# RACING FUEL

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# COMMENTS

Вот прочитал статью с Турбофаст.ком. Их советы действительны только для чистого Дрэг-рейсинга. Имеются в виду не раскаченные стрит-турбовки с гос. номерами и укуренными негроидами за рулем из всяческих "Форсажей", а настоящие ТорМетанол и ФанниКар драгстеры, тормозящие парашютом, по 6000л.с. с потреблением нитрометана в 3.5 литра в СЕКУНДУ! Примерно для таких аппаратов, которые описаны ниже.

***"The massive fuel amount is best visualized by telling that a Top Fuel heaves in 10 liters nitro every minute when it's idling. When the driver puts the pedal down the amount is up to 3,5 liters a SECOND going into the engine! Two mechanical pumps flowing 220-235 liters per minute each feed the fuel. After them a pneumatically controlled valve adjusts the flow back to the tank. The harder the clutch is locked, the more fuel is fed to the engine through limiting the flow back"***

Вывод после прочтения таков. Данный устаревший материал с успехом может быть использован для практикования в переводах с английского на уровне средней школы и для начального изучения теории топлива как таковой. Для трека, кросса, ралли, кольца, стритрейсинга вы не найдете здесь никаких действительно полезных советов.

Тем не менее, поскольку потрачено время на скачивание, верстку и конвертирование данного материала в PDF, ну не выбрасывать же. Пришлось закинуть на сайт.

По крайней мере из тех обрывков ХТМЛя, что представлены у ТурбоФаста, сделан более менее готовый к восприятию материал, который можно распечатать, сдать в переплет, полистать, поставить на полку ввиде готовой книжки, приобретенной нахаляву. После чего забыть про нее.

Естественно, как любой PDF материал от ТурбоЛовера, данный документ содержит рекламу, красной надписью проходящей слева направо и сверху вниз через каждую страницу книжки. Что поделаешь? Смотрел и я фильмы с гнусавым переводчиком и надписью посередине экрана DEMO TAPE ONLY или что-то в том же духе. Кому из читателей это не нравиться – может заново отсканировать, распознать, перемонтировать, скачать, сверстать и в итоге получит свою копию без ватермарки. Карочи, каждый дрочит как он хочит.

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# 1. SOME BASIC FACTS

WELCOME to the world of racing fuels. Within the pages of this book we will be discussing such exotic and volatile fuels and fuel additives as Methanol, Nitromethane, Dinitropropane, Acetone, Propylene Oxide, Nitrobenzene and others.However, in order to evaluate the advantages and disadvantages of these special fuels for use in high performance engines it is necessary to have a clear understanding of the laws of thermodynamics as applied to the internal combustion engine.

### *HOT AIR ENGINE*

For our purpose it is sufficient to state that such an engine is in simple terms a hot air engine depending on the expansion of a quantity of air, heated by the combustion of fuel, in a confined space, thus providing the driving force on the piston the reciprocating motion of which is converted by the crankshaft into a rotary motion, so driving the flywheel and thus the source of power. It follows, therefore, the more air, by weight, we can ignite in a given combustion space and the greater we can increase the temperature, the greater will be the expansion and the force applied to the piston.

### *COMPRESSION*

This at once highlights a term used by many without quite understanding its implications, the term being Compression Ratio. This is the ratio between the piston at the top of its stroke leaving a space in the combustion head and this volume added to that swept by the piston, that is the bore and stroke volume. If, for example, this works out at ten to one it means the mixture is compressed to one tenth of its normal volume and then ignited. If we assume the engine is not supercharged and at normal atmospheric pressure 14.7 Ibs. per sq. in. approximately, and 100 per cent volumetrically efficient, the force on the piston would be 147 Ibs. per sq. in. This, however, will not be the case in practice as the engine will not take in a charge of mixture equal to the space left by the piston at bottom dead center, in some cases the exhaust gases are not completely evacuated and the heat of the cylinder walls, head and valves, all have their effect on heating up the incoming charge, reaching, with petrol, some 700°F. Thus it is obvious, owing to the heat conditions existing in the engine, that there are definite limitations to the power output which can be maintained, and these conditions, so far as petrol is concerned, are reached much earlier than with alcohol.

### *LESS POWER*

There is a common mistake in thinking that so called racing fuels contain in themselves, quantity for quantity, more energy than petrol. This is not so and in fact alcohol's have considerably less internal energy than petrol, their respective calorific values being 19,000 British Thermal Units per-pound weight for petrol and some 8100 for alcohols. This means that, gallon for gallon, less power can be obtained from the alcohol's, but the limiting conditions mentioned above eliminate this particular drawback. The amount of air required by petrol to burn correctly is several times more than that required by alcohol, so that in effect the advantage of alcohol is that the amount of heat liberated per pound weight of air used is greater. Since the engine is an air engine where air is the working medium, heated by the ignition of the mixture, causing expansion, the fact that we can get a cooler and therefore heavier charge into the engine means a higher power output to be attained, fuel for fuel and weight for weight. In other words the advantage of alcohol is its high latent heat evaporation figure as compared with petrol, allowing it to act as a refrigerant. You may have at some time or other noticed inlet pipes tending to show frost when using alcohol. The difference, for those interested in the heat values, is some 135 BTU for petrol and 472 BTU for alcohol, and just to clear all that up, it might be worth while saying that one British Thermal Unit is defined as the amount of heat required to raise the temperature of one pound of pure water one degree F.

### *OPTIMUM ON PETROL*

Over the years the motor engine has been developed and adjusted by design features to operate at its optimum on petrol, this being available in bulk at a reasonable cost. This fuel is a natural product of the earth, but, as we know, it has undergone a number of changes and has had certain additives incorporated to produce the required results when used with the modern combustion engine. Here then is our reference level or datum line. If you have an engine, in good condition and tune, running, shall we assume, on top grade petrol and providing a known power output, it is possible by change of fuel to obtain a higher output, and to do this you can go to an alcohol based fuel. To get maximum benefit from the new fuel you will have to adapt the engine to run under the new conditions being applied, and you will at once find there are advantages and disadvantages. As we now have some understanding of the nature of the work the fuel is expected to carry out, they can be considered, and the new fuel used to its maximum.

# 2. ALCOHOL FUELS

RIGHT at this point it might be as well to point out to readers that the handling of alcohol fuel, even in small quantities, is dangerous since poisonous Methyl Alcohol is the basis of most of these fuels. In some cases to prevent it being used for drinking an additive is used, called Pyridine, about one half per cent being the amount. This gives it a nasty smell and a vile taste, but pure fuel is, of course, without this deterrent. The problem still remains, however, since it can get into the system by absorption through the skin or cuts, and can be inhaled from exhaust gases. The effects are cumulative and if enough build up is allowed it oxidizes forming Formaldehyde causing blindness and insanity. The use of rubber gloves, avoiding splashing and handling in confined space and in general treating with commonsense, however, reduces the risks to acceptable proportions. Should, however, any get in the eyes immediate medical attention is necessary. For those who have not handled alcohol fuel it might be as well to say it is a clear, colorless liquid, cool in touch, with an odor different from petrol, and has an attraction to moisture in the atmosphere.

### *ADVANTAGES AND DISADVANTAGES*

Let us now investigate the advantages and disadvantages of going over to this fuel, and at all times taking petrol as our reference level, having in mind the basic requirements of fuel in the heat engine. The first question must be is it easy to obtain and the answer is there are a number of garages retailing the fuel, in certain cases with other fuels added in specified quantities. Having obtained the fuel, as already explained, it must be handled with care and commonsense. There is no real problem in keeping in store any quantity left over from one meeting to another, provided it is kept in a can, or tank for that matter, with the cap kept on during the store period, which can extend into years, contrary to popular belief.

### *COST*

Cost of the alcohol depends on what other fuels have been incorporated, but as guide pure alcohol is, in small quantities, about just over half as much again as the cost of top grade petrol. You must bear in mind at this point, however, you will require double the amount of alcohol as compared to petrol for reasons which will be explained later. Another point to consider is that alcohol is a solvent and so far as certain paints are concerned it acts as a perfect paint stripper. Alcohol also has a very thorough scouring effect on tanks, pipe lines and so on, not forgetting it can on certain types of fiberglass tanks cause them to disintegrate into a rather nasty sticky mess.

### *CONSUMPTION*

Consumption of alcohol will be, in rough figures, double that of petrol, due to the calorific value being about half that of petrol.The correct air-fuel ratio for petrol is 14.1 to 15.1, but for alcohol it is 7.1 to 9.1 so that means we must pass at least twice the weight of fuel, in the case of alcohol, to heat the same amount of air to the same temperature as we need for petrol.Since the specific gravity of the two fuels is near enough the same it means in effect we have to pass through the jets double the quantity of the fuel.Apart from doubling up the flow capacity of the jets, and we would add here that this does not mean doubling up the diameter of the jet hole as many people think, but, in fact, increasing the diameter by 1.4 times or if you like by 40 per cent since a little thought will remind you of the fact you are dealing with the area of the hole in the jet and not the diameter. It is of little use increasing the capacity of the jet to pass double the amount of fuel unless steps have been taken to establish that the fuel lines, taps, float chambers and so on are also capable of passing double the fuel and the actual flow should be measured.

### *RICH SIDE*

Now unlike petrol you will find alcohol fuel will continue to provide increased power for a mixture well above the ideal mixture strength and you can always tend, therefore, to jet up on the rich side, and so avoid any possible chance of running into troubles through weak mixture causing burnt valves and holed pistons. This larger amount of fuel compared to petrol and especially as it is a fuel with much higher latent heat value tends to do two things. The density of the charge entering the engine is higher than petrol and a greater weight of mixture is therefore being exploded. This is a fuel with a large cooling effect provided by part of it evaporating after it has reached the combustion chamber and so tending to cool the valves, piston and so on. Some may well get into the combustion chamber as liquid, due to the reduction in temperature of the induction system, pipes, carburetor, etc., and so extending the cooling effect, in the process counteracting the effect of the high internal temperature. In view of this amount of fuel entering the chamber, with possibly some of it in liquid form, the ignition system must be beyond reproach since if the spark is weak the mass of fuel will just soak the plug and then at once ignition troubles arise affecting starting in particular. Owing to the use of alcohol a higher compression ratio can be used with this fuel as compared with petrol, another consideration is the type of plug used which will be a hotter type than used before with petrol.

### *NINETEEN TO ONE*

We have just mentioned the higher possible compression ratio used with alcohol and the limit that can be used with any particular fuel depends on the tendency of the fuel to detonate. As a rough guide the ratio for petrol is limited to about ten to one, or with certain additives to as much as 12 to one. With alcohol, however, you can go up to 19 to one or higher in certain cases. (For all practical purposes however, 14 to one should be considered the maximum usable ratio in modern short stroke automotive engines.) The possible use of a much higher ratio, of course, means we get a higher power output from the engine, and this, in fact, is almost the main advantage of alcohol fuel.

### *DETONATION*

Detonation with alcohol fuel is really not a problem, but pre-ignition is, or could be unless the mixture is kept well on the rich side. The reason for this is that if the mixture is on the weak side it burns slowly and can still be so doing when the exhaust valve has opened which then becomes overheated. This in turn ignites the next charge before the correct time, the whole process becoming a chain reaction causing even more rise in temperature and so it goes on until the piston holes and other damage then follows. The first signs of this process taking place are a loss of power, a general rise quite quickly of overall temperature, the head in particular. To avoid this, run on the rich side always and use plugs with a good heat capacity. It might be worth mentioning at this point that an engine set up correctly for running on alcohol, even though on a rich mixture, will be found to be (compared to petrol), a much cleaner running engine inside the cylinder head, and provided the ignition side is up to its job there will be less fouling of plugs than on petrol.

### *IGNITION SETTING*

Due to the different rate of burning of alcohol compared to petrol the ignition setting will have to be changed. It will have to be advanced and the amount necessary will depend on the shape of the cylinder head and general design. For example, on a well designed hemi-head an extra five to six degrees might well be enough, whereas on a poor designed head it might be something like 15 degrees. Optimum ignition setting is tied up with the air-fuel ratio and it will be found that with alcohol it is not so critical as with petrol, that is to say the drop off of power is not so progressive as will be seen later.

### *STARTING*

Provided the engine is set up for running on alcohol correctly there should be little trouble in starting except perhaps on a very cold day and it should be possible to start up on the fuel mix used for the actual racing. The main problem, due to the cooling effect of the fuel, is to get the engine to operating temperature in the short time available from fire-up to staging. For this reason so far as motor cycle type engines are concerned, you will note, in many cases, the finning on the cylinder barrels and heads is almost eliminated. This, by the way, also helps to increase the power to weight ratio, or if you like tends to counteract the weight of the extra amount of fuel carried as compared to petrol.

### *LIMIT*

From reading this far, you should have come to the conclusion that if your engine is now on its limit running on petrol, while large increases of power are obtainable by the use of higher compression ratios it is possible to get a reasonable increase in power output, ten per cent or so, with the existing ratio, provided you make quite certain you get enough fuel through to the engine and, in fact, that you tend to run on the rich side. Once you have gone over to alcohol and obtained satisfactory running, you have commenced an extension of your power output by anything up to 25 per cent as you adapt the engine to run with the new fuel. The rather attractive feature that you tend, even with the increase of power to stand less chance of doing damage to the engine than when on petrol should also be considered.

### *FINAL POINT*

One final point to consider. If you change over to alcohol from petrol where you were using a mineral oil, it is not necessary to change over to a castor based oil. For modern engines, the present type additive mineral oils offer a higher performance level than the additive castor based oils, and under controlled conditions the light viscosity oils have an advantage where the warm up time is limited.

## 3. FUEL FLOW AND CAPACITY

Now that the decision to change to fuel other than petrol has been made, the first thing to look at is the fuel tank. If of fiberglass, bear in mind the new fuels act as solvents and most petrol resisting paints, shellac, varnish, ethyl cellulose, cellulose nitrate and soft Bakelite suffer in contact, not forgetting sealing compounds such as Bostic, Hermatite, Osotite and similar leak stoppers. If the tank resists on test, do bear in mind that if, at a later date, you propose using Nitro Methane you will have to test still further as this acts as a solvent on many resins, polyvinyl acetate, acetylchloride, chlorinated rubber and low boiling hydrocarbons. The obvious way to test is to deposit a little of the fuel on the tank surface and see if it reacts, bearing in mind it may attack the paintwork and not the actual material of the tank itself, so do not get misleading results. If the tank is of metal construction, particularly of aluminum, it should be anodised, thus stopping chemical reaction causing a white deposit to form tending to clog fuel lines and carburetor parts that come in contact. If of steel and tin plated, the fuel will tend to take off the tinplate and form a deposit on other metal parts in the fuel system. Washing out the entire system is sometimes carried out with petrol to stop this deposit building up too much. Bear in mind alcohol will descale material unaffected by petrol and it is advisable to wash out and clean the whole tank first with a small amount of fuel, to make sure you start clean, and to frequently inspect it to keep in such condition. In passing it might also be worth consideration that at least one well known carburetor uses a plastic float that gets more than a little upset with fuel and another uses plastic cut-off valves in the float chamber which also object.

### *FUEL CAPACITY*

At this stage it is necessary to work out how much fuel you need to carry and at what flow rate it will have to leave the tank. There is no point in carrying more fuel than required, since, apart from the weight, you are just increasing the fire risk. The rate of flow will establish the diameter of the outlet pipe or pipes, and a point often missed, the diameter of the breather hole, usually incorporated in the cap. This last point does not apply if the tank is pressurised. Having decided on the amount and the rate of flow, you have to consider the cut-off valve and the fuel lines themselves. in the case of a small engine the minimum bore diameter anywhere in the system should be 6mm., and for the rest 13mm. and the fuel lines should have, at worst, that diameter, preferably up to twice the diameter to reduce friction, and be made of Polythene, Neoprene or other alcohol resisting material. Do not fall into the trap of using fuel lines of these diameters and use, at their termination's, unions which restrict the actual effective diameters to much less. The ideal set-up is where the internal diameter right throughout the whole system to the carburetors is of the same diameter, providing that diameter is large enough to reduce friction to a sensible minimum.

### *FUEL FLOW*

Now check the actual flow right down to the fuel line that supplies the carburetor or fuel block. If gravity feed is used this is simple to do, but remember to check with the tank at the same height as used, and time the flow and quantity. If the tank is pressurized, for your own interest, check with the cap open, then under pressure and the difference will surprise you, also how quickly the air pressure drops, more so if the air space over the fuel be smaller. If the tank supplies some form of fuel pump, remember the pump diaphragm will have to be of Neoprene or it will dissolve. Electrically driven pumps are easy to check, but those driven by the engine itself present a problem. If the makers' figures are available all is well, but if not you will have to establish the actual quantity of fuel pumped per stroke, then from the rate at which the pump is operated, calculate the actual flow rate. In all cases the rate should be at least twice the estimated maximum demand of the engine at peak requirement. The major obstruction will usually be found in the cutoff valve of the carburetor float chamber and although some manufacturers can supply valves modified to increase the flow at this point, they usually do not allow enough and you will have to fabricate your own. Remember here by increasing the diameter of the orifice by 40 per cent you will double the flow of fuel. Do check however the flow rate through the valve and make certain it is enough . . . so many fall into this simple trap. The figure of twice the required maximum demand rate may sound excessive, but bear in mind apart from the sudden demand, you have to force the fuel against the actual acceleration of the car or bike. One final comment before leaving the fuel lines and means of getting the fuel to the engine itself. Do check that the fuel cut-off valve, when in the open position, is in fact fully open, and having done that check, if the tank has a breather, that fuel cannot spill out and possibly be blown back onto or into the engine, or for that matter the driver.

### *TWICE AS MUCH*

The actual amount of fuel required by the engine will be double the amount it consumed when on petrol, but if you are starting from scratch so to speak, the a mount is determined by the amount of air consumed by the engine, which in effect is directly related to its capacity at full throttle. With regard to a supercharged engine the amount required will be dependent on the boost pressure, so that for every 15 lb. approximately of boost, that is the amount over atmospheric pressure, as would be indicated on the gauge, you will have to consider the actual effective capacity increased by the same amount as the basic engine capacity. For example a 1000 cc. engine running at a boost pressure of 15 lb. would be regarded as of 2000 cc. and the same engine running at some 30 lb. pressure would work out at 3000 cc. and proportionally for other boost pressures.

## 4. FUEL-AIR RATIOS

SINCE fuel-air ratios are quoted by weight of both parts it will be necessary to establish the actual weight of each component before we can determine the correct ratio we require. To put this into practice you must take the cubic capacity of one cylinder in inches, since we are considering weight in pounds, multiplied by the number of cylinders that are fired per revolution, times the total revolutions per minute for a normally aspirated engine, but for a supercharged engine this figure will be increased as indicated previously. This total figure will be the volume of air consumed per minute, which must now be converted to weight of air in order to find the amount of fuel necessary to mix with it at the nominated ratio. In order to carry out this calculation it is necessary to know that you convert cubic centimeters to cubic inches by dividing the total figure by 16.4, which must be converted yet again to cubic feet by dividing by 1728. Since one cubic foot of air weighs 0.081 pounds at a temperature of 32 degrees F, or alternatively one pound of air equals 12.4 cu. ft., it is now possible to determine the weight of air in pounds involved per minute. The next step is that of ascertaining, from the previous calculation, the actual amount of fuel involved by considering the fuel-air ratio.

### *SIX PARTS TO ONE*

In the case of pure methanol a ratio of approximately six to one, that is to say six parts of air to one part of fuel by weight. This means a total of seven parts, one will be that of the fuel itself, that is to say a seventh, but since the actual weight of the fuel is eight pounds per gallon of methanol, we will have to divide that figure by eight to convert to gallons. The final figure so obtained is the fuel required at full throttle in gallons per minute. Since this is assuming 100 per cent efficiency it means in effect this will be a mixture on the rich side, but as methanol is insensitive to small ratio changes this is unimportant and in fact a built-in safety factor, avoiding lean mixture troubles such as burnt pistons. From this calculation it will be possible to determine the total amount of fuel required to carry in the tank, plus the rate of flow to the carburetors or injectors, single or multiple as the case might be. Providing the actual fuel flow can be allowed to take place as it would under normal operating conditions, it will be possible to check the jet sizes related to the actual amount of fuel they will pass per minute. If this is not possible, for example in the case of an engine driven pump system, either the maker's figures will have to be used, or the displacement per revolution or stroke established, times the number of these per minute, giving the estimated flow. These figures are empirical but will at least provide a basis on which to start and experiment, and will prove whether the pump has sufficient capacity or not, and for the particular application in mind, this figure should be at least twice the estimated flow rate.

### *READY TO START*

At this stage we are ready to start up and from the actual running of the engine, commence to see if the mixture is about right by the normal methods, but -it must be appreciated our estimated requirements have been taken at full throttle or maximum fuel demand. Tuning, insofar as intermediate settings of the throttle, follows normal practice, but for starting conditions, it may be slightly different, as in most cases of fuel other than petrol, it is unnecessary to provide an excessively rich mixture for starting as this will only cause plug wetting, making it difficult or even impossible to start. As previously stated when the engine is set up, which is often not the case, and in tune, it will be possible to start up and run right away. However for those that may find starting a problem, especially in cold weather conditions, it may be advisable to add some volatile component to the fuel, or even start up by the simple means of introducing another fuel, such as lighter fuel, by the simple means of squirting a small amount into the air intake of the engine.

### *FIRE DANGER*

A warning at this stage would not be out of place in the use of Ether or compounds containing a high proportion of Ether, such as Easistart, . or similar aerosol packs, except those specifically formulated for spark ignited engines, as opposed to diesel, due to the danger of flash fires, and also damage to the engine caused by possible detonation. The preferred method of obtaining easy starting is that of blending certain other fuels with the methanol in controlled proportions, for example the use of Acetone up to a maximum of 5 per cent by volume, petrol also up to the same maximum amount, or Ether, but at a maximum of 3 per cent. With regard to Ether, the blending of this with the fuel should, for reasons of safety, be left to the fuel supplier due to the extremely low flash point of this material, in fact, a figure of minus 40 degreesF. Since as stated before, these fuels, if by any mischance, get into the eyes immediate medical attention is necessary. If this is impossible due to circumstances, to obtain, the following action will do until professional attention ca n be secured. The eyes should be continually washed out with clean water for a period of at least 15 minutes, needless to add, with care. Clothing contaminated with fuel should be removed to stop the fuel penetrating to the skin, and if it has, the area effected washed thoroughly with soap and water. It may seem some stress is made of the dangers of fuel, but it is better to know the dangers and take the necessary precautions, which after all only amount to common sense, rather than go along in total ignorance.

## 5. COMPRESSION RATIOS

WHEN we were first considering changing over to Methanol it was stated a small power gain would be obtained right away with just the change of fuel, but to obtain the full benefit the engine would have to be modified to do so. Going back to our simple heat engine again as a basis, we can say by the use of Methanol we are getting twice the weight of fuel to ignite, at the same time we can increase the compression ratio to a much higher figure thus producing much greater power or force on the piston, and so in fact obtaining a more efficient engine. This extra power will, however, do two things, one being to produce more heat so the engine will run hotter, the other being that it will create much higher mechanical stresses. The extra heat generated we can cope with, for example by using a richer mixture so gaining the cooling action of the Methanol itself, but the mechanical stresses are another matter. When the fuel is ignited the resultant force is applied to the piston top, also to the cylinder head, but since the head is fixed and the piston movable, the latter starts on its downward stroke, the closed valves making sure the whole force is so applied without possible escape elsewhere. Now if the studs or bolts, holding the head down, cannot cope with the now increased power we are going to be in trouble. On the other hand if the head is well and truly held down, the force will be applied to the bolts holding the cylinder barrel to the crankcase. Provided all these hold, the extra force is applied to the little and big ends, plus the crankshaft itself. This is why, as a good example, the dirt track JAP engine has the bolts that hold the head on extended right down past the barrel, or in some cases through the finning, right into the crankcase itself, making a really solid mechanical assembly.

## *HIGHER COMPRESSION*

There comes to mind as another example a well known twin cylinder machine with the engine made as an alternative in light alloy, the barrels and heads being interchangeable, the makers advising the use of the iron barrels for Methanol due to the alloy barrels tending to fracture at the base. We must also, at this point, consider if it is proposed at this stager or at a later point in time, to use Nitro-methane, the question of the actual compression ratio to be used will be determined by the amount of Nitro-methane in the Methanol and as a guide Chart 1 gives approximate values on the conservative side. Methods of obtaining higher compression ratios depend on many factors, which in a simple case, may be had by the fitting of high compression pistons, if available. In some cases a thinner head gasket may be the answer, or total elimination of the gasket and face grinding the mating surfaces. Again it may be possible to have the ratio increased by removal of metal from the head, or the block for that matter, but in such cases you must check that the valves have enough clearance to miss the piston. Another method is that of building up the inside of the cylinder head with new metal and then machining to the required shape. Remember in the case of a V-8 engine if you have the heads skimmed to get higher compression, you will be in trouble with the inlet ports now being out of line with the manifold, due to the heads sinking lower in relation to the manifold itself, so give the matter some careful thought before going ahead.

## *CHART 1*

Approximate compression ratios recommended for use with Nitro-methane / Methanol fuel mixes.

| Compression Ratio | % Nitro in Methanol per volume |
|---|---|
| 16 to 1 | 10% |
| 15 to 1 | 18% |
| 14 to 1 | 28% |
| 13 to 1 | 38% |
| 12 to 1 | 46% |
| 11 to 1 | 56% |
| 10 to 1 | 66% |
| 9 to 1 | 75% |
| 8 to 1 | 85% |
| 7 to 1 | 94% |
| 6.5 to 1 | 100% |

It must be remembered that for all practical purposes 14 to 1 should be considered the maximum usable compression ratio in modern short stroke automotive type engines.

# 6. NITROMETHANE

NOW that we are considering the use of Nitromethane it may be as well to get one well held idea out of the way before we go any further . . . that is that more power and therefore more performance can be obtained by simply adding more Nitromethane to the fuel tank. Nothing could be further from the truth, friends! In actual fact this is perhaps one of the quickest ways of running into serious mechanical trouble. The actual name Nitro in itself to most people sounds explosive and at once the idea of using this fuel leads the imagination to think of it getting into the cylinder head end then being exploded by the spark, thus producing a violent explosion in the engine, the extra power then doing more work and so giving the extra performance. The introduction of more Nitro-methane to the fuel is not just that of the addition until enough power is obtained, but rather that of well controlled amounts used in relation to the other factors.



## *CHART 2*

Recommended jet diameter increases (guide only) for Nitro - methane / Methanol fuel mixes over those used for straight Methanol fuel.

| % Nitro in Methanol per volume | Jet diameter increase over Methanol |
|---|---|
| 0% | 1.0 |
| 10% | 1.12 |
| 20% | 1.22 |
| 30% | 1.32 |
| 40% | 1.41 |
| 50% | 1.5 |
| 60% | 1.58 |
| 70% | 1.66 |
| 80% | 1.73 |
| 90% | 1.8 |
| 100% | 1.87 |

Chart 2 indicates the increase in jet size to allow the increased amount of fuel to flow as the ratio of Nitromethane to fuel is increased. Recommended jet diameter increases (guide only) for Nitro - methane / Methanol fuel mixes over those used for straight Methanol fuel.

These figures in all cases provide a mixture on the rich side since as previously pointed out, these fuels are relatively insensitive to mixture ratio compared to petrol, and the consequences of running weak mixtures with these fuels is likely to be more serious than with petrol since the power level will be so much higher, also the thermal stresses. Note how with 40 per cent nitromethane mixture the jet size has increased by 1.41, or put another way by 40 per cent on the diameter, which as mentioned before means an actual fuel flow of twice the original amount, so by comparison with petrol we now have four times as much fuel required by the engine. At 80 per cent mixture the fuel flow rate has become three times the rate and therefore six times greater than petrol, hence the need to check the fuel pump and fuel lines to make quite certain they can cope with this requirement.



## DANGERS

Now, as before, it is necessary to know the dangers involved with the use of nitromethane mixtures so that the necessary precautions can be taken and understood, reducing them to a degree that makes the use of such fuels acceptable under the circumstances in which we normally operate. Provided you know the dangers you can work with these fuels and come to no harm, but if you do not, then it is possible through lack of simple precautions to suffer, so bear them in mind at all times. After combustion, mixtures containing nitromethane exhaust relatively large amounts of nitric acid in vapor form, making the use of a proper gas mask essential by the driver, and for those close to the car in the start area. The reason for this is that nitric acid, when inhaled, causes a muscular reaction making it impossible to breathe. Little imagination is required to see the dangers involved with this possible event taking place, and in fact there have been cases of drivers becoming almost unconscious due to the bad fitting of face masks.

## FIRESUITS

The mandatory use of fire suits adds to the generally held view that with nitro-methane mixtures the fire risk is increased, but this is not so. If you care to test this you can do so as follows. Take a small amount of petrol, about one teaspoonful say, and place in a small tin lid and then ignite. It will catch fire almost with a bang. Now take the same amount of methanol and after the tin has cooled down, repeat the exercise observing the almost lazy manner in which it ignites, burning with a blue colour, the edges of the flame lined in places in yellow and orange. Now take the same amount of nitro-methane, 98 per cent if you like, and repeat the experiment and see how difficult it is to ignite, burning with a green tinted flame in a reluctant manner. This is due of course to the respective flash points of the three fuels, petrol being the lowest at between zero and 40 degrees F. approximately, methanol at 67 Degrees F., and nitromethane at 110 degrees F. In other words with petrol you have a major fire risk and far less so with nitromethane mixtures. The real problem with nitromethane is its ability to release high power, especially when ignited in a confined space. Associated with this is its liability to be affected by shock. Dropping a can of nitromethane will not cause an explosion, as the can, due to its construction of light weight material, will not have sufficient rigidity, but an amount in a very solid thick-walled container may.

## EXPLOSION

There are three main possible causes of nitromethane becoming shock sensitive and they are as follows: The use of hydrazine as an additive, which, be it noted, is barred by regulations in the USA for that very reason. The use of caustic soda or any other alkaline, used for cleaning out a tank or fuel lines. Alloy tanks, which before anodizing, have been cleaned with such a substance and have retained a small deposit. To avoid any such possible troubles the tank must be filled with water and 10 per cent vinegar, plus a little ordinary household washing-up liquid, and left to soak for several days. One final note of warning concerning burning nitromethane and methanol is that they can burn almost unseen in daylight, and you may well have a carburetor or injector ignited by a backfire without appreciating the danger

# 7. RUN IT RICH!

We are now in a position to consider the use of Nitromethane blends in practice. Like methanol, nitromethane has a strong tendency to pre-ignition, but unlike methanol it has a much lower knock rating, that is to say it will detonate. Both these conditions will be fully explained at a later stage, but in the meantime by making sure the mixture ratios are well on the rich side, these two conditions should be reduced to manageable proportions. In addition to rich mixtures it is highly desirable to have a very clean combustion chamber, giving both freedom from Carbon deposits and a smooth flowing surface with no sharp edges that can get too hot. While polished combustion chambers are the subject of much debate in conventional high performance engines, they have a real use when using nitromethane fuels. Since, as has been stated, the figures quoted tend to provide a rich mixture so as to be on the safe side, it will be as well to know the signs of an over rich mixture. Difficulty in starting coupled with mix-firing during the early part of the run, cleaning out at a later stage, or large quantities of liquid fuel coming out of the exhaust system are the two major signs.

### *PLUG READINGS*

Plug readings are another method and can be taken without the usual method of cutting the engine at full power. An examination when the engine has completed a run will prove quite satisfactory, provided new plugs are used. Signs to look for are as follows whenever the amount of nitromethane is 25 per cent or over, starting with a weak mixture, as this is the most dangerous condition and to be avoided at all cost. WEAK. The center insulator rather white looking in color and may well have the surface rough or blistered, even in some cases with the insulation chipped, a fairly sure sign of pre-ignition. One or both electrodes on careful examination may show very small beads of metal attached to them evident to the naked eye, and almost always considerable blueing of one or both electrodes. CORRECT. The porcelain center electrode insulator light grey brown in color, often with the earthed electrode just showing signs of heat. RICH. Sometimes difficult to distinguish from a weak mixture as in both cases the center insulator will be rather white looking, but in this case the surface will be smooth and both electrodes will be almost as the original metal. Another check as a rough indication is that with the engine being turned over with the ignition off, signs of vapor should be seen at the exhaust, and if not, a weak mixture could well be suspected. Fuel pump pressure is of importance since with Nitromethane (as already mentioned) we are dealing with a fuel that is liable to become unstable when confined and subjected to shock. If you now consider a high pressure pump forcing the fuel under pressure along the line, it is quite possible for an air bubble to form, which can then be regarded as a slug of air, which by the pressure behind it, will be forced along the line in a series of pulses hitting the fuel in front of it, now compressed in a narrow space, thus providing the ideal conditions for an explosion, hence the limit of 100 Ibs. per square inch mentioned. In view of this you must consider placing the fuel cut-off valve after the pressure pump, provided the re-lief valve is set well below the 100 lb. per square inch point, the advantages of so doing being evident on a little thought.

### *PUMP PRESSURE*

While on pump pressures there is also the question to be considered when using carburetors fed from float chambers, of the actual fuel cutoff valve lifting under pressure. In some cases some four pounds pressure will do just that and cause flooding, so a check will have to be made to establish just what line pressure can be utilized without this taking place.

### *OIL CONTAMINATION*

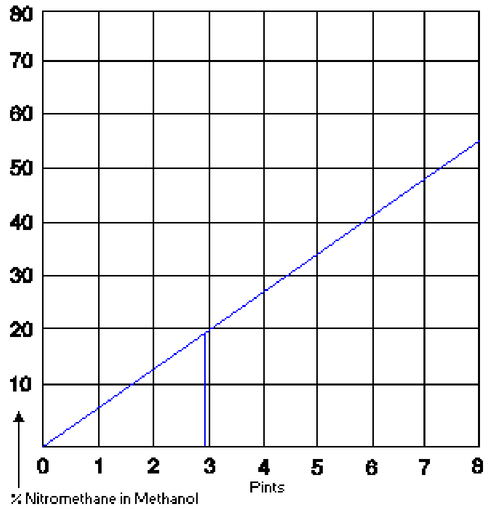
It is most important to check the oil at frequent intervals and if the amount has increased, as a result of the fuel getting down the bores past the rings, essential to change when the increase is 25 per cent or more for two reasons. In the first place such a mixture of fuel and oil is no longer a good lubricant, and in the second place there will now exist a danger of sump fires and even explosions, since the oil mist plus the oxygen-rich atmosphere is very liable to catch fire or explode. The only way to overcome such a fire is by the use of C02 type or «OnBoard» Freon type fire fighting equipment, the nozzles directed into the sump itself. The first signs of such a fire are lazy, yellowish flames, seen possibly at one or more of the sump breathers or rocker cover outlets. It is important when using over 20 per cent nitromethane mixtures to check the engine over after shut off for at least two minutes by visual examination for such possible fires.

# 8. BLENDING NITROMETHANE

BLENDING various proportions of fuels to provide our «experimental» batches of Nitro laced fuels means that at some time or other we will be left with quantities of unused fuel of a known percentage mixture strength. Because of its high cost, leftover fuel is remixed with more fuel to provide a new batch of greater or lesser Nitro strength as required. To accomplish this, a special mixing chart below indicates how this can easily be done. NITRO PERCENTAGE Provided you know the exact mixture you have in use and the amount, it is possible to get your supplier to provide additional fuel to bring the total quantity up to the new required percentage mixture. On the other hand you can do this yourself by using a hydrometer which is available specially calibrated for just this use, indicating by percentage the amount of Nitromethane in the fuel, checked by volume and not weight. For those unfamiliar with the hydrometer, it is a simple device which uses a calibrated weight to float in the fluid to be checked, the level at which the float sits in the fuel indicating the specific gravity of the fuel. As we know water is 1, Methanol coming out at 0.79 and Nitromethane at 1.13, it is easy to establish the fuel mixture. To avoid having to consult tables or graphs the special hydrometer mentioned is directly calibrated, so you just read off the actual content of Nitromethane in percent.

## *FUEL TEMPERATURE*

It must be mentioned here that the average fuel test hydrometer is calibrated to give a completely accurate reading at one specific temperature, usually 68 degrees Fahrenheit. Thus if you check 100 percent Nitromethane solution which is at 68 degrees Fahrenheit, the hydrometer will give you a reading of 100. If you mix one gallon each of 100 percent nitro and methanol and the temperature of this solution remains at 68 degrees your reading will be 50 on the hydrometer scale indicating that you have a 50-50 mix or 50 percent nitro content. Mix any ratio of nitro and methanol with the temperature at 68° F and the hydrometer will accurately indicate the percentage, be it 10 percent, 40 percent, 80 percent or any other ratio.




EXAMPLE: Our tank contains a 55% nitromethane mix and we wish to reduce it to 20% by the addition of straight methanol. On the graph draw a connecting line between the two percentages to be mixed with the lowest percentage (in this case 0%) on the left. Where this line intersects the required percentage line (20%), draw another vertically down to the base line. The number of pints to the left of this line (in this case just under 3) is the amount of the high percentage (55% in our example) required, and the number of pints to the right of the line is the amount of the lowest percentage (0% or straight methanol in our case) required. The two amounts will total one gallon. Changes away from the baseline temperature of the fuel (68° F) will have an effect on the hydrometer reading. Changes in fuel temperature affect the specific gravity of the nitro and therefore give you a false reading. If the temperature drops the reading will be high, giving the impression that the nitro content of the mix is higher than it really is. If the temperature goes up the reading will drop, causing you to assume that there is less nitro in the mixture than there really is. Here lies. the danger - the natural mistake in this instance would be to compensate for the false reading by adding more nitro, with the possibility that your engine may run lean with damaging results. If you run strictly according to volume (for example mix three gallons of nitro to one of methanol for a 75 percent mix) you'll always be on the safe side. However, unless you want to keep running that same mix, you will either have to dump what is left in the tank when you want to change percentage or use a hydrometer. With the hydrometer however, you can run into trouble, as you will NEVER find a location where you can guarantee the ambient temperature will be 68°F, and you will need to measure the temperature of the fuel before attempting to determine the percentage of nitro it contains. Whatever the true percentage of nitro in your tank is, it will always return accurate hydrometer reading when checked at 68° F. Let the temperature drop to 60°F and you'll get a higher reading (82 percent for an actual 80 percent mix; let it climb to 80°F and your reading will drop to 77 percent for the actual 80 percent mix. To combat this problem refer to the accompanying chart which lists actual percentages of nitro at various temperatures and hydrometer readings. As can be seen the variations in the true percentage are quite significant.

## *FUEL TEST CHART*

Test hydrometer reads 100% at 68° in known pure nitro.

**TEMPERATURE OF FUEL- (°F)**

| True % Nitro | 40° | 50° | 60° | **68°** | 70° | 80° | 90° | 100° | 110° | 120 |
|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 106 | 104 | 102 | **100** | 99 | 97 | 94 | 92 | 90 | 87 |
| 98 | 104 | 102 | 100 | **98** | 97 | 95 | 93 | 90 | 88 | 86 |
| 90 | 97 | 94 | 92 | **90** | 89 | 87 | 85 | 83 | 80 | 78 |
| 80 | 86 | 83 | 82 | **80** | 80 | 77 | 75 | 73 | 70 | 68 |
| 70 | 75 | 73 | 71 | **70** | 70 | 68 | 65 | 63 | 61 | 59 |
| 60 | 66 | 63 | 61 | **60** | 60 | 58 | 56 | 54 | 52 | 50 |
| 50 | 55 | 53 | 51 | **50** | 49 | 48 | 46 | 44 | 42 | 40 |
| 40 | 45 | 43 | 41 | **40** | 39 | 37 | 35 | 33 | 31 | 30 |
| 30 | 35 | 33 | 31 | **30** | 29 | 27 | 25 | 23 | 22 | 20 |
| 20 | 27 | 25 | 22 | **20** | 20 | 18 | 17 | 15 | 13 | 11 |
| 10 | 20 | 16 | 13 | **10** | 10 | 9 | 7 | 5 | 3 | 1 |

**ACTUAL PERCENTAGES OF NITRO**

EXTREMES of temperature can play havoc with nitromethane power output and provide for false hydrometer test readings. Graph above shows the effects of temperature changes on nitro-completely accurate readings can only be obtained with fuel at 68 degrees Fahrenheit.

### *KEEP IT RICH*

Once again we stress as you increase the use of Nitromethane you must run well on the rich side, even up to the point of the engine starting to misfire on the run, regarding the cost of the fuel as an insurance against engine failure caused by the increased power developed as the percentage is increased. A constant check should be kept on the valve clearances as this will at once indicate if by any chance a valve is stretching at the neck, both inlet and exhaust being suspect when running at high power levels.

## 9. TIPPING THE CAN

AS with the introduction of Methanol, the introduction of Nitromethane fuel means that ignition settings will have to be adjusted to take full advantage of this volatile fuel. Starting from the position found most satisfactory for Methanol it will be found that as the amount of Nitromethane is increased so will the ignition point have to be advanced, due to the slower burning of the fuel. The actual amount will depend on the engine design and will vary from engine to engine, but as a guide could be as much as 60 degrees, and since in fact the amount is not too critical some 40 degrees would be a good starting point. Insufficient advance is usually made obvious by misfiring under load and at high engine speed, plus a general feeling of lack of power. It is almost impossible to state a limit of advance as it varies so much engine to engine, but here again a falling off in power would indicate the limit point has been passed. With very high Nitromethane content fuel the ignition point may well come back to a lower reading since owing to the large amount of oxygen being released the mixture becomes more sensitive, the flame pattern changing and the lower setting more effective.

### *SAFETY FIRST*

Since we are talking about using Nitromethane in fair quantity, once again a warning to use a face mask for the driver when he is situated behind the exhausts and therefore in the fume area. In certain cases it will be possible to extend the use of Nitromethane until the absolute figure of 98 percent is attained, usually regarded as 100 percent, at which stage you really have to pour it in to keep the mixture rich enough as the fuel itself generates its own supply of oxygen, also at a very high rate. At 80 percent and above, the optimum air fuel ratio no longer exists and the power output becomes well related to the actual amount of fuel fed into the engine by weight. In all the information given the engine has so far been regarded as a normally aspirated engine, that is unsupercharged, but in fact the use of Nitromethane is providing chemically similar results to the mechanically supercharged engine, but of course advantage can be taken of both methods together, provided certain precautions are taken, in particular that of using a suitable compression ratio.

### SUPERCHARGING

If for example the normal compression ratio is 10 to 1, then if we now supercharge at some 15 pounds boost or approximately one atmosphere, the total compression ratio in effect is now doubled, or at 20 to 1 so far as the fuel is concerned, but in practice it would not be quite so high as this due to losses, but could well be some 16 or 17 to 1. We are now at a stage where having started on Methanol and then progressed to the introduction of Nitromethane, we are starting to consider other possible additives to obtain high power at perhaps a lower cost since as yet pure Nitromethane is relatively expensive in this country.

### OTHER ADDITIVES

Tetranitromethane which is very expensive and almost unobtainable can be used, but requires great care in handling as it has an explosive characteristic coupled with instability. Dinitropropane which is solid at room temperature and again normally almost unobtainable, could be however a fairly safe additive and effective. Isopropylnitrate is yet another very reactive substance, inclined to be unstable and unsafe in unskilled hands, and of course one may add, expensive. Propylene Oxide has some handling problems in pure state but is quite safe when blended in other fuels. Used in conjunction with Nitromethane it helps to increase power as it acts as an ignition accelerator, increasing the flame speed and up to 20 percent may be used. When used with other fuels up to 5 percent, better starting and smoother running are the result. In practice the usual amount used is some 10 percent as with more than this level it is necessary to introduce other components, such as for example, water or benzole to reduce detonation possibilities. It is only fair to say that when you get to this stage of mixing up your own blends of fuel you are, to a great extent, more or less on your own and you become part chemist plus mechanical engineer. Due to the high power levels involved great care must be taken and extreme cleanliness is essential. Yet again do check that at all times your fuel lines and pump capacity is more than adequate to cope with the heavy extra demand as you tend to get increased power output from these exciting fuels now available, and once again always tend to run on the rich side, the extra cost of the fuel being cheaper than a wrecked engine due to a weak mixture.

### CHECK YOUR PLUGS

The only sensible way of increasing the amount of Nitromethane is in small progressive steps, and at each step checking the plugs which will indicate when the limit for that particular engine is being reached by the following signs:-
1 Chipping of bode insulator, similar to weak mixture.

2. Overheating of all metal parts of the plug, in extreme cases to the external and exposed body of the plug.
3. The center insulator ashen in color with grey streaks, not to be confused with the white grey color of weak mixture.

being assumed at all times there is no question of the engine being on weak mixture and here again we repeat at all times work on the rich side.

## 10. PRE-IGNITION AND DETONATION

BEFORE we consider the use of other additives to the fuel we must get a clear understanding of the problem introduced by two well known conditions that occur, especially when you are seeking high performance from the engine, and in particular using fuel of the type we have been discussing. We have in mind of course Pre-ignition and Detonation and we did state we would explain these two conditions in detail. Let us therefore look at, perhaps, the easier one of the two to explain and understand, that of Pre-ignition. The name itself is self explanatory. The fuel is being ignited before it should be, causing all sorts of trouble. To understand we must go back to our simple heat engine and once again consider just what takes place, taking the compression stroke as our starting point, assuming that up to that moment of time the engine has been running satisfactorily. That being so, we have the piston commencing to travel up the cylinder bore, starting to compress the fuel ready for ignition by the spark at the plug.

### IGNITION SETTING

Depending on the ignition setting, the spark should occur at just the right time to allow the mixture to ignite, the resultant explosion being so timed that its force is applied to the piston just as it is ready to commence its downward stroke. As we have explained with Methanol for example, as compared to Petrol, the ignition setting point has to be advanced since this fuel is slower in igniting, taking longer to burn, hence the need to commence the operation just that bit sooner so as to get the force of the explosion at the right moment looking at it from the piston point of view. If the explosion takes place too late, then the piston has already started to descend, so the force of the explosion is reduced since there is now so much more room so to speak in the chamber. On the other hand if it occurs too soon, the force of the explosion meets the piston on its way up the bore, trying to force it down, so power is lost and a genera! state of opposing forces exists. It is just this that makes it necessary to time the ignition setting to agree with the type of fuel in use so as to get the maximum effect, also to have an ignition system that will ignite as much of the mixture as possible in the very short time it has to do so.

### DETONATION

Having we hope established a reasonable understanding of Pre-ignition we must now turn to the other troublesome condition known as Detonation, which again as its name implies, is an explosive force and as such destructive. Detonation is caused by the actual compression of the mixture to a level where it reaches the Auto-ignition point, becoming an uncontrollable explosion, the point at which this takes place varying from fuel to fuel, hence the use of additives to vary this point. The explosion takes place without the aid of any local hot spots, including the plug itself, and again is out of time with piston movement. A further cause and a frequent one at that is a small pocket of fuel, after normal ignition has taken place, getting further compressed by the explosion in the cylinder head in addition to that of the mechanical compression, then igniting, after the normal ignition point, so out of time, causing the well known "pinking" effect and in a severe case mechanical destruction of the engine. The amount of destruction is to some extent dependent on the actual shape of the cylinder head and the space available for the pocket of fuel to collect. If the pocket that is formed is relatively large, then the force of this very highly compressed fuel exploding can do mechanical damage, but if on the other hand it is small it may not do so, but it can, and will, form a local heat spot, which in turn will cause pre-ignition.

### SPARK PLUGS

Right away the first item that leaps to mind is the plug itself, which after all has just the essential job to do of igniting the mixture. If this gets overheated and then retaining the heat, becomes hot enough to ignite the fuel itself, without the aid of the spark across the electrodes, then it will do so as soon as the fuel is introduced into the cylinder and is directed by the upward motion of the piston towards the head and the plug, obviously well before the correct moment of time. This means that we must be selective in our choice of plug and use the correct grade, the so-called "hot" type being out, further to that the condition of the plug must be first class. It is quite useless and in the long run expensive, to waste time with poor plugs, so just remove the one you pinched from the lawn mower and treat yourself to the correct grade of "cold" plug right away.

### ENGINE TEMPERATURE

Let us now assume we can forget the plug situation and say all is well. We now have to consider engine temperature as the next possible cause of preignition, or some part of the cylinder head becoming so hot in itself that it acts as the plug, igniting the mixture all out of time with the piston movement. This means at once forces opposing each other in the engine, producing still more heat and so the whole thing getting into a vicious circle. The obvious possible cause would be weak mixture as a start since this can cause an increase in temperature due to the combustion of the fuel being more complete, eliminating the cooling effect of any fuel that may be left over in normal conditions, which in the case of Methanol could well be in liquid form, and sometimes when considerable overlap timing is used, can be seen ejected from the exhaust ports.

### VALVES

Remember we did point out that in the case of Methanol you had the advantage of a lot of fuel being introduced to the cylinder acting as a coolant, to the valves in particular. This being so it follows that if you do have a weak mixture, you are almost certain to have the valves reaching high temperatures, especially the exhaust valves which in fact can reach a high enough temperature to ignite the fuel thus causing pre-ignition. Now let us say we have the right plug, correct ignition setting for the fuel in use and adequate mixture being introduced to the cylinders. We can still suffer pre-ignition, however should there be a rough part of the head, say a small ridge by the plug hole, which, since it is so small in mass, can build up and retain enough heat to become a small red hot mass, again taking over from the plug and doing its work all at the wrong time. Yet again another cause could be faulty valve operation or incorrect tappet settings so that the fuel mixture, although in itself rich enough, is unable to be placed in the cylinder head at the right time, again causing the effort of the eventual explosion, when it does take place, to be out of time with the piston movement.

## 11. AUTO-IGNITION

CERTAIN fuels are more sensitive to pre-ignition than others and this is due to a function known as the Auto-ignition temperature characteristic, which in fact means that once above the flash point of the fuel under consideration, there is a temperature point at which this fuel will ignite, this being the particular temperature known as the Auto-ignition temperature of that fuel. Since this point varies from fuel to fuel, it does mean by the choice of the fuel selected for use, plus if required the use of additives, the optimum fuel mixture can be selected to reduce pre-ignition sensitivity by the act of raising the Auto-ignition temperature point of the total fuel mixture. In order therefore to take advantage of this information it is necessary to establish the actual temperature at which the fuel it is proposed to use suffers from this Auto-ignition characteristic. Once this information is obtained it then becomes necessary to make quite sure that the temperature inside the combustion chamber does not under any circumstances exceed this figure, as otherwise we run straight into trouble. If for example it does, due to the use of a very high compression ratio, we will, to avoid trouble, either have to reduce this ratio, or use another type of fuel, or yet again with the existing fuel, use an additive to increase the temperature point, bearing in mind that the higher the compression ratio used the greater the heat produced in the charge, as previously explained when looking at our simple heat engine. In connection with this statement it must be appreciated that apart from the heat produced by the actual compression of the fuel, there is to this added the residual heat from the engine internals, which in themselves may be below the critical point, but when added to, or combined with the other, exceed the vital figures A further point that should be considered is that the temperature of the fuel under compression is related to the actual time taken to compress it, so that as an example, a high revving engine may well pre-ignite at a certain point and not do so at lower revolutions. This explains why in the Start area, or on the line, all may seem well, but once the power is turned on and the engine speed increased troubles commence.

### *OCTANE RATINGS*

The Octane rating of the fuel in use indicates the detonation sensitivity of the fuel and relates directly to the maximum possible compression ratio that may be used with that particular fuel. Again the use of additives will allow that ratio to be a altered. Naturally every effort must be made to eliminate detonation and on the smallest indication of it taking place, prompt action taken at once to correct the existing conditions. With street vehicles it is possible to get the well known audible indications of “pinking”, but with the competition engine, due to the high noise level this may not be so. Also on multi-cylinder engines you may well have trouble in one or more cylinders, the rest of the engine then masking the trouble, and in fact running the faulty cylinders into destruction, the overall noise quite dominating the “pinking” to the point of it being inaudible. The only real way to check on detonation taking place is by examination of the cylinder head and piston, or what remains of the latter if the trouble has been severe, which is often the case. Yet once again you will appreciate how vital it is to make sure you are getting enough mixture to the engine, the cost of the fuel, even if most of it is blown out of the exhaust system being just so much less than that of mechanical failure and the resultant expense putting it right. While on the matter of getting fuel to the engine we would say without hesitation that on competitive engines over three litres in capacity, the use of normal carburetors fed by means of float chambers is suspect when using fuel other than petrol, and if supercharged, the capacity figure will be even lower.

### *FUEL INJECTION*

It is for this reason that fuel injection is so popular on large engines used on special fuels to produce high power outputs, and in the case of the very large engines it becomes the only practical way, the use of carburetors being abortive. Since in general for competition work you are not too concerned with fuel economy, the simpler forms of fuel injection are quite satisfactory, eliminating the expensive and elaborate but effective systems of holding the optimum fuel to air ratio over the operating range of the engine, and in general we see used continuous feed types, such as for example the Hilborn, Enderle, etc. Power is always difficult to obtain and you cannot take out more than put in, as many have found out, and in fact you cannot get as much in practice, so if you propose the use of certain horsepower, you must provide fuel in quantity enough to release the necessary energy to provide that amount of power, after taking into consideration the losses in the system of actually converting the energy from the input form to the output form. We are now almost at the end of the road. With the information we now have, it only remains for us to use certain additives to mix with the fuel in order to obtain a mixture that will enable us to extract more power out of existing engines, without stressing them mechanically to destruction.

## 12. POWER FUEL ADDITIVES

WE are now at the stage where you have come to the end of what one might term the usual fuels and enter the area of the additives, that is to say where you be come part chemist, part engineer, and full-time optimist. The main object in the use of an additive is to obtain out of the existing fuel a further increase in power output at the engine shaft. Other uses are to alter the tendency of the fuel to pre-ignite and/or detonate, to obtain easier starting, particularly under cold climatic conditions, to reduce running temperature, or as a means of obtaining better mixing of the fuels, that is to say to act as blending agents, not of course all of these attributes at the same time. Before we go any further let it be made quite clear that when you commence handling chemicals, liquids or fuels, call them what you will, it is essential to maintain a very high standard of cleanliness personally and with regard to containers used in the operation, also to mark the contents of each container with its known contents since you are now in the realm of chemical mixing, which under certain conditions could become dangerous.

## ACCURACY PARAMOUNT

Accuracy of measurement is paramount and attention to detail essential, and if you are not sure of what you are doing then leave it alone, and in no circumstances experiment with mixtures of fuels unless you really know what you are doing as the result could be poisonous or explosive, and the explosion could well occur long before the mixture gets placed in the tank. Any containers used must be clean internally, and made of a suitable material to resist the fuel chemically (see the Basic Fuel Characteristics <http://www.turbofast.com.au/racefuel15.html> page). They should be marked clearly with the nature of the contents, and re-marked when any changes are made. Many engines have been wrecked due to not marking containers correctly so make this one of the essential items to be done without fail.

## MARK CLEARLY

In general it is safer to obtain fuel, plus any required additives, already pre-mixed by the supplier who will do this and mark the container in such a manner there is no doubt at all of the contents, the proportions of the mixture being clearly marked. It also pays to keep a complete and very accurate record of all fuels and mixtures used, together with carburetor or injector system settings, and the results obtained for future reference, plus, of course, ignition data and type of plugs and so on. Having, we hope, given due warning, let us now consider which additives we can use, taking in turn the basic fuels we have so far discussed and the use of additives with them, with the objective use of the additive stated. In connection with this we have regarded the use of up to 10 percent as an additive, and over that amount we consider to be a major component of the fuel.

## PETROL ADDITIVES

Since almost our major requirement is that of getting more power out of the engine let us see what can be done taking our basic fuels in turn, starting with Petrol. Additives are:-

***Nitromethane.*** This increases power, measured at the engine shaft, in proportion to the percentage used, limited by mechanical considerations such as compression ratio, rate of fuel flow possible in existing system.

If the engine is on the maximum compression ratio usable with petrol, this ratio will have to be dropped by a figure of one ratio if 10 percent additive used, and by half a ratio if 5 percent additive is decided upon.

With regard to the fuel flow the jet diameter will have to be increased by a figure of 1.125 for use with 10 percent, and in proportion less for the 5 percent.

***Methanol.*** The use of Methanol enables a power increase to be obtained by the simple act of using a higher compression ratio and in fact with 10 percent the ratio can be increased by 1.5. That is to say an engine running on 10 to 1 on petrol can now, by the use of 10 percent Methanol, run on a ratio of 11.5 to 1 provided, and we stress this point, steps are taken to enable the fuel rate of flow to be increased by a figure of 1.125 minimum, or put another way, the jet diameter increased by that amount on the diameter. In each case, that is either Nitromethane or Methanol used as an additive, the mixture should be premixed and not just supplied to the tank relying on mixing taking place by accident as it were.

Before we leave petrol it might be pointed out while other additives are sometimes used, they do not as a result of being mixed increase the power output potential of the total fuel.

## METHANOL ADDITIVES

We must now consider Methanol as the basic fuel.

To obtain power increase additives are:-

*Nitromethane.* Bearing in mind we are, as an additive only considering a maximum amount of 10 percent, although we know in fact up to 100 percent can be used as has already been explained, the power increase at the engine shaft will be in proportion to the amount of additive used, provide' and once again we stress this, the fuel flow and jet diameter is increased by 1.125. The compression ratio will have to be modified, on the maximum for Methanol before the additive was introduced and for 10 percent will have to be lowered by a ratio of 1.

*Propylene Oxide.* This fuel additive in general is safe to handle except for two possible conditions, which under certain circumstances could well be dangerous these are the effects cause by the fuel coming in contact with copper/alloy containers, fuel tanks, etc., or by rust particles getting in the fuel by accident, for example from a rusty container, or from rust from damaged can top cap. To avoid this possibility this fuel is better kept in, and used from, a plastic container of the pure polythene type. If rust particles are introduced they can do two things. One is to Polymerize slowly, or put another way, change its chemical state, in this particular case to form slowly a nasty waxy solid akin to polythene. The second condition is where the polymerization process takes place quickly due to external heat on the container, say for example from strong sunlight, which causes the speed up, resulting in a possible explosion. The remedy is of course obvious so take steps to keep it cool, bearing in mind the boiling point of this fuel is 93 degrees F. Or as we now tend to regard temperature, 34 degrees C. The best increase in power is obtained by some 5 percent as additive, as above this figure the gain does not increase in proportion, like the other additives, but in fact tends to decline, so stay at the 5 percent mark. This fact is known and although reasons can be given for this behavior, at this moment of time there is a lot of experimental work to be done with this additive when used with pure methanol, but anyone carrying out such work must be very much out on their own.

### *NITROMETHANE ADDITIVE*

We now come to our last basic fuel, that being Nitromethane, assumed pure, and undiluted, and again our object in using the additive is to obtain a power gain at the engine shaft. The additive is:-

*Propylene Oxide*. We have a slight change here in that this can be used up to a figure of 30 percent rather than our previous 10 percent. Increase in power output will not be proportional to the amount used, but varies from engine to engine, and also with the use of other additives with the total fuel, water being a good example. In general terms one may well expect an increase of some 10 percent at the shaft for the addition of 10 percent additive, but over this figure it is almost impossible to give an estimate as so many factors will influence the result. Due to the oxygen provided by the Nitromethane, the usual air-fuel ratios no longer hold good and from that fact alone, it is very difficult to state what the actual power increase will be. It has been very clearly stated before that care should be taken when using Nitromethane, but this be-comes even more necessary when dealing with this fuel plus propylene oxide additive.

## 13. ANTI PRE-IGNITION ADDITIVES

WE now come to the use of additives for reasons other than power increase. In this chapter we will deal only with additives that can be of assistance to us in connection with Pre-ignition and the other problem of Detonation.

We again go through our three basic fuels in the same order.

### *WHEN USING PETROL . . .*

We have three additives in *Methanol, Acetone and Benzole* (Benzene) and all of them are introduced with the main object of reducing Detonation by increasing in effect the Octane rating of the total fuel. Pre-ignition in general should not present a problem when using as basic fuel petrol.

**Methanol in Petrol**. This is the **best from the point** of view of reducing Detonation, followed by Acetone and then Benzole in that order.

Methanol can be added in all proportions up to 100 percent, but as an additive limited to **10 percent will give an Octane increase of about 5 points**. For example 98 Octane can be increased to 103, or looking at it another way, cheap fuel of say 91 Octane can, by the use of 10 percent Methanol, or approximately three quarters of a pint per gallon, will produce fuel of 96 Octane.

**Acetone in Petrol**. Can be used up to 100 percent but with the nominal **10 percent will give an increase of 3 points** rather than 5.

The major difference from Methanol being that due to **the higher calorific value of Acetone, the consumption does not increase so much**, but still provides a higher octane rating.

Benzole (Benzene) in Petrol. Again can be used up to 100 percent but with the 10 percent amount will provide in points a rise of 2.

In many cases this additive is used to counteract detonation since some 10 percent will, in certain cases, provide enough rise in octane rating to do just that.

### *WHEN USING METHANOL .*

Now we come to Methanol as the main fuel, and as additives to reduce Preignition and/or Detonation we have two. Acetone in Methanol. Here we are concerned only with Pre-ignition since Methanol has itself a very high octane rating, and is therefore to be regarded as almost free from detonation problems. Once again our figure of 10 percent is the most advantageous use of the additive, as over that figure has a declining effect in proportion to the amount used. The effect of using this additive is to move the auto-ignition point upwards, and this was fully explained as will be remembered. Water in Methanol. Up to 5 percent or a maximum of 10 percent with the object of increasing the octane rating even higher, to reduce detonation under very high supercharge conditions.

### *WHEN USING NITROMETHANE*

Last of all now we have Nitromethane as our main fuel. Here we have three additives to help with preignition and or detonation.

Methanol in Nitromethane. Since Nitromethane has itself a tendency to pre-ignite and detonate, the sole object of up to 10 percent Methanol as an additive is to reduce this tendency to detonate while having only a minor effect on pre-ignition.

Water in Nitromethane. Up to a maximum of 2.5 percent as this is the maximum amount that will mix without separation taking place. It reduces both preignition and detonation due to the internal cooling effect alone.

In practice a combination of Methanol and Water is the better use of the two additives, the proportions being 2.5 percent water and 7.5 percent Methanol giving a good safe usable blend of Nitromethane, with almost the full power capability of undiluted Nitromethane.

Acetone in Nitromethane. Up to a maximum of 5 percent. This reduces preignition by raising the auto-ignition point and any small decrease in detonation is incidental.

## 14. EASIER STARTING ADDITIVES

WE now come to the last use of additives and that is to assist with starting, which should not be a problem but nevertheless sometimes is. Again we deal with our three basic fuels as before.

### *WHEN USING PETROL . . .*

***Acetone*** is the only safe additive to use, its function being that it increases the volatility of the mixture, without reducing the basic fuel properties too much. Up to 5 percent being quite enough to use. Ether is the only other additive to use with Petrol and may be used in the same manner as Acetone and for the same reason, but is in fact not recommended for use with spark ignition systems, and has obvious handling problems. It can also quite easily produce a wrecked engine, so use it if you must, but you have been warned

### *WHEN USING METHANOL .*

Acetone is the only additive and up to 10 percent maximum. The action of this is to increase the volatility of the total fuel or put another way it reduces the flash point temperature. Main use is on very cold days, but in fact it even then should not be really necessary, however let us say it is convenient.

### *WHEN USING NITROMETHANE*

When our main fuel is Nitromethane, the only additive is again Acetone for the same reasons as when used with Methanol. All fuels have one common blending agent, this being Acetone, but in most cases will mix satisfactorily without, but where found necessary, the amount used should be the minimum required to obtain complete mixing without trace of separation, visually checked. In some cases it may be necessary to use quite high percentages, for example some 30 percent when blending Benzole and Methanol. Over recent years the methods used in producing petrol have changed and with the modern petrol's better blending is obtained with Methanol due to the refining techniques now used without a blending agent being used.

### *STALE FUELS*

Many think that fuels when stored become less effective with age, but in fact this is not so provided the cans or containers are fitted with caps or snap on lids that fit correctly. Two fuels that are difficult to keep unless great care is taken in sealing the containers are Ether and Propylene Oxide, the high rate of evaporation being the problem. In conclusion, may we just repeat three major things to keep in mind. First of all apart from Petrol, always tend to keep the mixture on the rich side and never on the weak. In all cases never rush, take your time and be quite accurate in your measurements. Last of all do not experiment unless you know what you are doing as it could be both expensive and dangerous.

### *GOOD RACING!*

# BASIC FUEL CHARACTERISTICS

| GENERAL DESCRIPTION | BASIC CHARACTERISTICS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Flash Point* | | *Boiling Point* | | *Freezing Point* | | ***Specific Gravity*** | Lbs/Gall approx |
| | F | C | F | C | F | C | | |
| **METHANOL** (Methyl Alcohol) CH30H is a volatile, highly inflammable, water-clear liquid with a mildly spirituous odour. Miscible with water or nitromethane in all proportions and almost all with petrol. | 61 | 16 | 148 | 64 | -144 | -97 | **0.796** | 8 |
| **NITROMETHANE** CH3NO2<br>is an inflammable water-clear liquid with a mild odour, containing approximately 53% by weight of oxygen. Water will mix with nitromethane to the extent of 2.5% only, by volume. | 110 | 43 | 214 | 101 | -20 | -29 | **1.130** | 11.25 |
| **ACETONE** (Dimethyl Ketone) CH3COCH3<br>is a highly volatile, highly inflammable, water-clear liquid with a strong, sharp, characteristic odour. Miscible with all the chemicals listed here, and water. | 0 | -18 | 133 | 56 | -138 | -94 | **0.791** | 8 |
| **ETHER** (Diethyl Ether) C2H5OC2H5<br>is an extremely volatile, highly inflammable, water clear liquid with a strong, lingering, characteristic odour. Miscible with all the chemicals listed here but not with water. | -40 | -40 | 95 | 35 | -183 | -116 | **0.714** | 7 |
| **BENZOLE**, (Benzene) C6H6<br>is an inflammable water-clear liquid with a dull sweet odour Miscible in most proportions with all the chemicals listed here but not with water. | 12 | -11 | 176 | 80 | 41 | 5 | **0.879** | 8.75 |
| **NITROBENZENE** C6H5NO2<br>is an inflammable, yellow, oily liquid with a strong odour of almonds. Miscible in most proportions with all the chemicals listed here but nrot with water. | 190 | 88 | 412 | 211 | 41 | 5 | **1.200** | 12 |
| **PROPYLENE OXIDE** (1 :2. Epoxypropane) CH3-CH-CH2<br>is an extremely volatile, very reactive, highly inflammable, water-clear liquid with a light gaseous odour. Miscible with all the chemicals listed here but only partially with water. | 32 | 0 | 93 | 34 | -155 | -104 | **0.83** | 8.25 |
| **UCON** LB625 (Polyalkalene glycol)<br>A water-clear synthetic lubricating oil with exceptionally high film strength properties. Miscible with all the chemicals listed here but not with water. | 430 | 221 | - | - | -25 | -32 | **1.0** | 10 |

| | *Conservative Maxium Compression Ratio* | *Air/Fuel Ratio for Max Power lbs/lbs* | *Energy from Combustion B.T.U/lb* | *Coolling Effect (Latent heat of Vaporisation) B.T.U./lb* | Use in Internal Combustion Engines |
|---|---|---|---|---|---|
| **Methanol** | 17/1 | 4.5/1 | 9770 | 472 | Methanol permits the use of very high compression ratios when unsupercharged or high boost pressures when supercharged. The large cooling effect increases volumetric efficiency and is of particular use in the supercharged engine reducing charge temperature after compression. A tendency to pre-ignition is most noticeable at weak mixture levels. |
| **Nitromethane** | 6.5/1 (10/1 with rich mixtures) | 2.5/1 to 0.5/1 at least | 5000 | 258 | Nitromethane enables considerable power increases to be obtained (70 percent minimum with proper use). Most often used blended with methanol, in various propor ,tions to provide power increases consistent with engine strength, etc. A tendency to detonation is reduced by an increase in mixture strength, reduction in engine temperature, reduction in compression ratio or the addition of methanol. |
| **Acetone** | 17/1 approx | 9.4/1 | 12,500 | 225 | As a basic fuel acetone appears to have all the required characteristics, these in general Iying midway between methanol and petroleum. An exception is its very high anti-knock rating which approaches that of methanol. Other uses are as an additive to other fuels, notably to methanol to reduce pre-ignition sensitivity and promote easier starting under low temperature conditions, up to 10 percent for this purpose. |
| **Ether** | 4/1 | 9.8/1 | 15,000 | 153 | Not used as a basic fuel in spark ignition engines due to its very low knock-rating, but this characteristic is desirable in the small high-speed diesel engine where it is used in relatively large percentages (approx. 15 percent to 35 percent by volume) as an additive. Its volatile nature and low flash point make it useful as an additive tuP to 5 percent) to improve starting and give a rapid throttle response. |
| **Benzole** | 15/1 | 10.8/1 | 17,300 | 153 | Most often used blended with methanol to give a greater energy per unit volume with reduction in the latent heat vapourisation, this being a compromise often used for long distance racing where fuels other than petrol are allowed. |
| **Nitrobenzene** | not known | 8/1 | 10,800 | 143 | Blended in very small proportions with other fuels it is thought to act as an ignition accelerator. As this material has a strong odour even after combustion it is sometimes used as an additive in other fuels (approx. 0.5 percent) to mask the normal exhaust odour making it difficult to detect the base fuel type. |
| **Propylene Oxide** | not known | 9.6/1 | 14,000 | 220 | Used as an ignition accelerator additive particularly with nitromethane (up to 20 percent by volume with pure nitromethane) where noticeable increases in power are possible. Easier starting and smoother running are other benefits when blended with most other fuels (up to 5 percent) |

| | | |
|---|---|---|
| **Ucon** | At 0 F this oil compares to SAE 20 at the same temperature, and at 210 F it compares to SAE 50 at the same temperature | Used to advantage in all two stroke engines operating on fuel/oil mixtures. The unusually high him strength properties allowing a reduction in the amount of oil in the fuel by as much as 55 percent. Of particular use in very small high speed two stroke engines where the normal oil content can be up to 30 percent of the total volume, with the attendant restriction on the amount oF fuel that can be burnt. |



## NOTES

| | Corrosion | Handling |
|---|---|---|
| **Methanol** | • **Magnesium:** Attacked.<br>• **Tin:** White deposit (long term).<br>• **Polythene:** Cracks (long term).<br>• **Paints:** Most attacked severely.<br>• **Perspex:** Attacked. | Poisonous; do not allow to come into contact with skin as repeated absorption may have long term effects on health. |
| **Nitromethane** | • **Copper/Alloys:** May be attacked.<br>• **Polythene:** Generally resistant.<br>• **Paints:** Most attacked severely.<br>• **Perspex:** Attacked. | Do not allow to come into contact with caustic soda, amines or hydrazine. Pipeline pressures must be kept below 100-lb/sqlin. |
| **Acetone** | • **Metals:** Resistant.<br>• **Polythene:** Cracks (long term).<br>• **Paints:** Most attacked severely.<br>• **Perspex:** Attacked.<br>• **Neoprene:** Some attack. | Low flash point presents considerable fire risk. Extinguish with dry powder or CO2. |
| **Ether** | • **Metals:** Resistant.<br>• **Polythene:** Cracks (long term).<br>• **Paints:** Most attacked severely.<br>• **Perspex:** Attacked.<br>• **Neoprene:** Some attack. | Very low flash point presents serious fire and explosion risks. Vapour is heavier. than air and anaesthetic. |
| **Benzole** | • **Metals:** Resistant.<br>• **Polythene:** Generally resistant.<br>• **Paints:** Some attacked.<br>• **Perspex:** Some attack. | Poisonous; strong vapours must not be inhaled, may affect blood tissues permanently. |
| **Nitrobenzene** | As for benzole | Very poisonous; do not allow to come into contact with skin or inhale vapour. |
| **Propylene Oxide** | • **Metals:** Most resistant.<br>• **Polythene:** Cracks (long term).<br>• **Paints:** Most attacked severely.<br>• **Perspex:** Attacked.<br>• **Neoprene:** Some attack. | A very reactive chemical, must not be allowed to come into contact with copper/alloys or rust, reaction may be violent. |
| **Ucon** | No problems | No problems |