ETHANOL–WATER PHASE SEPARATION

What It Is—and What You Can Do

By Samir Jain

The use of ethanol as a fuel in North America has significantly increased over the past decade. Today, approximately 80 percent of all retail gas stations in the United States blend gasoline with up to 10 percent ethanol (E10). Ethanol is a renewable fuel and has been highlighted by the national Renewable Fuel Standard as a primary method of achieving the nation's renewable fuels goal.

With ethanol's ascension, the problem of phase separation in fuel is also on the rise. This article describes both what phase separation is and how it is being addressed across the industry.

> "Phase separation can lead to damage to petroleum equipment, damage to customer vehicles and unsellable fuel…Given these risks, the faster station owners learn about any occurrence of phase separation, the more quickly they can remediate to reduce the risk of exposure to potential deterioration."

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HOW PHASE SEPARATION FORMS

Water is naturally attracted to ethanol. When water enters into a tank of ethanol-blended fuel, some of the water will absorb into the fuel by binding to the ethanol particles. Because it is heavier than the fuel, the remainder of the water falls to the bottom of the tank, pulling some ethanol with it. In fact, it is rare to see pure water at the bottom of a tank of ethanol-blended gasoline.

Water will continue to be absorbed into ethanol-blended fuel until it reaches a saturation point. At 15°C, the saturation point for E10 fuel is approximately 0.5 percent water. Once the saturation level is reached, an ethanol-water mixture separates from the fuel and falls to the bottom, since it is heavier than the ethanol-gasoline blend. This separate layer is commonly known as "phase separation." The phase-separation layer typically contains 3 parts to 4 parts ethanol for each part water. Figure 1 shows water (dyed red for clarity) that enters a container of E10 gasoline and upon reaching saturation falls to the bottom as phase separation.

A related phenomenon can occur with less water than needed for phase separation. As mentioned above, as water falls to the bottom of a tank, it will naturally pull a small amount of ethanol with it. Over time, this

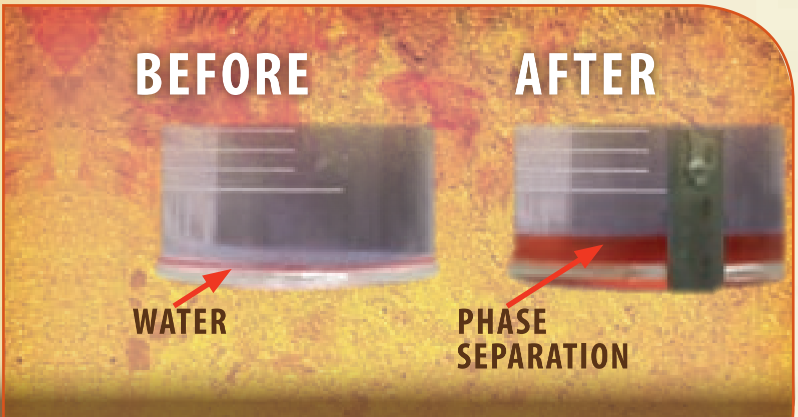
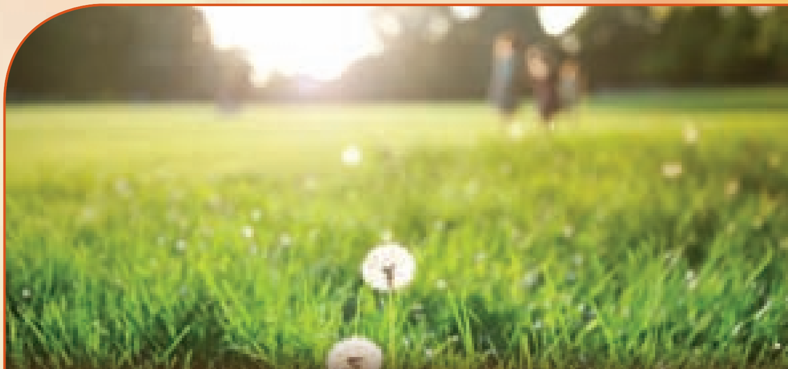


Figure 1: Phase Separation Formation

water-ethanol mixture will pull even more ethanol from the remaining fuel, creating a layer that is similar to—but less stable than—phase separation.

This layer, which is referred to as "temporary phase separation," will typically contain far less than 0.5 percent water. To demonstrate the instability of this layer, our tests have shown that if a tank is thoroughly mixed, a small amount of partial phase separation can be automatically remediated with another delivery of fuel. The result will be a tank of slightly "wet" but still sellable fuel.



Phase separation may slowly deteriorate the integrity of tank walls. A resulting leak due to tank degradation obviously will have a high environmental and financial impact.

EFFECTS OF PHASE SEPARATION

Phase separation can lead to three negative outcomes.

1. Damage to Petroleum Equipment

Because of its high ethanol content, phase separation is highly corrosive, compared with pure water or E10 gasoline. Older tanks rated to E10 may not be compatible with this ethanol-rich corrosive liquid. In these cases, phase separation may slowly deteriorate the integrity of tank walls. A resulting leak due to tank degradation obviously will have a high environmental and financial impact.

The remainder of the site infrastructure may also be at risk if the phase separation mixture enters into the piping system. Any resulting failures to piping, dispensers, submersible turbine pump (STP) and other components also can produce significant environmental effects. And replacement of the failed components can be extremely expensive.

2. Damage to Customer Vehicles

In a 10,000-gallon, 10-foot tank that is 60 percent full, 30 gallons of water will cause a full phase separation that is about 120 gallons or 5 inches deep. Typically, STP intakes also are set at around 5 inches to 6 inches.

This creates a significant risk that phase separation

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will enter the STP, travel through the piping and dispensers, and ultimately enter customer vehicles. In such cases, phase separation can prevent the engines from starting, resulting in stalled vehicles at the island. If that happens, the owners of the damaged vehicles will be understandably upset, and likely to share their bad experiences with friends and family.

Thus, the station suffers a hit to their brand and a loss of customer loyalty. The problem can be further exacerbated if the local news media shows up. In that case, the station may find it difficult to ever recover the lost business or regain its footing.

Remediation in these cases includes purging the piping system, replacing dispenser filters and likely disposing of the entire tank of fuel, which can be very expensive. Any resulting repairs to the vehicles also may be at the station owner's expense.

3. Unsellable Fuel

The octane of pure ethanol is approximately 113, which makes ethanol a fuel octane booster. Most companies that are blending 87-octane E10 gasoline actually use gasoline that is slightly below 87 octane, because the 10 percent ethanol will boost the octane level to 87.

Unfortunately, once phase separation occurs, the remaining fuel is depleted of ethanol, thereby lowering its octane level. When significant phase separation has occurred, the fuel may be out of specification due to its reduced octane level. In this case, even if the phase separation is removed at the bottom of the tank, the remaining fuel is not legally sellable.

CURRENT DETECTION METHODS

Given these risks, the faster station owners learn about any occurrence of phase separation, the more quickly they can remediate to reduce the risk of exposure to potential deterioration.

Most stations today use one or more of the following methods to detect phase separation. Each is effective but has limitations.

1. Automatic Tank Gauge With Water Detection

An automatic tank gauge uses a probe in the tank with floats for fuel and water that determine the respective levels of each. The water float is typically tuned for a density that will lift in water but not in other lighter fluids (such as gasoline or diesel). The float position is sent to the tank gauge console so that the station operator can read the height information and react accordingly.

While floats work extremely well for detecting water in various fuels, the addition of ethanol in the water leads to a lower density mixture that may not always be accurately detected by the float. Recalibrating the float by tuning it to detect a lower-density mixture would create the opposite risk. The float might incorrectly lift in gasoline, falsely indicating a problem.

2. Water-Finding Paste

Water-finding paste applied to the end of a stick is another common practice. The paste changes color in the presence of water. In recent years, paste manufacturers have added variations designed to detect phase separation.

Many stations have policies to stick tanks before/after a delivery or when water is suspected in the bottom of the tank. These practices can help determine if water came in during a delivery or through some other means. However, the changes in color are sometimes quite subtle and difficult to interpret. Nonetheless, paste remains an inexpensive and sometimes helpful method of phase separation detection.

3. Dispenser Filters

Newer dispenser filters are designed to filter out water and even phase separation. The filter will constrict the fuel until it eventually completely stops the flow of fuel.

Dispenser filters are effective in preventing most phase separation from passing through to cars. Note, however, that filters only begin operating once phase separation has reached the dispenser. At that point, remediation is a laborious process that involves purging the piping system of phase separation and replacing filters. And when the water-ethanol mixture has reached the dispenser, at least 5 inches to 6 inches of phase separation is likely in the tank itself—which may mean additional issues and costs.

Partial phase separation is more likely to have a higher percentage of ethanol and a lower density, making it more likely that existing methods of detection will miss it.

NEW SOLUTIONS

As the percentage of ethanol in fuel increases (by switching to E15, for example), the amount of water needed to create full phase separation increases. However, any partial phase separation is more likely to have a higher percentage of ethanol and a lower density, making it more likely that existing methods of detection will miss it.

Continuous, early detection of phase separation allows a station to quickly uncover problems and take action to reduce potential damage.

As ethanol becomes more prevalent and customers demand more effective solutions, a number of equipment manufacturers are working to improve existing products and create new technologies to better protect customers from phase separation.

For example, Veeder-Root recently developed a phase separation detection float that replaces the water float in fuel tanks. The complex float uses multiple densities to differentiate between phase separation and

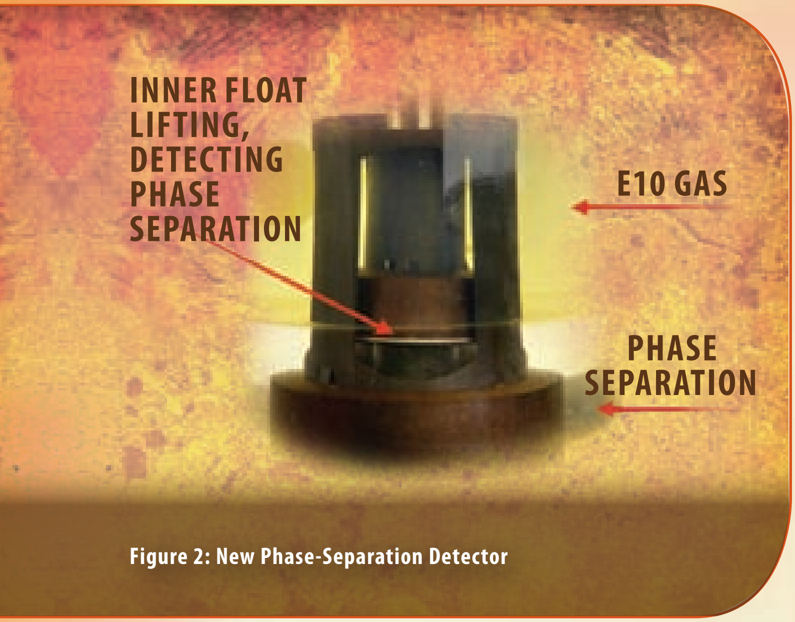

Figure 2: New Phase-Separation Detector

gasoline. Figure 2 shows the operation of this new "float-in-float" solution. The solution is retrofittable to existing Veeder-Root equipment.

CONCLUSION

The growing prevalence of ethanol-blended fuels is increasing the incidence rate and awareness of phase separation. The dangers are real—from equipment damage to stalled vehicles to lost business to potentially unsellable fuel. Proposed increases in the ethanol blend level will raise stations' risks even more.

Continuous, early detection of phase separation, however, will allow stations to quickly identify and address any problems, thereby reducing potential risk and loss.

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