New Chapter on Electro Scan

Office of Water Programs

U.S. Environmental Protection Agency
Office of Water Programs

Coming 2015
Electro Scan represents the first automatic, unambiguous assessment tool that locates and measures pipe defects that leak. Each defect found is given an estimate (in gallons per minute, or GPM) of the potential amount of water that may flow through the defect. By providing an objective numeric value for each defect, Electro Scan takes the guess work out of quantifying pipe defects.

5.60 Use of Electro Scan

Many traditional condition assessment techniques are conducted during periods of dry weather conditions, despite an ongoing need to understand how sewer and storm water pipes perform in wet weather conditions. Electro scan can be used year round and can detect defects often missed by visual inspection such as bad joints, defective service connections, and both radial and longitudinal cracks.

Electro Scan is designed to find and measure defects in non-conductive pipes, including asbestos cement, brick, clay, cured-in place pipe (CIPP), fiberglass reinforced pipe (FRP), high-density polyethylene (HDPE), plastic (PVC) and reinforced concrete pipe (RCP).

While early prototypes of Electro Scan technology utilized a standalone cable and reel design, later models use an adaptive approach (Figure 1) that utilizes existing CCTV cable and reel configurations available from major manufacturers. This provides a straightforward, familiar infrastructure that can easily change during operations from CCTV to Electro Scan, and back again, in generally less than ten minutes.

During scanning, the area around the probe is surrounded by water. While being pulled at a rate of 45-60 feet per minute, the probe emits a low-voltage, high-frequency electric current of approximately 10 volts and 40 milliamps--roughly equivalent to six AA batteries (Figure 2).

Defects in the pipe wall are found by measuring variations in electric current received from the probe. The displayed trace of this current variation is similar in looks to an electrocardiogram (EKG) that measures the rhythm of each heart beat (Figure 3).

A sharp rise in the electric current reading indicates a defect in the pipe. A solid pipe wall will resist electricity, but a defect in the wall will allow electricity to easily pass through. Reported defect location is accurate to within 0.4 inches (1 centimeter). Start and end dimensions of any defect are provided, and a defect flow rate is estimated in gallons per minute (GPM), or liters per second (LPS). GPM accuracy is ±40%, confirmed by flow meter testing and open trench smoke testing in accordance with ASTM F2550-13.

Data Consistency

A key advantage of Electro Scan over alternative assessment techniques is its ability to repeat data inspection results on a consistent and sustainable basis regardless of the equipment operator. As shown in numerous EPA-funded studies and benchmarks, data patterns remain similar after short-term periods of repeat scans (Figure 4).

Data Intensity

Electro Scan records data every quarter inch, or every 14 milliseconds. Thus, for an average 300-ft pipe segment, Electro Scan will generate 10,000 to 20,000 data points depending on the rate of speed that the probe is pulled through the pipe. Each data point is transmitted to an on-board computer located in the operator’s truck.
The Electro Scan system’s adaptive design allows for quick, simple transitions between CCTV and Electro Scan configurations. The Electro Scan probe connects to the reel with the same type of plug the CCTV camera uses. A switchover box allows for data switching to either the CCTV Terminal or the Electro Scan Controller, and then to the Computer for viewing and storage.

The Electro Scan Probe emits a narrow, focused beam of low-voltage high frequency electricity as it is pulled through the sewer pipe. The nonconductive walls of the pipe resist this electricity. However, if a defect with leak potential is encountered in the pipe, the electricity escapes and is received by the nearby ground stake. This variation in electric current is measured and used to locate and measure all potential leaks within the pipe.
The Difference Between Large v. Small Leaks

It is not necessary to manually interpret the electric trace to determine the location or type of defect. Electro Scan’s processing engine analyzes the area created by each defect according to its width (i.e. start to end) and height (i.e. maximum defect current) to compute an estimated flow rate for each defect.

The Critical Sewers® cloud application summarizes scans and creates reports for users to view. Critical Sewers® categorizes defects into two categories:

1. Small, Medium, or Large and
2. Minor, Moderate, or Severe

A defect is either Small, Medium, or Large based on the amplitude of electric current. The same defect is either Minor, Moderate, or Severe based on the estimated Defect Flow (in gallons per minute, or GPM) which is an estimate of the amount of water that could potentially flow through the defect. Defect Flow is estimated by the area under the curve of the defect in the electric current trace.

Large current readings over a large area often result in the largest estimated GPM (Defect Flow). However, it is not uncommon for the largest estimated GPMs in a scan to be caused by smaller current readings over larger areas (Figure 5).

For example, imagine a pipe segment has two defects:

**Defect 1**: A narrow crack that spans 10 feet of pipe

**Defect 2**: A crack wider than Defect 1, but only spans 1 inch

Defect 1 will have a lower amplitude of electric current compared to Defect 2. Since Electro Scan categorizes defects based on the electric current amplitude, Defect 1 could be categorized as “Small” and Defect 2 as “Large”.

However, the area under the curve for Defect 1 will be greater than Defect 2, meaning Defect 1 will likely leak more water. Accordingly, Defect 1 will have a greater potential Defect Flow than Defect 2. In terms of Defect Flow, Defect 1 may be categorized as “Severe”, while Defect 2 may be categorized as “Minor”.

It is important to remember that the amplitude of electric current for a given defect determines whether the defect is considered Small, Medium, or Large. And the estimated Defect Flow determines whether the defect is Minor, Moderate, or Severe. It is not unusual to have a Small/Severe defect or a Large/Minor defect.

Different Trace Patterns Show Different Defects, Without The Need to Interpret Location or Size
It is often asked whether Electro Scan can identify specific types of defects inside a pipe. The simple answer is “No.” Electro Scan will not indicate the clock position of a particular defect or indicate an alignment problem. However, the repetitive patterns of Electro Scan traces often give a good indication of likely problems.

While it is not necessary to interpret the specific patterns of an Electro Scan trace, it is advisable to compare the trace with known locations of service connections and other key pipe features. For example, regular defects on the trace corresponding to locations of joints indicates faulty joint connections. Similarly, problems at service connections are often shown by head and shoulder patterns in the trace (Figure 6).

**Figure 6 - Electro Scan Trace Pattern** - As shown above, the defect at 130 feet into the scan is located at a service lateral connection. This defect is likely a problem with the lateral to mainline connection. The defect at 50 feet spans a wide distance. This indicates a longitudinal defect. In contrast, the defect at approximately 90 feet has a narrower width, indicating a radial defect.

**How Electro Scan Differs From CCTV Surveys**

Electro Scan does not replace CCTV; but it adds an important layer of assessment data. While Electro Scan does not replace CCTV, it does locate & measure defects that are not typically seen by visual observations using high resolution, pan & tilt, panorama cameras.

In July 2011, the US EPA published results from its Field Demonstration of Condition Assessment Technologies for Wastewater Collection Systems, Kansas City, MO. The first major independent study to benchmark CCTV and Electro Scan, in addition to other field assessment technologies, the study evaluated seventeen (17) sewer mains, including side-by-side comparisons of CCTV and Electro Scan.

As shown in Figure 8, CCTV provides structural assessments from operator observations of visually identified impairments, while Electro Scan provides an automated quantification, i.e. no visual interpretation, of defects related to openings (e.g. cracks, fractures, joint defects, defects at service connections) in the pipe that provide pathways between inside a pipe and ground where water can enter or exit.

In some cases, no PACP defects may be observed from CCTV (Figure 9); however, by applying Electro Scan’s low voltage/high frequency technology, invisible defects not seen by CCTV operators, may be shown.

The City of Redding, California, had flow monitored every manhole segment (i.e. MH to MH), conducted smoke testing, CCTV, and if leaks were found, repaired; however, wet weather flows were greater than 450,000 gallons per day, with periodic overflows. Since traditional methods of condition assessment were unable to detect sources of infiltration, 25,000 ft of 6” and 8” sewer mains were electro scanned. Averaging 3,000 ft per day, Twelve (12) large defects were identified with significant defects excavated to verify electro scan results. As shown in Figure 10, electro scan results matched field locations of defective mains, with subse-
Figure 8 - Highlighted dotted-line box shows sewer main assessments for the same pipe segments comparing PACP standards (Top Chart), Electro Scan (Middle Chart), and Side-by-Side Comparison (Bottom Chart). Source EPA/600/R-11/078 and USEPA Sewer Electro Scan Field Demonstration Revisited, Terry Moy, Charles G. Wilmut and Robert J. Harris.

<table>
<thead>
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<th>*OPRI Grading</th>
<th>Structural Performance Grade (SPG)</th>
<th>Pipe Failure</th>
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<td>5</td>
<td>Immediate Attention</td>
<td>Collapse or collapse imminent</td>
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<tr>
<td>4</td>
<td>Poor</td>
<td>Collapse likely in foreseeable future</td>
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<td>3</td>
<td>Fair</td>
<td>Collapse unlikely in near future</td>
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<td>2</td>
<td>Good</td>
<td>Minimal collapse risk</td>
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<tr>
<td>1</td>
<td>Excellent</td>
<td>Acceptable structural condition</td>
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Figure 9 Comparing CCTV to Electro Scan
Finding Defects with Electro Scan Not Found by CCTV Inspection.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Amount of Structural Defects</th>
<th>Structural Grade</th>
<th>Structural Pipe/Structural Quick Rating</th>
<th>Structural Pipe Rating Index</th>
<th>Amount of OIM Defects</th>
<th>OIM Segment Grade</th>
<th>OIM Pipe Rating</th>
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Actual CCTV Report Example with Zero PACP Defects

Actual Electro Scan Analysis of same sewer pipe inspected by CCTV with no callouts

Defect found at approximately 280.5 linear feet with CCTV image at same position (no CCTV Callout)
5.600 Purpose of Electro Scanning Collection Systems

Electro Scan is best suited for finding possible sources of infiltration and exfiltration of flows, into and out of sewer systems, respectively. It is also well-suited to find and measure defects that may leak in post-rehabilitated sewer, storm water, and water pipes.

Accurate location, measurement, and characterization of all potential pipe leak defects are essential inputs for cost-effective design, testing, and certification of pipe repairs, renewal, and new construction. Commonly used sewer leak assessment methods, such as air and water pressure testing (Figure 7), are cost effective methods to provide overall Pass/Fail pipe assessments. However, these methods are limited by their inability to determine the location and size of leaks, particularly at individual joints and service connections. This limits their use in remediation and rehabilitation decision support.

Though CCTV is a long standing tool used to evaluate sewer mains and laterals in dry weather conditions (i.e. when pipes are dry or only partially full of water), Electro Scan represents the first wet-weather condition assessment tool that simulates pipe performance when full of water.

Electro Scan’s ability to find defects that leak makes it a multipurpose tool that can be used to: assess the condition of any existing non-conductive pipe; certify any new pipe installation as “leak-free”; or certify any post-rehabilitated lined pipe as “leak-free.”

5.601 Common Applications for Electro Scan

Electro scan has many applications, discussed in more detail later in this chapter. Highlights include the following:

- Sewer mains and laterals suspected of infiltration, including submerged, or partially submerged, pipes.
- Post-rehabilitation certification of lining projects.
- New property developments and their service connections, prior to acceptance by third-party contractors.
- Sewer mains televised multiple times with conflicting or no callouts.
- Assessment of Siphons.
- Sewer mains running underneath rivers or streams, unable to be televised.
- Sewer Survey Evaluation Studies (SSES) to more accurately pinpoint sources of infiltration.
- Pre- and/or Post-grout assessment.
- Large interceptors requiring leak detection from the surface of water and below.

5.602 Decisions Possible from Electro Scan Information

Sewer agencies, consulting engineers, and contract managers may use Electro Scan as part of an overall condition assessment program. These entities can then re-prioritize and re-rank their critical sewer repairs based on the findings from Electro Scan.

(Above) After electro scanning a sewer main that did not show any PACP CCTV defects, the City of Redding, California excavated to exposure the area shown as defective and performed an open trench smoke test. With water surcharging from the pipe, it was found that Fernco fittings had not been properly tightened.

(Above) After electro scanning a sewer main that did not show any PACP CCTV defects, the City of Redding, California excavated to exposure the area shown as defective and performed an open trench smoke test. With water surcharging from the pipe, it was found that Fernco fittings had not been properly tightened.

sequent repairs reducing wet weather flows from 450,000 gpd to 2,150,000 gpd.
Example Electro Scan and CCTV Report - Side-by-Side Comparison

Sample Critical Sewers® Electro Scan Report View
Pre-Rehabilitation Decision Making

Infiltration and exfiltration often result from defective joints not easily seen by CCTV inspection. In fact, in many cases CCTV will have little to no identified defects using National Association of Sewer Service Companies (NASSCO) Pipeline Assessment and Certification Program (PACP) standards. Electro Scan, however, will both accurately locate and measure specific defects.

For example, Electro Scan and CCTV results of the same pipe were compared in an area historically prone to severe flood and backup (see Figure 8). In this case, Electro Scan estimated +200 GPM infiltration rate in this sewer main, which was previously cataloged by CCTV as having “no defects.”

Electro Scan’s ability to re-prioritize and re-rank sewer mains to accurately define their criticality represents a major change in the way that sewers are assessed.

Post-Rehabilitation Decision Making

Electro Scan substantively changes the acceptance criteria for rehabilitated pipes. In a majority of cases, the main objective for sewer pipe rehabilitation is to ensure that groundwater is unable to enter the sanitary sewer system. Sewer rehabilitation methods such as sewer main point repairs, relined pipes, and new pipe installations have typically allowed CCTV to be the main recourse for verifying that pipes have been installed or rehabilitated properly.

As shown in Figure 11, Electro Scan can be used to objectively and consistently determine the success of a pipe repair, rehabilitation, or relining of sewers.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 43.

5.60A Generally, how does the Electro Scan probe find defects in non-conductive pipes?

5.60B What weather conditions may Electro Scan be used in?

5.60C Could a defect categorized as “Small”, based on the amplitude of the current reading, have more leak potential than a “Large” defect? Why?
5.61 Equipment and Staffing

5.610 Equipment and Components Required for Electro Scanning

The essential components of the scanning apparatus are:

- A controlled voltage source
- The probe
- An insulated cable to connect the probe to the voltage source and move the probe through the pipe
- A system to measure the position of the probe in the pipe
- A system to measure the focused current
- A system to measure the electrical current flowing through all three electrodes in the probe, called the total current
- A surface electrode
- When a sliding pipe funnel plug is used, a system to measure the water pressure in the pipe at the location of the probe, called the water head, is required.

Electro Scan equipment is shown in Figure 12, with example configurations shown in Figure 13.

5.611 Staffing Requirements

Electro Scan’s similarity to CCTV and absence of any in-field data review, analysis, coding, or data entry of defects allows a single TV truck operator to successfully staff and complete the Electro Scan procedure. If the sewer agency requires a two-person crew to operate the TV truck, then two people may be required.

Additionally, staffing of the water jet truck is required to provide a haul line to pull the probe the length of the sewer segment once the probe has been setup and placed in the upstream manhole.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 43.

5.61A Name three (3) essential components of the Electro Scan system.

5.61B At a minimum, how many people are needed to perform Electro Scan operations?
**Electro Scan Probe** - Contains three electrodes. Two on either end that act as guards to help focus the electricity emitted from the center electrode. It is the center electrode that finds defects.

**Electro Scan to CCTV Camera Cable Connector** - Electro Scan utilizes the same plug interface as CCTV for ease of transition.

**Funnel Cones** - Similar to a Sewer Kite, funnel cones help contain water that surrounds the probe during a scan. Different funnel sizes for different pipe sizes.
Mainline Console Software Application - Used by Operators to Setup Scans and Retrieve Data from Probe. The application also sends scan data to the cloud application, Critical Sewers®, which generates reports for users to view.

Controller - Powers and communicates with the Probe, relaying data to the computer in the truck.

Grounding Reel and Rod - The Grounding Reel cable clips to the Grounding Rod, which is inserted into the ground and attracts any electricity from the probe that escapes the pipe wall. The grounding reel could also be clipped to other sources of grounding, such as stops signs or telephone poles.

Probe Calibration Selector and Potentiometer - The Calibration Selector (switch) is used for calibration testing the Probe. The Guard Test position tests the two guard electrodes on either side of the Probe. The Defect Test position tests the center, defect electrode.

The Potentiometer (dial on left) is used to calibrate the total electric current for pipe material and soil conditions particular for each scan. For example, scans in highly-resistant PVC, or in sandy soil conditions, may need to be "dialed up" to the proper current range in order to scan accurately.
Figure 13 - Example Configurations of Electro Scan with CCTV Truck/Van Manufacturers

Electro Scan and Cues TV Truck

Electro Scan and IBAK KW 305

Electro Scan and Ipek RAX300
5.62 Operations

5.620 Job Site Preparation

See Figure 14 for graphical depictions of Electro Scan job site preparation.

1. Plan the Scanning Sequence for Multiple Segments

Like any method of sewer assessment, planning is imperative to efficient operations. It is recommended operators consult maps, geographic information systems, and other aids to develop a plan of attack that maximizes scanning production.

2. Traffic Control

During operations in vehicular traffic areas, operators must establish proper traffic control. This may include traffic cones, a designated worker with a “Stop/Slow” sign, high-visibility clothing, etc. Proper traffic control procedures will help maximize safety in high-traffic areas.

3. Converting from CCTV to Electro Scan

Electro Scan’s adaptive approach to condition assessment allows it to utilize standard CCTV camera equipment, including pre-existing cable and reels already included as part of the CCTV truck operation. Operators already familiar with the setup and operation of CCTV cameras should have no problem with the setup and operation of Electro Scan. In less than ten minutes, the TV truck can be converted to begin the Electro Scan process, and converted back to television inspection in the same time.

If the TV truck is already setup for television inspection, the first step is to simply unplug the TV camera and plug in the Electro Scan probe. Electro Scan’s probe is configured to each manufacturer’s cable and reel.

Since the cable and reel typically feed power to the CCTV camera and data back to the on-board computer, the operator must divert the data feed to the Electro Scan controller using a simple switchover box.

4. Assessing the Condition of the Pipe and Setting Up the Haul Line for the Electro Scan Probe

The Electro Scan vehicle is positioned at the upstream manhole. The manhole cover is then removed to assess pipe size and current flow rate.

A water jet truck with a jet hose is positioned at the downstream manhole. The jet hose serves two purposes: First, it will allow the funnel plug and probe to be pulled between the manholes of the pipe section tested. Second, the jet hose will provide sufficient water to surround the probe.

Electro Scan testing can be carried out in all conditions of sewer flow, from dry to fully surcharged pipes. It is important to assess the flow of water at both the upstream and downstream manhole to guide the correct setup for Electro Scanning. Even with constant flow monitoring of pipes, flow conditions are often unknown until you open the manhole cover.

- **Dry Condition - No Visual Water Level or Flow**

A dry pipe condition requires a sliding pipe funnel plug. The cone-shaped funnel plug helps contain the water surrounding the probe. The funnel plugs vary in size and can be used in pipes with diameters between 6 and 15 inches (150 and 300 mm). Using a sliding pipe funnel plug enables scanning to occur without completely filling the pipe with water over the length of the manhole-to-manhole section. The plug reduces the water head required to between 2 and 12 inches (50 and 400 mm). This considerably reduces the risk of backing up and flooding connected services.

Using the combination of an Electro Scan funnel plug and jet hose will ensure that a 3-6 foot long reservoir of water trails the funnel plug. This water allows electricity to conduct to the wall of the non-conductive pipe in order to scan the complete circumference of the pipe. Pipe defects or leaks will not be detected if pipe surfaces are not in contact with water.

- **Partially Filled Condition - Low to Moderate Flow**

If a pipe is partially full of water, the use of a jet hose as haul line and funnel plug is still appropriate. However, little if any water will need to be added to surround the probe.

An alternative to using a jet truck and funnel plug is to use a conventional sewer plug to block the line, allowing existing flow to fill the pipe segment before scanning.

- **Partially Filled Condition - Fast Flow**

In the event that the pipe is observed to have a high flow condition, it is recommended that a smaller funnel plug is used—at least one or two sizes smaller in diameter than the diameter of the pipe.

- **Full Condition**

If the pipe is already full of water, the funnel cone is not needed. The water jet truck, while still needed to pull the probe, will not need to spray additional water into the pipe.

- **Large Diameter Pipes**

For pipes greater than 15 inches in diameter with an existing flow level, it is not recommended to fill the pipe with any additional water.

Since Electro Scan finds all leaks where water is in contact with the pipe wall, Electro Scan will evaluate all...
pipes from the water line and below.

In the event of silt built-up on the bottom of the sewer, encrustations, roots, or fats, oil, and grease (FOG) -- all non-conductive materials -- Electro Scan’s low-voltage, high frequency current should still locate and measure defects that leak.

5. Grounding Rod and Reel

The grounding rod and reel are used to measure electricity emitted from the probe while scanning. These measurements are used to create the electric trace depicted on the scan graph. The grounding reel is also used to calibrate the probe before scanning by testing proper electrical output of the electrodes inside the probe.

The grounding rod should be placed in the ground within approximately 1,000 feet of the scanning location. The end of the cable on the grounding reel includes a clip that attaches to the grounding rod. Note that the grounding rod is not necessary. The grounding reel clip may be attached to any sufficient source of grounding such as a fire hydrant, telephone pole, stop sign, etc.

6. Downstream Prep

The water truck is positioned at the downstream manhole. A jet nozzle is attached to the end of the jet hose. The nozzle sprays water at very high pressure in order to propel the hose through the pipe to the upstream manhole. The hose, with nozzle, is inserted into the downstream manhole and jetted to the upstream manhole.

5.621 Equipment Setup

See Figure 15 for graphical depictions of Electro Scan equipment setup.

1. Retrieve Jet Hose and Connect Probe

Once the jet hose arrives at the upstream manhole, the hose is pulled from the manhole and the jet nozzle is detached. The funnel plug, if needed, is attached to the jet hose via a screw-on coupling.

The connection from the funnel plug to the probe is typically a 4-5 foot section of rope. This allows for easy insertion and removal of the probe in and out of the manhole. On the probe end of the rope, thick plastic cable ties are normally used to connect the rope to the probe. The use of cable ties allows the probe to disconnect safely in the event a blockage is encountered in the pipe.

2. Lower Funnel and Probe into Manhole

The funnel plug is inserted into the manhole first. Communication between the Electro Scan operator and jet truck operator, typically via 2-way radio, is needed to coordinate retraction of the hose. The funnel is guided into the desired pipe during hose retraction and stopped approximately 6 inches into the pipe. The probe is then lowered into the center of the manhole, pointed toward the desired pipe. Note that the probe is safe to touch, even if emitting the low-voltage signal.

Recall the probe must be surrounded by water to scan properly. If existing flow of water in the sewer pipe is insufficient, the jet truck operator will turn the water on. Normally water is added to the manhole until the water level reaches the top of the pipe to be scanned.

3. Software Setup

The Electro Scan truck is equipped with a computer, typically a laptop. Electro Scan software is installed on the computer to communicate with the probe, store data, and pass data to the cloud application on the Internet.

Prior to beginning a scan, the operator inputs information in the software such as manhole numbers and pipe diameter. Operators will often enter all manhole and pipe information needed prior to departure for the scan location. This saves time during actual scanning operations.

5.622 Performing Scan

See Figure 16 for graphical depictions of performing a scan.

1. Start Scan with Electro Scan software

The scan is initiated with the Electro Scan software. The probe then begins sending raw scan data to the computer.

The software displays an Operator’s Console that provides the operator with awareness of real-time scan conditions such as the amount of water surrounding the probe, how fast the probe is moving through the pipe, how much electric current is being received, and the distance traveled in the pipe. Based on this information, the operator is able to coordinate retraction speed and water flow with the jet truck operator (i.e. pull faster/slower, or water on/off).

2. Calibrate Total Current Reading (if needed)

After a scan is started, the Total Current received from the probe is displayed on the Operator’s Console (Figure 14). Depending on conditions, the Total Current may be too high or too low for ideal scanning. The ideal current range is typically 2500-3000. If needed, the potentiometer can be used to increase or decrease the Total Current reading as needed.

For example, a clay pipe surrounded by rain-soaked soil may initially give a high Total Current reading. The Operator uses the potentiometer to “dial down” the Total Current until it meets the ideal range.

3. Pull Probe to Downstream Manhole
The jet truck operator retracts the jet hose at a rate of 45-60 feet per minute. The Electro Scan operator monitors the Operator Console and directs the jet truck operator to change speed and/or water levels as needed. Unlike CCTV operations, no observations or data encoding is required. The probe is simply pulled through the pipe.

Once the probe reaches the center of the downstream manhole, the Electro Scan operator stops the scan with the software. The jet truck operator detaches the funnel plug from the probe. The probe is then retracted back through the pipe to the Electro Scan truck.

5.623 Equipment Removal and Cleanup

Once scanning is complete, all associated gear and tools should be placed back in trucks. Manhole covers are returned to manholes. Any traffic control materials should be recovered last.

If performing more scans, the water level in the jet truck should be checked to verify ample water is available.

5.624 Reporting

After a scan, if the Electro Scan truck is equipped with wireless Internet, the raw scan data can be instantly uploaded to the Electro Scan cloud application for processing and report generation. Otherwise, the scan can be uploaded later at the office where Internet is available.

The cloud application, called Critical Sewers®, processes the data and presents scan reports for users to view. The data may also be exported to third-party software applications including CCTV software, hydraulic modeling, asset management, and geographic information system (GIS) applications.

See Figure 17 for more information and screen shots of the cloud application, Critical Sewers®.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 43.

5.62A What are the two primary functions of the jet truck during Electro Scan operations?

5.62B What will Electro Scanning operations look like in a dry pipe condition compared to a full pipe condition? Specifically with regards to the water jet truck and funnel cone.

5.62C Approximately how close should the grounding rod be placed to scanning operations? Is the grounding rod itself actually needed?

5.62D Is it safe to touch the Electro Scan probe when it is powered?

5.62E During scanning, how does the Electro Scan operator know how fast the probe is moving through the pipe, or how much water is surrounding the probe?

5.62F Is the Electro Scan operator required to pause the scan to perform observations or encode data?
2. Setup Traffic Control to maximize safety

1. Use maps and other aids to plan scanning operations

3a. Operator Unplugs Main Cable Line from TV Camera

3b. Operator Plugs Main Cable Line Into Electro Scan Probe
4. Remove Manhole

5. Insert Grounding Stake

6a. Connect Jet Nozzle to Jet Hose

6b. Jet hose upstream
1a. Remove Jet Hose at Upstream Manhole

1b. Disconnect Jet Nozzle

1c. Connect Funnel Cone and Probe to Jet Hose

2. Position Probe at base of Manhole

3. Software Setup on Computer
1. **Operator's Console displayed after initiating scan.** Note the columns for Water Height, Probe Speed, Total Current, and Distance from Start.

2. **Calibrate Total Current Reading (if needed)**

   Depending on pipe material and soil conditions, the Total Current Reading may need to be adjusted with the potentiometer. “Dialing up” increases the Total Current, while “Dialing down” decreases the Total Current.

3. **Probe pulled downstream by jet truck**
Figure 17 - Reporting

Scan Summary view on Critical Sewers® cloud application

Table Explanations:

**Defect Count**
Number of Small, Medium, and Large defects, based on amplitude of electric current

**% of Defect Lengths**
The length of defects as a percentage of the pipe scan length. For example, if the total length of all defects was 20 feet for a 200-foot scan, the All Defects % of Scan Length would be 10%.

**GPM Summary**
Lists the amount of defect flow, in Gallons Per Minute, for defects categorized as Minor, Moderate, or Severe based on the GPM flow rate.

**Scan Graph**
The Scan Graph is the electric trace determined by the amount of electric current received by the grounding reel. The Small, Medium, and Large thresholds determine the categorization of a defect based on amplitude of current.

**Defect by Location in Pipe**
This table lists all defects found, their Grade (as Small, Medium, or Large), Start and End points within the pipe, length, GPM Flow, and GPM Defect Area.
5.63 Practical Applications

Gravity sewer mains are susceptible to a variety of defects that can allow extraneous water to enter, or exit, the lines often causing a broad range of environmental problems and contributing to Sanitary Sewer Overflows (SSOs). During Electro Scan analysis, the term ‘anomaly’ is often used, which means a deviation from the norm or desired condition. The most typical anomalies, or defects, are leaking joints, structural defects, and non-tight service lateral connections at or near the main sewer line. Electro Scan identifies all defects that have the potential for leakage under the right conditions.

Visual inspection techniques, such as CCTV, smoke testing, and dye flood testing share some common limitations: Unreliable location of leaks and inability to measure estimated water flow of defects. Electro Scan represents a new breed of assessment tool that overcomes the common challenges faced by sewer managers, operators, and engineers that have relied on visual inspection techniques.

While Electro Scan automatically finds defects that may not have been identified with the use of other techniques, some agencies may wish to re-review past television inspection videos in an effort to assist operators to better identify and catalog defects.

Due to its speed and accuracy, sewer agencies may opt to Electro Scan their sewers first, then have CCTV camera operators capture locations identified by Electro Scan to facilitate side-by-side comparisons and assessment. The combination of Electro Scan and CCTV allows for both wet weather and dry weather assessment of the pipe.

Since electro scan is a relatively new technique, the following section provides practical examples of how Electro Scan can be used and what the data may look like in particular situations.

5.630 Sewer Main Assessment

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter (Inches)</td>
<td>8</td>
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<tr>
<td>Scan Length (feet)</td>
<td>305</td>
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<tr>
<td>Location</td>
<td>Vancouver, WA</td>
</tr>
</tbody>
</table>

As shown in Figure 19, Electro Scan data divides defects into three categories – Small, Medium and Large - based on the amplitude of the electrical signal. The area under the curve of each defect in the scan graph is also considered when calculating the estimated gallons per minute (GPM) of each defect and the cumulative total defect flow for the pipe segment.

This particular pipe section has a large number of anomalies at joints throughout the entire segment, evident by the consistent signal spacing corresponding with the 3-foot joint lengths. Most of the signals between joints are small and therefore considered to have a very low potential for leakage.

It is interesting to note that one of the larger Electro Scan signals at 151 LF had no defect call outs on the corresponding PACP CCTV report.

Since electro scan is a relatively new technique, the following section provides practical examples of how Electro Scan can be used and what the data may look like in particular situations.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 43.

5.63A What are some limitations of visual inspection techniques as compared to Electro Scan?

5.63B If you were head of a sewer agency and had both CCTV and Electro Scan equipment, what would be an efficient way to combine the two methods?
Figure 19 - Sample Scan Graph with highlighted defect compared to CCTV (No Callout). Notice the regularly-spaced defects throughout the scan. These indicate problems at joint locations. Joint defects can be very difficult for CCTV operators to see, as shown in the highlighted area where Electro Scan found a significant defect that CCTV failed to locate.
5.631 New Development Sewer Assessment

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>PVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter (inches)</td>
<td>8</td>
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<tr>
<td>Scan Length (feet)</td>
<td>293</td>
</tr>
<tr>
<td>Location</td>
<td>City of Southlake, TX</td>
</tr>
</tbody>
</table>

The City of Southlake, Texas was experiencing high sewer system flows during periods of rainfall in a new PVC system, causing backups and surcharging of sewers immediately downstream of a new development. The system had been inspected by CCTV but not accepted by the city.

As shown in Figure 20, Electro Scan was used to inspect 2,803 LF of total sewer main in a new subdivision detecting a number of defects totaling an estimated leakage rate of 30 GPM, or 43,000 gallons per day (GPD) assuming one foot of groundwater above the top of the pipe.

Of the 12 pipes scanned, only 2 pipes were free of defects; the remaining 10 had between 1 and 15 identified defects, each. Nearly 84% of the total possible infiltration for the entire subdivision could be attributed to 3 of the 12 pipe segments. In other words, with a combined total length of 884 LF for those 3 pipe segments, 84% of the possible infiltration was coming from 32% of the sewer mains in this subdivision.

The graphic below is an example of an Electro Scan joint anomaly at 118 LF in one of the pipe segments. This leak, estimated by Electro Scan to have defect flow 0.9 GPM, this defect was not identified as defective during the original CCTV inspection.
5.632 Post-CIPP Assessment

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>CIPP</th>
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<tbody>
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<td>Diameter (inches)</td>
<td>8</td>
</tr>
<tr>
<td>Scan Length (feet)</td>
<td>293</td>
</tr>
<tr>
<td>Location</td>
<td>Miami-Dade Sewer, TX</td>
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</tbody>
</table>

Traditionally, CCTV has been used as a primary tool to inspect post-rehabilitation projects, such as relining, as shown in a typical CIPP installation and assessment shown in Figure 21. However, since the objective is to deliver a leak-free project, other available methods should be used to ensure that projects are delivered without built-in sources of infiltration. Water or air pressure tests may be utilized, though if segments fail the pressure tests, the specific locations of defects are not defined by these tests.

As a non-conductive material, recently lined pipes should not allow any electrical current to escape from the inside of a pipe. As there are no joints, the two greatest weaknesses of cured in-place pipe (CIPP) and other lining materials are either at the service re-connection or any material defect in the liner. One of the benefits of Electro Scan testing is the repetitive trace patterns that assists the user in defining the nature and type of defects.

As recommended in ASTM F2550-13, separate scanning tests should be taken before and after any pipe repair, relining, or renewal activity to compare electrode current values and to determine if any visual defects were missed during initial examination. Electro Scans should be compared to CCTV to calibrate defect locations with service connections and other pipe features.

Figure 21 - Typical post-rehabilitation steps after inversion of cured in place lining.

In Europe, many sewer contractors conduct pressure tests for post-CIPP sewers mains, prior to inversion (i.e. thermosetting or curing of the liner bag) and prior to re-connection of each lateral, to determine if there are any leaks or defects. While pressure testing may provide a PASS/FAIL of the entire segment, its inability to locate specific locations inside the pipe, may miss any post-CIPP deficiencies.

As shown in Figure 22a, the electro scanning of a post-CIPP sewer should have ZERO electrical current (i.e. a straight-line current reading) along the entire length of the pipe. Since most CIPP liners and coatings are made of non-conductive (i.e. without metal) materials, unless there is any opening, possibly due to a cut, tear, over-heated patch, or defective service re-connection, no electrical current or spikes should be seen.

As shown in Figure 22b, electro scanning of this post-CIPP sewer detected three (3) major defects -- each located at service re-connections that did not have either a top-hat or t-liner installation. For recently installed CIPP projects, it is recommended that defect flows be determined BEFORE and AFTER CIPP (or other rehabilitation activities, like point repairs) to determine whether the project should be accepted, or not.

In 2014, a major metropolitan sewer agency conducted a 70,000 ft electro scan project that surveyed 370 sewer mains, including forty-nine (49) pipe segments that were lined with CIPP in 2000 -- 14 years old. Surveyed by an experienced sewer contractor with the project overseen by a nationally-known engineering firm, one hundred percent (100%) of all CIPP pipes showed defect flows. More important, twenty (20) sewer mains or 40% of lined pipes surveyed, showed estimated defect flows of 10,000 gallons per day (GPD).

Why would CIPP show such high levels of defect flows, much sooner then their expected useful life? Since CIPP may not create a total sealed system. Sewer agencies traditionally assume that resin liners bond to host pipe; however, Fats, Oils, and Grease (FOG) in the sewer line and other lubricants to move the resin through a pipe, allow an annular space to be created as part of most CIPP projects, as shown in Figure 23. Shrinkage of the resin due to thermal expansion/contraction (i.e. after polymerization of the resin), contributes to the annular space between the liner and the host pipe (Burkhardt, Hüsgen, Kalwa, Pötsch, Schwenzer, 2011; Rahaim, 2010). Since CIPP represents a pipe-within-a pipe, operators should increase the electro scan current using the Electro Scan potentiometer.
Figure 22 - Electro scanning of a recent CIPP project. Figure 18a shows the typical electric current reading of a ‘GOOD’ CIPP project, with no defect flows or spikes, while Figure 18b shows a ‘BAD’ CIPP project with several large defect flows that occurred at each of the service re-connections.

22a - Post-CIPP Electro Scan with No Defects

22b - Actual Post-CIPP Electro Scan - Defects suggest improper installation

Figure 23 - While many pipe lining methods can navigate through major pipe fractures and failures, pathways of defect flow still exist. If ground water passages are not filled with composite matter, such as grout, then water will percolate through the soil & flow between the liner & host pipe, seeping into poorly connected services, often returning the sewer main or lateral to create defect flows that may return to pre-rehabilitation levels. A typical liner defect is shown below.
Post-CIPP Assessment with Top Hats

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>Vitrified Clay Pipe (VCP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter (inches)</td>
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<td>Scan Length (feet)</td>
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<tr>
<td>Location</td>
<td>Southern Nevada, NV</td>
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</table>

A Top Hat is resin-impregnated fiberglass, used to seal the connection between a lateral and main sewer pipe. The “brim” of the Top Hat circles the area around the lateral connection inside the main sewer pipe (Figure 24).

A recently lined CIPP project also included 9 Top Hats at each service connection (lateral). Electro Scan found each Top Hat to have small or medium defects (Figure 25).

Note that during Electro Scan testing, 12 to 18 inches of water enters the sewer laterals as the probe passes by. This enables Electro Scan to test lateral connection. If a defect is found at a lateral, additional evaluation may be required to determine if the defect exists at the point of connection to the main line or up the lateral past the end of the Top Hat.

Figure 24 - Top Hat liner
Source: Water Environment Research Foundation

Figure 25 - Electro Scan of Post-CIPP with Top Hats

Light-Colored Numbered Circles Indicates Anomalies With an Estimated Potential Leak
**5.633 Point Repair Assessment**

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>Vitrified Clay Pipe (VCP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter (inches)</td>
<td>8</td>
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<tr>
<td>Scan Length (feet)</td>
<td>342 &amp; 178</td>
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<tr>
<td>Location</td>
<td>Grand Strand, SC</td>
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</table>

One benefit of Electro Scan testing is the ability to evaluate the effectiveness of point repairs. The most common pipe used in sanitary sewer point repairs is PVC. The most common connector used at the ends of point repairs is the Fernco coupling. Some point repairs have been made using internal CIPP point repair liners.

As shown in the first scan graph (Figure 26), the PVC point repair is easily identifiable by the zero current trace between 206.5 and 218 LF. This is true because plastic is much less conductive than the host pipe, which is normally VCP or concrete. Since there is no scan signal at the ends of the point repair or at any point in between, this would be considered an effective repair with no potential for leakage.

In contrast, the second scan (Figure 27) depicts an internal CIP point repair starting at 146 LF with a very large signal at the downstream end near 150 LF. This large signal, which has a base almost 2 feet long, is directly below a drainage creek. As a result, with the head of water above the pipe, the estimated potential rate of infiltration is very high. This type of leak in this location has a very high potential for washout of bedding and backfill, and could result in pipe collapse in the future.

The data indicates the end seal was either not made properly during construction or has become loose over time as a result of variations in the underground environment. The material and condition of the point repair pipe can be verified by CCTV inspection but loose point repair end couplings often do not show up as defects during visual inspection.

---

![Figure 26 - PVC point repair identifiable between 206.5 and 218 Linear Feet (LF)]

![Figure 27 - Faulty CIP Point Repair near 150 Linear Feet (LF)]
5.634  Sewer Siphon Assessment

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>Asbestos Cement</th>
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</thead>
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<tr>
<td>Diameter (inches)</td>
<td>15</td>
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<tr>
<td>Scan Length (feet)</td>
<td>136</td>
</tr>
<tr>
<td>Location</td>
<td>Santa Rosa, CA</td>
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</table>

Sewer siphons (Figure 28 & 29) often trap and maintain water levels at the base of the pipe profile making their inspection an ideal application for Electro Scan technology.

The scan (Figure 30) shows a low level of “noise” throughout the segment, which is typical of concrete pipe. If the amplitude of the noise were larger it would be an indication of corrosion of the pipe material, which is a structure and leakage concern.

There were 26 anomalies that exceeded the Small threshold and one which exceeded the Medium threshold representing about 15 GPM, or 21,500 gallons per day, of infiltration potential assuming one foot of head above the pipe. See the Defect Summary (Figure 31).

Although major structural anomalies are not evident at this time, points of infiltration can result in wash out of bedding and backfill over time. If the pipe is not lined to mitigate infiltration, it should be monitored for ground subsidence, sinkholes, or indications of excessive soil or backfill material downstream. The pipe should also be scanned every 3 to 5 years to check for increased leakage or structural deterioration.

---

**Figure 28 - 1964 Side Drawing of Sewer Siphon**

**Figure 29 - Sewer Siphon. Manhole traverses underneath creek bed.**

**Figure 30 - Electro Scan of Sewer Siphon**

**Figure 31 - Electro Scan Defect Count and Gallons Per Minute (GPM) Summary Information**
5.635 Plastic Pipe Lining Assessment

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>PVC</th>
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</thead>
<tbody>
<tr>
<td>Diameter (inches)</td>
<td>4</td>
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<tr>
<td>Scan Length (feet)</td>
<td>147</td>
</tr>
<tr>
<td>Location</td>
<td>Richmond, CA</td>
</tr>
</tbody>
</table>

Plastic pipe and liners are extremely good insulators which do not allow electric current to pass from the pipe to the surrounding soil unless there is a defect present. With ground surface areas similar to this one, which is totally paved (Figure 32), the grounding cable can be attached to any metallic post, guy wire anchor, or similar structure to achieve completion of the circuit.

In this case, CCTV inspection did not detect any defects that could be responsible for the failure of the pressure test performed on the segment. The scan graph (Figure 33) shows that the pipe segment has one small defect near the start of the scan and multiple defects near the end of the scan, one of which spans several feet. This data gives the owner, engineer, and contractor clear guidance on where to look to address the pressure test failure.

Figure 32 - Scanning in paved area

Figure 33 - Scan of PVC pipe.
A 66-inch interceptor sewer in the Salt Lake City Public Utilities System had recently been lined with a Spiral Wound Rib Lok High Density Polyethylene (HDPE) liner in an effort to reduce infiltration and assure the structural integrity of the line.

Spiral Wound is a pipe lining method that covers the pipe wall with material, often HDPE or PVC, by “winding” it into the pipe. The edges are normally connected with a tongue and groove system.

After installation of a Spiral Wound pipe (Figure 34), the pipe owner and engineers detected high rates of infiltration after lining, verified by both flow monitoring and visual inspection during periods of high groundwater. An Electro Scan analysis was performed, with the pipe running three-quarter to one-third full, to gain more insight into the condition of the pipe and liner.

One scan segment (Figure 35) represents an estimated 14.9 GPM at a point where the corresponding CCTV inspection results showed a gushing leak. The second scan segment has an estimated leakage rate of 15.8 GPM at a point where no visible defect was identified by CCTV. The third scan (Figure 36) shows significant anomalies at 50 and 120 LF into the pipe segment. The GPM rates are based on 15 feet of head above the pipe (information provided by the owner’s consultant).

The total estimated leakage rate for the entire segment is 202 GPM or 290,500 gallons per day, for the one-third of the wetted perimeter tested. If the leakage rates are consistent throughout the entire circumference of the pipe near the defects, the potential leakage rate would be roughly three times the above figures or 600 GPM and 871,500 gallons per day. These rates actually compared well with the consultants estimates from flow monitoring studies.
Figure 35 - Close-up view of two defects identified by Electro Scan, and the corresponding CCTV inspection.

Figure 36 - Scan graph showing defects of a line segment. Two of the defects surpass the Large Threshold for Defect Current.
**5.637 Pre- and Post Grout Assessment**

<table>
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<tr>
<th>Pipe Material</th>
<th>Vitrified Clay Pipe (VCP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter (Inches)</td>
<td>8</td>
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<td>Scan Length (feet)</td>
<td>217</td>
</tr>
<tr>
<td>Location</td>
<td>Hickory Hills, IL</td>
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</table>

Electro Scan is ideal for identifying the two most common grouted defects in gravity wastewater collection lines: joints and service lateral connections that are not water tight (Figure 37).

One of the benefits of Electro Scan testing is the repetitive patterns that assist the user in defining the nature and type of defects. The first segment (Figure 38) scan below has a large number of anomalies at joints throughout the entire segment, evident by the consistent signal spacing corresponding with the 5-foot joint lengths. Signals in between joints are either leaking service lateral connections or structural defects.

The grouts most commonly used in gravity sewers are hydrophilic, meaning they must remain moist to maintain their integrity. The scan graph obtained after grout was applied shows the highly conductive nature of the installed material.

The second set of scan graphs (Figure 39) display signals that are very similar with a slight increase in conductance at some of the grouted joints.

![Figure 38 - Scan graphs of same pipe segment before and after grouting of joints](image-url)
Figure 39 - Scan graphs of same pipe segment before and after grouting of joints
Trenchless CIPP pipe liners are extremely good insulators which do not allow electric current to pass from the pipe to the surrounding soil unless there is a defect present.

The scan graph (Figure 40) shows a successfully lined segment with one large signal at the 195 to 196 LF point. This defective service lateral connection was verified by CCTV inspection (Figure 41). Small signals, like those at the 110 and 220 LF points, are not uncommon in post-CIPP scans. These small signals may represent minor defects in the liner but they are so small that they are not considered to be problematic in most cases.

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>Cured In Place Pipe (CIPP)</th>
</tr>
</thead>
</table>
| Diameter (inches) | 8 |}

Figure 40 - CCTV of Defective Lateral

Figure 41 - Scan Indicating Large Defect at Service Lateral Connection
5.639 Asbestos Cement Pipe Assessment

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>Asbestos Cement</th>
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<tbody>
<tr>
<td>Diameter (inches)</td>
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<tr>
<td>Location</td>
<td>Christchurch, New Zealand</td>
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</tbody>
</table>

Electro Scan has been widely accepted as a leak detection and liner assessment tool. Its ability to provide valuable data on corrosion in asbestos cement (Figure 42) and concrete pipe is not as well known.

Concrete-based pipes used in gravity sewer applications are susceptible to hydrogen sulfide deterioration, impact from industrial chemicals, scouring, and calcification over time. Scans of cement lines yield valuable information about specific defects, especially large ones, but the baseline scans typically display significantly more “noise” throughout the pipe segments.

The scan graphs in Figure 40 give a clear picture of the various levels of corrosion present in different pipe segments. The amplitude of these corrosion traces vary significantly based on the severity of deterioration present. Severely, and even moderately, corroded pipe segments not only have the potential for leakage, but can be in danger of structural failure.

Figure 42 - Asbestos Cement Pipe

![Figure 42 - Asbestos Cement Pipe](image)

Figure 43 - Scan Traces Indicating Varying Levels of Corrosion

![Figure 43 - Scan Traces Indicating Varying Levels of Corrosion](image)
5.64  Sewer Lateral Assessments Using Electro Scan

Many communities have undertaken a holistic approach to their sanitary sewer network with the goal of eliminating sources of infiltration that may be attributed to service laterals.

Electro Scan's adaptive products for CCTV trucks allow sewer utilities and contractors to scan pipe diameters from 8-inches in diameter and greater—typically sewer mains. For smaller pipes such as service laterals, a manually-fed probe reel, similar to reels offered for televising small diameter pipes, allows pipes from 3 - 8 inches (76-150mm) in diameter to be Electro Scanned.

5.640 Equipment and Staffing Required for Electro Scanning Laterals

Electro Scanning of laterals may be performed by a single person. The equipment required is similar to that of Electro Scan for sewer mains and includes (See Figure 44):

- a controlled voltage source
- the probe
- an insulated cable to connect the probe to the voltage source and move the probe through the pipe
- a system to measure the position of the probe in the pipe
- a system to measure the focused current
- a system to measure the electrical current flowing through all three electrodes in the probe, called the total current
- a surface electrode
- a service lateral plug
- a smartphone with Electro Scan application installed
- Bluetooth® capability to transfer data from probe to smartphone
- a field printer (optional)

5.641 Electro Scan Operation with Sewer Laterals

Operation of Electro Scan equipment for sewer laterals is similar to that of sewer mains. The overall concept of measuring variation of electric current to find defects within the pipe is the same.

Instead of a truck with a large cable reel system attached, sewer laterals can be assessed with a small, hand-operated cable reel system. The cable reel attaches to the Electro Scan probe and includes an onboard Bluetooth® module that allows communication with the operator's smartphone.

The Electro Scan software application must be installed on the smartphone. The application collects data from the probe through the Bluetooth® connection, and forwards the data to a cloud application, Critical Sewers®.

The general flow of operations is as follows:

1. Open and setup Electro Scan smartphone application. Enter data, such as pipe information, as needed. Pair Bluetooth® with reel containing the Bluetooth® module.
2. Calibrate Electro Scan probe.
4. Plug the lateral with the inflatable sewer lateral plug. This is done by unreeling the plug into the service lateral, pushing the plug to the end of the pipe segment. The plug is then inflated (typically with a bicycle pump) to fill the pipe. This creates a block that prevents water from passing through the lateral to the sewer main.
5. Fill lateral with water.
6. Manually feed the probe into the lateral until reaching the inflated plug.
7. Activate the scan through the smartphone application and begin pulling the probe back through the pipe. Scan data will be sent to the smartphone via Bluetooth®.
8. When the scan is complete, the Electro Scan smartphone application will send the data to the Electro Scan cloud application for processing. The processed data may be viewed on the smartphone application or via the web. If equipped with a field printer, the scan results can be printed.

See Figure 45 for graphical depictions of performing a scan.

QUESTIONS

Write your answers in a notebook and then compare your answers with those on page 45.

5.64A  At a minimum, how many workers are required to perform Electro Scanning of laterals? Is a CCTV truck required?

5.64B  What component of Electro Scan lateral operations both communicates with the probe and sends data to the cloud application?
Figure 44 - Electro Scan Sewer Lateral Equipment

Probe Reel - scans service lateral for defects

Service Lateral Plug - used to plug pipe in order to subsequently fill pipe with water

Grounding/Calibration Reel and Stake - used to calibrate probe and, during operation, detects electric current emitted from probe

Field Printer - used to print results of scan
Figure 45 - Operations Highlights for Electro Scan of Sewer Laterals

1. Open and setup Electro Scan Smartphone Application

2, 3. After probe calibration, place Grounding Stake into ground

4, 5. Insert Inflatable Plug to plug the lateral, then fill lateral with water

6. Insert Probe
7. Start scan on smartphone and slowly retract probe

8. Scan results may be printed on Field Printer

9. A detailed report of scan results may be viewed via the Critical Sewers® cloud application on the web
5.642 Practical Application

5.6420 Sewer Lateral Assessment #1

<table>
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<td>Location</td>
<td>Williamsburg, VA</td>
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</table>

The Electro Scan push probe system (Figure 46) was used to inspect several service laterals in the James City Service Authority system. The scan graph below (Figure 47) shows a PVC lateral that is mostly defect-free, except for two small signals near the end of the 52-foot scan. Push camera CCTV inspection pictures verified the existence of a faulty cleanout connection at this location. This result is typical of the data obtained from PVC lateral inspections – a flat scan with few (if any) defects.

Figure 46 - Electro Scanning a Sewer Lateral from a Cleanout

Figure 47 - Electro Scan Sewer Lateral Electro Scan Defect Comparison to CCTV.
5.6421 Sewer Lateral Assessment #2

<table>
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The scan graph below (Figure 48) is an example of an older VCP service lateral with significant defects throughout two-thirds of its length. The graph is shown side-by-side with CCTV results from a push camera inspection. As is often the case, Electro Scan found several defects that were not identified during the visual inspection.

This scan was part of a project that included scanning of 19 service laterals in a housing subdivision. The defect table (Figure 49) shows the results of the 19 scans.

Most of the laterals in the table have many Small defects. The Medium and Large defects are more concentrated in a portion of the sample. In this case, 50% of the total GPM estimated is concentrated in 5 of the 19 scanned segments.

Since the GPM estimates are based on both the amplitude and width of the defect signals, the estimated GPM totals for different laterals vary significantly and may not correlate in an obvious way to the number and size of signals. For example, a defect categorized as Large, based on the electric current reading, may have a lower GPM estimate than a defect categorized as Small. This may occur because the area under the scan graph curve for the Small defect may be larger than the area under the curve for the Large defect.

Figure 48 - Electro Scan of a sewer lateral side-by-side with CCTV report
### Figure 49 - Summary Report of 19 Sewer Lateral Scans

<table>
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<th>Rank</th>
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<th>Large</th>
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<th>Large</th>
<th>Joint</th>
<th>Other</th>
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### Figure 50 - Detail Report of 27 Sewer Lateral Scans Compared to CCTV Inspections
DISCUSSION AND REVIEW QUESTIONS
Chapter 5. INSPECTING AND TESTING COLLECTION SYSTEMS

(Lesson 6 of 6 Lessons)

Write the answers to these questions in your notebook before continuing. The question numbering continues from Lesson 5.

24. What are some advantages of Electro Scan over other sewer assessment methods such as CCTV, smoke testing, dye testing, or pressure testing?

25. Is it easy to switch from CCTV to Electro Scan?

26. What are some limitations of Electro Scan?
ANSWERS TO QUESTIONS IN LESSON 6

5.60A Electro Scan emits a low-voltage, high-frequency electric current inside the pipe. The current travels through the water that surrounds the probe, to the non-conductive walls of the pipe. If a defect with leak potential exists, the current will pass through and be detected by the Electro Scan equipment on the surface.

5.60B Electro Scan may be used in all weather conditions.

5.60C The amount of Defect Flow is based on the area under the curve of the electric current reading (trace). It is possible to have a low-amplitude reading span a wide distance, and a high-amplitude reading span a very short distance. The area under the curve of the low-amplitude reading can be much greater than the area of the high-amplitude reading.

5.60D Electro scan can be used to: assess sewer mains and laterals suspected of infiltration; assess new pipes and service connections; assess pipes with conflicting or no CCTV callouts; assess siphons; assess sewer mains under rivers or streams; certify lining projects; pre- and post-grout assessment; perform Sewer Survey Evaluation Studies; and assess large interceptors.

5.62A The jet truck jet hose is used to pull the Electro Scan probe through the pipe. The jet truck also provides water, if needed, to surround the probe.

5.62B In a dry pipe condition, an appropriately sized funnel cone is needed along with water provided by the jet truck to surround the probe. In a pipe already full of water, the funnel cone is not required and the water jet truck will not have to provide water.

5.62C The grounding rod should be placed within 1000 feet of the scanning location. The rod itself is not needed. Instead, the grounding reel clip may be attached to any source of grounding, such as stop signs, telephone poles, or fire hydrants.

5.62D Yes, the probe is safe to touch. The low-voltage current is approximately 10 volts, or the equivalent of 6 AA batteries.

5.62E The Electro Scan software displays an Operator Console during scanning that provides real-time information such as probe speed, water level, and distance traveled through the pipe.

5.62F No, the probe is pulled through the pipe at 45 to 60 feet per minute and does not require the operator to perform observations or enter data during scanning.

DISCUSSION AND REVIEW QUESTIONS

24. Compared to other methods of sewer assessment, Electro Scan is able to accurately locate and objectively quantify defects that have the potential to leak. Electro Scan is also objective and consistent, providing repeatable data regardless of operator. CCTV can often miss defects found by Electro Scan, and different CCTV operators may interpret and categorize defects in different ways. Smoke, dye, and pressure testing can indicate the existence of leaks, but cannot accurately pinpoint the location, or provide a quantifiable estimate of the defect size.

25. Yes, the adaptive design of Electro Scan allows equipment to be switched from CCTV operations to Electro Scan operations in less than ten minutes. The

SUGGESTED ANSWERS
scanning process is also simple and does not require the level of training needed to operate a CCTV camera.

26. Electro Scan is unable to specify the exact type of defect. For example, root intrusion into the pipe that creates a potential for leaking will be detected by Electro Scan, but would require CCTV to determine the root cause.
Chapter 5. INSPECTING AND TESTING COLLECTION SYSTEMS

AMPLITUDE
As related to an Electro Scan electric trace, the height of the signal for a wave of electric current.

CALCIFICATION
A buildup of calcium deposits on the wall of a pipe. Over time, heavy calcification can significantly restrict flow.

CIPP
Cured-in-Place Pipe (CIPP) is a trenchless pipe rehabilitation method that uses a resin-saturated felt material to line the walls of an existing pipe.

ELECTRODE
A conductor that emits an electric current.

ENCRUSTATION
Layers of salt deposits, or other sediments, that adhere to the pipe wall.

EXFILTRATION
Fluid exiting a pipe through defects in the pipe wall.

FERNCO COUPLING
A type of coupling used to connect two pipe segments together.

GROUT
Material used to fill gaps within a pipe wall, or to seal a joint connecting two pipes.

IMPREGNATE
To saturate or fill with. As used here, to saturate felt with a resin as part of the CIPP process.

INFILTRATION
Water entering a pipe through defects in the pipe wall. Similar, but opposite, of exfiltration.

INTERCEPTOR
Typically a large diameter pipe that acts as a main “trunk” of a sewer system. The interceptor is fed from sewer mains, which are fed by sewer laterals.

LATERAL
Typically a small diameter pipe that connects to a main sewer line. For example, the sewer pipe connecting a residential home to the main sewer line is a lateral. Also referred to as a service lateral.

PVC
Polyvinyl Chloride (PVC) is a polymer often used to construct a variety of pipes, including sewer pipes.

SCOURING
Abrasion of the service, often from rubbing with chemicals.

SERVICE CONNECTION
See LATERAL.

SIPHON
Part of a sewer system used to go under obstructions such as roads or tunnels. The siphon dips under the obstruction and connects to the sewer system on either side. The water is pulled by suction from the downstream end.