

Q&A

31Q7: How should I do a leakage investigation at the location where pipe is below the groundwater level (high groundwater level)?

(by Mr. Y.K, Sri Lanka)

**A1: Answerers: Mr. Oda Hiroto (Fukuoka City Waterworks Bureau OB)
Mr. Ooe Kitaru (Fukuoka City Waterworks Bureau)**

1. Water leakage investigation method

The most common method of water pipe leakage investigation is to detect the sound of water leakage from the leakage point.

There are other methods, such as a method using radar waves and a method of injecting gas into a water pipe for investigation.

2. Comparison among leakage detection methods

The main methods are as shown in Table 1.

Table 1. Comparison of currently used methods

Survey method	Details	Effectiveness in places where groundwater is high	Asses sment
1. Acoustic Survey method	Locate a leakage by a leak sound transmitted from a pipe to a road surface, a valve, a plug, etc. using a acoustic bar or a leak detector	Not suitable under the environment where leak sound is hard to transmit (hollow condition, underwater, PP or VP pipe) due to the limited locations to do listening, and limitation of the operator's hearing.	△
2. Correlation method	Use multiple leakage sensors installed directly on a pipe or valve, plug. Locating a leakage points by time gap among leakage sounds captured by each sensor at some points.	Effective even the groundwater level is high, if the exact pipe length is clear and the survey target distance is less than 200 m.	○
3. Tracer gas method	Inject gas, which does not cause any problem to water quality, into a pipe. And locate a leakage on the ground surface by detecting the gas leaked from leakage point.	Possible to identify leakage that cannot be detected by ordinary acoustic survey. Also effective even the groundwater level is high.	○
4. Under-ground radar method	Locate a leakage by the differences in dielectric constant between of the surrounding ground and wet ground due to leaked water	Unsuitable when the groundwater level is high because it is a method to identify the leak location by capturing changes in the ground wet condition.	×

5. Smart ball method	Insert a hearing sensor (ball shape) into a pipe and let it flow through the pipe. And detect a leakage location by information recorded during this time.	Since it has been developed overseas, there are a few results in Japan. It will be an effective measure also for high groundwater level places because it is not susceptible to the surrounding area of the pipe.	△
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3. Leakage investigation method of water pipe where groundwater level is high

The acoustic survey to locate a leakage point using an acoustic bar or a leak detector is the most commonly adopted at present. However, this acoustic survey will be very difficult to detect leakages because this method requires very high skills especially when the points to listen are limited, or groundwater level is high (where leakage sound is difficult to transmit).

For this reason, as shown in Table 1, it is considered that the correlation method using a correlation type water leak detector and the tracer gas method are effective for the leakage survey where the groundwater level is high.

However, these methods are not widely used in developing countries for the following reasons:

- 1) The cost of the survey is high.
- 2) Listening points (valves, taps, etc.) rarely exists within 200 meters.
- 3) In the case of correlation method, leakage cannot be detected unless the pipe information such as material, diameter and length etc. are clearly identified.

* The smart ball method has not been so popular because it is still new in its development.

From the above, under the situations that effective water ratio (revenue-water ratio) is low, the most effective measure is to strengthen patrols, detect existing leaks quickly and repair them immediately. For example, since there are many unpaved places in developing countries, leakages can be detected on the ground, if there is a certain level of water pressure and leakage as depending on the burial depth of a pipe. (Photo 1) In addition, bubbles may come to the water surface at crossing with waterways.

(Photo 2)



Photo 1: Leakage on the ground



Photo 2: Bubbles on the water surface at crossing points of waterways

4. Issues about leakage when groundwater level is high

1) In terms of leakage at high ground water levels, the most worrying thing is the possibility of water contamination; especially under the condition that there is constantly quite low water pressure in a pipe, or when the water pressure drops to low (possibly in developing countries). The underground water may flow into a pipe and the tap water be polluted. (Photo 3)

2) Repairing leakage and piping work at the place where the underground water level is high, it is essential to work properly with water replacement work and dry work. However, in developing countries, those works are often carried out in water by hand. In such cases, it is doubtful whether water leakage repair work or piping work can be done completely. (Photo 4)



Photo 3: Underground water flowing into pipe



Photo 4: Piping work (repairing leakage) in water

5. Considerations

If the groundwater level is assessed to be or become high, it is necessary to take measures to prevent a pipes from floating when it becomes empty; secure a minimum

burial depth of pipe. In addition, it is necessary to install accessories such as valves for enabling to stop water in emergency such as accident.

As described above, when effective water ratio (revenue water ratio) is low, "Ad-hoc responses" (a method to find out existing leakage and repair it immediately) is effective as immediate action.

Thus, the early detection of underground leakage is as very important as the immediate repair of leakages found on the ground.

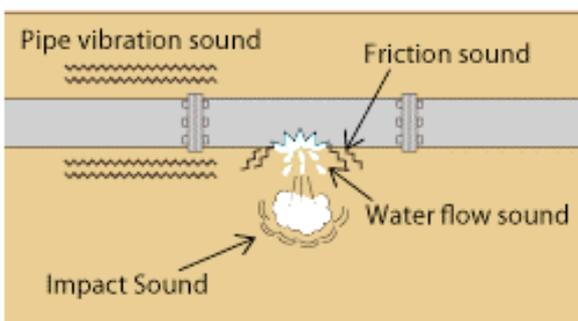
However, with few pipe accessories, it is very difficult to conduct planned leakage prevention surveys and identify leakage points.

From this point of view, it is urgently necessary to install pipe accessories at appropriate places. With such an initial investment, economical and high-quality maintenance can be possible in the future as a result.

A2: Answerer: Mr. Sekimoto Shinichi (Kyowa Engineering Consultants Co.,Ltd.)

I think the question seems to intend to capture the leak sound on the ground surface using a leak detector.

Leak sound is accompanied by a complex sound composed of the four elements; running water sound, impact sound, friction noise with a pipe, and pipe vibration sound as shown in the figure. If the underground water level is higher than the burial depth of a



Fig; Generation mechanism of the leakage sound

pipeline, it will be very difficult to detect correct position of leakage by acoustic survey using a leak detector because it is similar condition to a leakage in a swimming pool (a space is created around the leakage hole due to leaked water, and filled with water looking like a pool). This is because the each component of the leakage sound, in

particular the impact sound, is wiped out. For example, if you use a hose to jet water to a wall, you will find the place where a big sound "Bacha, Bacha" generates; the wall which the water splashes against. However, with the same amount flow, if you dip the tip of a hose into a water-filled pool, the sound will change to a small sound "Buku Buku". You won't know where the sound is coming from. Such a leak-in-pool detection requires careful and time-consuming work and skilled experience, and often it cannot be detected. If leak sound is propagating to the valves or meters near this pipeline, it is possible to identify the leakage position by a correlator.

By the way, when the road is paved with asphalt and the pipe is buried under the road surface as in Japan, the road surface acoustic survey using a leak detector is efficient. Conversely in many cases in developing countries, when pipes are buried on the shoulders of the road or under the embankment, it is not recommended to use the sound detection method using the leak detector. The reason is that soil plays a role of a cushion and silencer and it is difficult to capture the leak sound on the ground surface.

In Nyeri water & sewerage company in Kenya, instead of this acoustic survey, they use an ultrasonic flowmeter (UFM) as a main method of leak survey. Excavate every approximately 100 m, and set an UFM, then check the passing flow rate to narrow down the location of the leakage. From the upstream to the end of the pipe, they repeatedly work to track down the amount of leakage completely by flow measurement.



If the surface condition at the leakage survey of your question is not paved with asphalt etc., I recommend not to persist only in acoustic survey with a leak detector, but to apply a method of narrowing the leakage point by flow measurement with ultrasonic flowmeter. If it is easy to arrange a hand digger worker, the flow measurement method is even more effective. In this way, it is important to select an efficient survey method according to the local situation.

Verification of passing flow rate using UFM

A3 : Answerer: Mr. Matsuoka Yasuhiro (Yokohama Water Co.,Ltd.)

The case of question can be surveyed by conventional leakage survey (acoustic survey). The pipe laying condition might decrease the sound of leakage, but we can detect anyway. However, if the pipe is really in a water, it will be difficult. The following

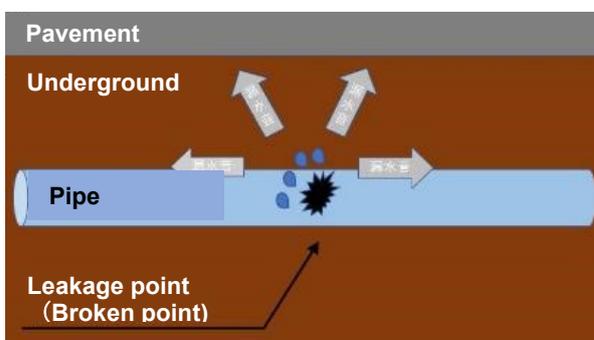


Figure 1 Normal Pipe Laying Condition

figures, from 1 to 4, depict the conditions of pipes in underground. **The usual condition of underground water is shown Figure 1.** The condition of the question is described in Figure 2. We often hear the similar question in developing countries. Our usual answer is “Is your country (survey area) under water? If not, we can do it”.

The basic theory of leakage survey is to hear the water spraying sound generated by leakage. The sound reaches to your ear or equipment through the pipeline or ground.

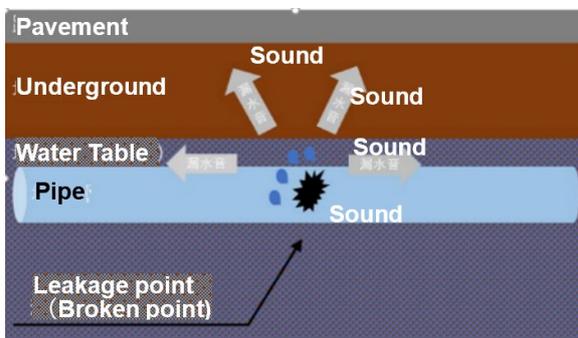


Figure 2 High Groundwater Level

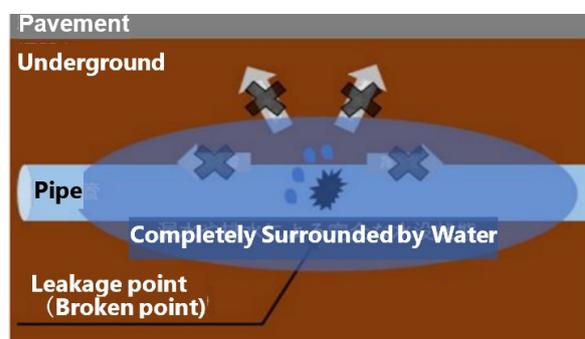


Figure 3 Pipe is in Small Body of Water

repeat the survey in such area.

Figure 3 shows the condition that the leakage point is fully submerged in water of leakage, effluent, etc. It is called “Pool”. The leakage water cannot generate any spraying sound, therefore, we cannot detect the leakage point by usual procedure (acoustic survey). Furthermore, we cannot know such situation happens from the ground surface. So that, we shall survey regularly and wait for the leakage to come to the surface or leakage sound to become sonic due to loss of “pool” water.

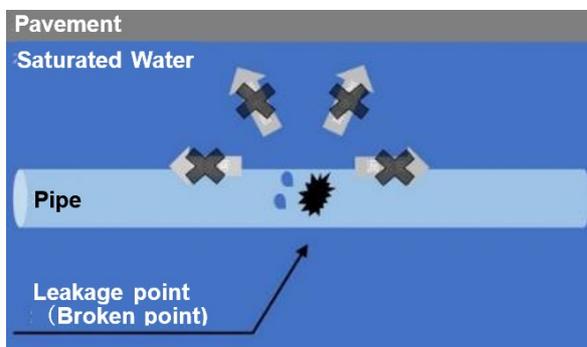


Figure 4 Pipe lays in Water

Figure 4 shows that the water pipe is laid in water. It is different from the case in Figure3,

We can detect the leakage as far as the spraying sound is there. The usual condition of underground water is shown in Figure 2. Even if it is under the underground water table, it is not fully saturated by the water. It is the mixture of particles water and soil, and there is sound of spraying water. On the other hand, the cases shown in Figure 3 and Figure 4, where the leakage point is fully inside the water, there is no sound of leakage. In the case of Figure 2, the leakage water generates the sound of spraying on soil and stones. Sometimes, the sound may not be so clear and difficult to find. Therefore, you would better take more time for the survey or,

If you cannot reduce NRW, cannot find any other leakages, should doubt such condition, and you need really to find out the leakage, we recommend you to conduct the water flow measurement in short distances so as to narrow the potential area of leakage point. This procedure has been used successfully in Nyeri City in Kenya.

because we cannot expect any surface leakage and future sound creation. We had better replace the pipe, or we can measure flow rate in short distances. I have seen such condition shown in Figure 4 in Southeast Asian countries. The pipe was in a waterway. You can imagine easily the problem of such condition.

I explained four types of pipe buried condition. I would like to request you to remember that there is no leakage survey method and equipment shall be applicable for all cases. It is very basic that the leakage survey needs time to spend with combination of multiple methods and instruments.

Please remember that it is very difficult to find out every leakage point at one survey. It is because of the case of Figure 3, disturbed by outer noise, or too small leak sound.

Leakage will occur again. So, you need to conduct regular and steady leakage survey in order to lower and keep the NRW level. Leakage survey is not so eye-grabber but very essential in water supply business. Please utilize the knowledge to improve your business.