



## Specification for Water Leakage Detection Survey

### References

1. 16/WSD/97, Leakage Detection of Buried Watermains Affecting Slopes - Stage I, Water Supplies Department
2. 3M Cable Locator User Manual
3. Course Note, Advanced Water Leakage Detection/Survey for Operators, Engineer/Specialists and managers, UTI, 2005
4. DC96/19, Investigation of Sewers and Drains Behind and Adjacent Fill Slopes and Retaining Walls, Drainage Services Department.
5. HKHA161/95, Detection of Leakage from buried water carrying services in the vicinity of slopes 'and retaining walls within the lands 'maintained by Housing Authority.
6. Hong Kong Institute of Utility Specialists(2006), Constitution.
7. King Wong (2000), The design of Water Leakage Detection Methods for Hong Kong. An unpublished Master Degree Thesis at The University of Hong Kong.
8. Works Branch (1996), Hong Kong Government, Code of Practice on Inspection & Maintenance of Water Carrying Services Affecting Safety of Slope.
9. W. Lai, S. Tsang & K. Wong, Applications of Ground Penetrating Radar in Civil Engineering Works, 2004

### **HKIUS Guidelines for Requirements for Water Leakage Detection Survey**

#### **Foreword**

It's been more than ten years now since the disastrous landslide that occurred in Kwun Lung Lau on Hong Kong Island on 23 July, 1994. Since 1995, the Government of HKSAR has awarded tens of millions of dollars in contracts related to detection of leakage from buried water carrying services throughout the territory. As expected, this sequence of events generated an increasingly large pool of "underground Utility Specialists", with most working almost independently, devoid of any standardized surveying methods, quality requirements (on survey results) and the "registration" of operation personnel in the market.

In view of the availability of the multitude of method statements, specifications, training manuals, and the contracts documents produced for the vast number of underground utility survey contracts (by government and private projects), the following sections try to provide a comprehensive set of guidelines, by addressing the following topics in general:

- **Utility Services Information to be investigated**
- **Level of Accuracies**
- **Types of Deliverables and Schedules**
- **Requirements for Personnel and Deliverables**

You are welcome to take reference to this Particular Specification for your contract and in case you need further information, please send an e-mail to [info@hkius.org.hk](mailto:info@hkius.org.hk) or call Ir Dr. King Wong.

*Ir Damien C.C. Ku (古志衆)*  
**President, HKIUS (2007/09 & 09/10)**

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**LEAKAGE DETECTION-Particular Specifications**

<i>Description</i>	<b>26.2 LEAKAGE DETECTION ON PRESCRIBED SECTIONS OF WATER MAINS</b>	<p>(1) The Utility Specialists shall conduct the preliminary visual inspection and LNC surveys at or between the two prescribed contact points to detect and find any leaks within the Survey Boundary. If LNC survey is found not suitable or could not produce a good result, the Utility Specialists shall carry out further leakage detection surveys by shortening (dividing the main into shorter segments) or shifting the contact points for the LNC surveys and by listening on top of the pipe and exposed features using other mechanical and electronic leak detectors (acoustic detectors) or carry the leakage detection work during midnight or low flow period until reasonable results.</p> <p>(2) The Utility Specialists shall perform further leak detection surveys at all associated branches of water mains within the corresponding Zone of Influence/survey boundary, and spikes found from the LNC surveys.</p> <p>(3) If the result from the LNC survey indicates a spike, the Utility Specialists shall carry out further leak detection surveys to verify the suspected leak. In case of the spike being found in the connection with other branch pipes, further leak detection surveys shall be performed to confirm the suspicions. Pinpointing by ELD/MLD for the suspected leaks is required unless otherwise instructed by the client not to carry out.</p> <p>(4) All LNC set up (contact) points and found leaks shall be marked on-site by red-paint with sufficient information confirmed with the client and photographed for inspection and record.</p> <p>(5) If contact points cannot be located or alternate contact points are desired, the Utility Specialists is responsible to propose in advance with a layout plan to the client to show the location of the new contact points. The Utility Specialists can break or extend the survey into a shorter or longer segment, but the necessity or request for modifications shall not affect the performance of the survey results.</p> <p>Contact points include hydrants, accessible valves, exposed pipes, and others as find appropriate. The Utility Specialists shall be responsible to inform the client to expose water mains for creating contact points for LNC survey, if necessary for completion of the leakage detection, and to reinstate the site back to its original condition complying with Highway Department, Geotechnical Engineering Office or related Government departments requirements and to the satisfaction of the Engineer.</p>
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<i>Survey Equipment</i>	26.2.3	<p>(1) The major equipment to be used for slope leakage detection Contract includes the following items:</p> <p>(a) Leak Noise Correlators</p> <p>(b) Mechanical Leak Detectors</p>
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<i>Leak Noise Correlator</i>	26.2.4	<p>(c) Electronic Leak Detectors</p> <p>(d) Noise Loggers</p> <p>(e) Pipe locators</p> <p>(f) Colour Closed Circuit Television (for further instruction from client)</p> <p>(2) Other equipment to be used for the Works includes the following items:</p> <p>(a) Measuring tapes and wheels</p> <p>(b) Flashing lights</p> <p>(c) Spray paints</p> <p>(d) Valve Keys</p> <p>(e) Manhole cap opening tools</p> <p>(f) Traffic diversion cones/signs</p> <p>(g) Safety equipment (including multi-sequence warning indicator mounted on working vehicle of each leakage detection team)</p> <p>(h) Chlorine/fluoride test kits and conductivity meter</p> <p>(i) Sign boards</p> <p>(j) Camera</p> <p>(3) The Utility Specialists shall submit detailed equipment list to the client for approval before the commencement of the Works. Unless otherwise instructed by the client, the equipment used for the Works shall be approved by the client before any survey is carried out.</p>
<i>Leak Noise Correlator</i>	26.2.4.1	<p>(1) Leak Noise Correlator is a leak location instrument. Leak Noise Correlator shall consist of two microphones (sensors), two hydrophones, and a Correlator. The microphones are attached to contact points while hydrophones are attached to the hydrants along the water main to be surveyed and using the Correlator to cross correlates the leak noise reaching the two microphones to calculate the suspected leak position.</p> <p>(2) The Leak Noise Correlator used for the survey shall operate at digital basis and shall have, but not limited to, the following functions and capabilities:</p> <p>(a) Survey distance shall be able to cover minimum of 1000 metres with a capability to measure different combination of pipe materials and different pipe diameters in a single measurement.</p> <p>(b) Radio transmission, maximum at 500 to 1000 metres.</p> <p>(c) Accuracy of measurement shall be within <math>\pm 5\%</math> or 5 meters of the survey length in meters.</p> <p>(d) Frequency interval for both cable and radio is 5 to 4000 Hz.</p> <p>(e) It shall allow the Operator to change and select different settings (such as pipe materials, filter ranges and frequency bands) and modes (such as survey mode, leakage detection mode and compute mode).</p> <p>(f) Display shall be high contrast LCD with display light or LED and control panel shall be a watertight membrane keyboard.</p> <p>(g) Power supply using rechargeable or alkaline batteries and provide with 220/240V battery charger.</p>

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		(h) The microphones shall be able to detect sound through pipe or valves and fittings and the hydrophones shall be able to detect sound/ leak through the carrying fluid.
		(i) The correlator shall have data storage and print out functions to record down the survey inputs and results.
<i>Survey Procedure</i>	26.2.4.2	The Utility Specialists shall follow the equipment supplier's operation procedures and instructions to carry out the Leak Noise Correlator survey. The survey procedure shall be described, but not limited to, as the following: <ul style="list-style-type: none"> <li>(1) Connect two microphones (sensors) to the transmitter and processor at either side of the pipe under analysis. Contact points include exposed pipes, valves, hydrants and stopcocks.</li> <li>(2) The signal from the transmitter shall be amplified and transmitted by radio telemetry to the processor automatically. The Utility Specialists shall apply different frequencies and filters to obtain the best accuracy results.</li> <li>(3) Type of pipe material, pipe diameter, pipe length under investigation shall be entered into the correlator correctly to reflect the field measurement or as provided in the record Drawings.</li> <li>(4) Sound propagator from the leak to each sensor. The processor compares this signal and determines the difference between the time taken from the leak to reach one sensor compared to the other, and the distance of the leak from the sensors at each end of the pipe shall be computed and the leak position shall be automatically indicated.</li> </ul>
<i>Submission of Survey Result</i>	26.2.4.3	(1) The Utility Specialists shall record the survey information and send the results to the client for each surveyed pipe. <ul style="list-style-type: none"> <li>(2) The survey result shall be prepared in a professional manner by MHKIUS (WLD) and to include all necessary information including: <ul style="list-style-type: none"> <li>✓ Name of Operator(s), (A/O/M/FHKIUS)</li> <li>✓ Location of Survey,.</li> <li>✓ Date and Time of Survey,</li> <li>✓ Total length of survey,</li> <li>✓ Number of survey setups,</li> <li>✓ Results (LNC print outs),</li> <li>✓ Analysis of Results,</li> <li>✓ Suspected or confirmed leak location with plan,</li> <li>✓ Any difficulties encountered,</li> <li>✓ Recommendations</li> </ul> </li> <li>(3) The photographs shall be taken at each LNC setup points and submitted with the survey report.</li> </ul>
<i>Quality Assurance</i>	26.2.4.4	The Utility Specialists shall perform the Works with integrity and apply all required quality control and quality assurance procedures per the approved QA/QC Plan.(to be referenced to WSD's major contract)
	26.2.5	Mechanical and Electronic Leak Detectors

Leakage Detection of Buried Water Mains		Particular Specification
	<i>Mechanic Leak Detector</i>	26.2.5.1 (1) Mechanical Leak Detector is a passive device similar to doctor's stethoscope which transfer the leak noise to the Operator's ear directly through ground microphones.
	<i>Electronic Leak Detector</i>	26.2.5.2 (1) Electronic Leak Detector consists of a microphone, amplifier and frequency filter. The sound of leak is amplified and transmitted to either headphones, loudspeaker or indicating meter electronically. Unwanted noise can be removed by electronic frequency filters. <ul style="list-style-type: none"> <li>(2) The Electronic Leak Detector shall have, but not limited to, the following functions and capabilities: <ul style="list-style-type: none"> <li>(a) ELD shall include noise amplifier, headphones, ground microphone and accessories.</li> <li>(b) With selectable frequency to filter other noises</li> <li>(c) A LCD indicator or screen shall be included for digital data readout or leak noise level display.</li> <li>(d) Power supply shall be provided by rechargeable and alkaline batteries. The charger for the rechargeable batteries shall be 220/240V.</li> </ul> </li> </ul>
	<i>Survey Procedure</i>	26.2.5.3 (1) Mechanical Leak Detector <ul style="list-style-type: none"> <li>(a) The Utility Specialists is responsible to find the location and alignment of water main by using pipe locator for locating pipes if necessary.</li> <li>(b) Use contact microphone to listen for leak sounds at meters, hydrants, valves and other points of direct contact.</li> <li>(c) Place the sensing heads on the ground firmly against the surface.</li> <li>(d) Move the sensing heads along the top of water main until the sound is the same intensity in both sensing heads and reaches both ears at the same time. This is the spot directly above the leak.</li> </ul>
		(2) Electronic Leak Detector <ul style="list-style-type: none"> <li>(a) The Utility Specialists is responsible to find the location and alignment of water main. The Utility Specialists shall use pipe locator for locating pipes if necessary.</li> <li>(b) Use contact microphone to listen for leak sounds at meters, hydrants, valves and other points of direct contact.</li> <li>(c) Place the sensing heads on the ground firmly against the surface.</li> <li>(d) Take readings along the top of water main at two meters</li> </ul>

		Particular Specification
Leakage Detection of Buried Water Mains		interval. Listen to the sound, and adjust the filter for the highest response to the leak frequency to locate the leaks.
<i>Submission of Survey Result</i>	26.2.5.4	(1) the Utility Specialists shall record the survey information and send the results to the client for each surveyed pipe.  (2) The survey result shall be prepared in according to PS Clause 26.2.4.3
<i>Quality Assurance</i>	26.2.5.5	The Utility Specialists shall perform the Works with integrity and apply all required quality control and quality assurance procedures per approved QA/QC Plan.
<i>Termination of Leakage Detection on Prescribed Sections after Preliminary Inspection</i>	26.2.5.6	(1) The client with the help from a qualified utility surveyor shall have the authority to terminate the leakage detection works on the pipes if the pipes are found from the preliminary visual inspection to be under any of the following conditions:  (a) dry pipes or non-pressurized pipes, (b) under redevelopment/construction, (c) can not be found, (d) site condition been changed, or (e) outside of the inspection scope.  (2) For the terminated leakage detection works on pipes, the Utility Specialists shall be compensated for only the associated preliminary visual inspection and reporting works.
	26.2.6	Noise Logger
<i>Noise Logger</i>	26.2.6.1	(1) Noise Logger is a leak location instrument, which is installed at valves along the water main to be surveyed and using the receiver unit to receive the radio signal. The information can be downloaded into a computer to display the leak location.  (2) The Noise Logger shall have, but not limited to, the following functions and capabilities:  (a) The Noise Logger shall include logger, receiver and accessories.  (b) Power supply of the receiver shall be provided by rechargeable and alkaline batteries. Power supply of the logger shall be provided by internal battery and replaceable at end of life.  (c) A LCD indicator or screen shall be included on the receiver.
<i>Survey Procedure</i>	26.2.6.2	The Utility Specialists shall follow the equipment supplier's operation procedures and instructions to carry out the Noise Logger survey. The Utility Specialists shall note that Noise Logger survey shall be used in QA/QC re-test and/or any other sections of water mains as required by the client. The survey procedure shall be described, but not limited to, as the following:  (1) The Utility Specialists shall carry out the preparation works, visual

		Particular Specification
Leakage Detection of Buried Water Mains		inspection and seepage water sampling and reporting, etc. in accordance with PS Clause 26.2.3 (2) to (7).
		(2) Install loggers to listen for leak sounds at appropriate locations of the pipe under analysis. The spacing between noise loggers shall not exceed 100m unless otherwise requested by the client.
		(3) The data from the logger shall be transmitted by radio signal to the receiver. The logger shall be interrogated from a moving vehicle or human.
		(4) The information shall be downloaded into a computer to display the leak position.
<i>Submission of Survey Result</i>	26.2.6.3	(1) The survey result shall be prepared in according to PS Clause 26.2.4.3
<i>Quality Assurance</i>	26.2.6.4	The Utility Specialists shall perform all the works with integrity and apply all required quality control and quality assurance procedures in his quality manual.

### 26.3. Deliverables

The Utility Survey Specialist shall supply the following for each site:

#### **26.3.1 Preliminary Stage**

- (a) One set of preliminary digital data.
- (b) One set of paper copy of drawings
- (c) Control results, including simple description of permanent ground markers.
- (d) One Copy of brief technical report.
- (e) One set of photographs.

#### **26.3.2 Interim Stage**

- (a) one set of interim digital data.
- (b) one set of paper drawings in 1:100 scale
- (c) one copy of interim technical report.

#### **26.3.3 Final Stage**

- (a) 2 copies of Final Report which is a compilation of all deliverables required under interim stage to incorporate all comments provided by the Engineer.

### 26.4. Delivery Schedule

**26.4.1** The Utility Surveyor shall supply for the Site preliminary digital data and paper check plots including a draft technical report with control results within one (1) week after the programmed completion of the works for the Site. The Engineer may direct the Contractor to submit preliminary reports of the Site during the execution of investigation, the Contractor shall submit the reports within 1 week after the Engineer has given such written instruction at no additional costs.

**26.4.2** The Engineer shall return a copy of preliminary data with comments and correction progressively within one week of receipt of preliminary data. The Contractor shall incorporate the Engineer's comments on the preliminary data within the preparation of his Final Survey report.

**26.4.3** The Utility Surveyor shall submit a Final Report for the investigation within 4 weeks after the completion date of the Works.

#### **26.5. Electronic Data Files for Utility Services**

**26.5.1** The results of the investigation (layout plan only) shall be supplied in AutoCad R14 or above or DGN/GIS/IDMS format. All surface and underground features shall be located as described in Clauses 1 and 2. Non graphic information shall be included in the AutoCad or DGN/GIS/IDMS file database as block attributes or similar. All data shall be separated by type into a logical system of AutoCad or DGN/GIS/IDMS layers as approved by the Engineer.

**26.5.2** The Utility Surveyor shall submit a schedule of AutoCad or DGN/GIS/IDMS standards to the Engineer for approval, which shall contain proposed division of investigation data into separate AutoCad or DGN/GIS/IDMS files and layers; naming conventions; symbol definitions and annotation.

**26.5.4** Data files shall be labelled with the filename, number, extent, size, date of investigation, or revision, to be agreed with the Engineer.

#### **26.5.5. Presentation of Drawings**

1. The investigation results (layout plan only) shall be plotted in 1:100 scale or other scale to be confirmed in A1 drawings on the specified grid and datum approved by the Engineer. The layout, border and title block shall be approved by the Engineer.
2. The drawings shall show building lines, roads with road names and traffic lane road markings, pavement and kerbs, and other significant physical features within the investigated area.

#### **26.6. Preliminary and Final Report**

The Utility Surveyor shall examine, analyse, process and interpret the investigation results and incorporate findings in a report. The report shall include the following essential information:

- (a) Introduction
  - Project name and Location
  - Site appreciation
- (b) Details of Investigation
  - Date of Investigation
  - Detailed description of the investigation procedure adopted
  - All equipment used for the investigation
  - Identification of supervisor and equipment operators carrying out the investigation

- (c) Investigation results
  - Summary of results
  - Report on examination, analysis and interpretation of the investigation results;
  - Identification of utilities, chambers (including all manholes) and sub-surface anomalies (if possible by GPR survey);
  - Records of on-site verification of data handled by the qualified person (MHKIUS) responsible for the Report;
  - Report on difficulties encountered
- (d) Appendix
  - floppy diskettes or CDR for the digital data files of qualitative and numeric data about the underground assets found;
  - Engineering Drawings (updated) showing the types and location of various underground assets;
  - Survey Photographs - 3R coloured photographs (prints and negatives/digital copy in JPEG format)

The drawings and textual report will be certified and stamped by the approved qualified person responsible for the preparation of the Report.

The Utility Surveyor shall supply the Survey Report as described fully as in the above. This report shall include all results with a detailed discussion and accompanying plans. It shall be prepared and signed by an qualified person who shall hold one of the following qualifications: -

- i) MHKIUS (WLD) plus 2 years local experiences or RPUS (WLD); or
- ii) MICE, or MHKIE or MHKIS with 10 years relevant training and experiences,

#### **Appendix 26A**

WLD Survey Report Sample

(Updated samples may be found in [www.hkius.org.hk](http://www.hkius.org.hk))