TRIUMPH TR'S AND UNLEADED PETROL

An essay by Neil Revington of Revington TR, based on a handout produced for the TR Register international show, Shepton Mallet 1998.

Firstly it is important to realize that all TR's from TR2-8 can and will run correctly on unleaded fuel, so there is no need to panic. With the exception of TR5-6 with Lucas fuel injection, the only modification required, if at all, is the introduction of suitably hard seats into the exhaust valve seat area of the combustion chamber of the engines cylinder head, and suitably hard exhaust valves.

BACKGROUND

Since their discovery in the late 1920's fuel additives containing lead in the form of lead alkyls, have been used in petrol to improve octane quality. In the early 1970's environmental and health pressures resulted in a progressive reduction in the lead content of generally available pump fuel. The advent of the exhaust catalyst resulting ultimately in the introduction of unleaded fuel.

Valve seat recession (VSR) is the main problem aggravated by unleaded fuel. Without protection the soft valve seats of an engine will rapidly wear. In engines with hydraulic valve lifters which automatically compensate for valve wear, many thousands of miles may be covered before a problem is detected.

VSR starts with localized welding of the valve to the seat, followed by separation of small particles of metal from the seat area. These metal particles may become oxidized under the extreme heat found in the exhaust seat area, and become embedded in the valve, eventually building up to form 'warts' of hard iron oxides. Repeated impact of these 'warts' on the seat causes further cracking, flaking and abrasive wear of the seat.

Lead alkyls prevent VSR by forming thin layers of lead oxides and sulphates on the valve and seat faces. These layers prevent metal to metal contact and hence localized welding.

Referring to the figure, it is clear to see that only lead contents above 0.05 gPb/l (grams per litre of fuel) give full protection against valve seat recession. However it is also clear that there is good reason for the two levels of lead content that we are familiar with. 0.04 gPb/l is the figure found in leaded fuel of the late sixties, the graph shows that there is little difference in VSR when using either 0.04 gPb/l and 0.05 gPb/l, and therefore 0.04 gPb/l was used. Current leaded fuel has 0.015 gPb/l and again, you can see from the graph that this is the lower end of the knee of the curve, thus affording maximum protection for the minimum lead content.

In an engine running with leaded fuel, lead deposits on valves and seats are simultaneously worn away and replenished from the fuel. When an engine which has run on leaded fuel is switched to unleaded there is a 'lead memory' during which the valves and seats are protected by existing lead deposits, until they are finally worn away. This memory can be as much as 20,000 km for some engines under moderate driving conditions. This can reduce to 8,000 km when an engine is worked hard.

This lead memory can be used to advantage whilst leaded fuel is still available. Tests have shown that running three tanks of unleaded fuel to one tank of leaded can produce as little as 0.1mm VSR per 16,000km of mixed driving, compared with 0.08mm on leaded 0.015gPb/l fuel

When driven hard though, the story is different. An engine run for 4000km on leaded fuel, (fast motorway driving) then a further 3500 km fast motorway driving on unleaded only, resulted in no valve seat recession for the first 4,000 km (not surprisingly) but, 1.1mm of VSR in the remaining 3500km.

This would obviously improve if the 3:1 tank mix had been used, but by how much?

So, it is clear that materials used in valves and seats, type of fuel used, and style of driving, all combine to determine how much VSR is experienced.

There are general solutions, relevant to all cars and solutions car specific. I shall deal with the general solutions first.

GENERAL SOLUTIONS

Solution 1. Do nothing at all!

As discussed previously, VSR is a function of many factors, and indeed over the years we have seen cases of significant VSR where only leaded petrol would have been used (before unleaded petrol became available). As a case in point, Don Elliott in Canada has owned his TR3A since new. After 36000 miles on leaded petrol he needed to replace two burnt out valves. After a further 80000 miles on leaded fuel two more valves were replaced during a rebuild. 37000 miles later to date, Don has used only unleaded fuel. During that time and with eight years elapsed, Don has had to open out the rocker clearances three times by 0.002" - 0.003" each time. All valves are standard TR3 and there are no valve seats.

As any valve seat recession will be eliminated by the inclusion of seats, you could argue that you should run unleaded until you experience valve seat recession, then take off the head to deal with the problem.

Solution 2. Chemicals

There are many 'jollops' on the market which purport to retard the onset of valve seat recession. These can include amongst others, phosphorous and zinc compounds which, at suitable levels protect the valve seats as well as lead, others such as sodium naphthanate do not protect so well. There is little independent evidence to establish their usefulness or not in our cars. There are however possible side effects when using alkali metals for VSR protection. The most significant being inlet valve sticking.

As we cannot expect to be experts on each manufacturer's product, I have confined my solutions here to mechanical ones.

Solution 3. Hard Valves and Seats

Valve seat recession will depend on how the car is used. For instance, a car driven at 40mph and not worked hard, could last for thirteen years at 2500 km per year, if you assume that after swapping from leaded to unleaded, you rely on the lead memory to start with, and accept the need to alter the rocker clearances from time to time, as VSR occurs, up to say a maximum total of 1mm.

With spirited sports car use however, the story may be different.

Although the words 'soft' and 'hard' are used to describe valve seats, these are made from a broad spectrum of metals that possess varying degrees of hardness, ranging from the parent material of the cylinder head as in TR2 - 6 to the very hardest specialist valve seat insert material.

The operating characteristics of a specific engine also have an important influence on VSR. In tests, a wide variation in VSR was observed on 22 European vehicles (all 1960's models) that had different valve seat metallurgy's. In general though, VSR decreases as seat hardness increases.

As a guide 'soft' valve seats use a form of grey or nodular cast iron with brinnell hardness values in the range of 180 - 220 (HB)

Typical 'hard' seats comprise induction hardened iron with hardness values greater than 400 HB.

If in doubt fit harder valves and valve seat inserts, only exhaust valves and seats are required. Most competent engine machine shops should have done enough of this type of conversion by now to be able to take on the job with confidence. Once fitted, VSR should be a thing of the past.

There are various grades of materials which can be used for valve seats.

A high chrome (13%) molybdenum steel should be used as a minimum. These are now freely available to engine machine shops. Valves should be stainless steel with a flash chrome stem.

Valve guides can be standard, although phosphor bronze (PB) can also be used, although these usually need larger clearances. In addition we usually internally knurl PB guides for better lubrication.

Do not fall into the trap of imagining valve seat inserts will fall out. ALL TR7 and Rover V8 engines have valve seats as standard. More of this later.

CAR SPECIFIC SOLUTIONS

TR2-4A

You can adopt solution 1, but as VSR will eventually be experienced with unleaded fuel, inserts and stainless steel valves are a good bet if you are inside the engine for other reasons.

TR250-TR6 Carb Comments as TR2-4A.

TR5-6PI Lucas PI

Here there are greater problems.

1. In addition to the cylinder head modifications commented on for TR2-4A, the metering unit will require attention. Not all seals used in the metering units over the years are lead free compatible. A properly rebuilt unit with appropriate seals will run unleaded. My own TR5 has now covered 20,000 miles unleaded with a standard lucas metering unit, with only the seals changed. Alternatively you can use a rebuilt unit incorporating a new rotor set. This solution will become more relevant when old units with 'in tolerance' rotor sets become scarce.
2. In principle this is all that needs doing. The Lucas pump will run unleaded, however the pump is fundamentally unreliable and to ensure that you are able to drive your TR without continually breaking down you should fit a Bosch conversion. Be careful here as there are conversions around that simply do not work well.

   A correctly designed and maintained Bosch fuel pump conversion should give trouble free motoring in even the hottest weather.
3. The other components, injectors and pressure relief valve are unaffected by unleaded fuel.

Electronic Fuel Injection (EFI)

By fitting EFI you ensure that your car will not only run unleaded but will run cleaner, smoother and use less petrol.

EFI components can be taken from other more modern cars and encouraged to fit onto a TR5-6.

There are however two manufacturers who provide basic kits of throttle bodies, injectors, pumps, computers, amps and sensors, designed as an aftermarket fit. These are Lumenition and Webcon Alpha

There are three grades of installation.

1. EFI distributor triggered

Here the fuel and ignition are mapped, with engine position taken from a distributor sensor. The normal distributor cap is used to distribute the sparks.

2. EFI Crank Triggered with Distributor

Here the fuel and ignition are mapped, but engine position is more accurately taken from the crank. The distributor is retained just to distribute the sparks.

3. EFI No Distributor

Here the fuel and ignition are mapped, but the whole of the distributor is dispensed with, a 6-way coil being employed to provide the sparks.

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TR7, 8 Valve and 16 Valve

All TR7's have aluminium cylinder heads with valve seat inserts. These inserts are quite hard, and will probably suffice as will the valves. The cars were aimed at the American market where unleaded fuel has been common place for years.

Solution 1 will probably work for you, but once again, if in doubt, change the exhaust valves and seats.

TR8

As with the TR7, Rover V8's have aluminum heads with inserts as standard. BL announced in 1986 (bulletin 23/10/86 item 763) that only Rover 213 (Honda), 820 (new 4 cylinder) and Triumph Acclaim would run unleaded. This was probably a 'back watching' exercise, as in 1989 Land Rover announced (bulletin 04*89 item 27) that all Range Rover V8's would run unleaded. It is interesting to note that from the Mid Eighties, just before Rover went EFI, Rover and Range Rover used exactly the same engine (as far as the heads were concerned)!

It would therefore be fairly safe to assume that post 1976 SDI type engine (identified by larger valves), are OK to run unleaded.

SUMMARY

In conclusion, the problems which have been discussed over the past few years have mostly been a lot of hot air. For instance, my own TR4 works rally car, 6VC, did 22,000 miles in 1997 on unleaded fuel, almost all of which was in competition, a busy year!

So don't panic remember that valve seat recession, if and when it occurs will be machined away when inserts are fitted, and that should you choose to 'try it and see' with your Lucas metering unit, you will only break down once, should it fail, you will then have the metering unit rebuilt, unleaded of course, after which the unit should run fine.

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