Designation: F3220 – 17 (Reapproved 2023)

Standard Practice for Prioritizing Sewer Pipe Cleaning Operations by Using Transmissive Acoustic Inspection[1]

This standard is issued under the fixed designation F3220; 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.

1. Scope

1.1 This practice covers procedures for assessing the blockage within gravity-fed sewer pipes using transmissive acoustics for the purpose of prioritizing sewer pipe cleaning operations.[2] The assessment is based on an acoustic receiver measuring the acoustic plane wave transmitted through the pipe segment under test in order to evaluate the blockage condition of an entire segment and to provide an onsite assessment of the blockage within the pipe segment. (**1**, **2**, **3**, **4**, **5**)[3]

1.2 The scope of this practice covers the use of the transmissive acoustic inspection as a screening tool. The blockage assessment provided by the acoustic inspection should be used to identify and prioritize pipe segments requiring further maintenance action such as cleaning or visual inspection, or both. Thereby, also identifying the pipe segments which are sufficiently clean and do not require additional maintenance action.

1.3 This standard practice does not address structural issues with the pipe wall.

1.4 The inspection process requires access to the manhole (MH) from ground level. It does not require physical access to the sewer line by either the equipment or the operator.

1.5 This standard practice applies to all types of pipe material.

1.6 The inspection process requires access to sewers and operations along roadways or other locations 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.

1.7 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.

1.8 *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 determine the applicability of regulatory limitations prior to use.*

1.9 *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:*

2.1.1 *authority, n*—party responsible for the generation and verification of performance to job specification(s) and contract requirements.

2.1.2 *blockage assessment, n*—the aggregate blockage within a pipe segment between two adjacent MHs.

2.1.3 *closed circuit television (CCTV), n*—a closed circuit pipeline inspection television system including a camera, camera transporter, integrated lighting, central control system, video monitor, and recording device.

2.1.4 *coordinated universal time (UTC), n*—the primary international time standard for regulating clocks and time.

2.1.5 *geographic information system (GIS), n*—system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data.

2.1.6 *global position system (GPS), n*—space-based navigation system that provides location and time information anywhere on or near the earth where there is an unobstructed line of sight to four or more GPS satellites.

2.1.7 *manhole (MH), n*—vertical shafts intersecting a sewer that allow entry to the sewer for cleaning, inspection, and maintenance.

2.1.8 *pipe segment, n*—the section of a sewer line between two adjacent MHs.

[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.

Current edition approved Sept. 1, 2023. Published September 2023. Originally approved in 2017. Last previous edition approved in 2017 as F3220 – 17. DOI: 10.1520/F3220-17R23.

[2] The transmissive acoustic inspection is covered by Patent US8220484B2. Interested parties are invited to submit information regarding the identification of an alternative(s) to this patented item to the ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

[3] The boldface numbers in parentheses refer to a list of references at the end of this standard.

2.1.9 *segment's acoustic fingerprint (SAF), n*—acoustic feature set which characterizes a pipe segment. The acoustic feature set is used in classifying the blockage assessment. (**2, 6**)

2.2 *Abbreviation:*

2.2.1 *ID*—identification

3. Summary of Practice

3.1 Transmissive acoustic inspection operational procedure is based on measuring the signal received from an active acoustic transmission through a pipe segment. Fig. 1 depicts the general configuration of a transmissive acoustic inspection. The acoustic transmitter generates sound waves just below the entrance to the MH which couple into the connecting sewer line segments. The sound wave propagates in the air gap above the wastewater flow from the speaker to the receiving microphone attached to the acoustic receiver located at the adjacent MH. The acoustic receiver measures the acoustic plane wave from the transmitted signal in order to evaluate the blockage condition of an entire segment and provides an onsite blockage assessment. Both the speaker and the microphone are placed just within the opening of the MH and should never come in contact with the wastewater flow. The operators have no requirement for confined space entry.

3.2 Transmissive acoustic inspection principle of operation is based on the observation that a pipe segment is a natural acoustic waveguide. Commonly encountered sanitary sewer defects, such as roots, grease, pipe sags, and pipe breakages naturally absorb or reflect acoustic energy. These defects change a segment's acoustic properties and produce a measurable impact on the received signal at the microphone, that is, the segment's acoustic fingerprint (SAF). Each segment has an individual SAF representative of its current state. Transmissive acoustic inspection measures and assesses the SAF to determine the Blockage Assessment, that is, an estimate of the aggregate blockage within the pipe segment between the acoustic transmitter and acoustic receiver.

4. Significance and Use

4.1 *Significance:*

4.1.1 Collection system maintenance requires allocating cleaning resources to the right place prior to system failure (sanitary sewer overflows, mainline blockages, and building backups). Transmissive acoustic inspection provides a tool to assist in allocating cleaning resources by prioritizing pipe segments based on their blockage assessment and thereby facilitating efficient cleaning resource allocation.

4.1.2 This standard practice provides minimum requirements and suggested practices regarding the transmissive acoustic inspection of gravity-fed sewer line blockage assessment to meet the needs of maintenance personnel, engineers, contractors, authorities, regulatory agencies, and financing institutions.

4.2 *Limitations and Appropriate Uses:*

4.2.1 The blockage assessment provided by the transmissive acoustic inspection may not resolve the type of blockage(s) within the pipe segment nor resolve the location(s) of the blockage(s) within the pipe segment.

4.2.2 Due to the physics associated with transmissive acoustic inspection, the blockage assessment may be confounded due to:

(1) Structural designs resulting in poor acoustic coupling,

(2) Pipe segments completely filled with water, for example, full pipe sag or inverted siphon, and

(3) Transient conditions within the pipe, for example, active lateral discharge or temporary flow surcharges.

These issues are addressed as part of the performance criteria specified in X1.5.

4.2.3 Due to physics associated with acoustics and trade-offs in equipment design for conducting transmissive acoustic inspection, there are limitations based on the following pipe segment attributes:

(1) Pipe diameter,

(2) Pipe segment length,

(3) MH depth, and

(4) Flow levels.

Inspections conducted outside the manufacturer's recommended ranges for these pipe segment attributes may result in the transmissive acoustic blockage assessment deviating from the performance criteria specified in X1.5.

4.2.4 Inspections conducted between non-adjacent MHs, for example, skipping an intermediate MH, may result in the transmissive acoustic blockage assessment deviating from the performance criteria specified in X1.5.

5. Procedure

5.1 If the work is to be conducted by an outside contractor, apart from the provisions generally included in an inspection

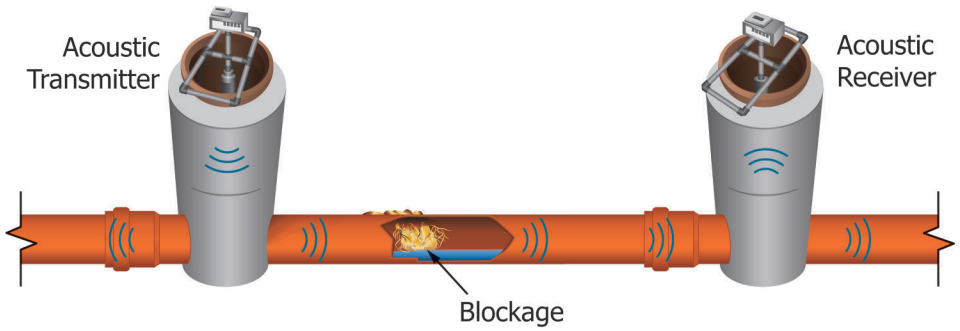

FIG. 1 Transmissive Acoustic Inspection System Operation

services contract, the transmissive acoustic inspection contract should define and assign responsibilities for the following items:

(1) Access to the site of work is to be provided to the extent that the authority 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;

(2) MH numbering system for all areas of the project;

(3) Location, exposure, and accessibility of all MH should be provided; and

(4) Geographic Information System (GIS) maps should be provided, when available.

5.2 The transmissive acoustic inspection procedure detailed in this practice is based on the transmissive acoustic inspection equipment meeting the minimum requirements detailed in Appendix X1.

5.3 The transmissive acoustic inspection should only be conducted for pipe segments which meet the manufacturer's recommended specifications for: pipe diameter, pipe segment length, MH depth, and flow levels.

5.4 The transmissive acoustic inspection shall be conducted using the following procedure for each pipe segment under test. The acoustic transmitter and the acoustic receiver shall be placed on adjacent MHs by their respective field operators. The transducers (microphone and speaker) shall be placed within the MH, as illustrated in Fig. 1.

5.5 The inspection shall follow the manufacturer's recommendation for the equipment with the procedure outlined as follows:

5.5.1 Based on the authority's policy for providing a pipe segment's length, the acoustic receiver operator enters the length of the pipe segment under test. This parameter is used in assessing the blockage assessment. The pipe segment's length should be based on the authority's GIS data, when available, and when deemed to be sufficiently accurate as specified by the manufacturer's requirements, for example, pipe segment's length is entered to within ±50 ft.

5.5.2 The field operators initiate the automated test. The test shall be started on both the acoustic transmitter and acoustic receiver within the time interval specified by the equipment manufacturer.

5.6 Following each inspection, the field operator shall record the following: acoustic receiver identification (ID), unique blockage assessment ID, upstream MH ID, downstream MH ID, pipe segment's location information, blockage assessment, date, and time. The operator's recorded data duplicate and augment the data recorded electronically by the transmissive acoustic inspection equipment and is used in the data registration quality control (7.3 and 7.4).

5.7 The transmissive acoustic inspection equipment operation shall be verified on a daily basis prior to use. Only the verification procedure specified by the equipment manufacturer shall be used. The verification results will be electronically recorded by the transmissive acoustic inspection equipment.

5.8 On a daily basis, the data recorded electronically by the transmissive acoustic equipment shall be uploaded for report generation and data registration quality control.

6. Report

6.1 A report shall be produced as described in 6.2 through 6.4. The objective of the report is to provide clear and concise information to assist in prioritizing cleaning operations on the pipe segments inspected.

6.2 *Daily Verification Report*—A table listing the operation verification results. The table is based on data recorded electronically by the transmissive acoustic inspection equipment. Each table entry will include: the date, the time, and the results of the equipment operation verification. If an operation verification fails, then the table entry will indicate the corrective measures taken as well as an additional operation verification entry to show that the corrective measures were successful.

6.3 *Summary of Pipe Sections Tested*—A table of pipe sections tested shall be produced that shows the name/number of the upstream and downstream MHs, the distance between MHs as specified by the authority's GIS data (when available), the distance between MHs as measured by using the inspection equipment global position system (GPS) location estimates, the pipe length specified by the operator in the field as recorded by the equipment, the acoustic receiver device ID, measurement timing verification, the blockage assessment ID, the blockage assessment based on the operator specified pipe length in the field, and the blockage assessment based on the corrected pipe length. In addition, the table shall indicate whether the:

(1) Pipe segment location was verified, that is, location was verified by correlating the field operator recorded information with the transmissive acoustic inspection equipment GPS location estimates and the authority's GIS data;

(2) Pipe segment was tested based on skipping an intermediate MH due to the intermediate MH not being located or not being accessible; and

(3) Pipe segment was not tested based on not being able to locate or access two adjacent MHs.

6.4 *Field Recorded Electronic Data*—The following reports will be provided based on the data recorded by the transmissive acoustic inspection equipment:

6.4.1 A table of the unedited Field Recorded Electronic Data, as illustrated in Fig. 2. The table will include for each pipe segment evaluated: unique measurement identification, coordinated universal time (UTC), GPS location, operator pipe length setting, blockage assessment, and acoustic receiver status. The authority will have access to the unedited Field Recorded Electronic Data.

6.4.2 Graphical representation shall be provided of the data as illustrated in Fig. 3.

6.4.3 When the authority's GIS data is available, the graphical representation should provide a color coding to indicate whether or not the MH was accessible by the field operators. Different colors or symbols should be used for the MH locations to indicate: the MH was accessible, the MH was unable to be located, or the MH was not accessible.

Select All | Export to Google Earth | Export to CSV | Enhanced Export

1 Page Size: 50 8 measurements found

	Meas. ID	RX Oper. ID	RX Hw ID	TX Oper. ID	TX Hw ID	Date/Time * =estimated	Meas. Dur. (sec)	Oper. Pipe Lng (ft)	Eval. Pipe Lng (ft)	Meas. Status	Pipe Status	Field Assess	GPS Assess	Notes	Rx Lat/Lon	Tx Lat/Lon
	1402	1	176	1	177	4/1/2015 11:55:52 AM	79	250	242	Valid	Poor	3 POOR	3 POOR	☑	**Lat:** 38.089815 **Lon:** –88.907756 **ID:** MH-07	**Lat:** 38.089858 **Lon:** –88.906915 **ID:** MH-06
	1401	1	176	1	177	4/1/2015 11:48:26 AM	79	250	188	Valid	Good	7 GOOD	7 GOOD	☐	**Lat:** 38.089887 **Lon:** –88.906925 **ID:** MH-06	**Lat:** 38.089373 **Lon:** –88.906895 **ID:** MH-05
	1400	1	176	1	177	4/1/2015 11:42:35 AM	79	50	130	Valid	Good	8 GOOD	8 GOOD	☐	**Lat:** 38.089348 **Lon:** –88.906938 **ID:** MH-05	**Lat:** 38.089408 **Lon:** –88.906493 **ID:** MH-04
	1399	1	176	1	177	4/1/2015 11:34:38 AM	80	150	100	Valid	Good	9 GOOD	8 GOOD	☐	**Lat:** 38.089361 **Lon:** –88.906473 **ID:** MH-04	**Lat:** 38.089088 **Lon:** –88.906457 **ID:** MH-03
	1398	1	176	1	177	4/1/2015 11:19:08 AM	80	150	159	Valid	Fair	5 FAIR	5 FAIR	☐	**Lat:** 38.089065 **Lon:** –88.906468 **ID:** MH-03	**Lat:** 38.088632 **Lon:** –88.906522 **ID:** MH-02
	1397	1	176	1	177	4/1/2015 11:09:08 AM	79	250	185	Valid	Good	8 GOOD	8 GOOD	☐	**Lat:** 38.08863 **Lon:** –88.906485 **ID:** MH-02	**Lat:** 38.088613 **Lon:** –88.905841 **ID:** MH-01
	1396	1	176	1	177	4/1/2015 7:19:14 AM	79	50	116	Valid	Close	9 GOOD	10 GOOD	☐	**Lat:** 38.631461 **Lon:** –90.779891 **ID:**	**Lat:** 38.63133 **Lon:** –90.780263 **ID:**
	1395	1	176	1	177	3/31/2015 1:51:28 PM	79	50	16	Valid	Close	10 GOOD	10 GOOD	☐	**Lat:** 38.130523 **Lon:** –92.715976 **ID:**	**Lat:** 38.130501 **Lon:** –92.71593 **ID:**

1 Page Size: 50 8 measurements found

FIG. 2 Transmissive Acoustic Inspection Field Recorded Data and Post Processing Blockage Reassessment Based on Pipe Length Evaluated Using GPS and GIS Data

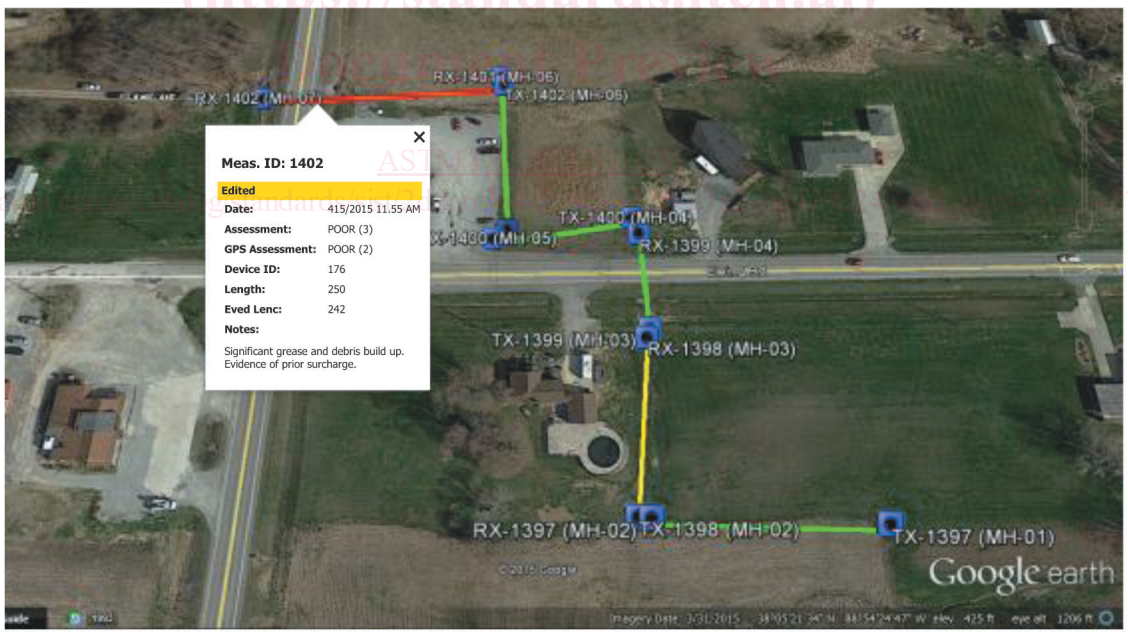

FIG. 3 Geographical Representation of Transmissive Acoustic Inspection

7. Quality Control

7.1 *Equipment Operation Verification*—The transmissive acoustic inspection equipment operation shall be verified on a daily basis prior to use. Only the verification procedure specified by the equipment manufacturer shall be used.

7.2 *Measurement Timing Verification*—For each pipe segment tested, the acoustic transmitter shall be verified to be transmitting over the time interval during which the acoustic receiver is assessing the pipe segment's blockage.