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Standard Practice for Locating Leaks in Sewer Pipes By Measuring the Variation of Electric Current Flow Through the Pipe Wall[1]

This standard is issued under the fixed designation F2550; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

Infiltration of groundwater into a sewer through defects in the pipe can considerably increase the operation and capital costs of a sewer system. Exfiltration of sewage out of a sewer pipe may cause degradation of aquifers and shoreline waters. 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. While commonly used sewer leak assessment methods, such as air and water pressure testing, represent cost effective methods to provide overall Pass/Fail pipe assessments, their inability to provide accurate location and size of leaks, particularly at individual joints and service connection, limit their use in remediation and rehabilitation decision support.

1. Scope

1.1 This practice covers procedures for measuring the variation of electric current flow to detect and locate potential pipe leaks in pipes fabricated from electrically nonconductive materials such as brick, clay, concrete, and plastic pipes (that is, reinforced and non-reinforced). The method uses the variation of electric current flow through the pipe wall to locate defects that are potential water leakage paths either into or out of the pipe.

1.2 This practice applies to mainline and lateral gravity flow storm sewers, sanitary sewers, and combined sewers with diameters between 3 and 60 in. (75 and 1500 mm). The pipes must be free of obstructions that prevent the probe passing through the pipe.

1.3 The scanning process requires access to sewers, filling sewers, and operations along roadways that are safety hazards. This standard does not describe the hazards likely to be encountered or the safety procedures that must be carried out when operating in these hazardous environments. (7.1.3) There are no safety hazards specifically associated with the use of an electro-scan apparatus that complies with the specifications provided in this standard. (6.7 and 6.10.)

1.4 The measurement of the variation of electric current requires the insertion of various items into a sewer. There is always a risk that due to unknown structural conditions in the sewer such items may become lodged in the pipe or may cause the state of a sewer in poor structural condition to further deteriorate. This standard does not describe methods to assess the structural risk of a sewer.

1.5 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and to determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *lateral, n*—sewer pipe connecting the common sewer collection system to the user.

2.1.2 *mainline, n*—pipe that is part of the common sewer collection system.

[1] This practice is under the jurisdiction of ASTM Committee F36 on Technology and Underground Utilities and is the direct responsibility of Subcommittee F36.20 on Inspection and Renewal of Water and Wastewater Infrastructure.

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2.1.3 *maintenance hole, n*—(MH) vertical shafts intersecting a sewer that allows entry to the sewer for cleaning, inspection and maintenance.

2.1.4 *owner, n*—entity holding legal rights to, and responsible for the operation and maintenance of the sewer pipe.

2.1.5 *probe, n*—scan electrode placed in a pipe.

2.1.6 *sliding pipe plug, n*—device that blocks the flow through a pipe and at the same time can be pulled through the pipe.

3. Significance and Use

3.1 The testing of sewers for leaks is a regular practice necessary for the maintenance and optimal performance of sewer collection systems so remedial action can be prioritized, designed, and carried out to reduce infiltration and exfiltration.

3.2 This practice serves as a means to detect and locate all types of pipe defects that are potential sources of water leaks either into or out of electrically non-conducting pipes. Leaking joints and defective service connections are detected that often may not show as a defect when viewed from inside the pipe. The scan data may be processed and analyzed to provide some information on the size and type of pipe defect. (8.4.1)

3.3 This practice applies to mainline and lateral gravity flow storm sewers, sanitary sewers, and combined sewers fabricated from electrically non-conducting material with diameters between 3 and 60 in. (75 and 1500 mm). The pipes must be free of obstructions that prevent the probe passing through the pipe.

4. Contract Responsibilities

4.1 Apart from the provisions generally included in a testing services contract, testing contracts for measuring the variation in electric flow through a pipe wall should define or affix responsibility for or make provisions for the following items:

4.1.1 Access to the site of work is to be provided to the extent that the owner is legally able to so provide or, if not so able, a written release from responsibility for the performance of work at sites where access cannot be made available;

4.1.2 Clearances of blockages or obstructions in the sewer system;

4.1.3 Location and exposure of all maintenance holes (MH);

4.1.4 MH numbering system for all areas of the project and MH invert elevations and depths;

4.1.5 Shutdown or manual operation of certain pump stations if such becomes necessary for performance of the work;

4.1.6 Permission to use water from fire hydrants at the work site, or other suitable designated sources within a reasonable distance from the work areas, which is necessary for contracted work performance;

4.1.7 Authorization to perform work that must be performed during nighttime hours, weekends, or holidays; and

4.1.8 Traffic control by uniformed officers or contract personnel when the safety of workers or the public requires such protection.

5. Principle of Operation

5.1 Most sewer pipe materials such as clay, plastic, concrete, reinforced concrete, and brick are poor conductors of electrical current. A defect in the pipe wall that leaks water will also leak electrical current, whether or not water infiltration or exfiltration is occurring at the time of the test.

5.2 The test is carried out by applying an electrical potential of 9 to 11 Volts rms with a frequency of 500 Hz to 30 kHz between an electrode in the electrically nonconductive pipe and an electrode on the surface, which is usually a metal stake pushed into the ground. A simplified electrical circuit for this procedure is shown in Fig. 1. The water in the pipe is at a level that ensures that the pipe is full at the electrode location. Provided electrical current is prevented from flowing along the inside of the pipe, the electrical resistance of the current path between the electrode in the pipe and the surface electrode is very low except through the electrically nonconductive pipe wall. The high electrical resistance of the pipe wall allows only a very small electrical current to flow between the two electrodes unless there is a defect in the pipe such as a crack, defective joint, or faulty service connection. The greater the electric current flow through the pipe opening, the larger the size of the leak.

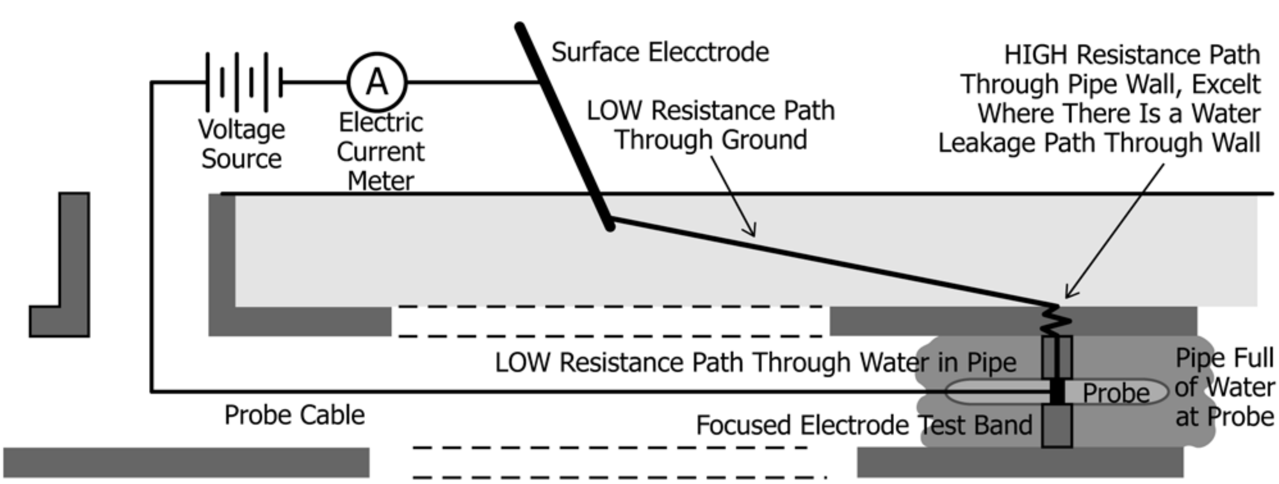

FIG. 1 Schematic of a Simplified Electrical Scanning Circuit in a Non-Conductive Pipe

6. Apparatus

6.1 The method for measuring the variation in electric flow through a pipe wall requires a means of preventing the electric current from the electrode in the electrically nonconductive pipe from traveling along the inside of the pipe before reaching the ground electrode. Such a means is a three-electrode array, known as a probe. The probe is constructed in such a way that when equal voltages are applied to all three electrodes, the electric fields of the outer electrodes prevent electrical current from the center electrode flowing along the pipe. This also causes the electric field of the center electrode to be focused into a disk about 1 in. (25 mm) wide. This electric field projects onto the pipe wall as a circumferential band with a width of about 10 % of the pipe diameter. The center of the band is located at the center of the probe. As a result, the electrical current flow through the center electrode of the probe, called the focused current, is dependant on the electrical resistivity of the pipe wall within the area of the band around the circumference of the pipe.

6.2 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; and a surface electrode. When a sliding pipe plug (7.1.6.2) is used, a system to measure the water pressure in the pipe at the location of the probe, called the water head, is required.

6.3 The geometric dimensions of the probe shall be such that the change of focused current as a result of a hole in the pipe with a diameter of 0.5 % of the pipe diameter will be detected and potential leaks separated by more than 25 % of the pipe diameter will be resolved. That is for a 10 in. (250 mm) diameter pipe a hole with a diameter of 0.05 in. (1.3 mm) will be detected and openings more than 2.5 in. (62 mm) apart will be shown as two separate leaks.

6.4 The focused current and the total current flowing between the surface electrode and the probe and the water head shall be measured and recorded at not less than 0.40 in. (10.0 mm) intervals along the pipe while the probe is pulled through a pipe at a speed of 32.8 ft/min (10.0 m/min).

6.5 The accuracy of the probe position measurement system shall be within ±0.5 % with a resolution 0.05 %. That is for a pipe test section that is 100.00 ft long the length of pipe measured by the system shall be 100.00 ± 0.5 ft and the smallest distance readout unit will be 0.05 ft or less

6.6 The resolution of the current measurements shall be equal to or less than 0.1 % of the maximum current. That is if the maximum current is 40 mA then the smallest current readout unit will be 0.04 mA

6.7 The applied voltage between the probe and the surface electrode shall have a frequency between 500 and 30 000 Hz and a voltage range of 9 to 11 volt rms. The maximum current between the probe and the surface electrode shall be 0.04 A rms. These parameters prevent the occurrence of sparks or electric shock to humans during normal operation or in the event of a short circuit.

6.8 The measurement of the probe location, total current, focused current, and water head shall be stored in real time as digital data in an electronic device.

6.9 The probe position, total current, focused electrode current, and the water head shall be displayed in real time on an electronic device on the surface when the system is activated.

6.10 The design of the electrical circuits shall prevent the occurrence of sparks or electrical shock to humans if faults or damage occur such as a severed cable.

6.11 Power cable winches shall have an automatic slip clutch to prevent overstrain of the probe cable that may occur if the probe becomes stuck in the pipe.

7. Procedure

7.1 *Sewer Preparation:*

7.1.1 The test is usually carried out by moving the probe through the sewer at approximately 30 ft/min (10 m/min). For the average MH interval of 300 ft (100 m), this takes about 10 min. The time to set up and dismantle the test equipment and fill the sewer in the region of the probe usually takes up most of the field time. Appropriate selection of the sewer section test sequence, establishment of a setup routine, and ready availability of suitable equipment can considerably reduce the test preparation time.

7.1.2 Generally, testing does not require any pipe preparation. However, the sewer must be clear of obstructions that prevent the probe passing through the pipe such as severe root intrusion or protruding service connections. Inability to pass the haul line (7.1.5) through the pipe will indicate the presence of such obstructions and should be reported (7.2.4).

7.1.3 *Person-Entry into Sewer MH's*—Field operations should not require person-entry of MH's. Person-entry is hazardous and requires additional time to carry out the safety checks and set up safety equipment. However, unforeseen situations may occur that require person-entry of a MH. Suitably trained personnel and safety equipment should be on hand just in case person entry is required. Prior to a person entering a MH the atmosphere in the MH must be evaluated for toxic or flammable gases and oxygen depletion in accordance with local, state or federal safety regulations and must be carried out in accordance with the owner's person-entry of MH procedures.

7.1.4 *Sewer Flow*—Testing can be carried out in all conditions of sewer flow, from dry to surcharged.

7.1.5 *Haul Line:*

7.1.5.1 A line is required to pull the probe between the MH's of the pipe section to be tested. The haul line is flushed between the MH's at each end of the pipe section to be scanned using either water or air.

7.1.5.2 An effective haul line is a jet cleaner hose.

7.1.6 *Filling the Sewer at the Probe Location*—Water in the pipe provides the electrical connection between the probe and the pipe wall (Fig. 1). To scan the complete circumference of a electrically nonconductive pipe, it must be full of water at the