DIESEL INJECTION

Ivor Carroll takes us through the modern diesel engine types, with an idiot's guide to Common Rail and Pumpe Düse...

Modern fuel injection and engine design have allowed direct-injection (DI) combustion – where the fuel is injected straight into the cylinder, above the piston, rather than into a small side-chamber - to be so finely controlled that the usual knocks and rattles associated with diesel engines have been all but eliminated.

The use of rapid-acting electronics in injection control is very much to thank for this, though another major contributor is the replacement of the traditional old, complicated mechanical injection pump with something far simpler, yet far more capable – the Common Rail system.

Common Rail is a diesel fuel injection system consisting of a simple engine-driven pump that generates extremely high fuel pressures, a thick-walled steel tube (the Common Rail) running alongside the cylinder head, and an electronic control unit and electrically-operated injectors (one per cylinder) supplied with fuel at high pressure from the rail. The Common Rail is 'common' to all the injectors/cylinders – hence its name.

Diesel fuel has to be injected at very high pressures in order to counter the huge compression pressure of the diesel engine, and also in order to burn efficiently. The higher the pressure, the more power is produced, and the cleaner are the exhaust emissions. Common Rail can double the injection pressure of the old 'distributor pump' type of injection systems, so injecting a far finer mist of diesel fuel than was previously possible, further enhancing DI engine efficiency.

When the engine is running, the system's pump continuously pressurises the common rail, so making it a permanent reserve of high-pressure fuel. When the engine is first cranked over, the rail pressurises within seconds, and the control system 'cracks' open each injector at just the right time to instantly inject fuel at – typically 1400-1600 bar - about 1400-1600 times the pressure of the air around us!

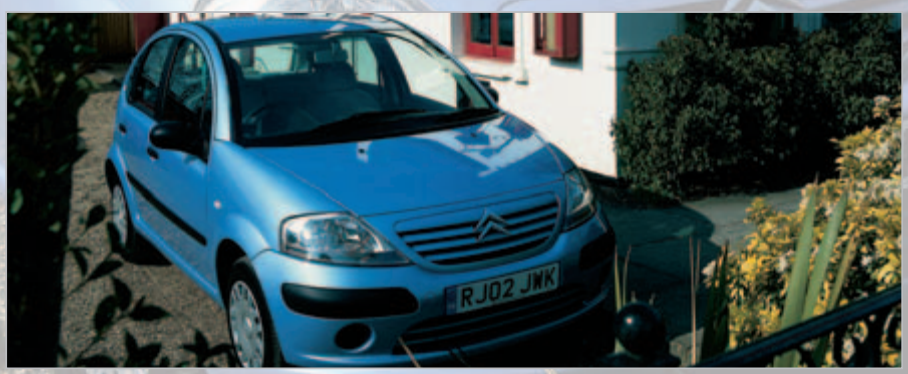
The fact that the engine won't fire until maximum injection pressure is built up means there's no more of that traditional diesel start-up puff of smoke, as everything works at peak efficiency from the word 'go'.

The electronics constantly monitor what the engine and driver are up to, and continually adjust injection timing and fuel dosage with complete accuracy. Consequently there is virtually no exhaust smoke under any engine operating condition, and combustion noise is decreased almost to petrol-engine levels.

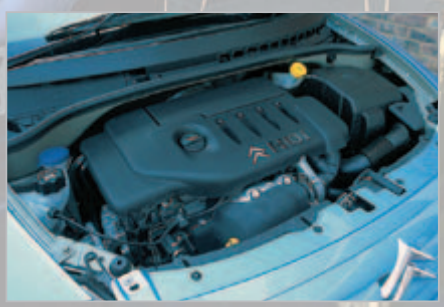
And that, in a nutshell, is what Common Rail is all about, although there's one more thing worth mentioning, and it's called 'pilot injection'. This is a tiny volume of fuel injected before the main injection starts. What this achieves is the creation of a small 'explosion' immediately before the 'big bang', so giving a gradual increase in combustion chamber temperature, rather than allowing a sudden one. And it's those sudden temperature increases that cause the familiar diesel knocks and rattles.

Thanks to Common Rail with pilot injection, Peugeot-Citroën's HDI engine, for instance, is some 3 decibels quieter at tickover than the indirect-injection XUD engine it replaces.

The Common Rail system components.

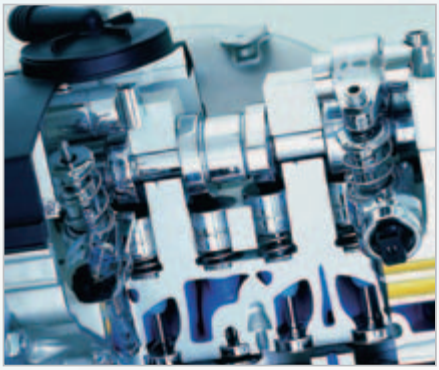


Cheeky, good to drive, and has the design and attention to detail we expect from Citroën.

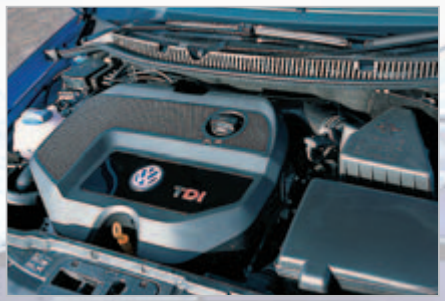


Citroën's 1.4-litre HDi Common Rail engine.

Pumpe düse (PD) is quite a rare beast, because in the world of diesel cars, it's only the Volkswagen Group that uses this technology. If you're wondering why it has such a strange name, it's because 'pumpe düse' is German for 'pump metering'. This refers to the PD unit being an all-in-one assembly comprising the high-pressure pump (that pressurises fuel to injection pressure) and the injector (which injects the pressurised fuel into the engine cylinder).



The Pumpe Düse-equipped engine in section.



A working example – the VW Polo TDI PD engine.

There is one complete pump düse assembly (otherwise known as a unit injector) on the cylinder head, serving each cylinder, and the pump part of the PD is driven by a camshaft in the cylinder head (usually the same camshaft that operates the engine's own cylinder valves).

PD is mechanically more fiddly than common rail, and it needs a specially designed cylinder head, so it's costly too. But its big advantage is that it can generate considerably higher injection pressure than even common rail can, and VW's PD units are good for 2,050 bar (against common rail's typical 1600 bar). That's great for producing more torque than would otherwise be possible, and it's also very useful for reducing polluting exhaust emissions.

Like common rail, detailed previously, PD has pilot-injection built into it, to hush combustion rattle, and Volkswagen has said that it will soon be possible to build multiple-injection technology (such as that incorporated into the very latest CR systems) to further clean-up emissions and reduce noise.

But the Volkswagen Group is unique in adopting this technology, and some say that other's shun it because its scope for further refinement – particularly in terms of the number of multiple injections possible – is limited.

Proponents of the system though, point out that it's safer, in that it doesn't store fuel in a rail at incredibly high pressure, but simply generates that pressure as and when needed.

Of course, as with CR, electronic management constantly monitors what the engine and driver are up to, and continually adjusts injection timing and fuel dosage with great accuracy.

Consequently PD, too, produces very little exhaust smoke under any engine operating condition, though in our experience combustion noise is not always as subdued as it tends to be with the latest common rail systems

VW's Polo looks good, drives well and is of course equipped with torquey Pumpe-Düse TDI diesel engines