

**A PARADIGM SHIFT IN MODERN FUEL
STABILIZING TECHNOLOGY**

***WORLD COMPLIANT
ENVIRONMENTALLY FRIENDLY
NON-CHEMICAL
IN TANK FUEL STABILIZING FILTER***



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SYNOPSIS

Fuel is Changing.

Today's modern gasoline is constantly changing, but not in a positive way as it relates to small engines. Ethanol content is rising. Fuel has inherent contamination, including water bonded to ethanol and particulate matter and is not delivered "safe" for engines and fuel injectors. The water problem becomes worse over time with condensation and water encroachment and we know that **WATER** is the greatest enemy to your fuel system and engine. We know that ethanol attracts water and at some point this corrosive mixture phase separates to the bottom of your tank. Tier 3 standards that reduce sulfur content will drive up peroxides and gums. As these issues compound, fuel will tend to degrade in as little as 60 days (or much less) before it is considered no longer acceptable to use. Consider marine equipment in which the fuel can sit for long periods of time before it is needed. This same contaminated fuel is what enters the engine, causing problems that lead to costly repairs and downtime.

What Can You Do? The FUEL LIFE Solution!

B3C Fuel Solutions, LLC, a manufacturer of environmentally friendly products and solutions that resolve engine and fuel system problems caused by today's modern gasoline and diesel fuels, including ethanol and bio-diesel blended fuel (bio-fuel) related problems, has developed a new, patented technology that combats all of these fuel related issues. We call it the FUEL LIFE In-Tank Fuel Stabilizing Filter. The FUEL LIFE Fuel Stabilizing Filter is a proprietary nanopore reactive molecular sieve that removes (neutralizes) the compounds in fuel that cause fuel decay. Once removed, fuel's ability to decay is drastically diminished, even when exposed to heat and sunlight. The FUEL LIFE Fuel Stabilizing Filter removes moisture from ethanol blended fuel in a fuel tank, and is **the ONLY scientific process that removes water bound to ethanol (all fuel containing ethanol, e.g. fuel pump gas with up to 10% ethanol, ALREADY HAS WATER in it because ALL ethanol contains up to 1% WATER)**. Fuel decay and water are top contributors to contamination and operating issues in engines. The concept is similar to desiccant packs, a time-tested standard method to remove moisture in critical items like pills and electronics. Benefits include potential reductions in fuel related warranty issues and costs, increased customer satisfaction, and positive environmental impact. FUEL LIFE is a highly innovative and creative long-term solution that OEMs can leverage to drive competitive brand differentiation, increased awareness, and ongoing customer satisfaction. ***Be sure to read this entire White Paper for details and please contact us for more information.***

Fuel is Changing.

Today's fuel is not the fuel of the past. Fuel, as we know it, is now in a constant state of change. And this constant change has created more and more confusion in the marketplace. First, there is the proliferation of ethanol. More than 80% of all retail gas stations in the United States blend gasoline with up to 10% ethanol (E10)¹. And as time progresses, we are finding that the ethanol content in gasoline at fuel pumps is rising to now include as much as 15% (E-15) to 85% (E-85) (Fig. A). Approximately 5,000 new pumps in the United States now offer E-15.

Fig. A



According to a 2015 Outdoor Power Equipment Institute (OPEI) survey, “consumers are ill-equipped to make smart decisions about new gasoline choices entering the marketplace, such as fuel blends greater than ten percent (10%) ethanol. According to poll results, Americans continue to choose gasoline on price, and do not pay much attention to pump warning labels.” In fact, ninety-one percent (91%) overwhelmingly notice price when they pull up to the pump and sixty-three percent (63%) choose the least expensive grade of gasoline whenever possible.²

This lack of awareness regarding today's changing fuels leads to problems in the market with consumer's equipment and engines. OPEI recently launched

the “Look Before You Pump” campaign in response to the U.S. Environmental Protection Agency (EPA) approval of gas with 15% ethanol content for automobiles from 2001 or later. Most people get the fuel for their power equipment from the fuel pump, often at the same time they are filling up their automobiles. 10% ethanol content is problematic and 15% is not even approved for use in small power equipment. Since most people will not notice the shift from 10% to 15%, and will continue their routine behavior of filling their gas cans for their power equipment at the pump with the lower priced fuel, OPEI is warning consumers to “Look Before You Pump”.³

Another change in fuel began in 2017. The U.S. Environmental Protection Agency (EPA) developed an important rule designed to reduce air pollution from passenger cars and trucks. Starting in 2017, “Tier 3 sets new vehicle emissions standards and lowers the sulfur content of gasoline, considering the vehicle and its fuel as an integrated system.” Federal gasoline will contain no more than 10 PPM (parts per million) of sulfur on an annual average (approximately 80% reduction from Tier 2 standards).⁴ Sulfur reduction in gasoline may be considered good for emissions, but there is a negative effect regarding fuel stability because sulfur has preservative properties that reduce free radicals, like peroxides.

What’s Happening in Your Gasoline Tank?

While gasoline in the past was considered stable, today’s modern gas is inherently unstable and the quality degrades over time. The proliferation of ethanol in modern fuel is continuing to exacerbate the already present issues with fuel degradation and water. First and foremost, ethanol inherently contains WATER. Consider the ethanol production process. A 3A molecular sieve is specifically designed for the dehydration of fuel grade ethanol. Ethanol can only be dried to an azeotropic point of 95.6% purity by traditional distillation. An ethanol-water mixture on fractional distillation yields a solution containing approximately 95% by volume of ethanol. Once this composition has been achieved, the liquid and vapor have the same composition, and no further separation occurs. After that point, a 3A molecular sieve selectively adsorbs the water from the solution to produce anhydrous (without water) ethanol with less than 1% water. Adsorption (not to

be confused with absorption) is the adhesion of atoms, ions, or molecules from a gas, liquid, or dissolved solid, to a surface. This is the drying method of choice for fuel ethanol producers (Fig. B).

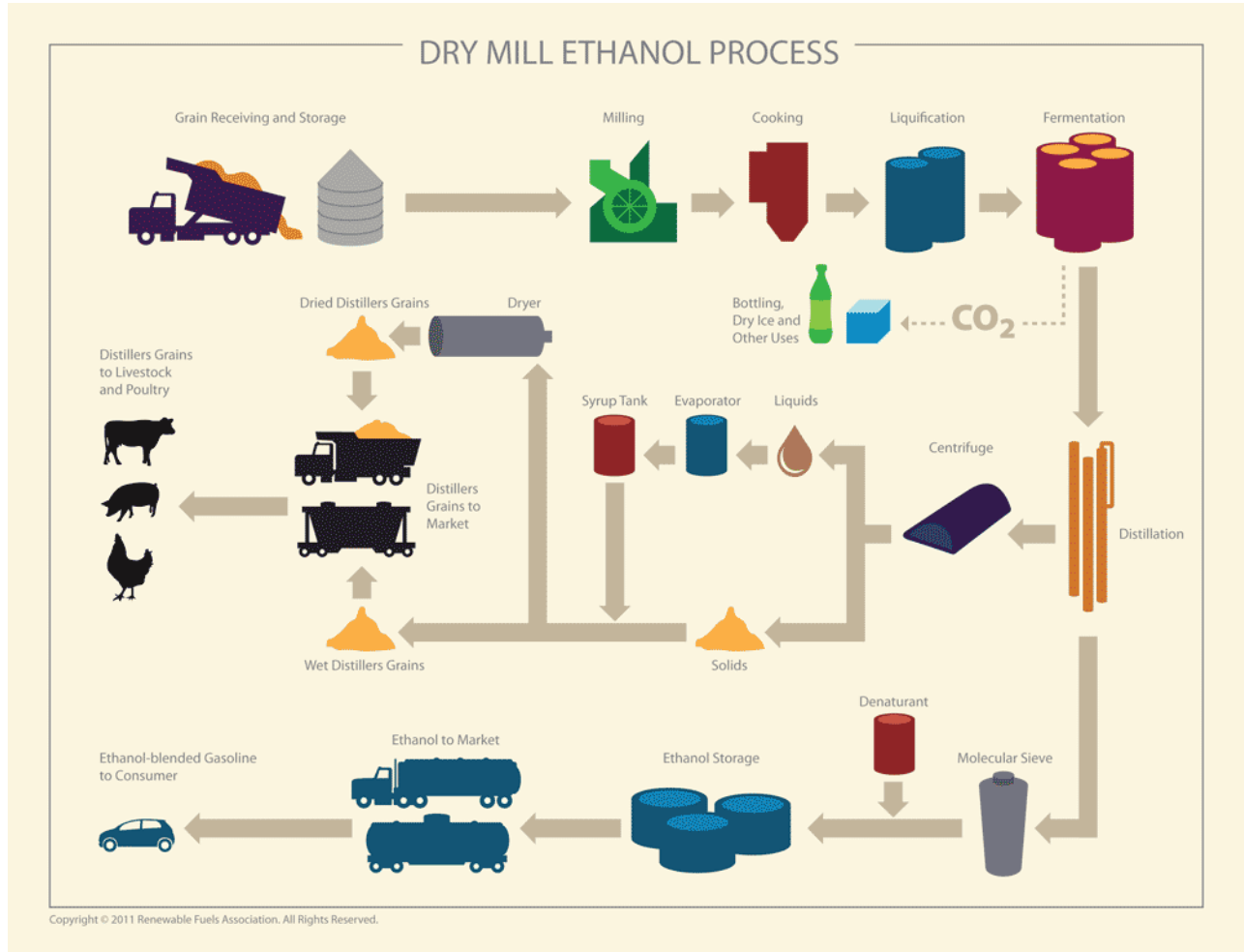



Fig. B

A 3A molecular sieve is specifically designed for the dehydration of fuel grade ethanol. A molecular sieve is a material with very small holes, or pores, of uniform size of certain molecules. Therefore, only certain size molecules can be adsorbed. Many molecular sieves are used as desiccants. (Diagram Source: Renewable Fuels Association).

“Less than 1%” is still a percentage up to 1%, meaning there is the presence of water. As an example, ADM Fuel Ethanol contains up to 1% water content per written specifications. According to the specifications, “ADM Fuel Ethanol

meets the current ASTM D4806 Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel”.⁵ This is the same fuel ethanol that is blended with today’s modern gasoline that everyone uses from the standard pumps at a typical gas station (Fig. C).

Fig. C




FUEL ETHANOL
Product Code 017609

Specifications

ADM Fuel Ethanol meets the current ASTM D4806 “Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel”. The ASTM specification is as follows:

Ethanol, volume %, min	92.1	ASTM D5501
Methanol, volume %, max	0.5	
Existent Gum, (solvent washed) mg/100mL, max	5.0	ASTM D381
Water Content, volume %, max	1.0	ASTM E203
Denaturant content, volume %, min	1.96	
max	5.0	
Inorganic Chloride Content, mg/L, max	32	ASTM D512
Copper Content, mg/kg, max	0.1	ASTM D1688
Acidity (as acetic acid), mass %, max	0.007	ASTM D1613
pHe	6.5 to 9.0	ASTM D6423
Sulfur, mass ppm, max	30.	
Sulfate, mass ppm, max	4	ASTM D7319, D7328
Appearance	Visibly free of suspended or precipitated contaminants, clear and bright	



Additional ADM Specifications (to comply with California Air Resources Board specs)

Sulfur, ppm, max	10	ASTM D5453
Benzene, volume %, max	0.06	ASTM D5580
Olefins, volume %, max	0.5	ASTM D1319
Aromatics, volume %, max	1.7	ASTM D5580

Corrosion Inhibitor
ADM adds a corrosion inhibitor (DCI-11) to all fuel ethanol at a target treat rate of 20 pounds per thousand barrels.

ADM Fuel Ethanol will meet the requirements of the state for its intended use.

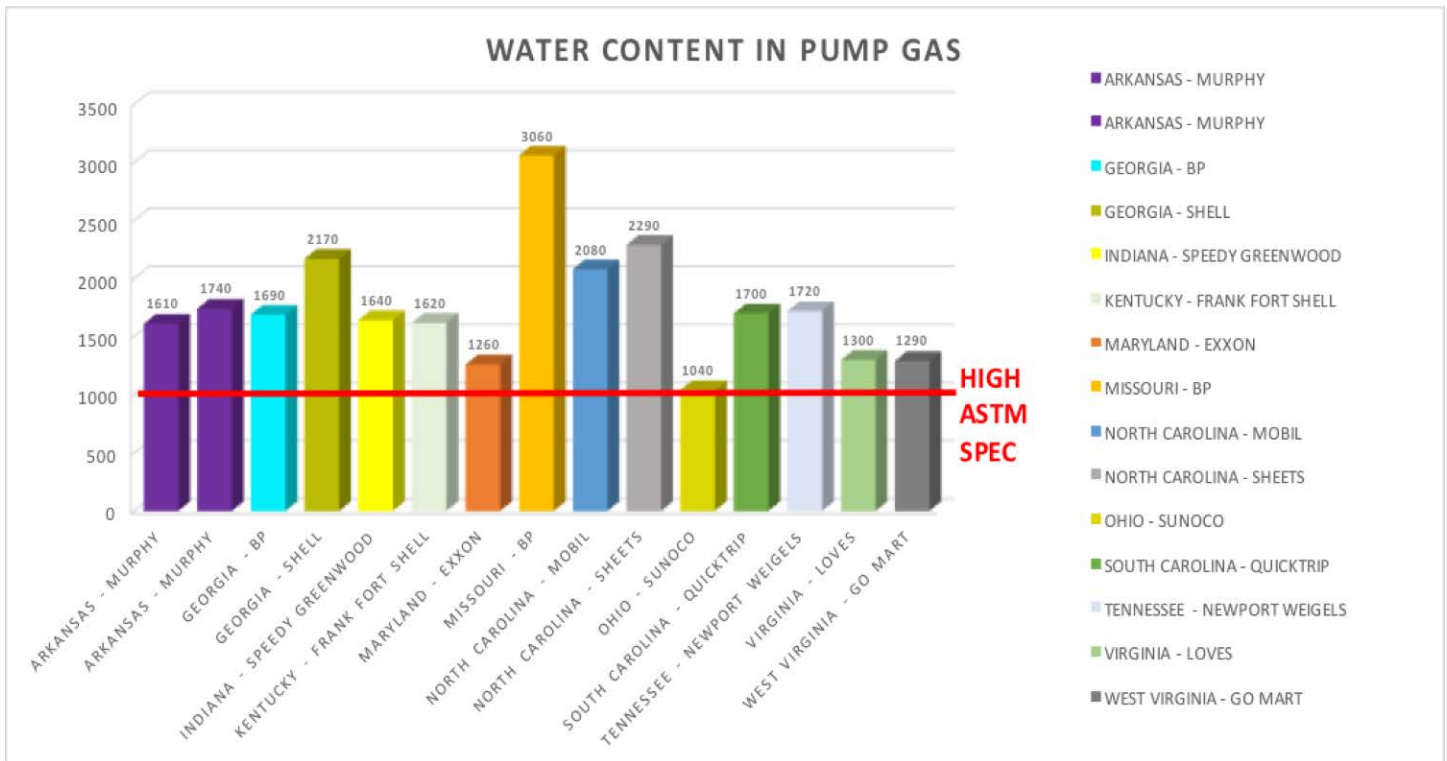
The information contained herein is correct as of the date of this document to the best of our knowledge. Any recommendations or suggestions are made without guarantee or representation as to results and are subject to change without notice. We suggest you evaluate any recommendations and suggestions independently. We disclaim any and all warranties, whether express or implied, and specifically disclaim the implied warranties of merchantability, fitness for a particular purpose and non-infringement. Our responsibility for claims arising from any claim for breach of warranty, negligence or otherwise shall not include consequential, special or incidental damages, and is limited to the purchase price of material purchased from us. None of the statements made here shall be construed as a grant, either express or implied, of any license under any patent held by ADM or other parties. Customers are responsible for obtaining any licenses or other rights that may be necessary to make, use or sell products containing ADM ingredients.

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Water is the greatest enemy to fuel and engine systems in your equipment. Yet, as we just indicated, pump gas, or any gas containing ethanol, will contain water because the ethanol used for fuel contains up to 1% water.

To demonstrate, B3C Fuel Solutions obtained gasoline straight from the pump at various gasoline providers in multiple states. We then had a ISO Certified laboratory perform a Karl Fischer analysis. As indicated in the chart below (Fig. D), every sample contained water. What is particularly alarming is that the amount of water in every sample exceeded 1000 PPM (parts per million), which is considered the high ASTM specification for ethanol to meet fuel grade standards.

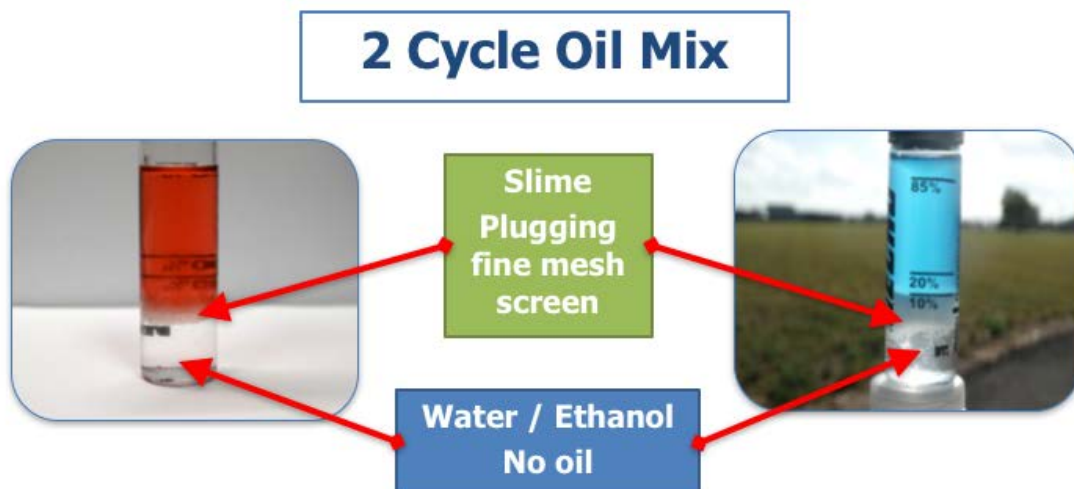
Fig. D



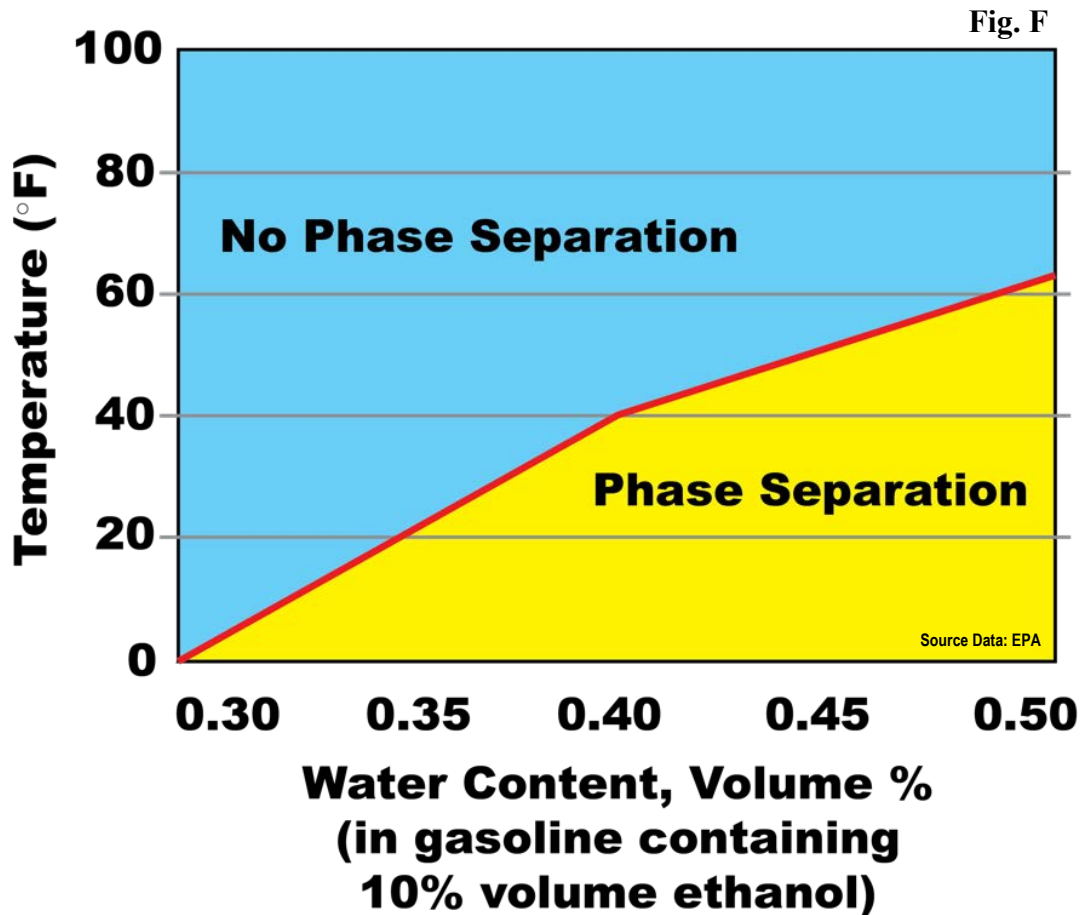
In addition to being inherent in ethanol blended gasoline, the amount of water in your tank continues to increase over time, caused by such things as condensation from temperature fluctuations and high humidity, and external leaks in tanks. In the U.S., gas stations have sold gas with 10% ethanol content for some time. When 10% became the standard ethanol content in fuel, gasoline powered equipment problems rose. Ethanol is hygroscopic, absorbing water from the atmosphere. If enough water is absorbed, *Phase Separation* occurs, which is the point the ethanol and water combination reach a saturation point and “falls out”, settling on the bottom of the equipment fuel tank. The following images shows phase separation in fuel containing a 2 cycle oil mix. An important point to consider is that water, ethanol and 2 cycle oil do not completely bond. Considering 10% is most likely the minimum amount of ethanol in most pump gasoline these days, with phase separation, at least 10% of the fuel in this image has no lubrication. For 2 cycle equipment, this can lead to engines seizing up due to lack of lubrication. Also, note the slime layer caused by detergent hydrolysis that develops. This hydrolysis occurs when the detergents in the gas and 2 cycle oil react to the high water content in the fuel. This slime can plug fine mesh screens in your equipment (Fig. E).

Fig. E

Problem with Modern Gasoline Blends



And, at lower temperatures, phase separation can occur with very little water present. This has great implications for equipment that sits outside or is stored over the winter in cold environments. This is one of the most critical times that fuel needs to be prepared or stabilized, and water removed to avoid phase separation from occurring (Fig. F).



Another factor causing issues with modern gasoline is the high amount of oxygen present in ethanol. Oxygen naturally decays gasoline, which is organic. Ethanol in fuel accelerates this fuel decay process. Fuel “sours” or becomes stale when oxygen reacts with it to form hydroperoxides. This is an unstable compound that can be easily broken down to water and oxygen. These unstable species decompose, forming free radicals that may attack some elastomers. This attack can cause either “reversion” (rubber softening), or further crosslinking, resulting in embrittlement. The olefinic portions of “cracked” gasoline are the most susceptible to oxidative attack, and gasoline blended with alcohol also tends to be unstable.⁶

Further issues occur due to the oxidation reactions of gasoline. Gasoline is a volatile, inflammable liquid composed of a mixture of paraffinic, naphthenic, olefinic, and aromatic hydrocarbons (C4–C12). During storage, these components react with atmosphere oxygen and with each other, promoting changes in their physical–chemical characteristics. Primary oxidation reaction products continue to react and form non-volatile molecules with high molar mass that are commonly called gums (Fig. G). The high gum content formed can be explained by the formation of five canonical resonance structures resulting from the reaction with peroxide (propagation step). These radicals have higher stability and longer life, which favors a higher oxidation of gasoline.

In the carburetor and near the admission valves, these deposits build up in large quantities, which makes their operation difficult, and results in inappropriate mixture and deficient fuel burn. Over time, the built-up deposits cause problems such as:

1. Engine stalling, hesitation, and choking.
2. Power loss, reduced acceleration, increased fuel consumption, and knocking.
3. Increased exhaust gas emission (CO, NO, etc.).

The formation of gums in fuels stored for a very long time and under normal temperature conditions depends mainly on the gasoline constituents, the origin of the petroleum, the type of refining, and the room storage conditions. Gasolines with a high olefin percentage present a high gum content.⁷

Fig. G



As mentioned earlier, the Tier 3 standards will only exacerbate the issues of peroxide and gum formation. The implications for gasoline are apparent, as proven by a study performed by The Naval Research Laboratory. They performed a study of diesel fuel used for ship propulsion, and the impact of sulfur reduction over time (for example, during storage). In order to meet the requirements for Ultra-Low Sulfur Diesel (ULSD), fuels with 15 ppm (parts per million) S (sulfur) or less, the sulfur is removed by hydrotreating and other processes. Since some naturally occurring sulfur compounds will decompose hydroperoxides, there are concerns that as ULSD is introduced into fleets, these fuels may undergo greater rates of peroxide and/or soluble gum formation during long-term storage. Historically, it is generally accepted that when hydroperoxide concentrations exceed the specification level of 8 ppm (parts per million), fuel system elastomeric materials such as O-rings and seals are attacked. Hydroperoxides have also been shown to initiate fuel autoxidation under long-term ambient temperature storage conditions (storage instability) and short-term high-temperature stress (thermal oxidative stability). These hydroperoxides greatly accelerate, as well as, lower the temperature at which gums and sediments can form.⁸

Fig. H

Finally, let's consider the phase separated ethanol / water mixture that ended up in the bottom of your tank. It is extremely corrosive. Problems to power equipment include, but are not limited to, severe corrosion, carbon/varnish/gum, and dried/brittle rubber and plastic parts (Fig. H). E15 or higher content only worsens these



problems and may even cause engine failure and may void warranties. Bad gas causes problems with all engines and equipment, including boats, ATVs, UTVs, snowmobiles, motorcycles, generators, pressure washers, snow removal equipment, mowers, trimmers, and more. For a consumer,

the end result is often an engine that will not start or that may start but runs poorly. For retailers, dealers, and service centers, the end result is unsatisfied customers, high returns and repairs, and warranty claims.

Given the inherent issues with fuel (like water) and negative forces of contamination, combined, working against gasoline, all of these issues are compounded. It is easy to see how fuel quickly becomes and stays contaminated.

Let's recap. We know that today's modern gasoline is constantly changing, but not in a positive way as it relates to small engines. Ethanol content is rising. Fuel has inherent contamination, including water bonded to ethanol and particulate matter and is not delivered "safe" for engines and fuel injectors. The water problem becomes worse over time with condensation and water encroachment and we know that **WATER** is the greatest enemy to your fuel system and engine. We know that ethanol attracts water and at some point this corrosive mixture phase separates to the bottom of your tank. Tier 3 standards that reduce sulfur content will drive up peroxides and gums. As these issues compound, fuel will tend to degrade in as little as 60 days (or much less) before it is considered no longer acceptable to use. Consider marine equipment in which the fuel can sit for long periods of time before it is needed. This same contaminated fuel is what enters the engine, causing problems that lead to costly repairs and downtime.

What Can You Do? The FUEL LIFE Solution!

Let's consider the words of Lew Gibbs, a senior engineering consultant and a Chevron Fellow who co-wrote the article, *Three Myths About Ethanol*. He says the best way to prevent phase separation in E-10 is to "**keep it dry, keep it dry, keep it dry.**" We can add to that statement, and say, "**keep it clean, keep it cool and keep it dry**". The purpose of fuel is to run your equipment. What's in the tank is what ultimately ends up in your engines. And, today's engines are more sensitive than in the past, so engine issues are becoming more prevalent.

Clean, well-maintained fuel leads to clean and efficient running equipment with fewer maintenance needs, less downtime, and lower operating and

repair costs. Of course, it only makes sense that one would want “clean and dry” fuel that lasts longer and that does not clog filters or damage equipment.

However, a clean, dry, healthy fuel system is not something that just “happens”. A healthy fuel system is free of water, particulate matter, and contamination. We call this “good fuel hygiene” and it requires a proactive plan of action to eliminate and prevent fuel contamination.

B3C Fuel Solutions, LLC, a manufacturer of environmentally friendly products and solutions that resolve engine and fuel system problems caused by today’s modern gasoline and diesel fuels, including ethanol and bio-diesel blended fuel (bio-fuel) related problems, has developed a new filter that combats all of these fuel related issues. In fact, this represents a paradigm shift in fuel stabilizing technology. We call it the FUEL LIFE In-Tank Fuel Stabilizing Filter. B3C was awarded two patents, one for fuel preservation technology (Patent no. 9,149,788) and another for fuel drying technology (Patent no. 8,828,104).

The FUEL LIFE Fuel Stabilizing Filter is a proprietary nanopore reactive molecular sieve that removes (neutralizes) the compounds in fuel that cause fuel decay (similar to the molecular sieve in Fig. B). Once removed, fuel’s ability to decay is drastically diminished, even when exposed to heat and sunlight. The FUEL LIFE Fuel Stabilizing Filter removes moisture from ethanol blended fuel in a fuel tank. It removes bound, emulsified, and free water, eliminating corrosion and phase separation. FUEL LIFE is non-toxic, non-hazardous and non-liquid and does not release anything into the fuel. The technology is third-party ASTM D525 (oxidation stability) and ASTM E 1064 (water presence) tested and simple to use.

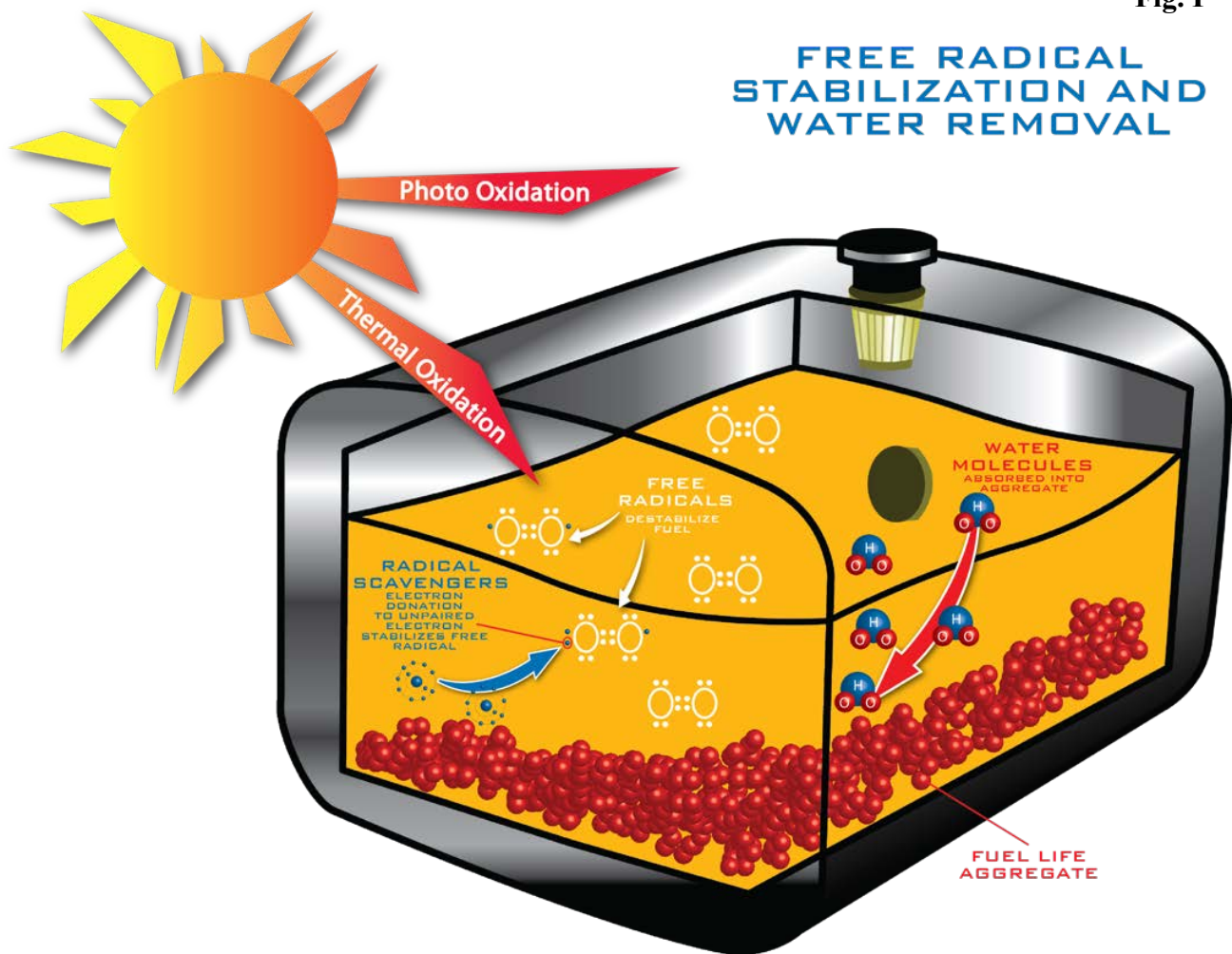
The FUEL LIFE In-Tank Fuel Stabilizing Filter is the ONLY in-tank technology that removes water bound to ethanol while neutralizing the compounds in fuel that cause fuel decay.

FUEL LIFE stabilizes fuel by donating electrons (radical scavengers) to the unpaired electrons in the free radicals that destabilize fuel. This stabilizes the free radicals and therefore the fuel. At the same time, FUEL LIFE adsorbs

the water in the fuel so the water can do no harm. Combined, the processes of the FUEL LIFE technology essentially eliminate fuel decay and provides LIFE long protection against fuel related issues (Fig. I).

In terms of moisture removal, the concept is similar to desiccant packs, a time-tested standard method to remove moisture in critical items like pills and electronics (although standard desiccants will not work in a fuel tank). Desiccants remove moisture through adsorption, by holding the water through a physical bond. So essentially, desiccant packs capture the water and holds it where it can do no harm. This is different than absorption, where the water becomes part of the absorbing substance.

Fig. I



FUEL LIFE works by donating electrons (radical scavengers) to the unpaired electrons in the free radicals that destabilize fuel. This stabilizes the free radicals and therefore the fuel. At the same time, FUEL LIFE adsorbs the water in the fuel. This eliminates fuel decay and provides LIFE long protection against fuel related issues.

This new technology has the potential to change the fuel additive industry as we know it today by stopping fuel related engine problems before they start. Millions of engines, for example boats, motorcycles, ATVs, and outdoor power equipment, either do not run, or run poorly due to bad fuel, both gas and diesel. Additionally, considering the environmental aspects of fuel disposal, when fuel goes bad, it is unusable and has to be disposed of properly, but proper disposal does not always occur. These problems are preventable with FUEL LIFE.

FUEL LIFE also offers an incredible opportunity for Original Equipment Manufacturers (OEMs) to build FUEL LIFE into new equipment or sealed gas cans (low permeation fuel tanks). At the point of manufacture, FUEL LIFE will stop potential issues with ethanol-blended fuels (fuel decay, gums, varnish, corrosion) resulting in completely stabilized and water free fuel. FUEL LIFE will clean slightly marginal fuel by neutralizing the negative chemical reaction that may have already started.

Benefits include potential reductions in fuel related warranty issues and costs, increased customer satisfaction, and positive environmental impact. FUEL LIFE is a highly innovative and creative long-term solution that OEMs can leverage to drive competitive brand differentiation, increased awareness, and ongoing customer satisfaction.

FUEL LIFE is revolutionary in terms of fuel stabilizers. It is multi-patented, worldwide compliant, non-liquid, non-chemical, and environmentally friendly.

It truly is a paradigm shift in fuel stabilizing technology.

WATER is fuel's greatest contaminant causing rust, corrosion, gums, varnish, phase separation & more

REMOVE the WATER, REMOVE the PROBLEMS

FUEL LIFE™
IN-TANK FUEL
STABILIZING FILTER

**PROTECTS all 2 & 4
Cycle Engines**

**Patented, Award Winning
In-Tank Fuel Stabilizing Filter**

- removes water & contaminants
- stabilizes fuel
- prevents ethanol issues
- stops phase separation
- protects from corrosion & varnish
- continuous, multi-year protection
- use in all fuels & fuel blends
- low cost & easy to use
- easy starting year-round
- no chemicals, non-toxic, non-hazardous

**ECO-FRIENDLY
CHEMICAL-FREE
FUEL STABILIZER**



FUEL LIFE removes water just like desiccant packs in vitamins!



*B3C's FUEL LIFE is a unique technology designed to remove water from fuel. The concept is similar to desiccant packs, a time-tested standard method to remove moisture in critical items like pills and electronics. Note: standard desiccant packs will NOT work in fuel.



B3C Fuel Solutions
Brochure 10-605-3

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About B3C

Headquartered in Conway, South Carolina, B3C Fuel Solutions, LLC manufactures a complete line of environmentally friendly products and solutions that resolve engine and fuel system problems caused by today's modern gasoline and diesel fuels, including ethanol and bio-diesel blended fuel (bio-fuel) related problems. B3C offers the most comprehensive line of solutions to resolve issues including water, corrosion, and contamination. As a Total Fuel Solutions company, B3C's patented products allow customers to TEST, FIX, & PREVENT fuel related issues so all engines will start and continue to operate efficiently, with minimal repair cost and downtime. B3C's products are found at a number of retailers, dealers and distributors worldwide. For more information about B3C, call 843.347.0482 or visit www.B3CFuel.com.

About The Authors



As the President / CEO and chief scientist of B3C Fuel Solutions, Brian Boezi has combined his knowledge of engine mechanics and his unique expertise in the field of chemistry to develop products and solutions that resolve modern fuel related issues.

With over 25 years of experience, Brian is also sought by major industry participants to consult about problem discovery and resolution. His results are verified through third party testing, endorsements from major engine manufacturers, as well as positive customer feedback and testimonials.



As Vice President of Marketing and Business Development for B3C Fuel Solutions, Greg Allen leverages his experience in brand management, advertising, public relations, partnership marketing and more to drive the marketing efforts for B3C and its core brands, including Mechanic In A Bottle and Ethanol Shield Fuel Stabilizer.

Greg has over 25 years of marketing and management experience with both large and small firms, including working with two of America's most prominent brands, Delta Air Lines and The Coca-Cola Company, as well as consulting in the lawn and garden industry.

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