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Partially Filled Pipe Flow Measurement Challenges and Solutions

Authors Rich Lowrie , KROHNE, Inc, and David Spitzer, Chesapeake Flow Solutions, Inc.

KROHNE has successfully deployed its TIDALFLUX electromagnetic flowmeter solution for many applications throughout North America to provide crucial process information. This document highlights the results of two such projects.

HALF FILLED MAGMETERS GIVE SEWER AUTHORITY COMPLETE SOLUTION TO WASTEWATER OVERFLOW

Is the magmeter half full or half empty?

That interesting twist on an old cliché is an apt question to ask the people of a certain small Pennsylvania city. The town is located in Schuylkill County, Pennsylvania, smack in the middle of the state's Coal Region, named for the abundance of anthracite coal that was first discovered way back in 1790.

With a little bit of background, the reasons for posing the half full/half empty question becomes abundantly clear. The town was experiencing a serious problem with wastewater overflow – not a complete surprise, given that the sewers themselves had been built back in the 1800's. These were not plastic or even metal pipes; the four-foot-diameter pipes were fashioned out of good, old-fashioned masonry.

For as many years as anyone can recall, raw sewage was being transported via the sewers and dumped straight into an open creek. Eventually, due to environmental concerns, state and federal regulations required that the water be treated before being discharged. Consequently, in the 1970's, an interceptor pipe was installed, which would grab a portion of this flow and send it to a recently built wastewater treatment plant.

Although the interceptor pipe remedied some of the problem, the solution had a serious flaw. The issue arose whenever there was a sizable rainstorm; in such instances, the interceptor system would bring an overabundance of storm overflow to the plant, which wasn't designed to handle the increased water volume. As a result, the plant would flood out, leading to some unpleasant scenarios – legal and otherwise.

"During high water events, the wastewater treatment plant was being flooded out, causing untreated or partially treated water to enter nearby streams," said Richard Lowrie, water and wastewater industry manager for KROHNE, a global technology leader in the development, manufacture and distribution of accurate, reliable and cost effective measurement instrumentation for the process industries. "This would result in fines from the state regulating agencies, not to mention the unfortunate impact on the environment."

Obviously, since nothing could be done to change the weather, a solution had to be devised that would control the flow of water to the wastewater treatment plant, particularly during heavy storms. The key would be regulating the initial flow of water into the interceptor system that fed the wastewater treatment plant.

To begin designing a viable solution, the city turned to Buchart-Horn of York PA, a full-service engineering and architectural firm. The firm answered a Request for Proposal (RFP) to perform an update of the city's 537 Plan. (The Act 537 Program, the Pennsylvania Sewage Facilities Act, was enacted on January 24,

1966. Its purpose is to correct existing sewage disposal problems and prevent future problems.) To meet this objective, the Act requires proper planning in all types of sewage disposal situations.

"The 537 plan is approved by the state Department of Environmental Protection," said Bruce Hulshizer, a senior engineer with Buchart-Horn and a project manager for sewer and water projects. "That's basically saying 'This is what we're going to do for our sewer needs.' Apparently, the DEP wasn't satisfied with the way things were going and they weren't going to meet their consent order, so that pulled us in."

As part of the solution arrived at by Buchart-Horn, KROHNE was brought in to provide a technical component to address the improvements that needed to be made to collection system; that component would ultimately form the centerpiece of the answer to the earlier half full/half empty question.

The component consisted of partially filled electromagnetic flowmeters (magmeters) to measure the lower normal flows and the higher flows during high water events. By using partially filled magmeters, the city is able to measure the normal flows, which would not keep a typical magmeter filled and also handle the higher flow rates in very rainy conditions. This would mean that the storm water flow in high-water events could be diverted away from the plant and into nearby waterways, solving the issue of plant overload (When the flow rates reach a preset flow, it is assumed that flow would consist of storm water run off and thus, can be safely diverted away from the treatment plants.) When normal flow rates resume, the flow is then directed back to the treatment plant.

"The city had a combined system, comprised from storm water and sanitary flow," said Hulshizer. "In order to have such a system, you have to have control structures that basically separate sanitary flow out away from a pre-designated amount of flow. After that, it would be storm flow, so you'd have to have some way of dividing the two. That's where partially-full magmeters came in."

The choice of KROHNE magmeters was a sound one. The company's Electromagnetic flowmeters can be used in almost all branches of industry for the measurement of liquids (with or without solids content) pulps, pastes and other fluids that have a specific minimum of electric conductivity. What's more, the sophisticated electronics provide superior results - reliable and repeatable even under difficult process conditions.

All KROHNE magmeters are wet-calibrated by direct comparison of volumes, the most accurate calibration method available. In fact, the KROHNE calibration rig is the world's largest and most accurate. This translates to a high accuracy - up to ± 0.2 % of actual value.

For this project, Buchart-Horn chose 21 of KROHNE's TIDALFLUX line of electromagnetic magmeters. KROHNE's TIDALFLUX flowmeters are combined with a capacitive flow-level measuring system, built into the wall of the measuring tube, thus providing accurate flow measurements in partially filled pipelines, with levels between 10 and 100% of the pipe cross-section. TIDALFLUX flowmeters offer precise factory calibration to ensure a level of measurement accuracy never before possible in partially filled pipelines. Featuring excellent abrasion and chemical resistance, the flowmeters' steady display of measured values is achieved regardless of rough product surfaces and distorted flow profiles.

Two different manufacturers bid on this part of the project, but KROHNE was the only manufacturer able to supply magmeters in the larger diameters necessary for the project. KROHNE also has an existing installation base to use as a reference for performance of partially filled magmeters. In other words, this was not the first time KROHNE had engaged in such an endeavor.

In the end, the load on the wastewater treatment plant has been substantially reduced in high water events, allowing the plant to operate within its specified ranges. What's more, the environmental impact of nontreated or undertreated water entering the streams from the plant has been greatly reduced.

"It's been a long process to where the city has come in terms of its wastewater treatment, but it has been a very effective solution," said Hulshizer. "And the KROHNE magmeters proved to be a critical ele-

ment." Which of course means that if you ask the city whether the magmeters are half full or half empty, you know what the answer will be.

HALF-EMPTY OR HALF FULL, KROHNE HELPS BACK RIVER ACCURATELY MEASURE FLOW

Some people look at the glass half full, some look at it as half empty. Neither approach is inherently bad, it's just two different ways of looking at things.

However, if a pipe in a wastewater treatment plant is only 50% filled, it doesn't matter whether you call it half full or half empty. When it comes to measuring the liquid in that pipe, either way presents a significant problem. The dilemma comes down to one undisputed truth: few instruments can accurately measure the level of flow in a pipe that is half full - or less.

Primnath Rambissoon, instrumentation supervisor at the Back River Wastewater Treatment Plant in Baltimore, was all-too-familiar with this issue.

"We had a process in the plant that had been shut down for quite a while, and when we restarted it, we had problems taking the measurement in that pipe," said Rambissoon, who is also in charge of the plant's remote pumping stations and remote media stations. "It was an application where the flow rate was very low and the pipe wasn't completely full. Unfortunately, the flowmeter we were using was simply unable to measure flow when it was that low."

Specifically, the trouble area was a section of piping that served as part of the plant's sludge handling process, transferring liquid from one section of the plant to another. The root cause was that the 12-inch pipe was oversized for the amount of material running through it: plant management had previously attempted to remedy the situation by installing a reducer to reduce the pipe from 12 inches to 8 inches, but that still wasn't enough to make the existing flowmeter work. Essentially, where the water originated at the entry point of the plant was a full pipe and the meter there could handle the flow rate. But plant personnel were unsuccessful trying to correlate that flow with what was coming from the other side of the plant.

"When I came here about three years ago, operations told me about it, but there was nothing I could really do without a full pipe to read," said Rambissoon. "It would just run and they would look at it when they got flow and they would just guess much of the time.

"What's worse, since we couldn't get a flow, we couldn't operate on automatic mode in that process, which would have reduced our operational costs. We operated in manual mode for years, probably from the time the system was designed."

According to Rambissoon, the flow measurement in this section of the plant didn't present any environmental or health dangers. At worst, it might lead to a situation in which tanks might be overfilled, causing leakage somewhere else in the plant. Still, accurate measurement was - and still remains - important to the plant's overall efficient operation.

Then, late in 2008, David Spitzer of KROHNE, Inc., a global leader in the design, development and manufacture of innovative and reliable processes, was making one of his regular sales calls to Back River. Spitzer, KROHNE's district sales manager for Maryland, Washington, DC, Virginia, and parts of Delaware, informed Back River that KROHNE had a unique product capable of measuring flow in partially filled pipes.

Rambissoon was intrigued by this prospect and decided to investigate further. Working with KROHNE would not be a real leap of faith, given that Back River already had a relationship with KROHNE (the plant had recently purchased a couple of KROHNE's OPTIWAVE 7300 C Radar Meters, one of which is being used to measure the level of a basin in the chlorination/dechlorination section of the plant).

What's more, some of the meters in the plant were actually KROHNE flow meters, although they were pushing 20 years old. Plus, Rambissoon said that at the plant where he previously worked, there were several KROHNE magmeters in place. Consequently, once Spitzer started calling on Back River, it was, more or less, a re-introduction to the KROHNE line of products.

"I did a little 'show and tell' on our meter products and it really clicked with Primnath," Spitzer recalled. "He was very interested in getting our flow meter into that low-flow pipe to see what it could do."

As a result of Spitzer's presentation, Back River bought the KROHNE TIDALFLUX Electromagnetic Flowmeter at the end of 2008; it was delivered and installed in early 2009. The TIDALFLUX, which is ideally suited for use in partially filled pipelines, is installed mainly in the intake and outfall structures of sewage works and stormwater basin outlets, as well as in transfer stations.

The measuring system is similar to that of a conventional electromagnetic flowmeter with two measuring electrodes, supplemented by a capacitive level measuring system which measures the filling level in the primary head with millimeter accuracy, regardless of whether the pipe is flowing full, half-full or even less.

As the two measuring electrodes are located below the 10% filling level, the TIDALFLUX is immune to any residues floating on the water surface and is not affected by flow profile or wave motion. The capacitive level measuring system is supported on large-area sensors that are embedded in the liner of the primary head. Thanks to this capacitive principle the measurement is less dependent on flow profile and wave formation, and levels can be measured accurately and continuously over the entire pipe cross-sectional area.

Spitzer, who since the installation of the TIDALFLUX meter has started his own company, Chesapeake Flow Solutions, stated that it is the location of the electrodes that creates the meter's distinctive capabilities.

"The electrodes are situated at about the 10-percent level in the diameter of the pipe," said Spitzer, whose new company represents KROHNE products in the same geographic area. "So we're measuring down there, and there's also a capacitate level sensor inside the meter that actually measures the level of the pipe. The electrodes reveal the velocity of the liquid going through, and the level-element indicates how full the pipe is. That all gets integrated into a volumetric flow. It basically operates as a standard magmeter, but we relocate the electrodes toward the bottom and put a level measuring element behind the liner.

"This is kind of a unique configuration within the industry," he added. "There are a couple other manufacturers out there that try to measure partially full pipes; they use multiple electrodes around the pipe, so in between they're just estimating."

A welcome byproduct of the TIDALFLUX's high measuring accuracy is low hydraulic losses and a low maintenance requirement. What's more, calibration of the meter in the field is not necessary; continued accuracy is virtually assured with little or no involvement by operators or technicians.

Rambissoon says that the TIDALFLUX meter has not only performed just as expected, but presented few challenges during installation and set-up.

"The entire set-up and installation was extremely simple," he mentioned. "In fact, we didn't even need a factory person to come out and install it; we did it ourselves in house. And our operations people love it because it makes their job so much easier.

"But the most important benefit is the meter's functionality and accuracy. Most of the time we wouldn't be able to read a flow unless it was relatively high. Now we can get an accurate read at flow levels as low as 2 gallons per minute. Also, we can't overstate the benefit of being able to run the meter in automatic mode."

Spitzer went "the extra mile" to ensure that the TIDALFLUX would continue to perform up to Back River's standards.

"There were some questions about the additional wiring involved," he said. "Just to be certain that everyone was on the same page, I brought in a service guy and we did a mini-seminar at lunch time, because it was a pretty new device for them. I wanted Back River's in-house technicians to understand the nuances of the system and be able to address any potential problem, however unlikely, using internal resources."

Spitzer's extra effort seems to have won over even the harshest critics.

"There's one guy there who is skeptical of just about everybody's product," he said. "After we were able to get the measurement from that pipe for the first time ever, he actually shook his head and said, 'It works.' "

Half full or half empty no longer matters to Back River. KROHNE has seen to that.

For more information about the TIDALFLUX please contact us or visit:
http://krohne.com/en/products/flow-measurement/electromagnetic-flowmeters/special-purpose-flowmeters/tidalflux-4300-f/

or www.us.krohne.com then navigate to the product pages.