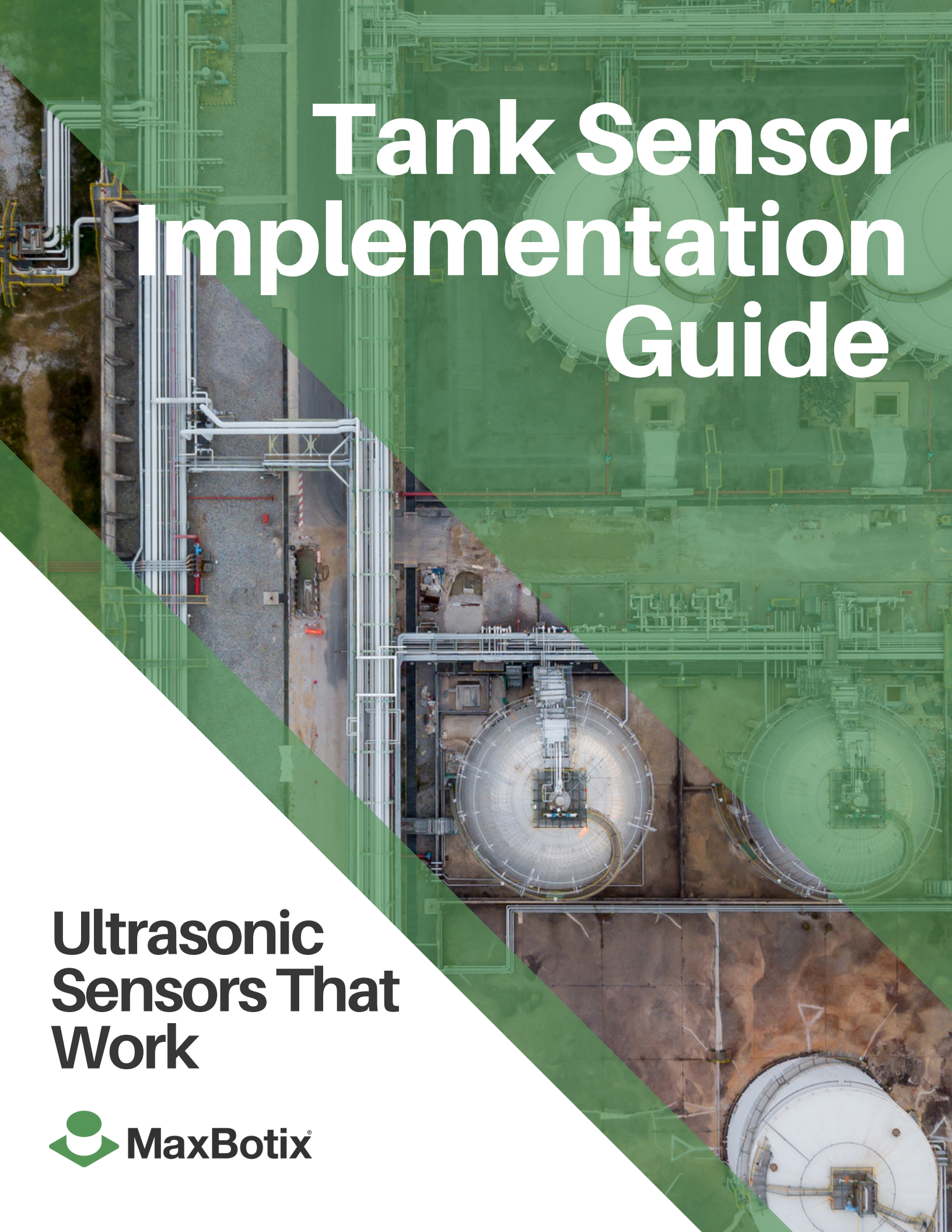
Tank Sensor Implementation Guide



Ultrasonic Sensors That Work

MaxBotix®

About Us

MaxBotix Inc. started in 2004 with a mission to provide affordable high-quality ultrasonic sensors for product developers.

By collaborating with our customers, we've been able to develop products that will truly work in their projects and industry.

We strive to be your **first choice for sensor solutions** by providing **high quality sensors that meet your application needs.**

We pride ourselves on *designing sensors that work* and *building relationships that last*.

Certified System ™
ISO 9001
Quality

Our promises to you

1. Sensors **Made in the USA** with US and imported parts.
2. Quality because we are **ISO9001:2015 Certified**
3. **Personalized Support** ensuring the success of your application

Introduction

What is this guide?

This guide is a list of recommendations to help you implement a MaxBotix ultrasonic sensor in a tank. We cover a number of common implementation questions and provide guidance so that you can install your sensor with full confidence. This guide is written with questions that cover these topics.

As you go through this guide, should you have any specific questions related to your application, please reach out to our support team who will be happy to assist you.
Email: techsupport@maxbotix.com Phone: 218-454-0766

What is an ultrasonic tank sensor?

Ultrasonic sensor technology has been proven reliable for detecting products even under conditions such as rain, high humidity, dusty environments, smoke, and extreme temperature.

We sell most of our ultrasonic level sensor products for use in liquid-level sensing (such as water), but we also offer them for applications such as detecting objects moving through air channels, monitoring fluid levels, and even measuring the distance between two points.

This sensor technology is ideal for high-accuracy, continuous-level measurement of a wide variety of liquids in storage and shipping containers requiring a non-contact measurement solution.

Why is an ultrasonic tank sensor important ?

Continuous-level sensors allow users to monitor product flow rates without having to open the container or remove the sensor. This allows the user to accurately track changes in volume over time, saving money and improving efficiency.

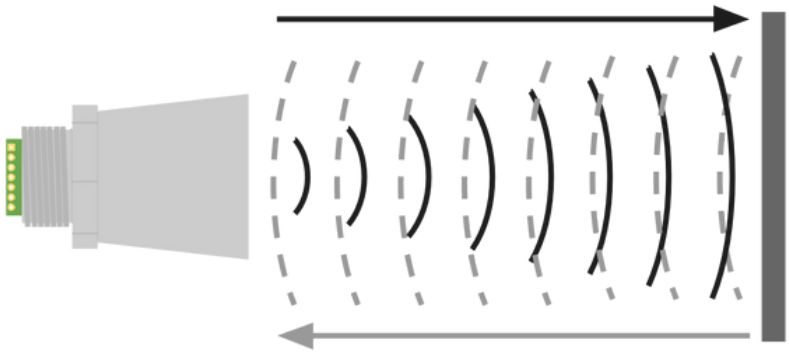
How does an ultrasonic tank sensor work?

An ultrasonic sensor sends out a short burst of ultrasonic energy at a specific frequency. When this energy hits something solid, it bounces back and returns to the sensor.

Ultrasonic sensors work by sending out a sound wave at a frequency above the range of human hearing.

The transducer of the sensor acts as a microphone to receive and a transmitter to send the ultrasonic sound.

Our ultrasonic sensors, like many others, use a single transducer to send a pulse and to receive the echo. The sensor determines the distance to a target by measuring time lapses between the sending and receiving of the ultrasonic pulse.



Common uses include:

- Tank Level
- Open flume flow monitoring
- Tank Farms

Our ultrasonic level sensors are easy to install and low maintenance. They are intended for non-contact level sensing, which means there will be a lack of build-up on the sensor face itself.

The level sensors must have an unhindered path to the surface you want to detect.

How does voltage affect the a tank sensor?

Sensor Operational Voltage

The operational voltage of a sensor has an impact on performance. This is detailed in the datasheet for each individual part. Each beam pattern shows the type of changes that may be expected at varying voltage levels. Each sensor is rated for operation over a specific voltage range also defined in the datasheet.

Reading a MaxBotix Beam Pattern

MaxBotix Inc. provides beam patterns for all of our ultrasonic sensors to assist users in choosing the correct sensor for their application, target size, and distance. Each beam pattern diagram is a 2D representation of the detection area of the sensor. In reality, the actual beam pattern is shaped like a 3D cone (having the same detection pattern both vertically and horizontally).

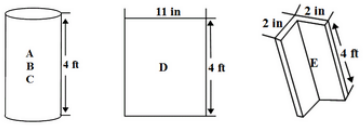
Complete details on reading a beam pattern can be found at the following link: https://www.maxbotix.com/articles/reading-beam-patterns.htm

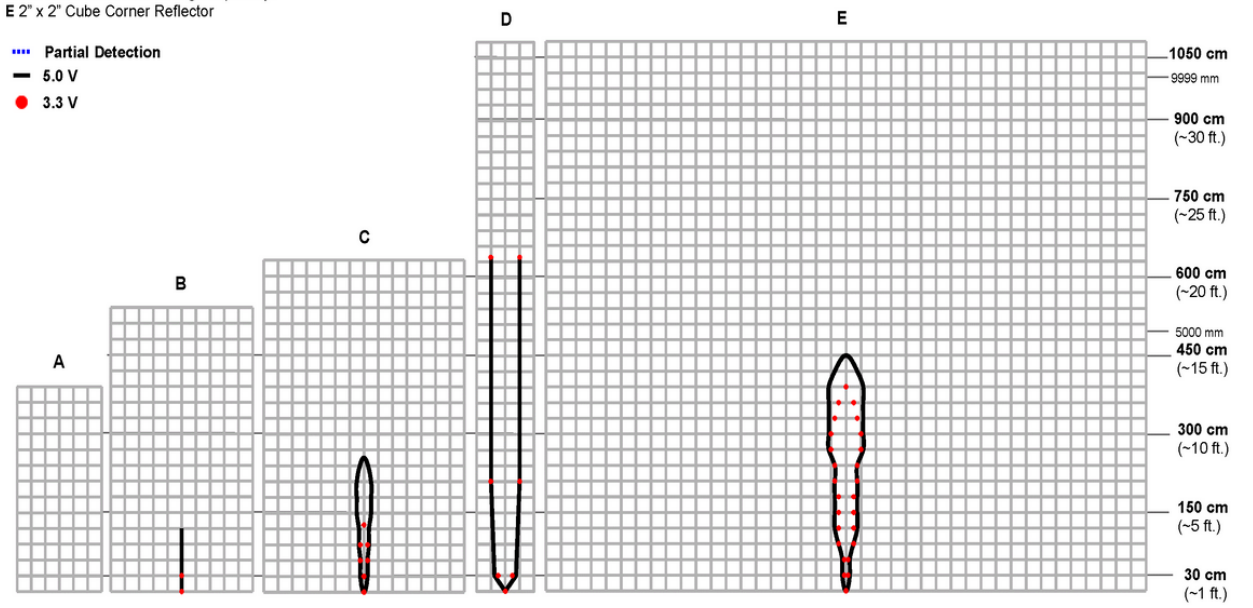
MB7850-BXX

XL-TankSensor-WRMA™ Beam Pattern

Sample results for measured beam pattern are shown on a 30-cm grid. The detection pattern is shown for dowels of varying diameters that are placed in front of the sensor.

A 6.1-mm (0.25-inch) diameter dowel
B 2.54-cm (1-inch) diameter dowel
C 8.89-cm (3.5-inch) diameter dowel
D 11-inch wide board moved left to right with the board parallel to the front sensor face. This shows the sensor's range capability.
E 2" x 2" Cube Corner Reflector





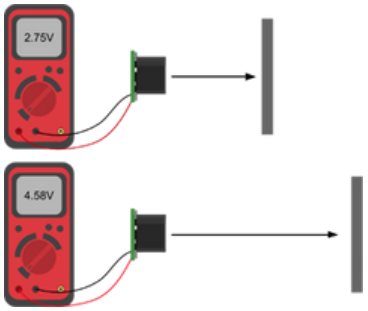
Beam Characteristics are Approximate

Beam Pattern drawn to a 1:95 scale for easy comparison to our other products.

How does the sensor report liquid level?

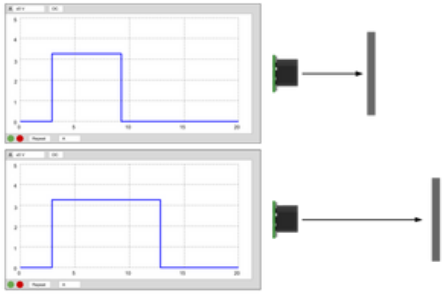
The four common outputs are briefly described below.

Analog Voltage (AN)



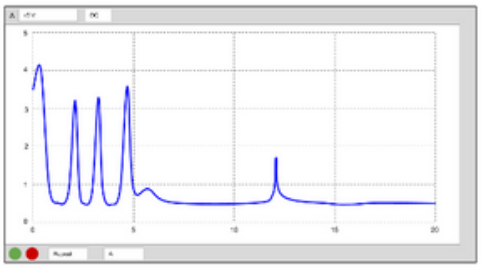
- Analog voltage output provides range information by a linear scaling of voltage; where the voltage that gets larger as a target increases in distance from the sensor or smaller as the distance decreases. The scaling factor varies between sensor lines, but it can be found in the datasheet.

Pulse Width (PW)



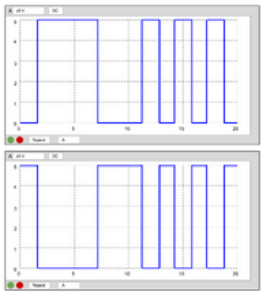
- The PW pin outputs a digital representation of range using a pulse width. A narrower high pulse indicates a lower range, and a wider high pulse indicates a larger range. The pulse will be at 0-Vcc voltage levels. The exact scaling between pulse width in uS and range is listed in the datasheet.

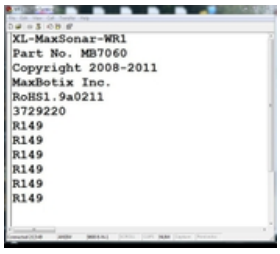
Analog Envelope (AE)



- The analog envelope output is a minimally filtered output of the acoustic waveform. The output allows the user to apply their own filtering and target detection scenarios. The time axis along the bottom directly corresponds to distance in a linear manner, and the height of each peak corresponds to the acoustic return of the target.

Serial Data (RS232 or TTL)



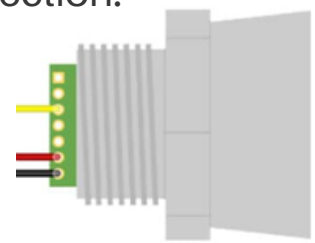


- Serial output is available in a two formants: RS232 and TTL The output is an ASCII capital “R” followed by ASCII character digits representing the range. The complete details of the sensors available serial output can be found in the datasheet .

How do I control my tank sensor?

Our ultrasonic sensor offers a straightforward method of connection and command. The sensors require a minimum of 3 wires for connection.

1. Power or Vcc
2. Ground or GND
3. Signal output
4. RX input (optional)



Complete wiring information is found in the datasheet.

Commanding sensors by the RX input

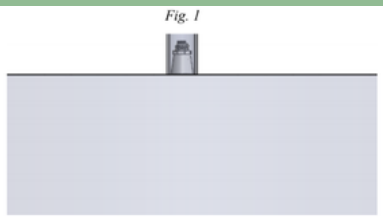
In general, our sensors do not require any additional inputs. Most sensors are designed to operate in free run mode. The standard input available on most sensors is the RX input that is used to toggle between the sensor taking a range reading and sitting in an idle state.

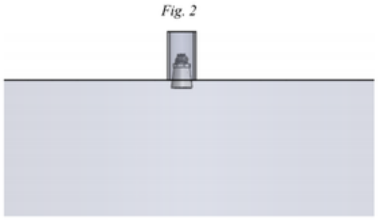
Advanced RX input commands

The XL-TankSensor-WRMA offers a robust series of input commands that can enhance the performance of your sensor. It boasts a teach feature for your specific tank environment. It will also allow for advanced range data to be sent over the serial output. Please reference the datasheet for this product to view the complete details. Link to datasheet: https://www.maxbotix.com/documents/XL-TankSensor-WR_Datasheet.pdf

What do you recommend for mounting?

The mounting of a sensor in a tank is critical to the success of the sensor. Our sensors offer a narrow beam pattern which reduces the chance the sensor will detect the wall of the tank.





Figures 1 and 2 shown above are acceptable mounting positions.

A number of our sensors contain most-likely and stability filtering. This improves the performance of the sensor in a tank by choosing the target that gives the largest acoustic return. This will generally be the liquid level inside the tank.

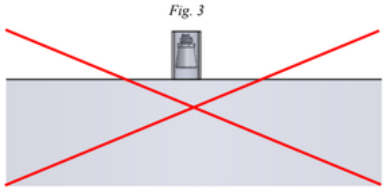
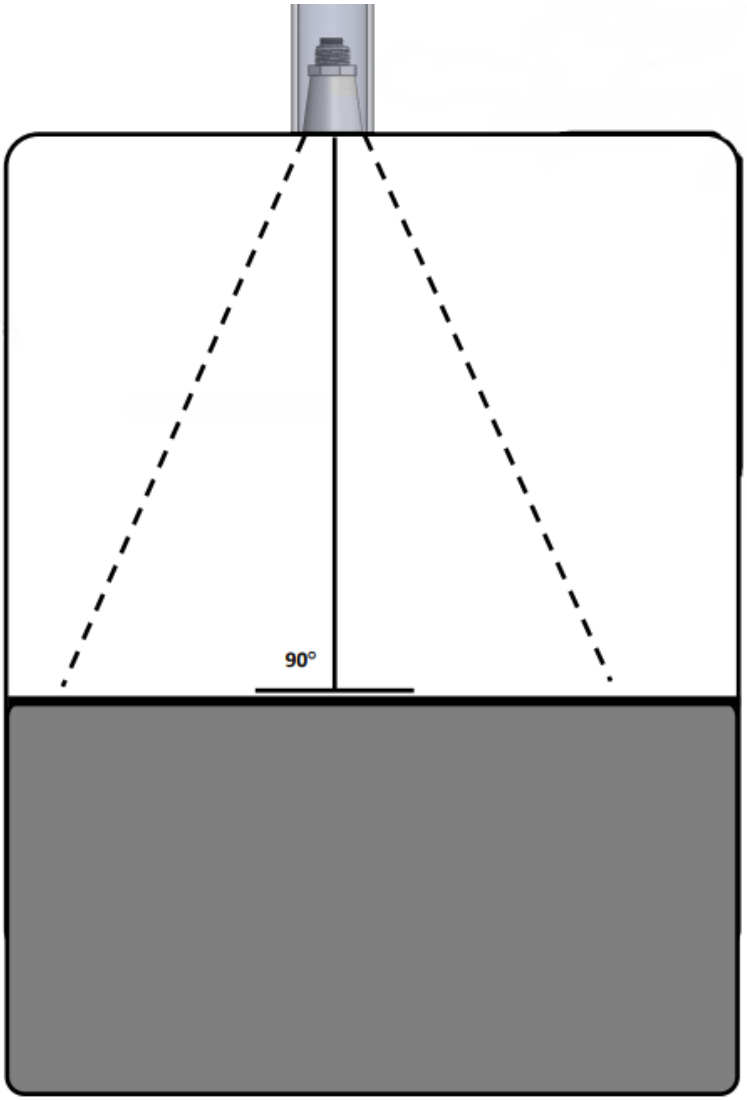


Figure 3 is **NOT** an acceptable mounting position.

The images below shows the ideal mounting of the sensor in a tank.



90°	The sensor must be perpendicular (90°) to the liquid level
– –	Ultrasound Pulse Beam
	Liquid Level

Do Not Recess the sensor

When mounting the sensor, the sensor should be flush with the top of the tank or extend slightly into the tank.

Avoid the Tank Walls

In non-smooth walled tanks, the sensor may need to be offset from the wall. We recommend 24-36 inches of clearance between the sensor and the sidewalls.

Keep a Clear Beam Path

The space in front of the sensor, between the ultrasound beams, must be free and clear of any wires, brackets, or other items that could be detected by the sensor.

The Ideal Sensor Mounting Position

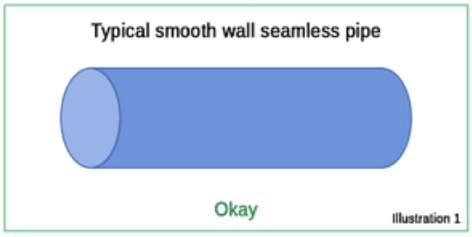
Don't directly center the sensor. Place the sensor 1-3 inches off center for the best performance.

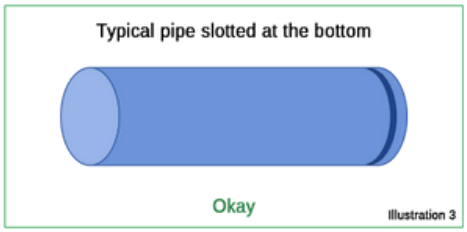
Can I mount my sensor in a pipe?

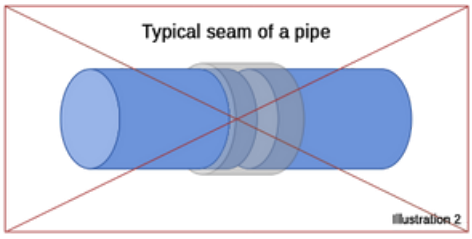
A common method of installing a sensor in a tank is to mount the sensor in a pipe.

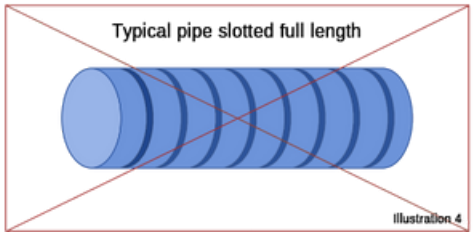
- Successful operation of an ultrasonic sensor inside a pipe has strict pipe requirements.
- It is possible to get accurate results in a pipe, however, many factors must be accounted for to achieve success

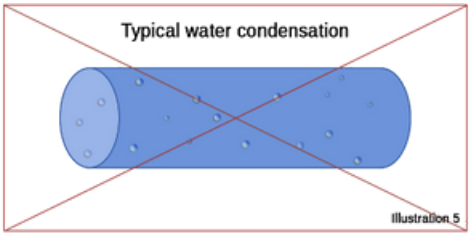
Our testing found that the sensors may work when placed in a seamless pipe. The testing was conducted in an 8-foot, schedule 40 PVC pipe.

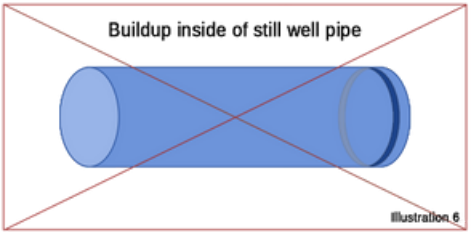












Additional considerations of pipe operation

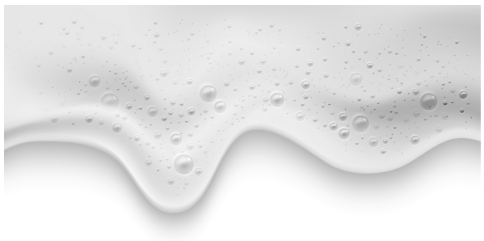
1. MaxBotix recommends that users consider a pipe diameter greater than 8 inches.
2. When operating inside of a pipe with imperfections, dents, dings, and breaks, the imperfections may give the largest ultrasonic reflection resulting in the range being reported to the imperfection.
3. Multiple path reflections can cause the target to appear to walk closer and farther as the temperature in the pipe changes. In some cases, this can be between 5-10 cm however it is common to see 1-2 cm.
4. Phase cancellation can happen which causes the acoustic reflection from the liquid level to disappear at certain distances or temperatures. When this happens, the sensor doesn't see the liquid level. Some of our filtering to help reduce this issue when it occurs for short periods of time.
5. A common question is if you can range targets outside of the pipe? An acoustic lens is created at the end of a pipe when it is pointed into the air. This typically creates a target at the end of the pipe which results in the sensor only ranging to the end of the pipe and not beyond the pipe.

Full details can be reviewed in the complete article at this link:
https://www.maxbotix.com/tutorials5/ultrasonic-sensor-inside-pipe.htm

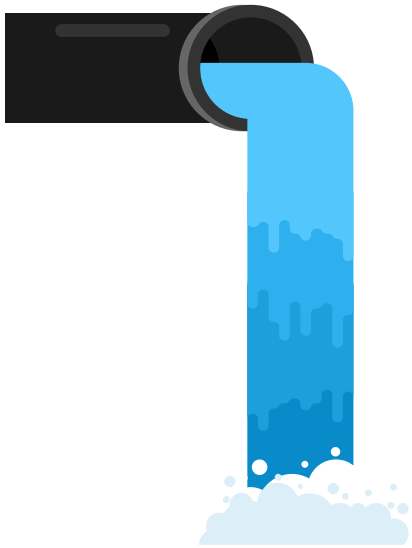
What affect do liquid properties have?

There are several factors that can have a direct effect on a sensor's performance. This section will cover three major areas of impact on the performance of a sensor along with potential solutions.

Foam on the surface:



- liquids that create suds and foam on the surface of the water may reduce the strength of ultrasonic reflections thereby making them more difficult to detect.
- Fill pipes that are above the liquid level and make foam and ultrasonic noise as a liquid is pumped into the tank.



Solution:

- Mounting the sensor in a pipe that acts as a still well can be a common remedy to this issue. Follow the guidelines previously discussed

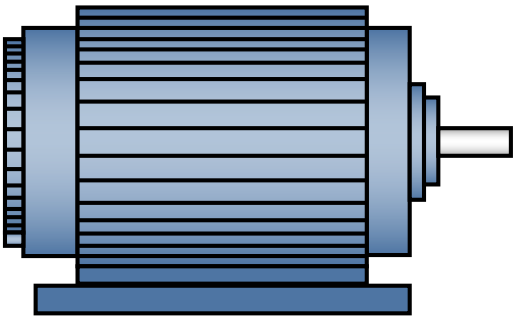
What affect do liquid properties have?

Waves in the water:

Any disturbances in the surface of the liquid may cause fluctuations in the reported range. As a wave moves across the surface of the liquid, the distance to the sensor will change thereby changing the reported range. To help mitigate this, a still well can be used to isolate the sensor from the waves.

Solution:

- Mounting the sensor in a pipe that acts as a still well can be a common remedy to this issue. Follow the guidelines previously discussed



Pump motors:

Noise generated by motors can decrease the reliability of liquid-level sensors by injecting unwanted signals that the sensor may confuse for ultrasonic reflections. This is especially true with top filling tanks where the sensor may be directly exposed to these devices.

Solution:

- To help mitigate this issue, position the sensor such that it is acoustically isolated from them, or limit sensor operation to times when these devices are not operating.

Can I use a sensor exposed to chemicals?

When selecting an ultrasonic sensor for your application, it's important to know the following about the chemical environment where the sensor will be used:

- Is it corrosive?
- Does it contain solvents or other chemicals that might affect the operation of the sensor?

You can review our chemical compatibility chart for more details. Click the image below to see our entire listing of solutions.

Chemical	PVC	Silicone	Fluorosilicone	Aluminum	Parylene
Hydrochloric Acid	<37% C	37% C	<37% C	NC	10% C
Sulfuric acid	<75% C	<10% F	NC	NC (*cold concentrated - C)	10% C
Hydrofluoric acid	<50% C, 75-100% F	NC	NC	NC	10% C

Key

NC = Not Compatible

C = Compatible

R = Required

F = Fair

https://www.maxbotix.com/chemical-compatibility-charts.htm

Solutions:

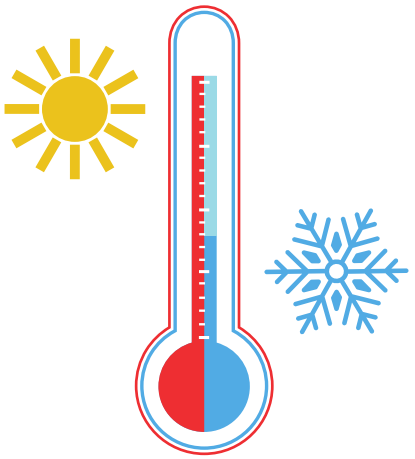
These are our two most common protections to increase the sensor's chemical compatibility in a wide range of environments.

- F-Option -The MaxBotix F-Option (IP68) provides additional protection necessary in a few hazardous chemical environments. Extremely corrosive gases or liquids can degrade or compromise the operation of the sensing unit.
- P-Option - The P-Option is a Parylene coating applied to the surface of the aluminum transducer. This helps to improve the corrosion resistance of the aluminum transducer.

What environmental conditions have impact?

Temperature

The speed of sound changes over the temperature range of -40C to +65C. This means that the distance reported will change over temperature.



Solution:

- Here is a PDF on how to conduct temperature compensation for use with sensors that do not have temperature compensation. Link: https://bit.ly/46KkBPc
- Select one of our sensors that has built-in temperature compensation.

When using a temperature-compensated part, direct sunlight on a sensor can cause solar loading which causes the sensor to incorrectly compensate temperature

Solutions:

- Bypass the temperature compensation to turn it off and compensate using a separate temperature sensor that is shielded from the sun.
- Shield the sensor from direct sunlight.

What environmental conditions have impact?

Humidity and Condensation

Typically, ultrasonic sensors are designed to work in high humidity (up to 99%) and non-condensing environments. When a sensor is installed in an enclosed environment with condensing moisture, the sensor can often have a condensation form on the front face of the sensor and cause the range data to become corrupted.

Solutions:

We offer two solutions to allow operation in condensing environments.

1. The MB7850 offers a novel design that allows the transducer to drain condensation off the front face of the transducer before it causes issues with the reported range values.
2. Our self-cleaning series of sensors have been proven to work to prevent condensation in most installations. The solution has a couple of requirements:
    - This sensor is required to be on all the time for the sensor to keep the condensation off the sensor.
    - The average current draw of the sensor is 68mA at 5V.

    - When the sensor is turned off, condensation forms on the sensor. It can take up to **24 hours** for the sensor to clear the condensation once the sensor is turned back on.
    - This solution is **not recommended** for environments that experience hot inflows often causing rapid condensation.

What environmental conditions have impact?

Gas Vapors

When operating in a chemical environment, the gas vapors will change the speed of sound which will cause an error in the reported distance to be observed. Typically the density of the gas-to-air ratio will affect the amount of change that will happen. You will need to research your specific environment if you want to complete full-range data compensation.

Liquid Expansion and Contraction

As the liquid of a tank changes temperature, the liquid can expand and contract. This impacts the amount of liquid that is in the tank. This should be considered compensation in your overall calculations.

The rate of expansion and contraction is determined by the properties of the liquid makeup.

Your Project is in Good Hands

We're **ISO 9001:2015** certified.

What our ISO 9001 certification means for you as a customer...

It means that we've taken the process seriously to ensure that you get the best products and customer service.

We're committed to providing our customers with a high level of quality, reliability & safety in all stages from design through production for your peace-of-mind when using MaxBotix Inc's product line.

How It Works

We have a wide variety of sensor solutions available, in fact over 1,500 SKU configurations.

Due to the complexity of options, we have simplified the buying process into three easy steps.

We are ready to help you find the right sensor for your application.

Step By Step

1. Discuss your application with our support team

2. Choose a Sensor

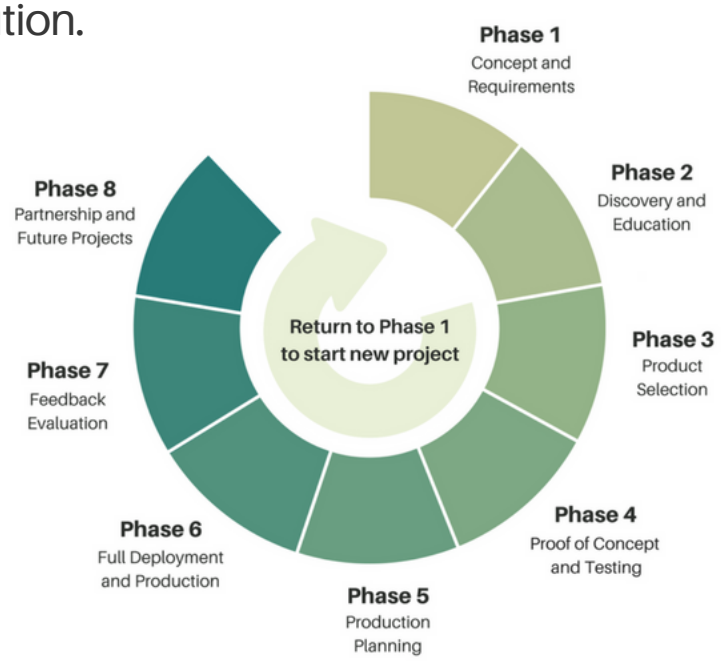
3. Integrate the sensor in your application

Click Here to Get Help Finding the Right Sensor Solution

Custom Sensor Solutions

We offer custom solutions for many of our OEM customers.

If there isn't a sensor in our current product offering that works for your needs, our team can work with you to see if we can develop a viable solution.



We'll walk you through every phase to ensure you have the best fit for your application.

Want to know more?

Visit us at www.maxbotix.com

We have resources on our website designed to answer questions and explain concepts. Our site features all of our products and a sensor selection guide to help you find what you need.

Email us with any questions you may have at sensors@maxbotix.com

Whether it's about sensor selection or tech support, we are always happy to help.

You can also give us a call at (218) 454-0766

Our staff is always happy to talk to you about tech support, distributor opportunities, and more.