

SSI Technologies - Application Note FT-AN6

Fluid-Trac® Liquid Level Sensor

for Urea, Diesel Exhaust Fluid (DEF), AdBlue Tanks

Urea (DEF and Adblue) Tank Applications

Governments around the world are creating legislation to control and reduce the amount of pollutants that can be released into the environment especially from the burning of fossil fuels.

Starting in January 2010, urea tanks will become standard equipment for most new diesel trucks, buses, sport utility vehicles and automobiles in the U.S. Tractors, bulldozers, and other non-road vehicles will follow to meet the new EPA standards.

Running without urea, would result in an engine exceeding the permitted emission levels and the vehicle operator subject to fines. The urea level in the tank is usually monitored by a level sensor that interfaces with some form of On Board Diagnostics (OBD) system. The OBD system usually supports warning actions (low urea level light and de-rating of engine performance) and emission limit enforcement actions (engine shutdown or blocking engine restart after shutdown).

The Fluid-Trac® level sensor is an optimal choice for urea tank applications. Fluid-Trac® is a non-contact ultrasonic level sensor that is designed to operate under harsh environmental conditions with an operating temperature of -40 to 85 ° C. It is non-contact so there are no parts to protrude into the tank to contaminate the urea solution or get damaged due to urea freezing and thawing in cold conditions.

In addition, the Fluid-Trac® urea level sensor's accuracy of 2.5% (resolution of 2 mm) makes it a better choice than resistive float senders or reed-switch senders for monitoring urea level in tanks.



Fluid-Trac® Urea Level Sensor

Fluid-Trac® Urea Level Sensor Basic Operation

Fluid-Trac® urea level sensors are non-contact, continuous liquid level sensors that use ultrasonic technology to generate a high frequency sound wave and measure the time for the echo to reflect off the urea's surface and return. The distance from the liquid level sensor to the urea is calculated based on the speed of sound. The measured distance is converted into a voltage based on a strapping table programmed inside the urea sensor.

The Fluid-Trac® urea level sensor's output drive emulates the signal of a resistive float sender and is designed to work with many popular analog fuel gauges, digital instrumentation and engine management systems.

The Fluid-Trac® urea sensor is mounted to the top of the urea tank and has no parts protruding into the urea.



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Background

The Environmental Protection Agency (EPA) in the United States and the European Union (EU) has specified emission limits for diesel engines.

Development of effective exhaust treatment methods was done to meet these requirements. A common NOx control technology used by engine manufacturers for diesel engine exhaust treatment is Selective Catalytic Reduction (SCR). SCR technology uses a catalytic converter with an automotive grade urea solution as a reductant. This urea solution is a 32.5 wt % strength urea in de-ionized water. The urea solution's generic name in the United States is Diesel Exhaust Fluid (DEF) and Adblue in Europe.

Urea is not mixed with the fuel but stored in its own dedicated urea tank. The urea solution is sprayed into the exhaust gas stream and then absorbed onto the catalyst. The catalyst transforms and reduces the nitrogen oxides into harmless nitrogen and water.

Urea Properties

It is essential that urea maintains its high purity in the SCR system. Impurities can clog and damage the catalyst, rendering the SCR ineffective and possibly reduce its life expectancy. Traditional float senders have parts that protrude into the urea tank and may contaminate the urea. FluidTrac is mounted to the top of the urea tank with no parts in direct contact with the urea.

Urea is slightly alkaline with a PH of ~ 9.0. Since its composition is 67.5% water it should not be kept in contact with aluminum, brass or mild steel. Urea

contact will rust steel, oxidize aluminum and leech brass. The use of traditional float senders requires them to be constructed of more expensive stainless steel.

In extremely cold weather, urea will start freezing at -11.5 °C (11.3 °F). This does not affect the performance of the urea and once it is defrosted it can be used. However it does affect traditional float senders. They tend to get stuck in the frozen urea and may break the float and/or give inaccurate readings. FluidTrac has an operating temperature of -40°C to +85°C and is not affected when urea freezes since it does not protrude into the liquid.

In temperatures greater than 60°C, ammonia is released from urea. The Fluid-Trac® sensor is a sealed unit that is not affected by the ammonia emissions.

Since the use of urea is relatively recent, the number of urea filling stations is currently limited. Accurate tank readings are essential to planning fill-ups to prevent running out of urea.

When urea runs out, it results in crossing over the legal emission limits. In addition, sensors are installed in the exhaust pipe to measure the NOx emission with results going to the On Board Diagnostics (OBD). The engine power on heavy duty vehicles will be reduced until the urea is refilled. Some automobiles with urea injection technology will light up a malfunction indicator light and won't start the engine when the urea level is "critically low".



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Summary of Fluid-Trac® Urea Sensor Advantages

- **Non Contact Sensor:** No moving parts to wear out
- Not affected by corrosive media
- Not Susceptible to damage from frozen urea and/or thawing process
- **Non Invasive:** No sensor parts protruding into media to contaminate urea.
- Operation Not Affected by Urea Solidification phenomena (“caking”)
- Urea is a high conductivity fluid – capacitive sensors that come into contact with urea may have inaccurate readings.
- **Accuracy:** +/- 2.5% full scale span of distance
- **Output Resolution:** 40 mV
- **Continuous monitoring** - No inaccurate “step readings” like reed switches
- **Digital filtering:** Factory programmable digital filter eliminates errors due to urea sloshing and vehicle motion
- **Tank Profiling:** Factory programmable strapping tables for volumetric to voltage conversion for unique tank shapes.
- **Minimal Dead Band:** No bottom dead band like on other senders. In addition, an optional Fluid-Trac® mounting adapter can be used to reduce or potentially eliminate the 2” top dead band.
- **Error Detection:** The Fluid-Trac® can also be programmed for error detection of tank volumetric levels. The 0.5 Vdc to 4.5 Vdc voltage output would be set for “in range” values instead of as “full” or “empty” indicators. An error will be indicated anytime the voltage output was < 0.5 Vdc or > 4.5Vdc.
- No issues with sealing or reading in the presence of Ammonia vapors
- **Operating Temperature:** -40°C to +85°C

Capacitive sensor operation will vary based on the dielectric property of urea. Capacitive sensors are not recommended for use with electrically charged liquids as they can't detect liquids with a dielectric constant less than 20. Urea is a high conductivity fluid with a dielectric constant that is 3.5.

Fluid-Trac® sensors are more accurate than traditional float senders. Reed switch sensor accuracy is physically limited by the number of “steps”. The number of steps is driven by cost and the mechanical limitations of reed placement within the tube.

Typical reed sensors have a resolution of about 22 mm.



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OEM Custom Designed Solutions

SSI's design engineering team works with the OEM to provide urea level sensing solutions to meet their specific needs.

Fluid-Trac® smart sensor technology has the capability of sensing and notifying the controller of certain tank conditions that affect the accuracy of the level indication.

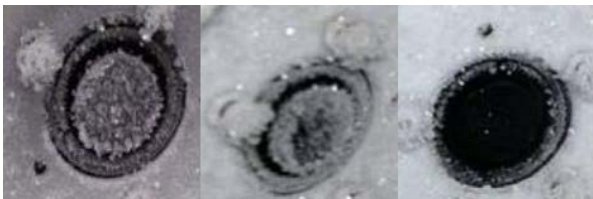
Fluid-Trac® level sensors can be designed with an added defrost capability. In extremely cold weather, urea will start freezing at $-11.5\text{ }^{\circ}\text{C}$ ($11.3\text{ }^{\circ}\text{F}$). Frozen urea causes freezing of vapors inside the tank to all materials. Reed switch and float arm sensors will be frozen inside the solid urea. Urea tanks have built in heaters to melt the urea. The SSI level sensor can utilize an internal temperature function to activate a self heating feature under certain conditions (when urea is frozen). Additionally the sensor logic assures the heating function is disabled when urea is in an unfrozen state. This defrost function allows the sensor to read actual frozen urea level until the urea becomes liquid.

Thaw Performance

@ 1 min...

5 min...

< 10 min...



Fluid-Trac® level sensors can be designed to provide other diagnostic indications, such as:

- Large incident angles causing inaccurate level readings (No Echo condition)
- Heavy slosh which can cause erratic readings
- Fluid inside dead zone of sensor
- Leak Detection and Urea Add
- Detection of frozen blocks of urea

OEM interest on custom urea design features should Contact us via the following email: CustomUreaDesigns@ssitech.com

Refer to www.ssitechnologies.com for more product details on the SSI Technologies, Inc line of Fluid-Trac® ultrasonic level sensors or to identify a regional sales manager in your area.

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