Diesel developments:

Prepare for a new diesel diet

Come the start of next year, tractor diesel will be sold with a reduced sulphur content. Andy Collings takes a look at the reasons for its introduction and how such developments could have a dramatic effect on the way we manage diesel fuel on the farm

Ultra-low sulphur red diesel is about to make its way onto UK farms – the final result of an EC directive that places red diesel very much in line with the diesel fuel consumed by road-going vehicles. It's a change that will be welcomed by engine manufacturers, who see the move as being essential if the latest exhaust emission limits are to be achieved.

For farmer buyers of the diesel, though, the inclusion of up to 7% biofuel in the product carries the prospect of causing significant problems and may call for a fresh approach to managing all on-farm diesel supplies. Before taking a detailed look at the effects of such changes, it is useful to understand just why they have been implemented.

The introduction of ultra-low sulphur diesel, of course, has been driven by exhaust emission regulations that, introduced in 1998, set out a programme of ever more demanding emission levels and the dates of their subsequent delivery by engine manufacturers.

It has not been an inexpensive exercise and, when the European Commission finalised its timescale, it is questionable whether or not it had considered just how much the price of compliance was going to be. It's impossible of course to be precise, yet it is likely to have cost the engine manufacturing industry billions of pounds – money that it could not possibly have planned to spend in such a short period of time.

It's also worth observing that, until the implementation of the emissions directive in 1998, new engine introductions were relatively few and far between. Tractor giant Ford, for example, has had less than a handful of different engines since its Fordson Major days, so a new engine has traditionally been an important event. Now, however, with new developments taking place so frequently, as designers and engineers attempt to keep up with emission compliance demands, changes that would have heralded major announcements pass almost unnoticed.
While compliance with the initial stages of the emission reduction schedule was

Farm fuel is going to be a hot topic as we head towards January 2011.

The introduction of ultra-low sulphur fuels, with their 7% biofuel content, will call for all on-farm diesel to be managed so that the fuel is not in storage for longer than 12 months.

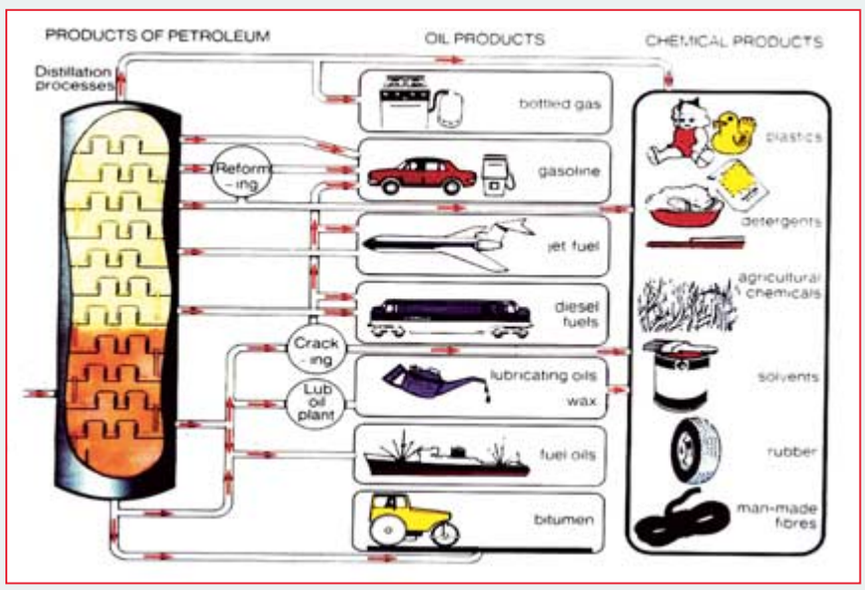
possibly not too taxing or, for that matter perhaps too costly, successive regulations demanding ever greater reductions in exhaust emissions have stretched design possibilities and budgets to the limit.
We'll be having a look at some of the key engine modifications that have been implemented later, but the point now is that engineers have hit the proverbial brick wall in their ability to reduce emission levels to meet requirements that come into force in January next year.

That's not, of course, too great a surprise for those tasked with lowering exhaust emission levels, because they deduced some time ago that one of the main stumbling blocks was going to be the quality of fuel being sold which, as an agricultural grade, has 1,000 milligrams of sulphur per kilogram of fuel (1,000ppm). The point is that modern high performance diesel engines are not too fond of sulphur – no problem when inline or rotary injection pumps prevailed but it's certainly not the penchant of today's precision-built fuel systems. The creation of sulphuric acid as a by-product is not good news, and many engine components tend to suffer. Also, there will be those who will recall the smell of rotten eggs (hydrogen sulphide) produced by catalytic converters when high sulphur fuel was being consumed by on-road vehicles.
So, to keep things in some form of order, first a look at where sulphur comes from. Sulphur is one of the components of crude oil, incorporated when it was formed over millions of years from dead sea creatures, and its percentage content within the crude varies depending on the area of the world from where it is extracted.
Brought to the refineries, the crude oil is processed to create a range of petroleum-based products – light petroleum gas at one end of the spectrum and heavy tar-like bitumen at the other. It is a distillation system activated by heat, the more volatile being collected at a higher distance up the fractionating column and successively less volatile being extracted at ever lower levels. Petrol is taken off some way above diesel with, interestingly, the heavy fuel oil used by the massive engines powering equally massive ocean-going ships taken off very near the bottom; these big boat motors will run on some pretty torrid, glutinous fuel, it seems.

Now the diesel element is collected there comes the question of removing its sulphur content. The EU Directive 2009/30EC introduces a requirement that, from the 1st January 2011, all gas oil (red diesel) used for non-road mobile machinery must contain no more than 10 milligrams of sulphur per kilogram of fuel (10ppm), which is, in reality, a level where it can be considered to be virtually sulphur-free.
Removing sulphur relies upon a process designed specifically to meet these new regulations and calls for the use of hydrogen to extract the sulphur as hydrogen sulphide. As a result, there are now reported to be significant volumes of sulphur amassing at or near refineries, and it is said that, while some of it is utilised as a form of plant fertiliser, there currently remains a global surplus for which there would appear to be little demand.

With the sulphur removed, what are the physical changes in the diesel? For starters, the removal of sulphur reduces the fuel's ability to lubricate, which means that it will be harder on pumps – though it is likely that additives will be added to counter this.
The big bonus, and the reasoning behind ultra-low sulphur fuel, is that sulphur's absence will allow reliable operation of pollutant emission control systems, which must be fitted to engines required to meet the 2011 emissions requirement. Without sulphur-free fuel there would be progressive and sustained damage to the control systems, which would eventually result in their failure.
Attention is now fully focused on reducing exhaust emissions post engine – by treating the exhaust gas itself. Two systems are currently 'in fashion': one is the use of a urea solution (AdBlue) in a process known

Products of petroleum



This chart shows how crude oil is distilled in the fractionating tower to produce different petroleum grades.

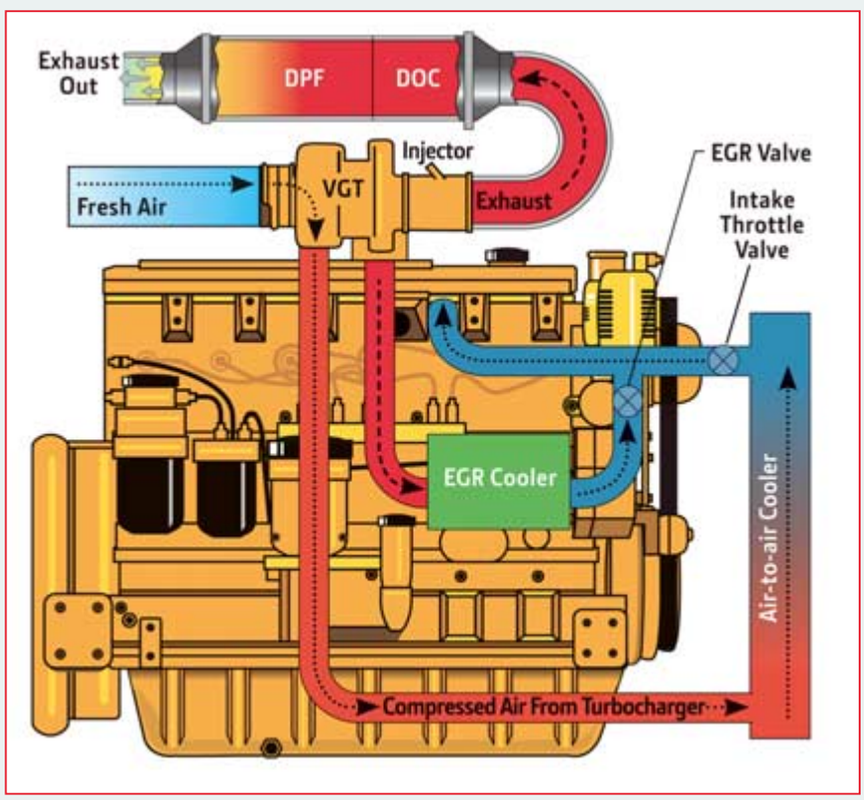
Processing crude oil into its different components is a global industry as the world demand for fuel continues to expand year on year. The volume of sulphur now being removed is reported to have resulted in enormous mountains for which there is little use.

as selective catalytic reduction (SCR); and the other employs a filtration system plus a catalytic converter.

SCR adds a stream of urea to the flow of exhaust gases and is then absorbed onto a catalyst; this then converts the nitrogen oxides – NOx – into nitrogen and water. The filtration route, in contrast, employs a filter, known as the Diesel Particulate Filter, which traps particulates – soot – in the exhaust and then, at timed or load-sensed intervals, burns them off to clear the filter. The presence of sulphur in both these systems has a detrimental effect on their capability to function and also, it is maintained, significantly reduces their operating life.

But for the engines themselves, the general feeling is that modern ag machines – tractors, combines, forage harvesters, for example – should experience no difficulties running on low-sulphur fuels and could actually benefit from having a higher grade of fuel. Timely at this stage, then, to refer to some of the development work that has been performed in the efforts to reduce engine exhaust emissions.

PowerTech PVX stage 3b technology



Ultra-low sulphur fuel will allow post-engine treatment of exhaust gas to reduce emissions. This system uses Exhaust Gas Recirculation (EGR) followed by a catalytic converter and a Diesel Particulate Filter. Pic: John Deere.

Attention has always been focused on the engine's fuel system; clearly the control of the way fuel is injected and how it is burnt within the cylinder are key parts of controlling emissions. But systems that offered benefits in terms of reduced emissions – later injection of fuel for a cooler burn to reduce NOx, for example – would rarely if ever provide any advantages to engine operation overall.

Electronic engine management, common rail injection systems and EGR (exhaust gas recirculation) all play their part in reducing exhaust gas emissions. EGR, it will be recalled, recirculates a percentage of the exhaust gas back into the engine. Its action is to lower combustion temperatures to reduce NOx emissions. Against this, though, can be a reduction in combustion efficiency, less fuel efficiency and, as a result, an increase in soot particles that need to be filtered out of the exhaust system.

Use now of modern high pressure common rail injection systems also mean that unused fuel is constantly being returned to the tank: as much as 60% of the fuel is circulated through the pumps, injectors and back to the tank. This increases the temperature of the fuel by a high degree, to the extent that a cooling system must be employed to control these temperatures; flash point for diesel is about 56°C. And one further point: the use of ultra-low sulphur diesel in older engines could result in problems with seals and pipes, and these will need to be inspected regularly for signs of leakage.

A look, then, at the actual grade of diesel we shall be buying next year. Classed as BS 2869, it compares well with the white 'road' diesel that is EN 590 – the grade used by designers of diesel engines. Arguably, the only notable difference is the

Cetane number, which, while assumed by many to represent the quality of the fuel, is actually a measure of the fuel's ignition delay – the time between start of injection and start of combustion. The shorter the time, the higher the Cetane number.
With a minimum Cetane number of 45, BS 2869 grade's ignition delay is slightly longer than the minimum 51 of white diesel. The relevance is that the burn will not be quite so good and, in the long term, could result in a build-up of carbon due to incomplete burns. This could mean injection nozzle restriction and blockages.
There has also been a suggestion that the industry could end up with two grades of rebated fuel – one with BS 2869 standard and the other to the EN 590 standard, the latter having a premium payment.

'Fame'

Having an acronym that's easier on the ear and also possibly the stomach is FAME which, being the bio-fuel element of the fuel, stands for Fatty Acid Methyl Ester. For the record, its European specification is EN 14214.
Blended in with the hydrocarbon oils to a maximum level of 7% by volume, FAME brings with it the potential for a whole packet of problems. Made as you would expect from vegetable oils – oilseed rape, palm, soy, sunflower, for example – biofuels can also include animal fats and used cooking oils.
All of which, one supposes, makes good use of sustainable products, which it undoubtedly does, but the downside is that FAME and the diesel blends containing it are more susceptible to biological attack by micro-organisms. Microbiological activity is about twice that experienced in 'neat' diesel and, worse, such activity is higher in diesel blends where fungi, bacteria and yeast can flourish at the fuel/water interface in tanks.
And mentioning water draws attention to the fact that biofuel has a hygroscopic nature – it attracts water – which promotes microbial growth. This results in a fuel that looks cloudy, the production of sediment and a high risk of filter blockages when used. Naturally, this focuses the mind on fuel storage, which is clearly going to need a tad more attention than it has probably received in the past.
For starters, the oxidation of the fuel will be higher, once again increasing the risk of solids being precipitated to block filters and cause frustrating stop-go days in the field. Every effort should be made to prevent water build-up in storage tanks, if only to restrict microbial activity; a check every month is recommended.
Overall, though, storage should be such that fuel is not on farm any longer than 12 months and hopefully less than half that period. Also, it should be recalled that the introduction of sulphur-free diesel may cause problems for sight glass seals, tap washers and so on, and it could well be prudent to replace these before the first batch of ultra-low sulphur diesel arrives.
Those that have large throughputs of fuel – contractors and large-scale growers, for example – will perhaps not have to be too concerned about storage intervals, but for a small farm with, say, one tractor and a 2,000-litre diesel storage tank, there could be issues. A 10 micron filter on the tank exit feed could be a profitable investment, and contractors who operate the 'arrive full – leave full' scheme by topping up with a customer's fuel should be wary of contamination from 'out of date' diesel.
Other considerations include draining combine and forage harvester fuel tanks when they're put away for the winter and being aware of dodgy-looking fuel that might be offered at attractive terms.

Out there is a whole industry that tries to beat the system by adding all manner of ingredients to help pack out the volume of diesel. Many, if not all, of these ingredients have the ability to inflict expensive and possibly terminal damage on a tractor's engine.
The point in all this is that modern tractor engines are now brimming with sophistication and have components engineered to high standards. What folly, then, to risk it all by not ensuring the fuel is of good quality and is kept in the best condition.

Summary: The introduction of ultra-low sulphur 'red' diesel in January next year should not affect the operation of modern engines, but it may cause a few problems in the seals/pipes of older machines.
A reduction in lubricity will probably be countered by a suitable additive, so wear on fuel pumps/injectors should not be an issue. A lower Cetane number is something to be aware of and is a detail that many believe will result in two grades of red diesel being available in the future.
Fuel storage needs attention: the opportunity for microbial/water contamination looks to be on the high side and the shelf life of the product is low.

Emission regulations

There are four types of emission: carbon monoxide, hydrocarbons, nitrogen oxides (NOx) and particulates.

- Tier 3/Stage 3a emissions regulations required a 40% reduction in NOx compared to the Tier 2/Stage 2 regulations
- Tier 4 interim/Stage 3b regulations require a 90% reduction in PM along with a 50% drop in NOx compared to Tier 3/Stage 3a
- Tier 4 interim/Stage 3b and Final Tier 4/Stage 4 must pass additional emissions tests including the steady-state 8-mode test (ISO 8178) and the rigorous non-road transient cycle (NRTC) test
- Final Tier 4/Stage 4 regulations, which will be fully implemented by 2015, will maintain levels of PM and require an additional 80% reduction in NOx compared to Tier 4 interim/Stage 3b.