mercruiser
STERN DRIVES & INBOARDS

service bulletin

TO: SERVICE MANAGER ☐ MECHANICS ☐
PARTS MANAGER ☐

No. 86-28

Today's Gasolines

Changes in the quality of fuel over the last few years have caused a significant increase in the number of hot engine starting problems on both marine and automotive engines. The problem stems from the use of more oxygenates (butanes, alcohols, etc) in the fuel. While the oxygenates help to increase the octane, they also have a negative affect of increasing the volatility of the fuel causing it to boil at lower temperatures. If these more volatile fuels are used in hot temperature areas or in applications with hot engine box temperatures, they can cause a condition know as vapor locking.

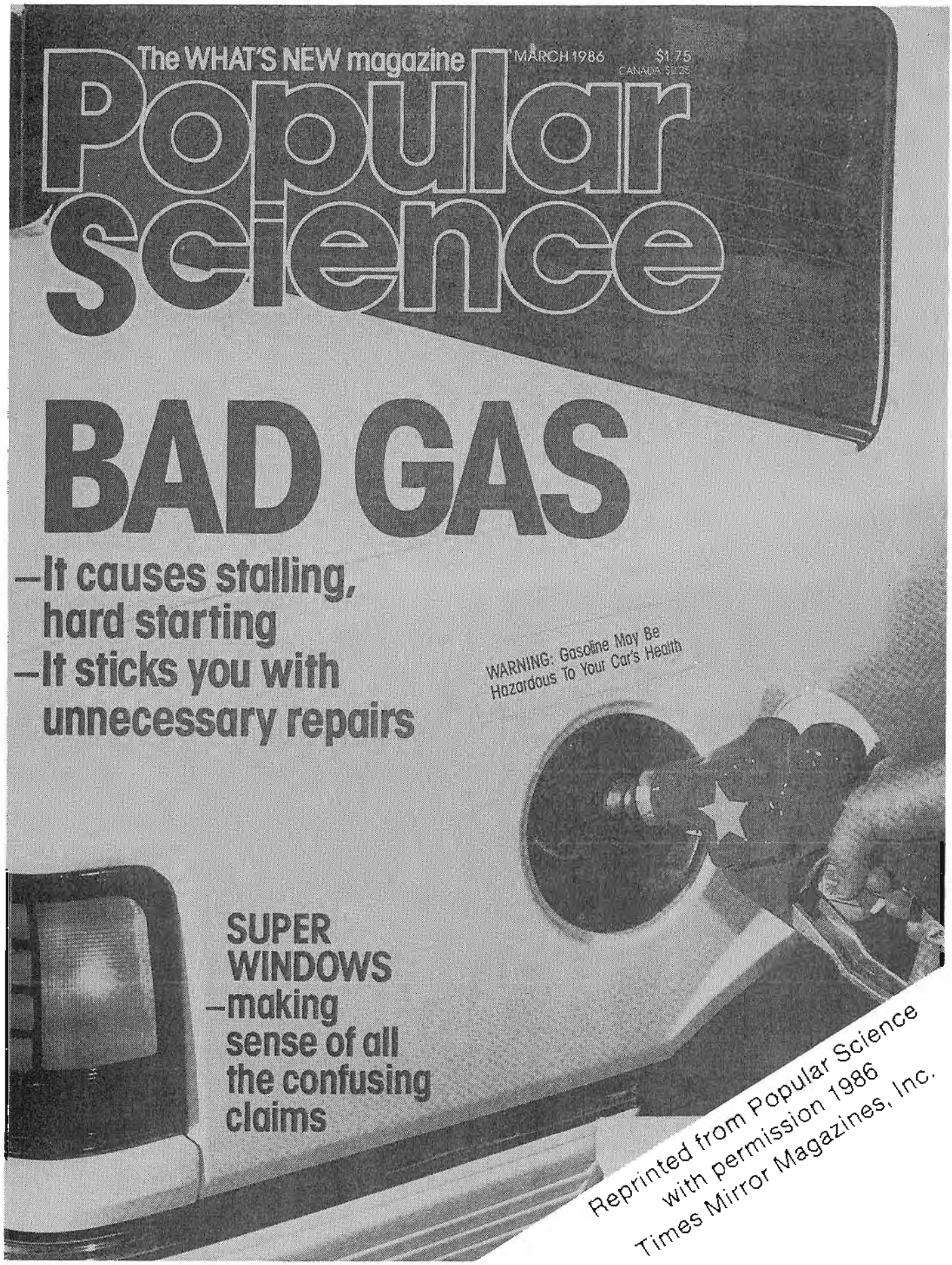
Vapor lock occurs when fuel boils in the fuel system and creates a vapor that reduces the ability of the fuel pump to deliver liquid fuel to the carburetor, in turn starving the engine. Vapor lock usually occurs in the following situation. The boat is stopped for 10 or 20 minutes after being run at cruising speed, heat builds up in the engine compartment, and the gasoline in the fuel lines and fuel pump vaporizes. The engine is restarted on the liquid gasoline remaining in the carburetor. Typically the engine runs for a short distance until this liquid fuel is used up and then stalls. The engine will not restart until the fuel system has cooled down and the fuel system has been purged of gasoline vapor. Extended cranking is often required restart the engine.

Another condition which may occur is called "percolation". If an engine is run long enough to be fully warmed up, then stopped, heat stored in the engine block will be conducted into the carburetor. The hot fuel in the carburetor will boil or "percolate". The vapor bubbles will force fuel out of the carburetor fuel passages and into the intake manifold. This causes a flooded condition and makes the engine difficult to restart. A long cranking period is again required to start the engine.

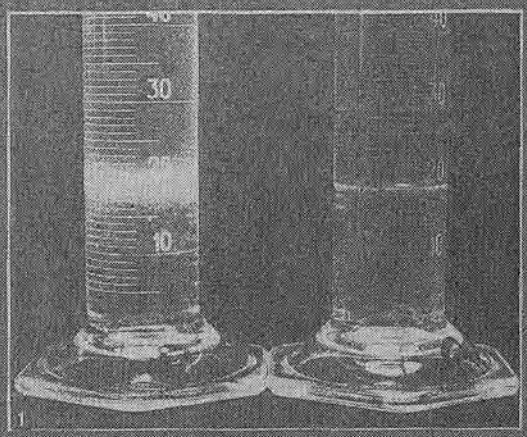
The key in solving hot fuel handling problems is to use lower volatility gasoline. Gasoline bought during spring will cause problems during unseasonable warm weather. Any alcohol blended fuel will also exhibit much higher volatility characteristics then non-alcohol blended fuels. Gasoline that is blended for cold temperature areas has a higher volatility to allow easier starting. These fuels should not be used in warmer temperature areas.

If a certain brand of gasoline gives you drivability problems with your car, it probably will not be satisfactory for your boat. Know your dealer, buy a major brand and avoid alcohol blends.

Please read the attached reprinted article from Popular Science Magazine (March 1986) titled "Bad Gas". As stated in the article, gasoline has caused major problems to the driving and boating public. This service bulletin and magazine reprint should be used to help you explain hot fuel handling problems to your customers.



BAD GAS



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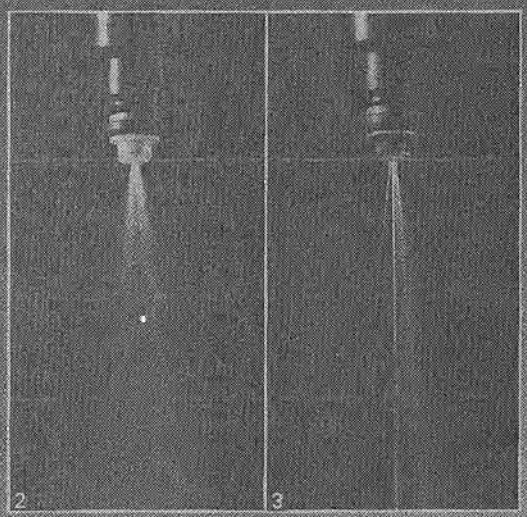
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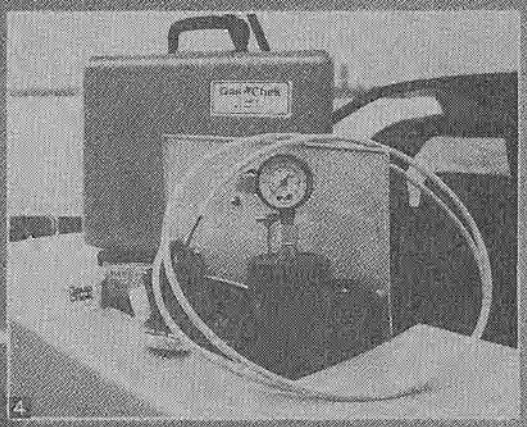
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Changing gasoline quality is behind some of the poor performance and drivability problems drivers complain about, and it undoubtedly has caused unnecessary repairs. Auto and oil companies don't agree on the best way to solve the problem. But you can minimize your troubles if you know what to look out for.

By JACK KEEBLER

Gasoline quality is changing.

- A characteristic engineers call vapor pressure has been rising for several years. Auto-company experts say this causes vapor lock, fuel foaming, hot-starting problems, unstable idling, and more.
- Alcohol added to gasoline, while defended by some authorities, is condemned by others. They charge it produces drivability problems and, in some cases, possibly damages parts in the fuel system.
- Detergency of at least some gasolines seems to be falling, producing clogged fuel injectors and carburetors.

Just how bad is the situation? It depends on who you ask. The most outspoken representative of the auto industry is Gil Clark, a fuel specialist at Chrysler. "Changes in gasoline quality," he says, "have never been more significant—or more troublesome to the motorist—than they have become in the last three years." Others have a different opinion: "In general," counters C. B. Hood, manager of fuels technical services at Mobil Oil Corp., "motorists are getting the best gasoline buy ever. All gasoline isn't the same, but gasoline quality overall is the best it's ever been, and that's certainly true so far as our company is concerned."

Where does the truth lie? As is often the case, the situation is both controversial and complicated. Certainly, most of the gasoline sold today, particularly that blended by the major oil companies, meets industry standards. It's the standards that need to be changed, counter the auto-company experts. Then there's the really bad gas—gas that is improperly and in many cases illegally blended. No one knows how much of it is being sold. This is the stuff that can really get you into trouble. To get at the facts, I interviewed engineers at major auto and oil companies and talked to independent experts. Here's what I learned.

What's happening and why

Gasoline is not a single substance, but a mix of scores of hydrocarbons—molecules made of hydrogen and carbon. They range from light, volatile substances to heavy, less volatile ones. An ideal fuel is balanced; it has low vapor pressure—a high boiling point—to avoid vapor lock, but enough volatile elements for easy starting. Petroleum companies vary the blend constantly. Winter gasoline, for example, is more volatile than summer gasoline for easier cold-weather starting.

Car manufacturers feel that the biggest problem today is volatility's upward creep, especially in the summer. It would seem to be an easy problem to solve: Simply blend a less volatile mix. In principle, that's true. But a complex web of economic, legal, political, and engineering considerations are conspiring to push gasoline's volatility up rather than down.

Volatility is measured in terms of vapor pressure. Vapor pressure quantifies a given fuel's tendency to vaporize—to turn from a liquid to a gas. It is measured by what engineers call the Reid vapor-pressure (RVP) test. One expert who spends a lot of his time studying trends in vapor pressure is Chrysler's Gil Clark. Clark describes himself as an evangelist, and he looks and sounds the part.

He showed me what the RVP test is all about. You start by chilling both a small brass container and a gasoline sample down to about 30 degrees F. "Then you completely fill the chilled chamber with the gasoline," he says in his soft Texas twang, "and screw it onto the bottom of a brass tube with a pressure gauge at the top. Now you have captured a sample of gasoline in a closed container with a vapor space above the chamber. Next you drop the whole assembly into water at a hundred degrees, and wait fifteen or twenty minutes while it all comes up to temperature. During that time some of the gasoline vaporizes and the pressure in the tube rises. Then you simply read the gauge."

That number—it used to be about nine in summer and 12 in winter—has been creeping up. Why is that important? Clark explains: "You pull off the freeway on a hot day to pick up a loaf of bread on the way home. The car is nice and hot, and in the five minutes you're in the store everything under the hood gets a hot soak. You come back, hop in, start the car, and head out. It will start and run across the parking lot, where the fuel demand is low. But the hot gasoline began to boil while you were in the store. It makes so much vapor that the fuel pump is windmilling full of vapor and not delivering enough liquid fuel. When you try to accelerate to reenter the traffic stream, the engine dies lean [is starved for fuel]."

The opposite can happen. "Some cars now have fuel pumps with sixty to eighty times the pumping capacity needed for constant speed," adds Clark. "In this situation, hot fuel instead of just vapor will reach the high-temperature environment under the hood and foam just like shaken soda pop. That fuel bubbles out of the bowl vent, falls into the carburetor, and causes the engine to run rich. Fuel foaming is a brand-new symptom that has just been recognized in the last few years as fuel volatility has crept upward."

The situation can be serious. Last June, a load of winterized, or high volatility, gas was shipped to Albuquerque, N.M. "Stalled cars were lined up as far as the eye could see," says Sandy Brady of Albuquerque's Better Business Bureau. "The worst time often comes on a unusually warm day in spring," says Robert Everett of GM's emissions-control staff. "Winter gas is still in the pumps, and

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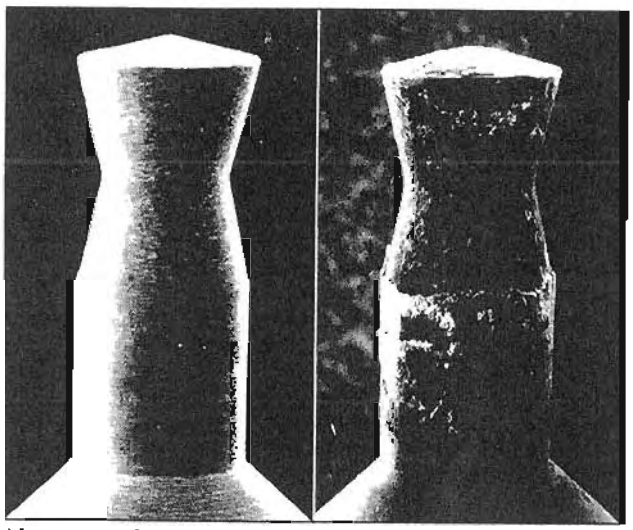
Like a ghostly sentinel, the fractionator tower of Mobil Oil's new alkylation unit (facing page, 1) looms on the nighttime horizon. Improperly formulated fuel detergents can create problems. In the top right photo (opposite) a soapy emulsion (2) has formed in the graduated cylinder on the left. Fuels without detergents can lead to fuel-injector plugging (3). The injector photo on the left shows a good injector with a healthy spray-cone pattern. On the right is a partially plugged injector. Poor cylinder-to-cylinder fuel distribution and inadequate vaporization can result in reduced engine performance and higher emissions. Gasoline buyers with sufficient curiosity and $150 can purchase a Gas Check kit from Miller Special Tools. The kit measures water content, alcohol percentage, vapor pressure, and the presence of lead in unleaded fuel. Tools for doing the tests come in a plastic carrying case.

cars are stalled all over the expressways. The problem for us is that those customers don't recognize the fuel-volatility problem. They blame the car."

And it may even cause unnecessary repairs. "If you spend an hour on the side of the road with your stalled car," says Clark, "the problem will cure itself as the car cools down, and you'll eventually be able to start again. But if you're unlucky enough to get a tow truck in a hurry, you'll be towed to the nearest garage where the mechanic may want to replace all of the pieces of the fuel system he can see. I heard of one fellow who had his fuel pump replaced seven times when the real problem was the gasoline supply."

Despite such stories, is the problem really serious? While some auto people claim it is, oil-industry experts take a different point of view. "Late-model cars," says Hood of Mobil, "are less sensitive to gasoline volatility than their predecessors. Many have fuel pumps in the fuel tank, making them less sensitive to vapor lock. Many individual cars may still be sensitive to vapor lock and other volatility problems because of one or more defects such as a misrouted fuel line, missing insulation, or a marginally defective cooling system." And Jim Smith, an Amoco Oil Co. product engineer, adds flatly, "The only time customers experience problems with vapor lock is during the summer. And these instances are fairly rare except with temperatures in excess of ninety-five degrees."



Above are photomicrographs of a clean and an obviously dirty fuel-injector pintle. A dirty pintle can seriously affect the injector's spray pattern (photos on previous page) and vehicle performance. The diameter of the pintle is about 0.8 mm (0.03 in.); the annular clearance between the pintle and the injector's barrel is a critical 0.05 mm (0.001 in.).

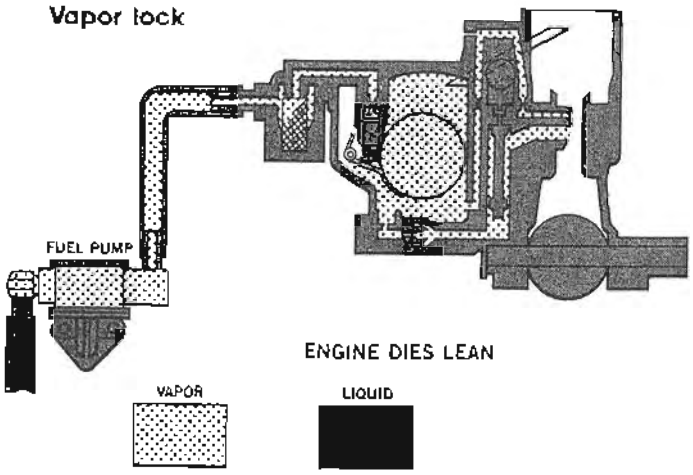
Why is volatility rising? The answer revolves around two fundamental facts: Crude oil doesn't contain the various kinds of hydrocarbons in the amounts they're needed for gasoline. For example, an average barrel of crude yields about 28 percent gasoline. The industry would like and could use 45 to 50 percent.

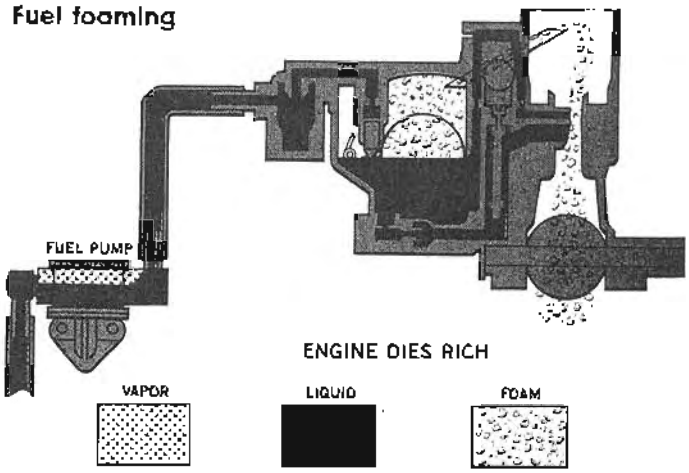
In addition, an engine fuel must have a sufficiently high octane for the engine in which it is to be used. Octane is a measure of a fuel's ability to burn smoothly and deliver power to the piston, rather than exploding suddenly and causing possibly damaging engine knock.

For decades, refiners added a substance called tetraethyl lead to gasoline to improve octane. But during the early 1970s, the Environmental Protection Agency (EPA) mandated that lead be removed from gasoline. That made the percentage of gasoline available from a barrel of crude fall further, since it didn't contain enough high-octane ingredients to make the whole mix satisfactory. So refiners turned to a refining technique called reforming—a process that combines certain light molecules to make more complex high-octane molecules.

Reforming is today's main octane-raising tool. It's not free, however: The higher the temperature and the longer it's held, the higher the octane—but the lower the yield. In fact, some 20 to 30 percent of the original is lost in the form of butane and other less valuable products. That's why unleaded gasoline costs more than leaded of a given octane.

Octane can also be improved slightly by adding butanes and a few other relatively cheap, light fractions. And that works right in with reforming. "Generally, the things that manufacture octane also manufacture higher-volatility components such as butane," says James De Jovine, manager of testing and refinery technology for Atlantic Richfield Co. "And butane, which has fairly high octane, is cheaper than gasoline. So to raise octane and at the same time make your product as economical as possible, you want to use butane to the fullest extent possible." Thus increasing octane also tends to increase volatility.





Vapor lock occurs when hot, vaporized fuel blocks the fuel lines. The fuel pump, designed to pump a liquid, windmills, starving the engine. Fuel foaming tends to strand owners of newer carburetor-equipped cars with high-capacity fuel pumps. High-volatility fuel reaches the hot under-hood environment and foams. This foam dribbles from the bowl vent and kills the engine with a rich mixture. The newest cars with carburetors will be fitted with a special anti-

Some refiners have also tried to ease the octane problem by adding alcohol to gasoline. Alcohol works as an octane improver. An 87-octane unleaded gasoline with 10 percent ethanol (grain alcohol) added will gain about three octane numbers and become 90-octane unleaded premium. This practice began more than a decade ago during the oil crisis, because adding alcohol not only helped raise octane numbers but helped stretch scarce petroleum reserves. Some marketers add up to 10 percent ethanol, producing gasohol. To encourage this trend, many states and the federal government have enacted tax laws giving gasohol special tax breaks.

Other marketers add methanol—so-called wood alcohol, actually made today mostly from natural gas. It also raises octane and burns well in an automobile engine. The problem: "When you add ten percent ethanol to gasoline," says Clark, "its vapor pressure goes up one-half to one-and-a-half pounds." Methanol can cause a similar problem: R. H. Thring of the Southwest Research Institute reported in a Society of Automotive Engineers paper that adding even just two percent methanol to gasoline can raise its vapor pressure by more than three pounds—enough to get a lot of cars into trouble.

So, because of the quality of crude oil, blending problems, removal of lead, addition of light elements for octane improvement, and use of alcohols, vapor pressure has been creeping upward since the early '70s. How much is it actually up? Twice a year, in January and July, the Motor Vehicle Manufacturers Assn. takes about 450 gas samples from several dozen cities across the country. As the accompanying graph shows, pressure has gone from nine to above 10 in the summer, from 12 to above 13 in winter.

These levels, oil companies are quick to point out, are within industry standards, set by the American Society for Testing and Materials, a widely respected standards-setting group including representatives of both oil and auto companies. ASTM standards allow volatilities up to 15 in winter and 11.5 in summer. Thus if all gasoline were at average levels, the auto industry could probably live with it.

However, some experts claim that many blends now sold are substantially higher. Says Clark: "One night last winter I stopped at the six or seven gas stations between here and my house and got gas samples. When I got home I ran vapor-pressure tests on my kitchen counter. I got numbers in the sixteen-to-seventeen-pound area, where it should have been fifteen. The next day I took them down to the lab and confirmed those results. That's not a national scientific survey. But if I got more samples, particularly in winter, I'd bet that most would be outside of the standard." Of course, the other side of the coin is that if some gasoline is above average volatility—a point few deny—then other gasoline must be below.

But the problem is even more complicated. Some auto experts say the numbers, while within standards, are too high, that they should be brought back down to the nine summer and 12 winter of several years ago. So why don't the oil companies and blenders simply blend gasoline to have lower vapor pressure? Because the resultant fuel would cost more.

Why don't auto companies make cars more tolerant of high-volatility fuels? In fact, they have been making cars less sensitive to rising volatility by making changes such as adding more-powerful fuel pumps. But some auto men claim this has backfired. "When the oil companies found out that the new cars were less sensitive," says Joe Colucci of General Motors Corp., "they pushed the volatility up." Marvin Jackson, an emissions-control engineer at GM, adds: "If we build cars in 1990 that solve the problem,

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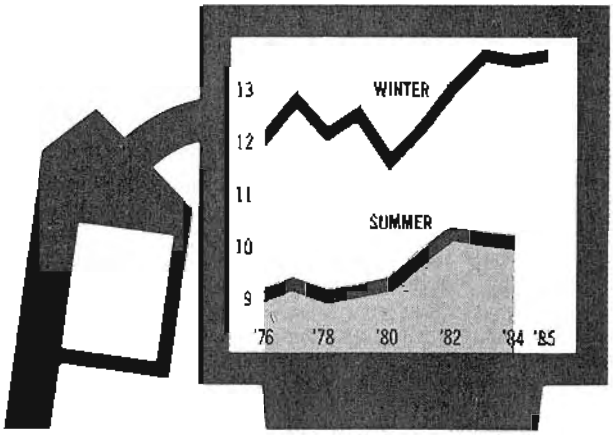
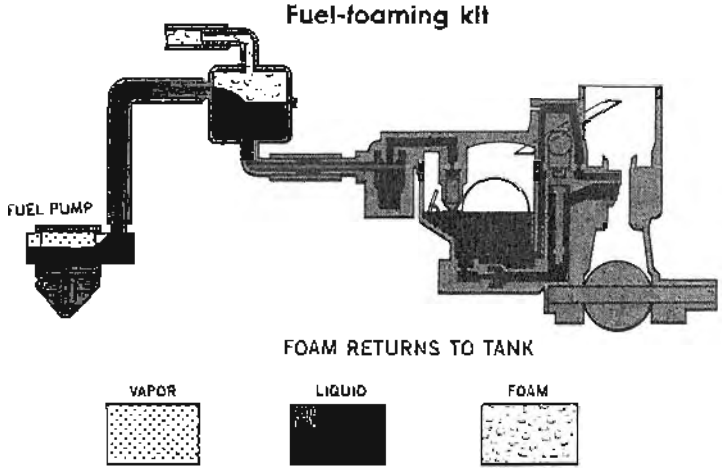


Gasoline volatility has been increasing for several years. Fuel specialists at the major automotive companies say it has affected both vehicle hydrocarbon emissions and warm-weather drivability. Further increases in gasoline volatility would mean more complicated emissions controls.

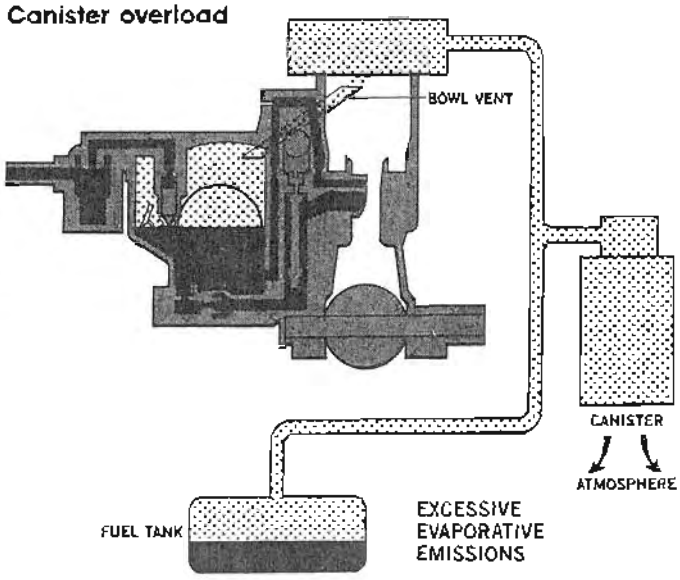
DRAWINGS BY RUSSELL VON SAUERS

Fuel-foaming kit



foaming trap. The trap returns fuel foam to the gas tank. Higher-volatility fuels produce excessive amounts of vapor, which cannot be contained by the emissions system's charcoal canister. Vapor overload then vents to the atmosphere.

Canister overload



Bad gas (Continued from page 75)

they'll realize that they can up the volatility again and make more trips to the bank."

The problem is worse in some areas than in others. "The more progressive oil companies have modernized their refineries to take care of the crude they have to work with," continues Colucci. "But the smaller guys are being pushed for octane. They don't have the facilities for refining the octane into the gasoline. So they're more likely to go out into the spot market and buy alcohols and other higher-octane feedstocks that you wouldn't ordinarily put in gasoline because they push up vapor pressure."

Increasing emissions

Another problem: When the EPA set auto emissions standards several years ago, gasoline was running around nine pounds in summer. Now, with averages higher, hydrocarbon emissions are up. A General Motors research team recently checked the emissions of cars across the country. They found that with RVP figures averaging around 10.5 pounds, emissions were up sharply. They also found that reducing pressure from 10.5 back to the nine pounds that was standard just a few years ago would reduce hydrocarbon emissions by nine to 25 percent. A GM technical paper points out that gasoline with high pressures overloads the current carbon canisters, which were designed to reduce pollution but were designed for lower pressure fuel. "Our canisters are simply not designed to handle these high-volatility fuels," says Colucci. (Another related problem: With high-volatility fuels that overpower the canisters, a certain portion of the fuel pumped into your tank never reaches the engine. It evaporates, and the canister isn't up to stopping it.)

The car makers fear that the EPA will demand expensive fixes to reduce pollution—fixes the car makers say wouldn't be needed if gasoline were made with lower vapor pressures. "All the work we're doing to build emissions controls will go down the drain," says Jackson. "It's easy to see a scenario where we get more expensive requirements put on, and the volatility continues to climb. We end up chasing our tail."

Yet more problems

Volatility isn't the only thing that worries the car manufacturers. Among the others:

• Methanol may damage some parts of the fuel system. "Alcohols are corrosive and react with lead, magnesium, aluminum, and some plastics and elastomers [rubbers]," says Thring in his SAE paper. He also points out that such problems are minimal when alcohol concentrations are kept below approximately 10 percent. Chrysler reports that some rubber carburetor parts have been degraded and recommends that Chrysler car owners not use methanol blends. Atlantic Richfield, on the other hand, has done extensive testing of many different materials and has published scientific papers reporting no significant difference in those materials exposed to Oxinol—a methanol blend—over those exposed to pure gasoline.

• Water may cause alcohol to separate from gasoline. "Methanol has an affinity for water," says Clark. "It may then separate. If that happens, it rusts the inside of the mild-steel fuel lines and fuel tank and corrodes conventional carburetor and fuel-pump metals." Atlantic Richfield, which sells Oxinol, says it has solved the separation problem with the inclusion of a cosolvent—a substance called GTBA (gasoline-grade tertiary butyl alcohol). Atlantic Richfield has also placed great emphasis on dealers thoroughly cleaning all tanks and eliminating the danger of water contamination before methanol blends are delivered. (The company also claims that GTBA lowers vapor pressure.)

At the moment, most auto companies approve of the use of ethanol blends. But they're divided on methanol. General Motors, Ford, Toyota, Honda, and AMC say up to five percent methanol is OK. Chrysler, Nissan, Mazda, Subaru, VW, and Volvo say don't use it.

How clean?

Twenty years ago Mobil Oil Corp. began an ad campaign pushing high-detergency gasoline. It goes on to this day. However, the emphasis on detergency has not been industry wide. In fact, there is some evidence that average detergency is falling, and that some gas contains no detergent at all. This can be important, especially to carburetors and fuel injectors, which are sensitive to low detergency. To see why, visualize a fuel injector's pintle valve. It's built like a garden-hose nozzle. When the pintle is activated, it lifts off the conical seat and produces a cone-shaped spray of fuel. Each time the valve closes, fuel left on the end of the valve evaporates. After many repeated cycles, there can be a deposit from the evaporating fuel. And the space at the top of the nozzle gets smaller, upsetting the spray pattern. The result is loss of power, misfiring, surging, and poor drivability. A good detergent can prevent deposits or remove them if they have already begun to form.

So serious is this problem that GM vice chairman Howard H. Kehrl recently wrote to major oil-company presidents and executives. "It has become increasingly evident that port-fuel-injection systems are sensitive to fuel quality," he said. "Their performance can be seriously impaired by deposits that form at the injector tip and inhibit fuel flow." He said that GM dealers could clean injectors, but the deposits could come right back. GM has asked the oil companies to reveal their plans, and some have indicated they will raise detergency. The GM letter implied that the company might recommend such specific brands of gas for GM cars.

So just where does detergency stand? Nobody knows for sure. Fred Ruhland, an account manager at the fuel-products group at Lubrizol, one of the country's biggest suppliers of additives for both gas and oil, says the picture has changed in recent years. He says the amounts of detergents used are sharply down, but the effect is hard to know because some newer detergent materials are more effective than older ones. "A few companies were using between three hundred and a thousand pounds of detergent per thousand barrels of gasoline in the early seventies," he says. "Now many of them have come down to between three and five hundred pounds. A growing problem has come about because the majority of the oil companies use a treatment in the range of eight pounds of detergent per thousand barrels. And some companies—it's about thirty percent—use no additives at all."

Yet other companies have apparently been actually increasing detergency. For example, Hood of Mobil says: "We've improved the detergent package to the point where our regular unleaded prevents deposit buildup in carburetors and port fuel injectors, and our new super unleaded can actually clean up dirty fuel injectors. This recent Mobil development has won auto-industry praise, notably by the vice chairman of GM." Adds De Jovine of Atlantic Richfield: "We use more detergent, a higher cost detergent, now than five years ago."

One other important point: The gasoline business—like all others—undoubtedly has some dishonest operators. In fact, industry insiders talk about a phenomenon called splash blending. During the day, a tank truck filled with legitimate gasoline pulls into a service station and partly fills the holding tank. That night a truck filled with alcohol or a cheaper but higher volatility gasoline fraction

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pulls in and dumps another load. The result, of course, is out-of-bounds volatility, extra profits for the unscrupulous operator, and headaches—and maybe extra repair bills for the unwary customer.

Many problems associated with bad gas undoubtedly come from such practices. Although the people who do such things don't usually admit it, one interesting case has come to light. Vic Rasheed, executive director of the Service Station Dealers of America, said he heard a blender at a recent trade meeting say: "I just add until they start complaining."

What can you do about it?

First, buy gasoline at stations that have pumps with labels saying the gas contains detergents.

Second, avoid buying gas at a station that gives you a tankful of problem fuel. You can also recognize that all gasoline is not alike. If you suspect that car misbehavior may be gasoline related, try another brand of fuel before attempting repairs. And when you find a gasoline that works, stick with it.

Finally, as with most other products, you're most likely to get quality from a reputable company with a reputation to protect.

What's the outlook?

Cars will undoubtedly be made more tolerant of high-vapor-pressure fuels. Fuel systems will be and are being designed to remove materials likely to be damaged by alcohol blends. More cars are appearing each year with fuel injectors. And fuel injectors, though sensitive to fouling, are more resistant to vapor lock and fuel foaming. Fuel pumps are being designed to pump more fuel, reducing vapor-lock sensitivity. And anti-foaming devices are also being built into fuel systems.

There is also a move toward state regulation. Twenty-eight states have requirements for labeling alcohol content, if any, and a few—such as California—actually regulate vapor pressure. Some are urging the EPA to attempt to control emissions by requiring certain levels of detergency, vapor pressure, and other qualities. The EPA reportedly has these matters under study. The Motor Vehicle Manufacturers Assn. has been urging complete disclosure on the label attached to every gas pump.

The fact is that both the auto makers and the oil companies are in very competitive businesses. Fuel with good detergency, no alcohol, or a lower vapor pressure costs more. In a study commissioned by the EPA, Bonner and Moore, Inc., an oil-industry consulting firm, estimates that vapor-pressure reduction costs 0.6 cent per pound of reduction per gallon of gasoline. A two-pound reduction would cost almost 1½ cents per gallon.

The oil companies, of course, would like to keep prices down. They'd rather see the automobile companies make the fixes. That would increase the cost of cars, of course. The car companies, on the other hand, would find life easier if average vapor pressure were brought back to the old standard level of about nine.

It's not the first time that similar situations have developed. The truth is that gradually new technologies will evolve that will chip off bits of the problem here and there; prices will go up a little for fuel and a little for cars; and some new problem will come along to attract our attention. In the meantime, you can be aware of the kinds of problems bad gas can cause and, so armed, have a good chance of being one of those drivers who don't get caught. PS