

## 2011+ Adjustable Tie-rod Ends (Mm5TR-2)



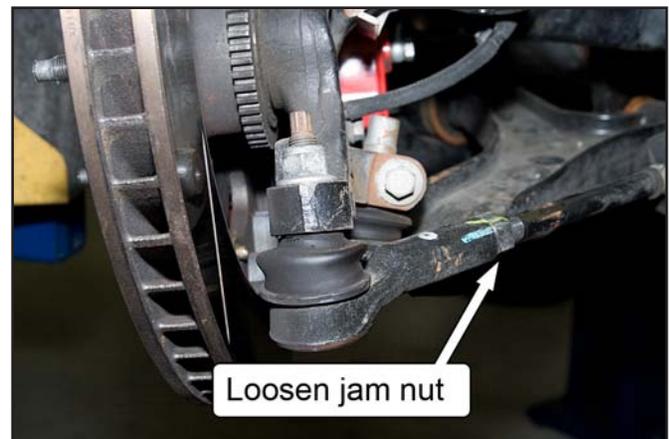
*Read all instructions before beginning work. Following instructions in the proper sequence will ensure the best and easiest installation.*

The MM Adjustable Tie-rod Ends are designed to allow adjustment of the steering geometry to minimize bumpsteer. "Bumpsteer" is when the front toe setting changes as the suspension moves up and down. If the toe changes, the car steers itself without any input from the driver. This makes the car feel unstable and unpredictable over bumps, with body roll, or during brake dive. Also, when the front suspension geometry is altered, the tie-rod geometry must be restored to minimize bumpsteer.

The stock tie-rod geometry on the 2011+ Mustang induces significant bumpsteer that is designed to make the car understeer. The Mm5TR-2 Adjustable Tie-rod Ends allow the bumpsteer to be dramatically reduced for improved stability and control.

### Instructions

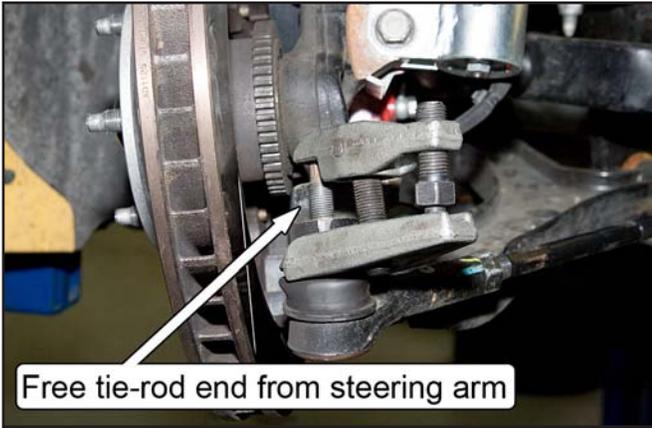
1. Set the parking brake and block the rear wheels of the vehicle to keep it from moving.
2. Jack up the front of the car and place it safely on jack stands.
3. Remove the front wheels.
4. Loosen the factory jam nut securing the outer tie-rod end to the tie-rod.



5. Loosen the nut securing the tie-rod end to the spindle, but do not remove it.



6. Spray penetrating oil on the tie-rod end tapered stud, just below the loosened nut.
7. Free the tie-rod end by hitting the front of the steering arm with a large hammer, or by using a suitable tie-rod splitting tool.



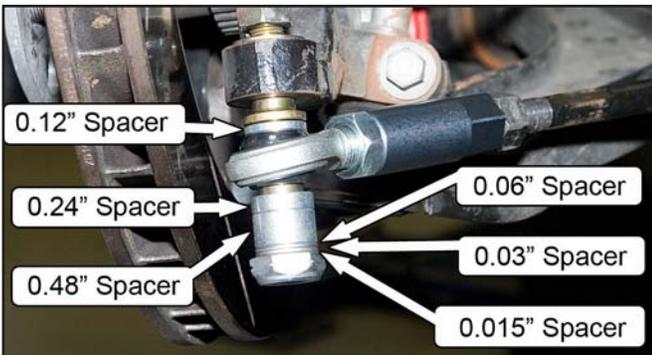
8. Remove the tie-rod end from the steering arm.
9. Remove the tie-rod end from the inner tie-rod.
10. Thread the MM Adjustable Tie-rod End onto the inner tie-rod until it contacts the factory jam nut.
11. Snug the factory jam nut against the aluminum adapter sleeve.

*NOTE: The tie-rod will spin freely at the steering rack connection (under the rubber boot) to allow the MM Adjustable Tie-rod End to be aligned with the Tapered Stud. Loosen the clamp securing the rubber boot to the tie-rod before turning the tie-rod to prevent damage to the boot.*

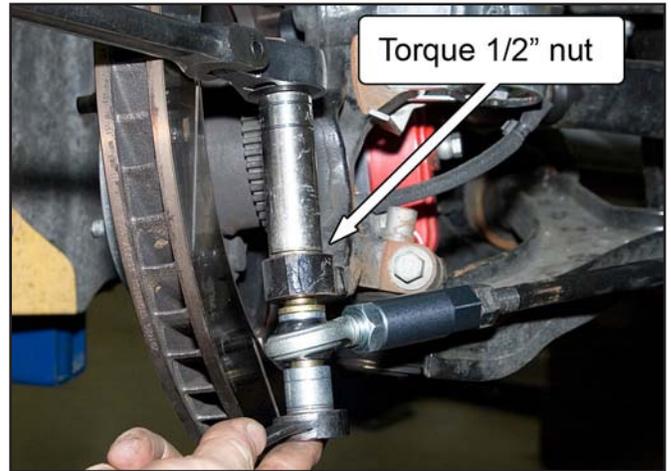
12. Insert the MM Tie-rod End Tapered Stud into the spindle, and secure it with a supplied 1/2" G8 washer and 1/2" Nylock nut. For now, the nut only needs to be threaded on by hand.
13. Slide one of the supplied 0.12" bumpsteer spacers onto the MM Tie-Rod End Tapered Stud, below the steering arm. Next, slide on the MM Adjustable Tie-rod End, followed by one 0.24", one 0.48", one 0.06", one 0.03", and one 0.015" spacers. Use the supplied 5/8" thin Nylock nut and hand tighten.

*NOTE: There must always be at least one 0.12" spacer between the 5/8" thin Nylock and the rod end.*

*NOTE: We recommend leaving the unused spacers on the Tapered Stud so they will be readily available if future adjustments are needed.*



14. Torque the 1/2" nylock nut that secures the tapered stud to the steering arm to 65 ft-lbs. Use a 15/16" wrench on the 5/8" nylock nut underneath the steering arm to stop the tapered stud from rotating.



15. Torque the 5/8" nylock nut to 65 ft-lbs.



16. Tighten the factory tie-rod end jam nut against the MM Aluminum Adapter Sleeve to 41 ft-lb.

*NOTE: The hex on the MM Adjustable Tie-rod End requires a 7/8" open end wrench.*



- Verify that the outboard 5/8-18 jam nut securing the rod end to the MM Aluminum Adapter Sleeve is tightened to 41 ft-lb.

*NOTE: The jam nut is secured from our factory using Loctite and should never be loosened.*



- Repeat Steps 4-17 for the opposite side of the car.
- Reinstall the wheels and safely lower the car to the ground.
- Torque the lug nuts to the manufacturer's specification.

### Street Driven Vehicles

If you will be primarily driving your vehicle on the street, the installation is done and toe must be reset to the factory specification by a qualified alignment technician.

***WARNING: If any modifications have been made to the front control arm pivot locations, the bumpsteer must be measured and adjusted.***

### Track Driven/Modified Suspension Vehicles

If you will be taking your vehicle on track and/or have modified the front suspension geometry, we have included the proper procedure to bumpsteer your vehicle. Please follow the directions carefully to obtain the most accurate bumpsteer readings.

### Preparing For Bumpsteer Measurement

Measuring and adjusting bumpsteer is NOT something most local alignment shops will know how to do. You will either need to find a good racecar prep shop, or learn to do it yourself.

Maximum Motorsports has a bumpsteer gauge tool (MMT-4) that allows the do-it-yourselfer to easily complete the bumpsteer procedure. Please use the following procedure when adjusting the bumpsteer on any 2005 and newer Mustang, as it is slightly different than the instructions included with the MMT-4 kit.

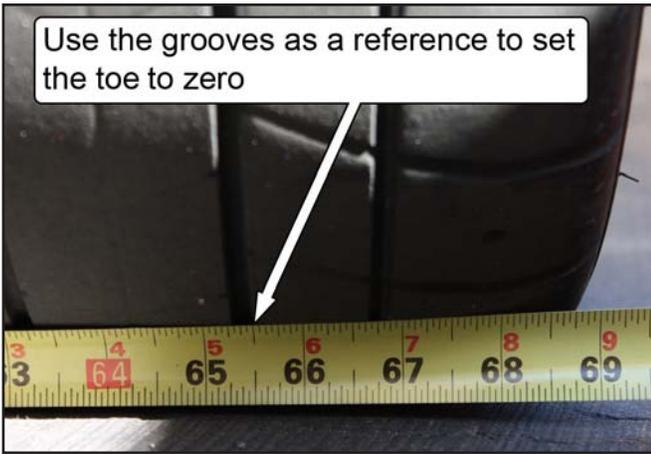
Measuring bumpsteer is really rather simple. The suspension is moved through its range of travel, and any changes in the toe setting are measured. There are a number of ways to go about measuring bumpsteer—once you know the basics we are presenting here, you can modify the technique to suit yourself.

- With the vehicle resting at ride height, set the toe as close to zero as possible. This can be adequately done using a tape measure. Simply measure the distance between the front and the rear of the front two tires. Use the same grooves in the tread block on each tire as a reference point. Equally adjust the length of the driver and passenger side tie-rods to make the distance between the front and rear faces of both tires equal.

*NOTE: The steering wheel's position should be centered prior to this adjustment.*

*NOTE: After setting the toe to zero, make sure that the tie-rod end jam nuts are tight, as loose nuts will affect the bumpsteer measurements.*





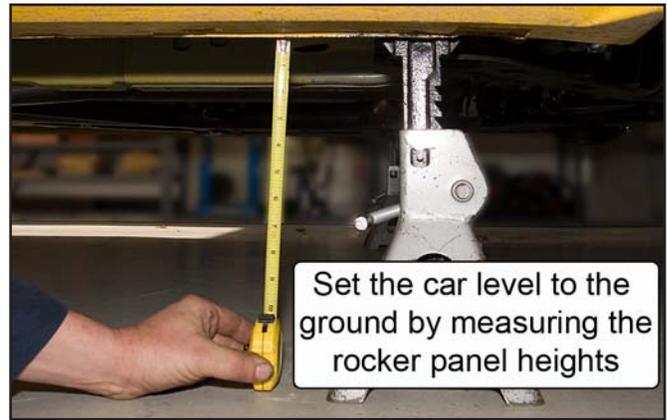
2. With the car on level ground, measure and record the distance from the center of each front wheel to the bottom lip of the fender opening. This distance will be used later to set the “ride height” reference position.

*NOTE: We recommend placing a piece of masking tape on the fender lip to mark the measurement location and to record the distance measured.*



3. Raise the car and place it safely on four jack stands. The jack stands must be positioned under the chassis rather than the control arms or rear axle.
4. Make sure the car is level to the ground by measuring from the bottom of the rocker panels to the ground. Adjust the height of the jack stands to get the car as level as possible. **It is critical for accurate bumpsteer measurements that the car does not rock around on the jack stands.**

*NOTE: It will be necessary to shim the jack stands so that the weight of the car is evenly supported on all four stands.*



5. Disconnect both front swaybar end-links from the struts.



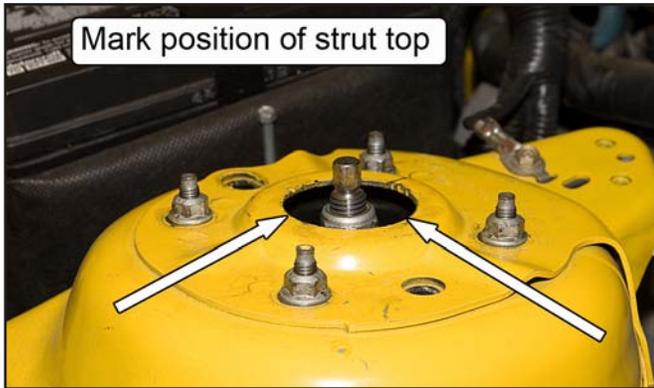
6. Remove the brake calipers and carefully hang them using safety wire or a zip tie.

*NOTE: Make sure that the calipers are located so that the suspension can be compressed without interference.*

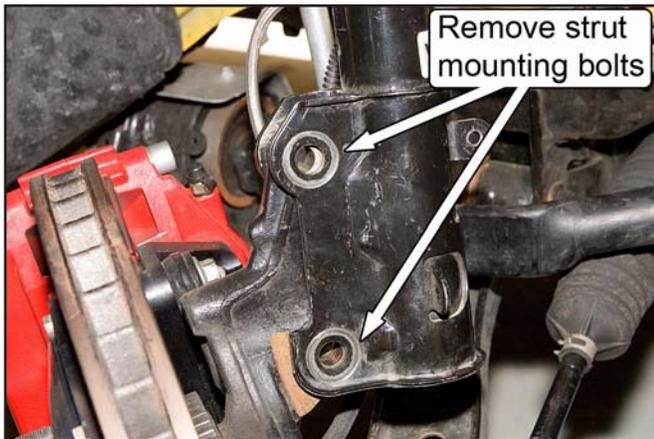


7. Place a floor jack beneath the control arm on the passenger side of the vehicle.

8. If using the factory upper strut mount, remove the four nuts retaining the strut mount plate to the vehicle. If using an aftermarket upper strut mount, mark its position to record the caster and the camber setting before removing the retaining nuts.



9. Remove the two bolts retaining the strut to the spindle and carefully remove the strut from the vehicle.



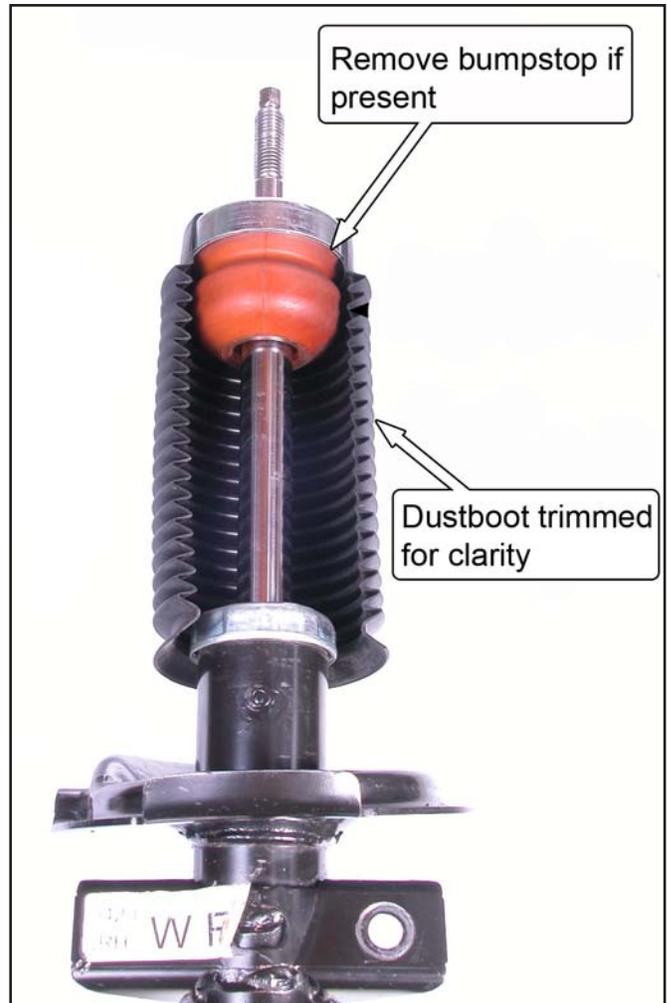
10. The front spring must be removed from the strut so the suspension can be cycled to measure bumpsteer. Place the spring compressor on the spring and safely compress the spring to remove any tension from the upper spring perch.

*NOTE: The compressed spring is extremely dangerous. Use caution when removing it from the strut.*

11. Remove the strut shaft mounting nut, strut mount, and then remove the spring.

*NOTE: If you are using strut shaft spacers as part of a caster/camber kit, record the spacer configuration and remove any loose spacers.*

12. If your strut has an external bumpstop, located beneath the dust boot, remove the bumpstop now.



13. Re-install the upper strut mount along with the correct spacer arrangement, if present, recorded in Step 11.

14. Re-install the nut securing the strut shaft and tighten.

15. Re-install the strut assembly into the vehicle along with the upper strut mount nuts and strut-to-spindle mounting bolts, and tighten. If an adjustable upper strut mount is present, be sure to position it in line with the marks made in Step 8 to preserve the vehicle alignment.



16. Remove the jack from the lower control arm.

17. Repeat Steps 7-16 for the driver side of the vehicle, once the passenger side has been measured using the following procedure.

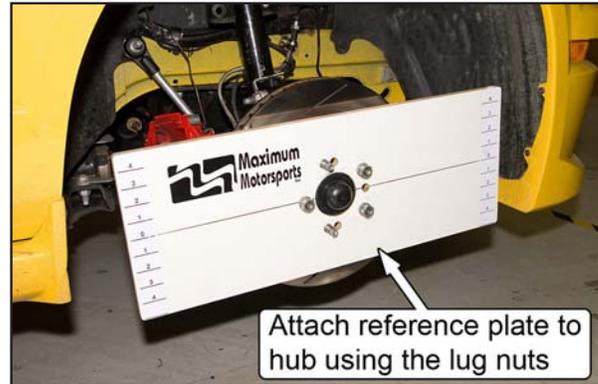
### Setting up the Bumpsteer Gauge

18. The suspension's ride height relative to the chassis must be known. This is the dimension measured in Step 2.

19. It is necessary to lock the wheels perfectly straight with zero play. The steering lock has too much play and does not hold the steering accurately in the straight-ahead position. The best method is to use Vice-Grip pliers on the steering shaft adjacent to the steering rack. Let the handle of the Vice-Grips contact the chassis or k-member. Then, use another Vice-Grip to clamp the first Vice-Grip to the chassis or k-member.

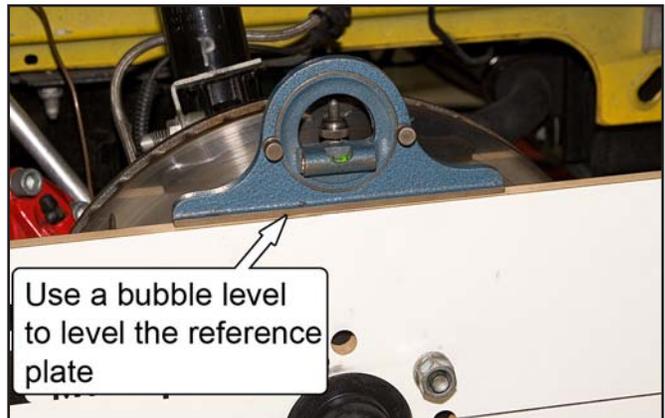


20. Attach the flat reference plate to the front hub. Secure the plate to the hub with at least three lug nuts and supplied 1/2" washers. Tighten the lug nuts enough that the plate is firmly fixed to the hub, but not so tight as to distort the plate.

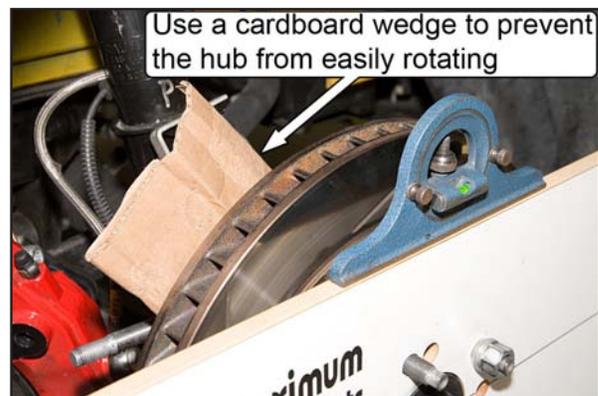


21. Position the reference plate so it is parallel to the ground by using a bubble level or by measuring up from the floor to each end of the plate.

*NOTE: The reference plate will not remain parallel as the suspension is cycled. We highly recommend using a bubble level so that the plate can be quickly adjusted parallel to the ground.*



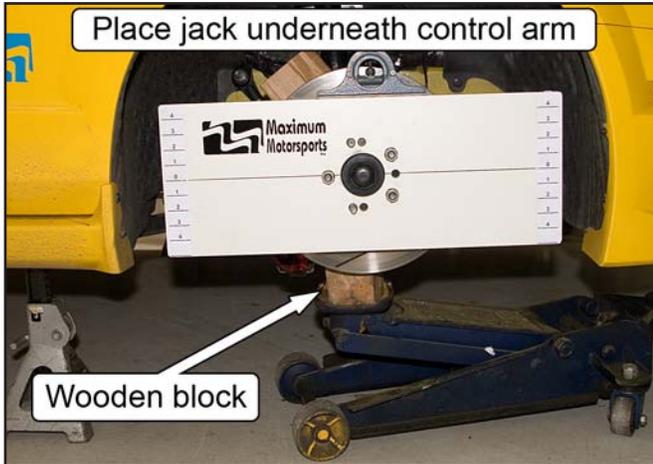
*TIP: The hub can be easily kept from rotating by wedging cardboard or something similar between the brake rotor and the spindle.*



22. Place a jack underneath the front control arm and raise the spindle to normal ride height. Use the dimension D1 you recorded previously to set the distance between the hub center and the bottom of the fender.

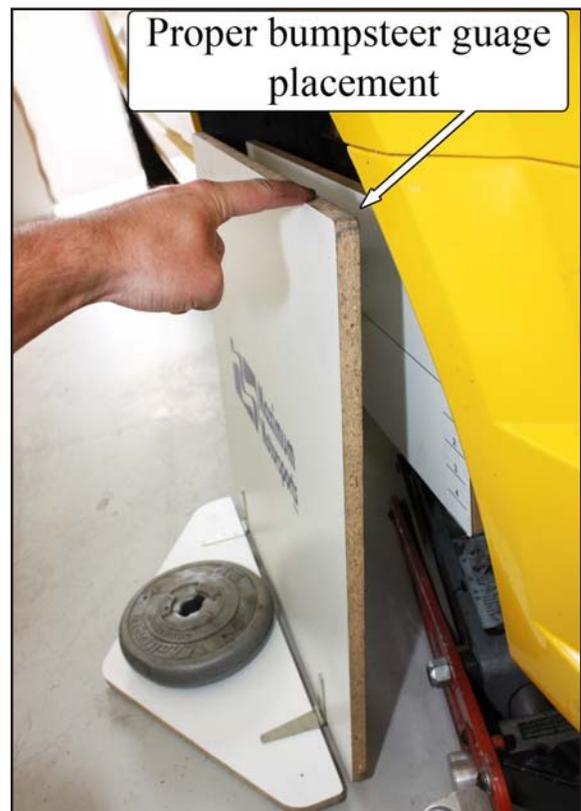
*NOTE: The jack should be positioned as close to the ball joint as possible. We recommend using a small block of wood between the jack and the control arm.*

*NOTE: Make sure that the wood block or jack does not contact the rotor as the suspension is cycled. If contact is made, the measurements will be wrong.*



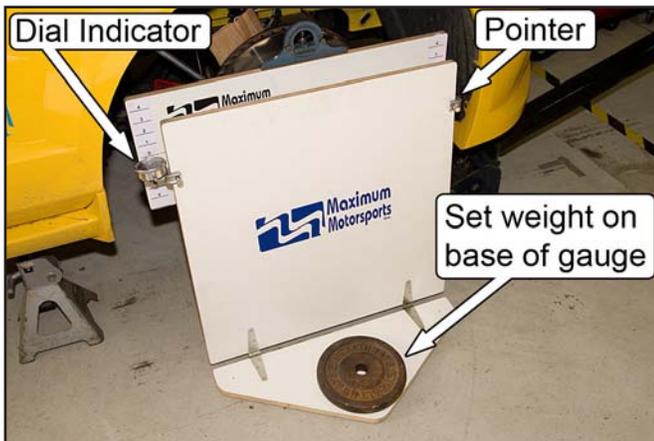
23. Set the bumpsteer gauge into position. The base of the bumpsteer gauge must be away from the car enough that the vertical portion of the gauge wants to fall toward the reference plate. Doing this causes the pointers (not installed yet) to follow the reference plate as you cycle the suspension.

24. Place a heavy weight on the base of the bumpsteer gauge to prevent it from moving. A dumbbell or sandbag works well.

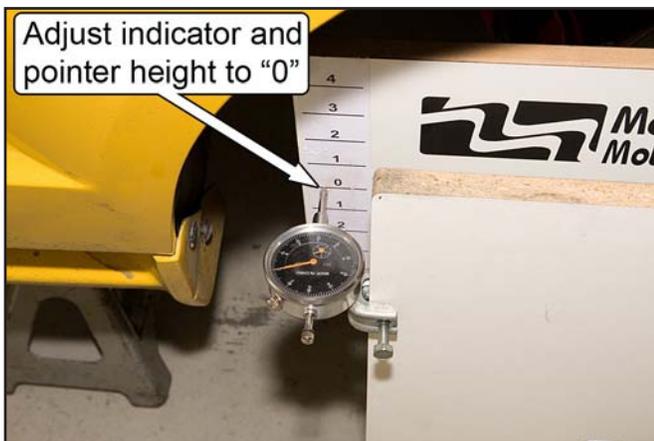


25. The dial indicator and the fixed pointer must be attached to the bumpsteer gauge at this point. When viewing the gauge from the side of the vehicle, attach the dial indicator to the rearward edge of the bumpsteer gauge and attach the fixed pointer to the forward edge of the bumpsteer gauge by hand tightening the clamp bolts. The pointers should be facing the reference plate.

*NOTE: Remember when checking the bumpsteer on the opposite side of the vehicle, the positions of the dial indicator and the fixed pointer must be swapped so that the dial indicator is still located on the rearward edge of the bumpsteer gauge.*



26. Adjust the vertical positions of the dial indicator and the pointer on the gauge so their tips are at the same height as the “0” (normal ride height) marks on the reference plate. After positioning the dial indicator and the pointer it may be necessary to readjust the position of the gauge base to maintain the correct position of the vertical portion of the gauge, so it wants to fall toward the reference plate.



27. When looking down at the top of the bumpsteer gauge and the top of the reference plate, the two edges should be parallel to each other. This will center the dial indicator in its travel range. Move the base of the bumpsteer gauge either towards or away from the reference plate to make them parallel with each other.



### Measuring Bumpsteer

**IMPORTANT NOTE:** The process of measuring bumpsteer involves cycling the suspension from full droop to full bump and measuring the toe change at discrete height intervals. On vehicles using rubber control arm pivot bushings, this poses a problem because the rubber is bonded to the bushing surfaces and is not free to rotate. Instead, the bushings deform, and the amount and direction of deformation can vary, depending on how the control arm is jacked up and on the condition of the bushings.

Because of this, it is important to never release the jack during a test cycle. Doing so will unload the bushings and cause the reading on the dial indicator to change. If the suspension is raised above the desired height interval, it is necessary to restart the test from the full droop position.

28. Lower the jack so that the suspension is at full droop. Then, raise the jack about  $\frac{1}{4}$ " to slightly compress the suspension, so that there is a small load on the jack.

29. Level the reference plate so that it is parallel to the ground.

*NOTE: The reference plate will need to be constantly adjusted and made parallel to the ground as the suspension is cycled through its travel range.*

30. Using the jack, raise the control arm so that the dial indicator and the fixed pointer are on the nearest mark on the reference plate. Be sure to check that the reference plate is level as the suspension is being compressed. It may be helpful to have a helper operate the jack while you level the reference plate.

31. Zero the dial indicator by rotating bezel on the face of the indicator until the needle is aligned with the "0" mark.

32. Raise the suspension up 1" inch and observe the dial indicator—it will give a direct measurement of the toe change. Record the dial indicator reading on the chart at the end of these instructions, next to the corresponding hub height.

*NOTE: If the front of the reference plate moved in towards the center of the car, then the toe setting changed towards toe-in (+ value). If the front of the reference plate moved away from the center of the car, then the toe setting changed towards toe-out (- value).*

*HINT: When looking down on the dial indicator, a clockwise rotation of the needle indicates toe-in.*

33. Raise the control arm to the next inch mark making sure to level the reference plate as necessary. Record the dial indicator reading on the chart at the end of these instructions, next to the corresponding hub height.

34. Repeat Step 33 until the suspension reaches full bump. If this point is between two reference marks, measure the distance between the two marks and record it on the chart along with the dial indicator reading.

*NOTE: Avoid lifting the car, as this will affect the last dial indicator reading. It is not necessary to fully compress the suspension; getting to within  $\frac{1}{2}$ " of full bump travel is close enough.*

*NOTE: Bilstein struts feature an internal bumpstop. It will not be possible to reach the last inch of bump travel without lifting the vehicle.*

35. We recommend that you repeat the test, cycling from full droop to full bump, recording all of the dial indicator readings. If all measurements do not repeat closely (within 0.010") then you should examine your testing technique for errors.

36. Once you are sure that the readings are accurate, it is necessary to zero your recorded readings about the normal ride height reference point. This is done by subtracting the dial indicator reading at normal ride height from the readings taken at each reference point. Use the chart at the end of these instructions to record your data.

### Adjusting Bumpsteer

Altering the height of the outer tie-rod end by using the Mm5TR-2 Adjustable Tie-rod Ends is the easiest method of adjusting bumpsteer on the S197 chassis. Changing the height of the outer tie-rod end (relative to the steering arm) changes the arc that the tie-rod end makes, relative to the arc that the spindle makes, as the wheel travels up and down. As the tie-rod end is raised closer to the spindle steering arm, the vehicle will exhibit increased toe-in under bump. Conversely, as the tie-rod end is lowered relative to the spindle steering arm, the vehicle will exhibit increased toe-out under bump.

By creating a graph of the toe change vs. suspension movement, the change in toe can easily be seen. The graph at the end of these instructions shows various bumpsteer curves.

When adjusting bumpsteer:

- Keep any toe change to less than 0.020" per inch of suspension travel.

37. Plot your toe change measurements vs. suspension movement on the provided graph. At the zero reference height (normal ride height) the toe change will always be zero. The slope of the bumpsteer curve will indicate which direction you need to move the outer tie rod end in order to minimize the bumpsteer.

- Excessive toe-in under bump => add spacers
- Excessive toe-out under bump => remove spacers

38. Keeping any toe change to less than 0.020" per inch of suspension travel may not always be possible at all points in the range of suspension travel. You may have to trade off reduced toe change in one range of suspension travel for more toe change at another point on the bumpsteer curve. Remember that minimizing toe change in the first inch of bump travel is most important. Reducing the amount of toe change in bump is more important than in droop.
39. Add or subtract spacers from between the tie-rod end and the steering arm of the spindle. Then repeat your bumpsteer measurements. Compare the new bumpsteer curve to your previous curve. Based on the results of your change, make further adjustments to the spacer stack and repeat the test. Eventually you will be able to reduce your car's bumpsteer to the minimum amount possible.
40. Repeat Steps 18-39 to measure bumpsteer on the driver side. If the arrangement of spacers is more than 1/4" different from the passenger side, you should inspect all front suspension components for damage or check for a faulty alignment.
41. Once the bumpsteer is finalized, torque the 5/8" thin nylock nuts holding the bumpsteer spacer arrangements to 65 ft-lb. Use a back-up wrench on the 1/2" nut on top of the tapered stud to ensure it does not spin.
42. Re-install the front springs, calipers, and sway-bar end-links; torque all components to the manufacturer's specifications.
43. Reset the toe. Changes in the bumpsteer spacer arrangement will change the toe setting, but later changes to the toe setting during alignment will not significantly affect bumpsteer.
44. Remember—any time you make a change in caster the bumpsteer will be affected. Small changes to the static camber setting will have a negligible effect on bumpsteer, although it will alter the toe setting.

This kit includes:

- 2 Tie-rod Sleeve w/Rod End & Jam Nut
- 2 Tapered Bumpsteer Stud
- 2 5/8 -18 Thin G8 Nylock Nut
- 2 1/2-20 G8 Nylock Nut
- 2 1/2" G8 Washer
- 2 Bumpsteer Spacer - 0.48" Thick
- 2 Bumpsteer Spacer - 0.24" Thick
- 2 Bumpsteer Spacer - 0.12" Thick
- 2 Bumpsteer Spacer - 0.06" Thick
- 2 Bumpsteer Spacer - 0.03" Thick
- 2 Bumpsteer Spacer - 0.015" Thick

**Example Worksheet showing actual 2012 GT Bumpsteer**

Sample Bumpsteer Data Table (Stock 2012 GT)			
	Hub height (in)	Measured Dial Indicator Readings (in)	Measurements Referenced to Ride Height (in)
Bump	4.0		
	3.5		
	3.0	-0.598	-0.273
	2.5	-0.552	-0.227
	2.0	-0.509	-0.181
	1.5	-0.465	-0.140
	1.0	-0.421	-0.096
	0.5	-0.376	-0.051
Ride Height	0.0	-0.325	0
	0.5	-0.278	0.047
	1.0	-0.231	0.094
	1.5	-0.185	0.140
	2.0	-0.132	0.192
	2.5	-0.085	0.240
	3.0	-0.040	0.285
	3.5	0	0.325
Droop	4.0		

1. Record all the dial indicator readings in the Measured Dial Indicator Readings column of the worksheet. Toe-out values are (-) negative and toe-in values are (+) positive.

2. Take note of the "Measured Dial Indicator Reading" at the 0.0 "Hub Height". In this example it is -0.325" inches.

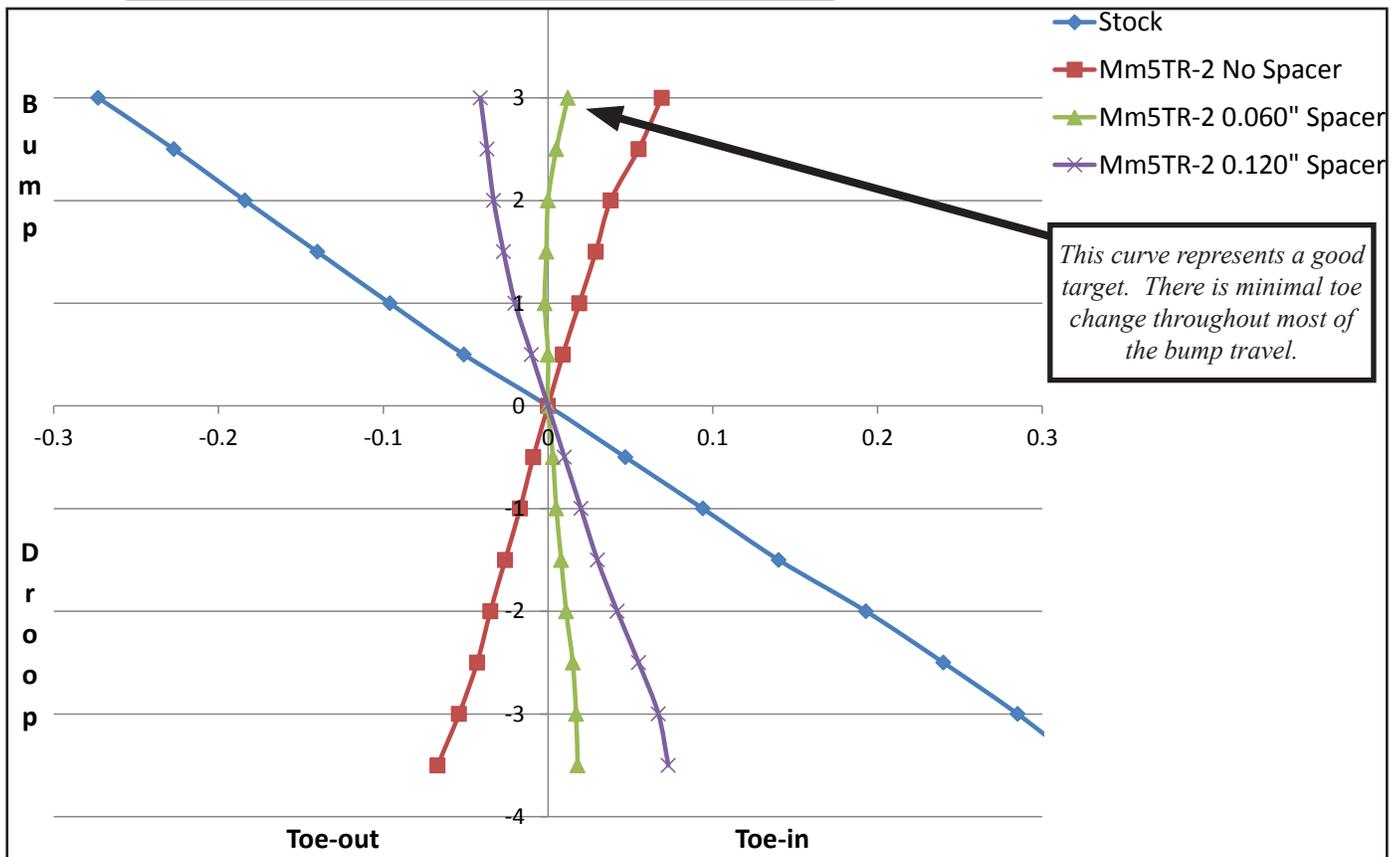
3. Subtract the value (-0.325 in this example) from each of the "Measured Dial Indicator Readings" and record the resulting number in the "Measurements Referenced to Ride Height" column.

**Example at 3.0" of droop travel**

$$-0.040 - (-0.325) = 0.285$$

*\*\*remember to include the negative sign\*\**

4. Graph each point in the "Measurements Referenced to Ride Height" column. Once done, draw a line connecting all of the points.



## Bumpsteer Measurement Worksheet

NOTE: Make copies of this sheet for use on the driver side of the vehicle, as well as for future use.

NOTE: Dial indicator readings that are toe-in, should be recorded as (+) values. Dial indicator readings that are toe-out, should be recorded as (-) values.

Bumpsteer Data Table #1			
	Hub height (in)	Measured Dial Indicator Readings (in)	Measurements Referenced to Ride Height (in)
Bump	4.0		
	3.5		
	3.0		
	2.5		
	2.0		
Ride Height	1.5		
	1.0		
	0.5		
	0.0		
	0.5		
	1.0		
	1.5		
	2.0		
	2.5		
	3.0		
Droop	3.5		
	4.0		

Bumpsteer spacer stack height used:  in.

Bumpsteer Data Table #2			
	Hub height (in)	Measured Dial Indicator Readings (in)	Measurements Referenced to Ride Height (in)
Bump	4.0		
	3.5		
	3.0		
	2.5		
	2.0		
Ride Height	1.5		
	1.0		
	0.5		
	0.0		
	0.5		
	1.0		
	1.5		
	2.0		
	2.5		
	3.0		
Droop	3.5		
	4.0		

Bumpsteer spacer stack height used:  in.

Bumpsteer Data Table #3			
	Hub height (in)	Measured Dial Indicator Readings (in)	Measurements Referenced to Ride Height (in)
Bump	4.0		
	3.5		
	3.0		
	2.5		
	2.0		
Ride Height	1.5		
	1.0		
	0.5		
	0.0		
	0.5		
	1.0		
	1.5		
	2.0		
	2.5		
	3.0		
Droop	3.5		
	4.0		

Bumpsteer spacer stack height used:  in.

Bumpsteer Data Table #4			
	Hub height (in)	Measured Dial Indicator Readings (in)	Measurements Referenced to Ride Height (in)
Bump	4.0		
	3.5		
	3.0		
	2.5		
	2.0		
Ride Height	1.5		
	1.0		
	0.5		
	0.0		
	0.5		
	1.0		
	1.5		
	2.0		
	2.5		
	3.0		
Droop	3.5		
	4.0		

Bumpsteer spacer stack height used:  in.

*Bumpsteer Graph Worksheet*

NOTES: Make copies of this sheet for use on both sides of the vehicle, or log on to [www.maximummotorsports.com](http://www.maximummotorsports.com) to download a copy of these instructions.

**Bumpsteer Graph Worksheet**

