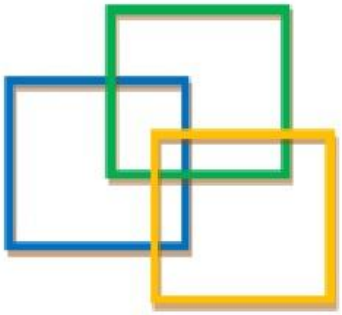
Hong Kong Institute of Utility Specialists
Non – profit Making Organization

Method Statement
For
Water Leakage Detection Survey
(WLD Survey)



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Foreword

It's been more than ten years now since the disastrous landslip 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 (BWCS) both on slopes and on the roads throughout the territory. As expected, this sequence of events generated an increasingly large pool of "Utility Specialists (US)", 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 before the establishment of HKIUS in 2002.

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 method statement, by addressing the following topics in general and where the abbreviation can be found in the Appendix:

(1) Standard Operation Procedure
(2) Standard Report Format
(3) Standard Safety Precaution

You are welcome to take reference to this method statement for your contract and in case you need further information, please send an e-mail to info@hkius.org.hk or call Ir Dr. King Wong.

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Water Leakage Detection Survey(WLD Survey)

1. Scope of the Works

To carry out Water Leakage Detection Survey by Pipe and Cable Locators to Locate Pipe Alignments and by utilizing Acoustic Methods (LNC, MLD/ELD) to locate defective sections of water pipes before remedial works are undertaken.

2. Methodology

2.1 Pipe and Cable Locator (PCL) Survey

PCL Survey will be undertaken to locate and map the underground-pressurized water supply mains by utilizing the Electromagnetic Induction Method.

An Alternating Current will be induced into metallic pipes utilizing a signal transmitter and the receiver above ground will then locate the signal. Acquired data will be marked on site by spray paint and mapped / surveyed by the land surveyor only when further instructions are received from the client with additional cost. A digital map will be submitted to client as one of the submittals, which can be easily updated as and when required.

2.2 Water Leakage Detection Surveys and repairing of defective sections of water pipes

Leakage Detection Surveys by employing Acoustic Methods can locate leaks accurately without interrupting the water supply system. Cable/Pipe Locator, Leak Noise Correlator – LNC and Listening Devices – Electronic Ground Microphones and Mechanical Listening Stick will be used for the survey. If the result from the LNC survey indicates a spike, a further leak detection surveys will carry out to verify the suspected leakage. In case of the spike being found in the connection with other branch pipes, further leak detection surveys will be performed to confirm the suspicious. The client will expose the leakage point and defective section of the water pipe will be replaced or repaired by non-excavation methods, Pipe Lining under a separate contract.

3. Field Procedures

3.1 Initial Site Inspection

Initial Site Inspection to understand the site situation and methods to be implemented.
(1) Identify the site boundary.
(2) Identify the major water consumption such as residents, restaurant and shop.
(3) Inspect any visible leakage near the survey area.
(4) Identify the prescribed section and predetermined points on site.
(5) Identify all valve pits and nearby manholes along the survey pipe.
(6) Use locators to confirm the alignment if the pipe route is unclear.

3.2 Verify pipe alignments by Pipe and Cable Locator (PCL)

An electromagnetic Locator will be used to identify the route of pipe. The equipment contains two parts – transmitter and receiver. The transmitter acts, as a signal generator to inject a low frequency signal to the target line and the receiver, which contains an aerial antenna is able to receive such kind of low frequency. The pipe alignment and depth can be located on site immediately for further action.

3.3 Localize the leaking sections by Leak Noise Correlator (LNC)

The typical set up for an effective leakage location operation involves the central unit (correlator), the radio transmitters or the cable drums or a combination of radio transmitter, cable drums and sensors (accelerometers or hydrophones or a combination of accelerometer and hydrophone).

The Leak Noise Correlator operates at digital basis and has the following functions and capabilities.
Survey distance shall be able to cover minimum of 1000m with a capacity to measure different combination of pipe materials and different pipe diameters in a measurement.
Radio transmission (Maximum at 500 to 1000m).
Accuracy of measurement shall be with in ±5% or 5m of the survey length.
Frequency interval for both cable and radio is 5 to 4000Hz.
It allows the operator to change and select different setting and modes.
Display is high contrast LCD with display light or LED and control panel is a watertight membrane keyboard.
Power supply using rechargeable or alkaline batteries and provide with 220/240V battery charger.
The microphones are able to detect sound through pipe or valves and fitting and the hydrophones are able to detect sound/leak through the carrying fluid.
The correlator has data storage and print out functions to record down the survey inputs and results.

The sensors are placed at the extremes of the section of pipe under analysis to pick up the leak noise. They can be fittings or any convenient contact points so that the sensors can be attached firmly. Accelerometers are attached to the valve spindles or hand wheels of valves installed along the section of pipe under analysis.

The leak noise will be transmitted back to the central unit, i.e. the Leak Noise Correlator (LNC) either by radio signals transmitted by the transmitters or by directly connected to the sockets in the LNC by cables.

The central unit will then calculate the leak position by relating the difference in propagation time of the leak noise signals arriving at each sensor to the velocity of sound along the pipe and to the measured distance between the sensors.

Types of pipe material, pipe diameter, pipe length need to enter into the correlator in order to reflect the field measurement or as provided in record drawing.

A correlator works by detecting the sound from the leak when it arrives at two sensor points on the pipe, either side of the suspected leak position. The sound firstly arrives at the sensor which is closest to the leak; then there is a "time delay" (Td) before the sound arrives at the furthest sensor. This time delay, combined with knowledge of the distance (D) between the sensors and the velocity (V) of the sound in the pipe, enables the correlator to calculate the exact leak position (L).

The correlation formula: $$L = \frac{D - (V \times Td)}{2}$$

3.4 Pinpoint the leak by Acoustic detection equipment (MLD/ELD) by the most experienced Leakage Experts

The leak is pinpointed by using acoustic detection equipment. Mechanical Leak Detector (MLD) is a passive device similar to doctor’s stethoscope which transfers the leak noise to the operator’s ear directly through ground microphone. Electronic Leak Detector (ELD) consists of a microphone, amplifier and frequency filter. The sound of leak is amplified and transmitted to either headphones, a loudspeaker or indicating meter electronically. Unwanted noise can be removed by electronic frequency filters. On solid surfaces the ambient noise protected microphone by suppressing noise caused by wind, rain as well as loud traffic. Special attention has to be paid to the optimum setting of receiver at narrow-band reception and the pre-selected setting has to be retained during the whole location. The microphone is set down on pre-marked route of the pipeline at an interval and the meter indication as well as noise in the headphones is compared. The point of maximum intensity is the potential leak position.

4. Quality Assurance and Quality Control

4.1 Total Station Survey Data

The topographic survey data will be downloaded to a desktop computer, edited for field errors, then attributes added to each separate feature. The results will then be checked against the existing utility maps and to re-confirm all existing buried services, which were mapped on site. Utilities will be shown at a scale of 1:200 or 1:100 and services will be shown to actual scale, except where otherwise noted. The drawings will be presented relative to an arbitrary control point set on site and all survey datum levels will be referenced in relation to the Hong Kong Principal Datum. It is important to note that the electromagnetic-induction-located data is referenced as depth to centre of the service, Radar Survey results are referenced as depth to the top of the anomalies and Sewer/Drains are referenced as the depth to invert of the pipes.

4.2 Drawing Editing

Drawings will be submitted in DWG/DGN/IDMS format. Alignments will be shown in different colors for different type of utilities and depth will be marked at an interval of around 10 meters on the plan. Information recorded by the surveys will be compared with the existing utility plans. Any doubts will be clarified by a site re-visit.

4.3 Report Writing

A technical report will be accompanied with the drawing this will state the findings and difficulties encountered on site. Photographs illustrating the progress and any problems encountered will be included in the report for the client's reference and comments.

It is expected that the client will return the marked up reports with their comments within 14 days from the date of submission. Otherwise, it will be regarded as approved by the client. Any other activity beyond this may induce additional costs as we may need to re-mobilize teams from other destinations.

5. Survey Accuracy

5.1 Control Accuracy

Well defined points of detail will be surveyed to less than ±60mm root mean square error, on the ground, when compared with co-ordinates determined by precise measurement from the nearest control point (90% of a representative sample of well defined points will be within ±100mm).

Spot heights on hard surfaces will be correct to better than ±10mm root mean square error, when compared with heights determined by precise levelling from the nearest bench mark (90% of a representative sample of spot heights will be within ±165mm) OR (0.1D which ever is higher (D = Depth of Buried Pipes)).

Additional tolerances shall be permitted for features without sharply defined edges and spot heights on soft surfaces.

5.2 Accuracy of Location and Survey for Normal Case

Underground services, which can be located without excavation, such as cables and connected metal pipes, which can be located by surface detection equipment, the Pipe and Cable Locator, and drains shall be located and surveyed to the accuracy given below:

Underground services will be located continuously and recorded in three dimensions at intervals not exceeding 5m at discrete areas or at intervals not exceeding 10m for survey along road, and at each surface feature, change of direction and bifurcation.

The position and level of locatable services, at the recorded points and intervals defined above, will be related to grid control points and bench marks to better than +100 mm root mean square error on the ground. (For normal case, 90% of a representative sample of points on locatable services will be within +165 mm or 0.1d (depth) whichever is bigger.

For services more than 1.5 metres below the surface, the accuracy in both position and level will be to better than +10% of the depth below the ground surface.

Positions and levels shall be related to the specified grid and datum and will normally be related to the centre of pipes, ducts or cables, and inverts of sewers and drains.

(1) The position and level of locatable services, at the recorded points and intervals not exceeding 1 meter, shall be related to the control survey stations to better than

(2) The position and levels shall be related to the Hong Kong 1980 Geodetic Datum and shall normally be related to the centre line of pipes, ducts or cables, and inverts of sewers and drains.

(3) Any known underground services or information which cannot be surveyed to the accuracies stated above, other than by excavation, shall be entered in unique AutoCAD layers defined as “unreliable”.

(4) Where full details of underground services cannot be determined without excavation, these details shall be deduced from the utility undertakers’ record drawings and entered into the drawing in a unique AutoCAD layer defined as “Record”.

(5) Wherever access is available from the surface, depth to the underground services shall be checked as a means of calibrating the survey work. Positions of exact measurements shall be noted as attributes in the drawings.

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) Constitution, Hong Kong Institute of Utility Specialists (2011).

(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) Particular Specification for Water Leak Detection, HKIUS, 2011.

(9) Sample report for Water Leak Detection, HKIUS, 2011

(10) Code of Practice on Monitoring & Maintenance of Water Carrying Services Affecting Slopes, ETWB (2006), Hong Kong SAR Government.

(11) W. Lai, S. Tsang & K. Wong, Applications of Ground Penetrating Radar in Civil Engineering Works, 2004

(12) Work procedures for Water Leak Detection, HKIUS, 2011

Appendix

A1 Abbreviations

Company/ Organization	
Code	Description
BD	Buildings Department, HKSARG
CEDD	Civil Engineering and Development, HKSARG
DSD	Drainage Services Department, HKSARG
EMSD	Electrical and Mechanical Services Department, HKSARG
EPD	Environmental Protection Department, HKSARG
HA	Hong Kong Housing Authority, HKSARG
HKIUS	Hong Kong Institute of Utility Specialists, HKSARG
HKURC	Hong Kong Utility Research Centre
HyD	Highways Department, HKSARG
LandsD	Lands Department, HKSARG
LD	Labour Department, HKSARG
PolyU	The Hong Kong Polytechnic University
UTI	Utility Training Institute
WRc	Water Research Centre
WSAA	Water Services Association Australia
WSD	Water Supplies Department, HKSARG
WTI	Water Training Institute
Others	
Code	Description
%	Percentage
BMP	Bitmap (Picture Format)
BWCS	Buried Water Carrying Service
CCE	Conduit Condition Evaluation
CCE(CCTV & ME)	Conduit Condition Evaluation(Closed Circuit Television & Man- Entry)

Company/ Organization	
CCES	Conduit Condition Evaluation Specialists
CCTV	Closed Circuit Television
CD	Compact Disc
CL	Cover Level
COP	Code of practice
CP	Competent Person
DN	Nominal Diameter
DP	Design Pressure
DVD	Digital Versatile Disc
e.g.	Exempli Gratia
GIS	Geo-Information System
EPR	Environmental Protection Requirements
etc.	et cetera
GL	Ground Level
H	Height
HKCCEC	Hong Kong Conduit Condition Evaluation Codes
HPWJ	High Pressure Water Jetting
hr	Hour
Hz	Hertz
ICG	Internal Condition Grade
ID	Internal Diameter
IDMS	Integrated Data Management System
IL	Invert Level
ISO	International Standards Organization
JPEG	Joint Photographic Experts Group (Picture Format)
kHz	Kilo- Hertz
kPa	Kilopascal
m	Meter(s)

Company/ Organization	
ME	Man Entry
MHICS	Manhole Internal Condition Survey
mm	Millimetre(s)
Mpa	Megapascal
MPEG	Motion Picture Experts Group (Video Format)
MS	Method Statement
MSCC	Manual of Sewer Condition Classification, UK
OHSAS	Occupational Health and Safety Assessment Series
PPE	Personal Protective Equipment
ppm	Parts per million
PS	Particular Specification
PSI	Pound Per Square Inch
QA/ QC	Quality Assurance/ Quality Control
Ref.	Reference
RMSE	Root Mean Square Error
RPUS	Recognized Professional Utility Specialist
RTO	Recognized Training Organization
SCG	Service Condition Grades
SOPs	Safe Operator Procedures
SPF	Sun Protection Factor
SPG	Structural Performance Grade
SRM	Sewer Rehabilitation Manual
STP	System Test Pressure
TTA	Temporary Traffic Arrangement
US	Utility Specialist
VHS	Video High Speed
W	Width
WLD	Water Leakage Detection

Company/ Organization	
WO	Works Order
WP	Work Procedure

A2 Requirements for Personnel Carrying Out Inspection

Training and Experience Requirements for Personnel Carrying Out Inspection (HKIUS standard, 2011)				
Title	Role	Minimum Training Requirement	Minimum Years of Practical Experience	Qualification
Project Leader	Responsible for contract administration and preparation, checking and certifying of reports for compliance with the technical specification.	➢ At least 35 hours of CPD every year ➢ At least 14 hours for refreshment training in every three years ➢ Relevant training in RTO (e.g. PolyU, UTI) for surveys and data collection ➢ Has attended training courses for relevant survey/detection methods, and Possesses a valid training certificate for relevant survey/detection methods used	10 years in contract administration, preferably in works related to the inspection, survey and in data management.	Either: M/FHKIUS, RPUS plus CP, CW or MHKIE/ R.P.E. plus CP, CW and relevant training in RTO (e.g. PolyU, UTI) for surveys and data management
Deputy Project Leader	Responsible for assisting project leader and acting the post of project leader when project leader temporary not with the team	➢ At least 35 hours of CPD every year ➢ At least 14 hours for refreshment training in every three years ➢ Relevant training in RTO (e.g. PolyU, UTI) for surveys and data collection ➢ Has attended training courses for relevant survey/detection methods, and Possesses a valid training certificate for relevant survey/detection methods used	10 years in contract administration, preferably in works related to the inspection, survey and in data management.	Either: M/FHKIUS, RPUS plus CP, CW or MHKIE/ R.P.E. plus CP, CW and relevant training in RTO (e.g. PolyU, UTI) for surveys and data management
Team Leader	Responsible for works arrangement and data processing including checking of raw data for quality and consistency.	➢ At least 35 hours of CPD every year ➢ At least 14 hours for refreshment training in every three years ➢ Relevant training in RTO (e.g. PolyU, UTI) for surveys and data collection ➢ Has attended training courses for relevant survey/detection methods, and Possesses a valid training certificate for relevant survey/detection methods used	5 years in works related to the inspection, survey and in data management.	M/FHKIUS, RPUS, CP, CW
Crew Leader	Responsible for supervising the field works and site safety.	➢ At least 35 hours of CPD every year ➢ At least 14 hours for refreshment training in every three years ➢ Relevant training in RTO (e.g. PolyU, UTI) for surveys and data collection ➢ Has attended training courses for relevant survey/detection methods, and Possesses a valid training certificate for relevant survey/detection methods used	3 years in works related to the inspection, survey and in data collection	O/MHKIUS, CP, CW
Operators	Responsible for operating equipment and carrying out inspection and survey.	➢ At least 35 hours of CPD every year ➢ At least 14 hours for refreshment training in every three years ➢ Relevant training in RTO (e.g. PolyU, UTI) for surveys and data collection ➢ Has attended training courses for relevant survey/detection methods, and Possesses a valid training certificate for relevant survey/detection methods used	2 years in works related to the inspection, survey and in data collection.	AMHKIUS, CP, CW