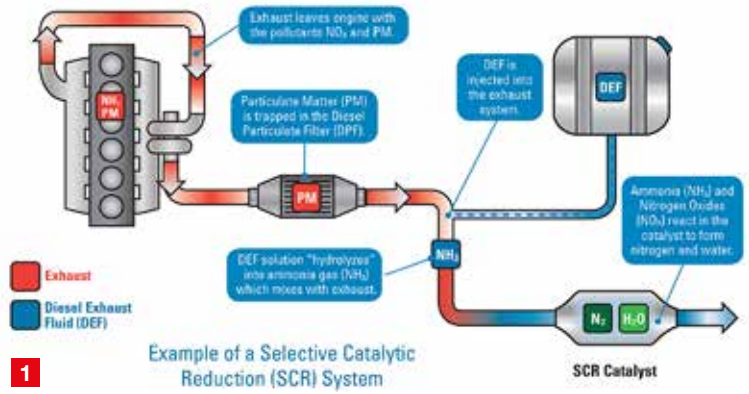
Selective catalytic reduction

with Brendan Sorensen

AdBlue, urea, diesel exhaust fluid (DEF) – whatever you want to call it, they are all different names for an ammonia-based liquid used in selective catalytic reduction (SCR) systems.

Even with combustion-technology advancements and problematic aids such as exhaust-gas recirculation (EGR), manufacturers have struggled to meet low nitrogen oxide (NOx) emissions targets. This has led to an increase in using SCR, an effective way of reducing NOx with minimal side effects.

During engine loads that produce high NOx (the system is not utilised at idle), AdBlue is sprayed through an exhaust-mounted injector upstream of the SCR catalytic converter. All going well, the NOx will react with the AdBlue and precious metals in the SCR catalyst, breaking NOx into nitrogen and water (pic 1).



1 Example of a Selective Catalytic Reduction (SCR) System

The rate of AdBlue injected is calculated in a similar fashion to the regular fuelling system using various inputs such as the mass air flow (MAF), manifold absolute pressure (MAP), throttle position, exhaust temperature, etc. However, the SCR dosing amount will also be adjusted in a closed-loop system using an exhaust-mounted NOx sensor, similar to how a petrol vehicle adjusts fuel trims via oxygen-sensor readings. This NOx sensor allows the system to fine-tune and also account for situations such as AdBlue that is past its recommended-usage date.

Quality AdBlue is available from various sources, including the bowser, aftermarket containers or direct from dealerships, with each going up in price. Because most dealerships now include an AdBlue refill as part of their servicing, I recommend keeping some readily available when keeping these vehicles in your customer base.

AdBlue has a two-year lifespan from the date of production when stored in a sealed container between 5°C and 20°C. Higher temperatures or a vented container will reduce the shelf life to around six months.

A good starting point for any SCR system-efficiency fault is testing the remaining urea content of the AdBlue. This is commonly done with a refractometer, which is readily available for low cost via a quick Google search.

AdBlue is not flammable and poses minimal risk to humans but, as with any vehicle fluids, it is wise to wear gloves and glasses when working with it.

AdBlue freezes at minus 11°C and, for this reason, you will typically see a heater in the AdBlue tank. The supply line to the injector will also be wrapped in a heating coil that's protected by a conduit-like outer sheathing on the line.

If AdBlue is accidentally put into the diesel tank and the key has not been turned, drain the tank immediately and clean extensively with warm water. Let it dry completely. If it's free of crystals, it can be used again.

If the car has been started, the entire fuel system is a complete write-off – often an insurance claim is the best option to replace the entire system. The AdBlue will corrode many metals, including steel, iron, brass, aluminium and zinc. Within 12 to 24 hours the ammonia also begins to crystallise, a function that will easily destroy fuel systems. On the bright side, however, it makes finding any AdBlue leak in the SCR system extremely easy (pic 2).

The AdBlue tank level in some models, including many VWs, can be a series of four resistors at staggered heights in the tank rather than a typical float sensor. The driver will be given warning messages of increasing intensity as the level gets lower, with distance until the engine will not be allowed to start estimated based on the previous level of AdBlue usage per kilometre. AdBlue usage rate, depending on driving style and vehicle size, is typically around one litre per 1000km.

2

Alternatively, a separate error message or warning light will be used if there is a fault in the system. Just the same as running out of fluid, however, a kilometre countdown can be given until the engine will no longer be allowed to start until the fault is rectified (pic 3 and 4).

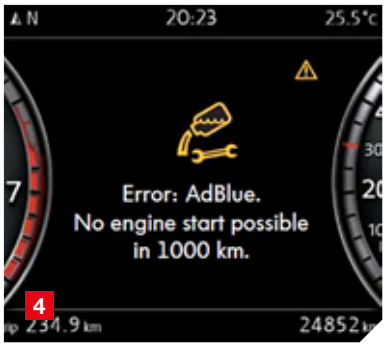
Efficiency of the system is typically monitored via pre and post-SCR catalyst NOx sensors. These heated NOx sensors will often wait until exhaust temperatures exceed approximately 140°C before activating their heater to boost that to approximately 800° and begin operation. This 140°C 'dew point' avoids damaging the sensor via any moisture accumulated on it.

NOx sensors can be expensive because they are typically sold complete with their own control module. They often use single edge nibble transmission (SENT) protocol – communication via data packets – and, as such, the efficiency of the system is generally best analysed via a scan tool. True to logic, while the system is operating correctly, NOx parts per million (PPM) should have a lower reading on the post-catalyst NOx sensor compared to the pre-catalyst NOx sensor while AdBlue is being injected. Many manufacturers' scan tools now include a functional test that will run the system while analysing these pre and post signals and simply give a pass or fail result.

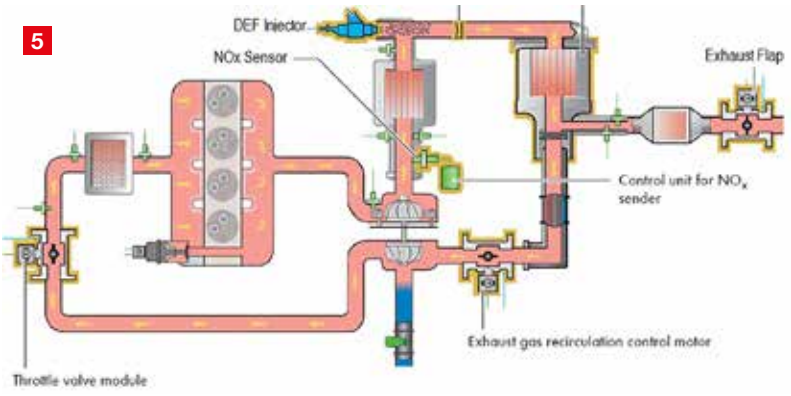
Later model SCR systems combine the DPF and SCR catalyst into one unit and can even perform system-efficiency evaluation using just one pre-catalyst NOx sensor with the aid of the low-pressure EGR system exhaust flap (pic 5), as discussed in my article Hybrid EGR (*TaT* issue 61, available via the www.tat.net.au search bar).

These clever single NOx sensor systems will periodically close the exhaust flap on decelerations for four seconds, sealing any exhaust from exiting.

3



4



5

The exhaust gas is fed back through the engine via the EGR system while AdBlue is being injected. As the exhaust gas passes through the engine – which is basically a non-combusting air pump during deceleration – the pre-catalyst NOx sensor can report the drop in NOx levels compared to the seconds before to determine if the SCR system is working correctly.

Furthermore, 'twin-dosing' systems have recently been introduced. Because ideal NOx conversion rates in an SCR system occur between 220°C and 350°C, having just one injector and SCR catalyst at one point in the exhaust does not always give the optimum position for different engine loads.

With twin dosing, the first AdBlue injector and SCR catalyst mounted close to the turbo outlet are used during low-speed/low exhaust-gas temperature loads. During high-speed motorway driving, or when fully loaded or towing, temperatures close to the turbo will easily exceed 350°C, so the first AdBlue injector is no longer used. Instead, a second AdBlue injector further down the exhaust stream in the ideal temperature zone is operated, utilising its own downstream SCR catalyst.