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GENERATIONS AHEAD IN SONAR & ULTRASONIC TECHNOLOGY

Properly Designed Ultrasonic Level Detectors Improve Water Overflow Studies

In order to reliably measure water flow within a complex sewer system, it is often necessary to accurately measure the level of the water as it flows in and out of the many manholes through the pipes within the system. Ultrasonic non-contact distance measurement technology is the most accurate and cost-effective method for measuring the water level within pipes, because the ranges of the distance to be measured are very short due to the small diameters of the pipes. However, most ultrasonic sensors have two major problems performing the measurements in the operating environment of a sewer.

The first problem is that the sensors typically have a minimum measuring range of 4 inches or longer, and they are also usually several inches thick. Therefore, if they are installed at the top of a pipe, they can't measure the water level if it is closer than 6 or 7 inches from the top of the pipe. Since many of the pipes in a typical system are 8 inches or less in diameter, these sensors cannot obtain readings if the water level is higher than the lowest 10% of the pipe.

The second problem is that most ultrasonic sensors utilize transducers with very narrow radiation patterns that are typically around 10°. This means that the sound radiates from the sensor in a very narrow conical 10° beam. This type of design allows the sensor to obtain longer detection ranges when the target is flat and perpendicular to the beam, but it does not work well when the reflecting surface is very uneven, such as occurs with the turbulent surface of water rapidly flowing in a pipe. This uneven surface causes the reflection of the sound pulse to scatter in many directions, so that the echo is outside the detection angle of a very narrow beam transducer.

Ultrasonic sensors can be properly designed to overcome these problems and provide the accurate liquid level measurements required in sewer applications. To accomplish this, the mechanical design of the sensor must be very thin so that when mounted in a pipe, the transducers will be as close to the top as possible. In addition, the sensors should also contain two transducers, one for transmitting the ultrasonic sound pulse when it is driven by a large voltage, and the other to receive the echo reflected from the surface of the water. Most ultrasonic sensors contain only one transducer that both transmits and receives the sound pulse. Because the transducer is a resonant device, the excitation voltage pulse causes it to ring like a bell that was hit with a hammer. It takes time for this ringing voltage to slowly reduce until it is less than the levels produces by the reflecting echo when it returns to the transducer. This is why most ultrasonic sensors have a minimum detection range, or lockout, of 4 inches or more. If the sensor is designed with two transducers, the receiving transducer does not have a large transmit voltage place across it when the sound pulse is being generated. Therefore, the sensor can detect the low voltage pulse produced by the receiving transducer from the echo very quickly after the transmitting transducer emitted the sound pulse.

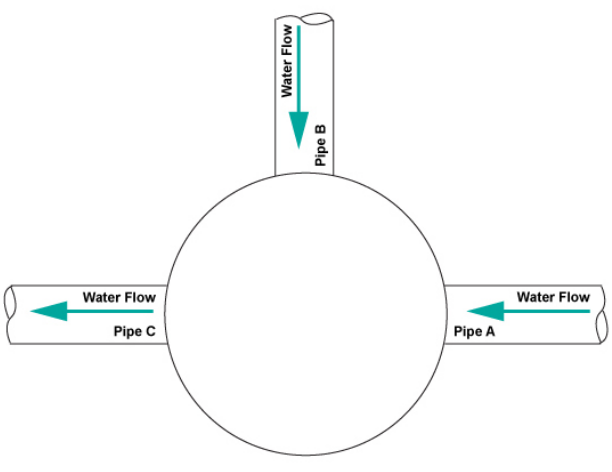
Also, the transducers used in the sensors need to be designed with broader radiating patterns. If the transducers have beam angles that are approximately 20°, the echo caused by the turbulent surface of the rapidly flowing water will be detectable. In addition, the sensors should have an IP68 rating, since they obviously will be completely submerged when a pipe is totally full during an unusually large water influx.

One ultrasonic level detection that contains these design modifications for operation in a pipe is the MassaSonic® FlatPack® Ultrasonic Sensor, shown in Figure 1. It is only 1 inch thick, so it can be shallowly mounted at the top of a water pipe. It contains two transducers, one for transmitting and the other for receiving, which allows it to measure the distance to the water surface when it is as close as 1 inch. The transducer radiation patterns are also 20°, which enables detections of the echo pulse when the reflection is scattered by the turbulent surface of the water flowing in the pipe. The sensor is rated IP68.

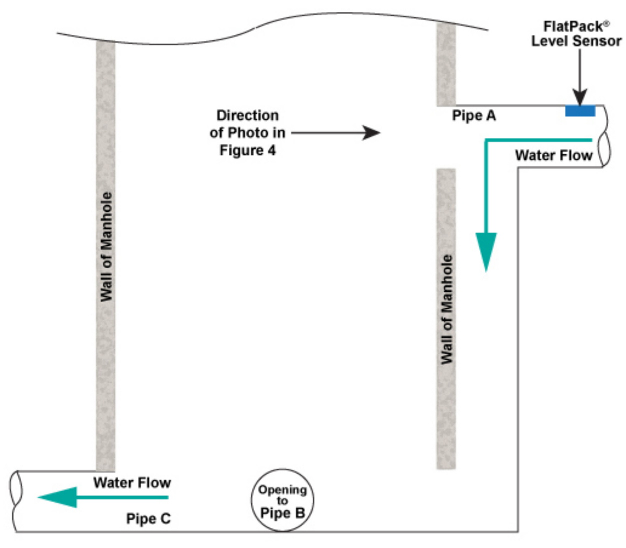
Figure 1

Photograph of a MassaSonic® FlatPack® Sensor Showing Its Shallow 1 inch Thickness and Dual Broadbeam Transducer Design

A very successful water flow study conducted in the MetroWest suburbs of Boston showed how a thin ultrasonic sensor with a dual broad beam transducer, such as the MassaSonic FlatPack, can effectively provide the required level detection in the pipes of a sewer system to enable reliable and accurate flow measurements. Figure 2(a) is an illustration looking down into one of the manholes in the system. Three 8 inch diameter pipes intersect at this manhole. Pipes A and B contain water that is flowing into the manhole, and the water flows out through Pipe C. Figure 2(b) is an illustration showing a cross-section side view of the lower portion of the manhole. As can be seen, Pipes B and C are located at the bottom of the manhole, and Pipe A is located above them. The water flows out of Pipe A and down to the bottom behind the wall of the manhole. A FlatPack Level Sensor is mounted at the top of Pipe A a short distance before it enters the manhole.



(a)
Illustration Looking Down Into the Manhole Showing the Direction of the Water Flow in the 8 inch Diameter Pipes



(b)
Illustration Showing a Cross-Section Side View of the Lower Portion of the Manhole and the Location of a FlatPack Level Sensor in Pipe A

Figure 2

Illustrations Showing Three 8 inch Pipes Intersecting at One of the Manholes of the Sewer System in the Boston Flow Study, and the location of a MassaSonic® FlatPack® Level Sensor Mounted Inside Pipe A

Figure 3 is a photograph looking down into the manhole, which corresponds to the illustration in Figure 2(a). The weirs that channel the water flow from Pipes A and B into Pipe C can be seen at the bottom of the manhole.

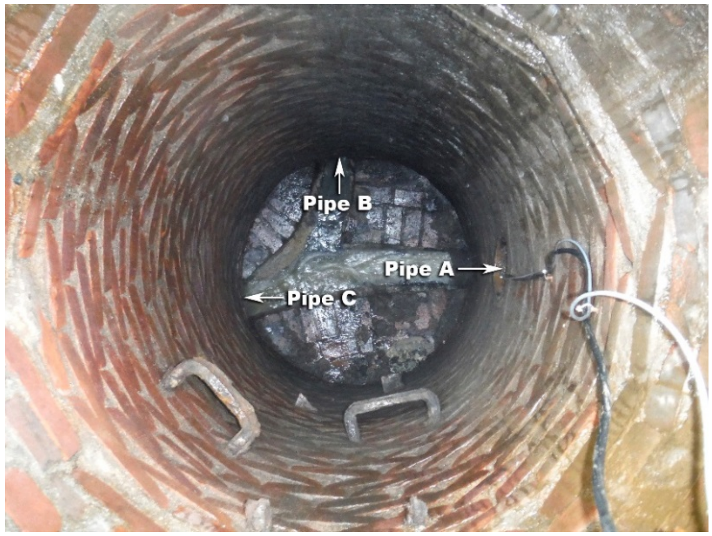


Figure 3

Photograph Looking Down into One of the Manholes In the Boston Flow Study That is the Same View as Illustrated in Figure 2(a)

Figure 4 is a photograph looking into the 8 inch diameter Pipe A from inside the manhole in the direction shown in the illustration of Figure 2(b). The water flowing out of Pipe A can be seen flowing down to the bottom behind the wall of the manhole. A FlatPack Level Detection Sensor is mounted at the top inside the pipe.

Figure 4

Photograph From the Inside One of the Manholes of the Sewer System in the Boston Flow Study Looking Into Pipe A, as Illustrated in Figure 2(b), Showing One of the MassaSonic FlatPack Level Sensors Mounted at the Top of the 8 inch Diameter Pipe A

The entire Program consisted of three separate flow studies that were carried out between January and June of 2017. During all three of these studies, the MassaSonic FlatPack Sensors were able to accurately measure the level of water in the pipes, which allowed for the precise and repeatable measurements of the water flow during the entire Flow Study Program.