SUBARU

Technician Reference Booklet

Noise, Vibration and Harshness

Module 505

AUTOMOTIVE Youth Educational Systems YES PROUD PARTNER

MSA5P1505C

March 2011

THIS TECHNICAL REFERENCE BOOKLET (TRB) IS DESIGNED TO BE USED IN A CLASSROOM ENVIRONMENT OR AS A GUIDE FOR SELF-STUDY.

THE TRB IS NOT INTENDED TO BE USED AS A SUPPLEMENT OR SUBSTITUTE FOR THE SERVICE MANUAL. ALWAYS CONSULT THE APPROPRIATE SERVICE MANUAL WHEN PERFORMING ANY DIAGNOSTICS, MAINTENANCE OR REPAIR TO ANY SUBARU VEHICLE.

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Introduction

Wheel in Motion

Noise, Vibration, and Harshness (NVH) is not limited to tires and suspension. Road surfaces, new and old, must be considered when determining the source of a vibration.

Road Surface 1

Road Surface 2

Expansion joints, potholes, railroad tracks and the quality of new road surfaces can change the sound (vibration) created by the tires as they roll down the highway.

NOTES:

Roof Rack Rail

Side Window Deflector

Vehicle accessories such as cargo or roof rails, window visors and spoilers can be the source for vibrations. These devices must be mounted and secured to the vehicle properly to prevent any detrimental interaction with air passing over the vehicle as the vehicle speed increases. Keep in mind during diagnosis that the vehicle is designed to be aerodynamic and any damage to the body or any parts added to the vehicle can influence the sound and vibrations created by the vehicle.

Hood Air Deflector

NOTES:

Vibration Basics

When a customer comes in to your dealership complaining about ride comfort or a shaking steering wheel or even saying “the car just doesn’t feel right”, what should you do?

How do you approach the problem so that the customer is satisfied and the repair is timely and correct?

First provide your service writer with a pre-call vibration worksheet.

Second make sure the correct information regarding the customer’s concern is documented.

Third confirm the problem with a test drive.

During the confirmation test drive you must be able to identify the problem based on tools you have on hand. The most important tool you have is your understanding of Noise, Vibration and Harshness (NVH).

There are 3 main elements of a vibration: A source, the transfer path, and a responder.

Source

Transfer Path

Responder

The source is a component that causes an object to vibrate.

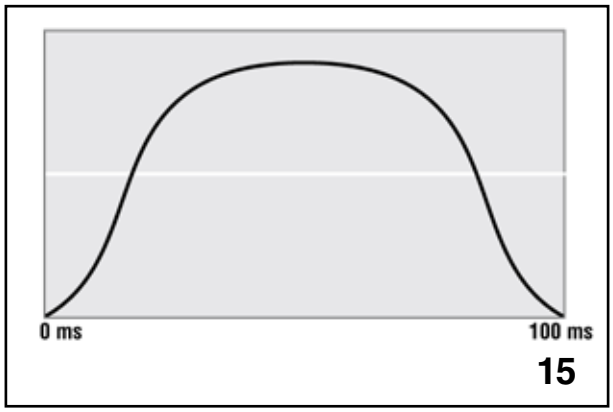
The transfer path is another part or a series of parts that allow the vibration to transfer to another part.

The responder is the noticeable vibrating part.

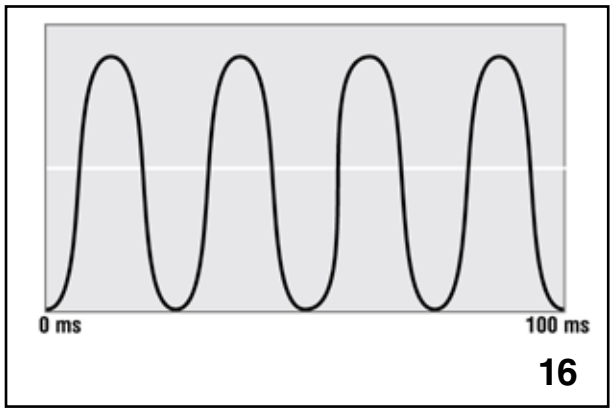
FOR EXAMPLE: **A tire out of balance will act as a source, creating a vibration as the vehicle is driven. The vibration moves the wheel bearing housing, the tie rod and steering rack making its way to the steering column. This is the transfer path. Finally the steering wheel shows a movement side to side or up and down. This is the responder.**

Let's discuss the source. The source introduces undesirable kinetic energy into the transfer path. It could be the engine, drive-line, tires, speakers, wind and many more. The rate of speed of energy transfer is called frequency. The process where the energy is transferred is always in waves. When energy is applied to a source a compression of material occurs and at the same time room for material expansion occurs. This appears as a sine wave when viewed on an oscilloscope.

The speed of the entire introduction of one energy pulse input, which includes this compression and expansion process is called a cycle. The number of cycles per second is the frequency (identified as Hertz or Hz). This becomes important because it assists you with identifying the source. This is often the most difficult part of NVH diagnosis.



Frequency 10 Hz



Frequency 40 Hz

Common vehicle frequencies:

Tires - 1 to 15 Hz
Front Suspension - 10 to 20 Hz
Drive Line (Engine and transmission) - 20 to 60 Hz
Differential Components - 120 to 300 Hz

Any rotating component's frequency increases with speed.

Each of these frequencies produces a unique feel or Harshness (H) factor. Frequencies of 1 to 20 Hz produce a shaking sensation. 20 to 50 Hz feels like a buzz-saw and frequencies greater than 50 Hz produce the feeling of holding an electric razor.

Cross Member Bushing, direction of gaps and solid material

Transfer paths of known vibration sources are designed to direct and limit the transfer of undesirable energy.

For Example: The open gaps in a bushing interrupts a straight transfer of the vibration. The gap allows some movement and absorbs the vibration and prevents it from continuing through the transfer path. The vibration never reaches the responder or steering wheel.

Responders or noticeable vibrating parts have a frequency that will cause them to vibrate. This is known as a components "Natural Frequency". If a vibration is below or above this frequency the responder may not show any sign of problem. In addition to the Natural Frequency, the strength or amplitude of the vibration must be great enough to create movement. For example: A tire slightly out of balance creates a minimum effect on the steering wheel while a flat spotted and out of balance tire creates a large effect on the steering wheel.

We have already discussed that vibration is the transfer of undesirable energy and it is important to know that when a responder has reached its "Natural Frequency" the responder absorbs energy much easier and this intensifies the reaction of the responder.

A common example of this is the action of pushing a child's swing. Pushing on the swing just as it starts moving down increases the swing's movement. Pushing on the swing before it starts moving down decreases the swing's movement.

Responders will also react if the input vibration from the transfer path or paths is double or triple its “Natural Frequency”. This may be rare in automotive systems but there is a good example in 2010 Legacy with harman/kardon® sub woofer speaker. This speaker can produce a frequency with sufficient amplitude that can vibrate the rear package shelf.

At about 21 Hz the rear package shelf vibrates and transfers the vibration to the body of the vehicle. Other parts begin to vibrate and this is known as Harmonic Resonance. Frequencies above 21 Hz will not cause the package shelf to vibrate until the frequency reaches 42 Hz. This excites the responder or package shelf and now the responder itself has become the source for the Harmonic Resonance heard all throughout the vehicle. As each part in the transfer path or vehicle body reaches its Natural Frequency it begins to vibrate and make noise.

Package Shelf

Mass Damper

This fact is known by automotive engineers when designing the vehicle. To control and eliminate this condition a Mass Damper is installed on the package shelf. This adds stiffness and mass to the package shelf and changes its Natural Frequency. It never becomes a responder or a source for Harmonic Resonance.

Crankshaft Harmonic Balancer

Dynamic dampers are also utilized to control vibration. They are installed on moving parts such as the crankshaft. Crankshafts are subject to many different vibrations, frequencies and amplitudes. Power pulses from combustion, uneven weights of each piston and connecting rod, and many more sources easily reach the crankshafts Natural Frequency and many of its multiples. The Dynamic damper or Harmonic Balancer offsets and balances out these energy waves or vibrations in the crankshaft and allows for smooth engine operation.

What about vibrations that come and go?
Sometimes a certain frequency may exist that has a slightly high amplitude. If a separate vibration is started and its frequency matches and is in phase with the 1st vibration but the frequency continues to increase, the feeling of the vibration may come and go away. This can lead to the improper diagnosis of a condition.

An example of this condition will be demonstrated in the lab.

Pre-call Worksheet

SUBARU

Subaru of America, Inc.
Vibration Analysis Worksheet

Save As

Technician Name | **T/L Case #** | **QMR #**

VIN | **Date**

◉ Initial Drive ○ After Balance | **Mileage**

CRITERIA: Check all that apply.

SPEED: ☐ Below 40mph ☐ 40 to 50mph ☐ 50 to 60mph ☐ 60 to 75mph ☐ Over 75mph

LOCATION: ☐ Steering Wheel ☐ Body (seat) ☐ Both

WHEN does the complaint occur? ☐ After parked for two hours or more. ☐ When tires have been warmed. ☐ Both

STEERING CONCERN

☐ Flutter (back and forth motion in steering wheel; oscillation)

☐ Vibration (up and down motion in steering wheel only)

At what speed is the vibration the worst?

BODY (SEAT) CONCERN

☐ Felt in seat/floor ☐ Visual (p/s seat moving; mirror vibrate) ☐ Felt in center console

At what speed is the vibration the worst?

OE Tires Installed? ○ Yes ○ No Brand?

Comments?

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Pre-Call Worksheet

Now lets return to that pre-call worksheet.

Ask your service writer to include questions during their interview with the customer such as:

- Does the vibration change with the radio or CD player in operation?
- Is there a particular engine speed that seems to intensify the problem?
- Is there a certain gear range that makes the condition more noticeable?

As your experiences with NVH issues increase so will the list of questions you pass on to your service writer.

Now that we have reviewed some of the basics of NVH, lets review a procedure that addresses some of the 2010 through 2011 Legacy Vehicles.

NOTES:

Service Bulletins

ATTENTION:
GENERAL MANAGER ☐
PARTS MANAGER ☐
CLAIMS PERSONNEL ☐
SERVICE MANAGER ☐

IMPORTANT - All Service Personnel Should Read and Initial in the boxes provided, right.

SUBARU
QUALITY DRIVEN® SERVICE

SERVICE PROCEDURE

APPLICABILITY: 2010~11MY Legacy and Outback
SUBJECT: Steering Wheel Vibration at Highway Speeds
NUMBER: 05-48-10R
DATE: 02/03/11

INTRODUCTION

In the event you encounter a customer concern of a steering wheel shake, shimmy or vibration at highway speeds, the following repair procedure should be performed to minimize the concern. **Please review this bulletin in its entirety before proceeding.** While the majority of these conditions can be greatly reduced, some road feel may be considered characteristic and can be compared to like model vehicles with similar mileage.

Note: Refer to Service Bulletin 05-50-10 for the proper balancing procedures and measurement of Radial Force Variation (RFV).

Regardless of previous repair history, be sure to follow the entire procedure in order as outlined below. This will ensure the best possible results.

1) Wheel Balance and Radial Force Variation (RFV) measurement.
2) Steering system component replacement.

Note: Countermeasure steering wheels were incorporated into production in November, 2010. Refer to the Parts Summary for C/M in production VIN break.

3) Install chassis/hardware kit components.
4) Check alignment and road test to verify fix.

PARTS SUMMARY

PART	PART NUMBER	QUANTITY NEEDED
Steering Wheel Kit Note: Vehicles after the following VINs DO NOT need to have the steering wheel replaced. B*369895 (Outback) B*231394 (Sedan)	SOA635088L - Leather -OR- SOA635088U - Urethane	1
Steering Column	34500AJ111	1
Ignition Key Lock Bolts	83140GA000	2
Chassis/Hardware Kit	34190AJ021	1

continued...

Note: The following is a review and highlights the key points of service bulletins 05-48-10R and 05-50-10R. This presentation is not meant to substitute for the actual bulletin. Always refer to STIS for the latest information on service bulletins and service manuals.

In the event you encounter a customer concern or a steering wheel shake, shimmy or vibration at highway speeds, the following procedure should be performed to minimize the concern. While the majority of these concerns can be greatly reduced, some road feel may be considered a characteristic and can be compared to like models with similar mileage.

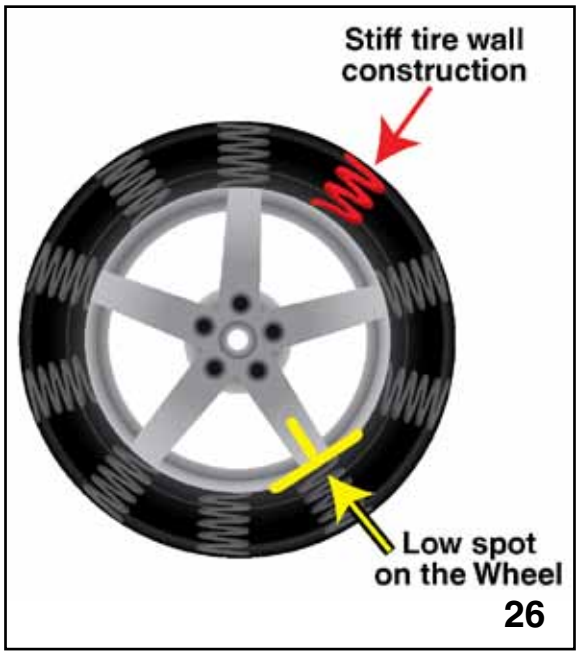
Note: Refer to service bulletin 05-50-10R for the proper procedures for balancing and measuring radial force values.

Hunter 9700

Subaru of America recommends the use of the Hunter GSP 9700 wheel Balance and Road Force Measurement system to properly balance the wheel and tire assemblies “dynamically” and to measure the radial force variation (RFV) of the wheel and tire assembly.

Before balancing the tires check the tire pressure and then drive the vehicle at least 10 miles. Mark the tires for location: LF RF, LR RR.

A unique feature of the hunter 9700 is that it can place a road load on the tire during the balancing process. Approximately 1400 pounds of force is placed on the rolling tire and the machine is able to determine if the structure of the tire has a spot that may be easier or more difficult to compress.



Side Wall Construction

Tire and Wheel matched

Imagine the side walls of a tire providing an even amount of spring force all the way around the tire. In theory each spring should compress at the same rate. If one of the springs or a section of springs offer more resistance, they will not compress the same as the others and the tire will lift the vehicle, producing a vibration.

If the rim of the tire is checked and it has a low spot, the stiff part of the tire can be mounted on the low spot of the wheel. This nullifies the condition and brings the tire closer to a balanced state.

If the vehicle is still exhibiting the customer's concern after the Road Force Variation Measurement (RFV) and Tire Balance has been corrected, proceed to the second half of service bulletin 05-48-10R.

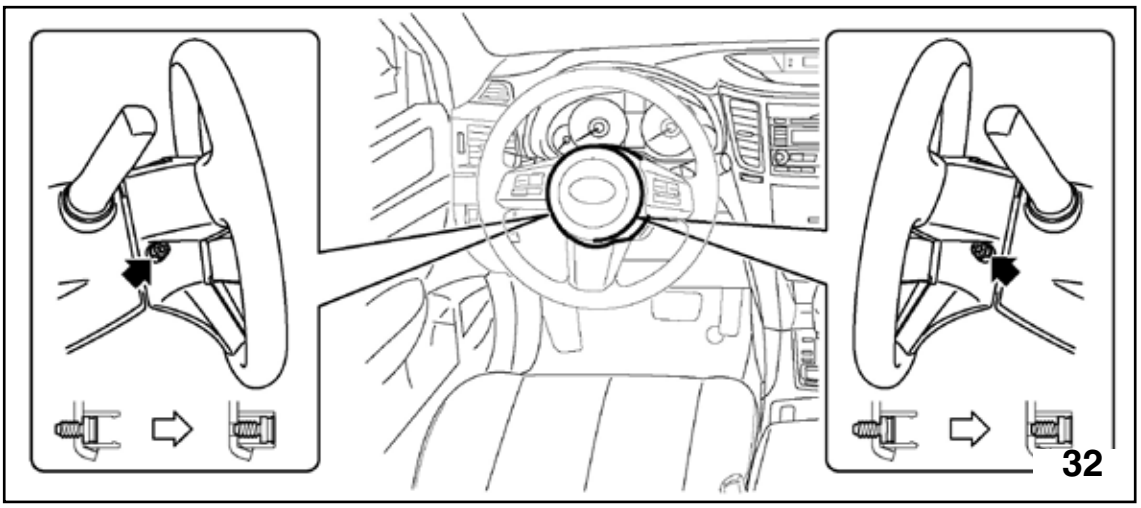
Hardware Kit

Steering Wheel with Dynamic Damper

Steering Column

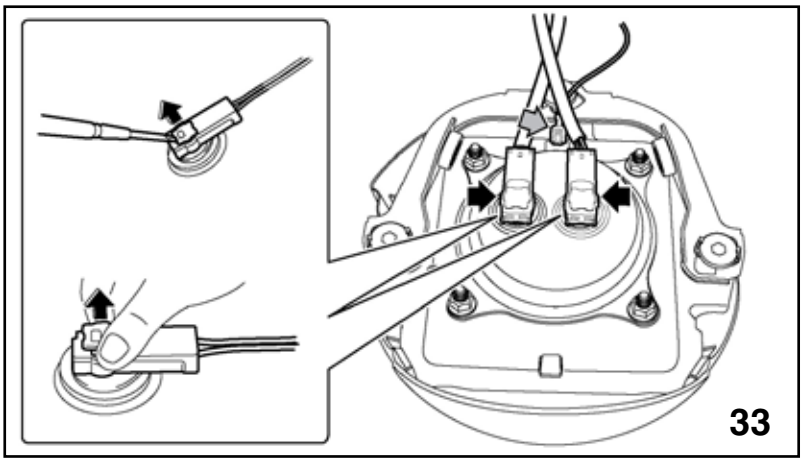
Lower Front Control Arms

The new parts supplied for the 05-48-10R Steering wheel vibration service bulletin are designed to provide improved transfer path isolation and energy absorption characteristics of the suspension. The steering column and steering wheel with dynamic damper work together with new “Natural Frequencies” that reduce the responder action to the driver.



Removing Airbag

Begin the procedure with the vehicle already on a lift and the battery disconnected. It is recommended that you record the customer’s radio stations so that the radio can be programmed after the repair.

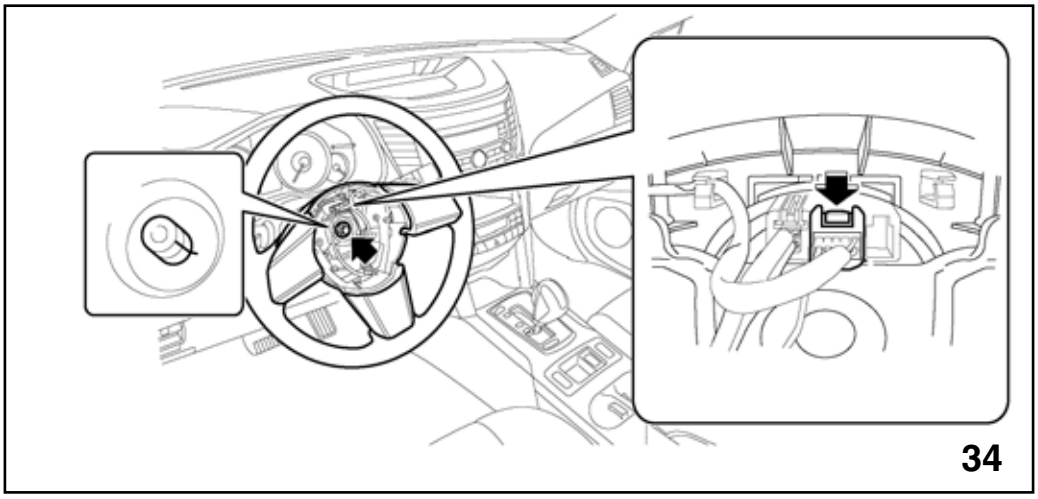


Disconnecting Airbag Harness

Remove the lower trim panels from the driver side of the vehicle and begin removing the driver side airbag module.

Disconnect the horn wire connector

Disconnect the steering wheel wiring harness connector from the roll connector.



Steering Wheel Harness

Remove the steering wheel nut and carefully pull off the steering wheel from the shaft using a steering wheel puller, set the steering wheel aside.

CAUTION: Always use the steering wheel puller for removal to avoid deforming the steering wheel.

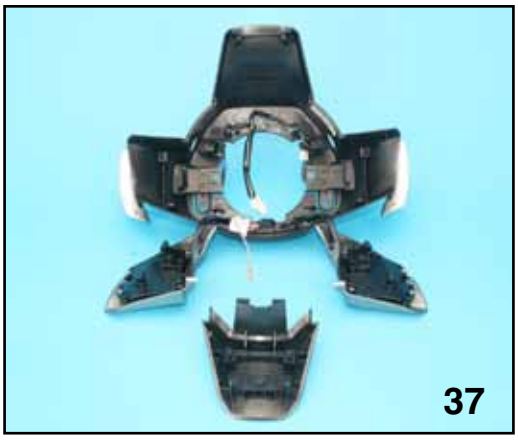
After the steering wheel has been removed, make sure that the roll connector is not turned from the original position.

Satellite Switch Bolts

Switches and Steering Wheel

Remove the satellite switches (audio / cruise) from the steering wheel.

Remove and discard the screws from the paddle shift switches. (Model with paddle shift).



Paddle Shifter and Covers

Remove the rear steering wheel cover by carefully prying near the 4 clips. Remove the rear steering wheel cover and the paddle shifter as a unit.

Transfer the center steering wheel cover, satellite switches and rear steering wheel cover to the new steering wheel. Observe wiring routing to ensure wiring is clear of any metal edges.

Harness Routing

Clip and Harness

Install paddle shifter to the new steering wheel using new screws supplied with the kit.

Ensure correct routing of satellite switch wiring harness to prevent interference with dynamic damper (DD) to be installed in the next step: Make sure the Satellite switch harness is securely seated in the retaining clips.

Dynamic Damper

Install the dynamic damper to the new steering wheel using the screws provided in the kit. Do not allow the wiring harness to interfere with the dynamic damper. Make sure there is a minimum of 5mm clearance between the satellite switch harness and the dynamic weight of the damper on all sides.

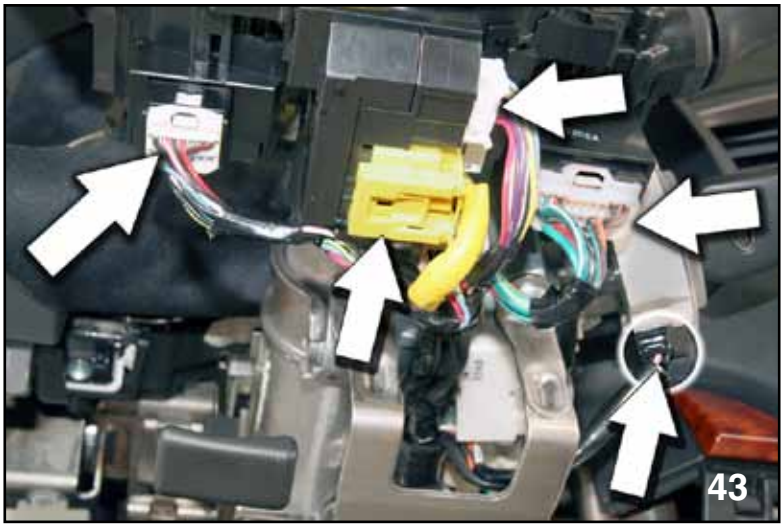
NEXT REMOVE THE STEERING COLUMN FOLLOWING THE SERVICE MANUAL INSTRUCTIONS.

Column

During column removal it will be necessary to disconnect the wiring harness and the clips securing the harness to the column.

Harness Clips

Apply pressure at the indicated points to release the clips.



Top of Steering Column 5 Connectors

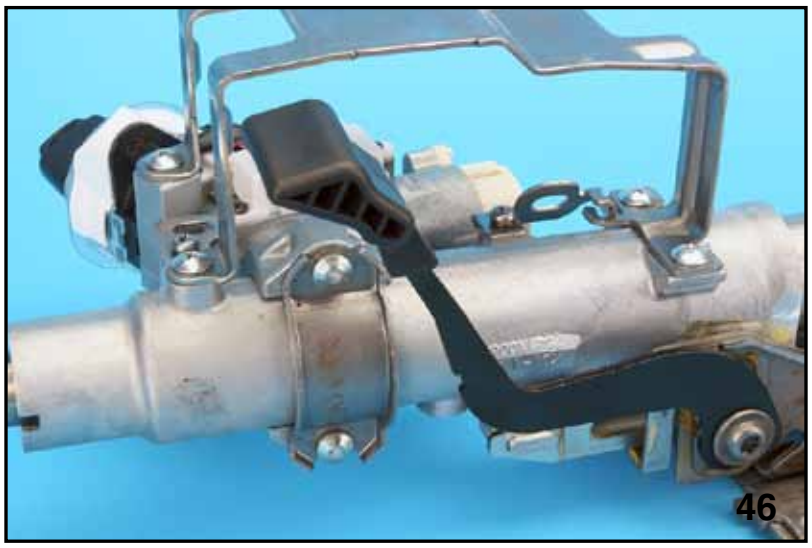
5 connectors must be disconnected from the top of the steering column.

Key Warning Switch Connector

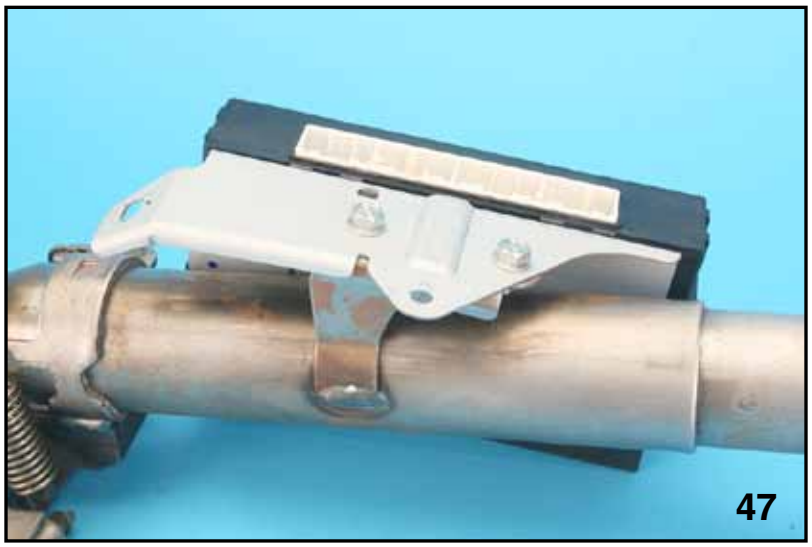
The key warning switch connector lock is disengaged by pressing on the tab on the switch not the connector. Pull downward on the connector as the tab is pressed.

Old and New Column

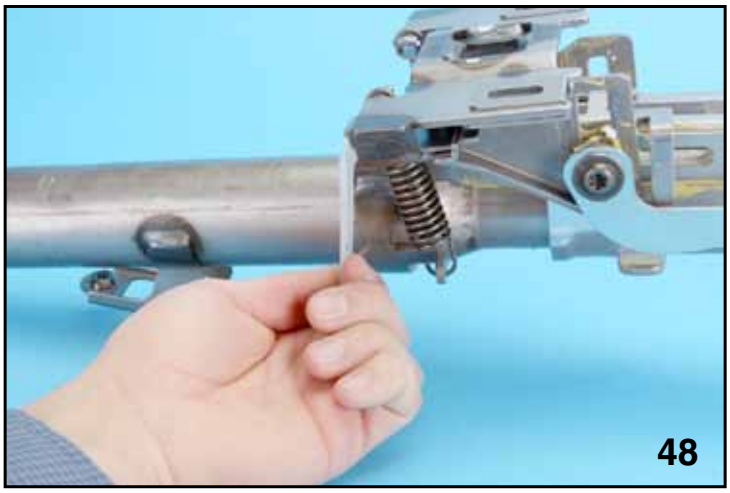
Parts from the original column must be transferred to the new column. They include the floor mat finisher, Knee guard and BIU.



Knee Guard



BIU



Plastic Shipping Tab

You must also remove the plastic shipping tab from the new column before installation.

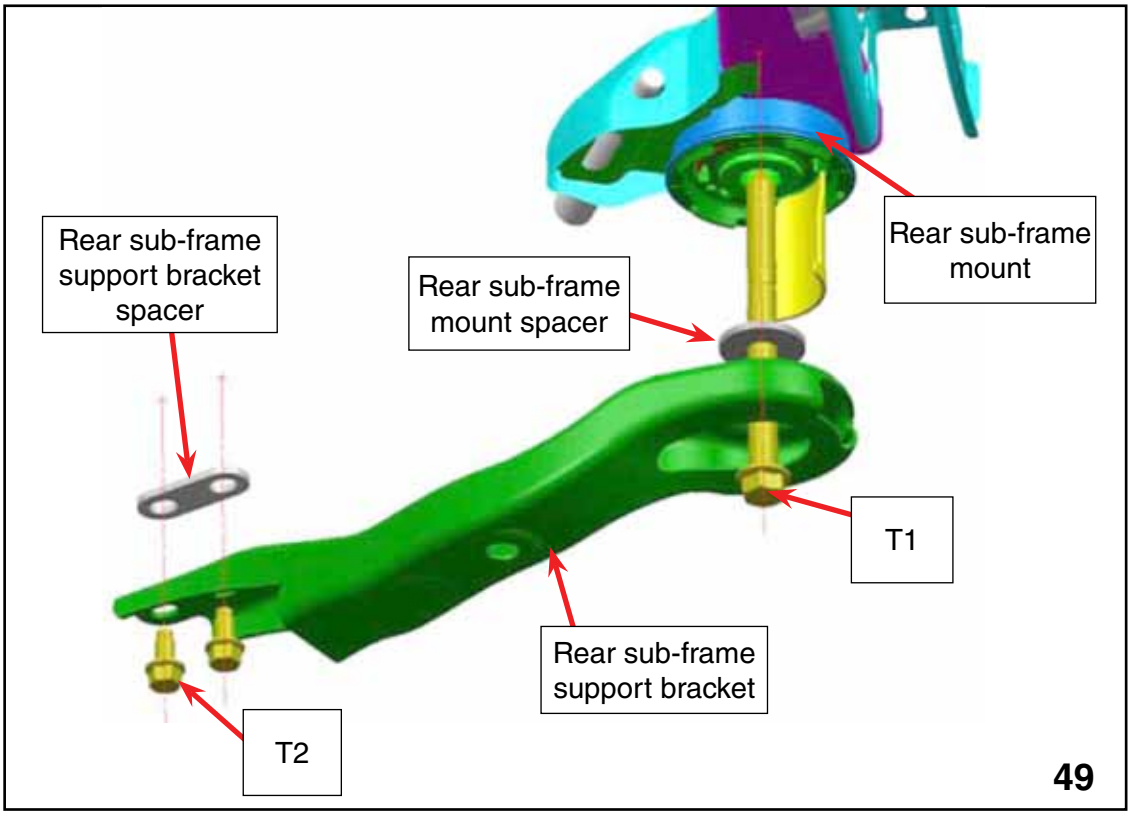
Set the column aside and begin installation of the under-vehicle parts.

Sub-Frame

Install rear sub-frame support bracket spacers and bushing inserts.

There are 4 rear sub-frame support brackets that must be serviced. Complete all the work on one bracket before proceeding to the next.

CAUTION: DO NOT remove both the right and left side brackets at the same time, otherwise the sub-frame can drop or alignment readings can be changed.



Sub-Frame Bracket (artwork)

Rear Sub-Frame Support Bracket Forward Mount

Bracket Close-up

Rear Sub-Frame, Rear Mount

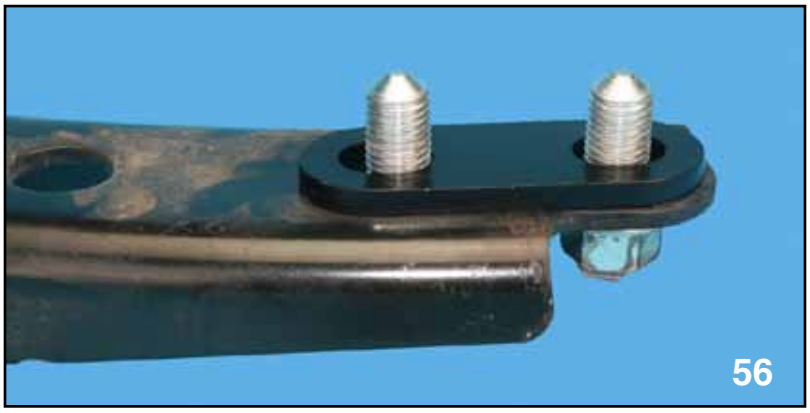
Piercing Bushing Flashing

Installing Shim

The rear sub-frame bushings are installed with one shim in place from the factory. You will be installing a second shim. The space for the shim must be cleared of any flashing material before installing the shim. Clear the space using a screwdriver. Perform this procedure as you service each of the four rear sub-frame bushings.

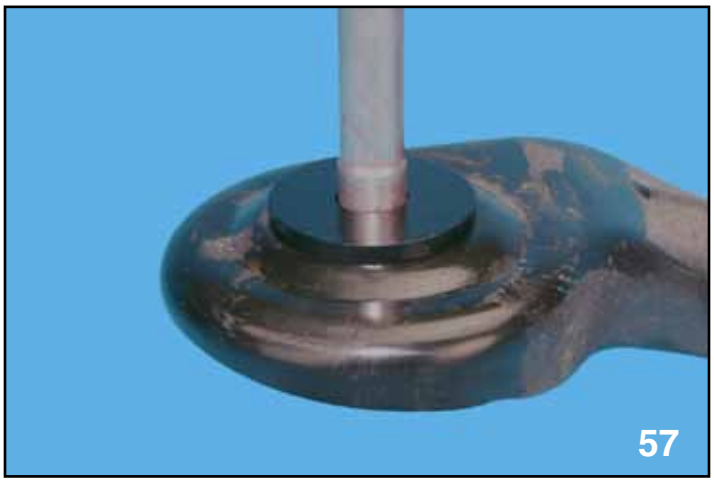
Rear Mount Spacer

A spacer is installed during reassemble to allow the bushing to increase its operating range.

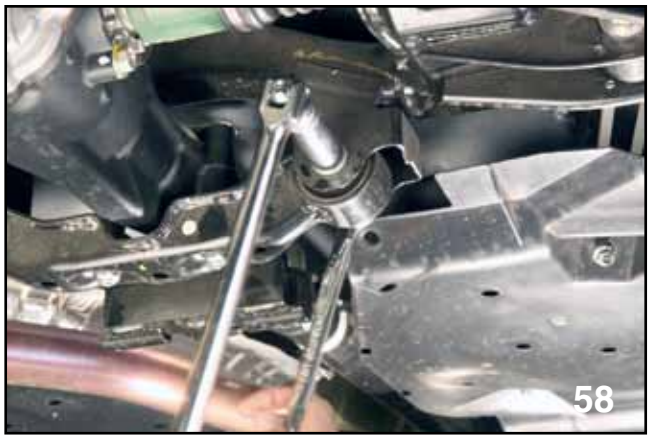


Forward Support Bracket Front Spacer

The forward bushing support bracket must have a spacer over the bushing and between the forward end of the support bracket and the vehicle body.



Forward Support Bracket Rear Spacer



Loosening Rear Differential Mounting Bolts

Loosen and remove the two rear differential mounting nuts. Allow the rear differential to drop down to the lower portion of the mounts.

Replace Mounting Nuts

Always install new mounting nuts.

Remove the exhaust. Be sure to disconnect all A/F and Oxygen sensor wires and location clips.

A/F Sensor Wire

Steering Gear Box Mounting Bolt Location

Remove the steering gearbox mounting bolt. This will provide room for the special tool ST 34199AJ050.

ST 34199AJ050

Locate the lock nut and adjusting screw for steering rack backlash spring and pressure pad.

Hold the adjustment screw while loosening the locknut with ST 34199AJ050.

Lock Nut and Adjustment Screw

Remove the locknut and adjustment screw.

Spring

Removing Tension Pad

Remove the spring and tension pad.

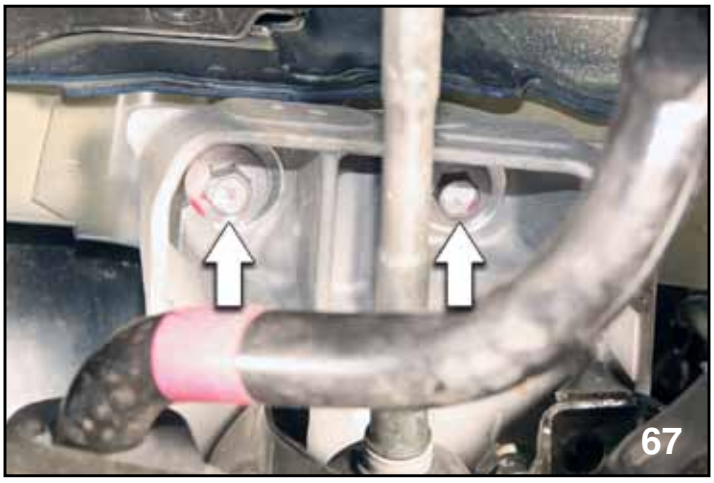
Tension Pad Side View

Lubricate all parts as directed in the service bulletin and reinstall the tension pad and new spring.

Tighten the adjustment screw to 7.4 foot pounds and loosen 1 complete turn. Tighten the adjustment screw again to 4.4 foot pounds.

Install the locknut and tighten. The adjustment screw must not turn during this process. If it does, begin the procedure from the beginning.

Reinstall the steering gearbox bracket bolt and torque to 44.3 foot pounds.



Sub-Frame Bolts

Next tighten the two sub-frame bolts on each side to 36.8 foot pounds.

Control Arm and Stabilizer Bushing

Following the procedure outlined in the service bulletin, replace both lower control arms. The final torque sequence for the lower control arm bolts must be performed with the weight of the vehicle on the tires. Also replace the left and right front stabilizer bar bushings.

Lift Point

Use a transmission jack and lift the engine 10 mm.

Gap

A gap should now be seen in the front engine mount near the top side.

Installing Insert

Position the insert into this gap. Make sure it is flat on both sides. Lower the engine and remove the transmission jack.

Next lower the vehicle and install the steering column and steering wheel. Adjust the column to the middle of the tilt travel.

Steering Universal Joint

Raise the vehicle and install the steering universal joint to the steering shaft. With the upper and lower universal bolts loose, slide the universal joint towards the steering wheel and then back towards the steering gear box. Perform this movement 10 times with the final movement towards the steering gear box.

Torque the lower bolt first and then the upper.

Move the vehicle to an alignment rack and perform a 4 wheel alignment.

Service Bulletins

No. Subject	Date		Title
05-48-10R	02/03/11	2010~11MY Legacy and Outback	Steering Wheel Vibration at Highway Speeds
05-49-10R	09/21/10	2010~11MY Legacy and Outback	Squeak Type Noise from Front Suspension
05-50-10R	02/03/11	All Subaru Vehicles	Noise, Vibration and Harshness (NVH) at Highway Speeds Caused by a Tire Imbalance or Excessive Radial Force

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SUBARU MASTER TECHNICIANS

Quality driven. Technician powered.™

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