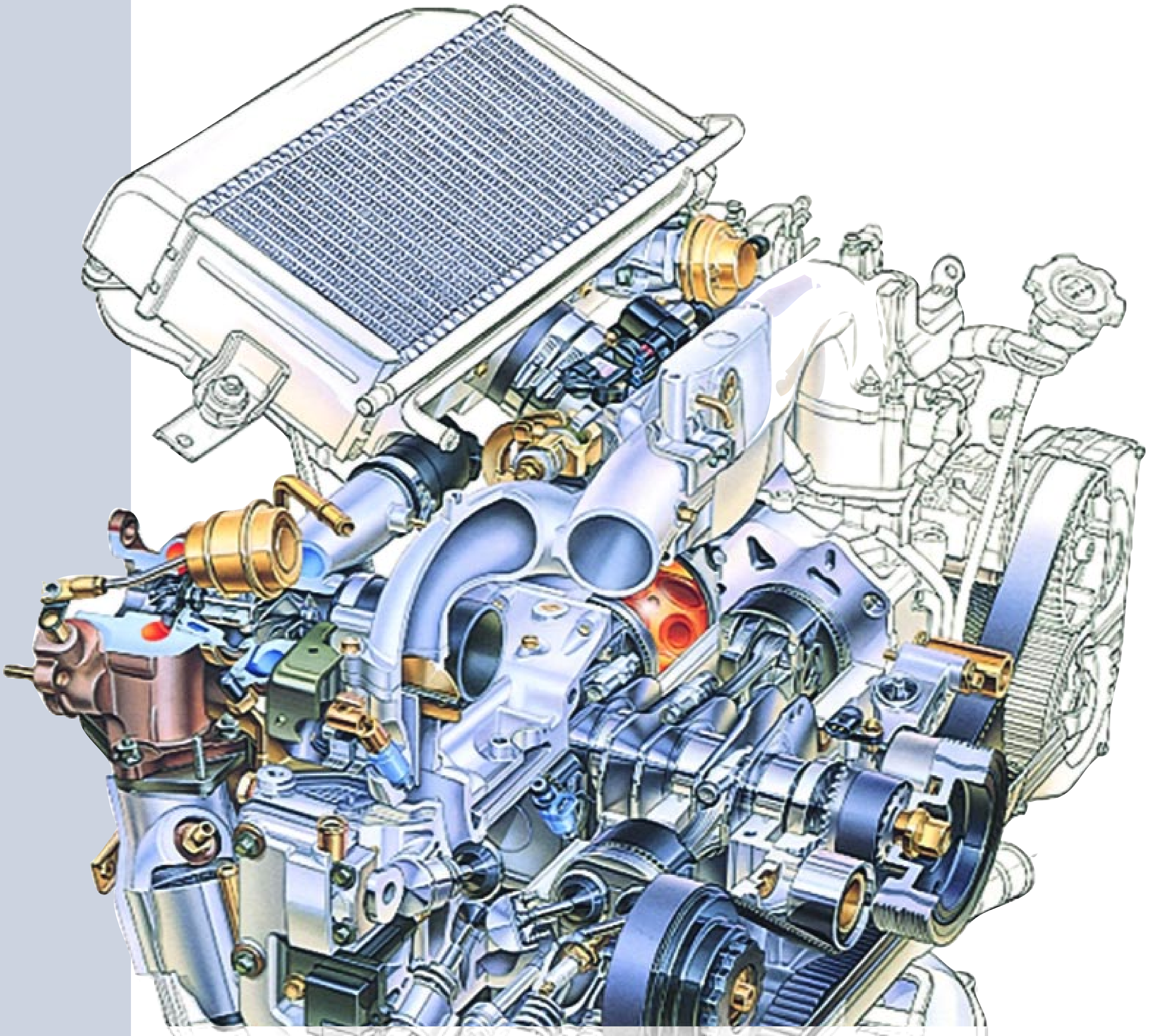


WRX Turbo Tech

The EJ-2.O engine is a double overhead camshaft engine equipped on all turbocharged Impreza vehicles. The timing belt procedure and routing is very similar to other Subaru DOHC, engines, however, the increased power output of the engine requires the use of an additional timing belt idler pulley. Manual transmission vehicles are equipped with additional belt guides that function during deceleration or fuel cut from high rpm running conditions. When servicing the timing belt return all idler pulleys and belt guides to their original positions.

The left bank intake camshaft sprocket is metallic and the camshaft reluctor is built into the backside. The timing marks for belt installation are at 12:00 (I) and 6:00 (II).

The left exhaust sprocket is made of a resin material. Its timing marks should be at 12:00 (II) and 3:00 (I) during belt installation. The exhaust 12:00 (II) mark lines up with 6:00 (II) of the intake sprocket. (A timing belt guide is located at the lower left side of the sprocket of manual transmission models.)

The right intake sprocket is also made of a resin material. During belt installation, its timing marks should be at 12:00 (I) and 6:00 (II). A timing belt guide is located at the upper left side of the sprocket of manual transmission models.

Finally, the right exhaust sprocket is made of a resin material. Its timing marks during belt installation should be at 9:00 (I) and 12:00 (II). The exhaust 12:00 (II) mark lines up with 6:00 (II) of


Left Bank Intake Cam Sprocket Timing Marks

the intake sprocket. A timing belt guide is located at the lower left of the sprocket on manual transmission models.

The engine class number is located near the front of the engine, behind the oil-sending unit and in front of the engine coolant temperature sensor.

A coolant pipe sealed with a rubber plug is installed at the factory. Do not remove the plug to service any part of the cooling system.

The EJ-2.0 valvetrain is the same design used on other Subaru DOHC engines. A new shim tool has been developed to allow valve adjustment without removing the camshafts. However, the camshaft inner cover, camshaft sprockets and camshafts must be removed to access the cylinder head bolts.

The rear of the right bank cylinder head serves as the mounting point for the oil and coolant return passages for the turbocharger.

Tumble Generator Valve

The EJ-2.0 engine is equipped with a tumble generator valve at each intake runner. This new system uses a shaft for each side of


Intake Tumble Generator Valve

the shaft is monitored by a sensor on the opposite end.

The shaft operates the tumble generator valve, which is a plate similar in design to the throttle plate. At idle the plate is closed (depending on coolant temperature and time from engine start). Off idle the plate is open.

When the plate is closed the

main air passage through the intake runner is blocked. This will force all air necessary for engine operation during idle to flow through the bypass channel. This action helps to mix the air fuel mixture by producing a tumbling effect to the incoming air, resulting in a cleaner operating engine while idling.

The new fuel injector is a top feed type with 12 holes. The new hole pattern produces a finer spray of fuel which assists with lowering the overall emission output of the vehicle. (No air assist on Turbo models.)

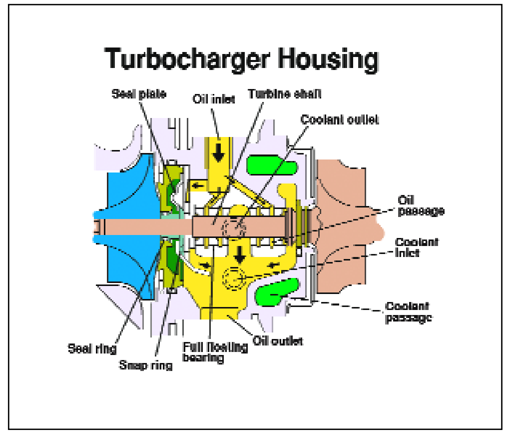
Fuel Injector

Turbocharger

The introduction of the 2.0 liter engine to the US market reintroduces the turbocharger, which was last used on the 1994 Legacy 2.2 liter. The new turbocharger and fuel system have been designed to produce higher engine performance and lower exhaust emissions.

The turbocharger consists of two sections: an exhaust side and an induction side. The exhaust side has a turbine wheel with vanes that are shaped to harness the exhaust gas energy. This drives the turbine and center shaft . On the induction side, an impeller wheel is attached to the center shaft, It also has vanes, but they are shaped in the opposite direction.

The movement of the wheel compresses the induction air as it rotates. Increasing engine speed and load increases the level of kinetic energy in the exhaust gas, making the turbine rotate faster. This causes the impeller, which is attached to the common center shaft, to also rotate faster, creating

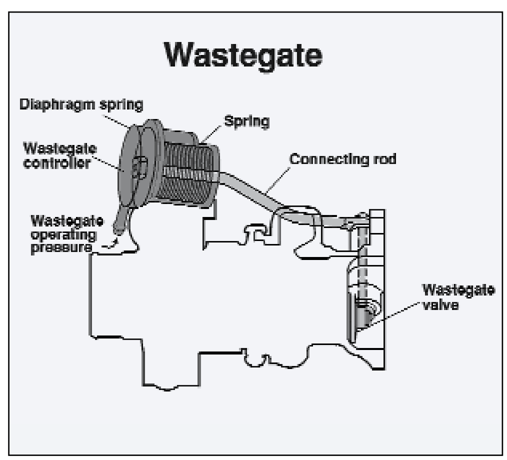


Turbocharger Cross-Section

greater compression of the induction air. Rotational speeds of the turbine are in the range of 20,000 rev/min. at idle, to 150,000-200,000 rev/min. at full power. These very high operating speeds and temperatures make lubrication and cooling of the center shaft bearings of prime importance.

The shaft bearings are lubricated by a constant supply of engine oil. An oil cooler positioned above the oil filter transfers heat from the oil to the engine coolant. Further cooling of the turbocharger is achieved by coolant fed from the right cylinder head to coolant passages around the exhaust turbine bearing.

There is a limit to the amount of boost pressure that can be used, due to the engine's design capabilities. The boost pressure is limited by a wastegate, which bypasses the exhaust gas around the turbine wheel when the desired level of boost is reached.



Wastegate

The ECM references a boost pressure map programmed into read only memory (ROM) after first reading the input signals. By calculating the actual boost pressure, and after compensating for engine temperature and atmospheric pressure, the ECM is able to provide an output duty ratio signal to the wastegate control solenoid. This regulates the amount of pressure applied to the wastegate controller diaphragm by leaking off boost pressure to the inlet side of the turbine.

The wastegate controller (in response to the duty solenoid) opens the wastegate flap valve to bypass exhaust gas and so decrease the rotating energy of the turbine keeping the boost pressure to the desired level.


Wastegate Control Solenoid

When operating at increasing altitudes, the atmospheric pressure becomes lower and therefore the difference between the desired level of boost pressure and atmospheric pressure becomes greater. To maintain the same level of boost pressure the air must be compressed more which requires more turbine rotating energy. Therefore less boost pressure is applied to the wastegate controller via the solenoid valve and boost remains constant.

However, at very high altitudes the extra compression of the air at maximum boost causes a too high intake air temperature even after intercooling and engine knock will occur. Therefore it is necessary to decrease the maximum boost pressure at very high altitudes.

Turbocharger Testing - Wastegate Control

Attach a regulated pressure sup-


Wastegate Valve Inside Turbo Housing

components in the boost control system, be sure that the wastegate is operating correctly.

Utilizing a dial gauge, measure the radial movement of the turbine shaft by accessing it through the oil outlet hole. Radial play should not exceed 0.17mm (0.006 inches).

To measure the axial movement of the turbine shaft, place the dial gauge against the end of the shaft at the turbine end, and push against the compressor end of the shaft. Axial play should not exceed 0.09mm (0.003 inches).

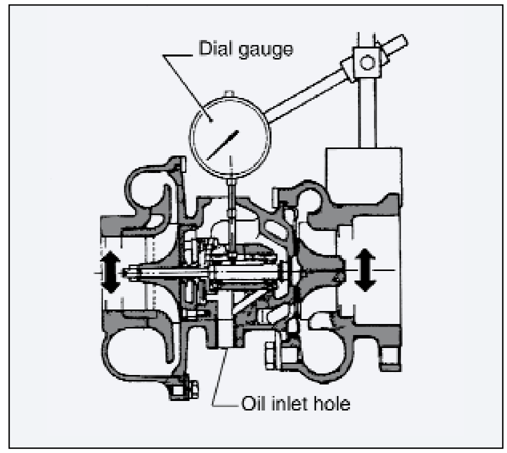

Turbocharger

Intercooler

The turbocharger compresses the intake air by using wasted exhaust gas energy. The turbocharger turbine is driven by exhaust gas, causing the compressor wheel to rotate. By compressing the intake air, the volumetric efficiency of the engine is greatly improved.

The compression of the intake air by the turbocharger causes an increase in air temperature, so an intercooler is located between the turbocharger and the intake manifold. The intercooler reduces the temperature of the intake air from 248-266° F (120-130° C) down to 158-176 F° (70-80° C) under normal operating conditions.

An air bypass valve redirects high pressures from the intercooler back to the inlet side of the turbocharger under deceleration.



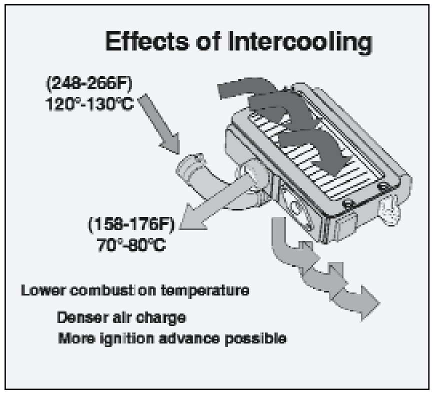
Turbocharger Bearing Testing

The temperature of the intake air is increased as it is compressed by the turbocharger. This rise in temperature causes a corresponding expansion of the air, leading to a reduction in air density. The intercooler is designed to transfer the heat of the compressed intake air to the external air flowing through as the vehicle is in motion.


Intercooler

There are two positive byproducts of decreased air temperature and increased air density: one; a reduction in combustion chamber temperature allowing for more advanced ignition timing, and two; improved volumetric efficiency due to the increase in air mass for a given air volume. With a denser air charge into the combustion chamber, more fuel can be injected, leading to greater power output.

The air bypass valve is located after the turbocharger, and provides a bypass passage for the compressed intake air back to the inlet side of the turbocharger. When deceleration occurs immediately after a period of high engine load (high boost pressure), a large pressure differential occurs at the compressor wheel of the turbocharger. This is due to the inertia of the turbocharger, which still generates boost pressure even though the throttle is fully closed. This high pressure may lead to increased



Effects of Intercooler

noise, and possibly damage the turbocharger due to the high pressure exerted at the compressor.

The upper chamber of the bypass valve is connected to the intake manifold, and the negative pressure (vacuum) during deceleration opens the valve by acting on the diaphragm.

Operation of the valve can be tested by attaching a hand held vacuum pump to the intake manifold connection. Apply a negative pressure with the pump and confirm that the valve opens.

Ambient Air Temperature and Pressure

As air temperature rises, the ability of the turbocharger to compress the air decreases. This phenomenon is directly due to the decrease in air density and the physical limitation of the turbocharger. Even when air temperature is low, the air density (barometric pressure) may be low. Under these conditions, lower than expected boost pressures may be experienced. Again this is due to the physical limitations of the turbocharger.

Intercooler Interior

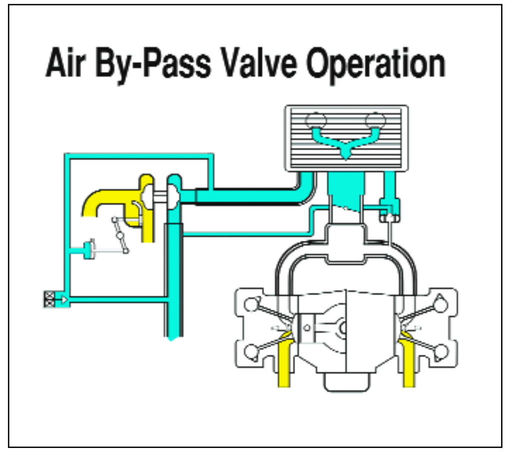
Exhaust Diameter

The diameter of the exhaust system will vary the pressure difference across the turbine. A larger exhaust allows the turbocharger to rotate faster, which results in higher boost pressures. Any increase in boost pressures would require ‘re-mapping’ of the ECM programs to accommodate different air flow rates and resultant ignition change requirements. Over speeding of the turbine can lead to turbocharger failure, particularly in conjunction with the increase in the pressure differential across the turbine.

Intercooler Air By-Pass Passage

Fuel Octane Rating

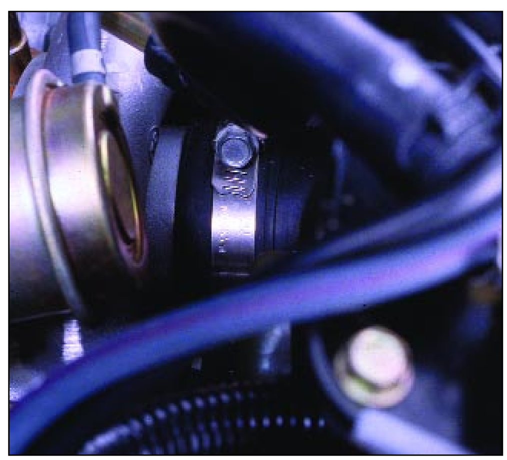
The high combustion pressures resulting from the increase in volumetric efficiency require a high-octane fuel. If the octane of the fuel is too low, knocking will occur. The end result of knocking is damage to the engine. The ECM is programmed to retard ignition timing if knocking is detected. Excess knocking will cause the ECM to enter a ‘Fail-safe’ mode where the boost pressure is reduced to the minimum value determined by the wastegate actuator.



Air By-Pass Operation

Turbo Lag

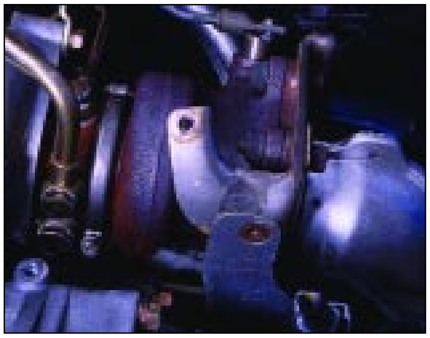
The pressure of the exhaust gas is low at low engine speeds. As the turbocharger uses exhaust energy to operate, it does not respond immediately when the throttle is opened. This phenomenon is referred to as ‘turbo lag.’ In an attempt to overcome this phenomenon, design characteristics of the turbocharger are matched to the prospective use of the vehicle.



Turbocharger Outlet Hose Clamp

Turbocharger Removal

Turbocharger removal is accomplished by first removing the intercooler mounting bracket. Then remove the eight bolts that secure the protective



Turbocharger Mounting Bracket

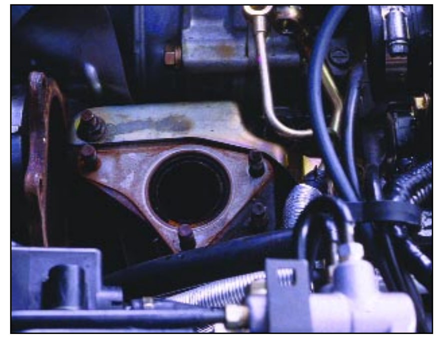
heat shield around the turbo.

Raise the vehicle and disconnect the rear oxygen sensor harness and remove the front exhaust pipe mounting bolt. Position the pipe so that there is some movement. Lower the vehicle and disconnect the wastegate hose to the vacuum hose leading to the wastegate control solenoid. Remove the coolant hose from the reservoir that connects to the turbo.

Disconnect the turbocharger outlet hose clamp and the small metal bracket that connects the cylinder head to the base of the turbocharger (strengthens the upper portion of the cross over pipe). Loosen the oil supply metal pipe at the cylinder head. Remove the banjo bolt and secure the copper washers from the top of the turbocharger. Gently pull the oil supply metal pipe away from the turbocharger.

Place a shop towel between the turbocharger and the engine and remove the two banjo bolts that secure the coolant supply and return hoses. Catch the copper sealing washers (two per bolt) or find them in or on the shop towel. Remove the shop towel.

Remove the five bolts that secure the turbocharger outlet to



Turbocharger Mounting Flange

the exhaust and slide the pipe back to clear the studs. Remove the gasket at this time.

Remove the three nuts that secure the turbocharger to the cross over pipe and secure the gasket (inlet). Remove the turbocharger from the engine compartment and cover all opening in the exhaust and on the turbocharger.