Blackwater Sensing: Providing long-term reliability for Blackwater sensors.

It is becoming increasingly unacceptable to discharge sewage from a toilet directly into the environment. With legislation also directing this trend, it is more important than ever that you have a robust solution for blackwater sensing in place.

In this paper we take a look at the issues that sensors face when measuring Blackwater, some of the ways these have been tackled up to now and how a new approach could finally resolve the measurement reliability and maintenance problems

GILL

Sensors & Controls

INTRODUCTION

Reliable measurement of all types of Black and Grey water tanks, without regular inspection and cleaning of the level sensors, is an ongoing challenge.

Currently there are a number of differing products available that attempt to overcome the unique difficulties of Blackwater measurement, including contact and non-contact sensors, with some located on the outside of the tank.

Since 2006, the Recreational Craft Directive (RCD) has required that new vessels have provision for a holding tank to be fitted and conventions including MARPOL and HELCOM impose restrictions on what can and cannot be discharged depending on vessel size and location.

Additionally, national legislation imposes restrictions on discharges and the facilities a vessel needs for entering their waters. However, it is not a consistent picture and some additional information can be found via the RYA and BoatUS Foundation.

These increasing requirements for holding tanks for Blackwater and in some cases Greywater, mean that sensors are required to monitor the levels within these tanks, as overflow can have unpleasant consequences for both the vessel user and the marine environment.

PROBLEMS FOR SENSORS…

Sensing the level of Blackwater presents a number of problems.

The first is simply what is contained within Blackwater. Apart from water there is primarily human solid and liquid waste and paper. It could also contain cleaning agents, detergents and other chemicals, depending on the individual circumstances. Obviously, the liquids/solids ratio will vary, as will the state of decomposition.

This is an aggressive mixture and being on a vessel it can also be subject to considerable sloshing around the tank, which means that any part of the tank or equipment in it can come into contact with the contents.

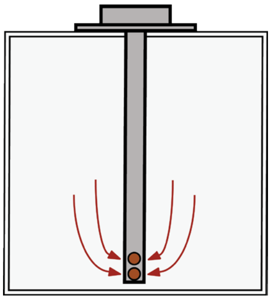
Additionally, the contents could be in the tank for a number of days, plus there is the issue of vessels being laid-up over winter. Although the tanks will have been pumped out before storage, there is the likelihood that there will be a residue remaining in the tank for a prolonged period leading to hardened deposits.

Finally, there is the fact that holding tanks are almost exclusively located in the bottom of the vessel where access is difficult- typically access hatches can be located in kitchen and bedroom floors-with little or no space around the tanks. This also results in the tanks being an irregular shape which complicates the ability of sensors to provide a true volumetric measurement.

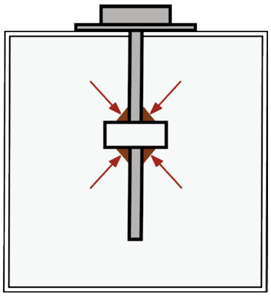
...AND THE ISSUES THEY CAUSE

The two principal effects these harsh conditions have on sensors are accuracy and reliability. Failure of either Of these attributes can have obviously undesirable effects.

Accuracy can be affected simply by pieces of paper within the tank sticking to a sensor and blocking inlet/outlet holes. This can occur even if the sensor has an additional outer shield to protect the sensor from the solid contents in the tank.



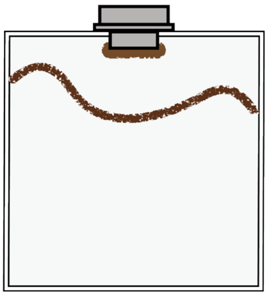
Traditional Capacitive



Float Type

More widely, any sensor with moving parts - (e.g. floats or swinging arms) - or those with holes to allow a flow of liquid to be measured can stick or clog from accumulated solids residue, leading to a false level measurement.

Even non-contact sensors such as Ultrasonics can slowly be coated with solid matter from sloshing in the tank which dries to render the sensor inoperable. The effect of an accumulation of dried material on surfaces can also affect the accurate measurement from a sensor by, for example, causing floats to completely seize up.



Ultrasonic

A combination of human waste and chemicals also forms a very corrosive mixture which will quickly corrode any metallic components including, over time, some stainless steels. If a sensor is manufactured from a poor quality plastic , the surface could become pitted and cracked, which will not only affect the smooth operation of a float, but also provide a 'key' for dried residue to accumulate.

Inaccuracy or unreliability will ultimately lead to an incorrect reading which, if it results in overfilling, will end with the tank overflowing either through an inspection hatch or through the lavatory. The consequences of this do not require any elaboration.

The requirements for holding tanks for Black and Grey water apply to all types of vessel.

POTENTIAL ANSWERS TO THE PROBLEMS

The actions to help prevent sensor failures currently centre on periodic maintenance, which can involve accessing the tank.

Cleaning either the tank or the sensor, or both, on a regular basis is the best way of minimising the likelihood of sensor failure. There are many methods suggested for cleaning a tank, from adding fabric softener through to putting ice cubes into the tank to scour it out. However, as a minimum it is widely recommended to quarter fill the tank with fresh water and take the vessel out to slosh the water around and then empty, preferably each time the holding tank is pumped out.

There are also chemical additives that can be added to help keep the tank clean and minimise sludge build-up. For particularly contaminated tanks using a high pressure water jet through the tank inspection hatch is also suggested, as is making sure the tank vent points are kept clear.

Another alternative is to use sensors that are applied to the outside of the tank getting over the issues of clogging and contamination. The only factors to be aware of here is that installing and accessing them could be very difficult in the confined spaces at the bottom of the vessel and that they do not work on metallic tanks. They also need to be kept clear from any metallic objects, a minimum clearance of 50mm is typical.

However, depending on the type of sensor and its location within the tank, even these measures may not be sufficient to keep the sensor clean enough to maintain reliable operation. Indeed, a high pressure water jet or some of the additives that can be added to the tank may either damage or degrade the sensor further, inhibiting its operation.

To solve the problems of long-term sensor reliability and accuracy in such a difficult environment, really requires a sensor that is designed specifically for the Blackwater tank that addresses all of the problems that the sensor will confront.

A NEW APPROACH

The three principal factors that prevent a liquid level sensor in a Blackwater tank from providing reliable, maintenance-free measurements are coating, corrosion and clogging.

Gill Sensors & Controls has created a new Blackwater level sensor that tackles these problems head-on, using a proven capacitive measurement technology, combined with innovative thinking.

Firstly, capacitive measurement is a solid-state technology and does not use any moving parts. Consisting of a smooth probe without any holes for fluid flow in it, the sensor immediately defeats the complication of the sensor becoming jammed or clogged by solids preventing operation.

Secondly, by covering the probe in a non-stick, chemically inert coating means that the sensors operation and performance will not be degraded by a build-up of dried solids over time. It also means that it is unaffected by the corrosive effects of the waste and any chemicals which may have also been added to the tank.

These principal features ensure that by eliminating the cause and effects of coating, corrosion and clogging the sensor does not require the periodic cleaning or maintenance that other sensors require.

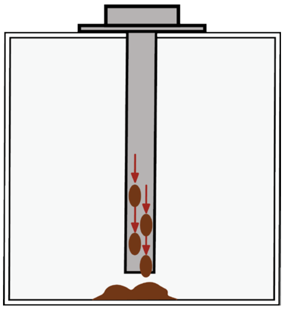
Capacitive measurement also delivers additional performance benefits. The measurement reading is a continuous, step-free output from empty to full rather than providing only one, two or three measurement points that many sensors offer.

The probe element of the sensor which goes into the tank has also been engineered to be robust and rigid enough to withstand the considerable forces that will be placed upon it by sloshing of the contents in rough seas.

Finally, the outputs from the sensor have been configured to make sure it is compatible with existing gauges and systems display screens.

PROOF

To ensure that the new Gill Blackwater sensor does provide the resilience to coating, corrosion and clogging that the application requires, it was essential that it was tested over an extended time period in demanding conditions.



To this end a prototype sensor was installed on an automated test rig that would prove it would not require cleaning or facilitate the build-up of any black water deposits on the sensor probe such that a change in sensor output would occur.

The probe was dipped into Blackwater for 5 seconds and then allowed to air dry for 120 minutes in a continuous cycle. The probe was visually checked for a build-up of scum/debris.

After 6 months of testing the voltage output of the sensor was unchanged. Additionally, there was no evidence of corrosion on any component or scum/debris build-up on the sensing probe.

The testing is ongoing to cover a 12 month period.

The Blackwater storage tank with the access cover removed showing the typical contents the sensor was tested in.

After 6 months it can be seen that the sensor probe was clean and free from scum/ debris build-up.

CONCLUSION

The need and legislative requirement for Black and Grey water holding tanks on vessels is increasing and, consequently, so is the need for sensors to monitor the levels of liquid in these tanks. Reliable and accurate sensors are required for any application but, because of the unpleasantness of the contents of Blackwater tanks, these attributes become even more critical to prevent overflow and spillage.

There are a number of sensors available that use a selection of technologies to measure the levels within these tanks. However, the typical contents of a Blackwater tank provides unique challenges (see pages 2 & 3)that means these sensors can struggle to provide long-term, reliable measurement without regular maintenance interventions.

Gill wanted to determine if these difficulties could be overcome to provide users with the reliability and accuracy they require. By exploiting their experience of capacitive technology and combining it with innovative materials to eliminate the problems Blackwater poses to sensors, Gill have developed a product fit for purpose.

It is one thing to produce a product that works in the unrealistic environment of a factory, but another to prove it in a long-term test in a real environment. By putting the new sensor through a rigorous test procedure in true Blackwater, you can be confident that a real answer has been developed to this long-standing and challenging problem.

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