Ethanol and Water Contamination: Results and Observations

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Abstract:

Ethanol is hygroscopic, gasoline is hydrophobic. Water contamination in fuel can cause engine non-starting and corrosion issues. Ten percent ethanol blends can hold small amounts of water in solution, above this level a phase separation of water and ethanol mix separates from the gasoline. Many fuel additives claim to solve this phase separation issue or claim to dry the gasoline, remove water, etc… This study endeavored to determine the amount of water ethanol blended fuels can hold in solution and determine the efficacy of common additives in their ability to increase the amount of water held in solution. Based on results from small 8 ml test tubes and larger 100 ml jars E0, E10, and E15 can hold Zero, 0.41% and 0.85% water respectively. Two of 8 tested additives increased the amount of water held in solution.

Methods:

Fuel was purchased at the UNL gasoline pump. Regular gasoline (E-0) was tested for presence of ethanol using water method described in NE Department of Weights and Measures policy #6.44. Two hundred proof ethanol added and stirred to make a 10% ethanol blend. At the same time we also purchased fuel from the adjacent E10 pump and tested using Weights and Measures procedure. The adjacent E10 pump measured 8.3 to 8.8% ethanol in three consecutive tests.

The entire experiment was completed in with three replicates of small test tubes using 8ml of fuel followed by water in increments of 0.1%. The experiment was repeated using two replicates of jars using 100 ml of fuel E-10 added to jars followed by tap water at increments of 0.1%. Once phase separation occurred tests were repeated every 0.01% to confirm the water holding level of the blend. We used the larger size jars to confirm the results of the small tubes with larger amounts of fuel making the separation easier to see in the larger jars. The amount of fuel was kept at 100 ml rather than varying the amount of fuel compared to the amount of water. The exact percent water is just slightly less than what is reported for example when we report 0.40% the actual percent water is 0.398%. The amount of water held is calculated using the actual percent water.

Tests:

E0: 0.2%, 0.3%, 0. 4%
E10:0.2%, 0.3%, 0.4%, 0.41%, 0.42%, 0.5%

E15: 0.7%, 0.8%, 0.81%, 0.82%, 0.83%, 0.84%, 0.85%, 0.86%, 0.9%
E10: plus additives at 0.40%, 0.41%, 0.42%, 0.43%, 0.44%

All tests were replicated three times at with 8ml of fuel and two times with 100ml. The results from the larger jars confirmed our findings with the small tubes. The larger volumes make it easier to see the water ethanol mix separation layer as well as aiding in the addition of finer increments of water at 0.01% vs 0.1%.

Results:

E0: in all three concentrations phase separation was observed,
- Observation the water drops stick to the walls of the jar.

E10: Phase separation observed at the 0.4% concentration jars, both 0.2% and 0.3% jars was clear.

Further tests showed that the exact point where phase separation occurs in the E10 was between 0.4% and 0.41%.

0.4% water is 3.06 tsp per gallon

E15: Phase separation observed at the 0.9% concentration jars, both 0.7% and 0.8% jars were clear.

Further tests showed that the exact point where phase separation occurs in the E15 was between 0.85% and 0.86%.

0.85% water is 6.47 tsp per gallon

Additives
STP:
  Amount used: 336µ (3.36 µ/ml)
  Solved the problem? No
BG – Ethanol Fuel System Drier:
  Amount used: 468µ (4.68 µ/ml)
  Solved the problem? Yes
  Maximum held: 0.43%. Separated again at 0.44%.
The addition of this additive increased the water holding by 0.23 tsp per gallon, a 7% increase over E10
ISO-HEET:
  Amount used: 469µ (4.69 µ/ml)
  Solved the problem? Yes
  Maximum held: 0.43%. Separated again at 0.44%.

The addition of this additive increased the water holding by 0.23 tsp per gallon, a 7% increase over E10

<u>STABIL – Ethanol Treatment:</u>

Amount used: 315.5µ (3.157 µ/ml)

Solved the problem? No

<u>Rislene</u>

Amount used: 664µ (6.64 µ/ml)

Solved the problem? No

<u>Heet</u>

Amount used: 469µ (4.69 µ/ml)

Solved the problem? Partially

<u>Seafoam</u>

Amount used: 781µ (7.81 µ/ml)

Solved the problem? No

<u>Valvoline Nitro Shot</u>

Amount used: 200µ (2.0 µ/ml)

Solved the problem? No

200 Proof Ethanol***

Amount used: 100µ (1.0 µ/ml)

Solved the problem? Yes

***100 microliters of pure ethanol in the 100 ml sample solved the phase separation problem on the 0.41% sample of E10. Did not test with more water. Ethanol does absorb water even when added at inclusion rates below what is called out in the additives yet pure ethanol is not available for purchase as an additive.

<u>Discussion:</u>

Water contamination of fuel can cause issues with engines including corrosion of engine components and inability to start. Additives containing alcohol has been a common to reduce the amount of water in the fuel system. This is evident in products such as HEET which is labeled to contain either methyl or Isopropyl alcohol. The alcohol absorbs the water and holds it in solution with the gasoline allowing it to move through the engine safely. Since the adoption of ethanol blended gasoline there is alcohol in each tank of fuel. This study showed the ten percent ethanol blend (E10) can hold 0.41 percent water or 3.06 teaspoons of water per gallon. This amount would equal 0.625 pints of water per 20 gallon tank. Above this amount a layer of ethanol water mix is formed and sinks to the bottom of the tank. This amount of water is slightly lower than Korotney in a US EPA memo which lists 0.5% water for E10. Gasoline with zero percent ethanol can hold zero percent, or zero teaspoons of water per gallon thus any water contamination will immediately sink to the bottom of the tank. Tests by Gregory at Kettering University suggest massive water contamination is equally bad for E10 and E0 blends.

Yet outside of a large volume water contamination event small amounts of water will constantly be absorbed and safely run through an engine using E10 fuel while one using E0 could accumulate the water over time.

Future Study:

There are many places in popular press and the internet stating how E10 blends will absorb water from the air in sufficient amounts to phase separate. Articles from Frazier at Oklahoma State Extension and Korotney at U.S. EPA disagree stating an E10 blends cannot absorb enough moisture from the air to phase separate over a storage season. A test could be developed to determine the rate of water absorption from the air. Additionally the condensation of air inside a storage container may lead to water contamination. The absolute amount of water entering fuel from condensation and absorption from the air over a winter storage season could be studied.

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