



Service Bulletin

Bulletin No.: 16-NA-339

Date: January, 2019

INFORMATION

Subject: Vibration Analysis Diagnostic Aids

Notice: This bulletin is intended as a Starting Point to help in providing common understanding and recommendations for proper diagnosis, correction, and repair verification of vibration concerns or disturbances which might occur on Full-Size SUV's.

Brand:	Model:	Model Year:		VIN:		Engine:	Transmission:
		from	to	from	to		
Cadillac	Escalade Models	2015	2019				
Chevrolet	Suburban						
	Tahoe						
GMC	Yukon Models						

Involved Region or Country	North America and N.A. Export Regions
Condition	Some customers may comment on a vibration concern in their vehicle, which may occur under specific vehicle speed or engine speed conditions. General conditions indicated when the vibration concern is noticed may be while: at highway speeds; climbing a hill; coasting; applying light throttle; related to road input; related to powertrain input, etc.
Concern	<p>Vibration concerns are typically related to rotating components which are out of balance or which have other abnormalities in stiffness, surface quality, roundness, vertical stability, lateral stability, or fore-aft stability, etc.</p> <p>The term 'Vibration' may be used by some customers to describe disturbances or roughness in a vehicle. These types of vibrations / disturbances / roughness can be more difficult to quantify / identify. They are typically related to either improper isolation of rotating component systems, or are related to non-rotating components allowing input / not properly isolating energy, and/or component reaction to energy input.</p> <p>Example of rotating component related vibration:</p> <ul style="list-style-type: none"> Vibration most noticeable between ~ 68-72 mph (109-116 km/h), not engine RPM dependent, still evident in Neutral – most likely tire/wheel related (1st-order or 2nd-order Tire related) <p>Example related to isolation of rotating component systems or non-rotating component related vibrations:</p> <ul style="list-style-type: none"> Vibration noticeable only while vehicle is stationary, most noticeable while stopped in Drive – most likely related to isolation of engine into frame / body (Engine 1-1/2-order disturbance)

Introduction

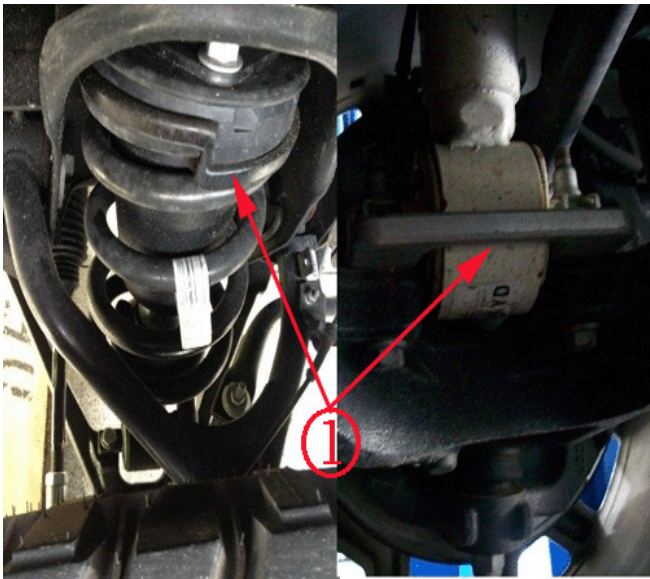
Review each of the areas listed below to first ensure pursuing the correct condition which the customer is concerned with, and ensuring complete vibration / disturbance frequency and amplitude data is captured on the Pico scope. Once the conditions around occurrence of the vibration / disturbance are better understood and data is available, refer to the Vibration / Disturbance Classification table for information and further assistance in analyzing and diagnosing the issue.

Recommendation/Instructions

Vibration Analysis Process

Important: The first step in determining the cause of a vibration / disturbance / roughness concern, is a thorough test drive with the Pico scope installed in the vehicle. The correct diagnostic tools and procedures must be used to help ensure correct root cause and correction.

1. Gain understanding from the customer around specific conditions when the vibration disturbance occurs and/or is most noticeable. Following are some key pieces of information to gather in helping to more quickly identify and root cause the vibration / disturbance concern.
 - For Example:
 - ⇒ Does the issue occur while on a flat road, crowned road, slight uphill or downhill grade?
 - ⇒ What type of road surface and surface condition, (asphalt, cement, etc.; with smooth surface, expansion joints, etc.)?
 - ⇒ While accelerating lightly, moderately, heavily, or while on decelerating?
 - ⇒ Specific vehicle speed ranges most noticeable?
 - ⇒ Specific engine RPM ranges most noticeable?



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2. Thoroughly inspect the vehicle for any aftermarket modifications, damage, etc., which may affect vehicle operating characteristics and/or modify or create transfer paths for road input, etc.; which may in turn produce or amplify any vibrations / disturbances into the vehicle.
 - Inspect for aftermarket leveling kits, lift kits, lowering kits, non-factory tires/wheels. Example shims (1) shown above. Refer to the latest version of PIT5403: Various Vehicle Handling Concerns Suspension Noise Or Damaged Suspension Components Due To Vehicle Modifications, for further information.
 - Keep in mind that aftermarket running boards, bug deflectors, window shades, etc., depending on mounting and component characteristics, may create a disturbance and/or create a transfer path.
3. Mark each tire valve stem location on each tire. This will be utilized to check for tire slip on the rims.



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(TA183 single axis pico sensor shown / TA143 is tri-axis sensor)

4. Place tri-axis pico sensor of vibration analyzer, CH-51450-A (Pico Oscilloscope), on the inboard seat track forward-most location to record measurement of the vibration / disturbance.
5. Add E1.5 to the displayed data, and Add Display Unknown Vibrations (Frequencies), under Add Vibration in Pico.

Vibration Duplication / Evaluation:

Common Steps for ALL Vibration Assessments:

1. To help ensure accurate vibration assessment, perform the following:
 - Ensure correct cold tire inflation pressures.
 - Drive vehicle at least 10-15 miles (16-24 km) to warm the tires first to eliminate possible contribution of flat spotting.
 - Drive with windows closed and sunroof closed.
 - Drive with radio Off.
 - Cycle both front and rear HVAC Off at times during assessment to ensure nothing is missed.
 - Attempt to operate vehicle under same conditions and even same road(s) as identified by the customer.
 - To ensure nothing is overlooked, use different styles during ride assessment – some customers drive with a lighter touch on acceleration and speed, while others driver with a heavier touch. This may affect gear selection, V8 vs. V4 Mode engine operation, driveline operation, during the specific vibration / disturbance concern of the customer.

Important: : While capturing vibration data with the Pico scope, it's important that you "bookmark" your data capture before and after you experience the vibration described by the customer. Identifying a specific segment of data with bookmarks is helpful to ensure your analysis can be focused on the correct

vibration data and avoid incorrectly zoning into an area that is not at all related to the vibration felt by the customer. These bookmarks are also serve as a valuable reference when sharing Pico scope data with TAC. The TAC agent can now review the data at the precise time of the vibration is present.

2. Perform comprehensive test drive, with Pico scope installed, attempting to duplicate the customer concern and capture all existing frequency data on Pico scope; (ensure adequate drive time to remove any flat spotting from tires).
3. During vibration analysis test drive process – keep in mind and perform the following steps to help during evaluation in narrowing down the primary issue and any possible secondary issue(s):
 - During assessment, will need to separate possible engine RPM related vibration, throttle position related vibration, narrow vehicle speed band related vibration, and possible highway speed related vibration, from road input vibration; while paying attention to what part or area of the vehicle is most affected.
 - Monitor Instant FE Screen in DIC (or on Scan Tool) to Determine V8 / V4 Mode.
 - Drive in Manual/Low 5th/6th depending on trans configuration to block out V4 Mode operation. While driving under same conditions – evaluate vibration.
 - Shift back to Drive and allow V4 Mode activation while driving under same conditions – evaluate vibration.
 - If vibration appears aggravated by V4 Mode, continue with V4 Mode and experiment with different engine RPM and throttle positions in vehicle speed ranges as explained by the customer – issue may be most noticeable during light throttle while in a higher gear, perhaps ~ 1,100-1,400 RPM, at a lower speed.
 - If vibration appears aggravated by V4 Mode, now continue assessment while driving in Manual/Low 5th/6th to block out V4 Mode contribution. Experiment with different throttle positions – issue may be most noticeable during light throttle, moderate throttle, heavy throttle, or during coast down.
 - Observe if vibration is notably affected by throttle position or during coast down, or if vibration is most noticed in a narrow vehicle speed band ~ 38-44 mph (61-71 km).
 - Observe if vibration is most noticed during highway speeds ~ 68 mph (109 km/h) or higher.
 - Observe if vibration is still noticeable while in V8 mode, and is not restricted to throttle position, nor a narrow speed band ~ 38-44 mph (61-71 km/h), nor highway speeds ~ 68 mph (109 km/h) or greater – continue to examine Road Input as possible source
 - Begin to classify what systems / areas of the vehicle may be most affected:

- ⇒ Feel in Steering Wheel, Floor, Front Seats.
- ⇒ Feel and/or hear in Cabin/Body / Rear of Cabin.

- ⇒ Rule out any possible noise contribution from 2nd / 3rd Row Seats / possible loose cargo / Jack/Tool Stowage / Spare Tire Stowage.
- 4. Using Pico scope data from test drive, in conjunction with this PI and SI diagnostics, etc., determine best area of focus based on amplitude of given areas:
 - 4.1. After the road test, verify that the tires have not slipped on the rim (from step 2). If tire slip has been found, correct the condition prior to any other repair. Refer to the latest version of Bulletin 12-03-10-001: Vibration Shortly After Tires are Mounted/Preventing Vibration from Wheel Slip (Tire Sliding on Wheel).
 - 4.2. First address any applicable rotating components: tire/wheel; drive axle; propeller shaft; engine related areas, etc.
 - 4.3. Next, if issue is Not related to known rotating component frequency orders, (and/or if needed following repair verification test drive), focus on isolation of rotating component systems and/or non-rotating components allowing input / not properly isolating energy, and/or component reaction to energy.

Note: At the bottom of this bulletin is a required Vibration Diagnostic Worksheet that MUST be completed and is required for the claim payment. Vibration Diagnostic must be retained by the dealership. This worksheet is required to be filled out before calling TAC.

5. Use the chart below to determine which type of vibration the truck has and what repair procedure should be utilized.
6. Verify effectiveness of repairs for each focus area addressed. Follow same methods and analyze Before vs. After repair frequency data on the Pico scope.

There are numerous Training Courses available to provide further understanding of Vibration Diagnosis and Correction, including use of various diagnostic tools, etc. Refer to the Vibration Analysis Diagnostic Training list near the end of this bulletin.

Note: If after working through the appropriate areas of this bulletin and any referenced bulletins, further assistance is needed, see the latest version of PIP5338 prior to contact Technical Assistance.

Vibration / Disturbance Classification

Type of Vibration / Disturbance	Go to Condition
1st, 2nd, 3rd Order Tire Related: T1, T2, T3 Tire related vibrations, especially T2 or T3 may be noticeable beginning in lower speed ranges, being most noticeable at highway speeds – always use Pico Scope as first step in evaluation	1
1st Order Prop Shaft Related: P1	2

Type of Vibration / Disturbance	Go to Condition
Drive Axle Ring & Pinion Related Disturbances: P-Related (typically P1), OR T-Related (typically T1) in a narrow speed range (most noticeable ~ 38-44 mph (61-71 km/h) range depending on gear ratio)	3
V4 AFM Exhaust Drone – 2nd Order Engine Related: E2 – Vehicle Moving (~1,100-1,400 engine RPM range)	4
Rough Idle in Drive – 1-1/2 Order Engine Related: E1.5 – Vehicle Stopped in Drive (or less often in Revere)	5
Rough, Harsh, Stiff Ride Concern; Z95 MR Suspension (most noticeable 35-55 mph (56-89 km/h) on relatively smooth roads with minor road input)	6
Shake, Shudder, possibly described as Rough, Harsh, Stiff Ride similar to Driving over Rumble Strips (8-Speed Trans Only) (most noticeable during light throttle acceleration, 25–80 mph (40–128 km/h), with Engine RPM below 1,600)	Refer to PIP5337 and 16–NA-175 to Investigate Possible Transmission Issue
Cabin Boom / Pressure Boom / Buffeting Drone	7

Condition 1:

1st, 2nd, 3rd Order Tire Related Vibrations / Disturbances: T1, T2, T3

Important: First Before performing any Road Force Balancing with the Hunter Road Force Balancer, Ensure that the wheel assemblies pass the centering test. Skipping this critical step may lead to inaccurate diagnosis and repair.

1st Order Tire Suggestions (Freq 11-14 hz at 60 mph or 97 km/h)

2nd Order Tire Suggestions (Freq 22-28 hz at 60 mph or 97 km/h)

3rd Order Tire Suggestions (Freq 33-42 hz at 60 mph or 97 km/h)

1. Remove the tire and wheel assemblies from the vehicle and perform the Road Force Variation (RFV) measurement.

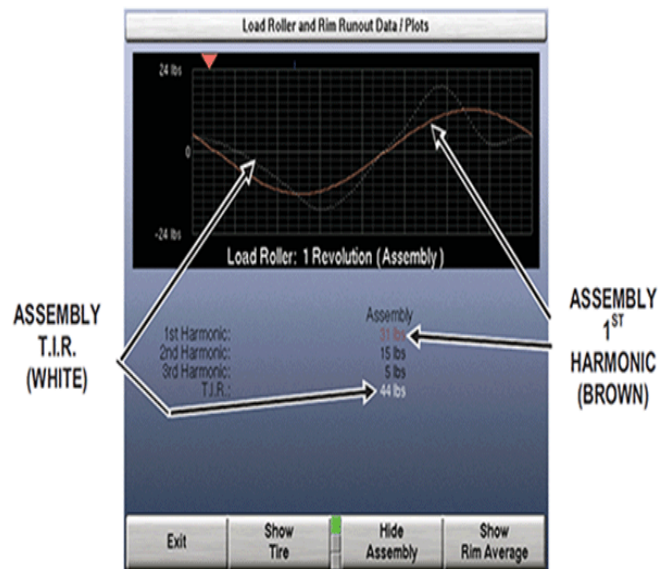
Important: Prior to taking any measurements, each tire/wheel assembly **MUST** pass the center check. Ensure wheels are mounted using the wheel's center pilot hole which mates to the vehicle hub pilot; do Not use the center cap hole. Refer to the latest version of Bulletin 17-NA-170: Information on Hunter Road Force Balancer, and Bulletin 00-03-10-003: Information on Tire Radial Force Variation (RFV) for additional information.

2. **Document the Before and After Road Force Variation (RFV) numbers on the vibration worksheet located at the end of this bulletin.**

Diagnostic Tips to Consider in Assessing Tire Related Road Force Variation (RFV):

Note: There have been cases of T2 RFV tire issues, most noticeable at highway speeds, (primarily with 22-inch tires), which may cause both a vibration and disturbance in the cabin / body.

- Some cases of tire/wheel assemblies have been shown to have acceptable T1 RFV numbers, but with further investigation, have been found to have bent inboard rim flanges with hidden tire damage, visible inside the tire sidewall when dismounted.



Measurements and Limits

Measurements	Road Force			Inner
	Tire	Assembly	Limit	
Radial 1st Harmonic	13 lbs	10 lbs	24 lbs	0.006 in
Radial 2nd Harmonic	14 lbs	14 lbs	24 lbs	0.007 in
Radial 3rd Harmonic	4 lbs	4 lbs	22 lbs	0.007 in
Radial T.I.R.	---	19 lbs	96 lbs	0.022 in

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Note: The screen shots shown above depict possible generation Hunter Road Force Balancer displays.

- The Hunter Road Force Balancer checks tire low-speed RFV only, in the radial plane only.
 - ⇒ The Hunter Road Force Balancer is set to display T1 RFV as the default.

Higher order RFV, T2 & T3 can be displayed in the Assembly Data Plots Screen, as shown above. Depending on the level of Road Force Balancer, the screen may be under 'Data' or 'Runout Plots,' then "Rim and Load Roller Runout Plots," or 'Road Force', 'Force Match', 'Data and Plots', 'Show Details.'
- Engineering analysis of 2nd order tire issues, especially as they relate to 22-in tires, has determined that tire bead to rim seating is a critical component. To address a T2 issue, deflate the tire and perform bead massaging on the tire changer, then re-inflate the tire and check on the Road Force Balancer. Ensure correct tire lube is used and that the lid is kept closed to preserve chemical integrity – if the lid is left open, the drying agent will be lost, promoting tire slip. Refer to 12-03-10-001: Vibration Shortly After Tires are Mounted/Preventing Vibration from Wheel Slip (Tire Sliding on Wheel) for information on Bead Seating.

- When checking tires on the Road Force Balancer, if (radial) T2 is high or close to the (radial) T1 value, the tire should be worked focusing on tire bead seating, then if necessary the Hunter 180 Match Mount Process should be utilized before tire replacement, as mentioned below.
- As an example, if a tire and wheel assembly is measuring T1 at 14 lbs RFV, the tire would be considered good; however, if in displaying the higher orders, it is found that the tire and wheel assembly also has T2 at say 11 lbs RFV, the tire may need to be worked further to reduce T2 RFV levels.
- As a general rule of thumb, if T2 RFV is approximately 75% or greater of the T1 RFV measurement, (with T1 at or near the specification limit guideline) with T2 as the primary issue of focus, the tire requires further work to reduce T2 levels. Refer to the following chart for 22-in tire T2 RFV specification limit guideline for T2 vibration concerns.

Road Force Variation (RFV) Specification to Address Ride Concerns	
Note: For SUV, arrange the tires on the vehicle in the following order: lowest RFV at LF, next RF, next LR, highest RR	
P-Metric Tires on Light Trucks, SUVs	T1 RFV: 15 lbs (6.8 kg) or Less
P-Metric 22-in Tires on Full Size SUVs	T2 RFV: 11 lbs (5.0 kg) or Less
Important: These tire road force numbers are lower than what is currently published in service information as some vehicles may react to tire/wheel assemblies that are near the higher limits. These numbers should NOT be used if the vehicle does Not exhibit a tire speed related vibration.	

Repair:

- For any assembly that has an out of balance condition (greater than 0.25 oz), remove the weights and correct the condition utilizing normal balancing techniques.
- For any assembly having Radial Force Variation (RFV) measurements beyond the specification above, attempt to correct utilizing the Hunter 180 Match Mount Process, (see Hunter 180 Match Mount Process below), prior to tire replacement. If this does not bring the assembly within specification, measure and document the RFV value on each tire. Then remove the tires and measure and document the runout of each rim assembly. Next match the tire with the greatest RFV value to the rim with the greatest run out. Continue matching tires and rims until you have 4 assemblies. If you are still unable to bring the RFV down to specification with the new combination, the tire should be replaced. The existing vectoring process cannot be utilized on Full Size Truck rims (except steel wheels) due to the removal of the out-board flange on the wheel which was utilized for the outboard rim runout measurement. Without this surface, an inaccurate rim runout measurement would exist and negatively affect the vectoring calculation.

Additional Notes on Balancing:

- Always perform a centering check.
- All tires need to be balanced under 0.25 oz (both static and dynamic). In many cases, it may be helpful to add weight to only one plane at a time.
- When using the Hunter – Balancer/Road Force Balancer, removal and remounting to the tire balancer should be performed to re-check balance and verify that results are repeatable to 0.25 oz or less.

Note: If on-vehicle rim runout reveals an issue – inspect wheel and hub mounting surfaces, including countersunk holes on back of wheels, intended to clear the tinnerman push nuts over two rear wheel studs. Refer to latest copy of PIT5530.

- Anytime a tire is removed from the wheel, the bare wheel should be mounted back on the vehicle and a runout check be performed on-vehicle. This process not only checks the wheel but also all mounting surfaces and suspension components that may affect runout.

Important: When replacing tires, the road force should be checked before a test drive and after a test drive (min of 10-15 miles or 16-24 km). Road force on new tires will change dramatically after being warmed up (as much as a 20 lb reduction). After the test drive, the tire's road force should be checked. If acceptable RFV cannot be achieved, first try vectoring the tire on the rim using the 180 Match Mount Process (Hunter), before an alternate tire is utilized. For additional information, refer to the latest version of Bulletin 17-NA-170: Information on Hunter Road Force Balancer, and Bulletin 00-03-10-006: Information on Tire Radial Force Variation (RFV).

Hunter 180 Match Mount Process

Most of the wheels used on Full-Size Truck and SUV are Flangeless. Flangeless refers to the outboard flange of the wheel where previously a clip-on weight would attach. Flangeless wheels do not have a machined outboard flange for the Hunter Run-out Arm/Wheel to ride on. The previous process for tire and wheel assemblies that had high Road Force, was using the tire Force Matching process. This process requires the use of the Runout Measurement arms or laser sights on the Hunter Road Force balancer (depending on version) to inspect rim runout. Without having this machined area, there is not a place for the Runout roller to measure. The Generation 3 and later RoadForce balancers have an alternate process called the 180 Match Mount. As an example, on Gen IV machines this procedure can be found under RoadForce - Procedures - 180 Matching (or by selecting Match Mount without Rim Runout after initial RoadForce measurement).

This process does not use the Runout Arms and instead utilizes the Load Roller to optimize Road Force. While this process requires that the tire may need to be rotated up to 3 times on the rim to obtain the lowest Road Force number, it is the only way for the technician to match mount these wheel and tire assemblies reliably.

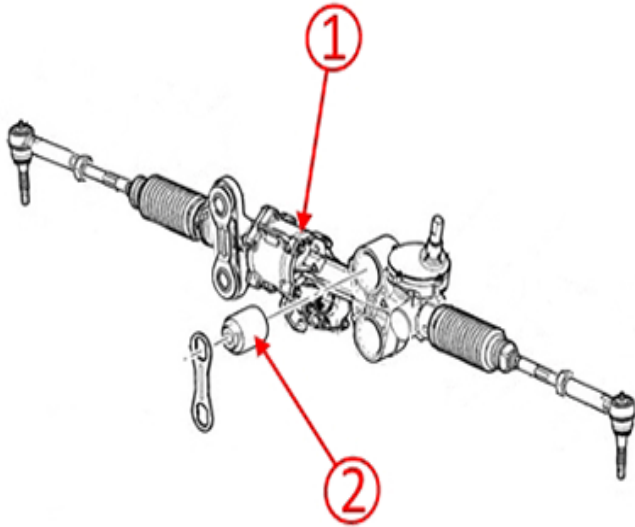
Refer to the latest version of Bulletin 17-NA-170: Information on Hunter Road Force Balancer, and Bulletin 00-03-10-006: Information on Tire Radial Force Variation (RFV) for the Hunter 180 Match Mount Process.

For additional information on the 180 Matching process, please review the following Hunter Video that outlines the process. <https://youtu.be/nswttgUKstk>

Steering Gear/Rack Bushing Replacement

Important: The following procedure should only be used for LD SUV's built prior to 11/4/2016 and after all tire issues have been corrected. Installation of revised steering gear/rack bushings will have little to no effect on trucks that still have tire conditions. T1 vibration must be reduced to under 20-25mg's for these bushings to be effective.

Notice: Care must be taken to not damage the EPS Motor electrical connectors or gear replacement may be required.



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A revised steering gear/rack (1) mounting bushing (2) has been released to address customer vibration concerns. After various testing and measurement of T1 vibration, a vibration path from the tie rods =>steering rack=>steering bushings=>frame=>body mounts=>cabin floor=>seats has been identified. To help isolate the steering rack, a revised hydraulic mounting bushing has been released and tuned for the T1 frequency. The new steering rack bushing dampens minor T1 vibrations. It has been found that the new bushing also helps dampen minor T2 vibration / disturbance. This is the reason that the causal part (normally the Tire/Wheel Assembly) must be corrected first. If T1 vibration is over 20-25m/g's, the bushings will have little to no effect. Likewise, for T2 vibration / disturbance, the causal part/area must be corrected first to benefit from the bushings.

For vehicles with T1 vibrations under 20-25m/g's, replace steering rack bushings per parts catalogue. Refer to Steering Gear Mount Bushing Replacement in SI.

Parts Information

Description	Part Number	Qty
BUSHING, S/GR (CK100 06 All LD SUV)	84234960	2

Condition 2:

1st Order Prop Shaft Related Vibration / Disturbance: P1

Vibration most noticeable between ~ 38-44 mph (61-71 km/h), most noticeable during acceleration or deceleration – most likely drive axle ring and pinion related or propeller shaft related (1st-order Prop / Pinion most likely / 1st-order Tire / Ring Gear possibly).

Suggested Process:

- Inspect propeller shaft for damage.
- Perform prop runout measurement.
- Disassemble/reassemble rear yoke joint – checks for shift in U-joint.
- Perform prop runout measurement.
- Evaluation drive.
- Index prop shaft 180 degrees to check drive axle input pinion flange and prop-driveline balance.
- Perform prop runout measurement.
- Evaluation drive.
- If necessary, balance driveline with Pico scope.
- Evaluation drive.
- For 4WD Trucks, remove the rear propeller shaft, seal output shaft and drive the vehicle in 4WD. If the vibration is gone, the rear prop shaft could be the source.

Propeller Shaft Runout Measurement Specification to Address P1 Related Vibration Concerns

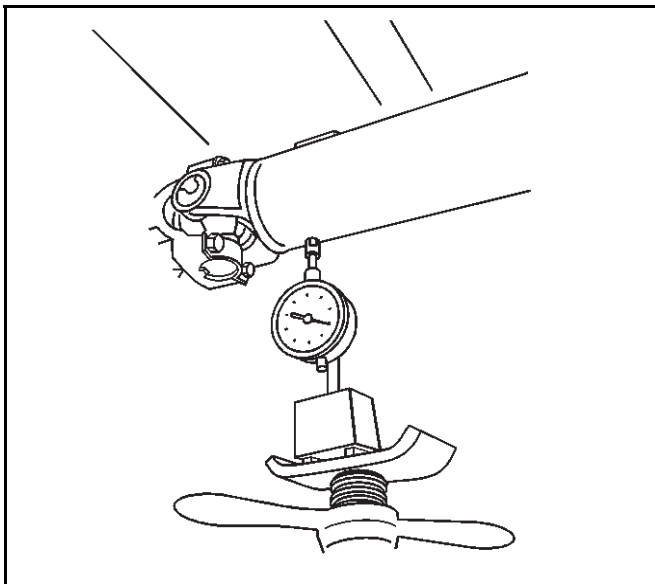
Note: These numbers are lower than the guideline specifications currently published in service information, to specifically address a 1st order prop-related vibration concern if present. These numbers should NOT be used if the vehicle does Not exhibit a P1 propeller shaft speed related disturbance.

Front, Middle, Rear Location Runout Tolerance Maximum	0.51 mm (0.020 in)
Actual Measurement:	



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1. Inspect the propeller shaft for dents, damage, and missing weights. There have been many cases of dented propeller shafts. Damaged prop shafts must be replaced.



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2. Perform the complete Propeller Shaft Runout Measurement procedure to inspect the propeller shaft, the transmission / transfer case output shaft, and the drive axle pinion input flange runout. Refer to the SI Document ID# 2084709.
3. Inspect the transmission / transfer case output shaft bushing for irregular wear.
4. If a damaged prop shaft has been replaced, and/or prop shaft runout has been brought to within runout tolerance specs for a P-related vibration; re-evaluate the vibration using Pico scope to determine level of improvement.
5. P1 measured level may have occasional peaks during testing, but should not exceed 4 mg for best outcome.

6. If P1 measures close to or greater than 4 mg; perform the Driveline System Balance Adjustment procedure using Pico. Refer to SI Document ID # 3753593.
7. If the driveline is Not able to be system balanced – errors-out during process; investigate the drive axle ring and pinion (pinion side issue) as the likely source of the P1 vibration. Refer to Condition 3 below.

Driveline System Balance Adjustment Specification	10 g - cm
Actual Measurement:	
Using the two hose clamp method, the best driveline balance results are obtained under 10 g-cm.	

Condition 3:

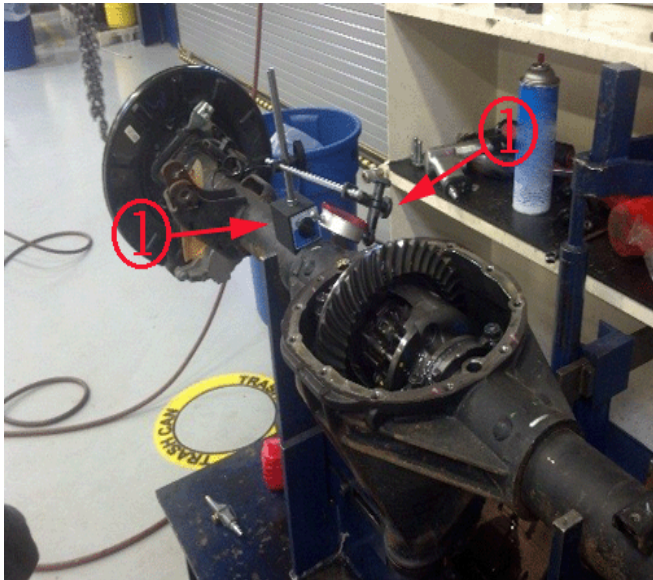
Drive Axle Ring and Pinion Related Disturbances: P-Related (typically P1), or T-Related (typically T1) in a Narrow Speed Range (most noticeable ~ 38-44 MPH (61-71 km/h) range depending on gear ratio)

Pitchline runout / gear set machining, followed by setup issues have been found to be contributors to vibration issues; not just whine noise concerns. Gear set machining issues in these axles seem to most often show up as P1 or higher order P related; with some showing as T1 or higher order of T related; all depending on gear set condition.

If tire/wheel assemblies and propshaft have been ruled out / repaired, and P1, T1 or a higher order of P or T is still present in the vertical or horizontal plane – other than in direct-response to road input, the drive axle must be investigated. Remove differential cover and check ring gear backlash to identify possible pitchline runout and/or setup issues. Every tooth Must be checked for excessive backlash. If there is more than 0.0508 mm (0.002 in) of variation, the ring and pinion and/or differential should be replaced to correct the condition (SI Document ID# 3269088).

If drive axle repair is necessary, we have heard some reports that during repair, tooling chatter marks may be observed in the pinion race counter bores. This issue lends to the idea that the races may not be fully seated until some vehicle use is introduced into the axle. This issue would most often result in a noise concern, though severe loss of preload might produce a vibration. The races should be able to be fully seated during repair.

Backlash Adjustment Procedure



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Note: The illustration above is for reference only. The axle does NOT need to be removed from the vehicle.

1. Perform the Backlash Adjustment procedure, with the following Exception: *Each Tooth* of the ring gear *Must* be measured. The SI procedure mentions 8-points; however to ensure a possible vibration disturbance point is identified, *Each Tooth Must* be measured. Refer to Backlash Adjustment, SI Document ID # 3269088.
2. The above picture is included to help clarify setup of the dial indicator for measurement.
3. Once the backlash and bearing preload is correct, perform a gear tooth contact pattern check in order to ensure proper alignment between the ring and pinion gears. Refer to the Gear Tooth Contact Pattern Inspection in SI, Document ID # 1990157.

Condition 4:

V4 AFM Exhaust Drone – 2nd Order Engine Related: E2 – Vehicle Moving (~1,100-1,400 engine RPM range)

Some owners may comment on a buffeting vibration and/or drone type noise, exhaust tone change, and/or body pressure booming.

This concern may be most noticeable while the engine is operating in V4 (4-cylinder) Active Fuel Management (AFM) mode in the 1,100-1,400 engine RPM range.

While some slight changes in exhaust tone and/or vibration/drone type noises can be normal when engine AFM is in V4 mode, there have been some complaints of them being excessive.

If the concern is excessive, it may excite the roof sheet metal and compound the issue. After working through V4 Mode Exhaust Drone, if necessary see Condition 7.

Pico readings should be E2 for this concern. Frequencies will likely measure in the 36-48 Hz depending on speed.

Note: Exhaust design changes have been implemented to address this concern for 5.3L equipped Full-Size SUVs built 7/1/2016 and later. Calibration changes have been implemented to help address this concern for 6.2L equipped SUVs beginning with 2017 model year.

If Pico readings line up as specified, refer to PIT5404 for specific V4 Mode Exhaust Drone diagnostic information.



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Note: There have been some cases of excessive V4 drone on 5.3L SUVs with the updated exhaust – a leak at the exhaust Norma clamp joint behind the rear converter may allow E2 V4 drone to manifest. 6.2L engines with a leak at the same exhaust clamp joint may allow excessive drone – more than comparable vehicles. Refer to latest version of PIP5442.

Condition 5:

Rough Idle in Drive - 1 ½ Order Engine Related: E1.5 - Vehicle Stopped in Drive (or less often in Reverse)

Some customers may comment about a rough idle and/or vibration at idle in Drive, (a few cases in Reverse).

This condition may be most noticeable following extended driving, after hard acceleration, while idling at a stop in Drive.

May feel like a lumpy or lumpy idle, or may be described as a low idle.

This condition will Not be present in Park, or Neutral.

This concern may be caused by ground out within the one or both engine mounts.

Refer to the latest version of 17-NA-166 for diagnostic information and procedures related to E1.5 related vibration disturbance noticed most while vehicle is stationary in Drive (or Reverse).

Condition 6:

Rough, Harsh, Stiff Ride Concern; Z95 MR Suspension (most noticeable 35-55 mph (56-89 km/h) on relatively smooth roads with minor road input)

Full-Size SUVs beginning with 2015, incorporate suspension design improvements for improved handling, decreased stopping distances, reduce body roll, etc. Many customers are very satisfied with the ride and handling, but some owners may feel the ride is not to their satisfaction. They may comment of a rough/harsh/stiff ride, or they may describe a vehicle vibration with a similar description.

Vibration / disturbance most noticeable between ~ 35-55 mph (56-89 km/h). Most noticeable under certain road conditions – most likely related to isolation of minor road input. The suspension will absorb larger bumps without complaints, but smaller/minor imperfections/bumps, which would normally be absorbed by the suspension, may not be absorbed as well as the owner would expect.

Note: When evaluating the vehicle for this concern, keep in mind that tire flat spotting, true T2 concerns, etc., can contribute to a ride feel of vibration / disturbance / roughness. Ensure other possible contributors have been addressed.

Scenario might be; vibration / roughness noticed on **fairly smooth roads, when coming in contact with small / minor road imperfections / bumps, expansion joints, etc.**

To ensure proper evaluation, drive the vehicle at least 10-15 miles (16-24 km) to warm the tires first to eliminate possible contribution of flat spotting.

Pico readings may show 2nd-order Tire in Direct-Response to minor road input Only; Not consistently like a true T2 issue. (Shocks somewhat creating additional 'bump' rather than absorbing.) Pico readings may also reveal Unknown-order frequencies (approximately 15-19 Hz) again, in direct-response to minor road input only (reaction of the cabin / body due to lack of isolation).

Use care to Not be confused with reaction / disturbance which can occur between certain pavement textures and certain tire tread designs.

Note: True 2nd-order tire related disturbance – as opposed to Z95 shock response to road input creating momentary T2 – may be noticeable beginning in lower speed ranges, being most noticeable at highway speeds. Refer to Condition 1 for further diagnostic and repair process.

Note: Shock design improvements and MR suspension calibration improvements were implemented for vehicles built 2/10/2015 and later. For vehicles built Before 2/10/2015, refer to PIT5429.

There have been some reports of Z95 MR system ride improvement following shock replacement and reprogramming the suspension control module; later to have the ride feel return to the original level of customer concern. This phenomenon occurs during a period of learning for the suspension control module of the shock

characteristics. Once the learning period is complete, the module will lock in the shock characteristics for that specific vehicle.

Addressing inputs such as T2 or P1, etc., will help reduce the feeling of roughness or poor ride quality. For vehicles which Pico shows to be sensitive to T2 road input, we have seen some level of improvement to both T1 and T2 and thus ride quality, using the updated hydraulic steering gear bushings. Refer to Condition 1.

Condition 7:

Cabin Boom / Pressure Boom / Buffeting Drone

Some owners may comment of a wind buffeting / drone noise or cabin / body pressure booming (the feeling of pressure in the ears) while driving. The body booming issue may be more noticeable when the engine is in V4 Mode for active fuel management (AFM). These concerns may be caused or amplified by reaction of the roof sheet metal to certain energy inputs.

Examples of energy inputs that can excite the roof sheet metal may be:

- Tires with excessive RFV – Especially 2nd Order Tire; T2 (refer to Condition 1)
- V4 AFM Exhaust Drone (refer to Condition 4)
- Rear axle ring and pinion related issues such as pitchline runout (refer to Condition 3)
- Road Input, primarily for Z95 MR suspension with 22-in tires (refer to Condition 6)

Vibration manifested in vehicle body or cabin – possibly producing boom, buffeting, and/or drone noise / possibly producing pressure in the cabin [vehicle structure reaction or 'light off' in response to: A) rotating component producing enough energy, such as a ring and pinion with pitchline runout; B) component system producing enough energy in a frequency range which can 'light off' an area of sheet metal, such as exhaust drone during active fuel management (AFM); C) sheet metal concern, such as lack of bonding, poor / missed spot weld, etc., allowing reaction to various road inputs, etc. (will demonstrate as rotating component frequency if applicable, and Unknown-order related to sheet metal / body reaction)]

Note: When evaluating the vehicle for this concern, keep in mind possible areas listed above that could contribute energy strong enough / in frequencies close enough to excite the roof sheet metal. Ensure other possible contributors have been addressed whenever possible.

Refer to appropriate Conditions covered in this bulletin based on Pico scope evaluation of the vehicle and address issues to reduce or eliminate primary contributors to cabin boom. Addressing inputs such as T2 or V4 AFM exhaust drone, etc., will help reduce cabin boom. For vehicles which Pico shows to be sensitive to T1 / T2 and/or T2 road input, we have seen some level of improvement to both T1 and T2 and thus cabin boom, using the updated hydraulic steering gear bushings. Refer to Condition 1.

Warranty Information

For vehicles repaired under warranty, use:

Labor Operation	Description	Labor Time
3080138*	Perform Pico Scope Vibration Measurement and Road Test	0.5 hr
8080108*	Perform Road Force Measurement	0.9 hr
	Add time to vector each tire correction (Before and after Road force number should be noted on Vibration worksheet)	0.2 hr
3080088*	Perform Prop Shaft Measurement and Balance (two hose clamp method)	0.8 hr
3080168*	Steering Gear Support Bushing Replacement Note: For steering wheel angle and/or front toe adjustment times, refer to labor code 8070012 and add the applicable base times to base labor hours.	3.0 hr
**	Replace Tire(s)	Use Published Labor Operation Time
*This is a unique Labor Operation for Bulletin use only.		
**Use the appropriate labor operation code in SI specific to the manufacturer of the tire being replaced.		

Version	5
Modified	<p>Revised March 20, 2017 - Updated the Recommendation/Instructions and Vibration Analysis Diagnostic Training sections.</p> <p>Revised June 8, 2017 - Removed SmartWeight information, updated bulletin reference and Hunter Balancer information under Condition 1.</p> <p>Revised December 14, 2017 - Added 2018 to Model Year section.</p> <p>Revised January 22, 2019 - Adding 2019 Model Year. Removed Vibration Diagnostic Worksheet table, include Vibration Diagnostic Worksheet Instructions.</p>

Vibration Analysis Diagnostic Training

Training Available			
US Courseware			
Course	Delivery Platform	Course Description	Length
13042.14D1-R2	Virtual Classroom Training (VCT)	Noise, Vibration and Harshness (NVH)	1.5 hr
13042.14D2-R2	Virtual Classroom Training (VCT)	Noise, Vibration and Harshness (NVH)	2.0 hr
13042.14H-R2	Hands-On Training	Noise, Vibration and Harshness (NVH)	8.0 hr

Training Available			
13042.14D1-R2-V	Video On Demand (VOD)	PicoScope Noise, Vibration, and Harshness Diagnostics Overview	2.0 hr
13042.14D2-R2-V	Video On Demand (VOD)	PicoScope Noise, Vibration, and Harshness Diagnostics Overview	2.0 hr
13042.14W	Web-Based Training	Noise, Vibration and Harshness (NVH)	2.0 hr
<i>GMCC Courseware</i>			
13042.12W	Web-Based Training	Noise, Vibration and Harshness (NVH)	2.0 hr
13042.13V	Video On Demand (VOD)	PicoScope Noise, Vibration, and Harshness Diagnostics Overview - VOD	15:05 min
13026.16H	Hands-On Training	NVH (Noise, Vibration, Harshness) Diagnosis & Correction Certification	16.0 hr

Notice: To access the Vibration Diagnostic Worksheet, Go to > Global Connect > Service Forms > General Information > Vibration Diagnostic Worksheet.

