

## Press Release

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### Volvo joins the diesel party in style

**The diesel engine arouse strong emotions. In the USA and Sweden, for example, diesel-driven cars evoke wide suspicion and even distrust – a ‘defensive posture’. In central and southern Europe, on the other hand, the diesel has long been a fact of life and an essential part of automakers’ ranges.**

**Volvo has now launched its third ‘attack’ on the diesel market. This time, the challenge is to market an efficient, modern unit in the face of the toughest possible competition – to sell the product and compete in the struggle for vital market shares – but also to demonstrate to public agencies and customers in more ‘hostile’ markets that the diesel really is an exceptional power source.**

**In this article, Jan-Erling Rydquist, formerly technical manager of Volvo’s own aluminium diesel engine project, examines the merits of the type compared with the petrol engine.**

Jan-Erling Rydquist has been a Volvo development engineer for over 30 years and has worked in engine development for many of these.

"Since the 1970s, I have seen how difficult and challenging it is to design petrol engines to comply with increasingly stricter emission control standards. I know how much research and development work has been involved in reducing emission levels to today’s extremely low values, which can even be below zero in the case of nitrogen oxides – thanks to PremAir™, which actually purifies the cooling air passing through the radiator!

"I took on a huge challenge when I was persuaded to take charge of defining and developing our own diesel. In recent years, diesel engine development has undergone what is effectively a revolution – one which has been fantastic to be associated with. Enormous advances have been made in terms of engine technology and characteristics, and the competitive level has been raised continuously.

"Those of us who have experienced the many years of development of the petrol engine are highly motivated to ‘run the same course’ again," says Jan-Erling Rydquist. "Developing environmentally compatible diesel engines is an extremely interesting and challenging engineering task. I firmly believe that it is preferable to solve the problems, working to develop new and satisfactory solutions rather than adopting a ‘wait and see’ attitude".

#### Clear vision

"The vision of both legislators and the auto industry is quite similar. Within about ten years, the diesel shall have largely caught up on the petrol engine in every respect. At present, the major challenge to petrol engine technology – which is certainly well advanced in terms of minimising exhaust emissions – is to continue to reduce the fuel consumption – an area in which the diesel is basically far superior. This is necessary to cut emissions of the greenhouse gas, carbon dioxide."

Jan-Erling Rydquist notes that it is difficult to be fully objective in this debate. However, such is his confidence in the competitiveness of the diesel that he believes the product itself is likely to bring about a change in attitudes in markets where there is some negative bias at present.

Nevertheless, he adds that it is worth noting that actual market shares are also related to the overall consumption of diesel oil at national level in many cold countries. An example is Sweden, where a high proportion of the total is used for heating purposes and a single household might use the same amount of fuel in a year as that burned by a diesel car in covering up to a hundred thousand kilometres.

As an aside when discussing the very mixed views held by people on exhaust emission sources, he becomes almost agitated as he recalls the thousands of houses which are heated by wood firing. Based on a very basic technology, combustion of this nature can give rise to emission levels many times higher than those from modern vehicles.

### **Deficient knowledge**

Nonetheless, the sceptics maintain that the diesel is inferior in terms of performance, noisy and difficult to start in cold climates. The fuel is also particularly dirty, they say, while diesel emissions – especially of particulates – are higher.

Jan-Erling Rydquist has heard it all so many times that he doesn't even shake his head, but explains, calmly and factually, what the modern diesel is all about.

"Public agencies and politicians in Sweden are involved in a politico-technical debate on the subject," he says. "I would say that perhaps 20% of the decision-makers are well informed of the rapid advances in this area; however, there obviously is a degree of mistrust, based primarily on the experience of old diesel technology. This gives rise to many misunderstandings.

"Just like in the USA, most people follow their gut feelings. This leads them to believe that the diesel is poor in cold weather, that it is noisy, smelly and smoky, and that it pollutes the environment. Diesel technology carries a great number of negative associations and I estimate that 6 out of 10 people are still opposed to it."

### **Much lower emissions**

He mentions that the level of nitrogen oxides is 75% lower compared with the levels of the early 1990s. In the case of hydrocarbons and carbon monoxide, the levels are the same or lower than those from a petrol engine, while emissions of the detested greenhouse gas, carbon dioxide, are up to 30-40% lower, depending on driving conditions. On the other hand, particulate emissions from the diesel are higher. Nevertheless, it should be noted that these emissions have already been reduced by almost 90% compared with the early 1990s levels and that improvement is continuing. The forthcoming 2005 legislation requires particulate emissions to be reduced by a further 50% compared with 2001 values.

"In terms of emissions of the very finest particles, the diesel is actually superior to the petrol engine," says Jan-Erling Rydquist. "So we are actually talking about very small quantities. And reduction of the remaining harmful particulates is ongoing.

"So the petrol engine is environmentally superior in some respects, but not in terms of its effects on global warming."

Another interesting fact is that the environmental impact of a 2003 diesel car will be less than that of a 1996 petrol-driven model. This means that a customer who trades in his or her older petrol-engined model for a modern diesel is actually making a positive contribution to environmental improvement.

Action to improve mobility in many areas would also yield better results than focusing exclusively on reducing the particulate content of diesel exhaust gases.

### **Many identical parts**

He tells us that Volvo's petrol and diesel engines are fairly similar in terms of architecture, engineering and construction. The cylinder blocks, crankshafts and other components are of similar design – an essential element of Volvo's philosophy of maximum modularisation.

This offers major benefits in terms of commonality and much simplified production at the engine production plant in Skövde, and is especially evident when installing engines in the cars built in

Volvo Car Corporation's various assembly plants.

On the other hand, although outwardly similar, the advanced fuel injection system used in diesels is much more expensive, as are the pistons, connecting rods and cylinder heads. These components are required to withstand the increased stresses due to the higher compression ratio, higher combustion pressure and other specific thermal stresses inherent in the diesel.

"The turbocharger is also more expensive," says Jan-Erling Rydquist. "We use the best available technology, employing efficient, variable guide vanes, which can be controlled continuously to ensure optimum running conditions at every load and speed. In addition, since the maximum exhaust temperature in the diesel (800°C) is about 200°C lower than in a petrol engine, we can use more advanced technology and a better supercharging system in our diesels. At present, petrol engines are limited to turbo technology with a wastegate valve and there are also some restrictions on the choice of alloys which we can use."

### **Same price for car**

Although the diesel engine is more expensive to produce, Volvo has opted, in Sweden, to sell its diesel cars at the same price as the equivalent petrol-driven models (for example, the 200-hp Volvo V70 2.4T is the equivalent of the 163-hp D5).

"The superior turbocharging of the diesel makes it better and more efficient – the engine can develop maximum torque from a speed as low as 1,700 r/min. As a factor which contributes to practical performance and makes driving easier, this gives an impetus to sales, especially in continental Europe with its high-speed motorways. And, of course, it makes the diesel an excellent car for towing.

"Given a normal driving style, a petrol turbo is also extremely efficient. However, it may burn relatively more fuel when driven very hard. The diesel is generally less affected by driving style, and also remains more efficient in specific terms when driven in a harder and more aggressive manner. These positive factors make the diesel more efficient in all instances, regardless of driving conditions and style," declares Jan-Erling Rydquist.

"Unlike the petrol engine, the diesel does not suffer from fuel limitations – for example, there is no risk of knock. In fact, the higher the pressure, the better it runs."

To further promote the competitiveness of the modern diesel, Volvo, in collaboration with Bosch, has developed a 250-hp version of a Volvo S60, which is competing successfully in the Swedish 'S60 Challenge' racing series.

### **Diesel, a basic product in Europe**

"While Volvo has had a diesel engine of its own design for only a couple of years, its European competitors have long taken a completely different approach," notes Jan-Erling, citing PSA (Peugeot-Citroën) of France as an example:

"Half of their engine designers work on diesel engine development, compared (so far) with only a small proportion of ours. In terms of production, over half of their cars are diesels. The major diesel engine manufacturers also position their engines more in terms of absolute performance and the diesel is very often included as a basic product. Offering good performance and low fuel consumption, diesels are usually easier to drive on European motorways than petrol-engined models. This is due to the fact that most of these are equipped with normally-aspirated engines, which deliver higher power but develop lower torque. For the same speed, this means more frequent gearchanging – and higher fuel consumption."

### **Turbo tradition**

Jan-Erling Rydquist notes that both Swedish carmakers have a well-established tradition of building turbocharged cars. In the case of petrol-engined models, over 40% of Volvo cars are turbos, while Saab's proportion is even higher.

"Because of this, Swedish customers are relatively used to the characteristics and advantages of turbo engines – they know that turbo cars are easy to drive and develop excellent torque. This means that they should be readily disposed to change over to the diesel on the basis of improved running economy," he smiles.

On that score, there is much to be said for the diesel, even when the annual mileage is not particularly high. The price of the car is the same, the engine uses perhaps 30% less fuel and diesel oil is about one Swedish krona per litre cheaper. However, the government has to have its say! Whereas the annual vehicle tax on a V70 2.4T is SEK1,700 in Sweden, the diesel owner has to fork out SEK7,000. So why change if half of the gain is eaten up by tax?

### **Time is ripe**

Jan-Erling Rydquist believes that the time is now ripe to increase the proportion of diesel cars in Sweden too.

"In the longer term, the diesel might also be a runner in the USA," he believes, "Its main attraction is that it is more economical and does not need to be refuelled so often. This is important to the owner, who may often feel somewhat exposed and vulnerable when filling up at the service station. In addition, the car population includes a high proportion of relatively heavy vehicles. Having said that, an enormous R&D effort will be needed to comply with the very low exhaust emission limits specified in forthcoming legislation, while a great deal needs to be done in terms of fuel quality, infrastructure, exhaust gas treatment technology, market development, and so on, before this can become a reality.

"Diesel developments is driven by what is happening in central and southern Europe," he notes, "as well as by the extremely rapid technological development we witnessed in the 1990s and which is now continuing at an ever-faster pace. If only customers, not to mention politicians and decision-makers, could grasp the true facts – that the diesel is not only just as good as the petrol engine, but is actually superior in terms of overall environmental performance, when CO<sub>2</sub> is included, and significantly better as regards running economy – we could have a diesel boom here and, perhaps, also in the USA in the longer term. If the trend starts in the States, things could move fairly quickly.

"You just have to look at the industry's introduction of SUVs. In Europe, these come with a diesel option from the outset. In addition, these are now the cars which offer really significant technical scope for achieving good fuel economy without compromising performance."

### **Lightweight engine**

Jan-Erling points out that the significant differences in weight are now almost a thing of the past. Volvo's diesel and petrol engines alike are built of aluminium. 'Fully clad', the diesel weighs only 185 kg, while the petrol engine is a mere 15 kg lighter. Furthermore, the problems of cold starting and diesel noise, especially when starting from cold, have been practically eliminated. On the road, there is no longer any noticeable difference in interior noise level, while messy refuelling is only a memory.

"Today's engine naturally complies with the 2001 EU III requirements," comments Jan-Erling Rydquist. "This is achieved with the aid of the latest combustion technology and variable turbocharging, as well as post-treatment in the form of electronically controlled EGR and catalytic conversion. Exhaust emission will have to be more or less halved to comply with the next standard (EU IV) in 2005. This will call for additional measures, such as greatly improved combustion and more advanced engine management systems.

"New technologies, such as a particle filter, may also be considered. However, much work remains to be done before solutions are developed which will enable this highly promising technology to comply with reasonable demands.

"Cleaner fuels are also essential if we are to achieve very low emission levels. The sulphur content of diesel oil must be reduced to the absolute minimum in order to utilise advanced purification methods. Present levels are also too high to enable advanced diesel catalytic converters to continue to operate with satisfactory efficiency at high mileages.

"Significant emission reductions have been achieved on an ongoing basis. Today, the quantity of particulate matter produced by brakes and tyres is actually greater than that from diesel exhausts," claims Jan-Erling Rydquist. "In major cities, such as Berlin, no less than 80% of particulates in the air actually originate from human activities other than traffic."

## Late, but important arrival

He notes that the development of the first diesel engine developed in-house by Volvo took only about 40 months. From the outset, some of the specifications – such as the high specific output of 50 kW per litre, a torque of 340 Nm, equivalent to that of the most powerful petrol engines (and from a speed as low as 1,750 r/min!) and the capacity to withstand the very high combustion pressure in a light and extremely strong aluminium structure – called for extensive use of the latest development methods, including computation, simulation and analytical techniques. At present, these tools are actually so advanced that some 'durability analyses' can even be performed on proposed critical system designs and components in the computer, saving a great deal of development time and yielding more reliable solutions.

To some extent, the development of the new diesel, with its advanced technology, has taken the form of a 'race' between the various competitors on the market. Among other things, the Volvo product was the first series-produced diesel engine with the Bosch Gen II type common rail system operating at 1600 bar.

"Although Volvo joined the party late, we made people sit up when we did," sums up Jan-Erling Rydquist, referring in particular to press reaction to the new unit, for example in Germany.

### Photos

1. Jan-Erling Rydquist, who was formerly responsible for the project to develop VCC's first diesel engine.
2. and 3. Volvo's five-cylinder, transversely mounted, aluminium diesel engine is one of the most efficient on the market in terms of weight and performance.
4. The Volvo diesel features a very light 'open deck' cylinder block of die-cast aluminium with hard-wearing, integral cylinder liners of cast iron.
5. Volvo's diesel engine features a VGT (Variable Geometry Turbine) – the most advanced type available today.
- 6 and 7.. Volvo diesel cars come into their own on any type of road.

## RELATED INFORMATION

*The cylinder head, showing the piston and four-valve arrangement.*

*Cooled exhaust gases are returned to the combustion chambers by the electronically controlled EGR system, efficiently reducing nitrogen oxide emissions.*

*The Volvo diesel is the first in the world to be equipped with the second generation of the Bosch common rail fuel injection system. The solenoid-controlled injectors operate at a pressure of up to 1600 bar.*

## FACTFILE

### Volvo diesel engine specifications

**Designation:** D5244T

**Type:** Five-cylinder, in-line, 2.4 litre (81 x 93.2 mm) displacement, all-aluminium, transversely mounted

**Output:** 163 hp (120 kW or 50 kW/l specific power) at 4,000 r/min

**Torque:** 340 Nm at 1,750 r/min

**Compression ratio:** 18:1

**Total weight:** 185 kg

**Maximum length/width/height:** 601/547/594 mm

**Fuel system:** Bosch common rail, generation II, max. pressure 1,600 bar

**Valve configuration:** Four valves per cylinder, double overhead camshafts

**Emission control system:** Electronically controlled EGR, oxidising catalytic converter

**Acceleration, 0-100 km/h:** Volvo S60 manual: 9.5 seconds

**Acceleration, 80-120 km/h in top gear:** 9.5 seconds

**Fuel consumption (as per EU mixed driving cycle):** 6.3 l/100 km

**Emission levels:** Approved under EU III (2000)

**Top speed:** 210 km/h (electronically limited)

**Service interval:** 20,000 km

**(The engine is also available in a variant developing 130 hp/96 kW and 280 Nm)**

## Keywords:

Old S60, S80 (2007), V70 (2007), XC70 (2007), XC90 (2002-2014), Environment, Press Releases

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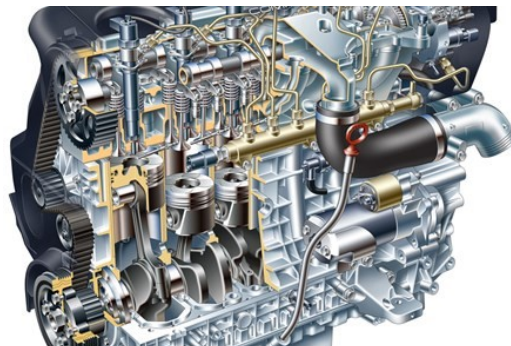
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