Bentley Mulsanne Turbo and Turbo R

Turbocharging System

Extracts from Workshop Manuals TSD4400, TSD 4700, TSD4737

Basic Principles of Operation – Systems with Solex 4A-1 Carburettor

The turbocharger is fitted to increase the power, and especially the low engine speed torque, of the engine. This it achieved by utilising the exhaust gas flow to pump pressurised air into the engine at wide throttle openings. Whenever this occurs, the turbocharger applies boost to the induction system.

Under most conditions, the motor runs under naturally-aspirated principles. The inlet manifold may be under partial vacuum but the pressure chest partially pressurised under conditions of moderate power demand.

The size of the turbocharger has been carefully chosen to give a substantial increase in torque at low engine speeds. The turbocharger is especially effective from 800rpm, with the engine achieving full torque at less than 1800RPM. Thus, maximum engine torque is available constantly between 1800RPM and 3800 RPM.

By comparison to most turbocharging systems, the turbocharger capacity may appear decidedly oversized. This selection is intentional, and is fundamental to the achievement of full engine torque at low engine speeds and the absence of any noticeable delay when boost is demanded. It also minimises heating of exhaust gases by ensuring minimal resistance to gas flow under boost conditions.

Furthermore, the design has been carefully chosen to avoid the need for the turbocharger to accelerate on demand, a feature commonly referred to as spool-up. By using a large turbocharger running but unloaded when not under demand, spool-up is not a phenomenon in the system. Instead, air is recirculated when boost is not demanded. When the turbocharger is running but unloaded, there is minimal heating of the induction air as the air is not compressed. Likewise, the energy consumed by the freewheeling turbocharger is negligible.

If not correctly controlled this would result in excessive boost pressure and power output at high engine speeds.

To overcome this situation, a wastegate and dump valve are fitted.

The wastegate is fitted into the exhaust system between the engine exhaust and the exhaust exit of the turbocharger. When either the boost pressure or speed reach a predetermined level. the wastegate opens and allows a proportion of exhaust gas to bypass the turbocharger. This ensures that the power of the engine is limited to a level that will not adversely affect engine durability.

To prevent surging of the turbocharger compressor when the throttles are suddenly closed, the dump valve is fitted into the side wall of the air chest.

The assembly allows the inlet air to be recirculated from the air chest to the compressor and relieves the boost pressure when the throttles are closed.

Whenever turbocharger boost is not required, the dump valve remains open. Air is therefore recirculated between the turbocharger and the air chest. This ensures that the turbocharger continues to pump air through the system but with no resistance. Thus, the compression pressure is negligible, and power loss is minimal whilst ensuring that the system is ready to provide boost on demand and without delay.

When the throttles are opened sufficiently, the dump valve closes. The boost pressure rises rapidly to increase torque with negligible delay. The system is specifically designed to avoid any delay, a phenomenon widely referred to as turbo lag.

Turbocharger

The turbocharger is an air pump driven by the energy of the exhaust gas. The main components are the exhaust turbine, the shaft, the compressor, and the centre housing assembly.

The turbine and compressor are mounted at opposite ends of the same shaft which is supported by plain bearings within the centre housing. The compressor is contained within an aluminium alloy housing, and the exhaust turbine within a cast iron housing. Both housings are bolted to the centre housing, and the complete assembly is mounted by the turbine flange to the exhaust manifold.

The plain bearings that support the shaft have floating bushes which are lubricated by pressurized engine oil. This oil is also used to cool the bearings and the centre housing assembly.

Oil seals are fitted at either end of the shaft to prevent oil leakage into the turbine or compressor housings.

Caution. If an exhaust extraction system is used when the engine is operated in a workshop, the turbocharger oil seal arrangement may temporarily leak The leak may continue for some time after the extraction equipment has been removed. This condition is normal.

The turbocharger is lubricated by pressurized engine oil, and therefore the supply of oil stops immediately once the engine is switched off. The exhaust turbine and compressor wheels continue to spin freely for some time before coming to rest. Damage may be caused during this slowing down time due to lack of lubrication and consequential heat build-up if the system is inadvertently mistreated.

Important. After sustained high speed operation the engine should be allowed to run at the idle speed setting for at least one minute before it is switched off.

Carburettor

The carburettor is a Solex 4A-1 four-barrel two-stage unit essentially the same as that fitted to most Corniche and Camargue vehicles. It is located inside a pressure chest above the inlet manifold.

The carburettor is further refined by an economy device piston. At part throttle openings the inlet manifold depression is sufficient to overcome the spring fitted beneath the economy device piston. The piston is therefore drawn downwards, moving the twin tapered air correction needles downwards. This allows additional air to the primary air correction jets. A second addition for this application of the carburettor is the choke pull-down heater.

Fuel Pressure Regulator

The pressure in the pressure chest varies from atmospheric pressure to approximately 12 psi during transients. The fuel pressure regulator controls the fuel supply pressure to 0.28 bar (4 lbf/in², 210 mm Hg, 8 in Hg) above the air chest pressure. This avoids fuel starvation under boost conditions.

The assembly consists of a spring and diaphragm unit that partially restricts the fuel return line to the tank. Boost pressure on the diaphragm restricts the flow of fuel returning to the fuel tank, causing the fuel pressure to rise.

The base fuel pressure may be set by means of an adjustment screw on top of the assembly. The pressure is set during manufacture of the vehicle. It should not require adjustment in service.

Dump Valve

The manifold depression operated dump valve is situated in the side wall of the air chest. At low engine loads, where the manifold vacuum is greater than 368 mm Hg (14.5 in Hg), it allows air to recirculate through the air chest and back into the compressor. At higher engine loads the dump valve closes due to a fall in the manifold depression, and pressure builds up in the air chest, increasing part-throttle engine power and improving throttle progression on the primary chokes. A solenoid valve operated by a vacuum switch connects the dump valve to atmospheric pressure whenever the inlet manifold vacuum is less than 368 mm Hg (14.5 in Hg) and allows the dump valve to close.

When the vacuum switch and solenoid are de-energized by inlet manifold vacuum greater than 368 mm Hg (14.5 in Hg), the solenoid connects the dump valve to the inlet manifold vacuum which in turn, draws the valve open. The dump valve also acts as a relief valve if the boost pressure exceeds approximately 0.59 bar (8.5 lbf/in², 440 mm Hg, 17 in Hg).

Boost Inhibit

This system prevents the build-up of boost pressure when the brakes are applied with the vehicle stationary but the transmission in Drive range, and the accelerator is depressed.

When the boost limiter system control box receives the appropriate signals – the brake light switch or the TPS throttle position switch - to indicate that the above conditions prevail. the boost limiter system is activated.

Boost Limiter

A boost limiter system is used to control the maximum speed of the engine. This is achieved by limiting the amount of boost pressure supplied to the engine. The Electronic Control Unit (ECU) used in the system senses when maximum allowable road speed is approached, and also activates an electrically-operated vacuum pump mounted under the wing on the right hand valance. The vacuum pump operated the vehicle speed control system under conditions of turbo boost.

At maximum road speed, the ECU energises a solenoid valve which connects the vacuum pump to the end connection on the wastegate. The vacuum applied opens the wastegate to limit the boost pressure and, hence, the speed of the engine.

Exhaust Gas Wastegate

The exhaust gas wastegate is used to control the boost pressure by regulating the flow of exhaust gas to the turbocharger turbine. This controls the energy available for compressing inlet air.

The boost pressure is taken from a tapping at the end of the turbocharger compressor volute, and acts on a diaphragm connected to the wastegate valve. As the boost pressure rises, the diaphragm acts against a spring and at a predetermined pressure the valve lifts off its seat, diverting some of the exhaust gas and limiting the boost pressure.

Cooling Requirements

Under most conditions, the motor runs under naturally-aspirated principles. Thus, there is no change in cooling requirements under those conditions. Under slow and stationary conditions, the turbocharger is not providing induction boost. When underway and under boost, air flows are such that localised heating is not inherent. However, special attention has been made to avoid the possible heating of components by radiation, particularly where exhaust components have been located to suit turbocharging.

For a given output power, under boost the turbocharging system increases the efficiency of power delivery. As such, the overall engine cooling requirements are reduced compared to vehicles without turbocharging. The cooling system on turbocharged cars, however, has not been reduced in capacity.

Localised heating by exhaust gases and compressed air may occur. As further protection, there is extensive use of supplementary heat shields to eliminate any likelihood of damage to critical suspension, steering and electrical components. Some heat shields were not originally fitted during production to the earliest vehicles. Those are the subject of a retrofit programme in accordance with service bulletins. Of particular importance is the heat shield for the power assisted rack and pinion unit, where the exhaust connection from the B-Bank passes nearby. This shield must be kept clear of debris and in good condition. Likewise, important are the shield for the turbocharger and those for the front suspension rear bushes. The hydraulic accumulators are relocated to the B-Bank due to space requirements, and the location and heat shields offer improved heat protection over naturally-aspirated vehicles.

Bentley Turbo R – Fuel Injected Systems

With the commencement of the 1987 Model Year, the carburettor is replaced by a Bosch KE-2 Jetronic fuel injection system. This is a mechanical fuel injection system with electronic fine control of mixture.

The basic function of the system is unchanged from that of the early carburettor systems, specifically in that the recirculative air feature and wastegate systems function identically. The turbocharger itself remains unaltered.