Impact of Ethanol Fuel Blends on Automatic Tank Gauging

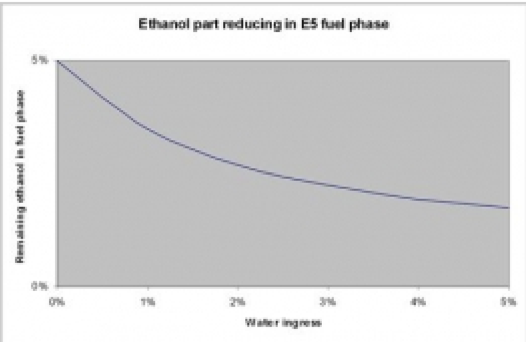

Figure 1: Ethanol part reducing in E5 fuel phase

By law, 10% ethanol (E10) in gasoline was introduced into Germany since January 2011. This caused a lot of concern as many motorists refuse E10 fuel as they feel unsure if there is an impact on the lifetime of their vehicles. Oil companies and station operators are also not happy as the introduction causes additional costs with no direct return on invest (accommodation of tanks, tanks with low turnover, information needed at price indication, dispensers and nozzles etc). The use of E10 fuel was already established in a number of countries with the USA about to introduce E15 and E25 common in Brazil for a number of years.

How does the addition of ethanol affect equipment such as the tank level measurement system? Ethanol may attack some materials of tank gauges, and systems using only stainless steel and Teflon have a distinct advantage as these materials are compatible with ethanol.

Another problem is the hygroscopic effect of ethanol. Water may ingress to tanks already within the logistic chain or later into storage tanks (of course it should not) and may cause problems in different ways.

Part of the water is absorbed by the fuel phase. Pure gasoline has a water absorptive capacity of up to 120 ppm, E5 fuel may already hold up to 2.500 ppm water (depending on temperature) and E10 even more. Some additives increase the absorption of water. In 100% gasoline nearly all water separates in a phase at the bottom of a tank because of its higher density.

If water is present in a tank with E10 then a smaller part is absorbed in the gasoline phase and the larger part will separate at the bottom as free water phase, until there is a balance of dissolved water in the fuel and free water/ethanol phase at the bottom. As we know from alcoholic drinks, water mixes very well with ethanol. On its way down to the tank bottom water will wash out a considerable part of the ethanol and separate at the bottom as a mixture of water and ethanol. This can easily be demonstrated by taking 1 litre of E10 in a measuring cylinder and pouring 100 millilitres of water into it. Within some seconds there is a clear separated water/ethanol phase at the bottom of more than 130 millilitres. At least 30 millilitres of ethanol is immediately missing from the fuel phase.

The reason is that the hydrogen bond (polar) between water and ethanol is stronger than the non-polar bond between gasoline and ethanol. Scientific report DGMK 645 states for E5 with a 1% separated water phase that 30% - 40% of the ethanol will pass from the fuel phase to the water phase. For a water phase of 5% it is possible that 65 - 78% of the ethanol may be washed out. So water can draw a lot of ethanol out of the fuel phase on its way down to the tank bottom, reducing the Octane number and thus the quality of the fuel considerably.

As an example take a tank with a content of 10.000 litres E10 and ingress of 100 litres of water. Depending on the tank shape, the water level together with the washed out ethanol may get dangerously close to the suction point of the dispenser which is typically 150 mm from tank bottom. While it is still being debated how engine parts react on ethanol or dissolved water in the fuel there is a new problem how to measure the water/ethanol phase in a storage tank. If the water/ethanol phase is not detected in time then the suction pipe from the dispenser may pump from the water/ethanol phase instead of fuel. This will neither amuse the motorist or station operator.

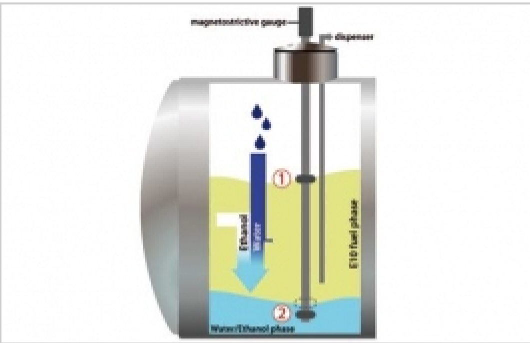

Figure 2: Magnetostrictive gauges with moving floats

E85 and E100 do not build a separated water phase, however, the challenge is how to measure the water/ethanol phase of E10 or other fuel blends at the tank bottom.

For technical reasons all types of probes do not detect a level less than about 20 mm. Is it possible to detect changes by measuring the density? Gasoline has a density of typically 720 - 775 kg/m³ (according to DIN EN 228), ethanol has typically 790 kg/m³. E10 does not mean exactly 10%, but something between 5.6% up to 10% ethanol. Changes in density of the fuel phase caused by variation of the ethanol part are much lower than the general allowed variation of gasoline density and vanish completely within this bandwidth.

Measuring the density of the water/ethanol phase would be complicated and do not provide more information than already known by measuring the level. So density is not the right method.

There are mainly two types of tank gauges in the petrol market

- magnetostrictive gauges with moving floats
- gauges without any moving parts measuring the capacitance.

Magnetostrictive gauges usually have two floats, one for the fuel (1) and one for the water phase (2);

see figure 2.

The water float must be heavier than fuel and lighter than water to float on the interface. If the float is only a little bit heavier than the medium then there is no buoyancy anymore.

Ethanol present in the water phase reduces the density of the mixture. If the water float (2) is now only a little heavier than the water/ethanol mixture there is no longer any buoyancy and the float will sink down to the bottom of the tank instead of floating on the interface. In this case existing water is no longer detected.

Another problem may occur when a second skin is drawn into the tank to retrofit a double-wall leak inspection. The skin is fixed with magnets to the inner side of the tank wall. Because of ethanol special material and stronger magnets may be needed for the skin. The magnetic field of the stronger magnets may influence the water float and cause false alarms.

Gauges with capacitive measurement do not suffer the same problems. Instead they continue to work with the same accuracy, independent from magnetic fields or density of the water/ethanol phase. Capacitance gauges are able to detect the separated phase even for ethanol blends up to E25 without the need to change any parts.

When using capacitance technology you can be sure that level and interface will always be measured accurately for all type of ethanol blended fuels.

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