ALAM

Newsletter

Spring 2008

The Association of Lecturers in Agricultural Machinery

www.alam.org.uk

Contents

ALAM Newsletter Spring 2008

The Engines Edition

By coincidence, this edition of the newsletter includes reports from the JCB engines day in Ocotber 2006, and the Bosch Diesel Fuel Systems part of the 2007 Annual Conference. Settle down for a long read!

Update Day - Legislation for Agricultural Vehicles on the Road

There is a much-anticipated one-day ALAM event covering the regulations relevant to agricultural vehicles on the public road. Pete Walley is co-ordinating the day, at Warwickshire College. There's a booking form in this newsletter, or you can get the same form from the website.

2007 Conference

Bishop Burton hosted the 2007 conference, organised as a joint venture by Charles Szabo, of Bishop Burton, and our very experienced conference organiser John Gough. The report from our day with Bosch fuel injection systems is in this newsletter.

2008 Conference

Plans are underway for a visit to North Wales for 2008 - watch this space. Over recent years there has been much discussion about the timing of the Annual Conference - do you prefer the traditional July slot, or the Easter slot as used for the Denmark and Italy conferences? Please jot any thoughts or opinions either way to the chairman via e-mail.

We are planning the conference for the 14th to the 17th of July 2008 - keep the dates free in your diaries.

Update Day - Torro - 2008

We have provisional plans for a day of updating on horticultural machinery, probably at Torro's premises in St Neots. More details will follow.

Committee Members

The latest details are included in this newsletter.

Parts Offer

John Gough has a range of warranty return items sourced from JCB,
which are available for colleges to use for teaching.

For full info about what is available, contact John by email at:

gough.j@btinternet.com - **<u>note this is a new email address</u>**

Phone - **01630 685 942 - evenings 7 to 10pm**, please.

ALAM Committee 2007-08

Updates are highlighted in **bold** text.

Position	Name	Work			Mobile	Home	
		Place	Tel	Email		Tel	Email
Chairman	Jonty Rostron	Appleby Heritage Centre	017683 53350		07976 966331	017683 52682	Jontyrostron @yahoo.co.uk
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	Peter Walley	Warwickshire College	01926 318309	pwalley @warkscol.ac.uk		01926 640883	petewalley @btinternet.com
	Neil Jewell	Reaseheath College	01270 613239	neilj @reaseheath.co.uk	07968 067298	01270 652554	neil.jewell @tiscali.co.uk
	Charles Szabo	Bishop Burton College					

ALAM ONE-DAY TECHNICAL UPDATE

Agricultural Vehicle Legislation

Highway Legislation for the Agricultural Industry

Wednesday 13th February 2008

10.30 – 16.30hrs

at Warwickshire College

Programme

1030	Arrival and coffee		
1045	Adam Wyatt	BAGMA	Tractor MOTs
1145	Tony Mitchell	HSE	Agricultural vehicles and the road from a HSE perspective
1230	Lunch		
1330	Adam Wyatt	BAGMA	Brake efficiency demonstration
1430	Andrew McMahon		Legal requirements / traffic law / licences.

....

Booking form

Please reserve ____ places on the Highway Legislation Seminar

Cost	Members	£ 50.00
	Non-members	£ 75.00

Name ....

Address ....

....

....

....

....

Email ....

Please return to

Peter Walley

Warwickshire College

Moreton Morrell

Warwick

CV35 9BL

ALAM ONE-DAY TECHNICAL UPDATE

The New JCB Engine

Our guide for the lecture was Paul Spray, a senior design engineer with JCB Power Systems, and his role was to introduce the audience to a in depth tour of the intricacies of the new JCB 444 engine.

A little history to first wet the appetite as to the origins of JCB and its current development of an engine of its own making.

- JCB was founded in 1945, and has grown from humble beginnings to now employing 5500 staff worldwide spread over 7 plants with a £1.2billion turnover.
- The engine saga began in the 1950's with JCB originally taking a Ford skid unit and converting it into a yellow digger. In the 1970's Leyland engines were fitted into the JCB product, with a change in 1982 to a Perkins lump. The Perkins was fitted into the backhoe loader until 2004 (about the same time as CAT purchased Perkins) when the new JCB 4 cylinder unit was brought on stream. The company still continue to use other engines from Cummins, Isuzu and Deutz.
- JCB's objective was to develop and put into production a new class leading engine (in the 75 – 150hp range) at a competitive cost.

This fits in well with the company's rationale –

- JCB brings innovative products to market in short timescales, with competence in and control over key components.

The results of a feasibility study carried out resulted in two key elements that were deemed important; the engine would be specific to construction equipment, and would have fewer inventory items.

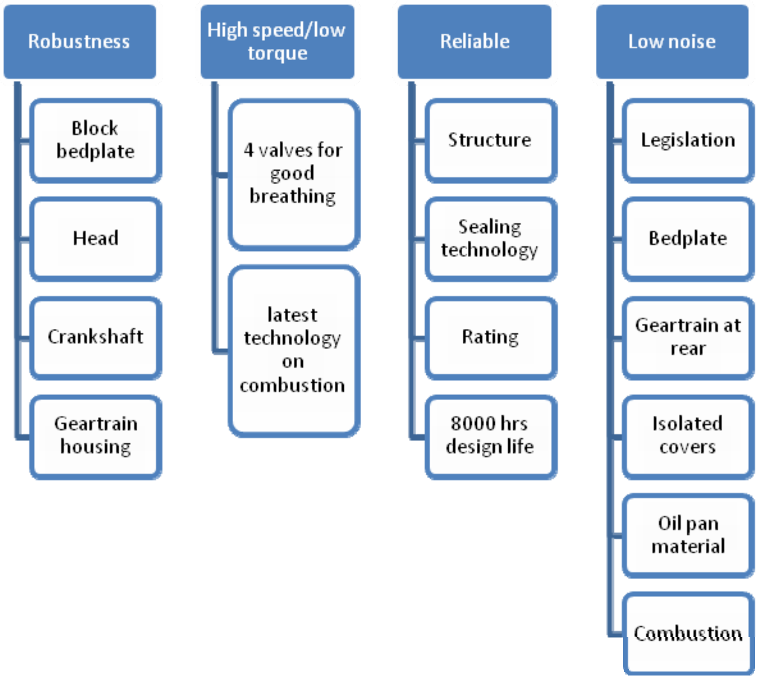
The total cost from design to production required an investment of £60million.

JCB is no stranger to engine production, having tried a number of times during its history

- 1974 – Trident engine – this was to be a 3,4 and 6 cylinder engine range, with 8 prototypes being made by Ricardo, but it never went into production.
- 1986 – 1991 – JCB 4000 engine – a 4 litre 4 cylinder engine, with 25 prototypes being made, with 67,000hrs of running carried out under test.
- 1998 – JCB 444 (Scout) engine – a 4.4 litre engine whose concept was developed in conjunction with Ricardo, with production starting in 2004.

The development of the engine brought together both Ricardo, several leading Universities and suppliers to make a reliable supplier base to ensure production and less rework. Future emission controls and fuels have also been catered for, with 5 engines currently being developed for running on biodiesel, through the fitment of uprated seals in the fuel pumps especially to cope with the acidity of biodiesel.

Main Criteria



Several design features stood out to achieve these criteria:

- Straight cut gears – this ensures no end thrust on the crank
- Steel oil pan – constructed as a laminate, with a 5 micron polymer layer to get rid of resonance
- Bedplate – this was not designed as a structural component, but to provide rigidity, stiffness and support
- Ancillaries – mounted at the back of the engine, a direct mounted alternator to ensure durability, and an integrated water pump built into the block
- Flywheel housing – built to SAE 3 to fit all JCB applications to date, and also future possibilities
- PTO – 80hp pto built on the side of the engine
- Cylinder head – developed by Maller Powertrain (formally Cosworth Engineering) with just 2 core plugs. The head uses three sand cores for the ease of casting
- Very low emissions - the best in class, with much more low speed torque

Future Developments

The future focus of the engine will be the Tier 3 regulation which comes into force in 2007. Using common rail technology, electronic engine management and new piston combustion chamber design, along with new turbos, JCB will achieve the standard.

The common rail can be run at 700 – 16,000 bar, with a central bore of only 2mm, utilising the extremely thick wall of the rail to cope with the extremely high pressures. Another advantage of the common rail engines is the ability to programme the injection to achieve two or more peaks on the pressure graph, giving a greater spread around TDC, with a small spurt of injection taking place before TDC for pre ignition. The common rail injectors are usually multi-holed, with Paul showing the group an example from a Isuzu engine with 7 holes, each being just 0.014mm diameter. Each injector also has its own code from manufacture which is programmed into the ECU unit for setting up the injection characteristics.

One word of caution was delivered at this point, as the common rail operates at such a high pressure, the old mechanic technique of cracking off an injector is no longer safe, as diesel at this pressure would just slice through the hand or fingers. The engine has specific drain points to relieve the pressure.

Through research JCB have found that 95% of problems with diesel systems stems from water, so 5 micron diesel filter are used. There is also a Stanadyne filtration system for agglomeration that is 99% effective on the first pass through.

To back up the fuel system, JCB have persuaded all its major component suppliers, in this case Delphi, to provide a “fix by replacement” policy.

An other interesting feature of the engine is the inclusion of all main oil galleries within the engine block, running at 4 – 5bar, with the only external pipes being for the turbo where fitted.

Other servicing features included a plug on the oil filter housing for draining, and a 50% antifreeze solution that is originally filled with de-ionised water.

Design development

Starting from a clean sheet of paper, JCB where able to use the very latest design methods and techniques (predictive tools, CFD, FEA, FMEA, combustion simulation, valve train dynamics, gear train dynamics, cost estimation and assembly simulation) to develop an engine that involved all the key suppliers in the process from the outset. During the concept validation stage, 6 engines each ran for 6,000 hours on test beds to provide conformation of performance, emissions and noise.

In the design validation stage, 72 engines provided 84,000 hrs, 22,000 of those hours in actual working machines. Engines on test beds were regularly stripped to assess component reliability and durability.

All of this testing and validation was to ensure that the engine achieved the desired “right first time” percentage, achieving 97% currently at hot test and 99.9% RFT at despatch (the original aim) at the current stage of production.

Each engine that leaves the line is run for 5mins to check for leaks, with 5% of production being subjected to a 20 minute test. 1% are drawn off the line for a full 24 hr test, checking for full power and torque levels and emissions reach legislative tolerance.

The estimated break even point for coverage of production costs, including the new factory at Dove Valley, Derby is 27,000 units.

Current production at the factory is 85 units per day shift and 60 units per night shift, with engines spending 4½ minutes per assembly station.

Phil Hurrell
October 2006

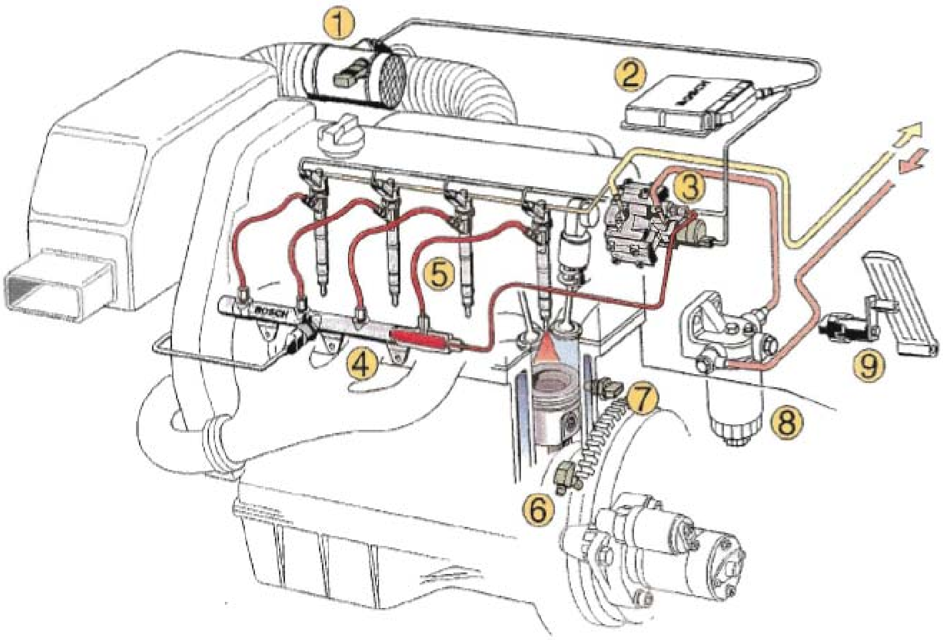
Bosch Common Rail Diesel Fuel Systems

Before we looked at the subject matter, there were the usual sheets of safety information given out, but I wonder how many of us took the time to read them? I confess to reading them purely for the purpose of compiling this report, and found there were a few surprises contained. We will all be familiar with the dangers of working near engines - rotating parts, hot components, and exhaust fumes, but who realised that hydrofluoric acid burn was a hazard of working near engines? Exhaust gas testing hoses can release hydrogen fluoride gas, which is made worse by fire or reaction with condensation. Did you know O_2 sensors contain alkalis? Even the liquid in an innocuous looking LCD display poses risks if in comes into contact with skin, or is inhaled or ingested. Modern diesel engines are also using higher voltages, maybe not up spark ignition voltages, but enough to give a nasty surprise!

The very high pressure present in the common rail also introduces a new hazard, as a leak in this part of the system can produce a high pressure jet capable of puncturing skin and causing serious problems.

Having established that the group were fully conversant with four stroke cycles, and fending off comments about the technology of Nuffields and MF135s, Kevin Crangles from Bosch started the technical information with a description of the various electrical sensors and actuators which could be found on a common rail engine.

System Overview



1 - Air flow meter

2 - Engine ECU

3 - High Pressure Pump with Pressure Control Valve

4 - Common Rail with a Rail Pressure Sensor

5 - Injectors

6 - Engine Speed Sensor

7 - Coolant Temperature Sensor

8 - Fuel Filter

9 - Throttle Pedal Sensor

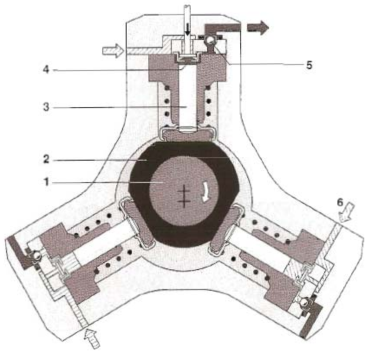
Other typical items not shown above include:

Camshaft Phase Sensor
Intake Manifold Pressure Sensor
Intake Manifold Temperature Sensor
Electric Fuel Pump

Fuel Supply Components

The flow of fuel from the tank to the engine can be either mechanically or electrically pumped, and Kevin spent a little time talking about the differences between the various systems.

The high pressure pump is the heart of the common rail system, and we heard a lot of information about this part of the system. Bosch generally use a 3-piston radial pump to generate the injection pressure which is stored in the common rail, with one-way valves on both inlet and outlet ports to ensure the fuel flows the correct way through the pump. Both the pistons and valves are high-precision components, as they can be working at pressures over 1500 Bar. This is one of the reasons that common rail engines must have good quality clean fuel, as contamination in these components will quickly damage the pump.



1 - Eccentric Drive Shaft

2 - Polygon Ring (Cam)

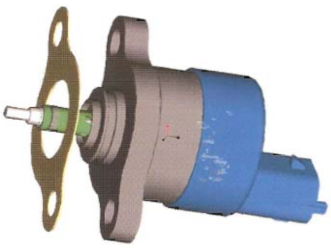
3 - Pumping Element

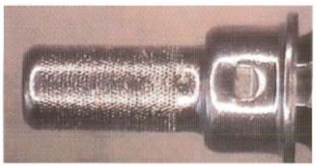
4 - Inlet Valve

5 - Outlet Valve

6 - Inlet Port

Control of the pressure in the rail is achieved by the Pressure Control Valve, which is a proportional solenoid valve on the outlet side of the high pressure pump.





The Pressure Control Valve is a high-precision component, and as a last-resort protection against contamination it has a built in filter screen rated at 5 microns. The filter is so fine that even touching it will block the holes!

The valve is vital to the running of the engine - if this fails, then rail pressure will fall and the engine stops.

Electrical Components

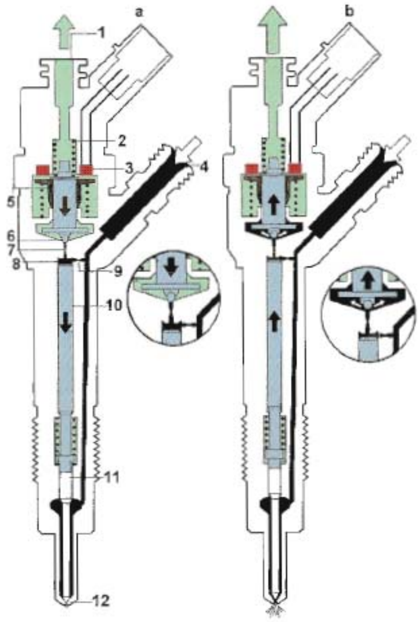
In order for the ECU to monitor the rail pressure and therefore regulate the Pressure Control Valve, there is a Rail Pressure Sensor mounted on the rail. It's purpose is to supply the ECU with a signal related to rail pressure, usually within the range 0 to 5 Volt range. If this signal is lost, the engine can continue to run in a limp-home mode, using basic settings related to engine speed.

A speed sensor measures the engine speed from a toothed ring on the crankshaft. The toothed ring has a missing tooth corresponding to a given position of the crankshaft, but remembering basics of the four stroke cycle will tell you that the ECU needs more information to identify when to inject fuel. A similar sensor on the camshaft produces one signal per revolution of the camshaft, thereby allowing the ECU to identify the correct point in the four stroke cycle to inject fuel. This is why sometimes an ECU controlled engine does not always start at the first flick of the ignition key - the ECU has to receive signals from both crankshaft and camshaft sensors before it can correctly calculate which injector to operate, and when to operate it.

The turbochargers' boost pressure is measured by a Boost Pressure Sensor mounted on the intake manifold, and from this signal the ECU can take increase fuel delivery when the turbo is working, but also prevent over-fuelling when the turbo is off-boost to prevent excessive emissions.

Injectors

To give a condensed description of the fuel flow through the injector, the high pressure fuel from the common rail is fed to both the nozzle and a control chamber at the top of the control plunger. This keeps the needle closed, until the injector solenoid is operated by the ECU. Operating the solenoid opens the valve ball, releasing the fuel in the control chamber, and therefore allowing the nozzle to open. In order than the solenoid responds quickly enough, the electrical supply to the injectors is approximately 80 Volts.



1 - Fuel Return

2 - Valve Spring

3 - Electromagnet

4 - High Pressure Connection

5 - Valve Armature

6 - Valve Ball

7 - Output Throttle

8 - Control Chamber

9 - Inlet Throttle

10 - Valve Control Plunger

11 - Nozzle Needle

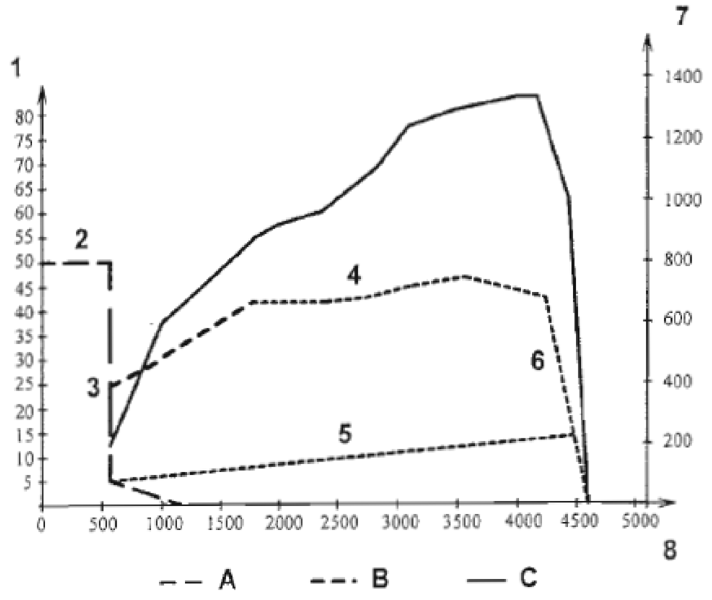
12 - Injector Nozzle

As most vehicles use a 12 Volt (or possibly 24 Volt) electrical system, then the ECU has to “generate” the higher voltages necessary for fast operation of the injector, and this is achieved using the coil in the injector in conjunction with capacitors inside the ECU. The injector coil is switched very quickly by the ECU electronics; when a coil is switched off it generates a high-voltage “spike” (think of the good old ignition coil and contact breakers), which is then “collected” in a capacitor and used for the next injector in the firing order.

To add to the demands placed on the ECU and injector speed of operation, most common rail engines have more than one delivery of fuel per firing stroke. Pre-injections are used to soften the initial ignition of the fuel, reducing the characteristic diesel knock or clatter sound. The main delivery of fuel can be split in two or more stages, to give a longer cleaner burn.

Fuelling Calculations

When the ECU has collected it's input data, it then computes the required fuelling, and the chart below gives a flavour of the many and varied possible outputs, depending on engine speed, load, etc.



A - Start and Idle Range

B - Injected Fuel Quantity

C - Rail Pressure in full load

1 - Fuel Quantity mm^3/stk

2 - Start Fuel

3 - Idle Characteristic

4 - No-load Characteristic

5 - Overrun Characteristic

6 - Governing Characteristic

7 - Rail Pressure (Bar)

8 - Engine Speed (rpm)

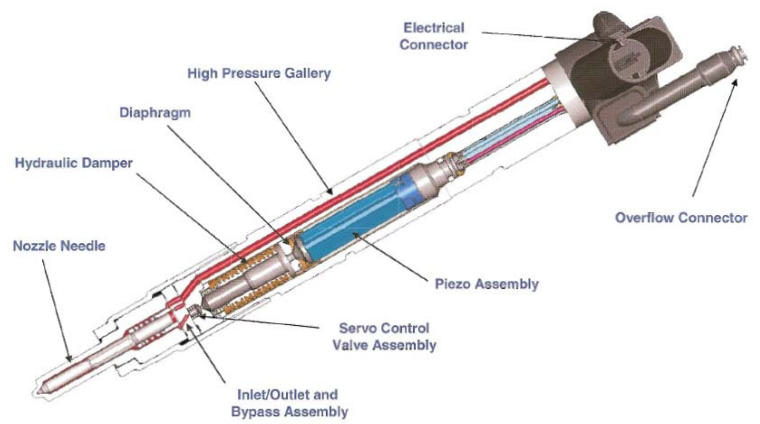
The Next Generation

Just when we thought we were keeping up with the latest technology, Kevin told us about 2nd generation common rail systems, using CP3 fuel pumps and Piezo-Ceramic Injectors.

The CP3 pumps are developments of the CP1 described above, with an integral mechanical lift pump and revised method of controlling rail pressure. Control of the pressure in the rail is now achieved by dual Pressure Control Valves. One valve is fitted on the high pressure pump, but it is now on inlet side of the high pressure pumping elements. Controlling the inlet means that the valve is working at much lower pressures of 2 or 3 Bar, but more important is the fact than the high pressure pump only pumps the amount of fuel necessary, preventing heat build-up in the fuel system. The way this system is designed means that a failure of the Pressure Control Valve does not stop the engine, as it did with the CP1 system. A second Pressure Control Valve is mounted on the common rail, and operates directly on the fuel in the rail if the pressure is too high, typically during overrun or when the fuel is cold.

The later generation common rail can also feature flow limiters on the outlets to each injector, so that if there is a failure in the pipe to any injector the flow limiter can close off that outlet.

Piezo-Ceramic Injectors are smaller, faster-reacting and can meter small volumes more accurately than solenoid type injectors. This gives the ability to increase engine power while also reducing emissions.



The injector uses the fact that Piezo crystals change size when electricity is applied to them, and this mechanical movement is used to open and close the nozzle needle. Reversing the current returns the piezo assembly to it's original size, and therefore there is a risk that if the injector electrical supply is disconnected while the engine is running the injector might be left open. To operate this type of injector, the ECU needs to supply 180 Volts and 15 Amps!

Pump Failures

Almost inevitably, the discussions during the day came around to "what goes wrong?".

The three overriding causes of failures of the high pressure pump are dirt, water, or petrol in the fuel system. Pre-filters with water separators are fitted to these engines to help prevent the first two "faults", but the third cause is entirely in the hands of operators.

If the tank is filled with petrol, it is important NOT to start the engine. If the error is realised before starting, flushing the low pressure fuel lines may save your engine.

If the engine is started with petrol in the fuel, but stopped within one minute, you MIGHT be lucky and prevent serious damage by flushing ALL the low and high pressure pipes. This is because the system is using unadulterated diesel already in the system for the first minute or thereabouts.

If the engine is run for longer, then you will have to replace ALL of the high pressure fuel system (yes ALL - pump, injectors, pipes, ££££££). The reduced lubricity of petrol passing through the high pressure pump will cause the pumping elements to overheat and their special coatings to flake off, leading to injector contamination problems, probably within a couple of months.

Summary

In addition to all the information Kevin shared with us, we were also able to see Bosch electronic fault diagnostic equipment in action on a Renault car, borrowed from a friendly local dealer. As could be expected, the range of functions and depth of information that the diagnostic system can display was impressive.

This report is just a summary of what was a very thorough description of the common rail system theory, operation and diagnostics.

I'm sure all those present would like to express their appreciation that Kevin was able to spend a whole day with us to really get to the nitty gritty of his subject.

David Heminsley
July 2007

ALAM ANNUAL CONFERENCE 2007

Caught Out!

ASSOCIATION OF LECTURERS IN AGRICULTURAL MACHINERY

Membership Application Form

Title	Initials	Forename	Surname

Home Address	College Name
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My connection with education in agricultural/horticultural engineering is:	
Signed	Date
Proposer (Member of ALAM) If you don't know any members, just return the form and we'll arrange contact with one in your area.	

HOW TO PAY- The current rate is £10 per annum, payable on April 1st each year.

By cheque: Cheques should be crossed and made payable to "The Association of Lecturers in Agricultural Machinery", and sent with this form to the treasurer.	
By standing order: It will help us provide an efficient service to members if you pay subscriptions by Standing Order, by completing the following, and returning the whole form to the treasurer.	
Bank Name	Name of Account
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Please pay to Lloyds Bank, 12 Lendal, York, YO1 2AF, (Sort Code 30-99-99) in favour of The Association of Lecturers in Agricultural Machinery (Account Number 1373714), the sum of £10 immediately, and then annually on the first of April each year, until cancellation by me of this standing order, debiting the account specified above. This order cancels and replaces all previous orders in favour of The Association of Lecturers in Agricultural Machinery.	
Signed	Date
Standing Orders are for a fixed amount, which can only be altered by you. It is not a Direct Debit, which allows the payee to vary the amount drawn.	

Return completed forms to David Heminsley, ALAM Treasurer,
The Old Byre, Lower Street, Doveridge, Ashbourne, DE6 5NS.

For use by the treasurer							
Details recorded		Payment received		Bank Order processed		Member number	

Form revised January 2004