Fuel Hygiene

This document refers to gasoline and ethanol blended fuels and discusses proper storage recommendations, cause and effect of storage issues, and recommendations and comments for some specific uses or situations.

General Storage Recommendations:

Five precautions will delay the deterioration/evaporation of gasoline:

1. Fill containers about 95% full
2. Cap containers tightly
3. Use only EPA approved storage containers
4. Store containers out of direct sunlight in a location where the temperature stays below 80°F most of the time (a vehicle or piece of equipment with gasoline in the fuel tank may be stored in direct sunlight as long as the tank is shaded from the sun)
5. Use Ethanol Shield to stabilize the fuel and prevent any harmful effects from ethanol

The first three actions reduce the evaporation of gasoline during storage and reduce the exposure of gasoline to air and water vapor. The 5% air space allows room for the liquid gasoline to expand if its temperature rises. New EPA regulations require that gas cans meet the permeation requirements.

There are many fuel additives on the market to choose from. Most of them will stabilize straight gasoline. However, with ethanol blended fuels, most will not work with the ethanol. It is important to note that there are additives that work by demulsifying the ethanol blended fuel. Unfortunately, this permits phase separation to happen sooner. When ethanol blended fuels are burned in an engine, the actual BTU's of ethanol are lower, however, the ethanol causes the mixture to burn hotter. In turn, this causes higher temperatures in the engine and in the exhaust/catalytic converter. Engines that run hotter have a tendency to have shorter life spans. Note: The volatility of gasoline is custom mixed for the range of temperatures expected in the area where it is sold. Engines fueled with "summer grade gasoline" may be more difficult to start in cold weather (see Volatility section, below.)

Storage Containers:

Store gasoline only in an approved container clearly intended for the use of gasoline. Also, store containers only in locations that are free from ignition sources or in approved cabinets. New gasoline containers must meet the EPA's regulation regarding permeation. This regulation indicates how much hydrocarbon light ends can escape through the actual plastic of the container. Older one, two, and five gallon containers should carry a sticker indicating that they are approved for gasoline storage by the Underwriters Laboratories (UL). A plastic container has the advantage that it will not rust if the gasoline is contaminated with water or if the container is stored in a wet place. The Uniform Fire Code has only approved a 60-gallon metal drum for the storage of more than five gallons of gasoline.

The Uniform Fire Code does limit the amount of gasoline that can be stored in residential buildings to the amount "necessary for maintenance purposes and operation of equipment," not to exceed a maximum of 25 gallons. Please note to check with your local Fire Department to determine their regulations.

Power Equipment:
This section applies to equipment designated as power equipment. This includes: 4-stroke and 2-stroke engines used in outboard motors, jet skis, snowmobiles, and lawn-and garden equipment, motorcycles, and construction equipment. Many owner manuals for small engines recommend that the equipment not be stored with gasoline in the fuel tank. The tank should be emptied and the equipment run until the fuel line and carburetor are empty. This recommendation is intended to protect essential fuel system parts from gum deposits. However, unless the fuel system is completely disassembled and cleaned, it is nearly impossible to get all of the gasoline out of the system. Using Ethanol Shield before the system is drained will protect the system from damage due to old gasoline and ethanol. By adding Ethanol Shield to the system, the gasoline and the system will be protected for up to three years.

Always follow the fuel and storage recommendations in the owner's manual for your equipment. Even if it is not recommended, always run a fuel stabilizer (Ethanol Shield) in the fuel as you never know when the last time a piece of equipment will be used for the season. If fuel is left in the equipment, follow the general storage recommendations on the Ethanol Shield bottle.
Please note that at the time of this publication, there is no power equipment approved for use with any ethanol blended fuel other than E-10.

Volatility:
Volatility describes a gasoline's tendency to form vapors. Gasoline in a liquid does not burn, only the vapors of gasoline burns. To start an either cold temperature or "cold" engine, the gasoline must vaporize at the engine temperature to form a combustible vapor-air mixture.

This is one reason that the volatility of either winter blend or summer blend gasoline is specific to the climate that is expected in the locality where it will be sold. "Winter gasoline" needs a higher volatility (vaporizes at a lower temperature) for easy starting in cold weather. "Summer gasoline" has a lower volatility (vaporizes at a higher temperature) to avoid releasing hydrocarbon vapors into the atmosphere which contributes to smog formation.

Evaporation:
The gasoline hydrocarbon "light ends" needed for easy starting have the same tendency for vaporization/evaporation in storage as they do in an engine. The warmer the storage area and/or the more agitation the storage container receives (i.e. a moving vehicle), the greater amount of vaporization/evaporation. If the storage container is not tightly sealed and does not meet the EPA permeation requirements, some of the hydrocarbon "light ends" gradually will be lost. Too great a loss will decrease the gasoline's ability to start an engine.

Like automobiles did in the late 1970's, power equipment is now required to control the evaporation of gasoline from the fuel system. The fuel system is now vented through a charcoal canister instead of the fuel cap. The charcoal absorbs the hydrocarbon "light ends" so that they are not released into the atmosphere. Evaporation of gasoline is kept fairly consistent with a constant temperature. Unfortunately, due to daily temperature changes, the evaporation rate fluctuates as well.
When gas is stored in an open container, as the day heats up, the pressure of the gas is higher (gasoline vapor and air) than the liquid gasoline, which in turn, allows the air/vapor mixture to

escape out of the container. Then when the temperature cools, it lowers the pressure of the gas, drawing fresh air into the container. Hydrocarbon “light ends” then evaporate from the liquid gasoline to saturate the new air. The daily repetition of this cycle gradually evaporates hydrocarbon “light ends” out of the container.

This cycle also brings air that is saturated with water vapor into the container, especially during periods of high humidity. The ethanol in the gasoline will absorb the water until phase separation happens (see Phase Separation). The oxygen in the air contributes to gum formation (See Oxidation section).

Keeping the container almost full of gasoline and controlling the temperature will minimize the loss of hydrocarbon “light ends” as well as the exposure of the gasoline to moist air, and the contamination of the gasoline with water.

Phase Separation:
Today’s gasoline contains ethanol in various blends with 10% (12.8 ounces per gallon) being the most popular. Phase separation is when the ethanol in blended gasoline has reached its saturation point (.5% [.64 ounces] at 70 degrees) of absorbed water. The saturated ethanol will separate from the gasoline and settle at the bottom of the tank. It is important to note that even through distillation and molecular filtering, ethanol contains up to 1% of bound water straight from the distiller. Ethanol by its very nature attracts water molecules from any source it can and bonds with it. As the amount of water increases, the lubricity of the ethanol decreases. When the ethanol/water has separated out of the gasoline, it becomes corrosive (PH of 5.0). The corrosiveness will affect rubber components by making them hard and brittle. The result on metal components is an etching effect, also known as white rust.

There are many ways that water will get into blended gasoline. Gasoline straight from the pump will have dissolved water in it. The ethanol in blended fuels will absorb water from the air. This will happen even in sealed containers if there is air trapped within the container. Gasoline will aerate itself during engine operation. The gasoline will “dance” within the fuel tank as the engine is running, due to the vibration from the engine. Therefore it will mix the gasoline and air trapped in the fuel tank.

Temperature will also cause water to enter into the gasoline. This can happen with condensation within metal tanks. This can also happen within plastic containers as well. As the hydrocarbon light ends evaporate, the air will cool and drop below the dew point. At this point, water will condense out of the air.

Oxidation:
Except for any added oxygenates and/or additives, gasoline is made up almost entirely of hydrocarbon “light ends” – molecules constructed from the building blocks of elemental carbon and hydrogen. However, there are two types of hydrocarbon “light ends” (olefins and diolefins) that can combine slowly with the oxygen in ethanol and in the air ("oxidize") at ambient temperatures. There are two main types of oxidation that have a dramatic effect on gasoline, Thermal Oxidation and Photo Oxidation.

Thermal Oxidation refers to high temperatures and Photo Oxidation refers to the exposure of sunlight. The stronger the sunlight, the faster gasoline can oxidize. The products of the reaction are larger molecules, collectively called "gum." This oxidation is dramatically increased with the introduction of ethanol into the fuel.

The gum-forming reactions become faster as the temperature of the gasoline increases.
This is why this paper recommends controlling the temperature of stored gasoline.
Most gasolines contain negligible amounts of gum when they are manufactured. It is B3C Fuel Solutions' Ethanol Shield that makes it possible to store gasoline up to three years.

Soluble Gum:
There are two types of gum formed by oxidation. Gum formed by oxidation is usually soluble in gasoline. However, when the gasoline evaporates, it leaves behind this gum as a sticky residue. Since gasoline will begin to evaporate in the fuel system, gasoline containing soluble gum may leave deposits on various component parts of the fuel system and on the intake valves. These deposits will be in addition to the deposits normally formed by a gum-free gasoline — a formation triggered by the elevated engine temperatures.

Engines are designed to run best when vital engine parts are clean. Deposits in the carburetor and/or fuel injectors can cause hesitation and stumbling on acceleration, lower fuel economy, lower power output, and higher emissions of hydrocarbon and carbon monoxide. Excessive intake valve deposits can cause many of the same performance problems, plus higher emissions of hydrocarbon "light ends", carbon monoxide, and nitrogen oxides.

Because the EPA recognizes that fuel system deposits increase emissions, they require all gasolines to contain a deposit-control additive. All deposit-control additives keep deposits from forming; the best ones clean up deposits formed by lower-quality gasolines.

If the gasoline contains a lot of soluble gum, the normal level of deposit-control additive may not be sufficient. This is why B3C Fuel Solutions recommends treating a tank of gasoline with Mechanic In A Bottle if a vehicle displays driving or running problems after being stored. The gum-forming reactions become faster as the temperature of the gasoline increases.

Insoluble Gum:
Severe oxidation of gasoline may produce insoluble, as well as soluble, gum. The insoluble gum will take the form of brown or black particles which can float in the gasoline or settle to the bottom of the tank.

When an engine is fueled with gasoline containing insoluble gum, the fuel filter will remove most of the gum. If the engine has an in-tank fuel pump, the screen on the pump's feed also may capture some of the gum. However, these devices can become plugged if the gasoline contains too much insoluble gum. This will cause the engine to lose power or stall because it is starved for fuel. Adding Ethanol Shield will keep insoluble gum from plugging filters and screens.

Fuel that has begun to oxidize or deteriorate is considered Marginal Gasoline. Marginal gas will allow an engine to run, however, it may be hard to start and even cause poor engine performance. When marginal gasoline is burned in an engine, the effects on internal engine parts can be devastating. The piston and cylinder can become covered in shellac. The valves can become stuck due to buildup on the stems and guides. On 2- stroke engines, the crankshaft and connecting rod will also become coated with the shellac.

Other Issues:

Microbial Activity:

Microbial activity tends to happen at the point where the gasoline and water meet. Moderate activity may cause the gasoline to lose brightness and clarity. Severe activity may stabilize gasoline-water emulsions and contaminate the fuel with visible particles of microbial sludge (biomass). Anaerobic microbial activity may generate hydrogen sulfide, giving the gasoline a "rotten egg" odor. With ethanol blended fuels, microbial growth is kept to a minimum or none at all.

Contamination:

The common contaminants are dirt, water, and rust (generated when gasoline and water are stored in a steel container). All of these contaminants can be detected visually. However, since they all tend to settle, a sample from the bottom of the container or fuel tank is required.

Disposing of Gasoline:

Always follow state and/or local ordinances for the proper disposal of gasoline and other hazardous material. There are organizations that will help dispose of gasoline in an environmentally responsible way. Finding the best option may take some searching. Sources of information are your community's fire department, recycling center, automotive parts stores, and hazardous waste disposal center. Check your phone book to locate these organizations. Commercial disposal organizations are listed in the Yellow Pages under Environmental & Ecological Services and Oils, Waste.

2-Cycle Gas/Oil Mixture:

When ethanol free gas and oil are mixed together the bond that holds them together is very strong. When oil is added to ethanol blended fuel the bond is very weak (Van der Waal Forces). The reason for this is that there is water bonded to the ethanol. It is almost impossible to have water free ethanol. Therefore, the water in the ethanol prevents the oil and ethanol to bond together. Conventional and synthetic oils do not bond to the ethanol at all due to the water in the ethanol. If E-10 blended fuel is used, 10% of the fuel is not lubricated. For this reason, it is important to use Ethanol Shield to prevent phase separation. Ethanol Shield will act as an agent to bond the ethanol/gas/water/oil together.

In untreated gasoline, if phase separation happens, the ethanol/water mixture will separate from the gasoline and sit on the bottom of the tank. When used, no lubrication will be provided.

Dealer Test Kit:

Detecting Deteriorated Gasoline:

Utilizing the Dealer Test Kit and its instructions, testing gasoline for deterioration is very simple. The Gas Quality Test Swabs are an easy and quick way to check for deteriorated gasoline and for

the presence of water. The test takes less than two minutes to perform and can be done in the presence of the customer. If there is still question as to the quality of the gasoline, 2 & 4 Cycle Gasoline and Diesel Fuel Test, High Sensitivity Test," can be used. Again this test only requires 2-3 minutes of time.

- **Gas Quality Test Swabs**
  - This tests the quality of the fuel utilizing a test swab
- **Phased Separated Fuel Test**
  - Performing this test is the same as the Gas Quality test; however, you are doing two tests in one. This test will use the test swabs and the Phase and Bound Water Testing Solution.
- **2-Cycle Oil Indicator Test**
  - This test will indicate how much 2-cycle oil is present in the fuel. Fuel can be checked at either the fuel tank or carburetor. If you suspect that the unit was ran without oil, using fuel from the primer bulb or inside the carburetor will provide the best results.
- **2 & 4 Cycle Gasoline and Diesel Fuel Test**
  - This test is a more in-depth fuel quality test. It is measuring the oxidation of the fuel. In other words, it is measuring how much the fuel is broken down.
- **Bound Water Test**
  - This test determines the amount of water that is in ethanol-blended fuel. Phase separation will happen when the water content reaches .5%. That is just a little more than one-half of an ounce per gallon of fuel.
- **Ethanol Indicato**r
  - This test determines if ethanol is present in the gasoline.
- **4-Cycle Oil Change Indicator**
  - This test will allow you to see the condition of the oil in the engine. This will also provide you a tool to use with the customer.

B3C Fuel Solutions LLC is a complete fuel solutions company that manufactures an environmentally friendly family of unique products and solutions for ethanol & bio-diesel blended fuel (bio-fuel) related problems. These bio-fuel problems began with the Clean Air Act Amendments in 1990 that started in 39 major US cities. Concern in our industry has risen with the increased usage of bio-fuels on a national level over the past decade. B3C is dedicated to resolving issues for today's modern fuels. Utilizing our unique chemical technology, we are among the first to solve multiple bio-fuel (ethanol and biodiesel) related problems. The majority of lawn & garden, as well as fleets and bio-diesel dealers, have a hard time explaining how bio-fuels cause the problems that consumers see in the form of expensive repair bills. B3C will not only solve their concerns, we will educate our dealers and end users as to how bio-fuels cause these problems.

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