Guide to Leakage Detection Of Buried Water Carrying Services Affecting Slopes

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This guideline is done in May 2011.

FOREWORD

After the disastrous landslip of 1994 occurred in Kwun Lung Lau on Hong Kong Island, the Government has paid more attention on utility maintenance with particular emphasis on leakage detection of buried water carrying services on both slopes and roads. The Government has increased resources and imposed additional legislation on the detection of underground utilities. As a direct result, the utility profession has been developing rapidly, and over the last decade, the number of "Utility Specialists" (管綫專業監理師) has grown as the Government's requirements for Competent Persons to carry out the investigations has been implemented, in addition, Recognized Professional Utility Specialist (RPUS) (管綫專業監察師) has been recognized in recent years. However, lack of standard surveying methods, centralized monitoring systems and organized management, have lead to unsatisfactory investigation results.

In order to address these issues, Hong Kong Institute of Utility Specialists (HKIUS) (香港管綫專業學會), targeting the promotion of knowledge and good practice in the utility profession, collaborated with Hong Kong Utility Research Centre (HKURC)(香港管線管理研究中心) and supported by the funding from the Professional Services Development Assistance Scheme (PSDAS) of HKSAR, published a series of guide books and pamphlets in 12 disciplines of the utility profession in order to set standards for the practitioners to follow. As part of HKIUS continual effort to enhance the professionalism of the utility profession, it is the intention of the series that the quality of the survey can be raised and that utility related incidents can be avoided by performing high quality utility practices. Hopefully, the resulting benefits can extend to the general public.

This issue provides methods and their procedures to carry out leakage detection of the buried water carrying services (BWCS) (地下帶水管道) affecting safety of slopes. The document states three common techniques used in the leakage detection, that is CCTV Survey, Manhole Internal Conditions Survey(MICS) and Water Leakage Detection(WLD), and intended to be used by all personnel involved in the works.

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April, 2011

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1. INTRODUCTION

Buried Water Carrying Services (BWCS) refers to conduits used for carrying water buried underground. These include sewers, stormwater drains and water mains. Leakage from water carrying services may cause structural failures to slopes and retaining walls even at some distance away. It is difficult to notice leakage from conduits especially the buried ones. The Kwun Lung Lau Landslide in 1994 was a fatal disaster that caused by the leakage of the conduits on the crest of the slope.

Professor Morgentern, investigated and produced a report on the incident, provided the following recommendation in the report.

"The Government shall develop a program for direct monitoring and repair of buried services at housing estates and other developments in all cases where leakage might impact on slope stability. Priority shall be given to older estates where loose fill is known to have been used in site development. Periodic inspection of buried services at hazardous locations shall become mandatory. The appropriate period is best established by experience, but in a five-interval appears reasonable at the stage."

Therefore, monitoring and repair of the buried water carrying services shall be carried out properly and periodically to ensure the structural integrity of the conduits and thus the stability of slopes. Moreover, Hong Kong is a hilly region with plenty of slopes and retaining walls, many structures are built on hilly areas, it would be important to carry out high quality survey to detect for any leakage of the BWCS to prevent the possibility of the recurrence of the Kwun Lung Lau incident.

Due to large demand for and large number of utility specialists who carry out such detections, Hong Kong Institute of Utility Specialists (HKIUS) (香港管綫專業學會), aiming at promoting knowledge and good practice in the utility profession, prepared guidelines to provide a standardized method and process of conducting leakage detections in order to promote a good practice for the practitioners. Note that such standards are for reference only, any other standards or requirements are acceptable as long as stated in the contract or there is mutual agreement between the Contractor and the Engineer/ Client.

2. OBJECTIVE AND SCOPE

The purpose of this guide is to provide guidance on the inspection and methods of leakage detection of the buried water carrying services affecting slopes. It introduces the steps and process of monitoring the BWCS including planning, common techniques of inspection and record keeping. Common methods like CCTV Survey, Manhole Internal Condition Survey and Water Leakage Detection will be illustrated. Since the result of the survey is crucial indicator to the remedial actions, quality and accuracy is a great concern. An up-to-standard inspection spots the points of leakage accurately and in turn reduces the waste of water which saves social resources and more importantly, avoids slope-related incidents in time which save lives.

This document emphasizes on the techniques of leakage detection of the BWCS affecting slopes. For maintenance and permanent preventive measures, please refer to the Code of Practice on Monitoring and Maintenance of Water-Carrying Services Affecting Slopes published by the ETWB in 2006. Also, users of this guide shall refer to relevant documents for further information on safety that are not covered in detail. It must be stressed that the guidelines given in this guide are in no way exhaustive, and professional judgment must be employed in all cases.

This guide is intended to be used by all personnel who are involved in the planning, commencement and supervision of leakage detection of the BWCS, including contractors, utility companies, consultants, government departments and other parties concerned.

3. PRE-SURVEY PREPARATION

As recommended by the Government, buried water carrying services (BWCS) that affect the slopes shall be checked every five years basically. They shall be inspected to find spots of leakage. Different methods can be used to detect leakage according to the condition of the BWCS. For drains, CCTV Survey, Manhole Internal Condition Survey, Water Test and Man-entry Survey can be used. For water mains, Water Leakage Detection can be carried out by Leakage Noise Correlators, Mechanic/ Electronic Leak Detectors, Noise Loggers and Hydrogen Gas Detection. Before inspection, preparation works shall be carried out to facilitate an efficient investigation.

3.1 Planning for Inspection

Checking Past Record

Prior to investigating the condition of the BWCS, they shall be first located and identified. Past records of the services are one of the sources to find out the location of them. The Client has the responsibilities to provide all relevant information, such as layout plan of the utilities, to the contractors. Besides the information given by the client, contractor can make reference to information sourced from various relevant Government Departments. Details of the slope feature can be obtained from the Geotechnical Engineering Office of the Civil Engineering Department while the DSD manholes and pipes can be obtained from Drainage Services Department. Information on ownership of land, buildings and slopes can be accessed via the SMRIS (Slope Maintenance Responsibility Information System) of Lands Department. (http://www.slope.landsd.gov.hk/smris/index.html)

Information obtained from the asset owner shall be verified in reconnaissance survey before commencement. The pre-survey inspection shall identify all errors and possible unrecorded services within the survey extent. Associated information shall also be recorded to update the plan for review in the future.

3.2 Locating Buried Water Carrying Services

The Utility Specialist(US) shall locate and identify all underground services within the sites to be investigated. Utility installations on the ground surface like manholes and fire hydrants give hints to the alignment and location of the underground utilities. Though excavation shows a clear picture of the underground utilities, it is inefficient, more dangerous and may cause damages to the utilities easily. Utility mapping/survey can be carried out to identify and locate underground services without excavation.

Utility mapping can be done by Electromagnetic Induct Utility Detection or Ground Penetrating Radar (GPR).

Electromagnetic Induct Utility Detection

The method of electromagnetic induct utility detection involves the use of a hand-held detector (pipe and cable locator), which detects the magnetic fields of the buried utilities, and a portable signal generator. The locator can only detect metallic cable or pipes with wires laid along as the detection bases on the signals generated by the alternating current. For non-metallic pipes, a transmitter such as a sonde can be inserted in the pipes for detection.

Passive detection involves only the receiver (locator). It detects passive signals that naturally present on the conductors. This method is fast and convenient but inaccurate because the passive signals may be weak and may change without notice.

Active detection involves the use of both receiver and transmitter. The transmitter produces active signals and applies to the pipeline so that the receiver can trace the pipeline. There are basically three methods for conducting active detection, direct connection, signal clamping and induction.

Direct connection is one of the most effective methods to trace the pipes. Pipe can be traced by completing a circuit. The transmitter shall contain two leads, the red lead and the black lead. The red lead is connected to the pipe directly or to an access point such as a valve or meter. The circuit is completed by connecting the black lead to the ground. Ground rod placement (the black lead) shall be as far away from the trace path as possible and at right angle to the path. The pipe alignment and depth can then be located. The method of signal clamping is clamping a signal clamp round the pipe. The signal from the transmitter is applied to the pipeline so that it can be detected on either side. This method requires excavation to reach the pipe. The method of induction requires no access to the pipes. The transmitter broadcasts signal into an area so that the receiver can locate the pipe. The transmitter shall be placed on the ground over the cable to be located and in line with the cable path. Adjust the frequency of the transmitter until the receiver detects the pipe. However, this method is used when the area has no other buried conductors or when all buried conductive services are to be located.

Methods mentioned above are applicable to metallic pipes and non-metallic pipes with tracer wires. For non-metallic pipes, a sonde transmitter can be employed. Sonde is a small self-contained signal transmitter designed for inserting into a non-metallic ducts, drains or sewers so that it may be located and traced with a receiver. Further information can refer to Guide to Utility Survey (UTI).

After the receiver has located the pipeline, the operator shall identify the pipe alignment with temporary markings.

Ground Penetrating Radar (GPR)

GPR is a trenchless method for locating pipes. The GPR transmits pulse into the ground and the pulse is reflected if there are buried utilities. It detects the features and depth of the utilities and is capable of distinguishing different services in congested areas. Different frequencies shall be used to detect different services. Normally, conduits of all materials can be detected. Higher frequency shall be used in the detection of cable while lower frequency shall be used in the detection of sewers and water mains. Details concerning the principle and use of GPR can refer to Guide to Ground Penetrating Radar Survey (UTI).

By using the above methods, the accuracies given below shall be achieved. Underground services shall be located continuously and recorded in three dimensions not exceeding 5 meters in discrete areas or at intervals not exceeding 10 meters for survey along the 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, shall be related to grid control points and bench marks to better than ±100mm root mean square error on the ground. 90% representative sample points on locatable services shall be within ±165mm or 0.1d (depth) whichever is bigger. For any known underground services that cannot be investigated to such accuracies, except by excavation, they shall be defined as “unreliable”. “Specification for Utility Mapping by Non-destructive Methods” adopted by HKIUS provides detailed requirements regarding the survey works.

3.3 Statutory Requirement

Both employers and employees shall comply with relevant occupational health and safety legislations and obligations to ensure a safe working environment and minimize disturbance to the public caused by the work.

The Occupational Safety and Health Ordinance (Cap. 509) and the Factories and Industrial Undertakings Ordinance (Cap. 59) specify several requirements for personnel involved in works, some of the requirements are stated in relevant ordinances or regulations such as working in confined space, road traffic control, excavation safety, dangerous substance, noise at work, etc. It is important to follow relevant ordinances stated on the Occupational Safety and Health Council (http://www.oshc.org.hk) before commencement of work.

Also, operators shall use Personal Protective Equipment (PPE) and shall have sufficient knowledge in both usage and maintenance of the equipment. PPE shall include:

Steel toe cap, rubber safety boots
Safety helmet
Safety vest (reflective at night)
Safety goggles/Anti-glare glasses
Breathing apparatus/Disposable respirator
Harness and Fall arrester
Gloves
Ear muffs / ear plugs
Handy gas detector
Audio-visual alarm
Resuscitator

In works for the Water Supplies, the Drainage Services or other government departments, appropriate steps shall be taken to minimize or even eliminate any potential risks of injuring the public. In case where excavations are required, the access around the work area has to be properly supervised by a Competent Person (CP)(合資格人士), under Cap. 406H, the Electricity Supply Lines (Protection) Regulation, at all times. The access for "essential services", e.g., police, fire services and ambulance, has to be retained. Access to other public services, such as bus stops, footpaths, etc, shall also be maintained and supervised. Such regulations can be referred to Cap. 28, the Land (Miscellaneous Provisions) Ordinance.

If excavations are required, no dirt, excess spoil or other material shall be left in the water channel to avoid polluting the drainage system. Sediment control procedures can be referred to the Environmental Protection Department (http://www.epd.gov.hk).

3.4 Personnel Requirement

In order to maintain the Utility Profession's requirements for the consistency, reliability and accuracy of reports, CCTV inspection shall be performed by properly trained and accredited personnel. Accredited personnel shall hold a certified qualification issued by a Registered Training Organisation (RTO), such as Utility Training Institute or The Hong Kong Polytechnic University or equivalent.

In addition, a minimum of 3 years post training experience will be necessary for a person to become competent. Besides, qualified personnel are required to attend refreshment course in every 3 years to refresh and enhance their knowledge.

All works carried out within sewers, manholes or other confined spaces shall be performed in accordance with the requirements for works in the vicinity of Confined Space and Occupational Health & Safety Legislations, as well as any additional precautions that may be specified by the asset owner.

Table of personnel requirement

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

3.5 Prevention of damage to pipes and other utilities

The operators shall aware that there is an extensive network of utility underneath the pavements. Breaking of pipes is usually caused by direct or indirect road opening works. It is essential that the operators shall avoid causing damage to the pipes during execution of their works.

Accident like the manhole cover falling back into the manhole when uplifting it may destroy other pipes and utilities passing through the manhole. Dropping of heavy materials may also cause damage to utilities. Therefore, the supervisor shall perform close supervision to the workers. The supervisor shall remind the workers occasionally to be careful and the importance of preventing damage to the water pipe and other underground utilities and the consequences of damage.

Circulate the layout plans with relevant details to Water Supplies Department (WSD) to request indication of the alignment of existing water mains so that the operator can have more comprehensive information about the pipes nearby and hence lower the risk of destroying other pipes. If excavation work is needed, operators shall use hand-digging method instead of using heavy mechanical plants near the water pipes. More information can be found in the guideline "How to Prevent Damage to Water Mains?" proposed by WSD.

As there may be explosive gases inside the chamber or pipe, explosion proof survey equipment shall be used to prevent the drain from being damaged by unexpected explosions. Use of fire and smoking near manholes must be strictly forbidden to avoid any fire-induced explosions and accidents.

4. LEAK DETECTION METHODS AND PROCEDURES

The method of detecting leakage shall be determined according to the type of conduits. Procedures shall be followed and specifications shall be complied properly to constitute an accurate survey. CCTV survey, Manhole Internal Condition Survey and Leak Noise Correlation are methods commonly used in the investigation of buried water-carrying services, other methods may also be employed according to contract terms and actual circumstances.

4.1 Visual Inspection

Visual inspection shall be carried out in the initial stage to find out if there are obvious clues of leakage like water spots and seepages. The source of leakage may be identified by observing the physical characteristics of the leaks and testing them.

Physical characteristics of leakage offer hints to the type of water sources.

- Sewage pipe - turbid, smelly, continuous, white grey slime
- Stormwater drain - clear, leaking during and after rainy days
- Salt water pipe - clear, continuous, leaking confined to isolated spots, high chloride content
- Portable water pipe - clear, continuous, leakage confined to isolated spots

Physical characteristics by no means give comprehensive data to the source of leakage. Water sampling and confirmation test shall be carried out.

Verification tests include laboratory chemical tests as well as physical tests on site. For fresh water supply system, a diethyl paraphenylene diamine (DPD) tablet can be used. For salt water supply system, chloride test (Merck) strip can be used. A few drops of 10% barium chloride solution can also test the chloride content of the salt water. For sewage system, smoke testing or fluorescent non-toxic dye test can be performed. It shall be noted that the water samples collected shall be kept away from contamination to retain an accurate result. Further information on water sampling and testing can be found in the Code of Practice on Monitoring and Maintenance of Water-carrying Services Affecting Slopes (Work Branch, 2006).

Visual inspection and seepage investigation gives clues to the type of water sources, to locate the exact location of leakage. The following methods can be employed depending on the types of conduits.

4.2 Leak Detection for Drains

CCTV Survey
CCTV survey is the propulsion of a camera along a conduit while observing the defects or features inside the conduit. Image/video captured by the camera is transferred to monitor by the cable. Operators can then judge the conduit condition by observing the internal condition of the conduit displayed in the monitor or on the video recorded in a computer later. It is an effective way to evaluate the conduit conditions, any sign of leakage can be observed by this method.

Generally, CCTV is mainly composed of the following components.

- A control unit, which controls the image capturing and mobility of tractor
- An image capture device (camera), which captures the internal condition of conduit
- A display device (monitor), which displays the image/video captured
- A record device, which records and stores image/video
- A text input device (keyboard), which allows input of information

The surveying equipment shall be capable of surveying a length of drain up to 350m. The Utility Specialist shall use color cameras with a pan and rotatable head with forward view and side viewing capability to enable a clear capture of internal conditions of the drains. And some cameras can have an inclinometer incorporated to measure the variations in gradient. If the site is difficult to access, such as step pipes and steep slope, a complete range of CCTV inspection equipment must be available to enable a safe working condition. Different types of Survey equipment shall be used depending on the environment and the pipe size.

If there are sediments or grease that obstruct the pipe and so the investigation, drain cleaning may be required. Usually, better result can be yielded after cleaning the drain. However, it is not a must unless instructed by the Client or Engineer after the initial survey.

The information obtained in a CCTV inspection very much depends on the quality of image captured, thus the machine has to be checked every day to ensure they are working in good condition. The checking includes monitor test, camera test and cable calibration. The image's quality check can be performed with a Marconi Resolution Chart Number 1. For cable calibration, a minimum of 30m of cable shall be checked.

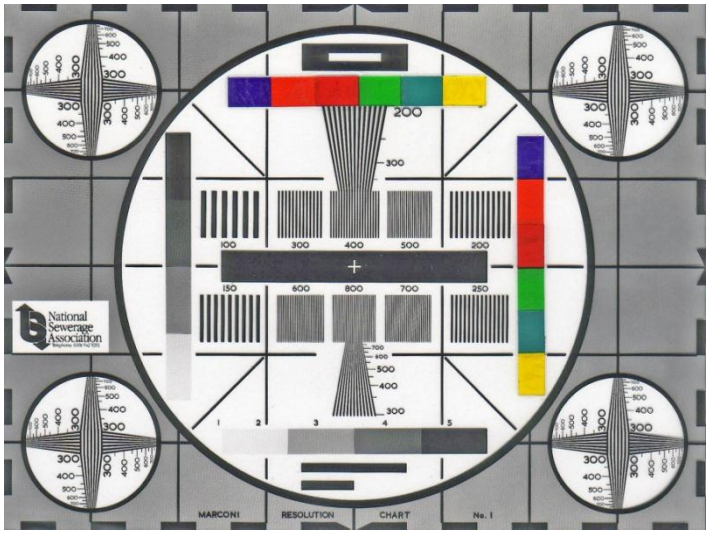

Fig. 4.1 Sample of Marconi Resolution Chart No.1 (C-National Sewerage Association)

The CCTV monitor shall comprise an automatically updated record in meters and tenths of a meter of the meterage of the camera position from the cable calibration point, which is also called "adjusted zero". Normally, the zero position is set in the manhole, so that the pipe end connecting the manhole is captured to identify the exact physical location of the zero position. The accuracy of the measurement shall be within 1% of total length or 0.3 m whichever is greater.

At the beginning of the survey, the operator shall ensure the meterage is zero and the meterage counter starts to register immediately when the camera moves. Before recording, the following information shall be displayed for a time period not less than 15 seconds.

Date of survey;

Starting time of survey;

Location of survey;

Direction of survey;

Pipeline classification (sewer/drain/conduit)

Name of company & qualified operator performing the inspection

Project and client reference; and

Node (from manhole to manhole) reference number.

The camera shall be positioned in the correct position to avoid image distortion. In circular or regular shaped sewers/drains, the camera lens shall be positioned at the centre. In oval/oviform sewers the camera lens shall be positioned at a distance two thirds of the height or the vertical dimension of the sewer/drain and vertically above the invert. A positioning tolerance of ±10% of vertical pipeline dimension shall be allowed. Normally, the camera lens shall be positioned looking along the axis of the pipeline. In case when the pipeline is very large, camera will be elevated on a tractor. The traveling speed of the camera in the drain shall not exceed:

- 0.1 m/s for sewers/drains of less than 225 mm in internal diameter (ID);
- 0.15 m/s for sewers/drains greater or equal to 225 mm ID

  but less than or equal to 300 mm ID;
- 0.2 m/s for sewers/drains greater than 300 mm ID; or
- other agreed traveling speed as long as all details are able to be extracted from the video tape recording

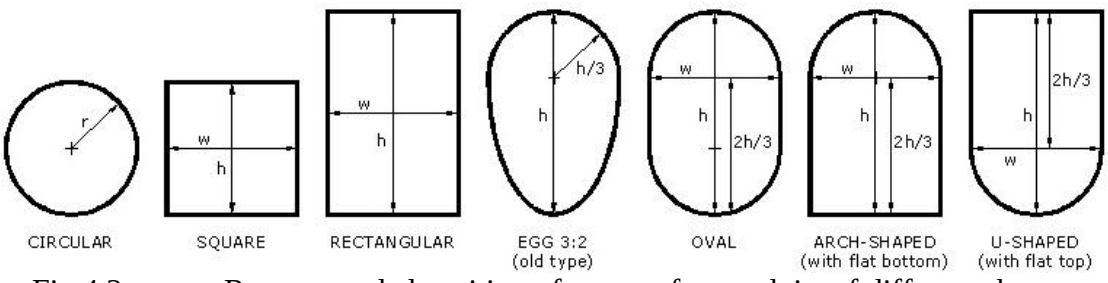

Fig 4.2 Recommended position of camera for conduits of different shapes.

Whenever defects are noted, the camera shall stop for a while (approximately 2 seconds) to ensure the record is accurate and clear. After the inspection, the operator shall report the results to the

client.

The operator shall provide a report on the locations and characteristics of reportable features including defects and features of interest. It shall include:

- A plan showing the location of the pipe surveyed.

- A summary of manhole references, sewer or drain lengths surveyed, diameter/section details and other information required by the client.

- A Conduit Condition Evaluation Coding Form recording the observations through the CCTV inspection. The form consists of two parts, header information and observation. The header information states the details and background information of the whole section of sewer or drain to be surveyed, the observation is about the condition, defects and features of the conduit.

- A summary of ranking scores for both structural and service conditions of sewers and drains surveyed. The grading shall be determined in accordance to Sewage Rehabilitation Manual (WAA/WRc) or HKCCEC2009 (UTI).

- A video record containing the whole inspection.

- Edited video clips of general condition and significant features.

- Photographs and video prints of general situation, significant changes and general condition of each significant portion of the sewers/drains.

A coding system is employed to record the defects and features of conduits, there are mainly three types of codes describing structural defects, service defects and construction features. Structural defects refer to the physical condition of drains; service defects indicate the reduction in capability of the conduit to meet its service requirement and loss of designed hydraulic flow capacity; construction defects are characteristics and defects related to the construction of the manhole. Structural defects are more likely lead to leakage. Some photographs of leakage related to defects are shown in Appendix B.

Codes are used as they are more convenient and allow easier information retrieval by trained person. To describe conduit conditions in the same manner, standard coding system has been developed. In the United Kingdom, the system Manual of Sewer Condition Classification (MSCC) is used while Australia follows the standard developed by Water Training Institute. In Hong Kong, the geographical feature is different from that of UK and Australia. It is hilly with a lot of slopes and most pipes and sewers are laid in early years. A tailor-made standard shall be established to suit the situation of Hong Kong. The Hong Kong Conduit Condition Evaluation Codes 2009 (HKCCEC 2009) (UTI) suggests a standard with the consideration of the special features of Hong Kong and the "Specification for Conduit Condition Evaluation (CCTV Survey)" adopted by HKIUS states the requirements of the survey works.

Manhole Internal Condition Survey

The decay of manholes may affect the flow of drain or even cause damages to the underground utilities. Manhole Internal Condition Survey provides information on the features and defects of the manholes like whether there is excessive infiltration or leakage. It also provides information for system maintenance. With information on the manhole condition constantly, remedial actions can be taken in time and in turn prevent potential landslips.

The manhole inspection collects information of the inspected manhole including basic information like node reference and location; detailed information like features of the compartments of the manhole, details of the incoming and outgoing pipes; and two sketches. They are location sketch and plan of manhole. It is important to note that information obtained from the site shall be recorded on site immediately and properly for the sake of accuracy, it would be difficult to recall the data after leaving the site.

Preparation works include reconnaissance survey and safety precautions. Manual handling shall be concerned when uplifting the manhole cover using the manhole key. Visual inspection and measurement shall be carried out. Defects are observed visually and the measurements shall be within the following tolerance:

Grid References	± 1m
Location Measurement	±300mm
Levels	± 25 mm
Relative levels of pipe inverts within the chamber	± 20 mm
Pipe sizes	± 20 mm
Box-culverts	± 20 mm
All other dimensions	± 50 mm

Levels shall be referred to Survey Bench Marks, the location and values of which are obtainable from the Lands Department and the Grid Reference shall be supplied in Hong Kong 1980 Grid Reference.

Location of manhole shall be clearly noted using the reference system of IDMS or alike. Two references systems are used to identify the manhole, the Node Reference and the Grid Reference. For the Node Reference, there must be a 10-character reference where the first six characters are the number of Hong Kong 1980 Grid Map Reference, the 7th character and the 8th character indicate which 100 m easting and northing quadrant respectively and the last two digits indicate the node/ point number in that quadrant. For the Grid Reference, there must be a 12-character grid reference where the first six characters are the Hong Kong 1980 Grid Map Reference, the following three characters represent the easting and last three characters the northing.

In order to get a clearer picture of the location of the manhole, sketches illustrating the manhole are required in the manhole record card. Two sketches shall be included, Location Sketch and Plan of Manhole. Location Sketch shall be drawn with the manhole referenced by at least two fixed structures shown on the 1:1000 base mapping survey sheets. The sketch shall show the manhole layout, including the distance and direction of offset from the main pipe. Note that lamp posts, traffic lights or similar shall not be acceptable as the fixed structures. If existing buildings are taken as the fixed structures, the building names and numbers shall be highlighted in the sketch. If village house are taken as the fixed structures, the house number shall be identified and indicated at the sketch.

The Utility Specialist shall provide a minimum of two photographs for each manhole as shown in Appendix B. Manhole location photo shall show the general location of the manhole with respect to the roads, slopes or buildings in the vicinity. The second photograph, Manhole condition photo, shall be a general view of the inside of the manhole. Manhole condition photographs may also be taken to highlight defects or special features of the manhole according to the opinion of the Utility

Specialist. The manhole reference number shall be shown on each photograph.

The report of manhole survey shall contain the followings:

- A general layout plan indicating the location of all manholes inside the boundary of investigation;
- A completed manhole card for each manhole; and
- A minimum of two photographs for each manhole.

Detailed requirements of manhole survey can refer to "Specification for Manhole Internal Condition Survey" adopted by HKIUS.

Water Testing

Water test on drains examines their water tightness and detects if there is any leakage by means of a pressure test. This method is recommended for testing of the newly constructed pipes. The pipe is blocked on either side and water is then pumped in the pipe to a specified test pressure to check if there is any leakage. If the leakage exceeds the permitted leakage level (tolerance level), it shall be subjected to further investigation to locate the leak point. Details and specification of the test can be referred to General Specification for Civil Engineering Works Appendix 5.5 and Clause 5.105-5.107.

Man-entry Survey

Man-entry Survey is one of the methods used in conduit evaluation. A person is required to enter the conduit to observe and record the internal condition of the survey. Defects and potential spots of leakage can be indicated. The inspector shall take video to record defects and features of the pipe. This method is suitable for the pipes with internal diameter larger than 1500mm and safety issues are given enough concern. It shall be noted that working in confined space is hazardous as lethal gas may be present in foul sewers and may cause fatalities. This method is discouraged due to safety reason. It shall be used when there are no alternatives. Safety regulations and instructions shall be strictly followed and the safety precautions of the person shall be properly done and the person's condition shall be closely supervised when he is in confined space.

Leak Detection for Water Mains

Leak Noise Correlation (LNC Survey):

LNC Survey is one of the most common methods to detect leakage. Other methods shall be used unless LNC Survey is not suitable or the result yielded is unsatisfied. Leak Noise Correlator is an electronic device that would analysis the leak noise and the location of leakage can be found. Manual listening of leak noise is exempted in this method.

Leak Noise Correlator consists of two microphones (sensors), two transmitters, and a Correlator. The microphones are attached to contact points (such as hydrants, meters and valves) along the water main to be surveyed and are connected to transmitters for collecting the leak noise. The Correlator will cross-correlates the leak noise reaching two microphones to calculate the suspected leak position. The Correlator is capable of filtering the background noise so that a more accurate result can be obtained. The equipment shall operate at digital basis and have the following capabilities:

- It shall be able to cover a survey distance of at least 1000 meters with the capability to measure different combination of pipe materials and different pipe diameters.

- The accuracy of measurement shall be within ±5% or 5 meters of the survey length. Maximum radio transmission shall reach 500 to 1000 meters.
- Frequency interval for both cable and radio is 5 to 4000 Hz.
- It shall have data storage and print out functions to record the survey inputs and results.

The Utility Specialist shall follow the instructions of the equipment supplier to carry out the survey. Basically, the procedures are as follows. First, connect the microphones to the transmitters; place the microphones on the contact points at either side of the pipes under analysis. Contact points include exposed pipes, valves, hydrants and stopcocks. Any leak noise the microphones detected would be transferred to the transmitter. The signal would then be amplified and transmitted by radio telemetry to the Correlator. The operator shall apply different frequencies and filters to obtain the best results. Information of the pipe under investigation shall be entered correctly into the Correlator to reflect the field measurement as provided in the Record Drawings.

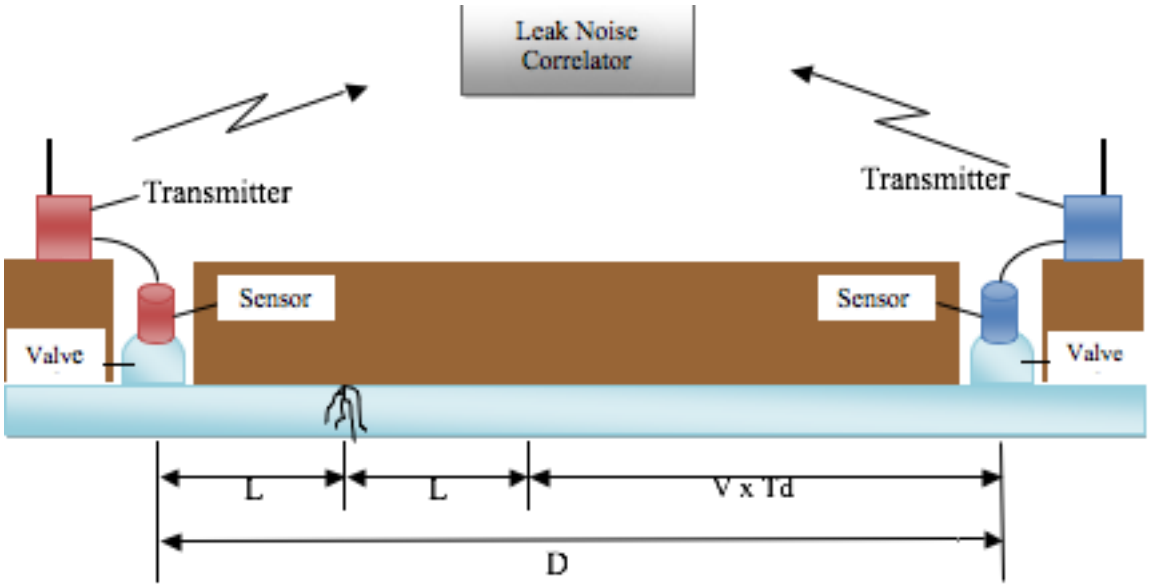

Fig. 4.3 Sample set up of LNC Survey.

The formula for calculating the leak point is $L = \frac{D-(V \times Td)}{2}$

Where: L=leak position
D= distance between sensors
V= velocity of sound for pipe under consideration
Td= time delay (transit time difference)

The Correlator compares the traveling time of the signals from the leak position to the sensors and calculates the distance by the aforementioned formula. Graph of frequency measurement is generated and the suspected leak position is indicated automatically.

Mechanic Leak Detector:
Mechanic Leak Detectors are passive devices including listening stick and geophone. Manual listening of leak noise is involved in these methods. The accuracy highly depends on the experience of the operators. Therefore, qualified and experienced personnel shall be employed. Sometimes contractors may too rely on LNC Survey. MLD can be employed to confirm the leak location according to the result of the LNC Survey.

Geophone:
A geophone is similar to doctor's stethoscope that amplifies and transfers the leak noise to the operator's ear directly through the sensing heads.

Direct contact of the sensing head against the contact points shall be made and the operator shall listen for the leak sounds. Contact points can be pipes, valves, fittings, and ground/ road surface. Place the sensing heads on the ground firmly against the surface. Move the sensing heads along the top of water main until the sound is the same intensity in both sensing heads reach both ears at the same time where the operator is exactly above the leak location.

Listening stick:
Listening stick is the oldest but extremely effective method for leak detection. It consists of a probe bar, a diaphragm and ear piece. The resonance chamber amplifies the leak noise so that the leak point can be located by identifying the highest leak frequency.

The probe bar shall be placed firmly on contact points of pipes to listen for leak sounds. Trace the leak position by listening against the ground surface. Move along the top of the water main under survey at two meters interval, listen carefully, the location with the highest leak frequency is the leak point.

Contact points of water mains such as hydrants, valves and meters are conductors. It is possible to have electric shock or even electrocution when conducting the survey. Therefore, the equipment shall be properly insulated to ensure a safe survey.

Besides mechanic listening stick, electronic listening stick is introduced for a more accurate result. However, some of the operators prefer the mechanical one as there is no crackle of electronic noise in the background.

Electronic Leak Detector
Electronic Leak Detector consists of a ground microphone, an amplifier and frequency filter. The sound of leak is amplified and transmitted to headphone, loudspeaker or indicating meter electronically. Unwanted noise can be removed by electronic frequency filters. A LCD indicator shall be included for digital data readout or leak noise level display.

Use contact microphone to listen for leak sounds at meters, hydrants, valves and other points of direct contact. Place the sensing heads on the ground firmly against the surface. Then, take readings along the top of water main at two meters interval. Listen to the sound, and adjust the filter for the highest response to the leak frequency to locate the leaks.

Noise Loggers

A noise logger shall include loggers, receivers and accessories. A LCD indicator shall be included on the receiver. It shall be noted that Noise Logger Survey shall be used in quality assurance/ control retest and/ or any other sections of water mains as required by the Client. This method is also suitable for long term monitoring of leakage.

The noise loggers shall be installed at valves or fittings along the section of water mains under investigation. The spacing between noise loggers shall not exceed 100m unless otherwise required by the client. It detects and records the source of the leak noise. The detection period shall be over two hours. The data from the loggers is transmitted by radio signal to the receiver. The result can be downloaded to the computer later for analysis. By comparing the sound data of the loggers, the leak position can be pinpointed and displayed.

Hydrogen Gas Detection

This method involves the use of light gases and a gas detector. Leakage can be traced by detecting the light gas rises up to the surface from the leak point. The low viscosity and low density of the hydrogen gas allow it to penetrate the ducts and the ground materials easily and then rise to the surface. The tracer gas is a standard ready-mixed industrial gas mixture containing 5% hydrogen and 95% nitrogen. The gas mixture is inexpensive and safe to use as the hydrogen is sufficiently diluted.

The tracer gas is first injected into the pipe. The gas would diffuse in the pipe, gradually penetrates out of the pipe material and rises to the ground surface. The rate of penetration of the gas varies depending on the pipe materials. The operator shall allow sufficient time period for the process. The higher the density of the ground, the longer the waiting time will be. For example, for dry sand, the waiting time would only be 15 minutes, but for 20cm asphalt, the process can consume more than 12 hours.

The gas rises from the alignment can be detected by a gas detector, which shows the concentration of the gas detected. The suspected leak point is where the highest concentration of gas presents.

Result of leak detection of water mains shall include all necessary information including:

Layout plan shows the alignment of the pipes and location of manholes.
A report consists of mandatory information (date and time, location, total length, number of setups of survey) and results, analysis of results and suspected or confirmed leak location.Photographs of each leak detection setup point.

Guide to Water Leakage Detection (UTI) provides more comprehensive illustration of the methods for detecting leakage. “Specification for Water Leakage Detection” adopted by HKIUS states standards for the survey works.

5. POST SURVEY DATA PROCESSING

5.1 Inspection report

After inspection, report shall be generated to illustrate the result of the observation and investigation. Data collected during the investigation shall be arranged and presented in the inspection report. It shall include the reconnaissance survey reports, slope reports and survey reports.

The reconnaissance reports state the locations of the utility installations and circumstances of the slope. Alignment of pipes verified by utility mapping survey shall be reported and presented clearly in the drawing. The report shall include the following items:

- Reconnaissance Survey drawing in A3 size which shows the Survey Extents, assets to be surveyed and any additional manholes and pipes to be surveyed.
- Digital photographs showing the slope and the surroundings.
- The slope reference number shall be clearly displayed on the cover and each page of the report.

On completion of all investigation work for the survey extent of slope features required in the Contract, the Contractor shall prepare the slope reports. The contractor is required to submit a total of two copies for each of the slope reports. The Contractor shall supply one original set of reports and photographs bound in the reports and the other set will be supplied loose for photocopy if required. The reports include all information regarding the slope and surveys carried out. It shall consist of the following documents.

Slope number title page – basic information of the survey including location and date of commencement and completion. Information of the slope to be investigated includes the location, features and history, the data of which can be found in the GEO catalogue and shall be provided by the Client.

- Summary of all manholes and pipes investigated and problems found.
- Drawing of slope showing survey extent, base map details and manholes surveyed
- List of surveys that have been conducted within the survey extent.

Survey reports shall be included as appendices of the slope reports. Reports of all surveys conducted shall be submitted. Complete set of reports in correct format shall be provided by the contractor in compliance with the contract terms. Two copies of survey reports shall be supplied. The quantity and format of the reports shall be stated in the contract clearly.

5.2 Quality Control

The quality control procedures and the level of accuracy shall be agreed with the client prior to the commencement of any contract. Quality control is essential to maintain the quality of the survey as well as the professionalism of the industry.

Surveys for investigating the buried water carrying services may involve the use of special

equipment and techniques, specific knowledge is required for making judgment based on the information available. Employing qualified and experienced personnel to carry out the survey gives a certain level of guarantee on the quality of the survey. The personnel requirement of carrying out the surveys has stated in section 3.3.

CCTV Survey

CCTV Survey involves detailed coding, grading and scoring system and may involve a large number of conduits. Huge amount of data shall be processed and interpreted, omissions and mistakes are commonly seen in the survey results. Quality control procedures ensure the accuracy of the results. The procedures are as follows:

- The surveyed conduits are numbered according to the time of survey;
- A portion of the survey results for each specialist is selected randomly by the computer for quality checking;
- The portion is normally set at 5%, or at least the survey results for 1 conduit shall be reviewed;
- Video clippings for the selected pipes shall be retained;
- Information and codes of the selected lengths are entered into a survey selection log;
- All header information, codes and numbers shall be checked to ensure correct entries;
- All the compulsory fields shall not leave blank.

To measure the accuracy of the result, the accuracy of each survey is determined by:

$$Accuracy = \frac{(The\ acutal\ number\ of\ entries - The\ number\ of\ actual\ errors\ /\ omissions) \times 100\%}{(The\ actual\ number\ of\ entries)}$$

Note that any error input/ omission shall be weighted equally, without dependency on the level of inaccuracy.

The specified accuracy shall be 95% for Header information, 85% for Detail information and the lowest tolerance is 80% or otherwise specified in the Contract.

If the report of any survey length fails to meet the specified accuracy level, re-coding and re-submission of the report are required.

Besides, additional quality checking is required by evaluation of the coding results for 5 conduits surveyed immediately before or after the failed length.

Shall there be any failure in meeting the accuracy requirement in the additional checking, re-coding and re-submission of the report are required, and another additional quality checking shall be performed in the manner stated in the previous paragraphs, until the required accuracy is achieved.

Manhole Internal Condition Survey

Instead of manual checking, manhole cards can be checked by computer software, IDMS or alike, which greatly enhances the efficiency of checking and data validation. IDmS or alike can check the consistency and accuracy of the data. It can be used to check the consistency of node data and to produce relevant inconsistency reports. There are groups of different types of consistency checks.

They are listed as follow:

Consistency of node/grid reference
Status, function, node type codes
Existence downstream reference
Identical up & downstream nodes
Existence of: Upstream reference Level
Existence of: Cover shape & depth
Existence of: Shaft size & depth
Existence of: Chamber soffit & construction
Existence of: Pipe size, shape, depth & material
Existence of: Consistency of downstream data
Existence of: Consistency of invert levels
Existence of: Fall to downstream node
Existence of: Downstream pipe length
Existence of: Criticality codes
Existence of: Maximum size tolerance
Existence of: Minimum gradient
Existence of: Maximum pipe length
Existence of: Ignorance of UTR/UTL/UTS/UTGA nodes

The first four checks (a-d) are normally sufficient to ensure that the sewer network is plotted because IDMS (or alike) will check the connectivity from one node to the next. The next seven checks (e-k) ensure that the data is able to be analyzed because checks are made on data coding. The last group of checks (l-r) is geared towards the use of the data for engineering analysis and final reports.

The very last check (r) allows the user to specify whether nodes with UTR, UTL, UTS or UTGA in the remarks field are included in the consistency check.

Similar to CCTV Survey, a checking of 5% or at least one manhole shall be subjected to quality assurance in random basis. Resurvey shall be deemed to have failed if any item of manhole measurement falls outside the tolerances stated in section 4.1.2. If the results of the resurvey are considered to be unacceptable to the Client, the Utility Specialists shall resurvey the failed portion at his own expense until it meets the requirement. An additional 5% of the inspected manholes shall also be checked in aforementioned manner. Quality control checks shall be repeated at the Utility Specialist's expense until the Client is satisfied that this portion of the work has met the requirement.

Water Leak Detection

The easiest and most direct way to verify the survey result of water leak detection is exposing the section of water main at the suspected leak location. As the sound cannot be retrieved in the office, the quality check shall be carried out on-site. The accuracy of the survey can be ensured by resurveying using alternative methods. Certain number of site checks shall be carried out by other teams in random basis.

Confirmation of LNC result can be performed by exchanging the position of the blue and red transmitter and repeat the survey to see if the result/ the position of the suspected leak point agree with the previous one. Also, qualified leak detection specialists can be employed to reconfirm the leak position using mechanic leak detectors. Other methods like noise loggers can also be considered if appropriate.

5.3 Rehabilitation

Rehabilitation work shall be decided by the Engineer or RPUS. Any suspected point of leakage shall be further investigated in detail immediately. Priority shall be set according to the severity of the leak and its threat to the stability of the slope. Suitable method of rehabilitation shall be applied according to the condition of the pipes and slopes.

Replacement or repair of defective pipes can be carried out by open excavation and trenchless technology. Open excavation is the most direct way and a low-cost method for rehabilitation. However, it causes nuisance and inconvenience to the public due to the temporary traffic arrangement that may block roads. Also, nearby utilities are vulnerable to damage during excavation and when they are exposed. Safety issue is another concern when digging the pipes as hazardous gas may be present in manholes and underground utilities.

Trenchless technologies involve a higher cost but cause less interruption to the environment. Joint grouting, relining using epoxy impregnated liner, relining using pre-deformed polyethylene liner, relining using smaller pipes, pipe bursting, etc. are some trenchless technologies used in pipe rehabilitation. Each method has advantages and drawbacks that shall be considered carefully before applying.

Sewer Rehabilitation Manual (WAA/WRc) and Guide to Pipe Rehabilitation by Trenchless Technology(UTI) illustrates details about methods, planning and implementation of the rehabilitation works. The former based on the situation of U.K. while the latter based on the situation of Hong Kong.

5.4 Keeping of Records

It is important to keep comprehensive and accurate records for good maintenance management. Completion of records can be in two stages, which are on completion of routine monitoring and on completion of routine maintenance.

As-built records of all water-carrying services can be found in relevant Government Departments to trace the past records of the services. After the maintenance activities including monitoring and rehabilitation, as-built surveys shall be carried out and the drainage records shall be updated for any changes in levels, positions and sizes of the services.

The owner of the asset shall keep all past records of monitoring and subsequent maintenance work of the slope. Duplicated copies of all records shall also be kept by the agent appointed to maintain the water-carrying services. Information may have been lost due to change of ownership for private installations, to avoid this, owner’s corporations, maintenance agents and property manager shall keep a copy of the records. Converting the data to electronic form is a common practice for data storage that enhances record management.

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Appendix A: 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
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)

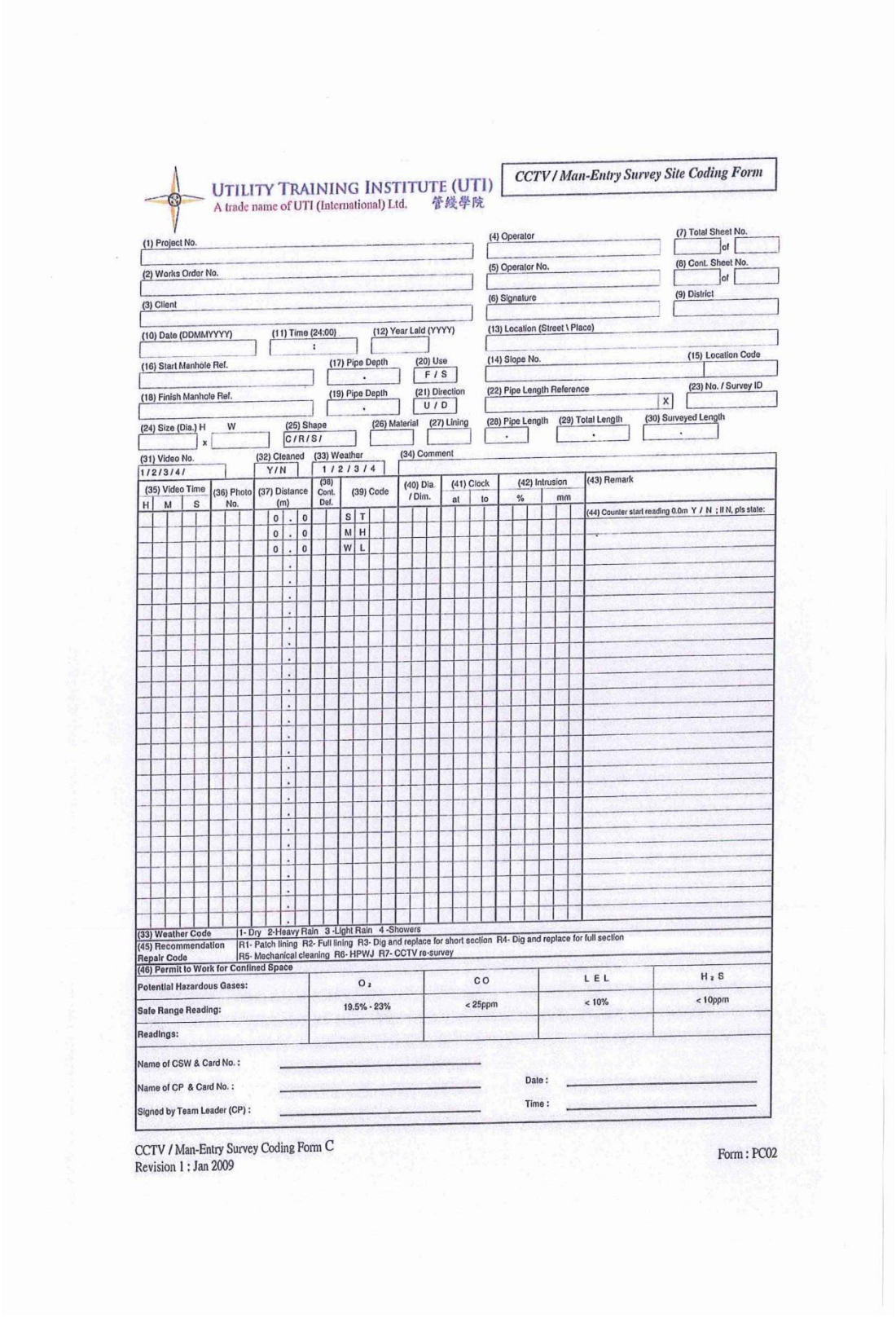
Company/ Organization	
CCES	Conduit Condition Evaluation Specialists
CCTV	Closed Circuit Television
CD	Compact Disc
CL	Cover Level
COP	Code of practice
CP	Competent Person
DN	Nominal Diameter
DP	Design Pressure
DVD	Digital Versatile Disc
e.g.	Exempli Gratia
GIS	Geo-Information System
EPR	Environmental 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

Company/ Organization	
m	Meter(s)
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

Company/ Organization	
W	Width
WLD	Water Leakage Detection
WO	Works Order
WP	Work Procedure

Appendix B: Sample Materials

B1 CCTV/ Man Entry Survey Coding Form



UTILITY TRAINING INSTITUTE (UTI)
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CCTV / Man-Entry Survey Site Coding Form

(1) Project No.
(2) Works Order No.
(3) Client
(4) Operator
(5) Operator No.
(6) Signature
(7) Total Sheet No. ____ of ____
(8) Cont. Sheet No. ____ of ____
(9) District
(10) Date (DDMMYYYY)
(11) Time (24:00) :
(12) Year Laid (YYYY)
(13) Location (Street \ Place)
(14) Slope No.
(15) Location Code
(16) Start Manhole Ref.
(17) Pipe Depth .
(20) Use F / S
(18) Finish Manhole Ref.
(19) Pipe Depth .
(21) Direction U / D
(22) Pipe Length Reference X
(23) No. / Survey ID
(24) Size (Dia.) H x W
(25) Shape C / R / S /
(26) Material
(27) Lining
(28) Pipe Length .
(29) Total Length .
(30) Surveyed Length .
(31) Video No. 1 / 2 / 3 / 4 /
(32) Cleaned Y / N
(33) Weather 1 / 2 / 3 / 4
(34) Comment

(35) Video Time H M S	(36) Photo No.	(37) Distance (m)	(38) Cont. Def.	(39) Code	(40) Dia. / Dim.	(41) Clock at	(41) Clock to	(42) Intrusion %	(42) Intrusion mm	(43) Remark
		0.0		S T						(44) Counter start reading 0.0m Y / N ; If N, pls state:
		0.0		M H						
		0.0		W L						

(33) Weather Code: 1- Dry 2-Heavy Rain 3 -Light Rain 4 -Showers
(45) Recommendation Repair Code: R1- Patch lining R2- Full lining R3- Dig and replace for short section R4- Dig and replace for full section R5- Mechanical cleaning R6- HPWJ R7- CCTV re-survey

(46) Permit to Work for Confined Space

	O_2	CO	LEL	H_2S
Potential Hazardous Gases:				
Safe Range Reading:	19.5% - 23%	< 25ppm	< 10%	< 10ppm
Readings:				

Name of CSW & Card No. : _____
Name of CP & Card No. : _____ Date : _____
Signed by Team Leader (CP) : _____ Time : _____

CCTV / Man-Entry Survey Coding Form C
Revision 1 : Jan 2009
Form : PC02

B2 CCTV Form A: Summary of Pipes

UTILITY TRAINING INSTITUTE (UTI)
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Summary of Pipes
(Form A)

Project No. & WO No.: ______________ Client: ______________ Date: ______________

Location: ______________ Slope No.: ______________ Surveyed By: ______________

Survey ID	Manhole				Pipe				Manhole (Start)			Grades			Remarks
	Use	Start Manhole Ref.	Flow	Finish Manhole Ref.	Size (mm)	Mat.	Shape	Length (m)	Depth (m)	I.L. (m)	C.L. (m)	SCG	ICG	SPG	
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															
13															
14															
15															
16															
17															
Total															

Note:
SCG: Service Condition Grade
ICG: Internal Condition Grade
SPG: Structural Performance Grade
In general SCG & ICG will be used
Inspecial case SPG will be used and in accordance with Appendix E of HKCCEC 2009

CCTV Survey Report Form A
Revision 1 : Mar 2009

Form: CR-A

B3 CCTV Form B: Summary of Defects

UTILITY TRAINING INSTITUTE (UTI)
A trade name of UTI (International) Ltd. 管綫學院

Summary of Defects (Form B)

Project No. & WO No.: ____________________ ____________________ Date: ____________________

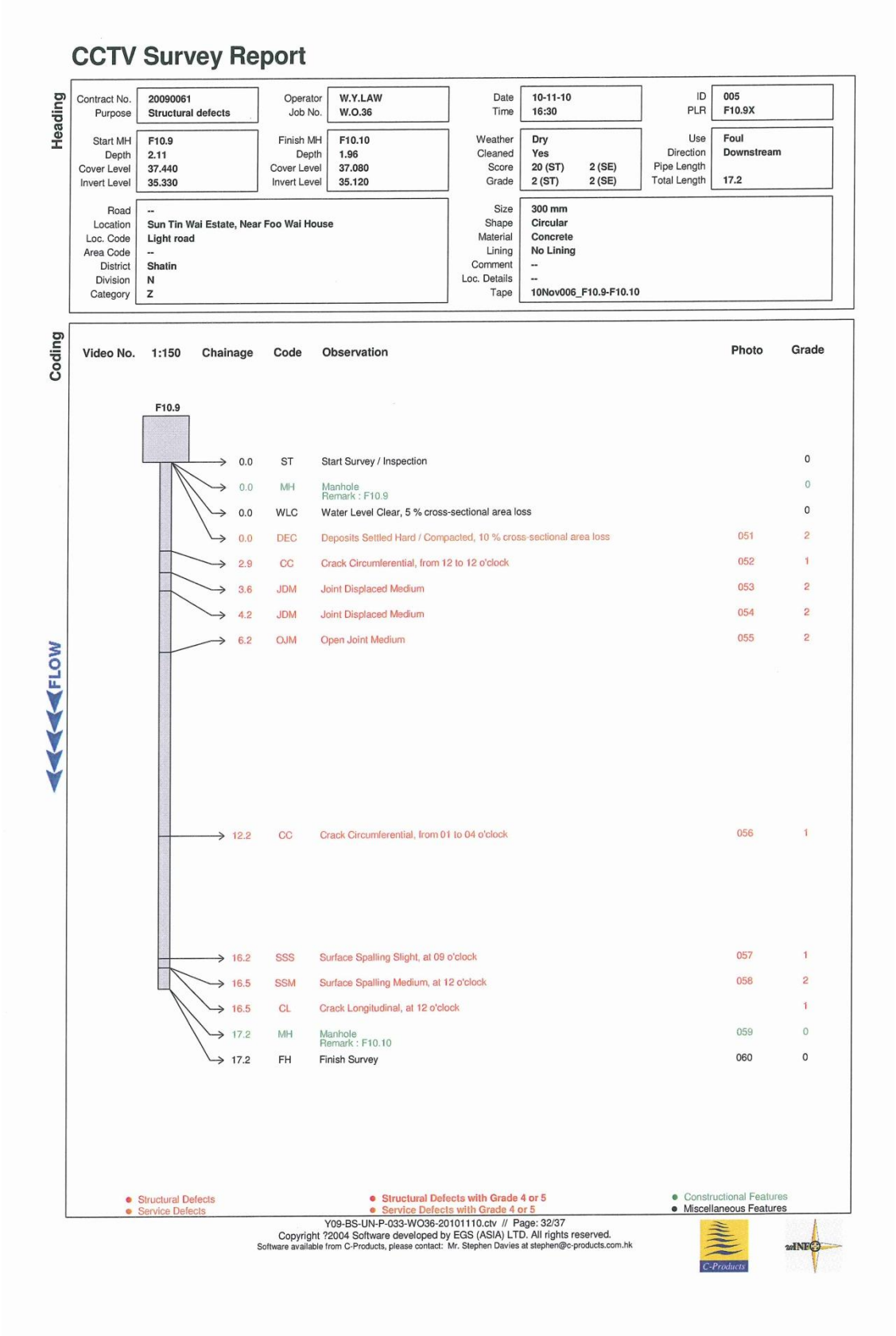
Location: ____________________ ____________________ Surveyed By: ____________________

Survey ID	Manhole				Pipe				Pipe											Service Condition								Misc.				
	Use	Start Manhole Ref.	Flow	Finish Manhole Ref.	Size (mm)	Mat.	Shape	Length (m)	Urgent	Surface Damage Spalling	Crack	Fracture	Broken	Hole	Defective Con. / Jun.	Deformed	Collasped	Joint Displaced	Open Joint	Roots	Infiltration	Encrustation	Debris	Grease	Obstruction	Water Level - 20%	Line	Survey Abandoned	Camara Under Water	Loss of Vision	Brick Defects	Others
1																																
2																																
3																																
4																																
5																																
6																																
7																																
8																																
9																																
10																																
11																																
12																																
13																																
14																																
15																																
16																																
17																																
Total																																

CCTV Survey Report Form B
Revision 1 : Mar 2009

Form: CR-B

B4 CCTV Form C: CCTV Survey Report (Filled)



CCTV Survey Report

Heading

Contract No.	20090061	Operator	W.Y.LAW	Date	10-11-10	ID	005
Purpose	Structural defects	Job No.	W.O.36	Time	16:30	PLR	F10.9X
Start MH	F10.9	Finish MH	F10.10	Weather	Dry	Use	Foul
Depth	2.11	Depth	1.96	Cleaned	Yes	Direction	Downstream
Cover Level	37.440	Cover Level	37.080	Score	20 (ST) 2 (SE)	Pipe Length	
Invert Level	35.330	Invert Level	35.120	Grade	2 (ST) 2 (SE)	Total Length	17.2

Road	--	Size	300 mm
Location	Sun Tin Wai Estate, Near Foo Wai House	Shape	Circular
Loc. Code	Light road	Material	Concrete
Area Code	--	Lining	No Lining
District	Shatin	Comment	--
Division	N	Loc. Details	--
Category	Z	Tape	10Nov006_F10.9-F10.10

Coding

FLOW

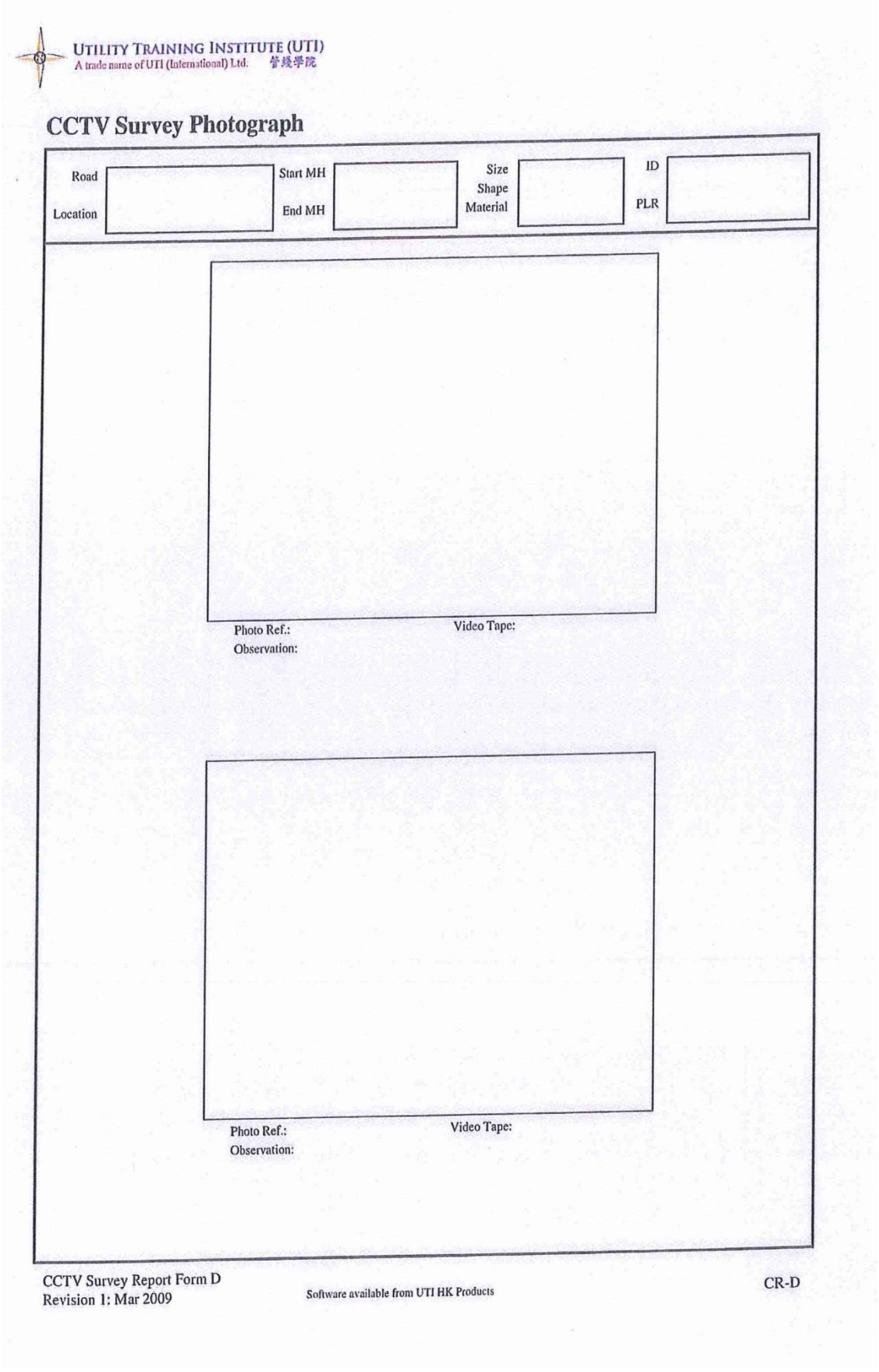
Video No.	1:150	Chainage	Code	Observation	Photo	Grade
	F10.9					
		0.0	ST	Start Survey / Inspection		0
		0.0	MH	Manhole Remark : F10.9		0
		0.0	WLC	Water Level Clear, 5 % cross-sectional area loss		0
		0.0	DEC	Deposits Settled Hard / Compacted, 10 % cross-sectional area loss	051	2
		2.9	CC	Crack Circumferential, from 12 to 12 o'clock	052	1
		3.6	JDM	Joint Displaced Medium	053	2
		4.2	JDM	Joint Displaced Medium	054	2
		6.2	OJM	Open Joint Medium	055	2
		12.2	CC	Crack Circumferential, from 01 to 04 o'clock	056	1
		16.2	SSS	Surface Spalling Slight, at 09 o'clock	057	1
		16.5	SSM	Surface Spalling Medium, at 12 o'clock	058	2
		16.5	CL	Crack Longitudinal, at 12 o'clock		1
		17.2	MH	Manhole Remark : F10.10	059	0
		17.2	FH	Finish Survey	060	0

- Structural Defects
- Service Defects
- **Structural Defects with Grade 4 or 5**
- **Service Defects with Grade 4 or 5**
- Constructional Features
- Miscellaneous Features

Y09-BS-UN-P-033-WO36-20101110.ctv // Page: 32/37

C-Products

B5 CCTV Form D: CCTV Survey Photograph



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CCTV Survey Photograph

Road Location		Start MH End MH		Size Shape Material		ID PLR	

Photo Ref.:
Observation:

Video Tape:

Photo Ref.:
Observation:

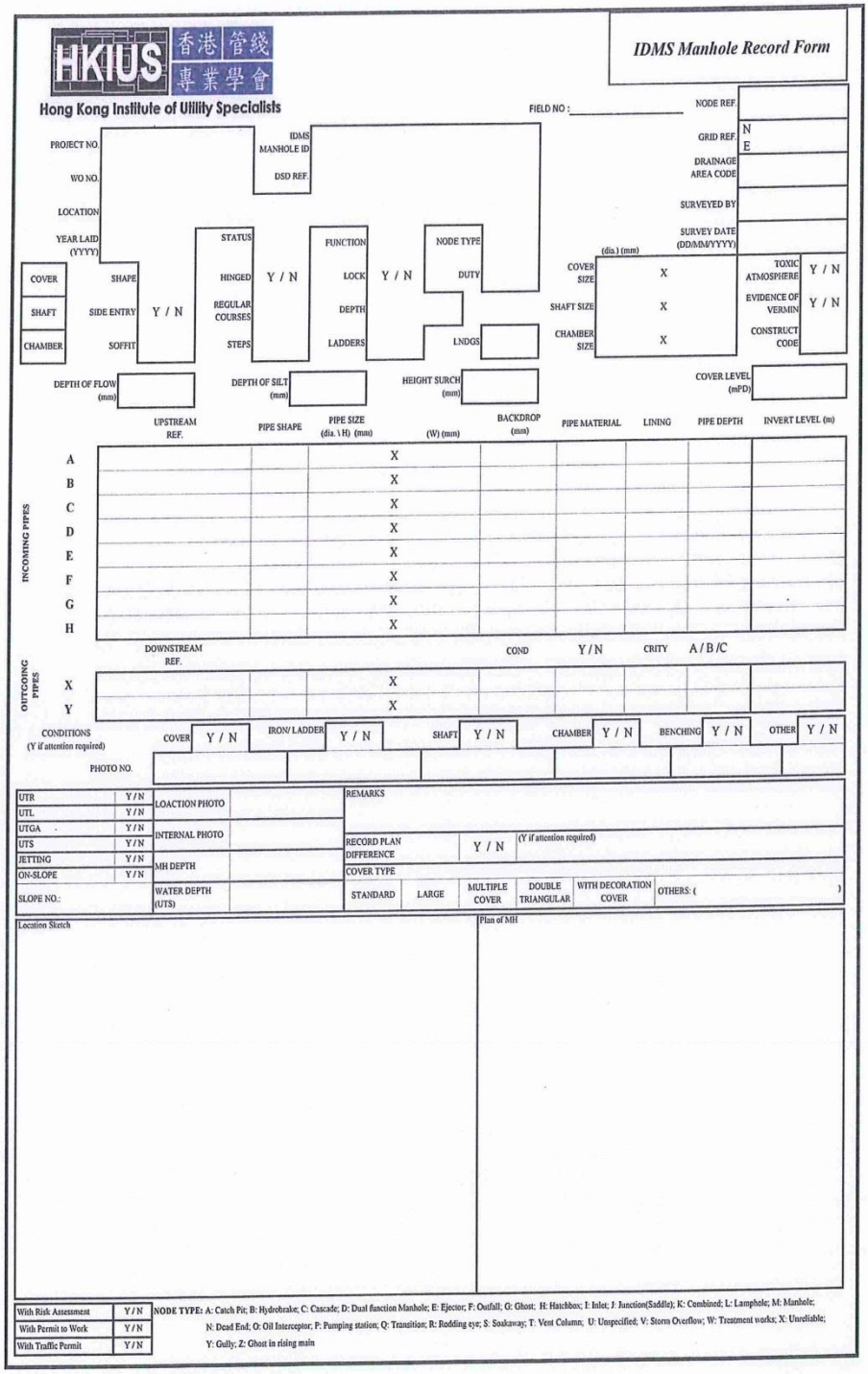
Video Tape:

CCTV Survey Report Form D
Revision 1: Mar 2009

Software available from UTI HK Products

CR-D

B6 Manhole Record Form



HKIUS 香港管線專業學會
Hong Kong Institute of Utility Specialists

IDMS Manhole Record Form

FIELD NO : _____

NODE REF.
GRID REF. N E
DRAINAGE AREA CODE
SURVEYED BY
SURVEY DATE (DD/MM/YYYY)

PROJECT NO.
WO NO.
LOCATION
YEAR LAID (YYYY)
IDMS MANHOLE ID
DSD REF.

COVER
SHAFT
CHAMBER
SHAPE
SIDE ENTRY
SOFFIT
Y / N
STATUS
HINGED
REGULAR COURSES
STEPS
Y / N
FUNCTION
LOCK
DEPTH
LADDERS
Y / N
NODE TYPE
DUTY
LNDGS

(dia.) (mm)
COVER SIZE X
SHAFT SIZE X
CHAMBER SIZE X

TOXIC ATMOSPHERE Y / N
EVIDENCE OF VERMIN Y / N
CONSTRUCT CODE

DEPTH OF FLOW (mm)
DEPTH OF SILT (mm)
HEIGHT SURCH (mm)
COVER LEVEL (mPD)

	UPSTREAM REF.	PIPE SHAPE	PIPE SIZE (dia. \ H) (mm)	(W) (mm)	BACKDROP (mm)	PIPE MATERIAL	LINING	PIPE DEPTH	INVERT LEVEL (m)
INCOMING PIPES A			X						
B			X						
C			X						
D			X						
E			X						
F			X						
G			X						
H			X						
	DOWNSTREAM REF.				COND Y / N		CRITY A / B / C		
OUTGOING PIPES X			X						
Y			X						

CONDITIONS (Y if attention required)
COVER Y / N | IRON/LADDER Y / N | SHAFT Y / N | CHAMBER Y / N | BENCHING Y / N | OTHER Y / N
PHOTO NO.

UTR	Y / N	LOACTION PHOTO	
UTL	Y / N		
UTGA	Y / N	INTERNAL PHOTO	
UTS	Y / N		
JETTING	Y / N	MH DEPTH	
ON-SLOPE	Y / N		
SLOPE NO.:		WATER DEPTH (UTS)	

REMARKS

RECORD PLAN DIFFERENCE Y / N (Y if attention required)

COVER TYPE
STANDARD | LARGE | MULTIPLE COVER | DOUBLE TRIANGULAR | WITH DECORATION COVER | OTHERS: ( )

Location Sketch

Plan of MH

With Risk Assessment	Y / N
With Permit to Work	Y / N
With Traffic Permit	Y / N

NODE TYPE: A: Catch Pit; B: Hydrobrake; C: Cascade; D: Dual function Manhole; E: Ejector; F: Outfall; G: Ghost; H: Hatchbox; I: Inlet; J: Junction(Saddle); K: Combined; L: Lamphole; M: Manhole; N: Dead End; O: Oil Interceptor; P: Pumping station; Q: Transition; R: Rodding eye; S: Soakaway; T: Vent Column; U: Unspecified; V: Storm Overflow; W: Treatment works; X: Unreliable; Y: Gully; Z: Ghost in rising main

Form Title: Manhole Record Form

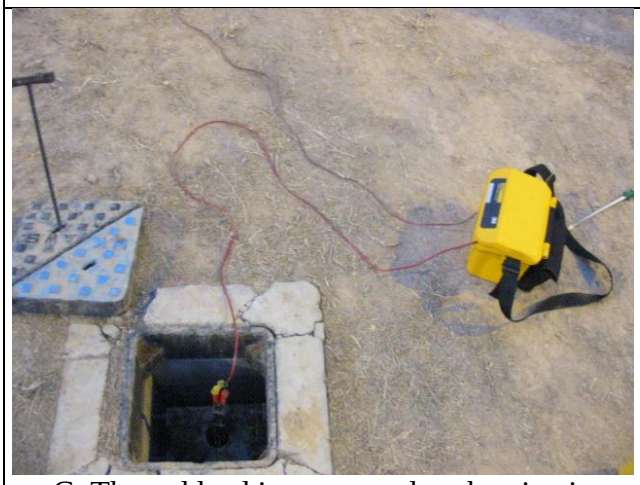
Form No.: PM02
Revision 1 (Jun 2011)

Appendix C: Related Photographs

C1 Photographs related to underground utility detection

A: A locating set for direct connection method.

B: Tracing the alignment.



C: The red lead is connected to the pipe in direction connection.

D: A signal clamp is used on an exposed cable duct.

E: Marking the location of the utility detected.

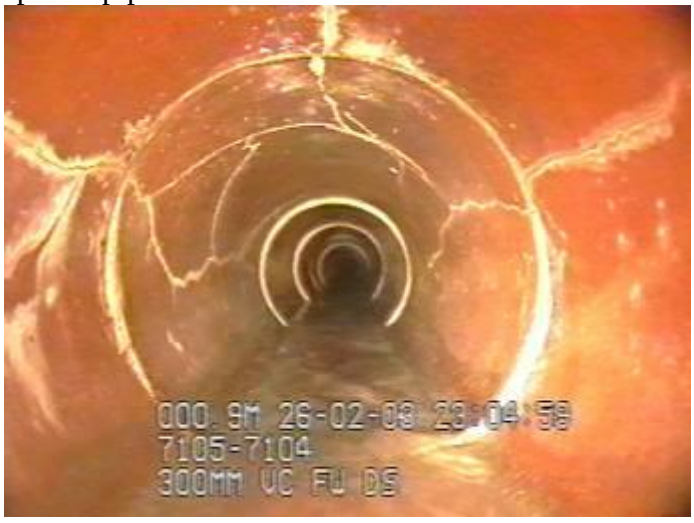
F: A Mini-Marker installed on a gas pipe.

C2 Defects that may lead to leakage inspected by CCTV Survey

Plate 1 - Structural Defects

A: Broken- no missing pieces but some have noticeable displacement

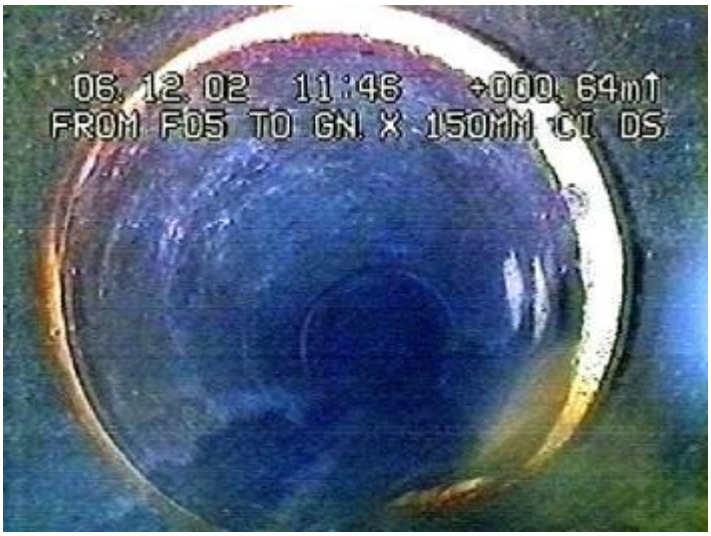
B: Collapse of pipe section with 30% reduction in cross sectional area



C: Multiple Crack from 9 to 2 O'clock

D: Circumferential Fracture from 9 to 3 O'clock

E: Hole at 12 to 01 O'clock



F: The displaced joint appeared as a meniscus

Plate 2 - Service Defects

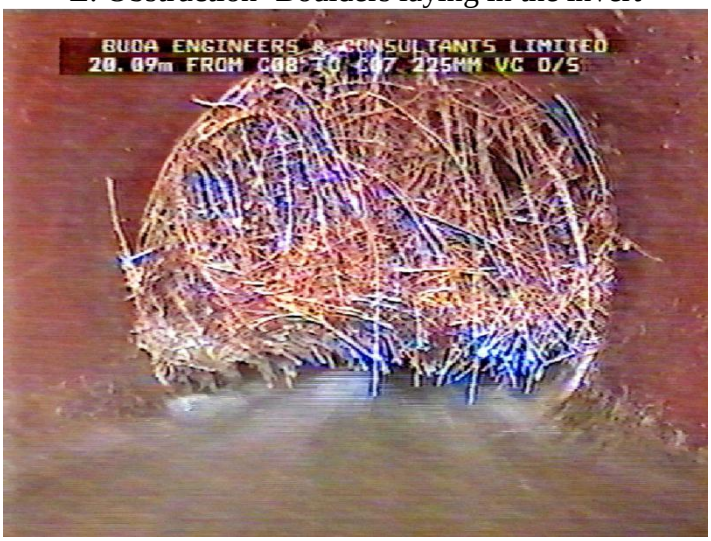
A: Deposit Attached- Foul material from the sewage attached to the inner wall of the pipe

B: Deposit Settled- Coarse material deposits at the bottom of the pipe

C: Encrustation- Heavy encrustation

D: Infiltration- Groundwater running continuously through faulty joint

E: Obstruction- Boulders laying in the invert



F: Tree Root- Roots mass blocking over 80% of the cross –sectional area of the pipe

Plate 3 - Construction Defects

A: Connection- A connection at 12 O'clock with defects and is in service

B: Connection Defective- A connection intruding into the main pipe at 2 O'clock

Photos are adapted from HKCCEC 2009.

C3 Manhole photographs

Fig. A.1 Storm Cover

Fig. A.2 Foul Cover

Fig. A.3Gully Cover

Fig. A.4 Rodeye Cover

Fig. A.5 Multiple Cover

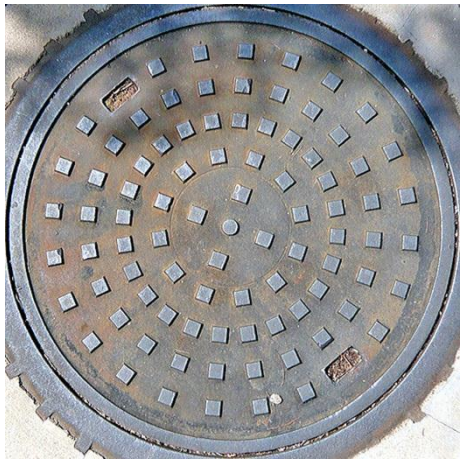


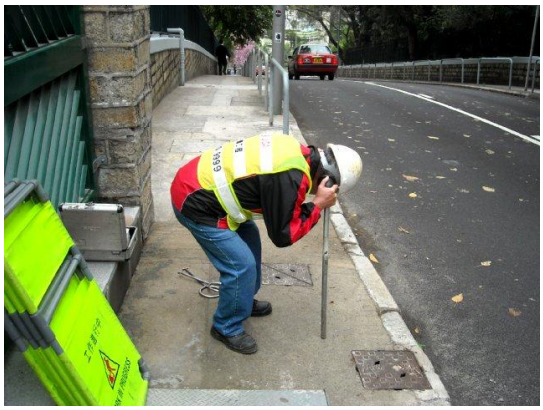
Fig. A.6 Private Cover

C4 Photographs related to water leak detection

A: Water burst from a deteriorated water main.

B: Finding out the alignment of the mains before leakage detection.

C: The LNC set is collecting the sounds of the pipe.



D: Manual listening by experienced operator gives a reliable result.

E: Hole drill for gas leakage detection.

F: A noise logger is installed to collect leak sounds.

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Guideline Amendment Form

Please fill in the following form if any error or mistake is found in this manual. We thank for your support and appreciate your continuous help in improving this manual.

Discipline*	Page No.	Description of Existing Content	Suggested Amendment

* A. Conduit Condition Evaluation (CCTV and ME Survey)
B. Manhole Internal Condition Survey
C. Utility Survey (Pipe Cable Locator Survey, PCL)
D. Water Leakage Detection and Control
E. Advanced Leakage Detection of Buried Water Carrying Services Affecting Slopes
F. Pipe Rehabilitation by Trenchless Technology
G. GPR(Ground Penetrating Radar) Survey
H. Flow Study in Drainage Conduit (流量監控)
I. Pipe Condition Surveys by other non-destructive methods
J. Data Management for Utility Records
K. Utility Management
L. Safety

Please fill in your contact information in case follow up is needed.

First Name: _____ Second Name: _____ Last Name: _____

Title: _____

Organization: _____

#Telephone No.: _____ #Email Adress: _____

#Address: _____

Please fill in one or more contact information in the blanks provided
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B W C S

Professional Service Development Assistance Scheme (PSDAS)
Professional Guide Notes and Pamphlet for utility professionals in Hong Kong
Project ref: Y09-HKIUS-P02-PSDAS