# Manhole Inspection: Existing Challenges and New Technologies

By Eric Sullivan
Business Development Manager – Atlas Inspection Technologies

Manholes form a crucial part of wastewater collection systems. This is true both in terms of gaining access to underground assets for cleaning, maintenance, rehabilitation, and inspection, but also in terms of the role of manholes in contributing to infiltration and inflow (I/I) in a collection system. The end goal of collection system personnel is to treat all wastewater while eliminating any sewer overflows. All activities related to collection system maintenance and rehabilitation stems from data collected on the condition of the system. From data culled from field inspections and reports, asset ratings and projections are made. Projects can then be planned and work prioritized. From these plans of action; maintenance, cleaning, and rehabilitation work on the collection system is then performed.

One of the major causes of sewer overflows is the occurrence of infiltration and inflow (I/I). The term I/I is described as the occurrence of groundwater and storm water entering the sewer system. Aside from causing pollutants to enter waterways, harming the ecosystem and posing a public health risk to humans, each instance of I/I is also extremely costly. For example, if a treatment plant were to reduce treated flow by 100,000 gallons per day (gpd), that treatment plant would save approximately $50,000 every year[1]. The cleanup costs of overflow events is also substantial in terms of the cost to remove wastewater from streets and basements, litigation and insurance claims, as well as the substantial state/provincial and federal fines associated with these events.

Considering manholes with respect to I/I is necessary when evaluating their place in the collection system. This perspective also points to the immense opportunity for I/I reduction that manholes provide. For instance, a manhole is essentially a vertical pipe that gives access to the horizontal pipes that form a collection system. An 8 foot deep manhole of typical design has about the same surface area as a 50 ft segment of 8 in. pipe[2].

When thought of in terms of surface area, manholes become a major part of a collection system. Manholes, in addition, ought to be a major priority in terms of inspection and rehabilitation needs when the general age and condition is considered. In the US, there are at least 20,000,000 manholes in the ground, and about 50% of those manholes were installed prior to 1960. Typically, a manhole will last 50 years before it requires serious maintenance and rehabilitation. As of now, it is estimated that 18% of all manholes are experiencing serious structural flaws.[3]

(continued on page 22)

# Manhole Inspection: Existing Challenges and New Technologies

(continued from page 21)

***Typical Problems in Manholes***
The problems manholes face can be broken down into seven general types: leaking manhole rings and covers, traffic loads, ground water loads, infiltration, hydrogen sulfide corrosion, runoff and inflow, and alteration by third-party utilities.

*Leaking manhole rings and covers:* a damaged seal between the manhole cover and the frame will be a source of inflow into the collection system. Occasionally covers can become loose in fitting over time due to improper design, and the inspector must take note of whether the manhole cover fits the frame properly.[4] More likely, loose-fitting covers may be due to deterioration of the cover itself, as these components of the manhole are subject to cracking, and corrosion.

*Traffic loads:* manholes on busy streets, particularly those frequently traversed by heavy commercial vehicles, are particularly prone to defects from bearing traffic loads. The primary areas affected are the frame and cover section and the manhole's chimney. As dynamic weight bears down on the manhole over time, the frame section of the manhole will shift and may sink below grade. This can affect how the cover sits on the frame and can create avenues for inflow from storm water runoff. The chimney can also be pressed into the cone or barrel section of the manhole and this can create problems such as joint displacement or more serious structural defects.

*Ground water loads:* this is an often overlooked challenge to manholes, but is becoming more of a priority as collection system managers attempt to tackle infiltration. Because water from the ground is constantly trying to enter the collections system, when a break does occur, the water pressure at the point of infiltration can be intense. Manholes are no different than pipes in this respect. Generally speaking, the deeper the manhole, the more susceptible it is to groundwater pressure.

*Infiltration:* an important issue for sure, there are several key places in the manhole where infiltration can occur. In brick manholes, any spot where the mortar has deteriorated or individual bricks have given way can be a prime spot for infiltration. On concrete manholes, the joints connecting segments of the cone and barrel are susceptible to infiltration, particularly if the structure has shifted and the joints have offset. Any type of connection from a pipe into the manhole, particularly break-in connections made after the manhole's installation need to be checked for infiltration. In concrete manholes, cracks and fractures can allow infiltration.
*Hydrogen sulfide corrosion:* in concrete manholes and sewers, corrosion is the prime cause of structural deterioration in 3 out of 4 damaged assets.[5] Decomposing human waste gives off sulfuric acid, and when oxidized, becomes hydrogen sulfide (H2S). Theobacillus bacteria thrive on H2S and are made worse by hydraulic problems in the collection system, heat, and turbulence that can release festering pockets of H2S.[6] The result is corrosion on the surface of the concrete pipe or manhole.

*Runoff and inflow:* manholes must be checked as sources of runoff and inflow. Older manhole covers typically contain many pick-holes or vent-holes, which allows storm water from the street to easily seep into the collection system. Converting all manhole covers to a design with fewer holes or with no holes and bolted access can have a major effect on limiting runoff and inflow[7].

*Alteration by third-party utilities:* this is becoming more and more serious of a problem, particularly in older, crowded cities and due in part to the proliferation of

(continued on page 23)

(continued from page 22)

high-speed Internet services. It is not uncommon to find other utility lines crossing with manholes and pipes in the collection system. If the utility line is a live gas pipe, this can be very dangerous. Also electrical lines that have penetrated the inside of a manhole can pose a unique risk of explosion as the cables deteriorate and their insulation erodes, giving off flammable gas and building up pressure inside the manhole. When an arc flash occurs, the built-up gases are ignited and an explosion can result[8]. Regardless of a fire hazard or explosion, each instance of alteration of the manhole after installation poses risks of becoming points of infiltration, while undermining the manhole's structural integrity.

***Panoramo SI 3D Optoscanner***

Panoramo SI has so far proven to be the most cost-effective and fastest method of inspecting large numbers of manholes, and produces a level of data superior to any other alternative currently available. The process for using Panoramo SI to inspect a manhole involves the operator remotely lowering the device to the bottom of the manhole, and then retracting the cable. Panoramo SI conducts its scan of the interior of the manhole on the way up, snapping images from the top and bottom camera every 2 in. on its way up the manhole at a speed of 14 in. per second. The operator will then save the data and move on to the next manhole. This technology is intended for analysis and reporting to be carried out later, in an office-setting, enabling the field technician to specialize and become only a data collector and equipment operator. The data is then turned over to a specialist in an office to complete the analysis and report at his or her leisure.

Since Panoramo SI produces a 360° field of view from anywhere inside the manhole, and an unfolded view of the entire surface of the manhole, nothing is missed. Human error on the part of the field operator can be eliminated to a far greater degree than any other method available. Also, the unfolded view allows for a significantly greater amount of detail at 3,000 horizontal lines

(continued on page 24)

# Manhole Inspection: Existing Challenges and New Technologies

(continued from page 23)

of resolution, compared to about 470 lines for most high-end CCTV cameras.

Perhaps the most valuable feature related to Panoramo SI, however, is its ability to produce geometric data on the manhole in the form of a 3D "scatter plot" profile. The down-hole facing camera, as it takes pictures every 2 in. on its way up the manhole, is photographing the stationary objects in the manhole as it moves away from them. The IBAK Panoramo software is able to account for the amount of contrast variance on the pixels representing the stationary objects as the camera is moving away from these objects. By comparing the change in contrast to the position of the camera, the position of the object can be triangulated and this data is represented in the form of a dot in a 3-dimensional space. The "scatter plot" consists of thousands of these dots. 3D measurement is possible in the profile, as well as analysis of the ovality of the manhole, as the Panoramo software enables measurement of circumference (or perimeter for square manholes). With this data on manhole ovality, the user is able to detect if the barrel of the manhole is buckling or if collapse is imminent, a level of analysis not possible with strictly visual methods of manhole inspection.

***Manhole Reporting***

It is one thing to understand the value of a robust, proactive manhole inspection program and for collection system personnel to generate large amounts of data on the condition of manholes. It is a far different issue to be able to turn that data into meaningful knowledge that can allow for predictive analysis, efficient maintenance activities, and proper manhole rehabilitation methods. For this reason, standardized reporting practices are essential. NASSCO has developed a comprehensive system for manhole inspection reporting, known as the Manhole Assessment Certification Program (MACP). MACP was developed in response to the increased awareness of the problems found in manholes and has built on the success and popularity of NASSCO's Pipeline Assessment Certification Program (PACP). Using many of the same codes and terms, MACP has proven to be a valuable tool for manhole inspection.

MACP certificates can be attained upon completion of a 2-day certification course taught by a NASSCO-authorized instructor. Generally speaking, the purpose of using MACP in manhole inspection coding is three-fold. First, the attributes and features of the manhole are defined. Second, details related to the manhole are recording, including its geographic position and all pipe segments connected to it, and the defects within the manhole are defined. Third, the defects identified need to be further categorized and given a structural, operation and maintenance (O & M), or I/I rating[9].

A final and important part of the manhole report is attaining information useful to performing rehabilitation work, specifically, dimensional data on the manhole. Using visual data and MACP coding in conjunction with dimensional information allows for the most appropriate rehabilitation method to be selected. In regards to Panoramo SI, this technology becomes even more relevant when considering that the 3D "scatter-plot" profile can be exported as a DXF file into a CAD program. From there a reline for the manhole can be pre-fabricated and installed, accounting for all the dimensions of the manhole.

***Proactive Solutions***

The separate components that form wastewater collection systems are all inter-related, and when one part fails, the entire system fails[10]. Manhole failure disrupts street traffic, affects other utilities, can lead to sink holes, causes numerous drainage problems in the collections system, and increases I/I.

(continued on page 25)

(continued from page 24)

Ironically, with all the attention and money currently being directed toward pipeline assessment and repair, many people fail to realize that neglecting manholes ensures a problem in a pipe, particularly I/I, will then become a problem in the manhole[11].

The solution lies in proactively inspecting and reporting on the manholes in our collection systems, and maintaining them in tandem with pipelines. For communities looking for cost-effective ways to reduce I/I, manholes hold the key as they are the easiest to inspect and the least expensive to repair[12]. By being aware of existing methods and technologies for manhole inspection, and by utilizing emerging reporting standards, collection system management personnel can make significant gains in reducing I/I while contributing to the long-term life of their assets.

***References***

1 Purtell, Joe. "Manhole Inspection Software: New Software Solutions Focus on Manhole Condition Assessment." Trenchless Technology, Special Supplement (2007): pg M-20, http://www.cuesinc.com/pdf%20docs/Manhole%20article%20cues.pdf

2 Gemora, Irvin and Rod Thornhill. 2008. "NASSCO's PACP/MACP Overview," slide 34, http://www.nassco.org/training_edu/pdfs/pacp-macp_overview.pdf

3 Pollak, Denis. 2009. Manhole Inspections: The Sometimes Forgotten Link in Collection Systems. Power Point Slides. 2009 Pumper Cleaner Expo Training and Education Seminar. http://www.nassco.org/industry_news/pdfs/edu_day_09.pdf

4 National Association of Sewer Service Companies, Version 4.3. (NASSCO, 2006) pg. 9-26

5 Najafi, Mohammad; and Gokhale, Sanjiv. 2005. Trenchless Technology: Pipeline and Utility Design, Construction, and Renewal. New York: McGraw-Hill Companies, Inc. Pg. 422

6 Ibid.

7 Pollak, Denis. 2009. Manhole Inspections: The Sometimes Forgotten Link in Collection Systems. Power Point Slides. 2009 Pumper Cleaner Expo Training and Education Seminar. http://www.nassco.org/industry_news/pdfs/edu_day_09.pdf

8 Marshall, Andrew, "Manhole explosions blow the lid off city-wide integrity problem," The Independent, June 16, 2000, pg. online, http://www.independent.co.uk/news/world/americas/manhole-explosions-blow-the-lid-off-citywide-integrity-problem-712476.html.

9 Pollak, Denis. 2009. Manhole Inspections: The Sometimes Forgotten Link in Collection Systems. Power Point Slides. 2009 Pumper Cleaner Expo Training and Education Seminar. http://www.nassco.org/industry_news/pdfs/edu_day_09.pdf

10 Najafi, Mohammad; and Gokhale, Sanjiv. 2005. Trenchless Technology: Pipeline and Utility Design, Construction, and Renewal. New York: McGraw-Hill Companies, Inc. Pg. 415

11 Ibid.