EFFECTIVE IDENTIFICATION OF SERVICE LINE DEFECTS WITH ELECTRO-SCAN TECHNOLOGY

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ABSTRACT

Defective service lines in wastewater collection systems have been known to be sources of rainfall dependent infiltration (RDI) and exfiltration. Prior methods of testing service lines for these kinds of defects included closed circuit television inspection (CCTV) in conjunction with dyed water testing, and smoke testing. Smoke testing is effective in finding inflow leaks. CCTV inspection is effective in defining structural problems, but not highly effective in defining specific leak points. This led to a need for a more cost-effective, time saving system to evaluate leaks in service lines made of non-ferrous pipes.

The introduction of electro-scan technology in the form of the FELL-41 (focused electrode leak locator) system helped in accomplishing the task of inspecting wastewater mains from manholes for pipe sizes that were a minimum of 6-in. in diameter. A similar analysis in service lines was not possible due to the larger size of the FELL sonde, the device that enters the wastewater line. This influenced Metrotech Corporation to redesign the sonde to cater to smaller wastewater lines like service lines. The new service line sonde is called the FELL-21, and is effective in testing pipes in the 3-in. to 6-in. pipe diameter range with access through cleanouts.

KEYWORDS

Sewer System Evaluation Survey (SSES); Focused Electrode Leak Locator; Infiltration/Inflow (I/I); Groundwater Infiltration; Exfiltration; Sonde; Electrode current, Service Lines.

INTRODUCTION

FELL 21 – A Leak Detection Tool for Service Lines

Leak Detection for service lines as part of SSES studies are commonly accomplished using CCTV, and smoke testing. These methods helped to quantify infiltration/inflow into the collection system. These techniques worked well as far as the conditions for proper inspection of the service lines were present. Historically, we have had to wait for long periods of time (even years) for high groundwater conditions identified during night flow isolation to return for CCTV inspection to evaluate leaks. Television inspection of the line “dry” provides little information on these defects.

The FELL-21 system for testing service lines was developed to carry out testing under a variety of conditions. Electro-Scan testing can be accomplished under all weather and groundwater conditions with accurate, repeatable results.

ADVANTAGES

The FELL system allows us to acquire accurate results on leak related anomalies in the case of service lines. Structural anomalies can also be identified. Prioritization of service line segments can be readily performed to reduce costs and capitalize on leak reduction. It can also be used as an acceptance-testing tool to verify that leaks have in fact been successfully eliminated.

Testing for leaks using CCTV would not easily reveal exfiltration defects merely by observation. In case of the FELL system, all leaking anomalies are located on the FELL plot as a spike in the current trace and hence exfiltration defects can be located. This is a major breakthrough for FELL over conventional methods.

The sonde emits an electronic signal that measures the level of conductance, at any point, to a ground stake above the pipe. FELL analysis facilitates the location of structural anomalies such as corrosion and multiple structural defects such as cracks. Using this technology, areas of concrete pipe that have corroded due to the impacts of hydrogen sulfide can be located. Spikes in the electrode current on the output plot generally indicate the presence of corrosion.

Due to the conductance of the sonde with respect to the ground electrode, changes in the conductance generally indicate a change in pipe material in the service line.

THE TECHNOLOGY BEHIND SONDE TESTING

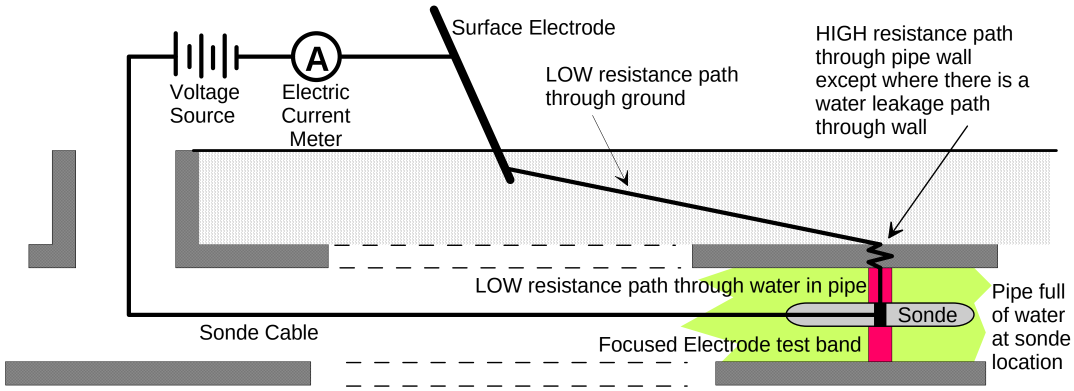
Electro-scan testing is based on the variation of electric current flow through the sewer pipe wall to locate anomalies that are potential water leakage paths into or out of the sewer pipe. Sewer pipe that are generally constructed from materials such as PVC, clay, concrete are materials of low electrical conductance. Hence the logic follows that if a pipe leaks water, it will leak also electrical current. Infiltration does not need to occur at the time of the test for the anomaly to be located.

The setup consists of four main components: The Sonde, the Surface Electrode, a Current Processor, and a Computer. The Sonde in itself is comprised of a three-electrode array with two electrodes surrounding a central electrode. This setup enables the electric fields of the outer electrodes to force the electric field of the middle electrode to be focused in the form of a disc. The positioning of the electrodes is such that the disc radius is perpendicular to the longitudinal axis of the sonde that is present at the center of the disc.

The electro-scan test is carried out by applying an electric voltage between an electrode in the pipe, called a sonde, and an electrode on the surface, which is usually a metal stake driven into the ground. A simplified electrical circuit for this procedure is shown in

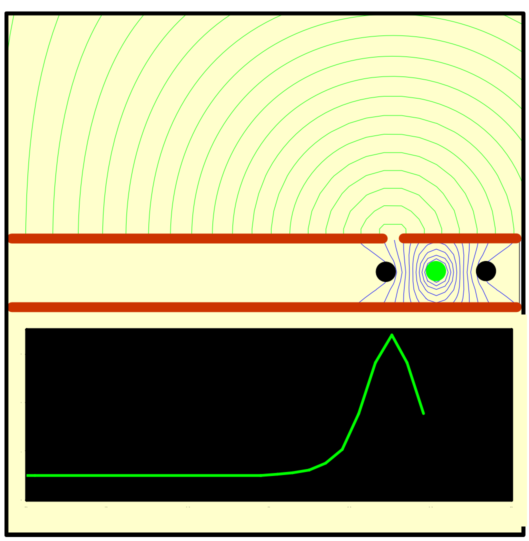
Figure 1. The water in the pipe is at a level that ensures that the pipe is full at the sonde location. The electrical resistance of the current path between the sonde and the surface electrode is very low except for through the pipe wall. The high electrical resistance of the pipe wall prevents electrical current from flowing between the two electrodes unless there is a defect in the pipe, for example, a crack.

Figure 1. Electro-Scan Electrical Schematic



The surface electrode receives the electrode current that escapes the pipe. The computer that is connected to the surface electrode receives this current and the software plots the distance traveled by the sonde on the x-axis and the intensity of the current on the y-axis. The lowest unbroken horizontal line on the current trace plot is called the Threshold Limit. This is the limit of current above which an anomaly is considered to be present. This is the limit that sets the smaller insignificant anomalies/defects from more severe ones. A severe defect will be associated with a higher current intensity and subsequently have a larger vertical amplitude in the current trace plot.

Figure 2. Focused Electrode Current in a Pipe



Pipes are generally low in conductivity (high resistance); hence the focused current from the sonde tends to remain inside the pipe until a point of high conductivity (low resistance), like a crack, an open joint, or a segment of concrete pipe that has been corroded by hydrogen sulfide. Figure 2 displays this phenomenon in the schematic.

Figure 3. FELL-21 System Equipment

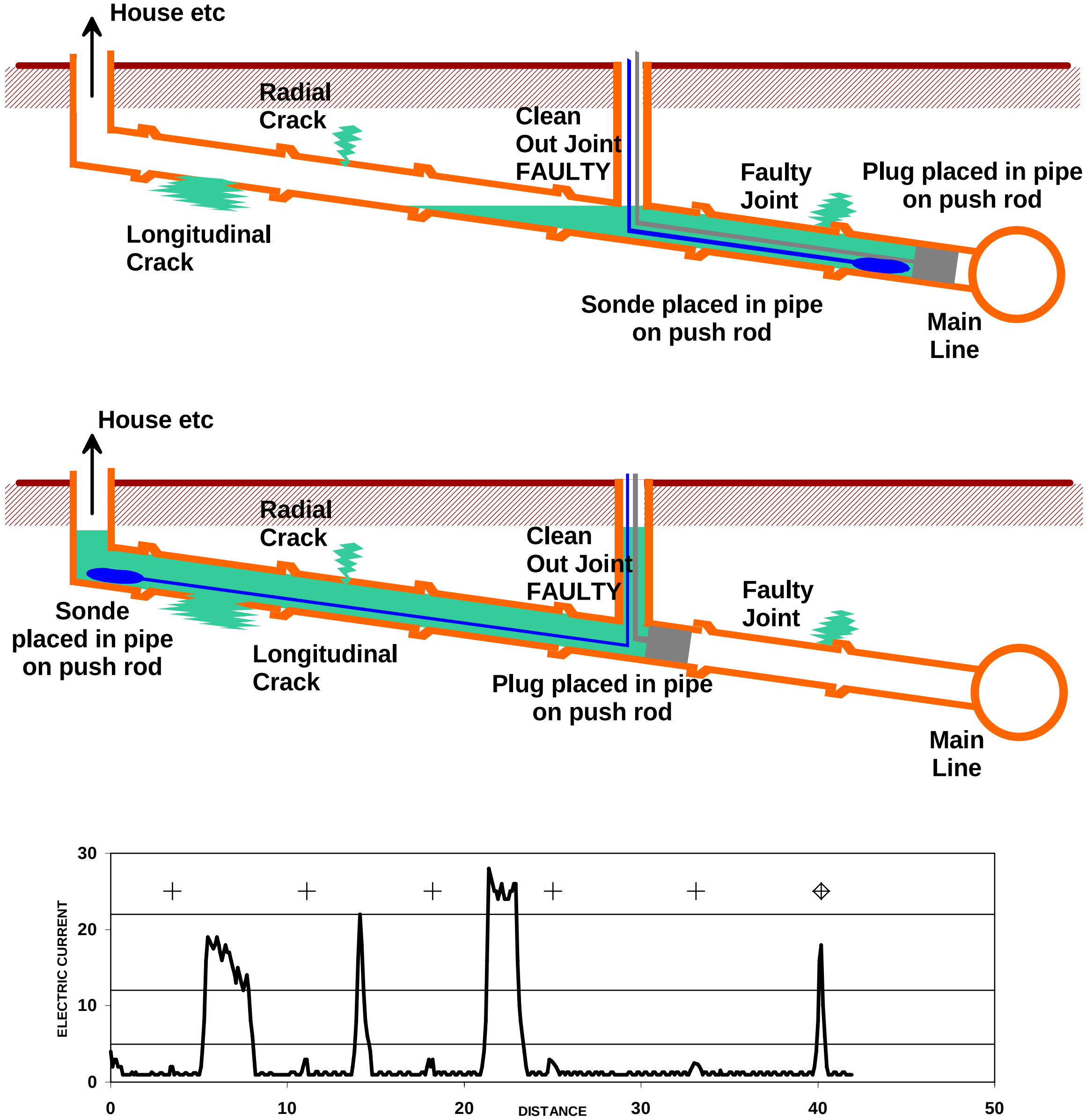
THE FELL 21 SYSTEM

The FELL-21 electro-scan system was designed for testing sewer services from the cleanout without the need to access the service from the mainline. The sonde utilized in this case is 50 mm(2 in.) in diameter with a length of 150 mm (6 in.). The sonde is attached to a push rod.

The testing begins with the placement of a pneumatic plug close to the service-main connection using a push rod. The service is then filled with enough water to cover the service-main connection. The surface electrode is then placed in the ground and the sonde is pushed into the pipe. The sonde is pulled out of the pipe at the rate of approximately 30 ft/min.). When the middle of the sonde comes within 20 to 30 mm of a defect in the pipe wall the electric current through the pipe wall increases, attaining a maximum value when the center of the sonde is radially aligned with the defect. The greater the maximum value of the current trace the larger the pipe defect. The sonde current is recorded in real time as a current trace on a PDA screen.

The upstream section of the service is also tested similarly.

Figure 4. FELL-21 Testing and Corresponding Electro-Scan Traces



IDENTIFICATION OF ANOMALIES IN THE PASADENA PILOT PROJECT

Electro-scan testing was carried out for 111 runs of 4-in. and 6-in. diameter sewer service lines representing 91 individual service line segments. Electro-Scan testing showed that many pipe sections had defects that were potential leaks or structural defects. However, analysis of the results showed that the number, size and type of the defects vary considerably between the pipe sections.

Processing the Electrode Current

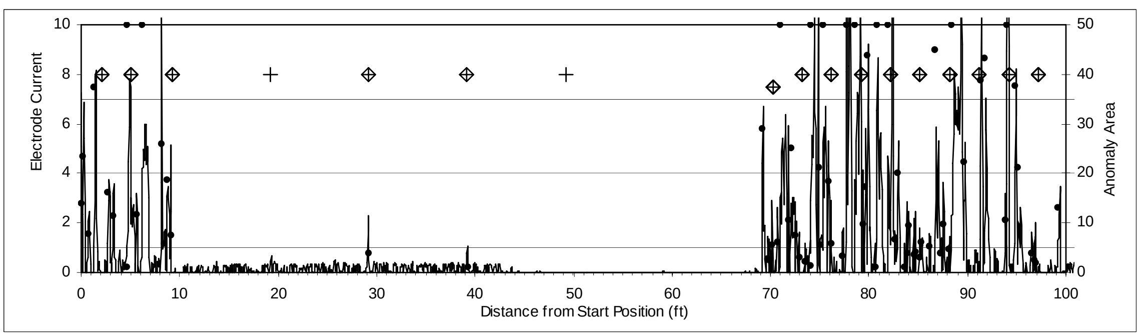
Processing removes the typical low frequency variation of the current flow due to the variation of pipe material between each joint and removes any “offset” variation due to the changes in the earth material surrounding the pipe. This enables the computer to directly compare the amplitudes of the defect anomalies.

Grading the Anomalies

The Large-Medium boundary and Medium-Small boundary current levels of 7.0 and 4.0 respectively are shown as unbroken horizontal lines on the current trace. The location and length of an anomaly is the location and longitudinal length of the electrical defect along the pipe. The maximum current level of the anomaly is a measure of the amount of current flow through the defect and is related to the size of the defect.

The boundaries between Large, Medium and Small may be refined using the results of other types of testing or investigation. These Grades provide a means of establishing priority for the further investigation and/or repair of the regions of the pipe. Anomalies that occur at regular intervals are usually due to joint defects.

Figure 5. Example of Processed Data showing Pipe Deterioration

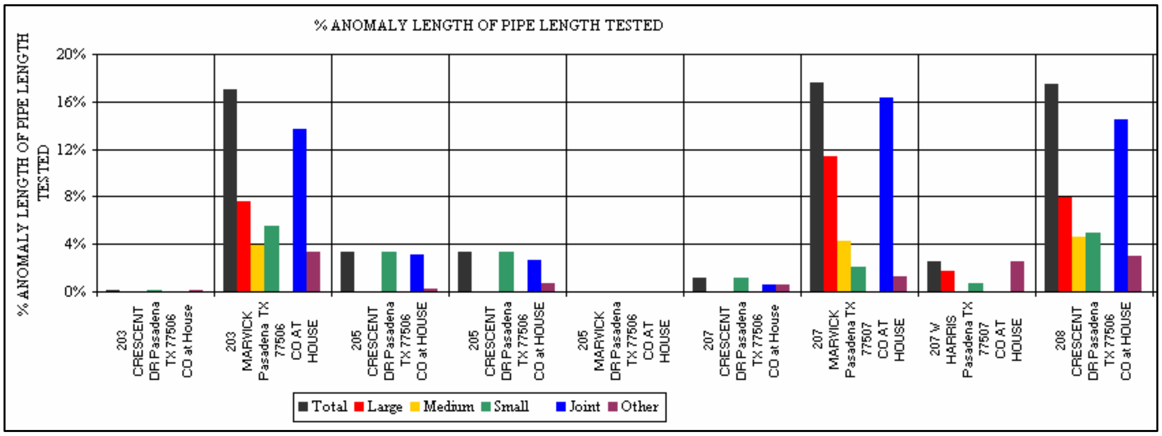


Detection of defective joints and structural defects like broken pipes in service lines can be easily located in the output plot in the form of spikes in the electric current. The processed electrode current in the case of corrosion tends to remain above the threshold and appears quite irregular in appearance. This is due to the easy passage of electrode current through the thin pipe wall.

Tabulating Anomalies And Calculating Relative Anomaly Occurrence

The analysis program picks, measures and grades the size and type (joint or other) of the anomalies and calculates the total length of anomalies for each test section. This is a measure of the potential relative leakage for each pipe section. The Anomaly Analysis shows the number of defects and the sum of the lengths of the defects within each grade for a particular test. However these parameters are dependant on length of the test section. So that pipe segments can be compared with each other the following parameters are calculated:

Percentage length of anomaly per foot of pipe tested
= (100 x sum of anomaly lengths in pipe test) / (length of pipe tested)



The electro-scan results provide a means of prioritizing rehabilitation works and designing the most appropriate rehabilitation method .

CASE STUDY

City of Pasadena – North and South Crescent Drive Project

The City of Pasadena conducted a pilot project of Electro-Scan testing of 91 sanitary sewer service connections that range in size of 4-in. and 6-in. in diameter in the subdivision along North and South Crescent Drive. These service lines were suspected to have high inflow and infiltration sources, which made significant impact to our collection lines, sanitary sewer lift stations and eventually to our wastewater treatment plant during significant rainfall in the area. To eliminate the inflow and infiltration sources, the City took a pro-active step of controlling the inflow and infiltration sources. The City executed a right-of-way entry agreement with the home owner to get access into their property to conduct electro-scan testing and executed another agreement for replacing the service line up to 3 feet from their building. Once the new service line is constructed, it is up to the owner to hire a plumber to connect to this new service line.

The results from the electro-scan testing showed that approximately 47 service lines were prioritized to be the candidates for replacement based on the percentage of anomalies. The City has replaced these service lines. The City has performed closed circuit television inspections on the remaining service lines and verified the electro-scan testing results.

CONCLUSION

The service line rehabilitation was funded as a pilot project in the hope of eliminating infiltration/inflow sources using the sanitary sewer rehabilitation program budget of the City. This budget included the rehabilitation fees collected from citizens to improve the sanitary sewer services in the City. This funding permitted the City to repair service lines up to three feet from the private facility, after which the citizen would, with the help of a plumber, make the connection to the newly constructed service line. The FELL-21 has been instrumental in accomplishing the task of locating defective service lines and prioritizing service lines based on the extent of damage, time constraints, and cost to an extent that has greatly benefited the City of Pasadena, Texas.