VOLVO

Turbo Engines

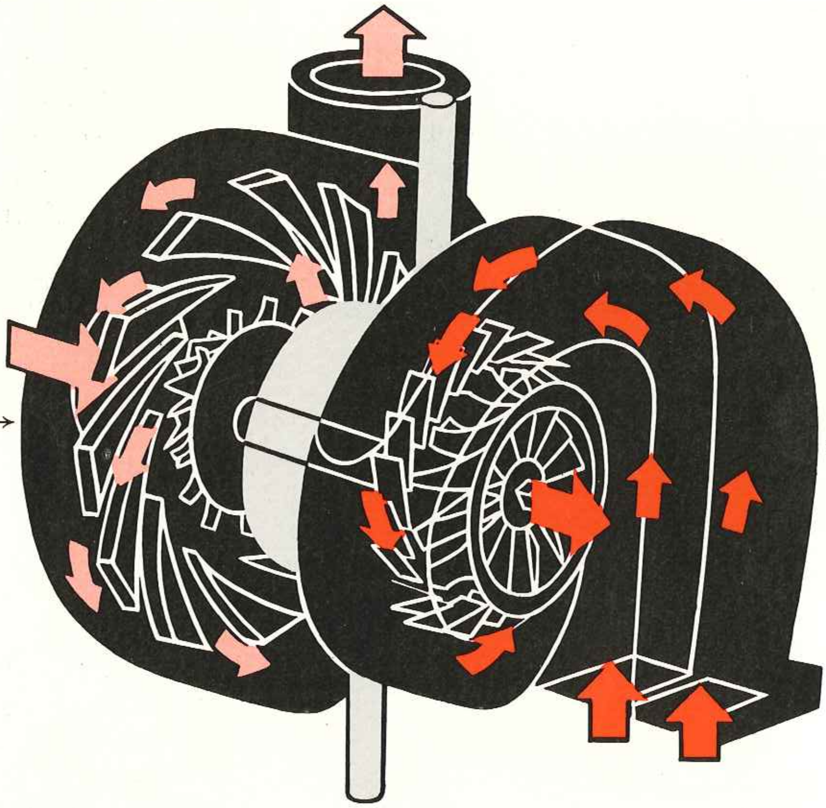
A close look at the truck — An information series from the Volvo Truck Division

Why more powerful engines?

The development of both road networks and automotive techniques has made possible the manufacture of trucks which can carry much heavier loads. Simultaneous to the increases in vehicle and vehicle combination weights grows the need for higher average speeds for reasons of transport economy and adaption to traffic rhythm. It is, therefore, necessary to increase truck engine power at a rate corresponding to these developments.

Many of the world's truck manufacturers still solve this problem by building bigger and bigger engines. This of course, gives the required increase in output but often at the price of increased engine weight and higher fuel consumption.

Turbo — a technically superior solution
As long ago as the early 1950's, Volvo chose a different method. To give the increased output Volvo started to build supercharged engines which gave the required power without any increase in displacement. As a pioneer in the field, Volvo was obliged to solve the many practical problems coupled to turbo-supercharging. The many years which have passed since then and the thousands of engines manufactured have allowed Volvo to develop an engine programme which builds on the many advantages provided by supercharging. One result of this long lead in supercharging techniques has enabled Volvo to develop an engine which will meet future requirements without departing from the reliable and economical six-cylinder in-line engine.



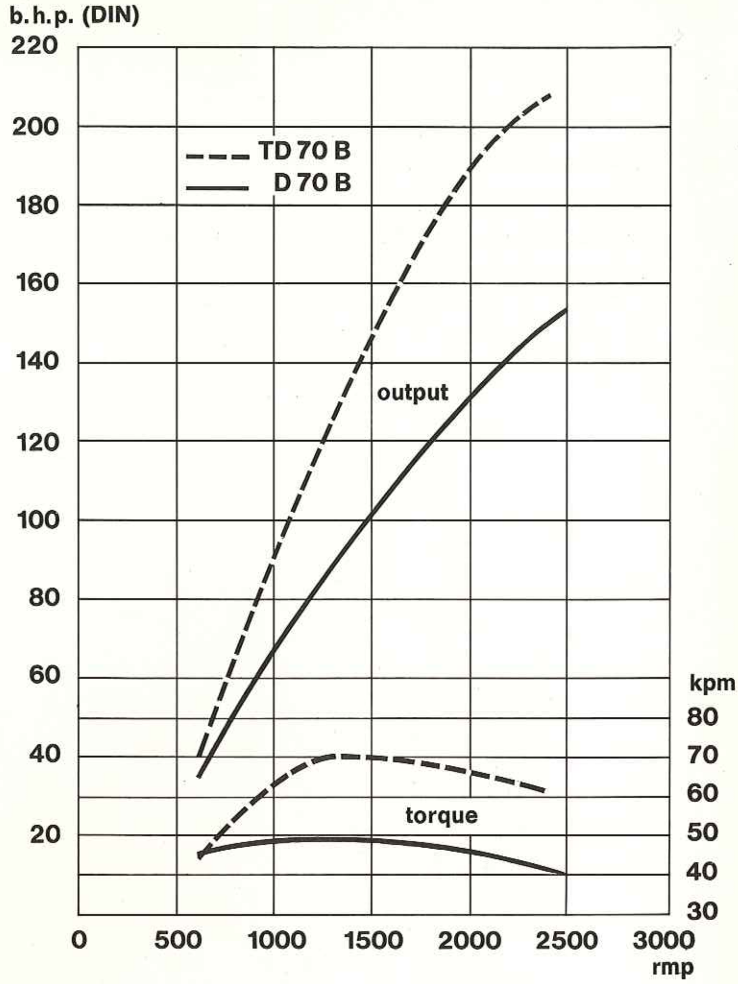
	Volvo TD 100	"Engine X"
Turbo	yes	no
Displacement	9.6 litres	13 litres
Output at 2200 r.p.m.	325 h.p.	355 h.p.
Inner frictional losses	65 h.p.	95 h.p.
Net output	260 h.p.	260 h.p.

Comparing the Turbo and normally-aspirated engines
In order to achieve the same net output without turbo it is necessary to increase displacement by about 35 % as can be seen in the table above. The larger engine has, however, larger internal frictional losses amounting to roughly 30 h.p. which must be compensated by a higher fuel consumption.

More fuel + more oxygen = higher output
The idea behind supercharging with a turbo unit is to attain higher output from an engine with a given displacement by feeding it more fuel. In order that the extra fuel can be burnt and converted into power a corresponding amount of air is required. This is achieved by forcing in air under pressure with the help of a compressor. This compressor is powered from a turbine which, in turn, derives its power from the stream of exhaust gases. The turbine and compressor sit on the same shaft and together form a Turbo unit.

Five vital advantages with turbo

Higher output from a given displacement.
The increase in power on Volvo engines is about 35 %.

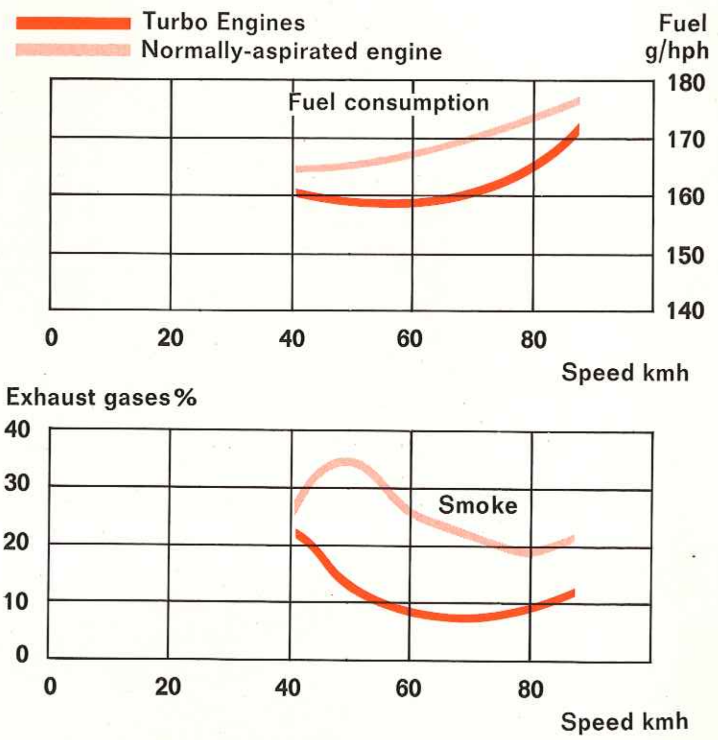


Better fuel economy.
The combustion phase in a turbo engine is more effective. Because of the surplus of air pumped into the engine combustion is much more complete than in a normally-aspirated unit. In addition, the increase in pressure brought about by the compressor lifts the temperature of the air. When the fuel is injected the compressed air in the cylinders has a high temperature which contributes to quick and complete combustion. The inevitable ignition delay is therefore cut considerably in a turbo supercharged Diesel. These factors give a lower fuel consumption.

Cleaner exhaust gases.
The almost complete combustion gives the added advantage of clean exhaust emissions.

Lower engine noise.
The reduction in ignition delay also gives a slower build-up of pressure. For this reason a turbo-supercharged Diesel runs quieter and smoother. Since a turbo engine is smaller than a normally-aspirated engine with the same output it also has a lesser expanse of "noise-generating" surface. In addition, both the induction and exhaust noises are damped by the turbo unit — the pressure waves are, so to speak, cut to ribbons.

Full output even at high altitudes.
Because of the lower air pressure a normally-aspirated engine gives reduced output at high altitudes. On the other hand, however, a turbo-supercharged engine gives practically the same output up to heights of about 2,000 metres above sea level. At this height a normally-aspirated engine would have lost about 20 % of its output.



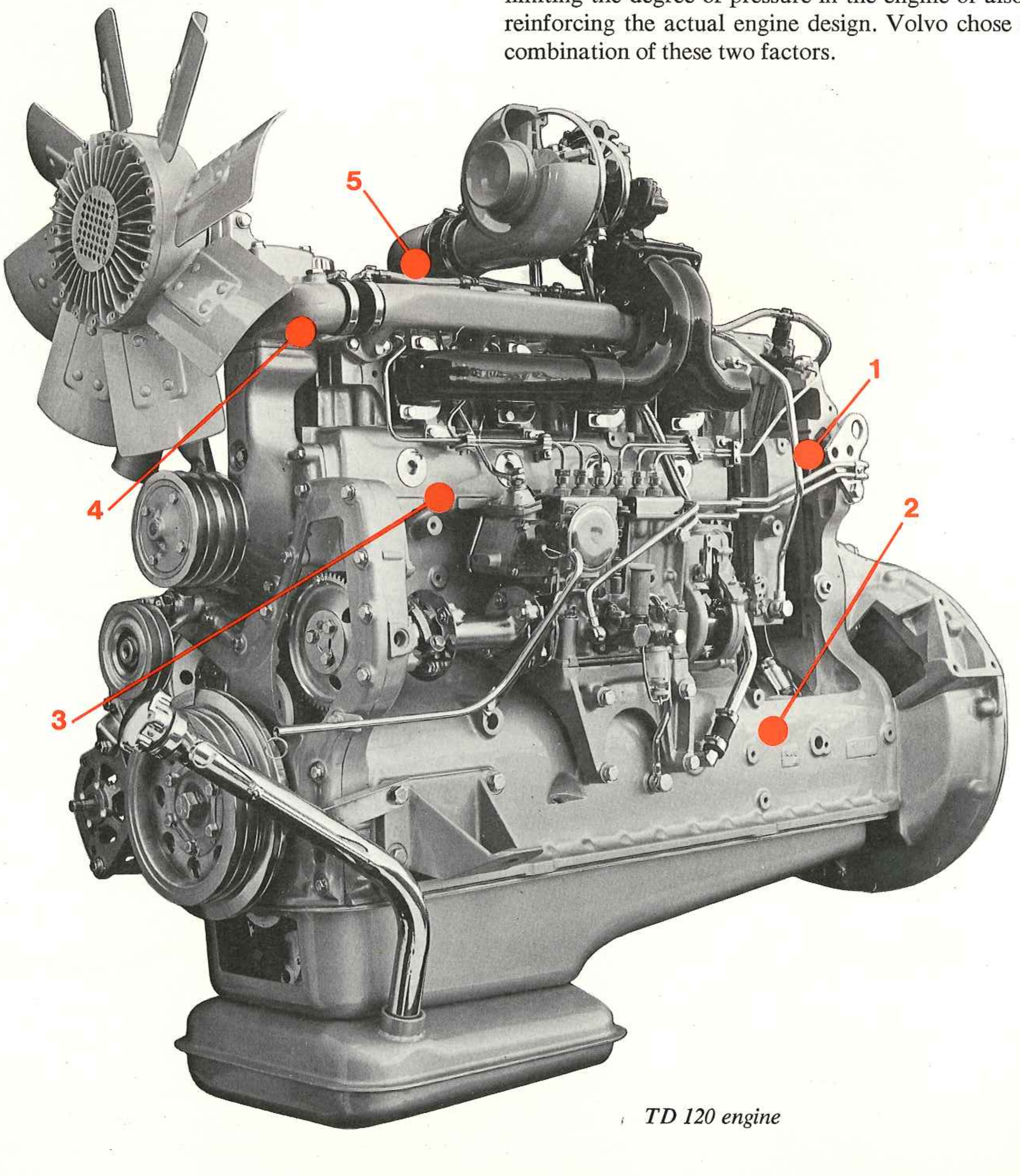
Comparative fuel consumption and exhaust smoke for a 7-litre turbo-supercharged engine and a 10-litre normally aspirated engine with the same output and maximum speed.

This is how Volvo builds a turbo engine

Turbo-supercharging does bring certain increased requirements to bear on the design of an engine. It is therefore important that the unit is intended for supercharging from the initial design stages. On the following pages we show you how Volvo has totally adapted its engines to turbo operation:

1. The higher pressures require utterly reliable sealing.
2. Loading on the crankshaft and bearings increases considerably.
3. The engine block is exposed to greater stress.
4. Higher output means greater amounts of heat — requires better cooling.
5. Turbo operation is also more requiring as regards cleaning of induction air, lubricating oil and fuel.

These requirements can be met in two manners: either by limiting the degree of pressure in the engine or also by reinforcing the actual engine design. Volvo chose a combination of these two factors.



TD 120 engine

Sealing.
The cylinder head has been "split-up" into individual units. In this manner the risks of stress and deformation in the head are cut and tightening torque can be applied more precisely. The cylinder head material is a special alloy cast iron with a very high heat resistance. The Volvo 50 and 70 engines have two cylinder heads which each cover three cylinders. The 100 and 120-series engines have one head for each individual cylinder. And Volvo's largest engine has eight cylinder head studs for each cylinder head.

The cylinder head gaskets are manufactured of solid steel and are fitted with a rubber seal around each oil and water channel. On both the cylinder head and the cylinder liner is a ridge which presses into the steel gasket from each side when the cylinder head is tightened down. This Volvo feature ensures extremely effective sealing.

Bearings.
Loading on the engine bearings is limited since all Volvo engines have a moderate compression ratio. Both the crankshaft and camshaft are of the seven-bearing type which gives not only less loading on each bearing but also resists deformation. The generous journalling of the camshaft also contributes to an exact valve timing.

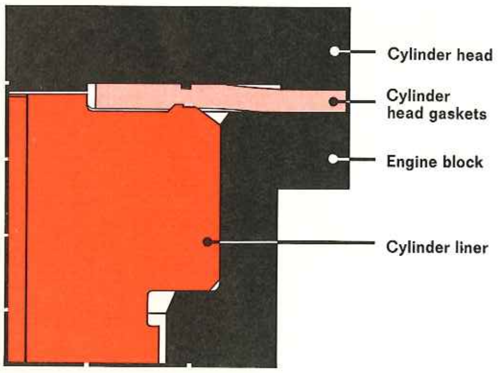
The main bearings are very large — the Volvo 120 engine has a main bearing diameter of no less than 108 mm and a total bearing area of 273 cm^2.
The gudgeon pins are also very robust — and their diameter is 45 % that of the engine bore.

Engine block.
The engine block is of very rigid and robust design. It also features reinforcements which absorb the pressure applied by the cylinder head bolts (for TD 100=50 tons per head: for TD 120=65 tons)

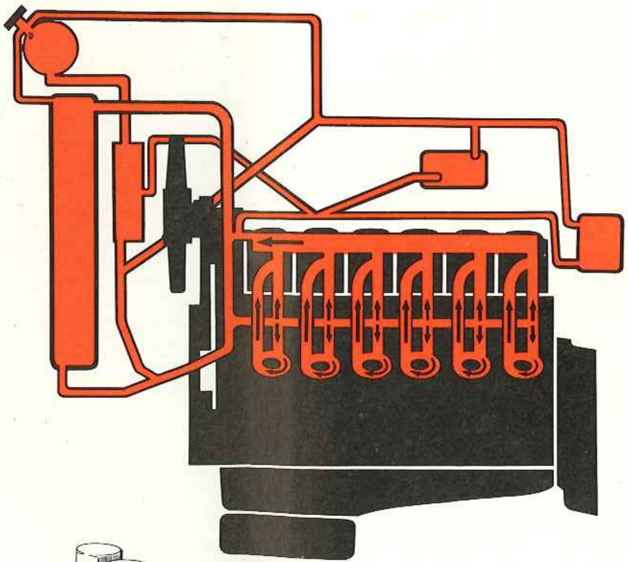
Cooling.
All Volvo engines have a centrifugal type water pump of large capacity. The cylinder liners are of wet type, that is to say they are directly encircled by cooling water. The cooling channels in the engine have been carefully and individually calibrated so that they correspond to the cooling requirements of each section of the engine. Volvo's 70, 100 and 120 engines also feature a high-location distributor channel which gives very effective cooling of the cylinder liners and cylinder head. Coolant temperature is controlled by two or three thermostats depending upon engine size. On the TD 100 and 120 engines the lubricating oil is cooled in a separate oil cooling fan. In forward-control trucks, these units have also a thermostatically-controlled fan.

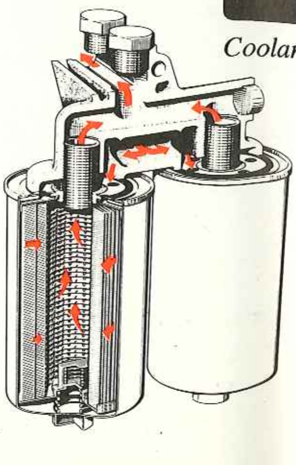
Cleaning.
If an engine is to last it is vitally important that impurities do not enter the unit in any form.

Volvo uses only paper insert filters of the disposable type. This system ensures fast maintenance and a filter which is 100 % clean after replacement. These filters have a very large effective area — in the larger engines no less than 3.5 sq.m. This results in the through-flow speed being low which, in turn, means that the degree of cleaning is extremely high. The lubricating oil filter is of full-flow type — all oil passes through the filter which gives effective cleaning even when the engine is idling.




7-bearing camshaft


Coolant system TD 120

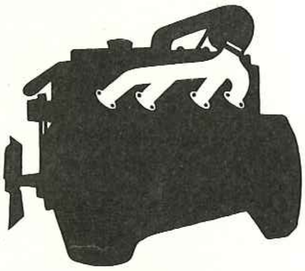

Oil filter

The Turbo engine in day-to-day use

The 15 or more years of production experience which Volvo has gained in turbo engine manufacture have resulted in the utter reliability which is today characteristic of these Volvo units. The turbo unit requires no special service. It is lubricated by the engine's normal lubrication system. Experience has shown that it is often economically advisable to overhaul the turbo unit after about 160,000 km but many run twice that distance without any trouble. At low engine speeds the stream of exhaust gases is so slow that the turbo unit is not driven sufficiently to give full output. For this reason the amount of fuel metered into the engine is controlled by means of a pressure-sensitive governor or smoke limitation device as it is sometimes known. This unit senses the partial vacuum in the induction manifold. It ensures that the engine never receives more fuel than it can effectively combust. This of course gives a slight reduction in output but this takes place within an engine speed range which is not used in normal operation.

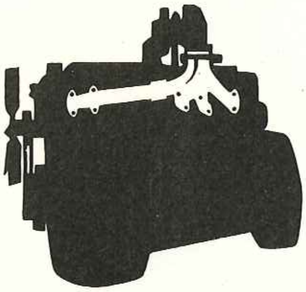
The Volvo Turbo programme

The "D" in Volvo engine designations stands for Diesel. "TD" means Turbo Supercharged Diesel. The figures indicate engine output. The last letter is changed each time the engine is altered to such an extent that one can speak of a new version.



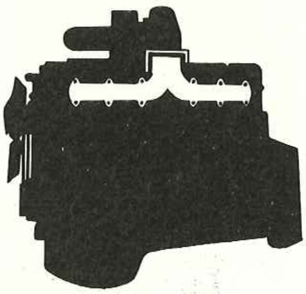
TD 50 B

Output:	165 b.h.p. DIN at 2,800 r.p.m. 170 b.h.p. SAE at 2,800 r.p.m.
Torque:	45 kgm DIN at 1,900 r.p.m. 47 kgm SAE at 1,900 r.p.m.
Displacement:	5.1 litres
Compression ratio:	17:1
Fitted to truck:	85 series



TD 70 B

Output:	207 b.h.p. DIN at 2,400 r.p.m. 210 b.h.p. SAE at 2,400 r.p.m.
Torque:	70 kgm DIN at 1,400 r.p.m. 70 kgm SAE at 1,400 r.p.m.
Displacement:	6.7 litres
Compression ratio:	16:1
Fitted to truck:	86 series



TD 100 A

Output:	260 b.h.p. DIN at 2,200 r.p.m. 270 b.h.p. SAE at 2,200 r.p.m.
Torque:	96 kgm DIN at 1,400 r.p.m. 100 kgm SAE at 1,400 r.p.m.
Displacement:	9.6 litres
Compression ratio:	15:1
Fitted to truck:	88 series

TD 120 A

Output:	330 b.h.p. DIN at 2,200 r.p.m. 330 b.h.p. SAE at 2,200 r.p.m.
Torque:	128 kgm DIN at 1,300 r.p.m. 127 kgm SAE at 1,300 r.p.m.
Displacement:	12.0 litres
Compression ratio:	15:1
Fitted to truck:	89 series

Advantages provided by Volvo Turbo

Fully effective combustion with a surplus of air gives:
a) high coefficient of efficiency
b) cleaner exhaust gases.

Moderate engine dimensions give:
a) moderate inner frictional losses, in other words, good fuel economy
b) low weight — a larger part of gross vehicle weight can be utilized for the payload.

Smooth running, low noise level.

VOLVO

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