SUBARU

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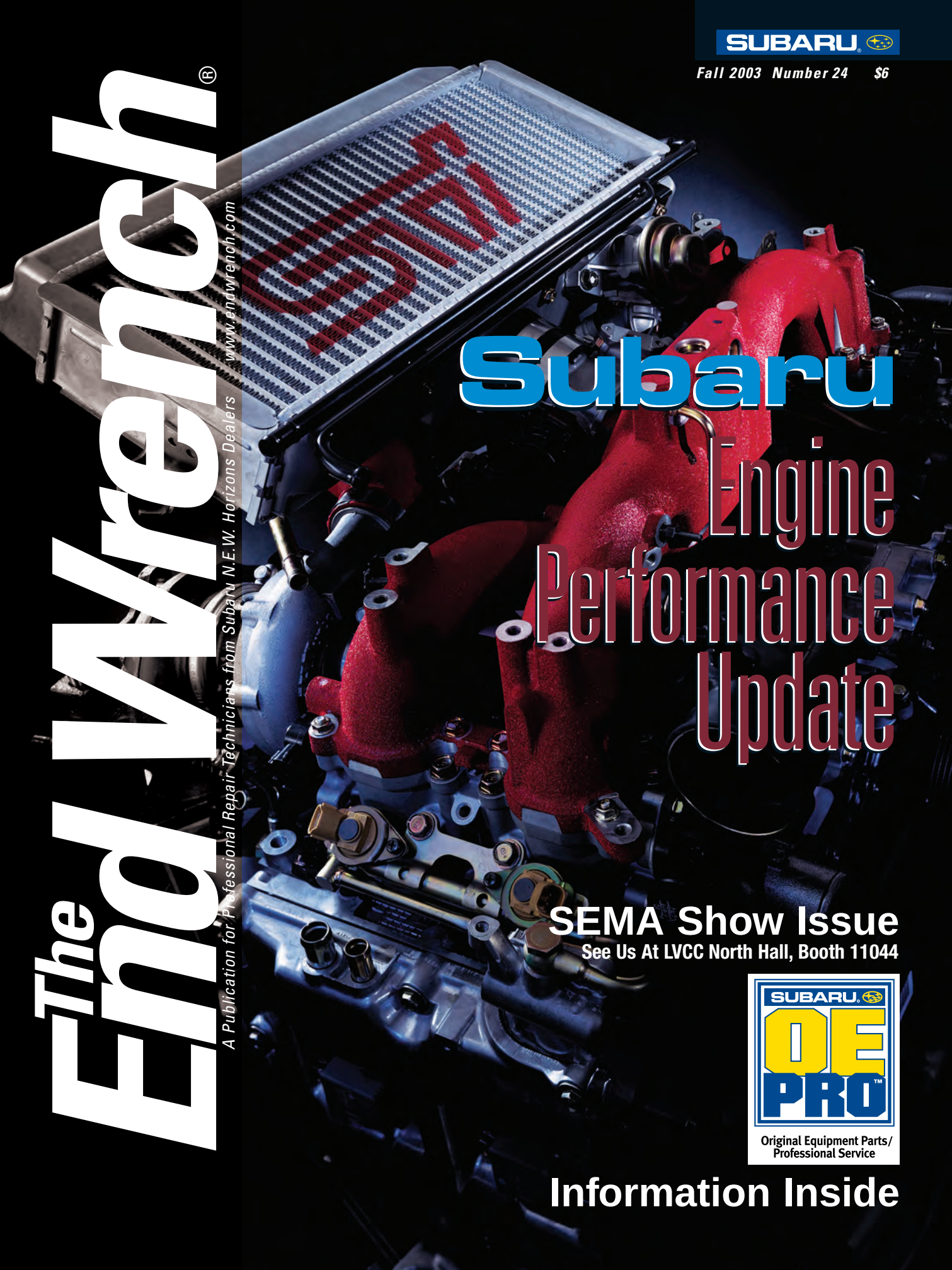
The End Wrench®

A Publication for Professional Repair Technicians from Subaru N.E.W. Horizons Dealers www.endwrench.com



Subaru Engine Performance Update

SEMA Show Issue

See Us At LVCC North Hall, Booth 11044

SUBARU OE PRO™

Original Equipment Parts/ Professional Service

Information Inside

CAUTION!

This ad contains fast moving parts.

More new performance parts for the Subaru Impreza WRX, WRX STi and 2.5RS models!

To meet the Subaru enthusiast's relentless demand for even greater performance and—let's be honest—even hotter appearance, Subaru continues to expand our line of Subaru Performance Tuning (SPT) parts including STI, Eibach® and KYB® products. STI ceramic/metallic clutch discs and clutch covers. STI chromium/molybdenum flywheels. Heavy duty STI timing belts and brake hose sets. STI performance suspension kits. Titanium shift knobs, turbo gauges and more. They're all available now at your local authorized Subaru dealer, or check out the full line of Genuine Subaru Performance Parts at **www.spt.subaru.com**.

SUBARU
DRIVEN BY WHAT'S INSIDE™

Note: Not all parts applicable to all models/model years.

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Caution:
Vehicle servicing performed by untrained persons could result in serious injury to those persons or others.

Information contained in this publication is intended for use by trained, professional auto repair technicians ONLY. This information is provided to inform these technicians of conditions which may occur in some vehicles or to provide information which could assist them in proper servicing of these vehicles.

Properly trained technicians have the equipment, tools, safety instructions, and know-how to perform repairs correctly and safely. If a condition is described, DO NOT assume that a topic covered in these pages automatically applies to your vehicle or that your vehicle has that condition.

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SUBARU

inside

SUBARU OE PRO™
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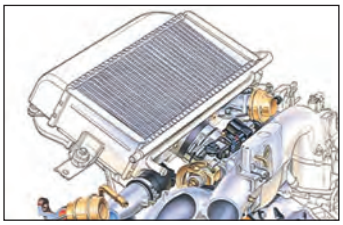
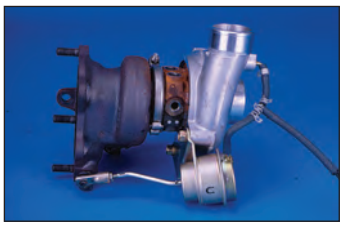
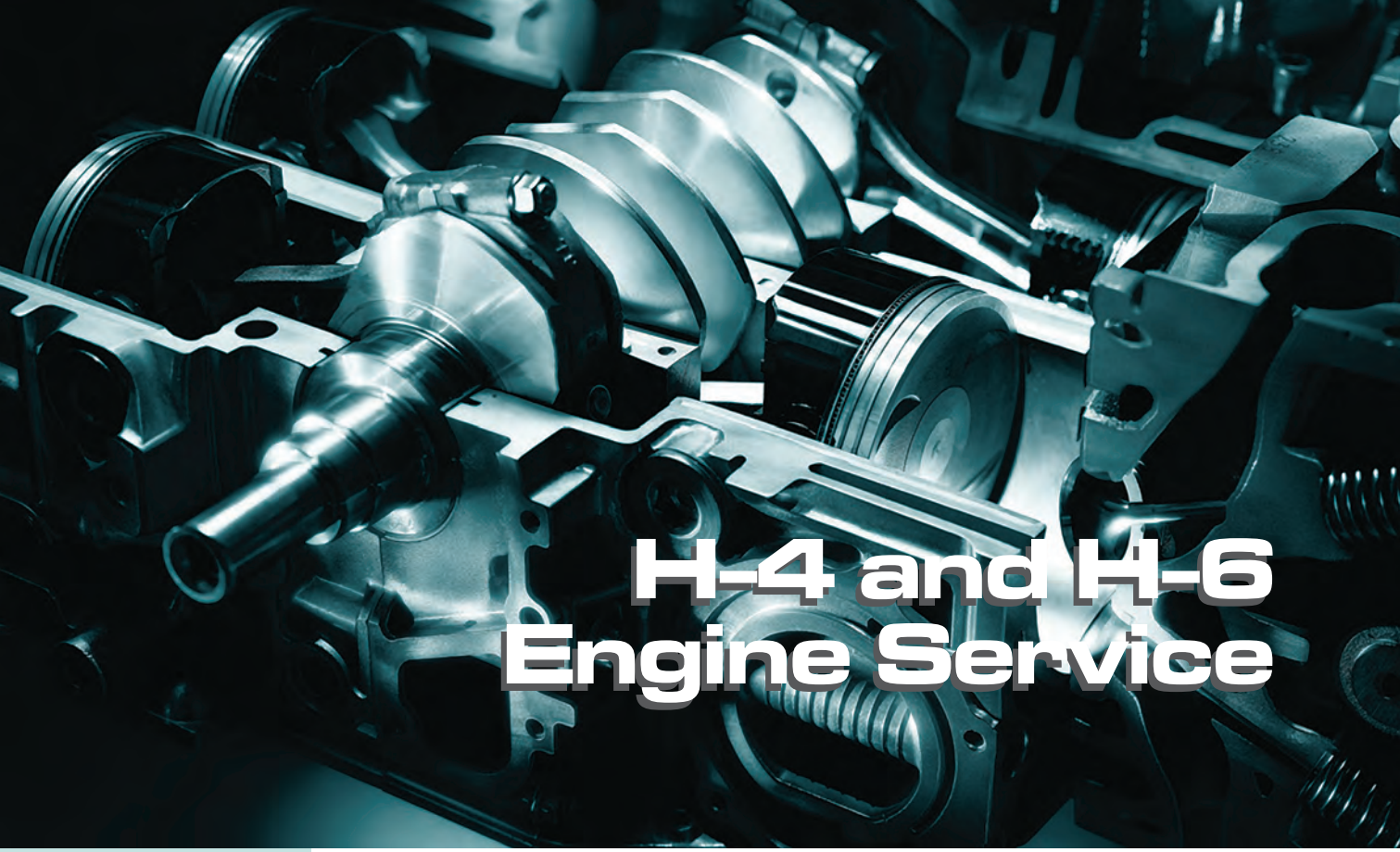






H-4 and H-6 Engine Service

The engines used in all Subaru models have received major changes and upgrades in the past few years, and some completely new engines have also been introduced. We'll explain the changes, especially as they relate to your vehicle service efforts.

2.2 Liter Phase 1 Engine Enhancements

The 2.2 liter Phase 1 engine has been enhanced, starting with 1997 model year. The single overhead camshaft (SOHC) engines have had internal and external changes that yield an approximately 10% increase in power and 3% increase in fuel economy. Accomplishing this involves many factors, one of which is engine friction reduction.

The piston, a major source of engine friction, has been coated with a friction reducing agent called molybdenum. This thin coating not only allows a smoother travel through the cylinder but also reduces cylinder wall scuffing. This coating will wear off over time and is not an indication of a problem.

The skirt of the piston has been reshaped and the overall weight has been reduced by approximately 100 grams. Compression ratio has been increased to 9.7 to 1 by reshaping the crown of the piston. This eliminates the clearance that was available between the piston at TDC and a fully opened valve. Piston pin offset has been changed to 0.5 mm. Piston to cylinder wall clearance has been reduced by increasing the piston diameter.

Another source of engine friction is the valvetrain. Hydraulic lash adjusters are always in contact with the camshaft or valve rockers. The hydraulic pressure of the lash adjuster must be overcome during operation and engine starting. To overcome this situation and to contribute to the total reduction of friction loss, the SOHC engines have solid valve adjusters.

The scheduled service of these valvetrains is set at 100,000 miles. The SOHC engine uses an adjustment screw and locknut. Follow the instructions below for setup and adjustment. Tools required for 2.2 valve adjustment are: thickness gauge, 10mm wrench, stubby standard screwdriver, crankshaft wrench.

Step 1

Remove the right bank camshaft outer cover. Standard value clearance:
Intake valves 0.20 ± 0.02 mm
Exhaust valves 0.25 ± 0.02 mm.

Rotate the engine until the arrow on the camshaft sprocket is at 12:00. The camshaft sprocket has an arrow and a mark for belt timing. Make certain the arrow is used, not the mark for valve adjustment only.

Using a standard thickness gauge, measure the clearance of the intake and exhaust valves on cylinder 1 only. Adjust the clearance by loosening the locknut and turning the adjustment screw until the proper clearance is obtained.

Adjusting Valve Clearance

Step 2

Rotate the engine until the arrow on the camshaft sprocket is at 3:00. Check and adjust the clearance of the intake and exhaust valves on cylinder 3 only.

Step 3

Rotate the engine until the arrow on the camshaft sprocket is at 6:00. Check and adjust the clearance of the intake and exhaust valves on cylinder 2 only.

Other Engine Modifications

The intake manifold has been reshaped to increase the airflow mass and speed, contributing to improved low and mid engine speed operation. Components located on the intake manifold have been relocated as compared to the 1996 models. EGR Solenoid, Purge Control Solenoid, etc.

1999 2.2 Liter Phase 2 Engine Enhancements

All 2.2 liter engine for 1999 are the Phase 2 design. The 2.2 liter Phase 2 engines are a SOHC design, with a newly-designed cylinder head. Changes in the 2.2 liter Phase 2 engines are as follows:

- The engine and transmission are fastened with six bolts and two studs.
- The thrust bearing has been moved to the number 5 position.
- The oil groove in the number 1 and 3 have been changed to supply additional lubrication to the crank journal.

Additional Phase 2 Engine Features

- The cylinder head is a two-rocker shaft, solid type valve system with roller followers.
- The valves are positioned at a larger angle than previous model years. The intake valves are positioned 23 degrees off-center with the exhaust valves positioned 20 degrees off-center. Prior model year engines utilized a 15-degree positioning angle.

Identification of Rocker Arms

- The intake rocker arms are marked so they are correctly placed on the rocker shaft when servicing. An IN1 or IN2 will be embossed on each rocker arm. As viewed from the front of the engine the Number 1 intake valve of each cylinder and the number 2 intake valve have an IN1 marked and IN2 marked rocker arm that mates with it. New IN1 rocker arms can also be identified by a Green painted mark on the top of the rocker arm. The IN2 rocker arms have a white mark. Proper positioning is maintained through the use of a wave washer located between the rocker shaft arm and rocker arm shaft support.
- The camshaft is secured to the cylinder head with the camcase. An oil passage in the cylinder head provides the passageway in the camcase with oil that leads to the intake rocker shaft. Oil from the camshaft is collected on the opposite side of the passageway leading to the intake rocker shaft to provide oil to the exhaust rocker shaft.
- Sealing of the camcase is accomplished by using a thin layer of Three Bond (1280B) applied in the channel around the camcase edge. After the three bond is applied, the camcase must be installed to

Continued on page 8.

Original Equipment Parts/
Professional Service

Subaru Takes Care of Business On the Road. At the Track. In the Field.

There's great satisfaction when someone you depend on comes through for you. That kind of trust and teamwork isn't easily earned. At Subaru, we appreciate the support from independent repair technicians throughout the country. You play an important role in keeping Subaru owners happy with their car's performance by using Genuine Subaru Parts on a regular basis. In fact, more Genuine Subaru Parts are being purchased by independents like you than ever before.

So, it's only right that you feel that you can depend on Subaru and the O.E.PRO team when it comes to helping you do your job. That's why we go to great lengths to ensure our prices are competitive. So you have margins that give you breathing room. It's also why we test every Genuine Subaru Part to guarantee it performs up to original equipment specifications.

To help your business, we also continually add new parts to the O.E.PRO Program and to the SPT and STI Performance Parts lineup. We back that up with our popular performance parts Web site, www.spt.subaru.com. Keeping a display in your shop and promoting your performance and styling capabilities can help generate a whole new cash flow.

Another way that Subaru also helps independents thrive is with a substantial investment in the racing scene from the international road rallies to the local SCCA events. Beside the fact that we love driving and watching Subaru vehicles perform at these venues, it helps spread the word that Subaru is a serious performance machine that can more than hold its own. And that's what you want in a partner: someone who takes care of business in every way that matters.

Subaru Spotlights SPT and Performance at SEMA

With the introduction of many new SPT and STI Performance Parts, including the great new 3-inch "cat-back" WRX Performance Exhaust System pictured here, Subaru should be drawing quite a crowd at the Specialty Equipment Marketing Association show taking place November 4 – 7 at the Las Vegas Convention Center. This year's booth for Subaru (#11044 - North Hall) will be a real treat. It'll showcase a variety of hot Subaru project vehicles, the Easy Street Motorsports Drag Racing 740 horsepower WRX, a 500 horsepower Baja, a replica of the Subaru U.S. Rally Team car and more. From new performance suspension bushings that help improve handling to new STI transmission and engine mounts to stylish SPT accessories like the Momo shift knob, plenty of interest at SEMA will be focused on the incredible Subaru Performance Tuning story.

This 3-inch "cat-back" muffler system is just one of the many new Subaru Performance Parts that will generate a lot of interest from your performance-oriented customers.

O.E. PRO CORNER

The Thrill of High Performance Racing

Over the past few years, Subaru has earned great respect in racing circles. As an independent Subaru automotive technician, you have a great opportunity to cash in on the huge interest in racing and performance with sales and installation of both SPT and STI Performance Parts and accessories. You can turn a Legacy, RS or WRX into a performance machine. Here's a quick review of where to find the thrills and opportunities in the exciting world of automotive racing.

Rally Racing Offers True Excitement and Speed

The draw of rally racing is the thrill of following a course through challenging terrain at the fastest time possible. When the Subaru Rally team takes on SCCA courses in the ProRally circuit, they know they can depend on the response of their carefully prepped WRX vehicles to handle everything from the wintry roads of "SnoDrift" in Michigan to the dusty switchbacks of "Rim of the World" in California. And their performance on the international rally scene has also been impressive. You can get your own customers involved in local rallies that the SCCA runs and share in the excitement by helping them create a car that's a kick to drive.

Drag Racing WRX Sets a Blistering Pace

Ever since two cars lined up side-by-side, drag racing has been part of the American landscape. Subaru has been making a big name for itself lately in this category, too, with a revved-up WRX that blisters down the quarter mile drag strip in 9.75 seconds at more than 141 mph. Featured on the Easy Street Motorsports Web site and in its own racing tour, this Subaru can inspire drag racing fans in your area to tune-up their own vehicles with performance exhaust systems, the high flow air intake, short throw shifter and more.

Solo Racing Lets Drivers Push their Skills to the Limit

Solo racing pits drivers against a course that tests responsiveness, speed and agility. There's a huge sub-culture of enthusiasts from the ProSolo driver to the local speed demon out there racing around the track and pylons while putting his or her driving skills and Subaru to the test. The SCCA regularly hosts solo events and you can help these performance thrill-seekers get the most out of their car with the performance parts you offer.

Performance Web Sites Worth A Look

There are plenty of Web sites you can visit to learn more about the variety of racing events held all around the country. Naturally, you should check out Subaru's own site at www.rally.subaru.com. It features pictures of the cars and drivers, descriptions of the events and more. The Sports Car Club of America's site, www.scca.org, describes all forms of rally, solo and club racing venues you can share with your customers. International rallies are covered in www.rally-europe.co.uk and American rallies are described at www.goss.com/rally.htm. To learn more about the drag racing WRX, visit www.esxmotorsports.com. Naturally, the site to find the finest in Subaru Performance Parts and the dealers who you can buy them from is **www.spt.subaru.com**.

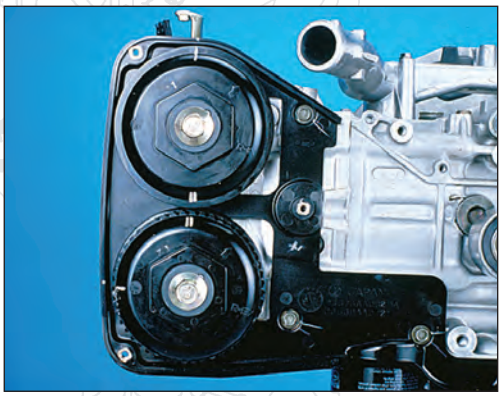
the cylinder head and onto the engine before the three bond has time to cure. Failure to do this will result in oil leaks.

Note: Cylinder head and camcase must be replaced together (line bored).

• The sparkplug pipe is pressed into the cylinder head and is not serviceable. If it becomes damaged the cylinder head must be replaced. The seals installed onto the ends of the sparkplug pipes seal against the valve covers and should be replaced when the valve cover is removed.
• Timing belt marks for the left bank are on the inner timing belt cover and the edge of the camshaft sprocket. The crankshaft timing mark remains on the reluctor with engine block mark, just below the crank angle sensor. The right bank camshaft sprocket has a mark at the edge that is matched with the seam line formed by the meeting of the camcase and cylinder head (12:00 position).
• The right bank timing mark can be checked with outer cover in place using the provided window.
• Pistons on the 2.2 liter engines have a 0.5 mm offset with the engine having a compression ratio of 10.0 to 1. The horsepower has increased to 142 hp @ 5600 RPM. Maximum torque is149 ft. lbs @ 3600 RPM.
• The 2.5 liter engine uses double overhead camshafts that are belt-driven. Belt tension is maintained through the use of the hydraulic tensioner which is also used on the 2.2 and 3.3 liter engine.
• Camshaft sprockets are constructed of a resin type material with a metal key pressed into the sprocket for maintaining proper sprocket to shaft orientation.

The timing marks on the left bank intake camshaft sprocket are positioned at 12 o'clock and 6 o'clock. The 12 o'clock mark, which aligns with a timing mark on the timing belt housing, is used for camshaft to engine timing. The 6 o'clock mark is used for timing the intake camshaft to the exhaust camshaft, which has a timing mark at the 12 o'clock positions. The remaining timing mark on the exhaust camshaft sprocket, positioned at the 3 o'clock, ensures the exhaust camshaft sprocket is timed correctly to the engine. With all timing marks aligned, the intake and exhaust camshaft are in a loaded state. If the timing belt were removed, the camshafts would suddenly revolve from the force of the valve springs. To prevent this from occurring maintain the intake camshaft position and carefully unload the camshaft by allowing it to slowly rotate counterclockwise, (exhaust clockwise) while removing the belt.

Note: Use special tool J-42908 for holding camshaft sprockets during belt installation. It may also be used for loading as well as unloading the camshafts. Caution: valve damage will occur if both camshafts are turned incorrectly after the timing belt has been removed.



Camshaft Sprocket Timing Marks (Right Bank)

• The right bank intake sprockets timing marks are similar in location and purpose to the left bank. However, the exhaust camshaft sprocket on the right bank uses a timing mark at the 9:00 o'clock position to ensure proper camshaft to engine timing.
• To access the cylinder head bolts, the camshafts must be removed. Follow the procedure outlined in the Subaru service manual for performing this task. The camshafts are held to the cylinder head with bearing caps that are marked (right side) I1TD, I3TD, E1TD, E3TD.
• 2.5 liter engine head gaskets are identified by the three notches located along the gaskets edge, 2.2 liter normally aspirated engine head gaskets have only two notches.

Caution: The bolt patterns for both gaskets are the same but are not interchangeable.

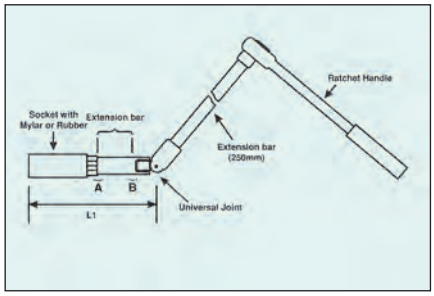
• The cylinder head bolts for the 2.5 liter engine are much shorter than those of the 2.2 liter engine, and are not interchangeable.
• Valve servicing is accomplished by utilizing special tool 499718000 and a universal valve spring compressor. The single valve spring is color coded red and rests on a metal spring seat which is used to prevent cylinder head wear . A special tool (498267700) is required to adjust valve guide height, if replacement is necessary. A valve guide reamer (499767400) and a valve guide remover (499767200) will also have to be used. The hydraulic lash adjuster is of the same type as the 3.3 liter engine and requires no servicing.
• Spark plugs for the 2.5 liter engine are platinum tipped, NGK PFR5B-11. (Same maintenance schedule as the SVX.) 2.2 liter engines use Champion RC10YC4.
• Engine oil viscosity for all '96 Legacy and Outback vehicles is 5W-30 to improve fuel economy.

2.5 Liter Engine Spark Plug Replacement Procedure

1. Remove battery, washer tank and air cleaner.
2. Remove high tension cords.
3. Cover ATF pipes and ABS pipes with cloth to prevent them from damage during replacement of spark plugs.
4. Remove spark plugs by using a general service tool with the special instruction described below.

Installation

1. Set the spark plug into the socket.
2. Tighten the spark plug in the cylinder head with the socket. It is necessary to support the end of the socket by a finger.
3. When the spark plug can be felt to be tightened with 2 or 3 rotations, remove the socket from the spark plug.



Spark Plug Removal

4. Confirm if the spark plug is screwed into the hole properly by touching it with a finger. If it is difficult to touch it by finger, confirm its condition by using mirror.

5. Reset the socket on the plug then tighten it with the proper torque.
6. Install high tension cords.
7. Install battery, washer tank, and air cleaner.

Note: Length L1 (100mm, 3.94") is most important for ease of removal and installation. Wrap points A & B with tape to prevent them from separating during work. An approximate 250mm extension bar is recommended between the ratchet and the universal joint.

1997 Phase 1 2.5 Liter DOHC Engine

The double overhead camshaft engines have had internal and external changes that yield an approximately 10% increase in power and 3% increase in fuel economy. Compression ratio has been increased to 9.7 to 1 by reshaping the crown of the piston. This eliminates the clearance that was available between the piston at TDC and a fully opened valve. Piston pin offset has been changed to 0.5 mm. Piston to cylinder wall clearance has been reduced by increasing the piston diameter.

Another source of engine friction is the valvetrain. Hydraulic lash adjusters are always in contact with the camshaft or valve rockers. The hydraulic pressure of the lash adjuster must be overcome during operation and the most critical time of engine start. To contribute to friction reduction, all DOHC engines have solid valve adjusters.

The scheduled service of these valvetrains is set at 100,000 miles. The DOHC engine uses an adjustment shim. There are 94 shim sizes.

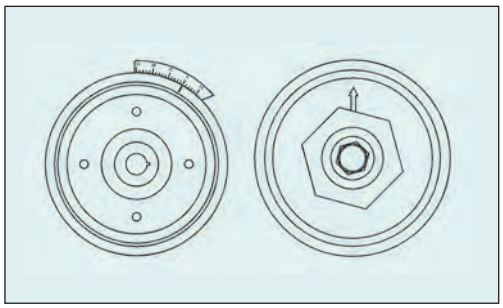
Note: Use a thin nonmagnetic tool placed in the notch of the lash adjuster to remove shim (special tool J-43979).

Note: The printed size of the shim should be installed away from the camshaft lobe.

The space between the valvetrain and the frame rail of a DOHC is somewhat limited, however valve adjustment is possible by performing the following:

Step 1

- Set the crankshaft sprocket at 0 degrees. (use crankshaft wrench)
- Set the left intake camshaft sprocket arrow at 12 o'clock. The camshaft sprocket has an arrow and a mark used for belt timing. Make certain to use the arrow and not the mark for valve clearance check.
- The engine is now set to check the clearance of the exhaust valves on cylinders 1 and 3 only. (Please remember that the profile of a camshaft with solid lifters has a ramp that is used to gradually take up the clearance between the lift of the lobe and the lash adjuster.)
- Measure and record the clearance.



Cams Set for 1 and 3 Exhaust Clearance Measurement

Step 2

- Rotate the crankshaft 180 degrees.
- The left intake camshaft arrow should now be at 3 o'clock.
- Check the clearance of the intake valves on cylinders 1 and 3 only.
- Record the measurement.

Step 3

- Rotate the crankshaft 180 degrees.
- The left intake camshaft arrow should now be at 6 o'clock.
- Check the clearance of the exhaust valves on cylinders 2 and 4 only.
- Record the measurement.

Step 4

- Rotate the crankshaft 180 degrees.
- The left intake camshaft sprocket arrow should now be at 9:00.
- Check the clearance of the intake valves on cylinders 2 and 4 only.
- Record the measurement.

Step 5

- Use the formula below to choose the new shim:

Built to provide peak performance at competitive prices

With dirt, dust, heat, friction and contaminants working to rob vehicles of power, why try to save a few pennies on non-genuine parts that can cost car owners so much more over time? Off-brand parts can result in poor performance, faster wear and possible damage due to poor fit or not being up to specification. But regular maintenance using competitively priced Genuine Subaru Maintenance Parts can help keep your customers' cars running smoothly for years without sacrificing quality or risking trouble.

These high quality parts are engineered to precise specifications so they fit right, perform better and last longer. Take the materials in Genuine Subaru brake pads. They're specially formulated to be compatible with the rotor surface to help prevent brake chatter, noise and excessive heat build-up, which can impair stopping effectiveness.

For part applications and prices, visit www.endwrench.com and contact your authorized Subaru dealer.

Genuine Subaru Maintenance Parts

Filters	Includes oil, air and fuel filters
Spark Plugs	Includes standard and platinum tip plugs
Brake Pads and Shoes	Includes front and rear plus repair kits
Belts	Includes timing, alternator and a/c belts

Intake valve S = V + T - .20
Exhaust valve S = V + T - .25
S = Shim thickness to be used
V = Measured valve clearance
T = Shim thickness in use
Standard valve clearance
(Intake valves 0.20 ± 0.02 mm)
(Exhaust valves 0.25 ± 0.02 mm)

Example:

To solve for the new shim or T:

- Cylinder 1 intake measured valve or clearance is 0.22 mm - no adjustment needed.
- Cylinder 1 exhaust measured valve or clearance is 0.15 mm - adjustment needed.
- Cylinder 3 intake measured valve or clearance is 0.31 mm - adjustment needed.

The shim in use on cylinder 1 exhaust is marked 240. This refers to the shim having a thickness of 2.40 mm.

T = 2.40 S = V + T (0.25 mm)
V = 0.19 S = .19 + 2.4 - (0.25mm)
SVC = 0.25 ± 0.03 S = 2.59 - 0.25mm
(Standard valve clearance) S = 2.34

The shim in use on cylinder 3 intake is marked 245.This refers to the shim having a thickness of 2.45 mm.

T = 2.45 S = V + T (0.20mm)
V = 0.31 S = .31 + 2.45 - (.20mm)
SVC = 0.20 ± 0.03 S = 2.76 - .20mm
(Standard valve clearance) S = 2.56

Step 6

- The current method of shim replacement is accomplished by removing the camshafts.

Caution: Follow the directions provided in the appropriate service manual for camshaft removal and belt installation.

Note: Special tool 498187100 may also be used for this procedure.

1999 2.5 Liter Engine Enhancements: DOHC (Phase 1) and SOHC (Phase 2)

The engines for the 1999 Subaru line are designated Phase 1 and Phase 2. 2.5 liter Legacy engines are the Phase 1 design, while the Impreza and Forester utilize Phase 2 design 2.5 liter engines. The 2.5 liter Phase 2 engines are SOHC engine with a newly designed cylinder head. The (Phase 1) 2.5 liter engine uses the same cylinder head configuration that it has used on prior year models with the crankcase and bell housing sharing the same characteristics of the new Phase 2 engines.

2.5 Liter (Phase 2) SOHC Engine Features

• The cylinder heads have a two-rocker shaft roller solid-type valve system.
• The valves are positioned at a larger angle than previous model years. The intake valves are positioned 23 degrees off center, with the exhaust valves positioned 20 degrees off center. Prior model year engines utilized a 15-degree positioning angle.
• Head gasket thickness is 0.7 mm.
• The intake rocker arms are marked for correct installation on the rocker shaft. An IN1 or IN2 is embossed on each rocker arm. As viewed from the front of the engine, the number 1 intake valve of each cylinder and the number 2 intake valve have an IN1 marked and IN2 marked rocker arm that mates with it. New IN1 rocker arms can also be identified by a green painted mark on the top of the rocker arm. The IN2 rocker arms have a white mark. Proper positioning is maintained through the use of a wave washer located between the rocker shaft arm and rocker arm shaft support.
• The camshaft is secured to the cylinder head with the camcase. An oil passage in the cylinder head provides the passageway in the camcase with oil that leads to the intake rocker shaft. Oil from the camshaft is collected on the opposite side of the passageway leading to the intake rocker shaft to provide oil to the exhaust rocker shaft.
• Sealing of the camcase is accomplished by using a thin layer of Three Bond applied in the channel around the camcase edge. After the three bond (1280B) is applied, the camcase must be installed to the cylinder head and onto the engine before the three bond has time to cure. Failure to do this will result in oil leaks.

Note: The cylinder head and camcase must be replaced together (line bored).

• Timing belt marks on the left bank are on the inner timing belt cover and the edge of the camshaft sprocket. The crankshaft timing mark remains on the reluctor, with the engine block mark just below the crank angle sensor. The right bank camshaft sprocket has a mark at the edge that is matched with the seam line formed by the meeting of the camcase and cylinder head (12:00 position).
• The right bank timing mark can be checked with outer cover in place, using the provided window.
• Piston design on the 2.5 liter engine remains the same as the 2.2 liter. The compression ratio is 9.7 to 1.

3.0 Liter Engine Features

The EZ-3.0 is the model name (engine designation) for the new six-cylinder engine introduced for the 2001 model year Legacy. The design idea for this engine was to create a power plant that could utilize the current body style, provide more power and decreased exhaust emissions. Many of the features refined for the current four-cylinder engine are employed on the EZ-3.0. However, new features such as Variable Intake Control and timing chain driven camshafts give the new engine a look and operation all of its own.

3.0 Liter Engine Timing Cover

The front of the engine features a large front timing chain cover, secured to the inner cover with 59 bolts. There are four different lengths used and is sealed to the inner cover with Three Bond (1280B). Special care must be used when servicing the timing chain covers to ensure the proper length bolt and sealing procedures are used. A single serpentine belt provides the power to turn all engine accessories. Tension to the belt is controlled with an automatic tensioner. Replace the serpentine belt when the indicator is at or beyond this line.

Additional 3.0 liter engine features:
• Two radiator hose connections are

located at the top of the engine block, connecting to each of the cylinder heads.
• An oil cooler is used to assist with bringing the oil to operating temperature.
• Direct ignition coils are fitted. The igniter and current control circuits are integrated.
• The lower hose is located on the thermostat housing, connecting to the lower section of the radiator. The thermostat is housed in the oil pan extension case. The oil pan is much smaller than previous model engines and contains a small magnet to collect metallic debris.
• Connections for the crankcase ventilation system are located at the top of the valve cover. Pressure is equalized from the right bank with a cross over tube.
• The new crank angle sensor, reluctor, and EGR pipe. The crank angle sensor and reluctor have been moved to the rear of the crankshaft. The EGR pipe has a new design and is mounted on the left bank of the engine.

3.0 Liter Engine Disassembly

• Begin disassembly by unloading and removing the serpentine belt.
• Remove the fuel rail protectors from both sides.
• The lower alternator bolt must be backed out before the manifold can be removed.
• Remove the alternator, compressor and power steering pump.

Note: The compressor is equipped with a speed sensor that sends a signal to the ECM. If the compressor speed drops more than 20% compared to the engine speed, the ECM turns the compressor off through the a/c relay. The refrigerant must be evacuated before removing the sensor.

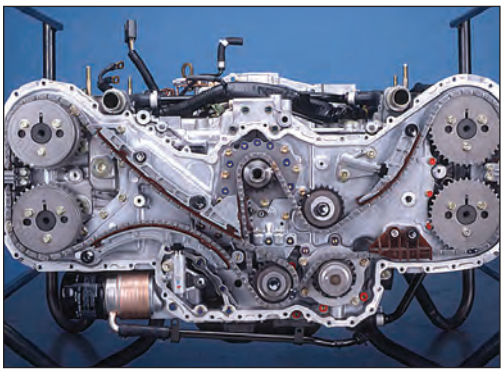
• Remove the crankshaft bolt cover, bolt and harmonic balancer. Use caution to avoid losing the O-ring that seals the crankshaft bolt cover to the harmonic balancer.
• Begin removing the outer cover bolts. Keep them organized to ease reassembly. The bolts must be removed in the proper sequence to avoid warping the outer case.
• The timing chain on the EZ-3.0 is designed to last the life of the engine. Proper engine oil maintenance is necessary to ensure its longevity. Two chains are used. Four (4) camshaft sprockets, one (1) crankshaft sprocket, two (2) idler sprockets and the water pump complete the timing chain routing.
• The timing chain is sprayed with oil from a jet located on the oil pump relief valve housing.

Caution: the sprocket teeth are sharp. Use extreme care when working around or near them.

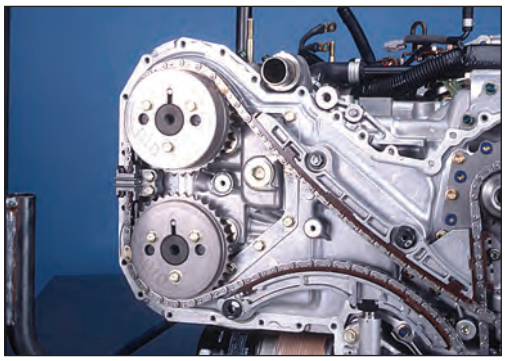
• The right bank camshafts are in a loaded state when the keyways are at 12:00. They must be unloaded in the proper way to prevent damage to the pistons and valves.
• Timing marks are located on the camshaft sprockets and the crankshaft sprocket. Marks and letters on the idlers are manufactures markings and are used only to establish which side faces outward. Do not use them to establish proper chain timing.
• The left bank camshaft sprockets are interchangeable when new. It is recommended they be returned to their original positions to maintain wear patterns after being used.
• The left timing chain is the longer of the two with 148 links. The right chain has 134 links.
• Turn engine clockwise to rotate it until the key ways of the cam sprockets are at the 12:00 position. Remove the right bank tensioner, chain and chain guides.
• Remove the left bank tensioner, chain and chain guides.

Note: Turn the crankshaft 90 degrees counter clockwise to reduce the chance of accidental damage to the pistons and valves in the event the camshafts suddenly unload.

• The left bank is currently unloaded. The right bank is loaded
and must be unloaded using the following procedure.



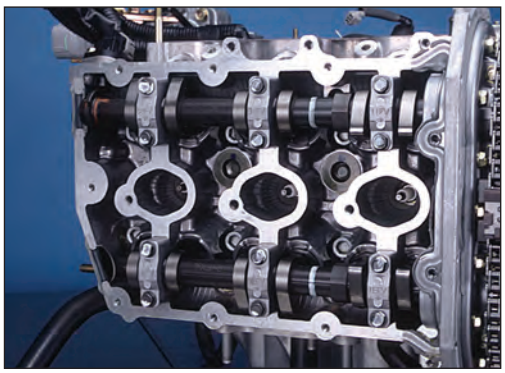
3.0 Liter Engine Timing Chain Routing



3.0 Liter Engine Right Bank Timing Components

Unloading Cam Sprockets

• Position the camshaft sprocket wrench on the right bank intake sprocket and turn 90 degrees counter clockwise.
• Position the camshaft sprocket wrench on the right bank exhaust sprocket and turn 90 degrees clockwise. Both camshafts are now unloaded.
• Remove both the intake and exhaust camshaft sprockets on the left and right banks.
• Remove the bolts from the water pump.
• Thread two eight millimeter bolts as shown and equally turn them in. This will assist with the removal of the pump. Remove the O-ring that seals the water pump to the inner cover.



3.0 Liter Engine Valvetrain

Valvetrain Construction

The camshafts are composed of carbon steel pipes with sintered metal lobes. During construction, the lobes are positioned on the pipe using a sintered metal paste. The camshafts are then baked until the paste is hardened. The lobes of the camshafts are offset by 1 millimeter to rotate the camshaft

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Aerosols	Includes chlorinated and non-chlorinated brake and carburetor cleaners, aerosol and pour fuel injector cleaners, top engine cleaner, application tools and adapters, glass cleaner, throttle plate cleaner and silicone lubricant
Fluids	Includes factory fill coolant, brake fluid, factory fill windshield washer concentrate and automatic transmission fluid/power steering fluid
Refrigerant	Packaged to the ARI 700 Standard

bucket and shim, to reduce wear.

The right bank intake camshaft has a reluctor built onto the end. The new camshaft sensor uses this reluctor to help determine injection and ignition timing.

The valve adjustment procedure is the same as other DOHC Subaru engines however a new tool has been designed to work specifically on the EZ-3.0 engine. The tool is a wedge fitted into place over the two shims requiring removal.

Some adjustment will be required to properly seat the bucket depression finger. Turning the top bolt pushes the fingers down allowing room for the shim to be removed.

Chain Tensioners

The chain tensioners are fed oil pressure from the engine oiling system. The supplied pressure combined with spring tension keeps the timing chains operating at the correct tension.

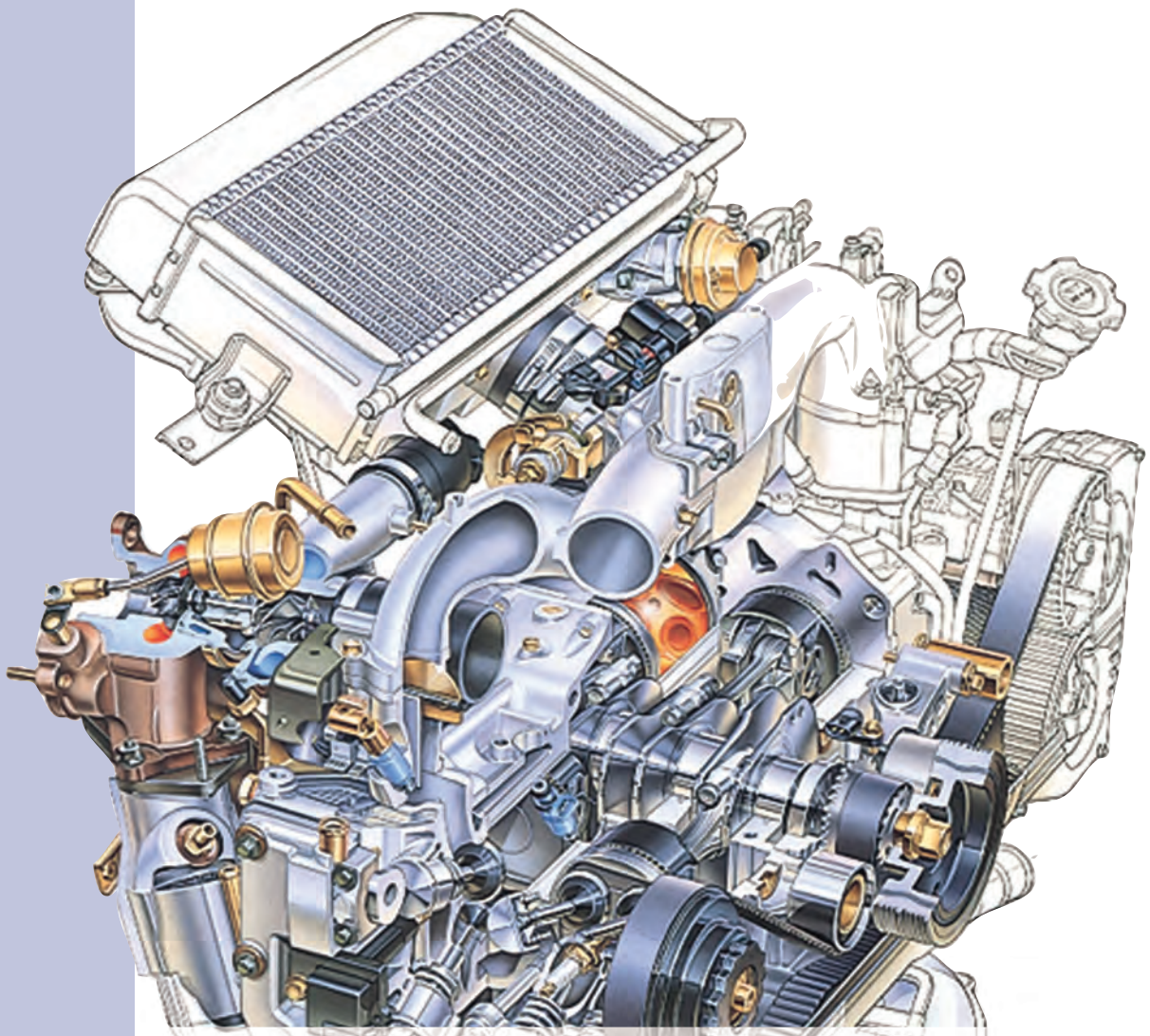
3.0 Liter Engine Chain Tensioners

Note: The left bank and right bank tensioners are not interchangeable.

The worm gear assemble and spring tension keep tension on the chains with the engine off, eliminating any tension problems that could occur during engine start up. The tensioners are turned in by hand for reassembly. Observe the order of the worm gear assemble. Make sure your hands are dry when depressing the tensioners. A rivet or large paper clip will hold tensioner in place. Do not use a press to depress the tensioner.

Oil Pan Removal

- Remove the oil pan bolts and oil pan. Observe that the oil pan has a different design from four cylinder Subaru engines. Note the placement of the bolts.
- Remove the oil pan extension housing bolts. There are 28 bolts with five different lengths. Follow the proper sequence to prevent warping the case. Confirm the O-ring placement.



WRX Turbo Tech

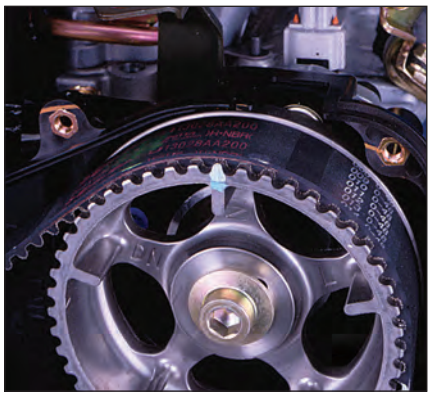
The EJ-2.O engine is a double overhead camshaft engine equipped on all turbocharged Impreza vehicles. The timing belt procedure and routing is very similar to other Subaru DOHC, engines, however, the increased power output of the engine requires the use of an additional timing belt idler pulley. Manual 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.

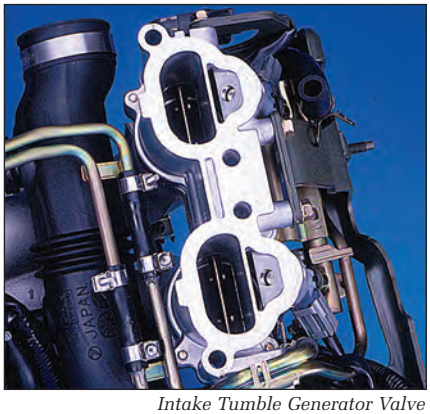
A coolant pipe sealed with a rubber plug is installed at the factory. Do not remove the plug to service any part of the cooling system.

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



Intake Tumble Generator Valve

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.)

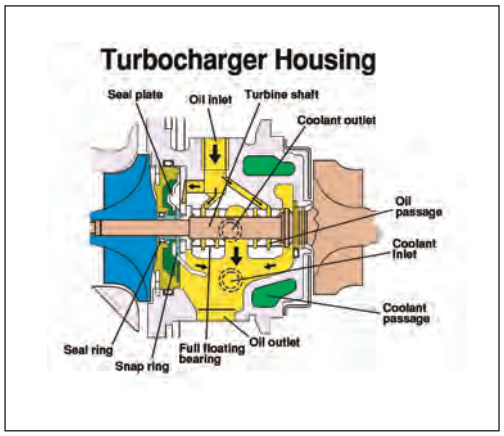
Fuel Injector

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

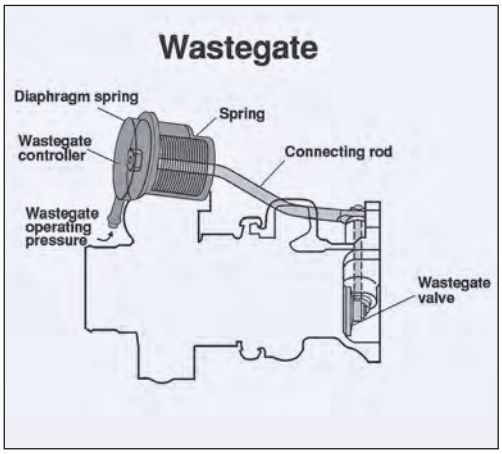


Turbocharger Cross-Section

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.

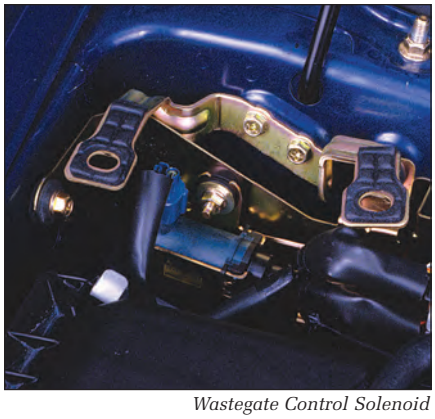
There is a limit to the amount of boost pressure that can be used, due to the engine's design capabilities. The boost pressure is limited by a wastegate, which bypasses the exhaust gas around the turbine wheel when the desired level of boost is reached.



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.



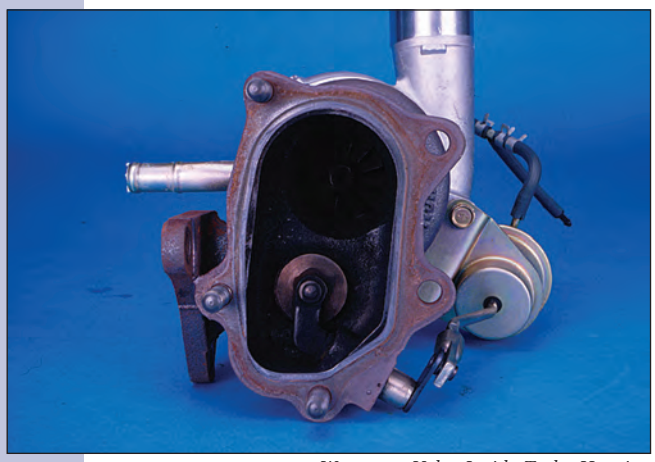
Wastegate Control Solenoid

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-

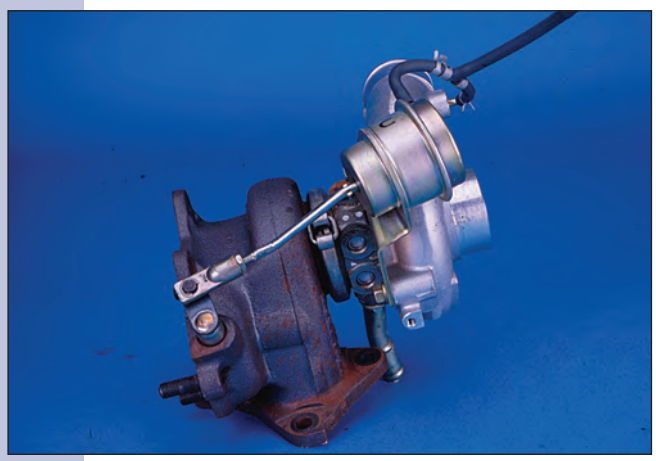


Wastegate Valve Inside Turbo Housing

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).



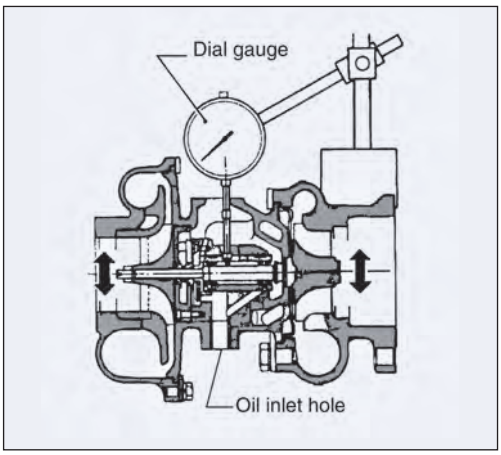
Turbocharger

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

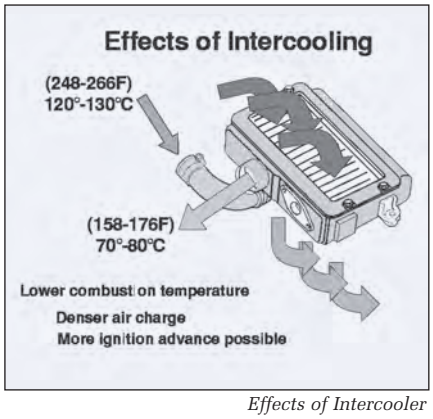
The temperature of the intake air is increased as it is compressed by the turbocharger. This rise in temperature causes a corresponding expansion of the air, leading to a reduction in air density. The intercooler is designed to transfer the heat of the compressed intake air to the external air flowing 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 noise, and possibly damage the turbocharger due to the high pressure exerted at the compressor.



Effects of Intercooler

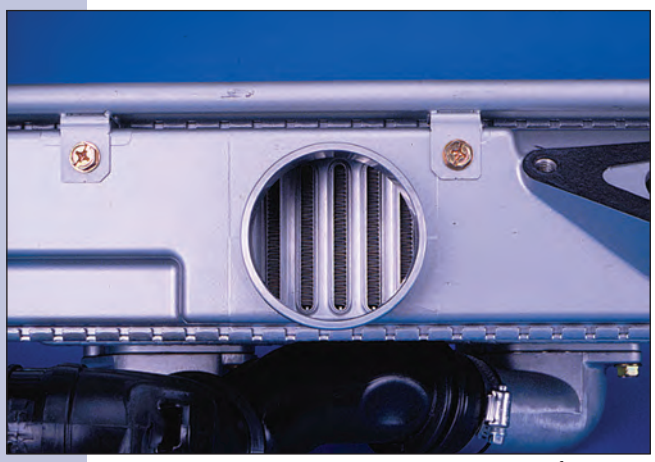
The upper chamber of the bypass valve is connected to the intake manifold, and the negative pressure (vacuum) during deceleration opens the valve by acting on the diaphragm.

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

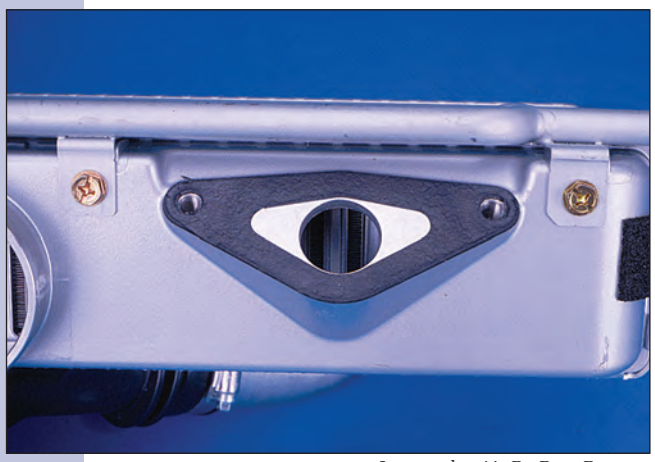
due to the physical limitations of the turbocharger.



Intercooler Interior

Exhaust Diameter

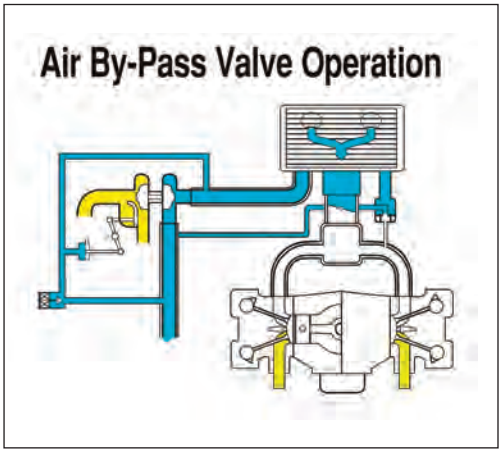
The diameter of the exhaust system will vary the pressure difference across the turbine. A larger exhaust allows the turbocharger to rotate faster, which results in higher boost pressures. Any increase in boost pressures would require 're-mapping' of the ECM programs to accommodate different air flow 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

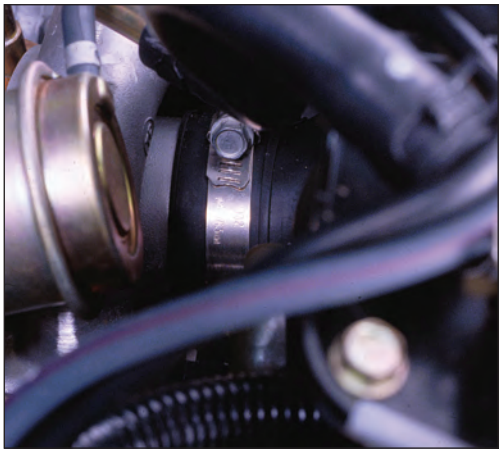
The high combustion pressures resulting from the increase in volumetric efficiency require a high-octane fuel. If the octane of the fuel is too low, knocking will occur. The end result of knocking is damage to the engine. The ECM is programmed to retard ignition timing if knocking is detected. Excess 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

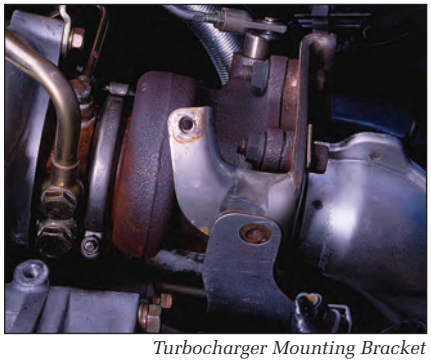
The pressure of the exhaust gas is low at low engine speeds. As the turbocharger uses exhaust energy to operate, it does not respond immediately when the throttle is opened. This phenomenon is referred to as 'turbo lag.' In an attempt to overcome this phenomenon, design characteristics of the turbocharger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

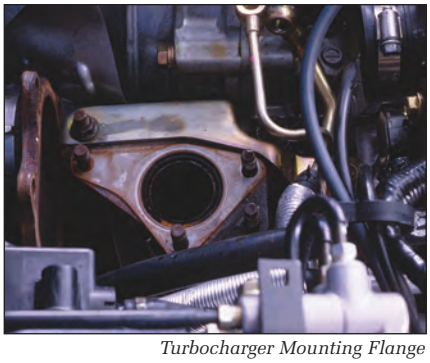
heat shield around the turbo.

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



Turbocharger Mounting Flange

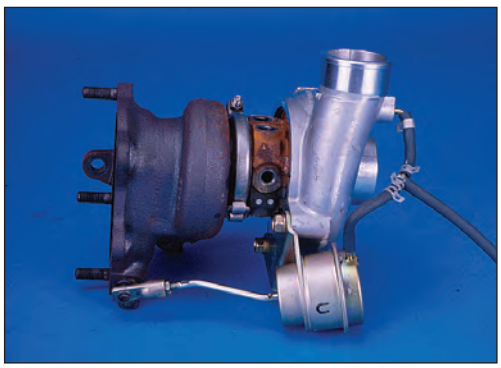
Remove the three nuts that secure the turbocharger to the cross over pipe and secure the gasket (inlet). Remove the turbocharger from the engine compartment and cover all opening in the exhaust and on the turbocharger.

insider info.

WRX Turbo Cool Down Procedure

It is not necessary to perform a "cool down/idling" procedure on Subaru WRX turbo models, as was recommended with past turbo models. "The current 2.0 liter turbo engine has a far greater cooling capacity and, coupled with technology advances, makes this practice no longer necessary. This explains why information about a cool down is not included in the Impreza Owner's Manual.

The heat contained in the turbocharger begins to vaporize the coolant at the turbocharger after the engine is stopped. This hot vapor then enters the coolant reservoir tank, which is the highest point of the coolant system. At the same time the vapor exits the turbocharger, coolant supplied from the right bank cylinder head flows into the turbo. This action reduces the turbocharger temperature. This process will continue until the vaporizing action in the turbocharger has stopped or cooled down.



WRX 2.0 LIter Turbocharger

Three Bond Sealer

The Subaru H-6 engine timing chain cover is sealed with Three Bond 1280B sealer. Subaru of America has located a source this sealer in the U.S. The sealer should be ordered from your Subaru parts department under part number S0A5499100. One tube can be used for approximately seven engines.

If you are working on an H-6 that requires this sealer, be sure to use Three Bond 1280B and not Three Bond 1215.

Knocking Or Tapping Noise: 2.5 Liter Engine

Before condemning a 2.5 liter engine for having an engine knock or a valve tap, make certain that all the spark plug wires are firmly connected to their corresponding spark plugs, The spark plugs are deeply recessed in the cylinder heads, so the sound that is produced by a loose plug wire can easily be confused with valve tap or piston slap.

Engine Noises

Engines in some 1997 and later Subaru vehicles have been fitted with solid valve lifters. These lifters help increase the power of the engines. Some of these engines use a lifter setup that requires the use of a shim to adjust the clearance. A characteristic of this setup is a slight tapping noise, heard especially at idle. The intensity of the noise may vary with engine temperature. Typically, this noise is not apparent in the passenger compartment. No attempt should be made to repair this noise because it is a characteristic of the system.

Assembling 1997 And Newer Engines

When assembling 1997 and newer engines, please remember that on vehicles with non-hydraulic lifters, special precautions must be taken to ensure that no valves are bent during the assembly process. There is no longer any clearance between a fully opened valve and a piston near top dead center. This means that you must position the crankshaft and the camshafts properly before installing the cylinder heads. After the head is in place, do not turn the crank or move the cams in the wrong directions.

Before installing the heads, the crankshaft should be positioned with the crank sprocket aligned with the mark on the block. The camshafts should be installed on the heads with the cam lobe in their "zero lift" position. On the passenger's side head, this position will be the same as the belt installation position, so position the cams that way prior to bolting them to the head. On the dri-

ver's side head, however, this position is approximately 80 degrees counterclockwise from the belt installation position for the intake cam and approximately 45 degrees clockwise from the belt installation position for the exhaust cam. So hold the cams appropriately while bolting them to the head. After the cylinder heads are installed, the cams can carefully be aligned with their corresponding marks by rotating the driver's intake cam 80 degrees clockwise and the driver's exhaust cam 45 degrees counterclockwise.

Oil Pumps: Replacement Versus Resealing

When diagnosing a leaking oil pump, don't automatically replace it with a new pump when a simple reseal will do. The only time a pump should be replaced is if the housing is porous, cracked, or damaged in some other manner.

Valve Shim Measurement

Several Subaru engines use shims to adjust valve clearance. If you don't have a micrometer, acquire one that is calibrated in millimeters. Even though the service interval for adjusting the valves is 100,000 miles, there are 16 of them per four-cylinder engine, so proficiency is a plus.

Leaking Front Crankshaft Oil Seals

If you encounter a 2.5 liter engine with a leaking or dislodged front crankshaft oil seal, consider the oil pump as a possible cause. It may be necessary to remove the oil pump and examine the rear sealing plate of the oil pump. The screws holding the rear sealing plate may be loose. Some have been reportedly backed out 1/16-inch. This allows oil to exit the pump rotor area and get into the oil pump body where it is pressurized. This pressurized oil pushes on the seal, causing it to leak or pushes it out of its mounting.

Oil Leaks

The engine oil and automatic transmission fluid used in Subaru vehicles are similar in color. When diagnosing an oil leak and it has a reddish color, don't automatically assume it is automatic transmission fluid. It might be engine oil. A quick way to find

Continued on page 30.

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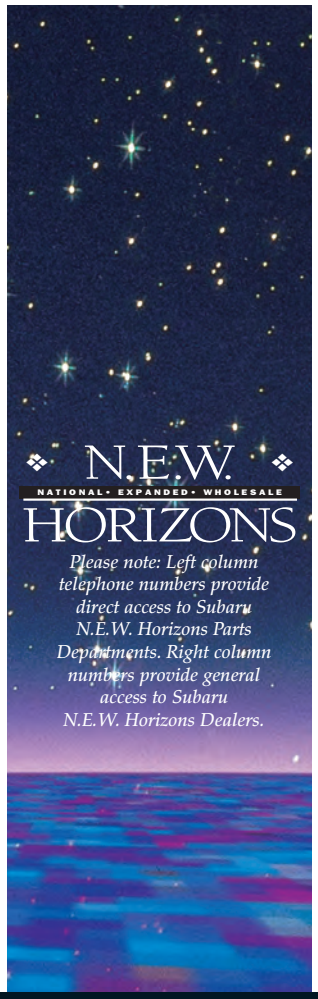


Continued from page 25.

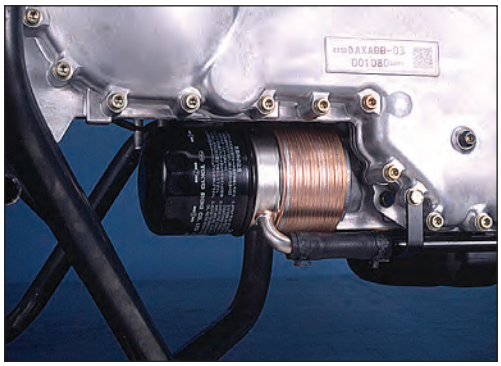
out is to take a sample of the oil and place it on a clean white paper towel. If the sample turns brown on the paper towel, it is engine oil. If it stays red, it is automatic transmission fluid.

Oil Filters: H-4 Versus H-6 Engines

Subaru H-4 engines come from the factory with an OEM P/N 15208AA060 oil filter. The same part number is used for replacement. H-6 engines come with an OEM P/N 15208AA031, and S0A5165109 is used as a replacement.

Both filters have the same physical dimensions as far as threads, O-ring, and bypass valve opening pressure (23 p.s.i.) are concerned. However, the H-4 filter has 141 square inches of filtration surface, while the H-6 filter has 201 square inches of filtration surface.

The H-4 filter should not be used on the H-6 engine. Using the H-4 filter may cause it to become contaminated faster and allow the bypass valve to open, allowing unfiltered oil to circulate through the engine.

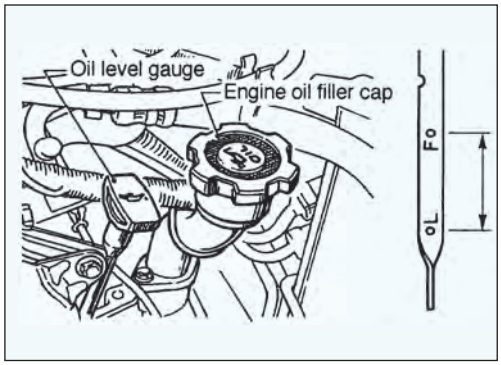


H-6 Engine On Stand w/Oil Filter

Cold Engine Noises

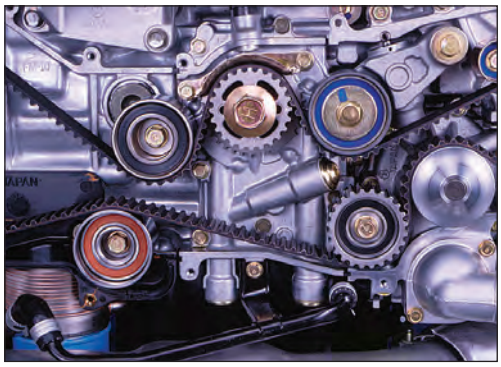
Beginning with the 1997 model, the 2.2 and 2.5 engines were made more fuel efficient, more powerful and have a flatter, more usable torque curve than in previous years.

Some of these engines may exhibit some engine noise during the warm-up period after a cold start-up. This noise is a consequence of the engine improvements and is not, in any way, an indication of any engine problem. A light engine knock, after cold start, that gradually dissipates as the engine warms up and is virtually undetectable (from inside the vehicle) once the engine has reached operating temperature, is a normal characteristic of these engines. Repair attempts to reduce this type noise are generally unsuccessful.



Checking Oil Level and Quality

If you have a vehicle in which an engine noise is other than that as described above, be sure to take the time to check all possible causes prior to condemning the internal components of the engine. Before replacing parts in an attempt to eliminate engine noise, the engine should be inspected externally and internally for another source of noise. A look at the engine oil is a good place to start. New engines will have a small amount of metal particles in them, but after that should be relatively free of metal.



Timing Belt, Idlers and Tensioner

Another area to look at would be the timing belt tensioner and the belt and sprockets. There have been cases where noises under the belt covers and from external components have made noises that sounded like a deep internal knock.

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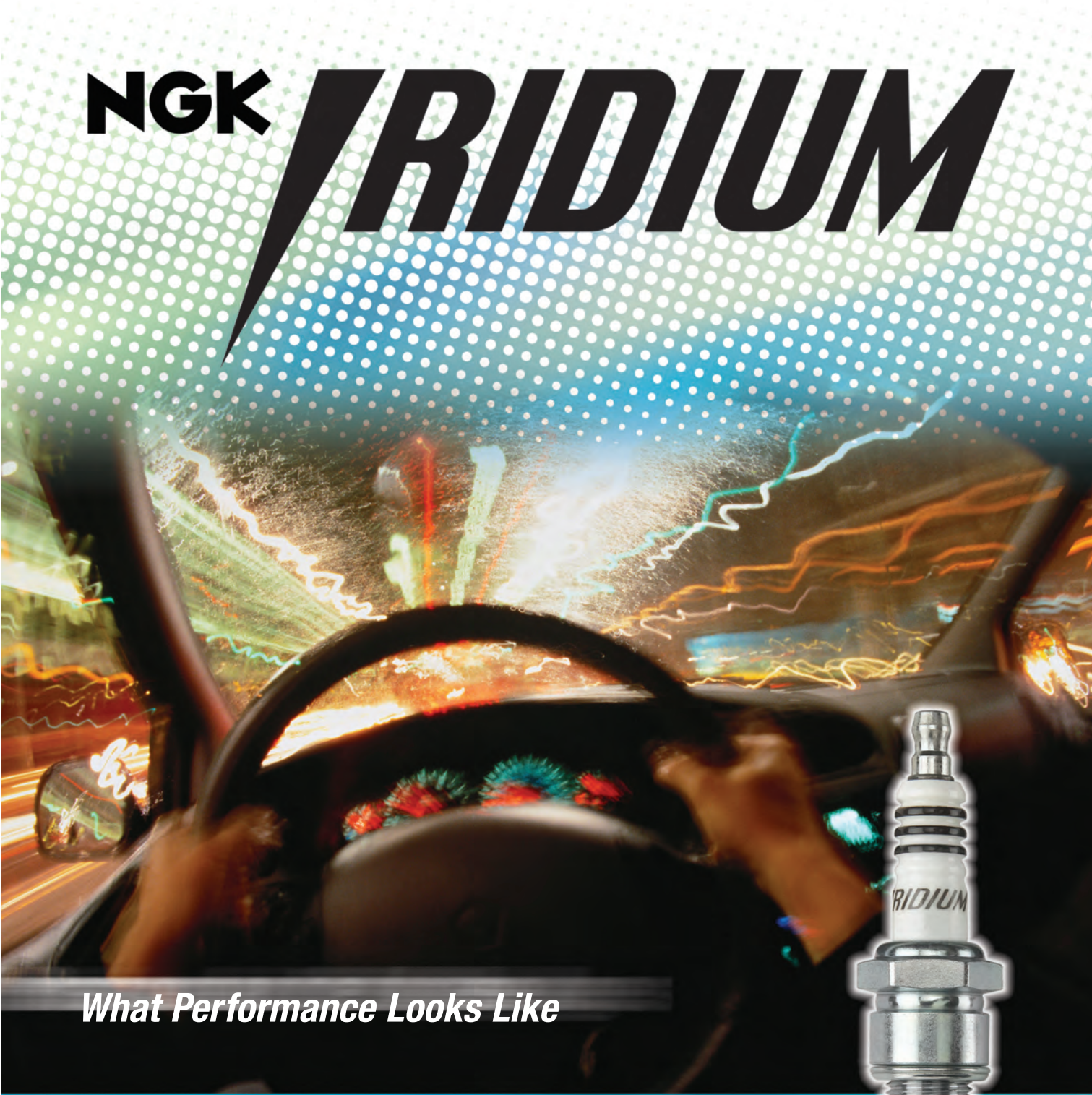

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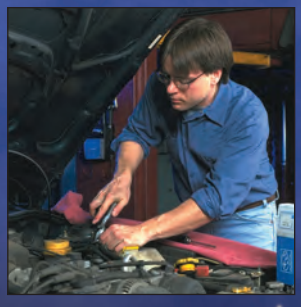

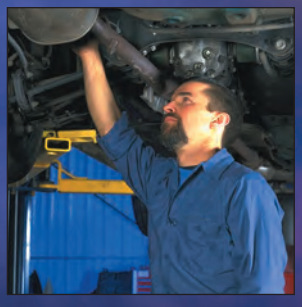

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