February 2018 | V2 N1

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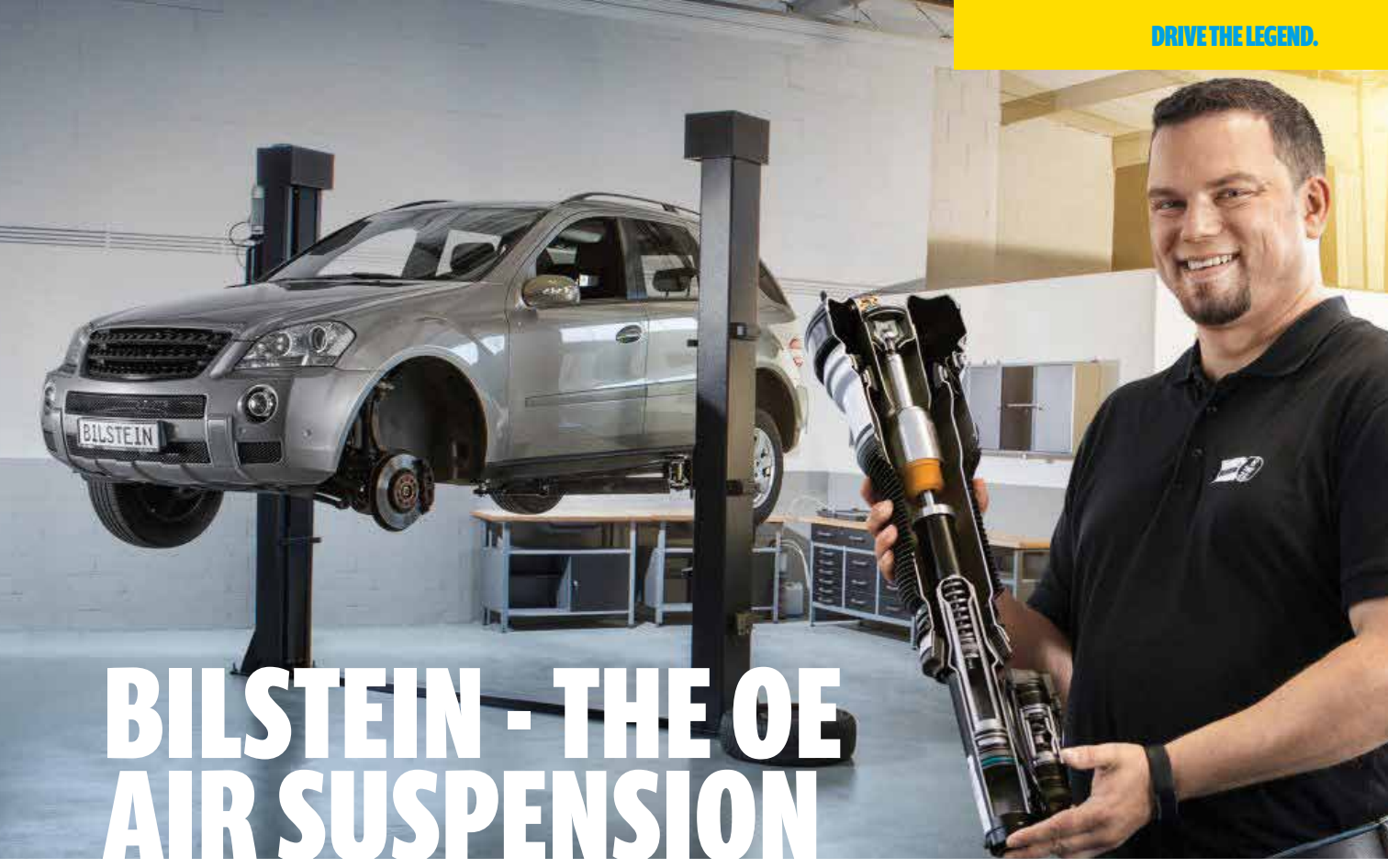
Turbocharging Porsches

VW Driver Assistance Systems
Engine Oil Leak
Fasteners

Audi Suspension Systems
Audi Sunroof Service

DRIVE THE LEGEND.



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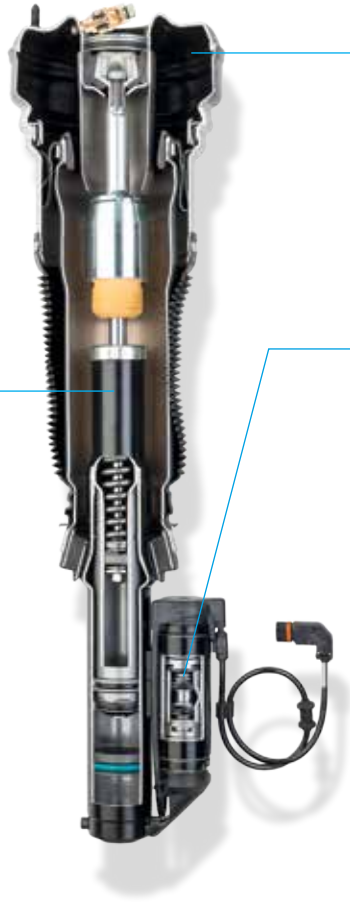

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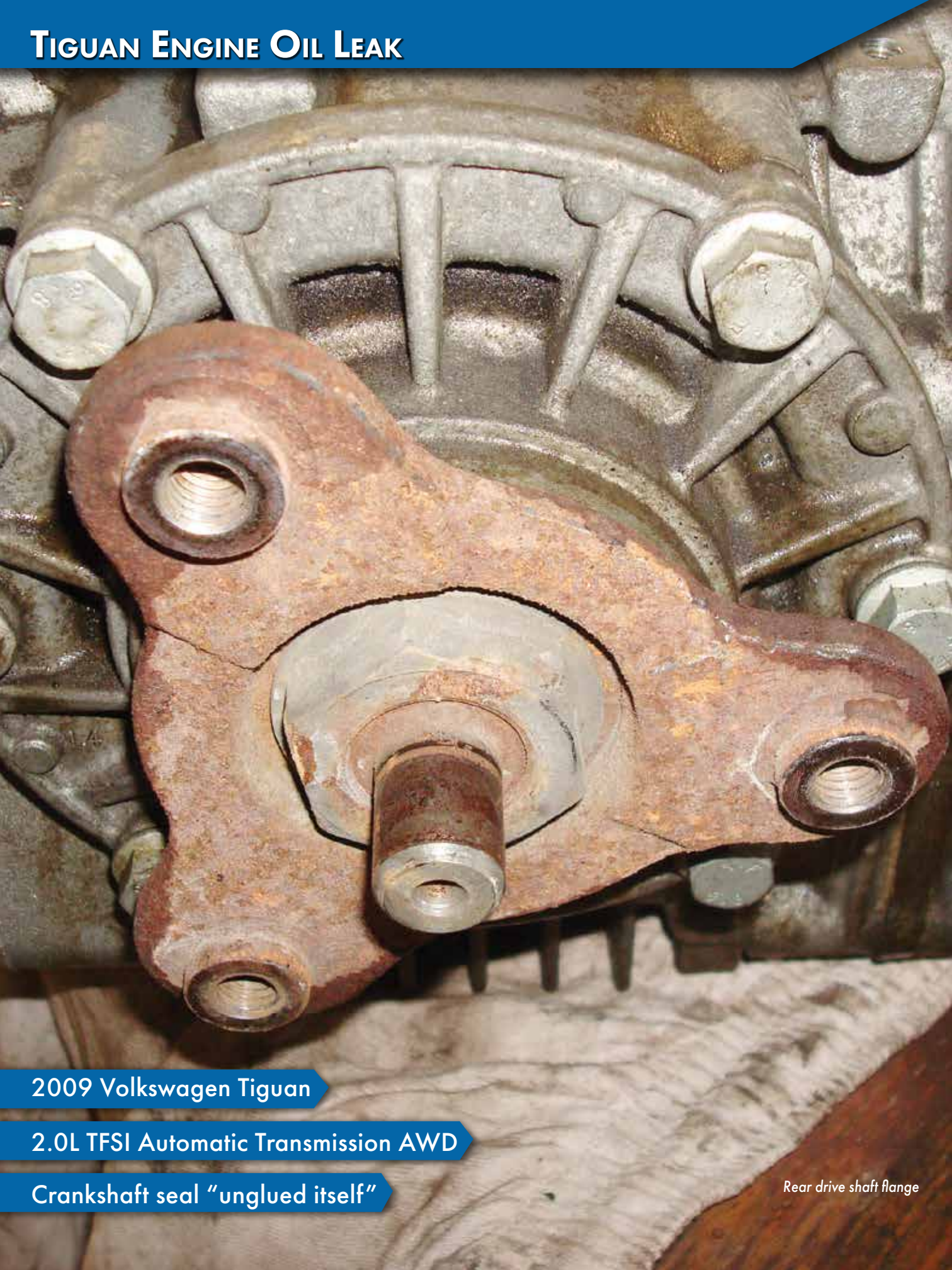
Tiguan Engine Oil Leak



2009 Volkswagen Tiguan

2.0L TFSI Automatic Transmission AWD

Crankshaft seal "unglued itself"

Rear drive shaft flange

This article is specific to an oil leak that developed very quickly. This vehicle required a flat bed to be returned to the city. The oil consumption within a 4 hour drive out of the city was approximately 3 quarts.

Inspection proved the oil leak came from the crankshaft flange seal between the engine block and torque converter drive plate.

All research dictates specific bolts and seals that must be replaced when the transmission is removed for inspection. Any seal that is removed or disturbed must be replaced. Scan and save the entire autoscan. Adaptations will be required on the first start-up to prepare for delivery to the vehicle owner. This procedure will apply to all CCTA TFSI engines with or without 4WD.

Special tools used:

- Ross-Tech VCDS
- Smoke Pro smoke machine
- Engine bar support
- Transmission jack and strap
- Torque wrenches
- Transmission drive plate holder
- Pressurized transmission fill reservoir or equivalent tool
- Camera

Note: Be well prepared when attempting this type of repair and note the seals/bolts with replacement parts that must be available before and during disassembly and reassembly. Capture the entire initial scan and have a copy of the PR code to accurately identify the model being worked on and in conjunction with installed factory equipment. Print and read the repair instructions first.

Upon inspection on the lift, clean all areas of the oil leak and capture the contaminants for proper disposal. In this specific case, a smoke machine was used to identify the leak between the engine block and transaxle. The smoke machine was attached to the dipstick tube for the inspection.

When the operation is confirmed and the repair authorized, remove the battery, tray, upper air inlet tubes and hardware to expose the transmission with upper mount.

Prepare this model by loosening the axle bolts (one-time use), remove the front wheels, LF inner plastic liner, and remaining lower air induction tubes. Remember to replace all disturbed seals, o-rings or one-time use bolts. Prepare a safe and correctly fitting engine lift bar onto the fenders with rubber pads/insulators. The illustration indicates the correct position.

Disconnect the ball joints and link pins on both sides, remove both drive axles. Clean and lightly lubricate the splines before reassembly. With the LF inner liner removed, inspect/prepare the transmission jack angle and height when ready for final removal.

Remove the rear drive shaft from the bevel gear flange and clean that flange surface and drive shaft surface.

Remove the transmission center support mount attached to the subframe. Access the bevel gear bolts and notice their lengths. Remove the bevel gear assembly. At times, and depending on the model, a wedge is required to gently tilt the engine/transmission assembly for ease of access. Remove the wedge when the transmission is ready for removal.

Remember that both mounts will "hang" the assembly for access and safety. Notice the next image and placement of the two inner bolts. There will be a high degree of appreciation when those bolts are in position during reassembly. Ensure the surfaces of the bevel gear and transmission are cleaned before assembly.

Engine lift bar

Bevel gear bolts before assembly

Gently clean off any extra debris and oil. Wipe down all bevel gear mating surfaces, shafts and mounts. With the bevel gear removed, align the first torque converter nut using the crankshaft bolt, turning in the direction of engine rotation.

Mark one torque converter stud and remove the remaining nuts while turning the crankshaft in direction of rotation.

Disconnect the transmission cooler lines at the transmission aluminum block and plug both the aluminum block and lines to prevent any fluid leakage and injection of debris (plastic caps work well).

Note: To access some plumbing and fasteners, remove the remaining induction tube from the throttle body to the intercooler. Pay attention to the harness connecting the pressure sensor at the induction tube. Disconnect the transmission harness and shift cable. Make sure all electrical connections remain clean for reassembly.

Clean that surface and the ground stud before assembly.

With the correct amount of support, the transmission mount, cables, harnesses and grounds can be removed. Remove the mount as illustrated. Angle the transmission with the engine lift to clear the body with the transmission jack in unison. Hold the engine in that position with the support bar for correct alignment.

Remove all transmission bolts (except for one) with the transmission stand in place and transmission strapped to the jack. Check all clearances. Remove the last bolt when assured of a simple maneuver with a clean floor to easily roll the jack safely. Maintain the alignment for assembly.

Notice the white painted stud on the converter. Do not remove or disturb the torque converter. Do find a way to gently hold the converter in position. I used a wooden rod with spacer attached with bolts to the bell housing. This will ensure the correct position if the transmission needs to be rolled or moved to another position. If for any reason the torque converter is removed, the seal must be replaced.

Clean the splines on the transmission differential side and do not disturb the inner seal. Do not use harsh chemicals. Apply a light weight, clean wheel bearing grease in a film on the spline and bevel gear surface. Clean all traces of oil around the torque converter and bell housing.

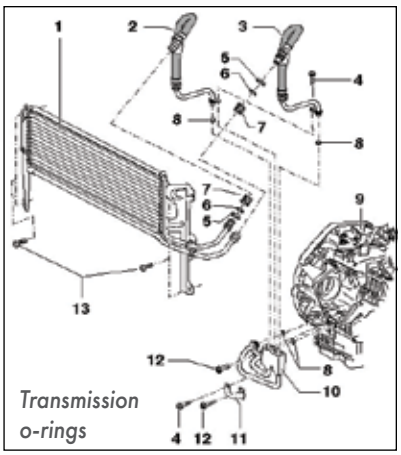
These are the components removed that indicate some floor space required for storage. Magnetic trays are a great way to keep the mounting hardware in a relative order. On one side of the inner wheel well, lots of leaves, twigs and other debris were noticed. Remove the opposite liner and clean out both sides. The vehicle owner will appreciate the "fermenting" debris removal.

Torque converter nuts

Transmission mount and bolts

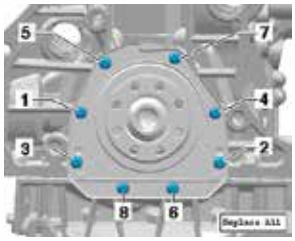
Transmission removed

Removed components



Transmission o-rings

Crankshaft flange seal



Torque sequence

Transmission drive plate

Consider this as part of "maintenance" when debris does enter the area between the body and inner fender liners. You will be surprised when viewing the amount of collected debris.

As mentioned before, the seals number 8 need to be replaced because those seals were inserted to aluminum block number 10. Clean that area very well before removal and make sure the tubes and block are absolutely clean before assembly. The connections will leak with old rings and compromised sealing surfaces. This option was chosen to keep the transmission removal compact and lessen the chances for other transmission cooler line damage at the quick connects. Take great care not to bend or pinch the transmission cooler lines.

Once the transmission drive plate is removed (mark it as well) and the crankshaft flange seal unbolted from the engine block, prepare/clean the block of old sealant, oil and any debris. Look at the original seal. It has "unglued itself."

Note: The entire block surface must be clean with no oil residue. The seal (PTFE) surface and crank surface must not have any oil present.

The crankshaft area should be cleaned/polished slightly with extremely fine pads similar to Scotchbrite.

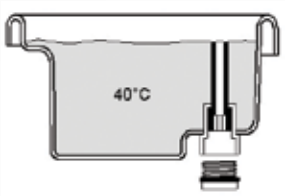
Apply the sealant to the new sealing flange similar to that shown in the image. Ensure that the engine block surface is clean and dry or the sealant will not cure correctly and will eventually allow oil to migrate. It will take substantial force (with the supplied tool) to gently push the flange seal squarely onto the crankshaft to meet the prepared engine block surface. Use new bolts only.

Note: do not rotate the seal or the crankshaft for a minimum of one hour before and after final assembly with torque setup.

The PTFE seal requires time to set up. Use the printed/repair information/specifications to torque using the proper sequence/value for the model you are working on.

Replace the oil separator on top of the valve cover. The upper one is the most common one to fail. The lower vent system rarely fails but when this model is due for the intake cleaning, the lower one will be replaced at that time.

Assemble and torque all components in the reverse order following the repair information. Change the oil and filter with the correct oil rating and quality oil filter. Run the vehicle for a few moments, check for leaks but do not run the engine hot at this time.



Transmission top-up

If this model has high mileage, this is a very good time to replace the transaxle fluid by removing the plastic port above the fill/inspection plug. Capture all the fluid and calculate the amount of fluid removed. When complete, re-insert the plastic port and inject 75 percent of the measured new fluid and attach the fill/inspection plug lightly.

Prepare VCDS, start the vehicle and enter Transmission Electronics. Start this test at ambient temperature. Have enough of the correct transmission oil on hand. Pay attention to the transmission fluid temperature within VCDS during the warming phase and with the fill/inspection plug removed. Watch the spill port and VDS at idle only. The measured value for temperature is group 006, field 1 for ATF Temperature sensor G93.

The "filled" test is as follows:

- Apply the forward and reverse gears a few times and test in Park with the plug in place.
- At idle and the plug removed with VCDS:
  Not dripping = Requires topping up at the required temperature.
  Dripping = Full at the required temperature. Make sure a new gasket is available and torque the plug. Check for leaks.

These are the steps in the correct order to clear the faults on startup and preparing for a road test with VCDS.

Make sure a clean and stable power supply is attached to the battery - KOEO

A. Completely scan the vehicle and clear all faults - save that scan.
B. Set up throttle body adaptations at the ECM (basic settings).
C. Set the clock and radio.
D. Reset the HVAC (basic settings).
E. Apply the TPMS re-learn (button on console) and re-set all tire pressures.
F. Re-set all the windows for "One trip." Cycle each window three times up and down, on the fourth cycle, hold the switch(s) up for 5 seconds.
   Remove and store the power supply, start the vehicle.
G. At operating temperature and with all fluids topped up, road test above 50 kmh (30 mph) for approximately 15 to 20 minutes. Perform a few figure "8s" in safe and open space, apply the ABS once in the straight ahead position and stop the vehicle. Cycle the key once to re-start.
H. Check faults again. If any faults return for ABS or TPMS, begin the test again.

Perform the final re-check for any leaks, routing of plumbing/electrical connections and final assembly. The final autoscan should have no faults recorded unless the radio does not have a Sirius XM subscription.

Attach the belly pan and ensure wheel torque.

Parts used:

- New dealer or OEM equivalent crankshaft flange seal
- New dealer or OEM equivalent crankshaft flange seal bolts
- OEM equivalent sealer or "the Right Stuff"
- New dealer or OEM equivalent transmission cooler tube seals
- Dealer or OEM equivalent transmission fluid
- New dealer or OEM equivalent bolts and drain plug/inspection washers
- New dealer or equivalent axle bolts
- New dealer or OEM equivalent oil separator (top)
- New dealer or OEM equivalent oil separator (bottom) if required.

Remember: Search for all available TSBs and Dealer Campaigns associated with the vehicle. ■

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Das Original

Almost every vehicle in the Audi line has adopted a double wishbone suspension design for good reason. Outstanding stability and control are the hallmarks of this design.

Overview

Audi has always been known for building great handling vehicles. Since the company's beginnings, they have strived to push vehicle design and performance into the future. The suspension design of any vehicle plays a large role in ensuring safety, handling, and performance. Audi has this quality in spades.

The double wishbone is the most common suspension layout in modern Audi vehicles. This design has been proven to have the best handling characteristics and is in use on most higher-end vehicles across the globe.

This multi-link suspension design allows vehicle designers to control movement through the suspension range very precisely. Compared with a standard MacPherson strut suspension design, camber, caster and toe angle offer much better control.

Apply penetrant liberally to avoid breaking off the bolt head.

If the upper control arms become stuck during removal, lightly striking the steel base of the ball joint will help break the arms loose. Corrosion on the upper control arm mounting points can become severe.

Standard Front Layout

The standard front layout on Audi includes upper control arms mounted to the strut mount bracket and the upper spindle. The inner bushings take a lot of abuse, particularly with larger wheels and in heavier vehicles. Small cracks and tears in these bushings are normal. However, once split through, replacement is necessary. When the vehicle is on a lift, visual examination of the upper bushings is straightforward.

Replacing the upper control arms can be a time-consuming task. Due to space constraints, the strut assembly must often be loosened and moved to allow access to the securing bolts. Always refer to work instructions for different vehicles. On certain models, removal of the inner fender liner is the only step required to access inner control arm bolts.

If you live in a climate where rust and corrosion are a problem, the upper outer control arm bolt can become quite stuck. This long bolt lives in the direct path of spray from the tires and also suffers from galvanic corrosion. After the zinc coating on the securing bolt wears off, corrosion quickly sets in, especially in humid climates.

If you are lucky, the upper bolt will work loose with a liberal application of patience, rust penetrant, and/or heat application. And, if you have access to an air hammer, it will assist in pushing the bolt through. Be very careful with the upper spindle. It is aluminum and can easily be damaged if care is not taken.

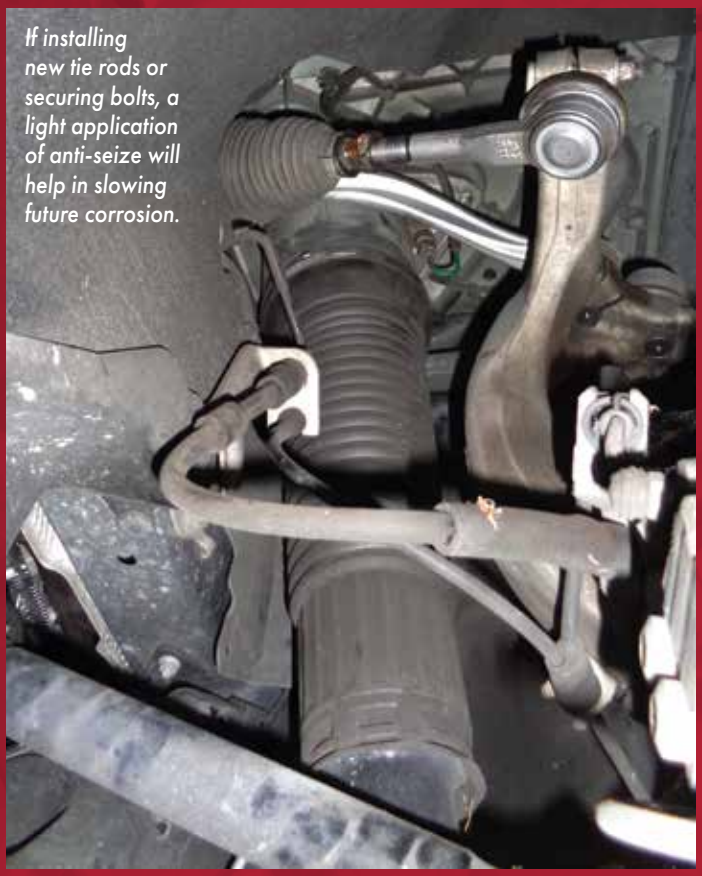
As a rule of thumb, always replace the securing hardware when doing control arm replacement. Applying a layer of assembly grease or anti-seize compound aids in re-installation and protects from future corrosion intrusion.

During re-assembly of the upper control arms, it is critical to install and tighten them in the proper position. Pay attention during disassembly, and note arm position. Failure to properly assemble will result in premature bushing failure and strange handling characteristics. The point is to tighten fasteners with the suspension in its normal loaded condition. If you tighten fasteners with the suspension hanging, the bushings will be subject to twisting when the suspension is loaded, which is virtually all the time the car is in motion.

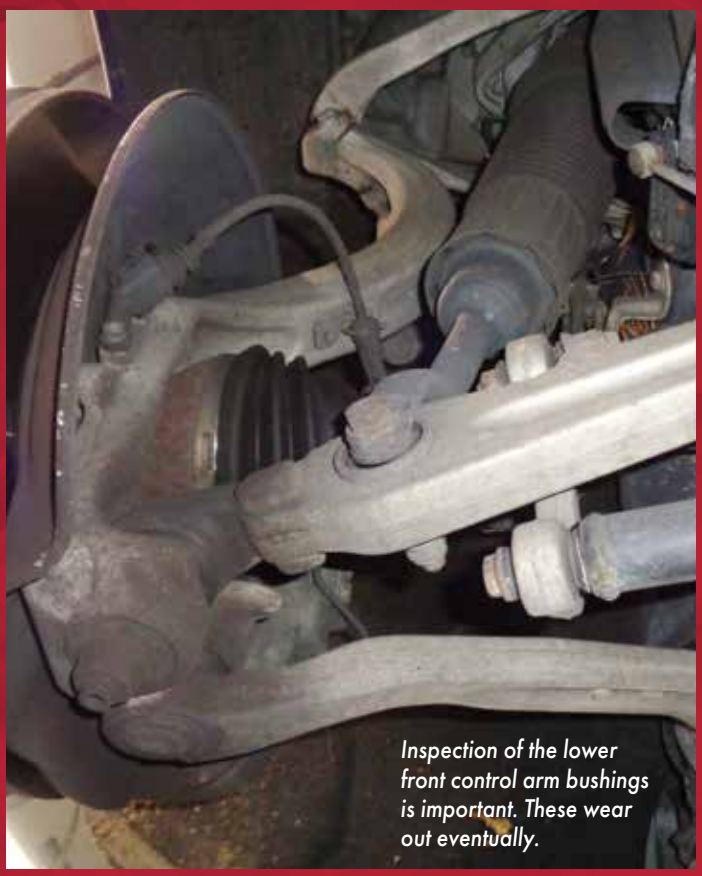
Tie Rods

One additional note: Always check for tie rod end play. The tie rod ends are notorious for developing play, and can be unsafe if left unchecked.

The tie rod adjusters often seize, and performing an alignment can be a headache. Do not apply heat to loosen Audi tie rods. Most Audis have bushing dampeners in the tie-rod ends, and heat will destroy these and potentially cause tie rod failure. No heat!



If installing new tie rods or securing bolts, a light application of anti-seize will help in slowing future corrosion.



Inspection of the lower front control arm bushings is important. These wear out eventually.

Lower Control Arms

The lower control arms are generally trouble-free. But the lower control arm bushings tend to wear out eventually. Fluid leakage from the bushing itself is the most common visual clue of lower bushing degradation.

Audi uses a fluid-filled design to aid in ride quality characteristics. When the bushing has reached the end of its service life, the dampening fluid leaks out and appears to be ATF or gear oil. The engine mounts also share the same fluid-filled design and commonly leak or wear out.

The lower bushings can be replaced easily with most bushing press tool kits. When installing, always check for alignment positions. These bushings are made specifically to be in one position. If installed incorrectly, poor alignment and handling characteristics will result.

The ball joints in the Audi suspension design are overall robust, but care should still be taken during the inspection process. When checking for ball joint play, having a helper assist in loading components can be very useful in cases where play is minimal or hard to locate.

Air Suspension

Vehicles with air suspension are becoming more popular as technology progresses. Having an air spring, or pneumatic spring

Air suspension systems offer multiple comfort modes, as well as an automatic dynamic mode that will change ride characteristics, depending on road conditions and driving characteristics.

suspension, allows vehicle engineers to exercise much greater control over ride quality and handling. These systems are much more complicated than standard steel spring suspension designs.

The shock absorber, or air spring, is the workhorse of the air suspension system. The air spring is constantly adjusted at all four corners to ensure proper ride height and comfort for the occupants. Most designs utilize a twin tube damper design with an oil chamber to assist with

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When working on or around the air springs, it is important to deflate the air spring. Damage can occur, particularly if twisting and moving the strut assembly. This can break the seal.

Ride height sensors usually have a locating bracket on the control arm. This minimizes the risk of improper installation.

damping control. Between the air spring and oil damping control, comfort, safety, and handling can be ensured. This is the same for both front and rear struts.

The brain of the Audi air suspension system is the adaptive ride control unit (J197), which receives signals from multiple sensors to control the system. It is usually located behind the passenger glove box near the firewall. The control unit operates on the CAN network to operate solenoids in the system as well as controlling the compressor to inflate the air springs.

The ride height sensors provide the primary input the suspension control unit uses to determine how much air pressure each air spring needs. The vehicle ride height sensors (G77) are a critical piece of the suspension system. They are located on both front lower control arms, as well as in the rear of the vehicle. If any of these sensors are damaged or misaligned, the suspension control system can malfunction. The most common damage to these sensors is from impact due to being close to the road surface, improper installation, or even technicians forgetting to re-install them. The sensor arm is plastic. Be careful not to damage it during removal and installation.

In addition to ride height sensors, the suspension control unit monitors acceleration sensors within the vehicle. This allows the system to compensate for changes in the vehicle when driving over bumps and around turns, increasing stability and ride comfort. These are also used

The air compressor is located in the lower fender area or undercarriage toward the rear of the vehicle.

by the stability control and ABS systems. If faults are stored for the acceleration sensors (G341, 342, 343), they may affect suspension riding characteristics.


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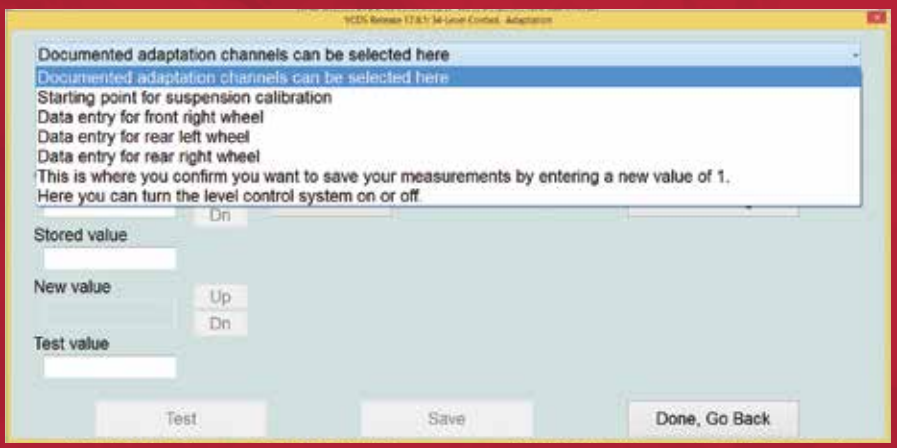
Air Compressor

The air compressor or air supply unit is used to fill the air struts. It may be located in the rear undercarriage or, more commonly, behind the driver's fender liner. This system uses a 12 V electric motor to drive a small air compressor. These air pumps have a safety system designed into the pump. A temperature sensor shuts down the pump if it runs for too long, preventing an overheat situation. The most likely cause of the air supply unit overheating is a leak in the system. The vehicle usually stores faults if it senses an overheating air compressor. This is part of the reason Audi installs the air pump in locations that receive air flow; the pump does get hot and can eventually become degraded after extended use.

Air compressor failure is, unfortunately, common. Often a leaking air strut forces the compressor to run constantly in an attempt to keep up with the leak. This eventually burns out the pump or relays that control the air compressor. The air suspension relay (J403) should not be ignored if diagnosing an inoperative air compressor. These can burn contacts internally from overuse. If pump failure can be confirmed, it is always wise to replace the relays as well during the repair, as they will most likely suffer from internal burnt contacts.

Air lines are color coded. Do not mix up line connections when servicing.

Air compressor replacement is straightforward. There is a single plug for the electric motor, a connection to the thermal sensor, as well as air inlet and outlet connections. Most air compressors are mounted on spring seats. These keep vibration and sound transmission to a minimum. They can be finicky to re-install and overcome the spring tension that properly secures the air pump. The spring mounts are necessary to ensure a trouble-free system.



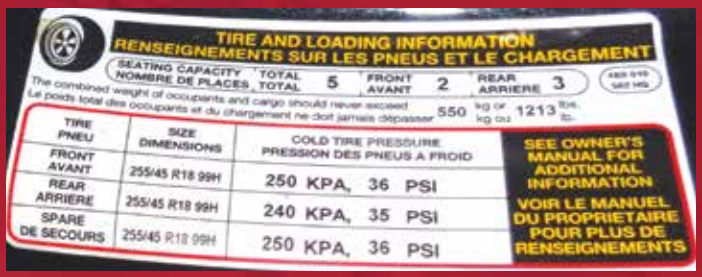
Be careful when making adaptations. Improper values can cause many issues including uneven vehicle ride height and even damage to the air suspension system.

The compressed air travels from the air compressor to a solenoid-activated valve block (N111). This valve block has outlets to each air strut that control ride height independently at each corner.

Most Audi air suspension systems operate on 16 bar or 230 psi pressure or less. These systems also use a pressure sensor to detect proper pressure levels at each corner. The pressure sensor is built into the valve block (N111) and is not serviceable.

Depending on the model, the valve block may be located in the driver's side fender liner or in the rear undercarriage of the vehicle. The valve blocks are quite sturdy and are generally trouble free. If repairs are necessary, the air line connections are color coded so it is easy to install without fear of mixing up lines. The right front strut is marked green, LF strut marked red, RR strut marked blue,

Running the bleed procedure will completely de-pressurize the front or rear axle separately to allow for safe repairs.



Checking and setting correct tire pressures seems obvious, but is often a neglected step. Setting pressure to 34 psi all around is a common mistake. Most Audi vehicles require higher tire pressure in the rear. Check the sticker!

Making the rear camber adjustment can be a nightmare! Low profile wrenches are a necessity here.

left rear marked gray. The air tank line is marked yellow. Note that this can aid in diagnosis if searching for suspension system leaks.

Here is a tip for installing air lines into the valve block or struts: Do not disassemble the securing nuts from the new air block. Remove the old sealing washer from the air line after disconnecting it. To install, just push the air line into the pre-assembled valve block or strut. The sealing ring will be pushed onto the line correctly and be trouble free. There is no need to use line wrenches in a cramped location or guess how deep to set the securing washer.

Pressure Accumulator

The pressure accumulator, or air tank, also plays an integral role in the air suspension system. It is used to store air pressure for the system during operation. Using the stored air pressure from the accumulator instead of relying soley on the air compressor results in smoother, quieter operation of the air supply system. The accumulator/air tank usually resides in the rear corner of the trunk in Audi vehicles.

The ID tag is often worn or water damaged and may be difficult to read.

Any time service work to air suspension components is performed, depressurizing the system is a critical first step. This can be done manually at each connection. However, seal damage can occur to sealing rings when under pressure. Use caution! When using factory level scan equipment, you can safely bleed pressure from the system without risk of damage.

Alignment

Any time suspension repairs are done to an Audi, which includes bushing, strut, and control arm replacement, the alignment should be checked and adjusted. This includes the multi-link design. Audi incorporates camber and toe adjustments for most models. If proper alignment angles are not achieved, adverse tire wear and poor handling occurs. This is particularly true with larger heavier models like the Q7 or A8.

Setting the correct tire pressures before doing an alignment seems obvious, but technicians often forget this critical step. Incorrect tire pressures can affect vehicle camber, ride height, and handling characteristics.

If your aligner offers ride height adjustment, it is wise to take the time to measure this value. This allows the alignment equipment to accurately determine alignment angles and compensate for different ride height. If a large variation is found from side to side, this may lead to suspected worn or damaged components, such as a collapsed strut, spring, or worn bushings. It is also important to verify which suspension option your vehicle has installed. The ID tag is usually located under the trunk mat. This verfies whether the vehicle has sport-lowering suspension installed, or any other options. This affects alignment specifications.

Always start the alignment process at the rear of the vehicle, working your way forward. Every newer Audi model allows for both camber and toe adjustments in the rear. In the front of the vehicle, often only toe angle is adjustable without aftermarket options.

As a good rule of thumb, always adjust camber before toe angle. Vehicle camber can affect toe angle, whereas toe generally does not affect the camber angle.

On most Audi models, the camber adjustment can be found at the inner mounting point of the lower rear control arm. On certain Audis, the rear camber adjustment is located at the upper spindle area. This can be difficult to access and even more difficult to make the adjustment. Access from the outside top of the wheel well is often the best approach to making the camber adjustments.

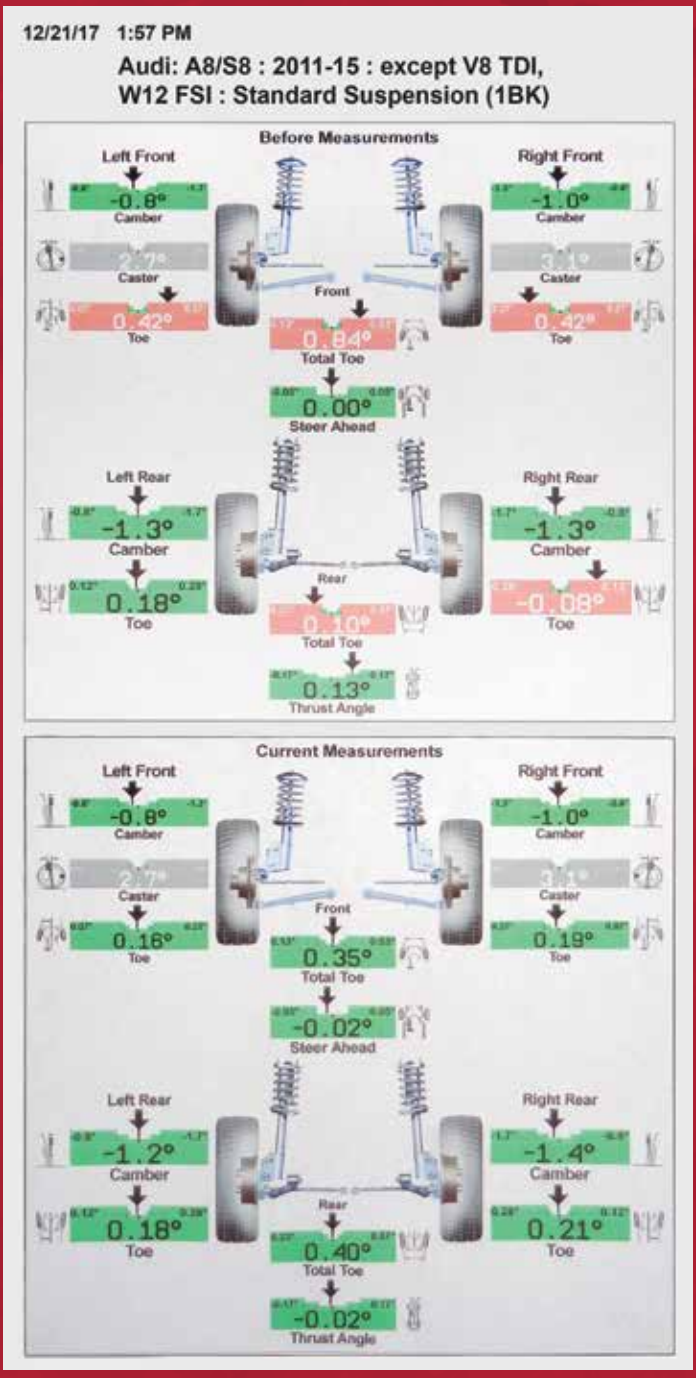
Rear toe adjustment can be found at the rear upper control arms on most models.

Making sure the rear toe angle is in specification is critical for tire life and stability. Almost every Audi model has adjustable rear toe angles.

Audi vehicles generally do not require specialty tools for making alignment adjustments.

Front tie rods on many Audis are located in the upper portion of the wheel wells. This makes tie rod adjustment much more difficult due to access limitations. It is important to never use heat to loosen seized tie rods, or you will damage and destroy components in the process.

If all steps are followed, it is easy to get Audi alignments to be fully within specifications. This keeps customers happy, tire wear to a minimum, and the vehicle operating safely and efficiently. ■



Look at all that green! An alignment printout to show customers will ensure they are satisfied and feel involved in their Audi repairs.

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I know it's in there somewhere!
930 turbo, buried behind the rear bumper.

History

Turbocharging may seem synonymous with Porsche cars to many of the folks reading this article, but like so much automotive technology it was preceded long before it had been made popular by Porsche. Dugald Clerk was the man who originally obtained a patent for supercharging He got the idea of shoving fuel and air into an engine by means of a Roots style blower, as opposed to just allowing the engine's vacuum to suck it in, and there was a moment in automotive history genius.

The very idea of force-feeding an internal combustion engine must have caused heads to spin with all the potential of that technology. Then along came the Swiss engineer, Alfred Buchi, who figured out that you could drive a supercharger by using an exhaust driven turbine that captured the untapped power of the heat and velocity of previously wasted exhaust gases. Turbocharging, while being extremely innovative, is nothing more than an exhaust driven supercharger.

Porsche rocked the sports car world when they introduced their 930 Turbo model in 1976. Porsche engineers had turned to turbocharging as a means of competing with cars using larger engines and creating more horsepower than the 3.0 liter, air cooled, horizontally opposed, aluminum engine could produce.

The impetus behind building a street legal version of the 911 using turbocharging was to meet homologation requirements for racing sanctioning bodies. Homologation requirements state that a certain number of cars built by a manufacturer had to be produced and sold to the general public in order to qualify for a specific race class. This was to prevent the manufacturers from building a radical one-off car that was not representative of a vehicle that could be sold for public consumption.

By today's standards this 3.0 liter engine, producing 260 horsepower, seems unremarkable, but modified and massaged for racing, this car was indeed very remarkable. The street legal 930 Turbo utilized a compression ratio of only 6.5:1 but, with the addition of 12 psi boost, the car accelerated like a rocket when the turbocharger came to life. It wasn't long before Porsche, as well as many other auto manufacturers, began to add turbocharging to other cars in its lineup.

Over the years Porsche produced many models that utilized turbocharging, and most of these were modified and raced by both factory entries as well as private entrants. In addition to the 930 Turbo, Porsche eventually adapted turbocharging systems to most of its lineup, including the 924, 944 , 964, 993, 996, 997 and 991 models. Because of the advantages that turbocharging provides with emissions as well as horsepower, it is now suggested that most, if not all Porsche models will eventually receive forced induction via turbocharging. Proof of this is the new horizontally opposed, four cylinder engines finding their way into the new Boxster and Cayman models.

As the iconic horizontally opposed six cylinder models evolved, so did improved turbocharging. The models 993, 996 and 997 all benefitted from using two, smaller turbochargers, which greatly reduced the turbo lag issues as well as dramatically increasing horsepower output. Some of the more exclusive models such as the GT2 and GT2RS would produce horsepower in excess of 600.

Nothing, especially horsepower, comes without a price tag. In addition to spending extra dollars to purchase one of these turbocharged models, there is added complexity when it comes to servicing as well. Lack of space in the engine bay of turbocharged models adds challenges when service becomes necessary. Many of the supporting components to these engines, such as intercoolers and exhaust components, have to be removed before other vital components can become accessible.

The basic designs of the actual turbocharger unit vary but there are more similarities than differences. Each unit has two separate housings; a "hot" side that the engine's exiting exhaust gases use to spin an impeller, and a "cold" side that houses the impeller which creates pressure in the intake manifold. The two impellers are joined together via a common shaft. This shaft must float in a bearing with an excellent supply of oil provided from the engine's normal lubrication system.

Due to the extremely high rpm the shaft between the hot and cold side impellers must turn, in excess of 100,000 rpm (even higher in some applications), even a momentary loss of lubrication can be fatal. Balance is also critical as the extremely high rpm leaves little room for error. The clearances at this bearing are greater than you might see at a conventional bearing on the inside of an engine. This increased clearance allows the impeller shaft to literally float in a cushion of oil. It is not hard to imagine what 100,000 rpm can do to a bearing and shaft if lubrication is disrupted even momentarily.

Lubrication is one of the areas where many, if not most, turbo failures occur. Turbos run at exceedingly hot temperatures, sometimes in excess of 1875 degrees F. When an engine is shut down, especially on a hot day, that heat has nowhere to go. In fact, temperatures from exhaust components can cause an increase in localized temperatures within a turbocharger unit. These higher temperatures cause oil to break down and form coking deposits, which then restrict oil passages that will then create loss of oil volume and pressure to the turbo's bearings.

Allowing a hot, turbocharged engine to idle for a minute or two, especially on a hot day, is a great idea. This allows the cooling system to take away some of the excess heat and gives time for fresh oil to circulate and cool the turbo to some degree. It also assures that the turbocharger has plenty of time to spool down from running at 100,000 rpm.

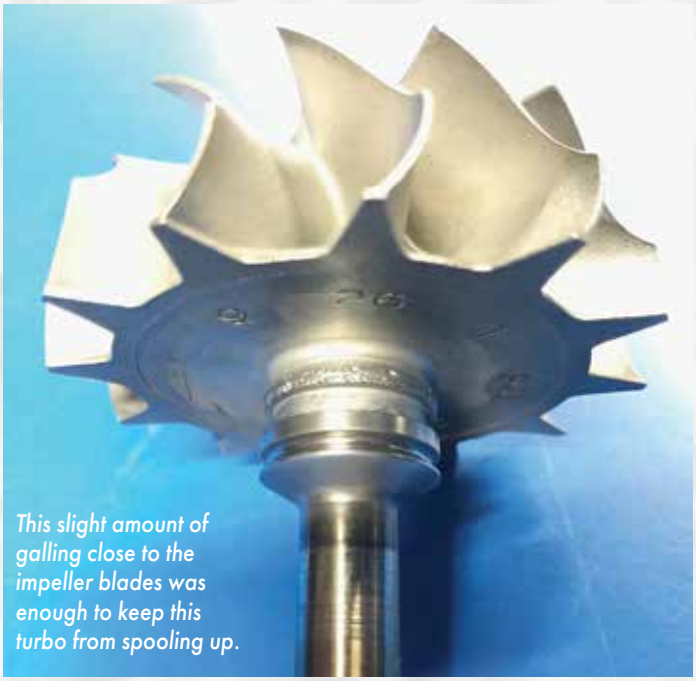
Note the bearing in the center of the shaft. Lubrication is key to the survival at extreme rpm.

All turbochargers are over-engineered to deliver more boost (overkill) than will ultimately be required by the engine. This is in a large part to address some of the inherent turbo lag issues, having more power available sooner. Additionally, the nature of turbocharging can be compared to a snowball rolling down a hill. The more boost generated at the beginning of the process as it spools up increases the exhaust volume that then spins the turbine faster, increasing boost even more.

To regulate this runaway boost a wastegate is used. This is a very simple device, nothing more than a valve very similar to the valves found in a cylinder head. As the boost increases, the valve, which is controlled electrically or by using a pressure line from the intake manifold, is lifted and exhaust gases that normally go to spin the turbine wheel of the turbocharger are dumped back into the exhaust or simply dumped out to the atmosphere.

The closer a turbocharger's location is to the exhaust exiting the cylinder head, the better or more efficiently the turbo will run. The expanding of hot exhaust gases increases the flow of exhaust leaving an engine. Directly after the combustion process has ended, the hot exhaust gases are expanding at their highest rate. A properly placed turbocharger will take advantage of these expanding gases by locating the unit as close as possible to the cylinder head.

While this makes sense in terms of efficiency, it creates challenges due to location as it often makes getting rid of the external heat difficult. The more heat added to an already cramped and relatively hot engine compartment, the more problems could arise. The cast iron "hot housing" will glow like an ember when these engines are pushed to the limits. Gaskets, rubber seals, different rates of thermal expansion of various materials are all issues that need to be dealt with when turbocharging is introduced to an engine. It isn't an uncommon sight to see an older turbocharged Porsche hemorrhaging oil due to various heat-worn seals and gaskets finally giving up.



This slight amount of galling close to the impeller blades was enough to keep this turbo from spooling up.

Notice the dedicated exhaust pipe, which will dump excess exhaust pressure to the atmosphere.

Intercoolers are often used to maximize the effect of turbocharging. The act of compressing air actually has the effect of raising the temperature. By cooling the incoming air to a turbocharged engine, the density is increased and further power is achieved. This also has the effect of cooling the combustion chamber temperatures as well, which helps control the damaging effects of detonation.

There are essentially two types of intercoolers; air-to-air and water-to-air. The air-to-air are the more common types as they utilize the air in an already accessible stream rather than a separate, cool water supply. These appear to look much like a radiator and they function in a very similar way to a radiator. As the incoming air is forced into the intake manifold, it is drawn through a series of pipes just as water is forced through the pipes of a radiator. The pipes have light fins attached to them that allow heat dissipation to the atmosphere. Thus the air charge is cooled just prior to entering the engine.

Porsches use air-to-air intercoolers on virtually all their cars with turbochargers. The bigger the better and it is all about location. On the air-cooled cars the intercoolers generally live just below the intake air grille on the engine compartment lid. With the water-cooled versions they are often placed in the rear fender well where air is then ducted to them.

"Turbo lag" is a common term used to describe the most apparent driving challenge that is inherent in turbocharged engines, especially with the earlier versions. As one might imagine, the process of exhaust spinning a turbine wheel, coupled with the compressor side building up pressure, there is a significant time delay. This lag time can feel like waiting for a snail to cross a road when a driver is trying to accelerate out of a corner. When the boost finally does kick in, the rush of power is quite exhilarating.

Bigger is better...sometimes. Can you imagine the amount of exhaust flow necessary to get this huge turbo to wind up? Ultimate horsepower comes at the expense of substantial turbo lag.

The early turbocharged Porsche 911s used a relatively large turbocharger and lowered the compression ratio of the engine to a very low 6.5:1. The lower compression ratio allowed the engine to pull smoothly under hard acceleration and low rpms. Smooth, however, did not mean strong. When the boost finally does decide to develop, around 4,500 engine rpm, it comes on like gangbusters and the car feels like a rocket. Drivers had to learn to mash on the gas pedal much earlier than with normally aspirated race cars in order to take advantage of the huge power when it does arrive.

The earliest street-going Porsches made a relatively modest 265 horsepower, but their sudden development of power made it feel like much more. The bred-for-racing cousin of the street legal Porsche 930, designated the 935, had water cooled heads and produced around 750 horsepower out of a 3.2 liter engine. Just imagine what the rush of 750 horsepower might feel like as it arrives almost all at once!

Turbo lag was a big reason that Porsche engineers went to the use of two, smaller turbochargers in later versions of the 911. The Porsche 993 had two turbos; one small unit for each bank of three cylinders. The smaller turbos did not require as much exhaust flow to get them spinning, and turbo lag was all but eliminated. These new turbocharged 911 models produced slightly over 400 hp, a significant increase over the more modest 265 hp of the earliest versions.

Porsche provided other goodies to help keep the car planted firmly in concert with the extra power — larger brakes, modified suspension, a wider stance and improved aero bodywork to name a few. Twin turbocharging also gave the opportunity to position the turbos in an ideal location; close to the engine's exhaust ports and directly under the heads where they can receive the greatest benefit from the expanding exhaust gases, but also with the ability to stay cooler by being closer to air flow under the car. Another notable change was an enormous intercooler that mounted over the top of the engine. This was a simple air-to-air unit, but was essentially all you could see when the engine lid was lifted as it takes up every available square inch of top-side real estate in the already cramped engine compartment.

It was a sad day among Porsche fans when the air-cooled models were discontinued. While the early, water-cooled 996 models were received with a certain level of tepidness, they were actually superior to the air-cooled versions as the heat could be controlled better.

The basic layout of the water-cooled engine was so similar to that of its air-cooled cousin that some of the internal components, such as

the crankshaft and connecting rods, were interchangeable. The liquid-cooled engines still benefitted from a dry sump lubrication system while the normally aspirated 996 models had a completely different engine block and did not enjoy dry sump lubrication. Water cooling also resulted in greater power and less turbo lag as these units became more efficient. Redesigned body work and lack of need to accommodate airflow to the actual engine permitted the use of huge intercoolers located in the flared rear fender wells of the 996 as well.

The other Porsche models to receive turbocharging were the four cylinder, entry-level models introduced in the late 1970s and through the 1980s. Porsche's popular line of four cylinder, water-cooled models, the 924 and 944, were praised for their handling and ergonomics but not for their power.

It was no surprise then that the 924 and 944 models both received help in the form of turbochargers. One might argue that the 924 was the worst Porsche ever built and you would be on some pretty solid ground. Turbocharging added some much-needed punch for the 924, but it only made a reluctant engine slightly more acceptable. The 944, on the other hand, was transformed by forced induction into something beyond acceptable, all the way to extraordinary, and it became one of the best entry level cars Porsche ever made.

Turbocharging added a level of complexity to the servicing of these vehicles, which some folks already considered to be difficult to service. Accessing the valve covers and adjusting the valves of a 930 Turbo, a normal mileage-based maintenance item, required additional disassembly and added easily another three or more hours to the operation. Some of the inherent problems with these engines like cylinder head stud breakage and various gasket ruptures would occur at an earlier time than in the normally aspirated 911. It wasn't unusual for a routine maintenance visit to a repair facility to turn into a major overhaul if broken head studs and excess oil leakage were discovered.

Now you see it, now you don't. Many components on the top of this 944 engine have to be removed before you can even get a glimpse of the turbo!

Accessibility of many components, including the turbo itself, was one of the more vexing problems confronting a technician when attempting to replace one of these units on an earlier 930 or, worse yet, a 944 Turbo car. The air-cooled 930 positioned its turbo where it was relatively easy to access once the rear bumper and its trimmings were removed. The 944 Turbo was a very different challenge. To access the turbocharger on one of these models it was necessary to disassemble the entire intake manifold, loosen up the steering rack and remove many difficult to access heat shields and supporting brackets. Being something of a contortionist and possessing many universal sockets and extensions was necessary for replacing these units. Luckily, the turbochargers were reasonably reliable and the need to replace one of these units on either the 930 Turbo or the 944 Turbo was relatively rare.

Additional horsepower was well within reach simply by turning up the boost, which could be done by means of regulating the wastegate. The early 930 Turbo cars and the 944 Turbos had wastegates that

Replaceable and programmable EPROM sits in the brain and signals valves controlling the turbocharger.

This turbo's impeller was lightened and balanced by someone lacking skills and equipment. The result was a total loss of the turbo itself. Note the pieces trying to escape from the housing.

were controlled by pressure being applied to a diaphragm on top of a valve. As the boost increased, the pressure on the diaphragm lifted the valve and allowed boost to bypass the hot side of the turbocharger.

The application of the pressure was partially regulated through the fuel management system on the 944 models but the system applied to the 930 was completely mechanical in the sense that the pressure to the wastegate was not controlled by any electrical means. Many savvy tuners would create mechanisms that allowed the boost to be adjusted by means of a simple knob on the dashboard.

There was an over-boost cut-out feature that would shut the fuel pumps off at a certain level, about 14 psi. This safety device would have to be bypassed when modifications to the boost were made. Increasing the boost on the 930 without assuring that there was sufficient fuel being delivered and no over boost protection could have catastrophic results. Engines running lean under extreme turbocharging pressures would cause piston melt-down in a hurry. Contrary to some folks' belief, a lean engine at wide open throttle will not necessarily run poorly or give the operator warning that something is amiss. Even if it did, the catastrophic meltdown occurs so suddenly that it is unlikely that it would occur without damage even if an astute driver did become aware that something was wrong.

The 944 Turbos often had their boost modified by utilizing a slightly different strategy of restricting the pressure line signaling the wastegate and internal modifications to the EPROMs controlling the fuel and ignition management. The resulting significant increase in power would often be followed by a head gasket failure as the pressures in the combustion chambers were too much for the stock configuration. An updated, improved head gasket that utilized a much wider fire ring would help mitigate this problem.

Further reliability could be achieved by machining a small, circular groove cut into the cylinder head that would interface with the middle of the fire ring. A stainless steel wire, which stood about 0.010" higher out of the groove, would then be carefully installed into this groove. The effect of this cylinder head o-ringing process would be that the stainless steel wire would bite into the fire ring of the gasket slightly and help retain its position and strength under higher combustion pressures. This modification was very effective and most head gasket problems could be eliminated even under relatively extreme boost conditions.

Internal repairs to turbochargers are best left to specialists. Just swapping out bearings and seals is the easiest part of the job as a turbocharger is not that complex a device. What is absolutely critical is the balancing procedure after repairs have been completed. The tiniest little wobble in a shaft or imbalance in an impeller can have catastrophic results. At 100,000 rpm things happen very quickly and self-destruction will not be pretty.

It has been predicted by many astute observers that one day all Porsche models will be turbocharged. The development of the new four cylinder, turbocharged Cayman and Boxster engines would seem to bear this out. Smaller engines create fewer pollutants by weight than larger engines. Turbocharging allows high horsepower yields out of smaller engines, resulting in fewer overall emissions. This is a win for both auto enthusiasts as well as those of us dedicated to preserving our environment. ■

Audi Sunroof Service

Sunroofs have become standard equipment on all Audis. Many models also offer a larger, panoramic option. And, in addition to a panoramic size, motorized sun shades are available to increase comfort.

On models with a motorized sun shade, a seperate motor with attached control unit (J394) controls this feature. It is located at the rear of the sunroof assembly. The primary sunroof control unit (J245) is integrated into the drive motor at the front of the sunroof assembly.

Safety Features

On Audi vehicles that support LIN bus communication, a diagnostic line is connected to the control unit. This allows some diagnosis and fault tracing for the sunroof system.

Anti-trap protection is an included safety feature as well. This works the same as normal passenger power window protection. If the sunroof motor detects that increased motor force is required, it reverses motor direction. This eliminates risking injury to a passenger.

If there is damage to the sunroof system, this may also engage pinch protection. If a sunroof engages pinch protection, it often loses its motor adaptation and must be reset. This procedure also needs to be done after disconnecting the battery, or doing repairs or adjustments to the sunroof system.

The sunroof control unit memorizes certain endstops in the sunroof system. Without re-learning the sunroof positions, damage to components can occur. Resetting the sunroof is a simple procedure. On models with motorized lower sun shades, these will be adapted as well during the re-adaptation process.

Shown above: Larger models such as Q5 and Q7 as well as Avant models may have panoramic sunroof options as well as motorized sun shades.

It may be necessary to remove the overhead console during repairs. Removal will allow access to the sunroof drive motor on most models.

Slowly pull the rear edge of the gaiter away from the glass to separate.

The primary interior fuse block, located at the base of the A-pillar is very susceptible to water damage if there are leaks at the sunroof drains.

Although less common, the antenna seal can become damaged, appearing to be a sunroof leak.

With the ignition on and all doors closed, make sure the sunroof switch is in its home position. Next, if equipped, press and hold the sun blind close switch. Continue holding the close button during the entire reset procedure. During this process, the shade closes fully and then slides about halfway open. Continuing to hold the button the entire time is the only critical step in this procedure.

The glass sunroof must be adapted as well after the sun shade adaptation. For the sunroof, pull and hold down on the sunroof switch dial. Continue holding during the entire process. Releasing the control button early terminates the adaptation, and it will have to be restarted. The sunroof glass will fully close, fully tilt, and then retract along its entire length. The reset procedure generally takes about 30 seconds to complete. Once re-adapted, the sunroof will have one-touch convenience features available, and, if repairs are completed, full sunroof operation.

The sunroof glass must be positioned well to function properly. A misaligned sunroof glass can cause water leaks, noise, and friction in the system, causing anti-trap activation. If the leading edge of the sunroof glass is too high, wind noise becomes a problem. Adjustment of the glass is fairly straightforward. First, set the sunroof to vent position. This allows greater access to the rubber gaiter. This needs to be separated from the glass carefully to access the mounting screws. Be careful. The rubber is quite thin and easy to tear while removing.

The rubber gaiter is a necessary addition to the sunroof for diverting rain water and minimizing noise. Once the gaiter is removed, lower the sunroof back to closed position. The front edge of the sunroof glass should be slightly lower than flush; 1mm below the roof edge is a safe position. At the rear of the sunroof, the edge should be flush or slightly higher than the roofline. This sounds counterintuitive, but mounting the glass slightly lower in the front helps decrease noise and drag. After adjusting the glass position, don't forget to tilt the glass again and reinstall the gaiters on the glass.

Drain Tubes

The most common reason to work on an Audi sunroof is to check and clear the drain tubes. A common misconception is that sunroofs are

The vehicle battery and primary body control module are located in the right rear corner on this 2012 A4 Avant.

The audio amplifier location on an Avant model, located at the base of the C-pillar. This is prone to water ingress from clogged rear sunroof drains.

"waterproof" and impervious to the elements. This is, unfortunately, not true, and periodic maintenance is necessary for all vehicles with sunroofs. Rain water drips in along the sides and particularly along the front edge of the sunroof assembly. This water is diverted to drain tubes at each corner and drained down the A-pillar in the front and the C-pillar in the rear of the vehicle.

Depending on where the Audi is driven and parked, plant matter, pollen, etc. tend to collect in drain locations. If left unchecked, this can block a drain tube completely, causing water intrusion into the cabin of the car. Water leaking down the A-pillar can be a problem on many Audi models, as a fuse block is located at the base of the A-pillar.

Fully opening the sunroof allows access for inspection.

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Photo by Michael Furman | Vehicle courtesy of Don Meluzio

Air pressure can be used to clear drains. However, be very careful. You run the risk of creating more leaks and possibly disconnecting drain tubes with excessive pressure. Using a regulator inline to limit pressure will ensure you do not cause damage.

Problems with the rear sunroof drains are less common but can still be an issue, particularly with Avant models. If a rear sunroof drain becomes blocked, the most common outcome is water damage to modules located in the lower rear corners of the Audi. These are not cheap!

If a blockage at the sunroof drains is suspected, a quick visual inspection can help determine the blockage. A great way to check drain tube function is to pour water directly into the sunroof drain channel. A small amount of warm water is recommended to help soften blockages and aid in flushing out debris. Always be careful to only pour water into the drain area. Otherwise, you can pour water directly into the cabin.

Often overlooked, the drain tube itself may cause issues with water ingress. The junction at the corners of the sunroof may shrink or swell and allow water to escape past the drain tube. This may appear to just be a clogged drain so further inspection will be necessary. Drain tubes can be removed and resealed, but it is best to replace them once damage to the sealing end has occurred.

Periodic sunroof maintenance should be a recommended service to customers. Keeping water out of the cabin is critical for both vehicle electronics and driver comfort. ■

If you have to remove the grab handles to gain access to the drain tubes, be careful! The securing clip is easily damaged and very difficult to re-secure once bent.

This pinched drain tube was caused by a previous repair and appeared to be a clogged tube until closer inspection. Note: This image is not on an Audi vehicle but still good information.

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Understanding Volkswagen and Audi Driver Assistance Systems

Images courtesy of Volkswagen of America, Inc.

The purpose of this article is to express what is here and now, but also what is in the future for many Volkswagen models. The same technology will, and is, being used within the Volkswagen group that includes Audi, Porsche, Bentley and Lamborghini. In Europe those same technologies can be present in Škoda and Seat models to name a few.

To understand the vehicle, one needs to know what systems and components are installed in that model. Not all models have the same equipment or behave the same way with similar equipment and combinations.

A word of caution 1. When working on this Driver Assistance equipment, and when testing and diagnosing these networks on wheels, never attempt to diagnose using scan equipment alone. A second technician must be present to read the measured values during the test.

A word of caution 2. Never rely on assistance equipment to make driving choices. It is up to the driver to make those responsible choices.

A word of caution 3. Any vehicle that displays any body or structural damage and has concerns about safety equipment must be recorded. All images and scan records must be passed to the vehicle owner/driver.

Something to think about: The average human brain reacts to stimuli in many different ways. The reaction depends on many factors such as age, sleep, drugs/alcohol and outside distractions/influences. A programmed controller(s) will react profoundly faster than human intervention.

Fact: Before the human brain reacts to a situation, the brain first has to see, recognize, assemble data then react. That reaction also means the brain has to lift that foot and slam on the brake. What just happened is in the past and the vehicle has traveled far down the road.

What should the service facility look for?

Not every option is evident in the model that is in the repair facility. There are two ways to determine what equipment and systems are installed in the vehicle. One is viewing the PR code list in the trunk or maintenance manual, and the other is a complete scan of that vehicle.

This specific example is of an Audi Q3 and very similar to the Tiguan.

Follow the scan and notice addresses 10 "Park/Steer Assist," 3C "Lane Change," and 6C "Camera." The gateway example identifies the installed components/equipment as the vehicle was built at the factory.

PR Code

Complete Gateway Scan from the vehicle in the PR Code

01-Engine – Status: OK 0000
02-Auto Trans – Status: OK 0000
03-ABS Brakes – Status: OK 0000
04-Steering Angle – Status: OK 0000
05-Acc/Start Auth. – Status: OK 0000
08-Auto HVAC – Status: OK 0000
09-Cent. Elect. – Status: OK 0000
10-Park/Steer Assist – Status: OK 0000
15-Airbags – Status: OK 0000
16-Steering wheel – Status: OK 0000
17-Instruments – Status: OK 0000
19-CAN Gateway – Status: OK 0000
22-AWD – Status: OK 0000
25-Immobilizer – Status: OK 0000
2B-Steer. Col. Lock – Status: OK 0000
3C-Lane Change – Status: OK 0000
42-Door Elect, Driver – Status: OK 0000
44-Steering Assist – Status: OK 0000
46-Central Conv. – Status: OK 0000
47-Sound System – Status: OK 0000
52-Door Elect, Pass. – Status: OK 0000
55-Headlight Range – Status: OK 0000
56-Radio – Status: OK 0000
5F-Information Electr. – Status: OK 0000
62-Door, Rear Left – Status: OK 0000
6C-Back-up Cam. – Status: OK 0000
6D-Trunk Elect. – Status: OK 0000
72-Door, Rear Right – Status: OK 0000

Driver Assist explanations and functions:

ACC Controls

Adaptive Cruise Control

ACC, or **A**daptive **C**ruise **C**ontrol, is designed to maintain a safe distance and road speed relative to the traffic in front of the driven vehicle. Engine management and the radar controlled Front Assist traffic monitoring system will also send messages to intervene with the ABS in case of a required braking event. The driver is warned immediately.

The driver controls the speed range, acceleration, braking and distance. The driver can also restrict the speed limit. The added radar sensor immediately detects any traffic that is slowing in the radar range and reduces speed to match traffic speed. If in any event the management system detects a vehicle slowing rapidly and/or cutting into a lane, the system will first warn the driver acoustically and then perform a rapid brake nudge. If necessary, the system will stop the vehicle completely.

Adaptive Cruise Control

Included: Follow to Stop

This feature can stop the vehicle in normal traffic flow if it is necessary to prevent a collision. Applying the throttle or using the Resume control will return the vehicle to the pre-programmed speed.

Fact: In many cases and studies, the data acquired during a braking event or accident indicates that the majority of drivers insufficiently apply the brake. This is also indicated in a braking event where the driver reaction is slower.

At normal programmed highway speed, the ACC system requires no intervention and the driver can increase or decrease speeds via steering wheel controls. The steering wheel controls are connected via CAN with the ACC, radar sensors, ECM and TCM. The radar system is in constant monitoring mode when ACC is active.

ACC – Front Assist

Front Assist

The Front Assist system is designed to monitor road conditions/traffic speeds in front of the vehicle in conjunction with the ACC system. ACC calculates the road speed and distance of the vehicle being approached. With ACC enabled, the vehicle will decelerate to create a safe distance between each vehicle. If for some reason road traffic or environmental issues cause a potential rear-end collision, the Front Assist will intervene by issuing a driver alert and prepare the brake system for an emergency braking event. If the calculated event perceives insufficient brake pressure, Front Assist will provide the extra increase braking within the event.

The design

If the ACC and Front Assist systems sense a collision, "pre-priming" the brake system is also an aid to reducing the traveled stopping distance when the driver applies the brake. Front Assist intervention is carried out by the ABS, preventing wheel lockup and maintaining driver steering control. The radar sensor has a range of up to 650 feet with a beam angle of 12 degrees. The control unit and radar sensor are combined into a single unit.

Lane Assist

The Lane Assist system is comprised of a camera and vibrating device built into the steering wheel as a driver warning. The software for the camera is located within the rear-view mirror assembly. This system monitors the road markings and warns the driver of an unintentional deviation from within the marked driving lane. If the signal indicators are used, the system recognizes the intention and Lane Assist is disabled. If Lane Assist is enabled and the vehicle deviates, then Lane Assist sends a warning to the driver via steering wheel vibration

Note: If there are no visible markings on the road surface because of surface repairs or snow, the system will not be active.

The design

When the system is activated, Lane Assist is active at about 37 mi/hr and above. The camera begins to calculate the position of the vehicle by detecting the marked lanes. If the vehicle begins to deviate or drops below about 40 mi/hr, Lane Assist warns the driver to correct the vehicle position within the lane with a steering wheel vibration.

Activation

When Lane Assist is activated, a yellow symbol is illuminated and the camera begins to analyze the marked lanes. When the analysis is complete, the illumination switches to green, indicating that Lane Assist is active and ready.

Warnings

The system recognizes marked lane changes and if the driver's hands are off the steering wheel. The system will warn the driver with an acoustic sound and display a warning. When the driver is back in control, the warning is disabled. The driver can also counteract the warning by steering in the correct direction.


Lane Assist Warning

Side Assist

When the driver intends to make a lane change, the system warns the driver when other vehicles are excessively close or within a blind spot. If another vehicle is approaching and closer than about 165 feet, a warning LED will flash in the side mirror. The system is generally designed for highway driving and can be switched off. On surface roads and general city driving, warnings can be constant. Therefore be aware that Side Assist is constantly scanning when enabled.

The design

Oncoming vehicles or stationary objects do not trigger any Side Assist warnings. Any vehicles that are one lane across the monitored lane do not trigger warnings. This system only works on speeds of about 37 mi/hr and above. The sensors have a range of approximately 200 feet. If the steering wheel is turned towards the vehicle detected, the system will intervene to avoid a collision and steers in the opposite direction (found only in combination with 'Lane Assist').


Side mirror warning


Blind spot warning

Note: Some models, and depending on the market, will have the warning symbol in the glass or mirror housing facing the driver.

Side note: Once again, pay attention to body damage, paint or debris on or near the sensors. During a road test for Side Assist issues, use caution and follow the rules of the road your grandfather taught you! Look over your shoulder and use all of the mirrors.

Park Assist

The Park Assist system is integrated with, and monitors, the radar sensors, electric steering rack, engine management, transmission and ABS controller systems via CAN.

The design

Enable Park Assist with the switch. Use the turn signal indicator before the vehicle passes the chosen parking space. The ultrasonic sensors in the front bumper cover will scan that open space. Park Assist will calculate if there's enough room to maneuver the vehicle into a parallel position. When the vehicle is stopped and reverse gear is selected, Park Assist will indicate the calculated path. The driver releases the steering wheel and can view the path on the multifunctional display via rear camera. The Park Assist system begins to calculate the starting position and steers the vehicle into the chosen space. The driver has access to the throttle and brake/clutch pedals. The driver can take control and deactivate the system by steering or braking to a stop. Specifications are about 1.6 and 5 feet from the curb.

This system can allow the vehicle (if it fits) to maneuver into that chosen space multiple times by controlling the vehicle with the throttle and brake/clutch pedals. Again, take control by holding the steering wheel or stop the vehicle completely.

Side note: Do these vehicle owners actually get a pass on a driving test?

Park Assist

Park Distance Control (PDC)

The Park Distance Control uses ultrasonic sensors that warn the vehicle operator of objects in its path. Depending on the system and with a rearview camera, the driver can see objects in reverse and hear the warnings. The closer the object detected, the faster the warnings sound. With the multimedia interface, the driver can also use the grid lines on the display to accurately maneuver the vehicle into position.

PDC warnings

Other systems also incorporate PDC in the front bumper cover and with close proximity to front objects, the driver is warned audibly.

Post-Collision

Quite a bit of research has been compiled after a collision and, of course, one factor comes into play.

Newton's first law of motion: "An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force."

Not all collisions are the same. There are multiple/complex factors to consider but the Post-Collision system can mitigate more potential damage or injuries.

The design

The air bag controller and the sensors attached to the vehicle are constantly recording data. That data will come from the ECM, TCM, ABS and the sensors attached to the air bag controller.

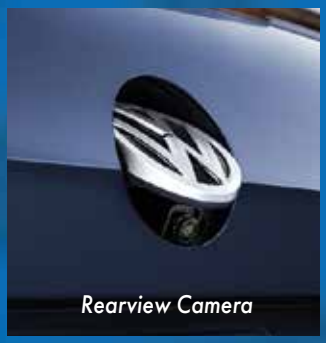
Post-Collision

At the moment of impact, the air bag controller will record the event and the Post-Collision system is informed via CAN messages. The system will initiate the ABS system until the vehicle decelerates to about 6 mi/hr.

At the moment of impact, the brakes will be applied immediately and as long as necessary, to slow the vehicle and help prevent other damage or injuries. During the Post-Collision event, the driver can still maneuver the vehicle as necessary using the steering control, brakes or throttle back to a safe path.

Rearview Camera

The rearview camera is connected via sensors and the multimedia display to aid the driver when in the reverse direction. Via CAN and also with Park Assist the camera is enabled with the Park Assist switch.



Rearview Camera

Multimedia Screen

The design

A common feature with the camera system is also the acoustic warnings with the PDC system. The multimedia interface incorporates grid lines in the display to align the vehicle or help indicate objects while the camera is enabled. The display will also indicate the direction the vehicle will travel via steering angle sensor.

Along with the rearview camera and multimedia device, options such as navigation can be added when the vehicle has that option enabled and/or installed.

Rear Traffic Alert

The rear traffic alert is a system that uses radar sensors to warn the driver when a vehicle approaches (especially in a blind spot), sounding an audible alarm. The range is approximately 165 feet on both sides.

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Radar sensors

The design

When the system is active, sensors at the rear bumper monitor the lateral area behind the vehicle. The sensors sweep a wide area (about 180 degrees) to inform the driver of any obstacles in its path. If the driver does not take action and an impending collision is calculated, the ABS intervenes and applies the brakes. Warning messages are also sent to the driver information center and/or multimedia interface.

Something to think about

The modern body shop will be horrified when they find out what the costs will be for replacement and adaptations for these intelligent and complicated systems. Work with the reputable body shops and explain to the vehicle owner the complexities and adaptations of Driver Assist systems.

Driver distraction is now the leading cause of accidents, just above drunk driving.

Intelligent Crash Response System (ICRS)

In the event of a collision that deploys the air bags, the ICRS can turn off the fuel pump, unlock the doors and activate the hazard lights. That will mean that the engine will stall but critical electrical systems will remain active.

Dynamic Light Assist

The system relies on sensors and lighting control that offer the driver automatic assistance when approaching another vehicle when the normal lights (low beams) are active.

Dynamic Light Assist

The design

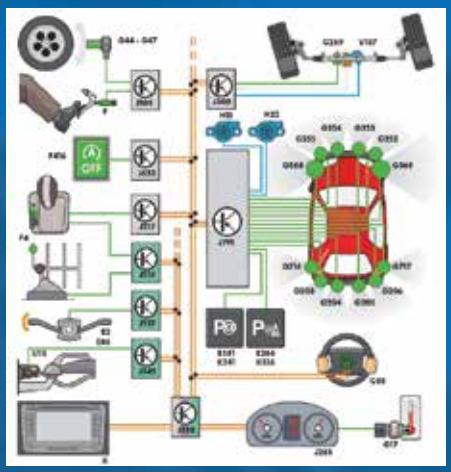
If the vehicle has cornering lights added as an option, the beams will move slightly to the right. The camera in the rearview mirror monitors the incoming light and relays the message to the Dynamic Light Assist system, controlling the dynamic headlamp motors.

Light Assist

Another improvement for driver control is the Light (high beam) Assist system. The system also uses the camera built into the rearview mirror.

The design

The system is activated above about 37 mi/hr automatically when the driver selects the low beam switch position. With the built in camera, the incoming light messages the controller to switch the high beam to low beam when detecting oncoming traffic if the high beam switch is in the On position. Light Assist control monitors the camera, road speed and the Hi/Low switch position.



Park Assist Network

This included image is in relation to Park Assist only. It gives a very clear idea of the Park Assist complexity. If for any reason tests are to be performed on any Driver Assist systems, familiarize yourself and your staff by reading the operators manual first! Understand how these systems operate, how to enable and disable the systems. Ultrasonic and radar sensors require adjustments and adaptations after replacement.

Light Assist

Remember: Search for all available TSBs and Dealer Campaigns associated with the vehicle if repairs or adjustments are required.

If programming updates are required, do them as well.

Any adjustments or replacement of chassis, suspension, and suspension control components will require alignment and control module adaptations.

To date, the chart below indicates the modern vehicles that do or don't have some or all Driver Assist options. ■

LEGEND	no	not available		yes	installed		O	optional			
Columns	1	2	3	4	5	6	7	8	9	10	11
JETTA (2018)											
S	no	no			no	no	yes	no			
SE	no	yes			no	yes	yes	no			
SEL	yes	yes			no	yes	yes	yes			
GLI	no	yes			yes	yes	yes	no			
PASSAT 2018 O/DAP optional with Drivers Assistance Package											
2.0T	O/DAP	O	O	O	O	O	yes	O/DAP			
V6 SEL PREM*	yes	yes	O	yes	yes	yes	yes	yes			
V6 GT	no	yes	O	no	no	yes	yes	yes			
TIGUAN 2018 RPAvailable with R-Line Appearance Pkg Later availability											
S	no	DAP	no		no	DAP	yes	DAP	DAP	no	no
SE	no	yes	no		no	yes	yes	yes	yes	no	no
SEL	yes	yes	no		RP	yes	yes	yes	yes	no	no
SEL PREM	yes	yes	yes		yes	yes	yes	yes	yes	yes	yes
ATLAS											
2.0T	O	O	O	no	O	O	yes	O	O	no	no
V6	O	O	O	O	O	O	yes	O	O	O	O
2017 Touareg											
Sport	yes		yes		yes		yes	yes		no	
Wolfsburg	yes		yes		yes		yes	yes		no	
Exec	yes		yes		yes		no	yes		yes	
GOLF 2017											
S		no				no	yes	no			
Wolfsburg		yes				yes	yes	yes			
GOLF GTI 2017											
S	no	no				no	yes	no			
Sport	no	no				no	yes	no			
SE	no	no				no	yes	no			
Autobahn	yes	yes				yes	yes	yes			
GOLF SPORTWAGEN 2017											
S	no	no				no	yes	no			
SE	no	no				no	yes	no			
SEL	yes	yes				yes	yes	yes			
GOLF R 2017											
	yes	yes			yes	yes	yes	yes			
COLUMNS	1	2	3	4	5	6	7	8	9	10	11

1. Adaptive Cruise Control
2. Blind Spot Monitor
3. Lane Assist
4. Park Assist
5. Park Pilot
6. Rear Traffic Alert
7. Rear View Camera System
8. Forward Collision Warning and Autonomous Emergency Braking (Front Assist)
9. Pedestrian Monitoring (with Front Assist)
10. Overhead View Camera (Camera View)
11. High Beam Control (Light Assist)

Driver Assist Options

Volkswagen Fasteners
Beyond Length and Thread Count

This 2013 Beetle GSR TSI engine includes TTY bolts for greater clamping force, encapsulated bolts for corrosion resistance in water-immersion applications, and many other different types of fasteners.

Threaded fasteners — It's not just length and thread count! Tips for decision-making about non-reusable bolts and joining technologies.

It's a fact: automotive bolts are application-specific. We make sure we have the correct length bolt for the application. If a bolt is too short and only engages a few threads in the component, it may pull the threads out of the joint. If it is too long, it may bottom out when installed in a blind opening.

If a bolt is reusable, we measure to check that it has not already been stretched beyond its factory-specified length before reusing it. We torque a bolt to a factory-specified amount in an effort to ensure a durable assembly.

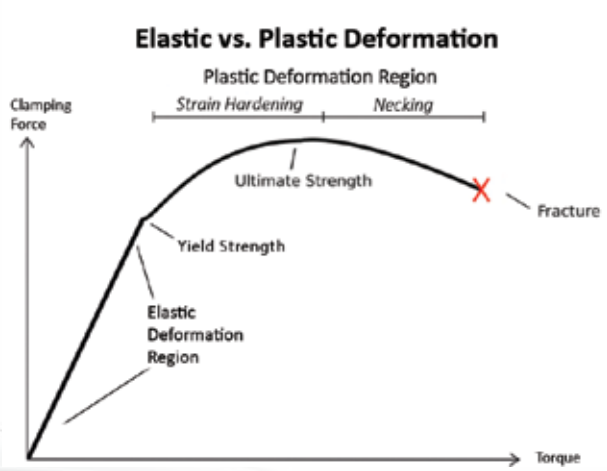
Newer bolt designs feature differences beyond length and torque specification that require a bit more attention to detail.

Torque-to-Yield bolts: A stretch beyond

Torque-To-Yield (TTY) bolts are designed to be stretched to a degree that requires greater precision than can be achieved using torque measurement alone. The benefit is a more uniform amount of clamping force being applied to the materials being joined.

A great example of where this is important is use in cylinder head installation. The fact that some head bolts may need to be a different length than others, possible variations in friction between individual bolts, compressibility of the head gasket — or in the case of newer Multi-layer Steel (MLS) gaskets, non-compressibility — and other factors must all be taken into account when determining the amount of clamping force required for a strong seal between the cylinder head, gasket and block.

All bolts stretch slightly when tightened. Like with rubber bands, stretching increases the clamping force, for more durable holding power. In the past, bolts were typically tightened to a torque amount intended to stretch the bolt to just below the point at which it would permanently deform. This amount of torque caused elastic deformation, or stretching of the bolt, but not so much that it could



Elastic deformation offers a linear relationship between torque and clamping force. Each additional unit of torque generates clamping force at the same rate as the prior unit. In the plastic deformation region (above the yield strength limit on the graph), additional torque generates incremental clamping force at a nonlinear rate that peaks (strain hardening) and then tapers off. Volkswagen engineers calculate precisely how much beyond its torque yield limit each TTY bolt can be rotated to maximize its clamping force.

TTY cylinder head bolt design eliminates threads wherever they are not necessary along the shank length. This reduces shank diameter and bolt weight, which contributes to fuel economy improvement and materials cost reduction. These non-reusable TTY cylinder head bolts fit many Volkswagen models, including the 1999-'05 Beetle, 2000-'06 Golf, and the 2000-'05 Jetta and Passat.

not return to its original shape once the load was released. The bolt retained its shape and strength, and was thus reusable.

TTY bolts are intentionally tightened beyond their elastic limit. The bolt stretches and changes its shape permanently. It cannot bounce back to its original length when uninstalled. A TTY (or other) bolt that has entered this state, called plastic deformation, cannot be reused. Further stretching would weaken it and reduce performance.

When properly installed, TTY bolts provide their intended clamping force whether the engine is hot or cold, and maintain it after many thousands of heat cycles. The original Volkswagen application of TTY bolts was to lock down the cylinder head. Due to their reliable clamping performance, you now will find TTY technology in many applications on Volkswagen vehicles. The list has expanded beyond cylinder heads to include crank pulley, flywheel, brake caliper, and oil filter housing bolts, suspension, sub-frame, and drive axle-to-hub bolts, ball joint nuts, strut-to-body nuts, as well as transmission assembly and transmission/engine mount bolts.

Your Volkswagen repair information may not identify a TTY bolt using that acronym or name. Be on the lookout for installation procedures that state that the bolt cannot be reused, and must be replaced. Additionally, your parts manager may inform you that the component or system being repaired requires a new replacement bolt which also may simply be labeled a "bolt," even though it most likely features TTY technology.

Torque plus angle of rotation

TTY bolt installation is a multi-step operation, and typically requires an angle gauge as well as a torque wrench. You first torque the bolt to near the high end of its elastic deformation range. This extracts all of the clamping force you can get from that portion of the torque-clamping force curve that is linear, and therefore, predictable.

Next, you rotate the bolt through a factory-specified angle. This ensures that the bolt is stretched near to its "ultimate" strength. Extensive testing has verified that the clamping force generated is directly proportional to the amount of rotation. Factory engineers and bolt manufacturers can therefore specify an angle amount with confidence that it will generate the precise amount of clamping force desired.

Many different types of TTY and other bolts can be used on the same model Volkswagen vehicle. Some may be different for the same model, due to running changes during the model year. Look for technical bulletins, repair manual updates, and other recent information sources for the latest specifications for the vehicle in your bay.

Each application may be different, with torque and angle specifications customized for the component and joint. Some bolts are mandatory — the only type that can be used for a specific application. Some aluminum bolts can be reused, but only once, and only for the same application as originally specified and used. Refer to your Volkswagen repair manual or technical bulletin for the specifications for a given bolt or fastener.

Encapsulated bolts

Another category of bolt that is often not recommended for reuse is those that come from the manufacturer with either a thread locking coating compound or an anti-corrosion coating on the threads. The issue is not that thread locking and corrosion resistance coatings cannot be applied in the field. Rather, using new, pre-coated bolts is simply a better way to maintain quality control.

By installing a new pre-coated bolt instead of applying thread-locker or corrosion coating to the existing bolt for reinstallation, you can be assured that the adhesive or corrosion protection is on the fastener in the correct amount and at the exact location needed. The coating is applied by the bolt manufacturer in a manner that is carefully controlled. It ensures a level of bonding or corrosion protection that enables the joint to meet clamping or corrosion resistance requirements.

Always check the information in the ELSA repair manual and in technical bulletins to confirm whether the bolt you are removing is recommended for replacement or reuse.

Friction and torque

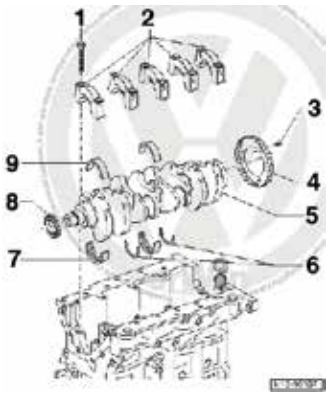
Friction absorbs most of the torque used in tightening a joint. As you tighten a bolt, torque is divided among three main functions. Fifty percent or more of total torque is absorbed by underhead friction, the tension between the underside of the bolt head and the top surface of the material being joined. Forty percent of torque is soaked up by thread friction, which is resistance to tightening due to the presence in the threads of any irregularities, damage, or debris. Only ten percent of torque is available to stretch the bolt and develop the clamping force that keeps the joint together.

This is the reason many repair procedures specify cleaning any debris from the thread area, and applying lubricant to the threads and underside of the bolt head. Just a five percent increase in friction in either the underhead or thread areas can cut in half the amount of torque remaining to develop clamping force.

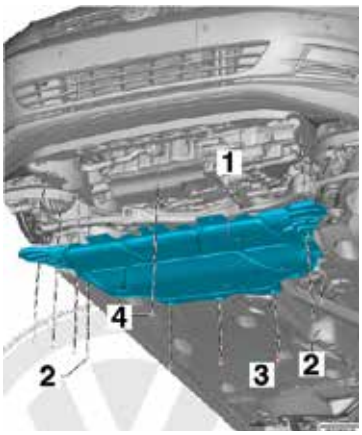
Mechanical thread lockers such as lock washers and nylon inserts work by increasing friction between the mating threads in a joint. Sure, it may help resist vibration-related damage over time, but based on how friction affects tightening torque, it may be undesirable. Unless the factory specification calls for a mechanical thread locker, use of one may actually prevent achieving the precise level of fastening power required.

More durable

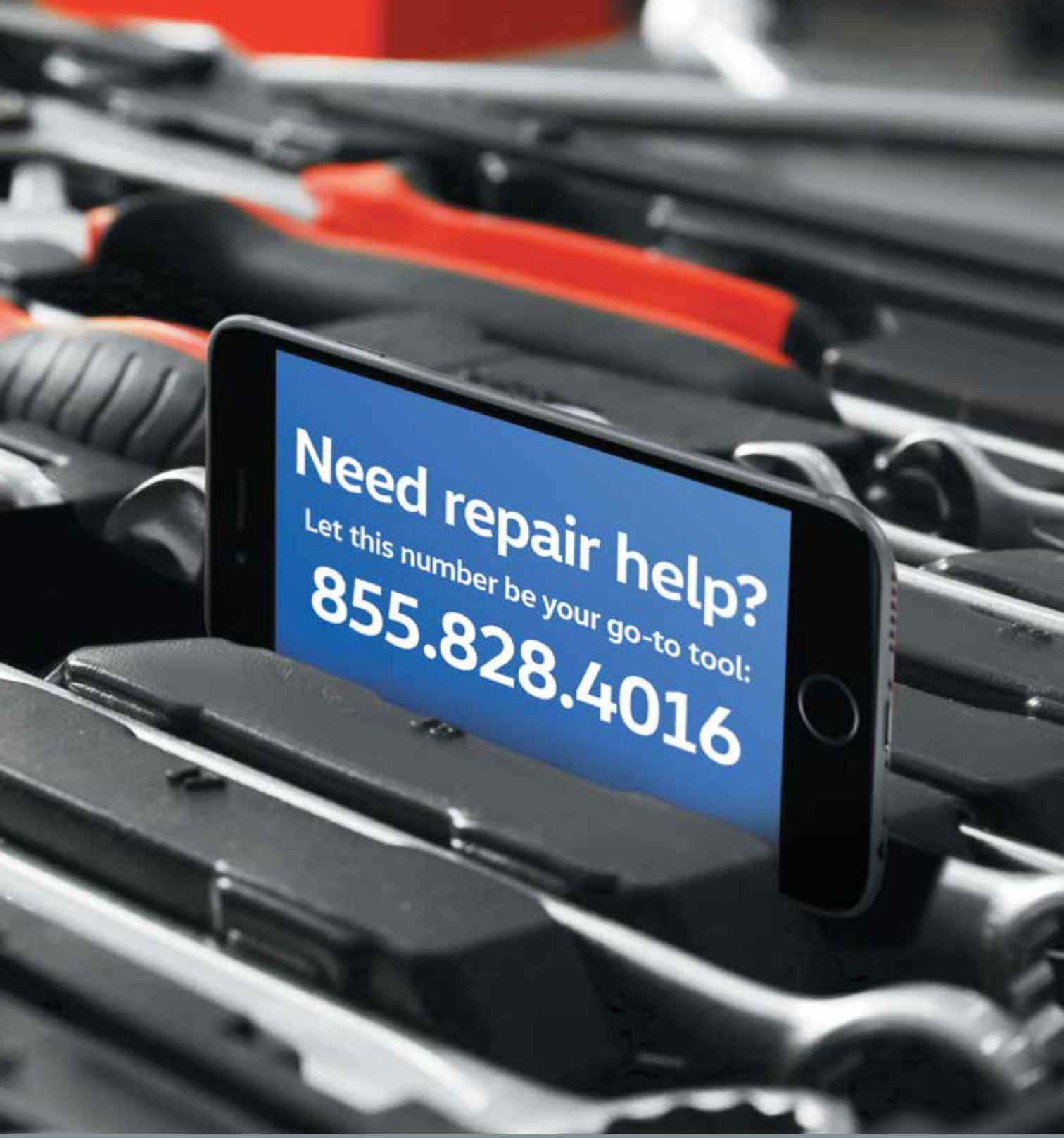
There are many additional factors that introduce the potential for variation in the amount of tension created in a bolt when torque is applied. To ensure more durable assembly and repair, follow the Volkswagen recommended repair procedures when using fasteners. Your repairs will provide their intended clamping force over many thousands of start and stop cycles. ■



The bearing cap bolt (#1 in this image) on the 2004-'12 Golf and 2006-'14 Passat is a TTY bolt that must be replaced if removed. The new replacement bolt must be torqued to 65 N-m, then rotated an additional 90 degrees (1/4 turn) to achieve its optimal clamping force.



Three of the eleven bolts holding the Long Noise Insulation Cover under the engine (#3 across the rear of the cover) on the 2015 and newer Golf are microencapsulated, and not reusable. They must be replaced with new bolts if removed.



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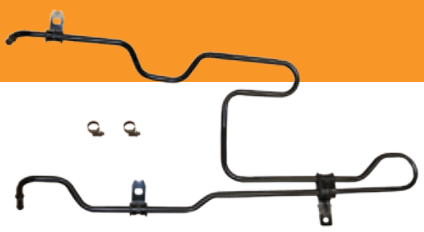

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