterization of Leak Signals using Accelerometer in Water Pipelines

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Introduction

Water leakage on water supply pipelines causes a loss of limited water resources. In addition, it has become a potential risk of land subsidence that has recently occurred in the city. It is not possible to inspect the leakage directly for buried pipelines. When the water leakage from the water supply pipelines has occurred, it is very difficult to quickly detect whether a leak or not early and it is more difficult to locate the exact leak points concurrently. Therefore, a rapid and accurate leak detection method not only can maintain the water supply pipelines without difficulty but also provide important information in order to prevent serious damage of human life. It has been known that a leak signal is good to find the location of leak points on the pipelines. Although there are several proposed methods to find the leak location by detecting leak noise using various sensors, efficient sensors have not well established in a field. This paper discussed the characteristics of leak signal and the limits of detection range for an accelerometer in a field.

Materials & Methods

1st Lab Tests

Table. 1 Specifications of accelerometers

	Model	Manufacturer	Measurement range (g)	Resolution (g)	Frequency Range (Hz)
1	MG-102S	TOKKYOKIKI	2.0	0.0000001	0.00 ~ 100
2	OEM	OEM	0.1	< 0.0001	0.05 ~ 2 k
3	393B31	PCB	0.5	0.000001	0.07 ~ 300
4	624B01	PCB	50.0	0.001	0.80 ~ 10 k
5	352C33	PCB	50.0	0.00015	0.50 ~ 10 k

Table. 2 Single sine vibration conditions

Frequency(Hz)	Acceleration (g-peak)	
2	0.05	0.1
5	0.05	0.1
10	0.05	0.1
20	0.05	0.1
50	0.05	0.1
100	0.05	0.1
200	0.05	0.1
250	0.05	0.1
400	0.05	0.1
500	0.05	0.1
750	0.05	0.1
1000	0.05	0.1
1250	0.05	0.1
1500	0.05	0.1
1750	0.05	0.1
2000	0.05	0.1

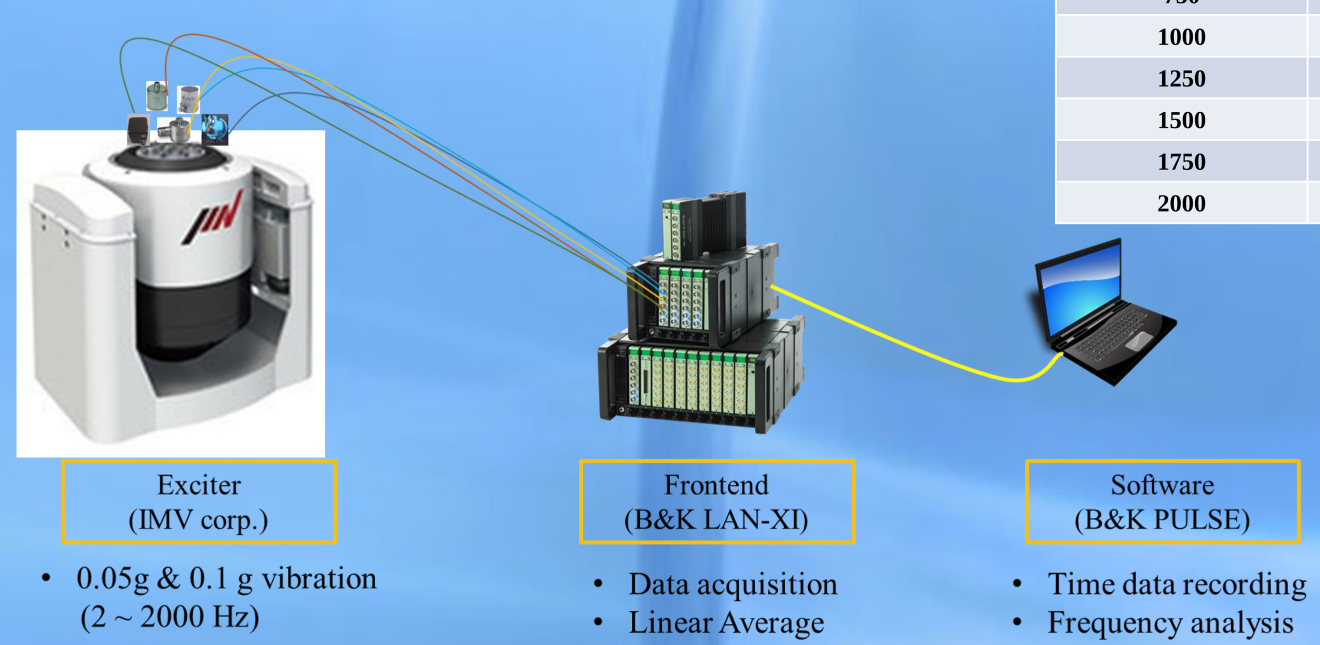


Fig. 1 Test equipment and data acquisition system

2nd Pilot Tests

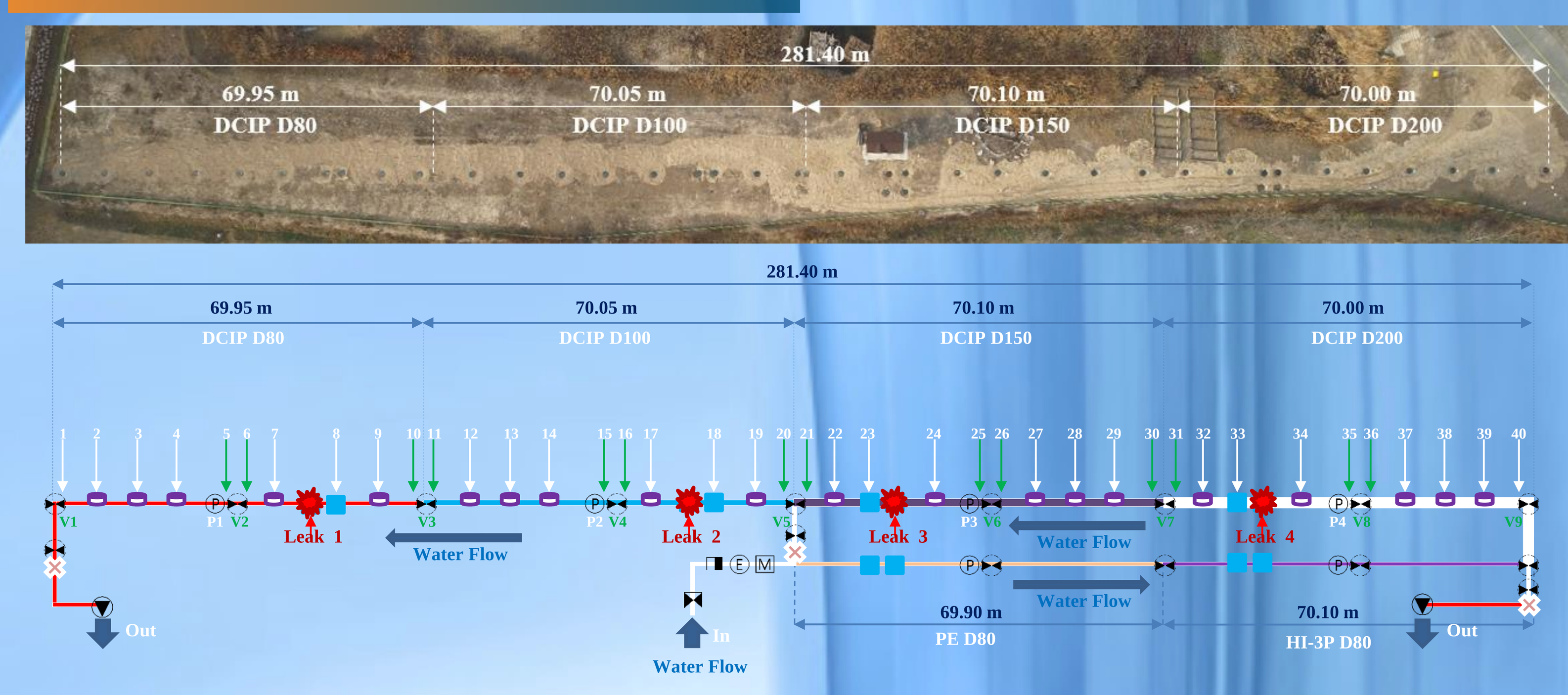


Fig. 2 leakage test facility

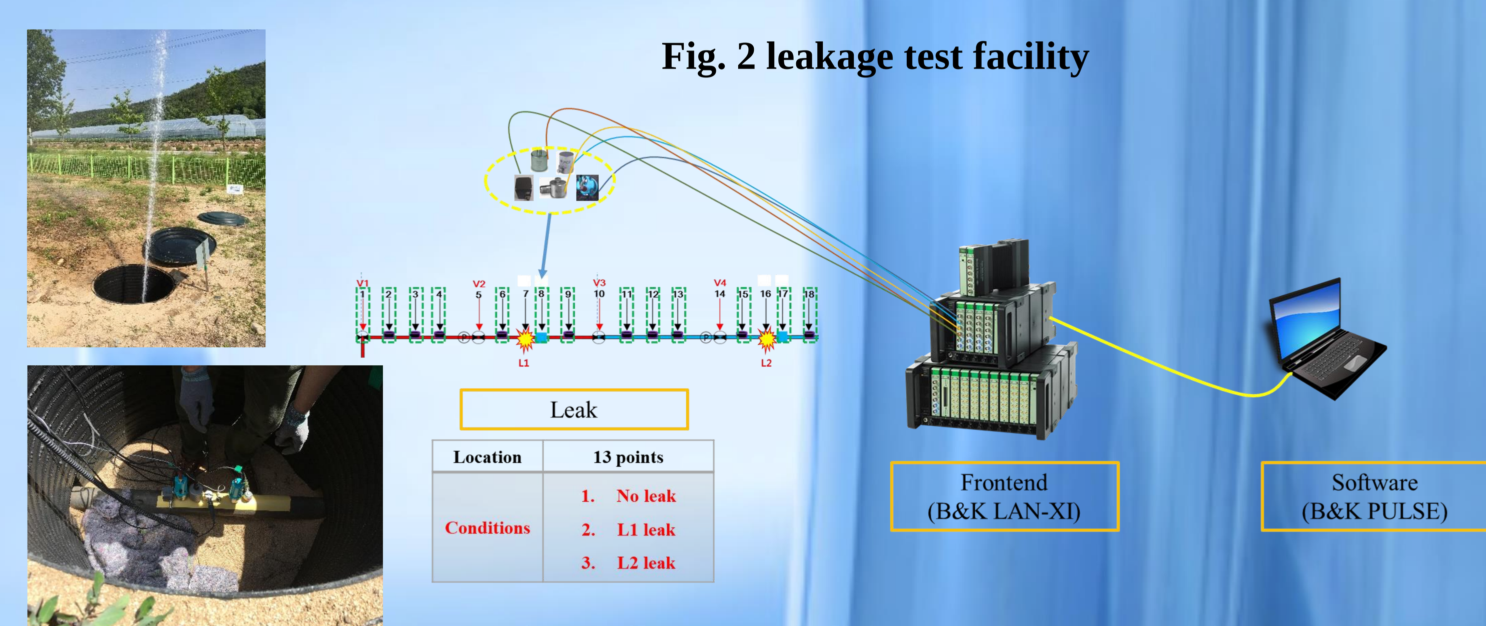


Fig. 3 Pilot test conditions and data acquisition system

RESULTS & DISCUSSION

1st Lab Tests Results

0.05g

Accelerometer	Frequency [Hz] 2	5	10	20	50	100	200	250	400	500	750	1000	1250	1500	1750	2000
Tokkyokiki	0.05	0.05	0.05	0.05	0.05	0.05	0.03	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
OEM	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.14	0.15
PCB393B31	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.07	0.18	0.07	0.02	0.01	0.00	0.03
PCB624B01	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.07	0.21
PCB352C33	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.09	0.10

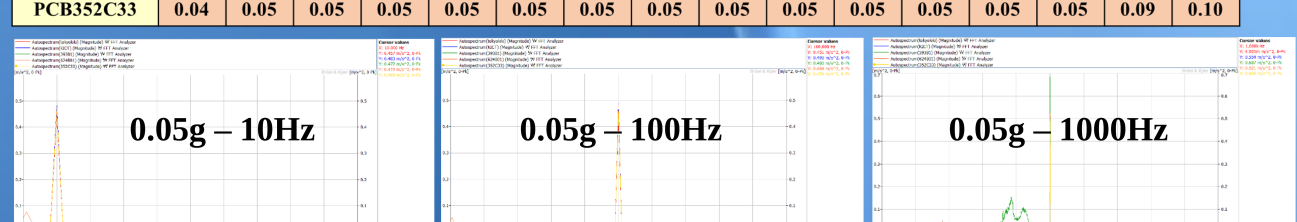


Fig. 4 Performance evaluation of accelerometers (0.05g)

0.1g

Accelerometer	Frequency [Hz] 2	5	10	20	50	100	200	250	400	500	750	1000	1250	1500	1750	2000
Tokkyokiki	0.10	0.10	0.10	0.10	0.10	0.10	0.07	0.05	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
OEM	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.12	0.11	0.13	0.13	0.16	0.16
PCB393B31	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.12	0.14	0.37	0.15	0.04	0.01	0.00	0.06
PCB624B01	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.12	0.10	0.15	0.39
PCB352C33	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.11	0.10	0.12	0.10	0.19	0.18

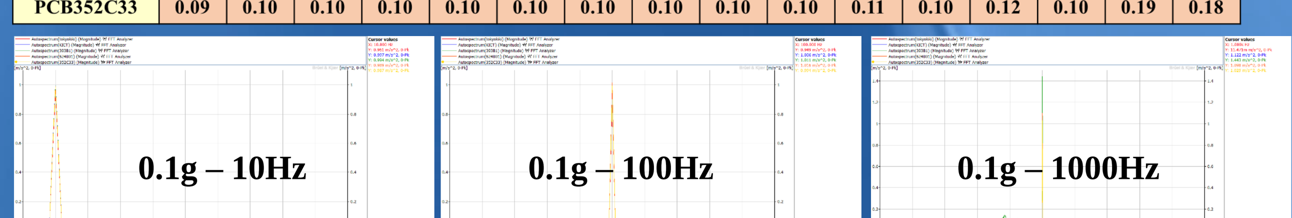
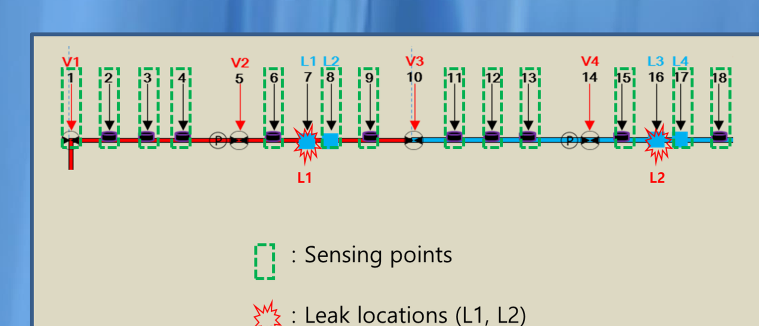


Fig. 5 Performance evaluation of accelerometers (0.1g)

- ➢ The smaller the resolution, the more stable the output in the lower frequency band.

2nd Pilot Tests Results



Accelerometer	Locations 1	2	3	4	6 (L1)	8	9	11	12	13	15 (L2)	17	18
Tokkyokiki	X	X	L1 B	L2 S	L1 B	L1 B	L1 B	X	X	L2 B	L2 B	L2 B L1 M	L2 B L1 M
OEM	X	X	L1 B	L2 B	L1 B	L1 B	L1 B	X	X	L2 B	L2 B	L2 B L1 M	L2 B L1 M
PCB393B31	X	X	L1 大	X	L1 B	L1 B	L1 B	X	X	L2 B	L2 B	L2 B L1 M	L2 B L1 M
PCB624B01	X	X	X	X	L1 S	L1 B	L1 B	X	X	L2 B	L2 B	L2 B L1 M	L2 B L1 M
PCB352C33	X	X	X	X	L1 B	L1 B	L1 S	X	X	L2 B	L2 B	L2 B	L2 B

B : Big amplitude
M: Middle amplitude
S : Small amplitude

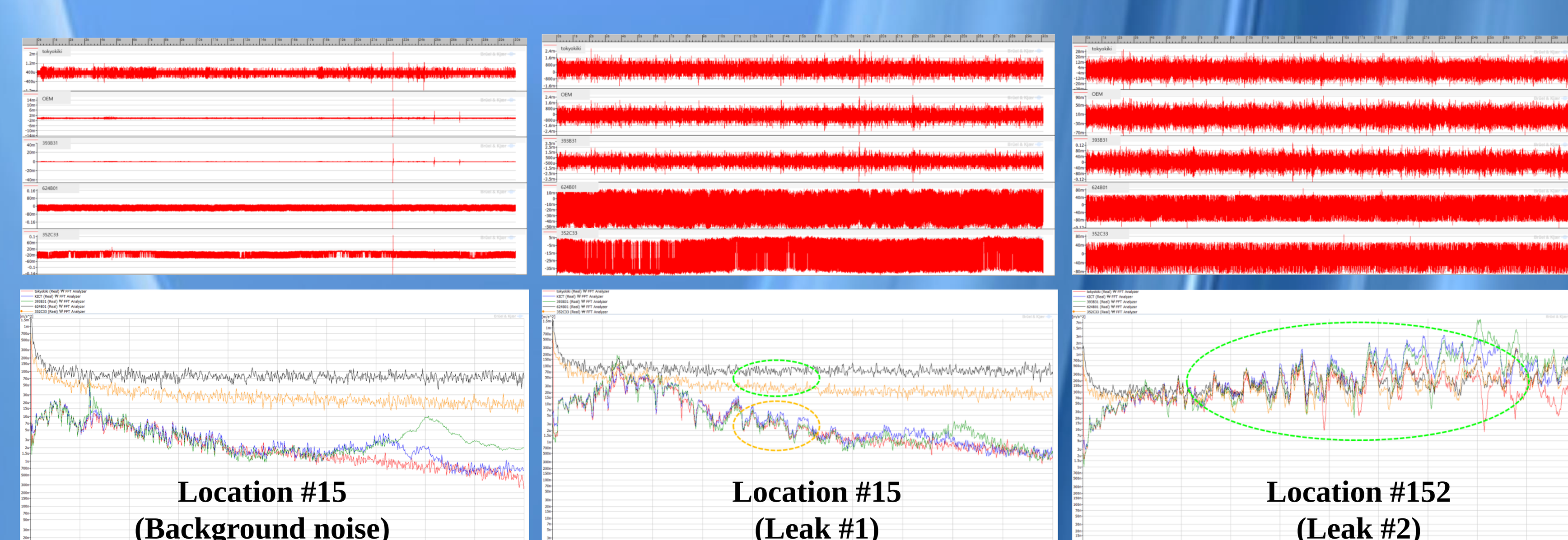


Fig. 6 Time and frequency domain for leak signal

- ➢ In the case of background vibration, the five sensors show different measurements (small amplitude of vibrations, due to different measurement ranges and sensitivities of the sensors)
- ➢ The signal size increased with distance from the point of leakage and the signal value decreased with distance.
- ➢ Accelerometers with smaller resolutions were found to better detect leak signals.

Conclusions & Further Study

In this study, a real scale leakage test facility was built under the ground. Leak signals were measured from the outside of pipelines using various accelerometers. To understand characteristics of the l eak signal, leak signals were collected at each of distances from a leak location. The characteristics of different data sets were presented in time and frequency domain. The implication of acoustic char acteristics on the design of an accelerometer for leak detection was discussed and accelerometer specifications to pinpoint a leak location was proposed based on leak signal.

The specification of the sensor to measure the leak signal in leak detection is important. In this experiment, various accelerometers were used to measure the leakage signal. Experimental results show that the accelerometer with smaller resolution is more advantageous for leak detection, and the sensor with the minimum resolution of 0.00001 or less can be used effectively.

In addition, it is desirable to determine the frequency range where there is a difference and perform leakage monitoring through numerical value such as rms value.

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