Unleaded Gasoline and Antique Marine Engines

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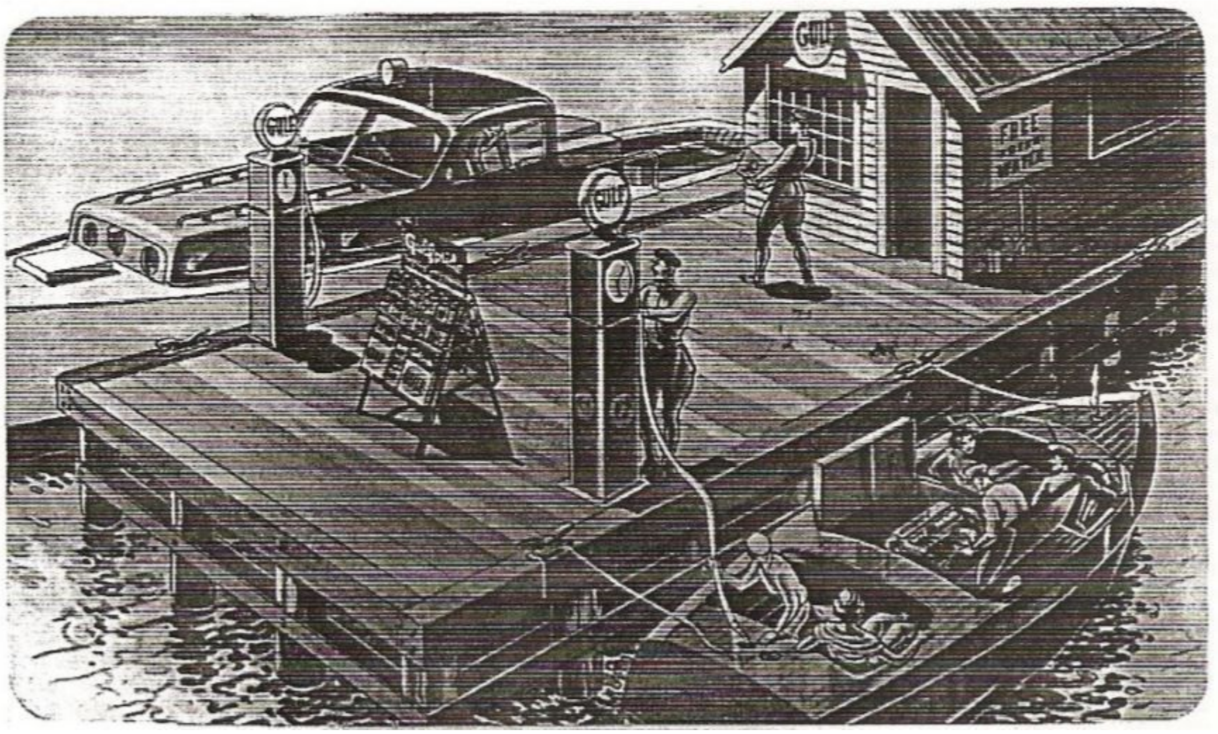


Owners of antique and classic wooden boats designed and built prior to the mid-1960s continue to fret about the fact that tetraethyllead (TEL) has been removed from automotive gasoline which is also the base gasoline sold for marine use. About this issue trying to allay the fears of our society's members with regard to TEL, the question still comes up, and some owners and operators continue to worry about damage to their engines with use of unleaded fuel.

Let me make it clear once again. The engines which our antique and classic boats were designed in a period of time when unleaded fuel was the normal marine fuel, and virtually all the engines were designed initially to run on unleaded fuel. Towards the end of the wooden boat era when TEL was introduced into marine fuels, some modifications were made to the later model marine engines to accommodate the use of TEL, but these modifications were relatively minor and had virtually no effect on the engine's ability to operate on unleaded fuel.

As I have done before, it is probably worth a paragraph or two to go over the history of petroleum use leading up to today's almost insatiable demand for the refined product.

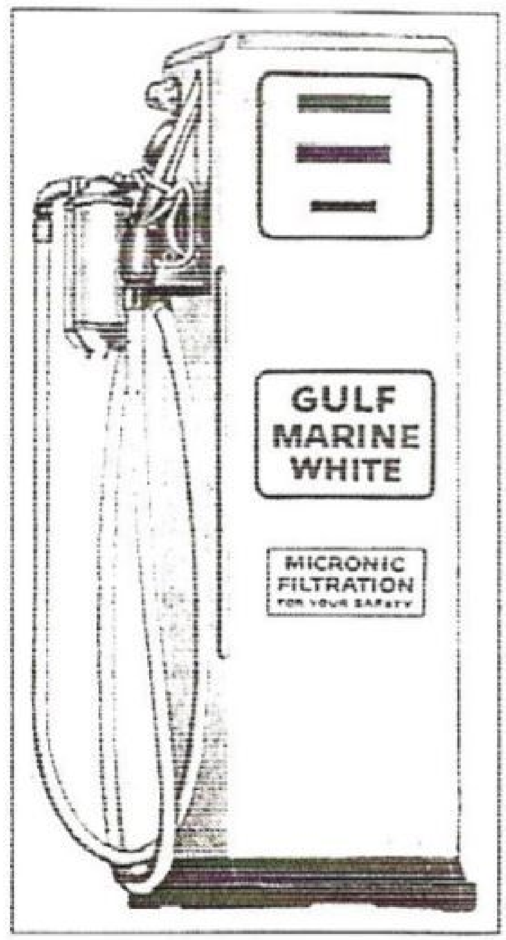
References to the use of petroleum products go back as far as the time of Christ, when petroleum-based compounds were used as a glue in the manufacture of jewelry and, in some cases, mixed with mortar as a sealant to improve the construction of mud-based block buildings in the Middle East. In many parts of the world, crude oil seeped from the ground unaided, and in these very early years land on which this occurred was considered valueless because it could not support agriculture. The more modern uses of petroleum primarily as a fuel and as the basis for a wide range of lubricants is generally considered to begin with a well drilled by Drake in Pennsylvania in 1859. In the following year the United States consumed about 2000 barrels of oil, which provided a tidy income for Drake and his associates. The state of Pennsylvania, where the well was located, for many years remained the primary source of crude in our country.

It was not until the advent of the internal combustion gasoline engine about the turn of the century that gasoline, a by-product of the early primitive distillation techniques, saw any market demand. Far more important to the well owners was the development of gas-oil which was a clean burning fluid heavier than gasoline and used primarily as a fuel for lamps, and in later years, home heating and cooking apparatuses. The distillation process in the years prior to 1900 was adjusted to maximize the production of gas-oil and minimize gasoline as a waste product.

All this changed dramatically between 1900 and 1914, when the demands for gasoline escalated, as both commerce and military immediately recognized the advantages of mobility. It was during this period that the first marine engines saw service.

The problem now facing the petroleum refiners was how to maximize gasoline production to meet the ever-growing demand.

During the decades of the 1920s and 30s, gasoline production was maximized through a series of developments which included thermal cracking, catalytic cracking, reforming and additive development. These activities substantially improved the amount of gasoline derived from a barrel of crude oil and at this same time improved dramatically the performance of the fuel when used in internal combustion engines. Today the process is being reversed as the demand for gasoline levels off in the wake of a rapidly escalating requirement for diesel and turbine fuels. This current day change has little effect on the fuels available for our use in vintage Marine power plants.



During the 1920s and 30s, petroleum refiners produced a special fuel for marine engines which was marketed as *Marine White* or similar names. These gasolines consisted of straight-run stock largely composed of saturated hydrocarbons distilled directly from petroleum crude oil. They had excellent inherent resistance to oxidation for long periods of storage. This inherent resistance was especially desirable because at the time marine fuel tanks were usually made of copper due to its excellent resistance to corrosion and ease of fabrication.

Copper acts as a catalyst for the oxidation of branched-chain gasoline, but was not affected by the straight-run marine fuel. For this reason, the production of straight-run marine gasoline lasted until the middle 1930s when it was no longer acceptable as a marine fuel because of its low octane number and its costly use of very select crude oil stocks in its manufacture.

The dockside fuels available to us today are almost universally fuels taken directly from the pool of motor fuels sold for road use in automobiles. They have good octane numbers, excellent corrosion resistance, contain additives which resist gum formation and can be stored for long periods of time without harmful effects either in the copper tanks of vintage boats, in the stainless steel tanks of modern boats or in the galvanized steel tanks of storage depots. These fuels meet all the requirements for marine use, and there is no need for the user to add anything to these fuels for use in vintage boats or for their storage.

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Chapter 2

During the early years of internal combustion engine development, prior to and during World War I, engineers faced the increasingly difficult problem of engine knock. It became clear that as compression ratios increased, engine performance and efficiency was dramatically improved. As compression ratios increased, however, the fuel-air charge in the combustion chamber would burn almost instantaneously before it was consumed by the normal flame. This abnormal combustion process produced a rapid pressure rise and an audible sound not unlike a hammer blow to the cylinder head. If allowed to continue, this condition caused engines to overheat and mechanically self-destruct. This limitation to engine performance was the primary obstacle to the early development of high performance gasoline engines and, to the same extent, remains with us even today.

To quantify gasoline with regard to its ability to resist knock, engineers in the early 30s under the leadership of the society of automotive engineers, organized the CRC, cooperative research Council. This organization developed the method for measuring anti-knock quality of gasoline and developed the laboratory means for making the measurement which remains in use today, which we call octane number. The antiknock value of a gasoline is determined by comparing a gasoline sample with a known reference fuel in a single cylinder laboratory engine.

The octane number resulting from this laboratory test is the percentage of 100 octane number reference fuel contained in a mixture of 100 octane number reference fuel with zero octane number for knock resistance. Two laboratory methods were developed in recognition that some engines operated at relatively light duty, and other engines, such as marine engines, operated in a more severe mode.

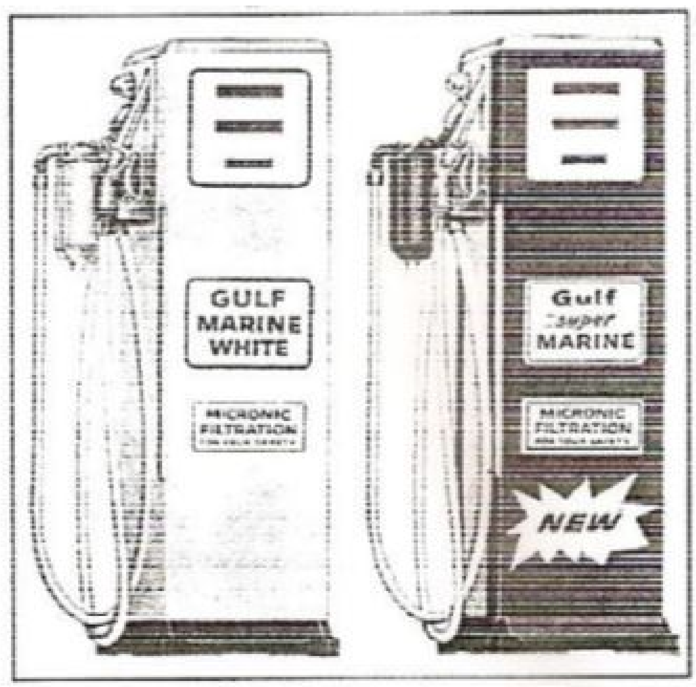
These two methods were called the *research method* and the *motor method* and resulted in octane number differences generally in the range of 5 to 10. The motor method is the more severe of the two measurements and results in a lower octane number for the gasoline tested. The difference between the research and the motor octane numbers is largely dependent on the hydrocarbon composition of the fuel, and this difference is termed "sensitivity".

During the early 1960s, in an effort to systemize the marketing of gasoline, the federal government required that fuels marketed for automotive service be clearly marked with the results of the octane number measurement. Great debate ensued over which number, the research method or the motor method, should be published on the pump.

The marketers obviously wanted the higher research method number, with the federal government in its cloak of bureaucratic morality insisting that the lower motor method number was the true value. A typical bureaucratic solution was agreed upon, and the number published on the pump dispensing fuel for automotive service is not octane number at all but a new term coined for the purpose which is called octane number index. ONI =(R+M)/2. From an engine development point of view, the octane number index is a meaningless average of the motor and research methods. It is, however, a guide for automotive services, and because the fuels today are much higher in octane number than the fuels for which our vintage Marine engines were developed, it does not present a problem. It is, however, important to realize that there is less cushion in the octane number index then we might expect.

Marine engines operating against a propeller load curve cannot be operated at full throttle and low engine speed due to slippage of the propeller. Full throttle low engine speed is the operating condition most prone to knock in automotive service. If an engine does not knock, the octane number of the fuel has absolutely no influence on the combustion process or the power output of the engine.

The Research rating closely predicts the ability of a gasoline to satisfy an engine octane number requirement at high outputs and low speeds. The motor method, on the other hand, more closely correlates with engine requirements at high speeds and full throttle operation. It is clear from this comparison that the motor method of octane number measurement is the important number when determining the suitability of a gasoline for use in marine engines.



Marine engines in the near post World War II. Were designed to operate on either Marine white gasoline which seldom exceeded a motor octane number of 70 or on regular grade automotive fuel. Motor octane numbers for regular grade fuel varied from a minimum of 74 in 1946 to a maximum of 84 in 1958.

Today's regular grade motor fuel available for marine use has an octane number index which averages about 87. If we assume that the difference between the research method and the motor method of fuel in question is 10 octane numbers, which is probably the maximum difference that will be found, when 87 is arrived at by averaging a motor method of 82 with a research method of 92. 92 plus 82 is 174, and the average is 87. The thing to keep in mind is that when you buy a fuel with a posted octane number index of 87, you are actually getting a fuel which in a Marine engine may act like a fuel with a motor octane number of 82.

On the safe side, however, it must be mentioned that most fuels show differences between research and motor methods usually less than 10. Although I have no current data, my guess is that a normal marine fuel would have a difference between five and 10 octane numbers.

The net result of all this is that the regular grade automotive fuel today has adequate octane numbers to satisfy all the vintage boat engines built up through the middle of the 50s. If any doubt exists with regard to your fuel supply, the simple remedy is to use premium fuel, but for the most part that does not appear to be necessary. The boat owner must also keep in mind that the octane number specification on a pump is the minimum octane number index permitted, and, in all probability, the fuel has one or two numbers margin to ensure compliance with government standards.

It should be pointed out that if you are running later model engines derived from high output automotive power plants, you should be very careful about the fuel used. An engine transplanted directly from an automobile to a boat will have a higher motor octane number requirement than the same engine used in a car for the simple reason that it is virtually impossible to run a car engine at full throttle and full speed for any length of time. Full throttle, full speed engine operation in a car will result in a crash or, at best, a lecture from the Highway Patrol and an attendant fine.

Every generality has an exception, and automotive operation is no different. Pulling a trailer through the mountains is a good example. With a heavy trailer in Hill country, you can run the engine in a car in low gear at full throttle and full rpm for quite long periods of time. If you are expecting this type of operation, good insurance is to use a premium fuel which usually has an octane number index in the range of 92.

Let's talk about additives. Much is made from time to time of additives like TCP (trichlorophosphate) or boron, which are designed to enhance the scavenging of tetraethyllead combustion deposits. TCP is enormously effective, and the addition of TCP, which is readily available on the market, is worth the effort with the use of leaded fuel.
TCP is not needed with unleaded fuel.

I have no quarrel with the additive industry if it can convince people to spend money for products which, at least, do not do any harm. But most gasoline additives sold in the open market are basically mineral oil with trace amounts of metallic scavengers. Metal-based additives are notorious for creating deposits and promoting rings sticking, lube oil contamination and exhaust valve burning. I reject the argument that owners of antique boats must now pay premium prices for fuel additives to protect their engines from the use of unleaded fuel when these additives are almost always unnecessary, and in some cases, harmful!

There are no reasonable published data which document the need for owners and operators of antique and classic boat engines to use any additives whatsoever in the motor fuel they use in their boats. Tetraethyllead was never conceived as a lubricant, and all engine design efforts were focused on the elimination of the harmful deposits caused by TEL.

For several decades after World War II, large portions of the South Eastern part of the United States advertised unleaded fuel for use in automotive service, and no engines of that era suffered from the lack of the lead additive.

In rare cases the deposits of TEL may prevent valve seat recession, but this is such a minor problem in antique and classic boat engines that no additive of any kind is required in current gasolines to alleviate this phantom problem. Owners and operators of antique and classic boat engines are well-advised to save their money when it comes to fuel and oil additives which seldom are necessary.

One more article on the use of unleaded fuel in antique and classic boat engines will probably not relate to the rest the concerns all owners have with regard to the problems which may result from elimination of this powerful anti-knock additive from their fuel. It must be remembered, however, that TEL for one simple purpose, to raise the octane number of motor fuel so that compression ratios could be raised and engines could develop more power and better economy.

Nothing you can buy over-the-counter can change this relationship. The best thing owners can do is buy quality fuel, keep the fuel system clean to the extent that it is possible, keep water from entering the fuel tank and, if in doubt, go to an intermediate or premium fuel so that the engine always has adequate octane number protection. We may be faced with the problem of running reformulated gasolines in our antique and classic boat engines. Reformulated gasolines contain a relatively high percentage of the short-chain alcohols which are not always compatible
with Marine engine operation because of their affinity for water.

At this writing, there are no documented problems associated with running reformulated gasolines in marine engines, but it is clear that this is something we should keep our eyes on.