Courtesy of: **Lloyd Specialist Developments Ltd**

WISDOM & WOE FROM THE WORKSHOP

This month we will be looking at one of the key components within your fuel injection system, the fuel injectors...

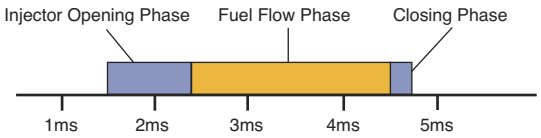
Fuel injectors are electrically controlled solenoids that are opened for the required amount of time to deliver a specific quantity of fuel within a certain time frame. These solenoids have two electrical connections - a constant 12V+ when the engine is running or cranking and a switched earth. The switched earth is controlled via the engine control unit *(ECU)* and this dictates how long the injector is open for, which in turn dictates how much fuel is delivered for a given fuel pressure. The length of time that the injector is open for is called pulse-width, measured in milliseconds, and the percentage of time that the injector is open for within a complete engine cycle *(2 crankshaft revolutions and 1 camshaft revolution)* is called the duty cycle.

So how is this relevant to a TVR owner looking to improve their engine in terms of performance, driveability or even economy?

Any engine modifications will require at least the fuelling to be adjusted to keep the engine running optimally. Any improvements in performance will require an increase in fuel and, assuming that you are able to adjust the ECU calibration, you will need to increase the amount of time that the injector is open for. As an example - a Griffith 500 might originally require the injectors to be open for 9.5 milliseconds at wide open throttle *(WOT)* and 6000 rpm. After some engine modifications the same car will then require 10 milliseconds at the same load/rpm site and will have the ECU re-calibrated to suit. This 0.5 millisecond increase does not mean a lot by itself, but when we look at the duty cycle, or the percentage of time that the injector spends open, you can see where the injector is within its operating range. So the corresponding duty cycle on the Griffith 500 fuel injectors may have increased from 94% to 100%. This is a problem, as the injectors cannot open anymore than this and might even already be beyond their operating range, causing the engine to run lean in a dangerous load/rpm zone. Ideally the fuel injectors will not be operating any higher than 85% duty cycle, so the Griffith 500 required higher flow-rate injectors before it was even modified!

So if we need higher flow-rate injectors, why not fit the 'largest' fuel injectors that we can afford? How do we rate the size of an injector?

Fuel injectors are rated in terms of their static flow-rate - this is how much petrol the fuel injectors will flow at 100% duty cycle for a specific amount of time at a specific fuel pressure. Standard Rover V8 fuel injectors flow at approximately 188 cubic centimetres per minute *(cc/min)* at 43.5psi of fuel pressure.



When the fuel injectors are operating at lower pulse-widths, at idle for example, a large proportion of this pulse-width includes the time it takes for the fuel injector to open and to close. If this opening and closing time is the same or close to the same as the complete pulse-width, then the injector will not be able to accurately and consistently provide the correct fuel quantity. In practice this means that the engine will have an unstable and inconsistent idle - it may not even be able to idle without increasing the pulse-width to the point where the engine is running with an excessively rich fuel mixture. Fuel injectors with higher flow-rates typically have longer opening and closing times and are therefore likely to be more difficult to control at lower pulse-widths.

So if you are looking for the correct fuel injectors for your application, you require a fuel injector that operates at no more than 85% of the duty cycle and has a minimum operating pulse-width that is comfortably greater than the injector opening and closing times combined.

There are many online calculators to help choose the correct size injectors, but here are some examples of suitable size injectors for TVRs with Rover V8 engines, based on our experience:

- **4-litre or '400' Rover V8 - standard, no modifications, approx. 220bhp at the flywheel- 188cc/min;**
- **4-litre or '400' Rover V8 - some engine modifications, approx. 250bhp at the flywheel - 215cc/min;**
- **5-litre or '500' Rover V8 - standard, no modifications, approx. 280bhp at the flywheel - 215cc/min;**
- **5-litre or '500' Rover V8 - some engine modifications, approx. 300bhp at the flywheel - 240cc/min;**
- **Supercharged Rover V8 - approx. 400bhp at the flywheel - 340cc/min.**

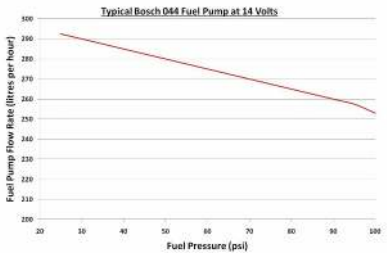
Lucas 4CU Ballast Resistor & Low Impedance Injector

Remember, a 'bigger' injector is not always better! Particularly if you want a smooth idle and a normal idle speed. However, injectors that are maxed out in terms of flow-rate *(i.e. are not 'big' enough)* will ultimately damage your engine through lean mixture.

Another consideration when selecting a fuel injector is the spray pattern. The original Lucas injectors are single-hole injectors whereas more modern fuel injectors *(e.g. Bosch EV6)* are usually multi-hole, giving a finer spray pattern. The finer spray pattern leads to better fuel atomisation which improves combustion at lower engine speeds *(better idle quality)*. This also reduces emissions and fuel consumption. Conversely, if the fuel is too finely atomised it will displace oxygen in the intake which can reduce the power potential of the engine. This is one of the reasons why fuel injectors tend to be located close to the intake valve, as opposed to further outboard.

It is also worth noting here that early fuel injected engines *(e.g. Lucas 4CU)* were often fitted with low impedance injectors *(typically 3-4 ohms)*, whereas most fuel injected engines *(Lucas 14CUX onwards with the Rover V8)* are fitted with high impedance injectors *(13-14 ohms)*. The early injectors used a ballast resistor box to prevent excess current draw from damaging the ECU. It is essential to use the correct type of fuel injector for the engine management system that is fitted.

Why can we not simply increase the fuel pressure to provide more fuelling with the original injectors? It is acceptable to increase the fuel pressure to achieve a richer fuel mixture overall, but there is a limit as to how much the fuel pressure can be increased. The fuel injectors have a fuel pressure limit, beyond which they will not be able to function correctly. It is also worth noting that increasing the fuel pressure will also reduce the flow-rate of the fuel pump, as pump flow is inversely proportional to fuel pressure. For these reasons we would not recommend increasing the static fuel pressure to more than 60psi.



We hope that you found this article interesting and useful. If you have any particular questions that you would like us to answer, or technical articles you would like us to write, then either write to Sprint magazine or contact us at enquiries@lloydspecialistdevelopments.co.uk

Daniel R. Lloyd & Nathan J. Lloyd