Ford Motor Company JAGUAR PSA PEUGEOT CITROËN

High Performance Refinement Efficiency

Hautes performances Raffinement Efficacité

3rd PHASE OF DIESEL COOPERATION

3ÈME PHASE DE LA COOPÉRATION DIESEL

2.7 V6 Diesel

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Jaguar Engineering Centre, Whitley, Coventry, UK

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SECTION 1

FLAGSHIP ENGINE DELIVERS HIGH PERFORMANCE, REFINEMENT AND EFFICIENCY

A new 2.7 litre, common-rail, direct injection V6 diesel engine, announced today, is the third stage of the highly successful agreement between the Ford Motor Company and PSA Peugeot Citroën. It will make its debut in 2004 in a Jaguar, the first marque to benefit from using this advanced engine.

The two companies embarked on this historic co-operation in 1998, and expanded the agreement a year later to allow for the shared design and production of four families of common-rail, direct injection diesel engines.

This co-operation is already delivering a world-class range of engines for volume vehicle segments and is rapidly positioning all parties involved as the world's leading manufacturers of diesel engines.

Highly acclaimed 1.4, 1.6 and 2.0 litre common-rail diesel engines for volume vehicle segments have already been jointly developed, announced and are now in production. The new 2.7 litre V6 engine, the result of an intensive collaborative engineering programme between PSA Peugeot Citroën and Ford Motor Company, takes the partnership into the premium diesel niche segment for the first time. It is an engine of outstanding power, economy and emissions performance that sets a benchmark in 'V' configuration diesel engine design.

Jaguar engineers were involved from the very beginning of the V6 diesel programme within the main project team of Ford Motor Company and PSA Peugeot Citroën to help define the base engine specification and technologies necessary to deliver the high standards of power, refinement and driveability expected of a Jaguar.

Combining power and performance in a premium diesel

The 60-degree V6 engine, with a capacity of 2,720cc, is new in all respects. Developed as a premium high-performance diesel engine for use in both 'north/south' and 'east/west' applications, it will feature in a number of brands from Ford Motor Company/PSA Peugeot Citroën.

The new V6 engine range will provide high performance and driveability, with a spread of power outputs up to 207 PS (EEC), depending on application, and maximum torques of up to 440 Nm (EEC). The top end of the range gives best-in-class specific outputs.

Delivering refinement

Delivering premium level refinement was central to the design philosophy of the engine architecture. The engine features were selected and optimised for radiated noise level and noise quality using advanced analytical and measurement techniques. The cylinder block, for example, is manufactured in Compacted Graphite Iron (CGI) and coupled with a separate aluminium ladder-frame to provide a lightweight, compact and very stiff bottom end of the engine. Additionally there are cross bolts that "tie" the main bearing caps into the structure and control their high frequency behaviour.

The valve train and fuel injection system of the engine are belt driven to enhance refinement. The belt covers are designed to ensure their surfaces radiate the minimum amount of noise, while special attention was paid to the operating dynamics of the belts themselves. The cam covers are manufactured from composite material and isolated from the remainder of the engine structure by use of elastomeric material, which reduces the transfer of vibration.

Management of the engine's noise characteristics has focused particularly on the areas of mechanical noise and the combustion process. The latter has been subject to especially detailed optimisation and has benefited from the painstaking work carried out on the design of the engine structure. Further control of combustion excitation is achieved through the use of next generation common-rail technology, including "multiple pilot" injection and closed loop injection control, ensuring the quality of combustion is maintained under all operating conditions.

Overall, the result is class leading refinement, with the V6 engine demonstrating impressively low levels of radiated noise in terms of both mechanical and combustion noise

Environmentally efficient engineering

This diesel engine was designed from the outset to meet future emissions levels and is further proof of the way in which common-rail direct injection diesels provide an effective solution for controlling 'greenhouse gas' emissions. The high technology incorporated in this power unit reduces emissions at source through a highly optimised and efficient combustion process, managed by advanced control strategies. Further benefits in reduced emissions have been made through the employment of electronically actuated turbochargers, an Exhaust Gas Recirculation system and port deactivation. The advanced design of the V6 ensures it is Euro IV capable and with the application of Diesel Particulate Filter technology, particulate emissions are reduced to a level where they are almost undetectable.

SECTION 2

ADVANCED TECHNOLOGICAL INNOVATION

CGI block technology

One of the most significant technical aspects of the engine lies in the construction of its engine block. It is cast in Compacted Graphite Iron (CGI) and will be the first use of this material in volume engine production. As a result of the outstanding strength and durability of CGI, less material is needed than for a conventional cast iron block, ensuring reduced engine weight and length with higher structural capabilities. In fact, the new V6 is the lightest unit of its type at 202kg (DIN 70020), a factor that contributes significantly to the excellent power-to-weight ratio and fuel economy. The increased strength and hardness of Compacted Graphite Iron necessitated the introduction of new manufacturing technology and machine tools (developed over the last eight years) to deal with the application of this material at volume production rates.

Other features at the heart of the engine provide the capability to deliver high performance and excellent durability. Within the block are cast aluminium pistons incorporating "double wave-gallery" cooling. In this process, oil is sprayed precisely on to the inside of the pistons from jets in the block. The oil then flows through two internal wave-shaped channels to help cool each piston crown. This arrangement also has the indirect benefit of reducing piston "slap" noise. The big-end bearings on the connecting rods are "sputter coated" – a manufacturing process that layers the bearing material to produce a higher load capacity for improved durability and reduced width. The connecting rod big ends are fracture-split steel and the small end has a trumpeted bore for better force distribution into the weight-optimised shank. The belt driven timing system employs the latest in material technology enabling the engine team to provide a 'designed for life' capability. Fuel economy is improved through use of a friction reducing PTFE coating. This also contributes to the excellent refinement delivered by the drive system.

High-efficiency combustion system

The high-grade aluminium alloy cylinder heads are equipped with four valves per cylinder and double overhead camshafts. This combination provides for optimum induction and exhaust actuation with attendant benefits in performance and emissions.

The cylinder head design, which includes a port deactivation system and pistons with toroidal combustion chambers, delivers highly efficient combustion. A low (by diesel standards) compression ratio of 17.3:1 contributes to improved emissions quality, quieter combustion and compatibility with the engine's unique

forced induction system. In a diesel engine, reduced compression means less heat build-up in the piston bowl and more efficient fuel burn, resulting in the production of lower levels of pollutants.

Electronically actuated turbochargers

Aiding both performance and emissions is a forced induction system comprising twin turbochargers with state-of-the-art electronic actuation. Traditionally, turbochargers are vacuum actuated, but this new form of rotary electric actuator gives a higher degree of control, providing benefits in the areas of emissions, transient engine performance and in balancing performance/emissions between the two cylinder banks. The turbochargers are small with low inertia for quick response.

Next generation common-rail direct injection

Significantly, the new V6 engine utilises next generation common-rail injection. A higher operating pressure - 1650 bar - has been achieved compared with previous systems. The fuel quantity provided by each injector is controlled by a Piezo actuator, which together with closed loop control, enables highly accurate fuel metering of up to five injections per cycle. These features enable the V6 engine to achieve both high power and the desired emissions capability. The injectors have orifices with a diameter of 145 microns, i.e. equivalent to the thickness of a single hair. They provide an extremely fine spray of diesel fuel, which ensures the most uniform fuel-air mixture possible. As a result, the combustion process is more complete.

Advanced electronic control unit

The ECU high capacity processor employs advanced software strategies that continuously control the engine's operating parameters. It gathers information from 23 sensors and provides output to 20 actuators. The ECU operates a port deactivation system, which closes or opens butterflies in the inlet system to provide the optimum swirl and flow conditions throughout the operating range of the engine. It also controls the actuation of the Exhaust Gas Recirculation system, the Variable Geometry Turbochargers and the throttle, giving faster and more accurate response. Additionally, a full torque-based strategy supports multiple injection control and integration with transmission and braking controllers. Transient torque and boost control enable vehicle performance to be optimised without compromising engine durability.

The ECU also forms an integral part of the engine's service strategy. It monitors an integrated oil level, temperature and

quality sensor mounted in the sump, and uses a complex algorithm to assess the oil duty cycle. It can then inform the driver of the time and distance to the next service, the current oil level, and if necessary, display an oil level warning. The algorithm is responsible for monitoring and deciphering the input data from the sensor, while also taking into account other engine operating parameters, including oil temperature, level and quality, vehicle speed, engine speed and torque, elapsed running time and total vehicle mileage.

SECTION 3

DAGENHAM SET TO BUILD NEW GENERATION DIESEL

The new 2.7 litre diesel engine will be built at Dagenham in the UK – in Ford Motor Company's new, high technology Diesel Business Centre with its modern assembly hall and user-friendly workplace environment. The new facility opens from July 2003.

The Diesel Business Centre is the first major building on the Dagenham Estate for more than 30 years. The contemporary design and workplace layout of the Diesel Business Centre will be industry leading. It includes a dedicated 'Clean Room Assembly Hall', which will enable teams of designers and engineers to work alongside their manufacturing colleagues, improving communications, speed of development, and purchase and quality control operations.

This state-of-the-art centre continues the €550 ($600) million transformation of Dagenham into Ford Motor Company's global centre of excellence for diesel engineering and manufacture that has created 400 new jobs to date.

The investment by Ford Motor Company and PSA Peugeot Citroën in manufacturing and engineering for the V6 diesel engine programme is €350 ($380) million.

The engine block machining facility is housed in the existing engine plant and will incorporate the first high volume production line to machine and produce Compacted Graphite Iron blocks.

The initial production volume of the new V6 engine will be up to 150,000 units per annum, with the scope for further expansion as required. The engine will be installed in PSA Peugeot Citroën and Ford Motor Company brands. The engine will debut in the Jaguar S-type in a year's time.'

The Diesel Business Centre will be supported by CEME (Centre for Engineering and Manufacturing Excellence), a new 1,200 student, world-class learning partnership between the Ford Motor Company, regional government, local colleges and the Universities of Loughborough and Warwick. As well as providing education and training facilities for Ford and the local community, CEME will support the training and development requirements of the Diesel Business Centre to Masters degree level and beyond, and research programmes around manufacturing, engineering, commercial and technological themes.

SECTION 4

TECHNICAL SPECIFICATION

ENGINE	
Engine:	Ford/PSA/Jaguar V6 Diesel
Displacement:	2,720 cc
Bore & Stroke:	81.0 x 88.0 mm
Max power (EEC):	147kW/200 PS or 152 kW/207 PS (depending on application)
Max torque (EEC):	Up to 440 Nm (depending on application)
Cylinder block:	60 deg V, Compacted Graphite Iron (CGI) cross-bolted block with ladder frame stiffener
Crankshaft:	Forged steel, fillet rolled
Main bearings:	Four, with 4-bolt mains
Pistons:	Cast aluminium bowl design, double wave gallery cooling
Compression ratio:	17.3:1
Connecting rods:	Fracture split steel rod with trumpeted bore in small end
Cylinder heads:	High strength aluminium
Valve train:	DOHC with four-valves per cylinder
Induction:	Twin turbochargers with air-to-air intercooler. Electronically actuated variable geometry with transient over-boost capability
Fuel system:	1650 bar, Piezo-actuated, common rail direct injection
Primary Drive:	Belt driven camshafts and fuel injection pump. Direct, crankshaft driven oil pump
Emissions:	Euro Stage IV capable plus Diesel Particulate Filter technology
ECU:	Torque-based structure allowing multiple injection pulses for after-treatment control, improved emissions and noise performance
Lubrication system:	Cyclone type oil separator, oil temperature/level/quality sensor allowing calibration of service strategy