HEALTHY PIPELINES ESSENTIAL FOR HEALTHY LIVING CONDITIONS

(Alaster Goyns of Pipeline Installation and Professional Engineering Services CC)

1. INTRODUCTION

For a healthy population it is essential to have healthy pipelines supplying clean drinking water and disposing of dirty wastewater. This is needed in South Africa's urban areas, where the demand for these services resulting from the rapid densification is inadequate or has not been met. This is in established areas already serviced as well as in informal and semiformal areas developing around the urban centers. To exacerbate this there is an imbalance between supply and disposal. Hence the wastewater accumulates in these communities, drains into the natural water courses and pollutes them. With unhealthy pipelines the problems escalate.

Under these conditions, due spatial constraints, installing new services or replacing existing ones in trenches causes disruption and costs to residents and businesses. These implications are seldom considered. This occurs in both unserviced areas, and established areas as densification frequently means that existing services need upsizing. There is also the need for replacement due to deterioration with age.

The alternative is using trenchless techniques for both installing new pipelines as well as rehabilitating existing ones. These techniques minimize disruption and can cost significantly less when trenches are deeper that 1,0 to 1,5 m. A critical factor frequently inadequately addressed when doing things underground is doing the necessary assessment of the subsurface conditions. This frequently results in site problems and higher costs due to unexpected conditions. To avoid this, it is essential that any decisions about the action needed should be supported by a thorough assessment of the performance and condition of the asset to be rehabilitated.

2. CONDITION AND PERFORMANCE ASSESSMENT

To ensure that pipelines remain healthy they should be periodically checked and when necessary maintained or rehabilitated so that they remain effective and efficient. This evaluation of their health should not be left, as so often happens, until deterioration is obvious as shown by sewer manholes surcharging, ground subsidence or sinkhole formation. Assessment should be a planned for when the pipeline has reached a certain age and then periodically repeated so that preventative measures are taken before having to handle unplanned, unexpected and costly failures. Such check-ups should consist of a holistic evaluation of the hydraulic performance and condition assessment of the pipes and manholes. This should not be viewed just as a means of determining their current status. What happened in the past should be evaluated, so what is learnt at present, is applied to future planning and service provision.

To effectively evaluate the performance and condition of a pipeline the basic functions and the theory of how these were applied during the design of the pipeline being investigated should be understood. Any differences between performance and condition expected after studying site conditions, drawings if they are available, and details obtained from the inspections can be investigated and the underlying causes established.

The primary function of any water conveying pipeline, whether a gravity or pressure system, is to provide the required hydraulic capacity. To effectively and efficiently do three support functions are needed:

- Water- tightness to prevent losses due to exfiltration and additional flows due to infiltration.
- Structural soundness to handle both internal pressures and external loads.
- Durability so pipeline can continue conveying the required quantity of water any losses or additional flows and carrying the loads imposed upon it.

This remainder of this article covers gravity pipelines flowing partly full. A distinction needs to be made between stormwater drains and sewers. Stormwater drains, particularly those in the warmer parts of the globe only flow a few times a year as rainfall is seasonal. Hence access to them is easy. On the other hand sewers flow continuously and access may have to be done at periods of low flow or under certain conditions may require the use of over-pumping.

The conditions in sewers can result in the generation and release of hydrogen sulphide (H_2S) gas which poses a serious corrosion potential in cementitious sewers, resulting in strength loss. H_2S is toxic and inhalation even at low concentrations can be fatal so the necessary precautions must be taken during inspections.

A realistic assessment of a pipeline requires onsite inspection, in addition to an understanding of the theory used in their design and then combining this information. Hence the output from multisensory inspections (MSI) and the basics of pipeline design need to be combined.

3. INTERNAL INSPECTIONS OF GRAVITY PIPELINES

The traditional approach of sending a camera on a tractor through a pipeline when empty or at low flows only gives a visual output showing the problems, their location, their extent and an indication of their severity. Typical problems noted are leaking pipe and manhole joints, invert settlement, longitudinal and circumferential cracks, siltation, wall material loss and distortion of the pipeline circumference. However, the actual severity of problems, or their underlying causes are not provided.

Using a combination of camera with laser and sonar profilers mounted on a pontoon floated through the pipeline adds value by providing full circumferential dimensional details along the pipeline length. When the external and internal dimensions of the original pipe are known this allows for the material loss and remaining wall thickness around the pipe circumference to be calculated. This means that the extent, severity and orientation of cracks, wall material loss, circumferential distortion of the pipeline and siltation depths can be determined. In addition this information could indicate the probable underlying causes of the problems.

The camera on a pole development, as illustrated in Figure 1, used in combination with a surface level survey along the pipeline route greatly simplifies the initial gathering of information and gives an understanding of the pipeline conditions without needing to send a camera on a crawler, or pontoon through the sewer. On the basis of this an initial hydraulic and structural analysis can be done showing where:

- there are blockages to be cleared
- ponding has occurred indicating invert settlement
- there is cracking and its location and type
- jointing is poor or misaligned
- there is ground water infiltration
- H_2S corrosion has taken place above the water line.

Figure 1: Camera on pole inspection

This provides the information needed to decide whether a more detailed inspection of each section of sewer is needed or not. If the condition of a section is still adequate as there are no problems, the cost and time of doing a detailed internal inspection of it will not be necessary and rehabilitation may not be needed.

EXTERNAL INSPECTION OF PIPELINE ROUTE

By following the route of the pipeline along the surface various external loading conditions such as transportation corridors, buildings and natural features such as water courses, wet lands and ponds can be obtained. The seasonal variations in the latter are very important because this will indicate the annual variation of groundwater levels. This is particularly important for larger diameter sewers that closely follow the alignment of natural water courses.

Part of this investigation should be the surface and invert levels at each manhole along the sewer route as well as the condition of the manholes. A long section of the pipeline showing invert levels and the surface profile can be drawn, assuming no pipeline settlement. From the manhole invert levels and the distances between them the theoretical hydraulic performance of the pipeline can be determined assuming that the gradients between the manholes as shown are correct. The earth and traffic loading along the pipeline can then be determined and the required pipe strengths calculated.

The location of any surface settlement should be recorded as this could indicate that the pipeline has for one or other reason settled. The local authority should be asked about any problems along this pipeline route due to manholes overtopping,

Figure 2: Severely corroded sewer

settlement or sinkhole formation.

With cohesive backfill material even though the pipe walls may corrode through in places the pipes may not collapse, as is shown in Figure 2. However, when exposed these pipes may collapse. Several phenomena shown are that the corrosion at spring line is more severe than at crown, longitudinal horizontal sills have formed, corroded reinforcement is masked by corrosion products and no corrosion below the low flow level. This 900 mm ID sewer was fed from a rising main with long retention times. The 70 mm walls were corroded through after 10 years.

The digitized output of the MSI scanning above and below water level provides dimensioned internal profiles along the whole sewer. This also shows where siltation levels reduce capacity and corrosion losses reduce strength. The details from the MSI should be complemented by measurements at a few locations as shown in Figure 3. This means identifying sections of sewer where severe corrosion is anticipated and which can be easily exposed from the surface so that inspection windows cut to do inspections, take measurements, photographs and material samples. These physical measurements can verify the digitized data and confirm the sewer's condition.

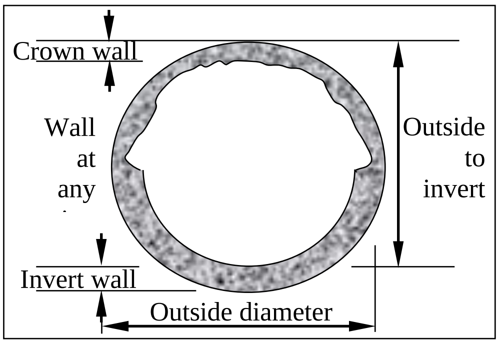

Figure 3: Physical dimensions to check

CONCLUDING COMMENT

Combining MSI observations with the sewer profile identifies the problem areas. By applying theoretical principles the underlying causes of these can be established and if necessary, ways of addressing them investigated and applied before undertaking rehabilitation. The rehabilitated pipeineqqqqqqqqqqqqqqqq may actually operate more effectively and efficiently than when it was originally installed and its rehabilitated life span can be several times that planned for the original sewer.

From the utility owner's perspective the critical issue is the sewer's remaining life before rehabilitation or replacement is needed and the most the most suitable method for doing this. A secondary issue is how effectively and efficiently the sewer will perform during this remaining life to minimize its maintenance.

By investigating the differences between the anticipated and actual performance the underlying causes to problems found can be identified and the preventative measures needed when designing new pipelines as well those to take during their operation to avoid past problems.

The two most serious underlying causes of problems observed are variable gradients along a sewer's length causing H_2S formation, its release and the corrosion of cementitious pipes, and the settlement of founding material under the pipe causing the opening of joints, resulting in exfiltration, infiltration and sedimentation.

However problems with sewer health are not just due to design defects or site conditions, but also their misuse due to ignorance. These two factors causes serious operational problems. Utility owners should address these issues with users to ensure healthy wastewater systems for future generations.