The Sonic Caliper - A Pipe Inspection Tool

Ted Price

Abstract

Increasing needs for repairing and replacing municipal sewer systems and similar pipe network has stimulated the development of new rehabilitation tools and new inspection methods. One of the newer, and more successful, inspection methods is the use of sonar to image the interior of the pipe. The first system to apply sonar methods, and to date the most versatile is the Sonic Caliper, developed in 1985.

The prototype Sonic Caliper was developed and first used to assist the city of Tampa, Florida to evaluate six miles of large-diameter interceptor pipes that were known to have severe crown corrosion. In fact, the city had experienced several street collapses in one twenty-four hour period. The city was looking for a way to determine the extent of the corrosion. They realized that video inspection only gave an approximation of the problem. Since sonar has been used for tunnel and cavity detection from boreholes, work done for the military and the petroleum industry it was adopted. City engineers estimated they saved nearly six million dollars, using the sonar information to specify sliplining instead of full replacement for most of the six miles of pipe.

The concept of measuring pipe interiors with sonar is simple. The travel time of a sonic pulse, to a target and back, can be converted into the distance to the target if the velocity of sound in the transmission medium can be determined. As examples, the velocity of sound in water is about 4800 feet per second; in air, about 1,100 feet per second. Typically the denser the medium, the greater the velocity; although the elasticity of the medium enters into the equation. Lead is denser than aluminum, but the velocity of sound in lead is lower- than in aluminum. The combination of density and elasticity make up the acoustic impedance of a material.

Sonic pulses are reflected from any acoustic impedance boundary. The greater the difference in the impedance of two materials, the more of' the sonic energy will be reflected. The impedance mismatch between water and the rigid wall of a pipe, or between air and the same pipe wall provide excellent sonic reflectors, as does the interface between air and water.

Sonic transducers are capable of both transmitting and receiving sonic pulses. The first Sonic Caliper tools had a array of ten to fourteen sonic transducers fixed in position to interrogate various points around the pipe - primarily at the crown and the invert. The most recent Sonic Caliper- tool, the ROTATOR, has a single transducer. As the name implies the transducer rotates around the center of' the tool. For each rotation the distances to fifty points around the wall are recorded.

The ROTATOR can be set to scan any arc, up to 360 degrees. In general use, when measuring debris in the bottom of the pipe, the arc is set at 180 degrees. When measuring sidewall and crown corrosion the arc is set at 200-235 degrees to provide full coverage from waterline to waterline. The fifty distance readings taken from each rotation are used to draw a cross section of the pipe in realtime; and are stored so the cross sections can be recalled and displayed in the office. One cross section is recorded for about every foot of pipe inspected. Corrosion and debris thickness can be read directly from the cross section Wall deflection in flexible pipes can be displayed and measured.

The distance resolution of the ROTATOR Sonic Caliper is better than 0.05 inches in air, and 0.07 inches in water. Accuracy is dependent on the stability of the ROTATOR platform. A skid-mount is more stable than a float Placid flow permits better accuracy than turbulent flow. As a general rule, accuracy is better than plus-or-minus 0.15 inches.

The ROTATOR has been used to measure corrosion and/or debris in pipes as small as eighteen inches and as large as 120 inches and manhole-to-manhole lengths of up to 2000 feet. The ROTATOR can be used in low-flow to near-surcharged conditions, in any type of pipe material.

Inspection results are presented as a series of cross sections that can be called up on a computer, a set of profiles of the crown corrosion and the top-of-debris in the pipe, a summary page showing the average and maximum corrosion and debris for fifteen-foot increments, and the debris volume in cubic feet.

As with any tool. there are limitations. high-velocity, turbulent flow will degrade the accuracy of readings through the air to the crown of the pipe, and can prevent sonic energy from reaching the insert to measure debris. These limitations hold for any system using sonar as a measurement technique. Other systems suffer a more important limitation. They are not able to measure distances through the air to the crown or sidewall of a pipe but must depend on having a surcharged pipe for corrosion -inspection.

The ROTATOR. as any sonic system. only measures the distance to the first acoustic interface. At the frequencies used. no system will penetrate past the surface of the pipe, or the top of debris. The ROTATOR, using a lower sonic frequency than other systems. will! penetrate and not be confused by the moving blanket of low-density sludge that is often found at the bottom of a flowing pipe.

Sonic systems are not adapted to detecting features normally seen with CCTV: roots, infiltration, open joints or laterals; but CCTV is a one-eyed man, with no depth perception. The combination of CCTV and the ROTATOR Sonic Caliper provides excellent coverage of the interior of large diameter pipes, showing discrete features add recording accurate measurements. At this time, several cities are using this combination for their primary sewer system evaluations.

If you have any questions, please contact **Dr. C.Vipulanandan**

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