**HOW TO MEASURE FUEL IN THE TANK**

**COMPARISON of KEY TECHNOLOGIES powered by OMNICOMM**

You already know that fuel takes up as much as 40% and sometimes even up to 50% of all the direct costs your fleet-based business incurs.

**FUEL - UP TO 50% OF FLEET’S TOTAL OPERATING COSTS ARE YOU SURE YOU KNOW WHERE IT GOES?**

<table>
<thead>
<tr>
<th>FUEL THEFT</th>
<th>15-20%</th>
<th>Transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>35%</td>
<td></td>
<td>Agricultural sector</td>
</tr>
<tr>
<td>45-50%</td>
<td></td>
<td>Construction</td>
</tr>
</tbody>
</table>

It is only logical prevent fuel theft in order to cut operational costs and optimize the processes!

There are many frameworks and systems designed to deliver fuel monitoring, but each has its advantages in the mix with downsides.

**Typical Fuel Management Practices**

First of all it is important to know the difference between fuel consumption and fuel level. Fuel consumption shows how many miles or kilometers per gallon or liter you’re doing. But only fuel level data can help you detect fraud.

While the industry employs an extensive range of different fuel control solutions, there are a few more common ones, let’s look at them in details.

<table>
<thead>
<tr>
<th>SENSOR TYPE</th>
<th>REFFUELING AND DRAINS CONTROL</th>
<th>INACCURACY</th>
<th>INSTALLATION COMPLEXITY</th>
<th>UNIVERSITY</th>
<th>CONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ULTRASOUND SENSORS</td>
<td>YES</td>
<td>± 15%</td>
<td>MODERATE</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>TURBINE FLOWMETER</td>
<td>NO</td>
<td>± 15%</td>
<td>LIGHT</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>CAPACITIVE SENSOR</td>
<td>YES</td>
<td>± 1-3%</td>
<td>MODERATE</td>
<td>YES</td>
<td></td>
</tr>
<tr>
<td>STANDARD INJECTOR SENSOR, (CAN)</td>
<td>NO</td>
<td>± 15%</td>
<td>VERY HARD</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>STANDARD FLOW SENSOR, (CAN)</td>
<td>YES</td>
<td>±2-3%</td>
<td>HARD</td>
<td>YES</td>
<td></td>
</tr>
</tbody>
</table>

**INDUSTRY’S TOP TECHNOLOGIES**

CAN bus - One of the most popular systems for measuring fuel.

Main function:

The CAN bus injector sensor delivers information on the events of fuel injection into the engine cylinders, helping assess consumption during the drive.

The CAN bus float sensor combines a float and a float value switch in the form of a variable resistor. It evaluates how full the fuel tank is. Some fleet operators choose to use both sensors in order to create a more enhanced measurement system.

There are certain issues with both types of CAN bus sensors:

- Vehicle must be of recent model, CAN bus is not installed on vehicles manufactured earlier than 2000 and other vehicles (e.g. special transport).

**CAN BUS INJECTOR SENSOR**

Advantages:

- Delivers information in real time, helping the driver evaluate immediate fuel consumption by the vehicle.
- Easy to connect.

**CAN BUS FLOAT SENSORS**

Advantages:

- Help the driver know when it is time to refuel. The float and the variable resistor switch deliver information on the extent to which the tank is filled.
- Easy to connect.

Disadvantages:

- Inaccuracy up to 20%. There are two blind spots, one at the top and one at the bottom of the fuel tank. While the bottom blind spot is less important (clearly, the vehicle won’t get far with an empty tank!), the top blind spot is critical, as it may account for up to 10% of the total tank volume. And refueling the tank from 50% to 100% may translate into an up to 20% error of the value of the total refuel. You can easily witness inaccuracy when you fuel your car, drive for about an hour and onboard computer still shows the full tank.
- CAN bus float sensor requires you to calibrate the tank to be able to get your information in liters.
- Also there are consistent reports of the variable resistor suffering wear over the time; this makes it lose contact occasionally and, therefore, distorts the signal.!!
- Variable resistor has just 30 steps. So the accuracy in the middle of the tank could not be better than ±3% of the volume of the tank. Let say if tank has 700 L of volume the accuracy will be ± 21L

**ULTRASOUND NON-INVASIVE SENSORS**

Main function:

Measure the time is takes for an acoustic wave to travel from the bottom of the fuel tank to the surface of the fuel inside it and back. The sensor is attached underneath the fuel tank on the external side of its bottom wall.

Advantages:

- Since the sensor is attached with acoustic glue, there’s no need to drill or deform the fuel tank to install it: this is what being non-invasive is all about, and it is a clear advantage of this solution.

Disadvantages:

- Complicated installation: you will need to locate the perfect spot to attach the sensor, which may not be easy, given the multiple internal signal echoes, the uneven metal texture of the bottom of the tank or any additional structures inside.
- Once you’ve picked the spot, you will use acoustic glue to fix the sensor, and this glue takes 24 hours to set; all the while you should keep the vehicle in a stable warm environment, exerting stable pressure on the sensor to fix it right and tight.
- If you’re not careful and do not take all necessary precautions, the glue may deform, which will weaken the link between the sensor and the tank and may lead to wave signal distortions.
- Risk of being knocked off by rubble and stones, water or sidewalk edges. It’s also worth mentioning that the drivers sometimes knock it off altogether on purpose, knowing they could always say it just fell off because of the bad road conditions or other external factors like wind.
The major pitfall, though, is not the actual measurement accuracy. Whenever the road is bumpy or downhill or uphill, the acoustic signal gets lost because the reflection of the ultrasonic beam do not return to the receiver, which makes it hard to aggregate trustworthy data. Sand and dirt on the bottom of the tank can destroy the ultrasonic beam and make measurement unpossible.

FLOW-TYPE SENSORS EMPLOY SPECIAL SMALL TURBINES THAT HIT THE FUEL PUMP DRIVE OF THE VEHICLE

Main function:
The flow meters read the value of the direct flow towards the engine (forward flow) and the value of the flow on its way back (backward flow). This provides fuel level data by measuring and comparing the volume of the cold fuel inside the tank and the volume of the heated pulsating fuel interspersed with air bubbles after the high-pressure pump and inside the jets.

Key advantage:
▲ Provides fuel level control of acceptable accuracy for short distance routes.
▲ Can be used instead of CAN BUS if it is not installed.

Disadvantages:
▼ The inaccuracy of measurements grows over time and distance traveled.
▼ Fuel of low quality, as well as low outdoor temperatures, adversely affect the sensor’s ability to account for fuel flow correctly.
▼ The need to cut into the fueling main to embed the sensor and its fittings. This is forbidden by many vehicle manufacturers and will cost you your servicing warranty.
▼ Flow-type sensors do not measure the level, so do not account for either the events of refuels and drains or the volume of fuel associated with them.
▼ The complexity of installation (the flow-types require highly skilled personnel to work them and specific fittings and hoses)
▼ There's also a high risk of clogging and subsequent emergency engine shutdown.
▼ Flow-type sensors are easily disabled by sand grains that block the flow meter and engage the bypass valve, sidestepping the meter altogether. Unfortunately, this may well invite dishonest behavior by the drivers.

PRESSURE-TYPE SENSORS

Main function:
Compare two measured pressure values – at the top and at the bottom of the tank; the difference in the two values is reflects the fuel column pressure. Known unit weight of fuel combined with these readings helps figure out the fuel level in the tank.

Advantages:
▲ Resistant to water and dust.

Disadvantages:
▼ Inaccuracy: Large volumes of compressed air in the tank confuse the sensor.
▼ Requires calibration otherwise, you will get your data in percentages and not in liters.

CAPACITIVE SENSORS

The most popular fuel level control technology in the world. They were originally introduced for the aviation industry, but are now widely used across multiple industries, including cargo and freight services, logistics, oil and mining, and many others.

Main function:
These sensors measure the capacity of the coaxial-type probe condenser as it is filled up with fuel.

Advantages:
▲ The results are highly accurate and therefore very reliable.
▲ There are no mechanical parts to fiddle with, there are no blind spots no matter how much fuel is currently left in the tank, and sensors of this kind do not require technical maintenance over their lifetime (no need to take out sensor for scheduled diagnostics and etc.).
▲ The sensor forwards data on the fuel level at any given moment in time, including information on the events of refuel and drains, which helps stay in the know of the vehicle's operations.

Disadvantages:
▼ Capacitive sensors only work with a single type of fluid, whichever was used originally; should you switch the vehicle to another fuel liquid (say, go from petrol to diesel), you will get lower accuracy data readings.
▼ Therefore, you will need to recalibrate the sensor every time you switch from one fuel type to another (but the vehicle operates on one type of fuel anyway, so you don’t really get to do that).
▼ Getting information in liters requires calibrating the tank, and this is why you cannot easily switch from one fuel type to another.

There is a major myth about the capacitive technology – cutting into fuel tank question warranty. This is not true. Those who are afraid of losing their warranty need to realize that cutting into a fuel tank does not rob them of the whole range of warranty services; in fact, the only part of the vehicle that is under threat of losing warranty services is the fuel tank. Say, yours fell apart; since it could technically be linked to the drilling associated with securing the sensor, you are unlikely to get a new fuel tank replaced under warranty conditions. On the other hand, should anything else go wrong with your vehicle – for example, its chassis becomes dodgy or the on-board computer is experiencing errors, – it will be impossible to link it to a drilled fuel tank, and all your warranty options, therefore, remain safe.

Choosing fuel management solution is an important decision. The main thought to keep in mind is that you should not to spend money on solutions that give you incomplete, inaccurate data or that you don't need, and not to invest in technology that doesn't provide the information you need.

Pick the solution that delivers top accuracy and that you can rely on in the widest possible range of conditions (any temperature or landscape, any fuel tank). Inefficient technology is not going to help you increase efficiency in your own business, it may even lead to further cost increases, which is certainly something you do not want.

So, have you made up your mind? Be prepared to experience upgraded efficiency first-hand with Omnicomm or another provider by using capacitive sensors for your fuel level control needs, and feel free to send us any feedback on your experience.

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