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## General Driveline Inspection

### Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages. They provide information that can help prevent serious personal injury, damage to components, or both.

#### **WARNING**

**To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.**

**Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.**

**Check end yoke retaining nuts and bolts for looseness. Tighten loose fasteners to specification. Check the input and output shaft splines for wear and damage. Replace worn or damaged splines. Check for loose, missing or damaged driveline fasteners and parts. Tighten loose fasteners and replace damaged and missing parts. Loose, damaged or missing parts can cause the driveline to separate from the vehicle. Serious personal injury and damage to components can result.**

**Only service a driveline when the engine is OFF. A rotating driveline can cause serious personal injury.**

## Components

### Driveline

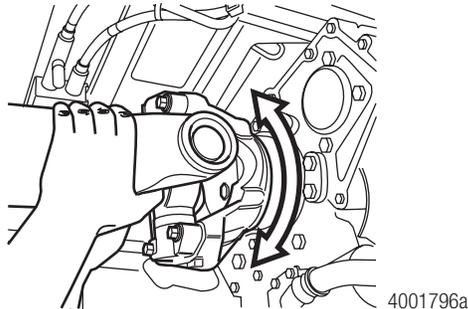
1. Park the vehicle on a level surface. Block the wheels to keep the vehicle from moving. Raise the vehicle so that the area you will service is off the ground.
2. Inspect the driveline at regular intervals. Loose end yokes, excessive radial movement, slip spline radial movement, bent driveline tubing or missing plugs in the slip yoke can damage universal joints and bearings.
3. Check the output and input end yokes on both the transmission and axle for axial looseness.
4. Refer to the axle or transmission manufacturer's service instructions.
  - **If the output and input end yokes are loose:** Disconnect the driveline. Tighten the end yoke retaining nut to the correct specification. Refer to the axle or transmission manufacturer's service instructions.
5. Inspect for worn universal joints. Apply vertical force of about 50 lb-ft (22.7 kg) to the driveline near the universal joints.
  - **If movement is greater than 0.006-inch (0.152 mm):** Replace the universal joint.
6. Inspect the slip section to ensure the welch plug and dust seal are in the correct position.
7. Inspect the driveline for damaged or bent tubing. Carefully remove contaminants, such as mud and road debris.

### End Yokes

Perform the following procedures before you lubricate universal joints or slip yokes. If you lubricate these components before you inspect them, lubricant can cover wear, damage and looseness.

1. Inspect all input and output end yoke retaining nuts and bolts for gaps between mating surfaces.
  - **If gaps are present:** Refer to the transmission, axle or transfer case manufacturer's service instructions.
2. Use the following procedure to check all input and output end yokes for looseness.

- Hold the end yoke with both hands.
- Move the end yoke UP-AND-DOWN and SIDE-TO-SIDE. There shouldn't be any movement where the yoke connects to the input and output shafts.



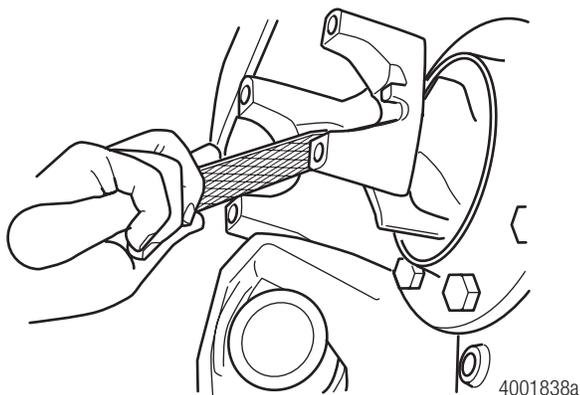
- **If the input and output end yokes are loose:** Disconnect the driveline. Tighten the end yoke retaining nut or bolt to the correct specification. Refer to the axle or transmission manufacturer for correct inspection and replacement procedures.
- **If the input and output end yokes are not loose:** Check that the transmission output shaft and axle input shaft splines aren't loose at the end yoke. Hold the yoke with one hand and rotate it LEFT-TO-RIGHT while you check end play for radial looseness.
- **If you find excessive radial looseness:** Replace the end yoke, or input or output shafts, as necessary.

3. Inspect for worn, damaged, missing and loose parts. Replace as required.

 **WARNING**

Use a fine-tooth file or an emery cloth to remove raised metal or fretting from yoke cross hole surfaces. Take care not to remove an excessive amount of metal. These conditions can damage the cross and bearing and cause the driveline to separate from the vehicle. Serious personal injury and damage to components can result.

4. Inspect all end yoke cross hole surfaces and bolt hole threads for damage. Remove raised metal or fretting with a fine-tooth file or emery cloth.
- **If bolt hole threads are damaged:** Replace the yoke.

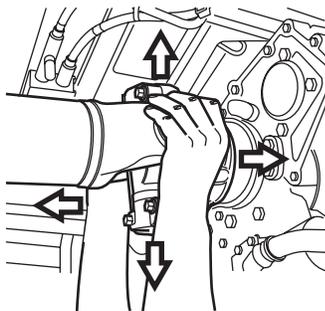


## Universal Joints

### **WARNING**

Excessive looseness across the ends of the universal joint bearing cup assemblies can cause imbalance or vibration in the driveline assembly. Imbalance or vibration can cause component wear, which can result in separation of the driveline from the vehicle. Serious personal injury and damage to components can result.

1. Use the following procedure to check for looseness across the ends of the universal joint bearing cup assemblies and trunnions.
  - A. Hold the INBOARD yoke on the driveline with both hands.
  - B. Try to move the yoke UP-AND-DOWN and SIDE-TO-SIDE by applying at least 50 lb-ft (68 N•m) of force to the driveline near the universal joints.
    - **If movement is greater than 0.006-inch (0.152 mm):** Replace the universal joint.

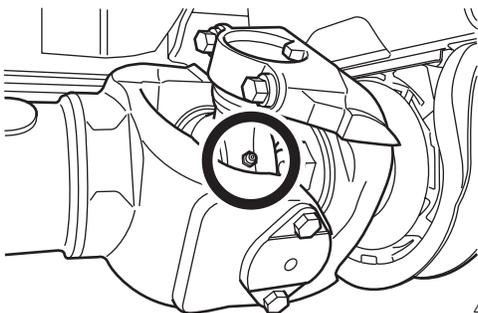


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2. Inspect all universal joint kits in the driveline assembly.

## Greaseable Universal Joints

1. Check that all grease fittings are installed. Replace missing or damaged fittings. Tighten to 6 lb-ft (8 N•m).

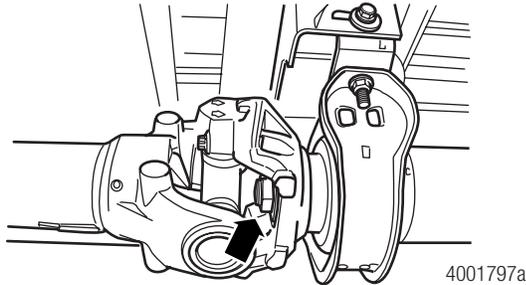


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2. Check for loose grease fittings. Tighten to 6 lb-ft (8 N•m).

## Center Bearings

1. Inspect all center bearing and end yoke midship nuts for gaps or looseness between the mating surfaces.
  - **If you can see gaps between the mating surfaces:** Disconnect the driveline. Tighten the coupling yoke retaining nut to 450-600 lb-ft (612-816 N•m).



2. Inspect the center bearing bracket bolts for looseness.
  - **If the bolts are loose:** Verify that the bracket is aligned correctly before you tighten the bolts. Tighten the center bearing bracket bolts. Refer to the vehicle manufacturer's procedures for the correct torque specification.
3. Inspect the center bearing rubber cushion for damage. If equipped, check that the deflectors are not rubbing against the rubber cushion. Verify that the rubber cushion is correctly seated in the metal bracket.
  - **If any of these conditions are evident:** Replace the center bearing assembly.

## Self-Aligning Center Bearings

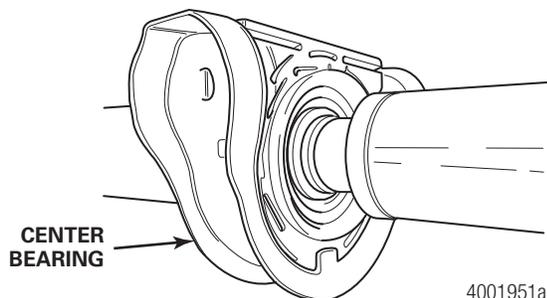
A self-aligning center bearing accepts +/- five degrees of angular misalignment. This helps to ensure that the hanger bearing is correctly aligned to the driveline under all operating conditions.

Use the same service procedures for a self-aligning center bearing as for a standard center bearing. You can identify a self-aligning center bearing by the bright gold color of the integral deflector.

Deflectors are integral to a self-aligning center bearing, so separate deflectors are not required.

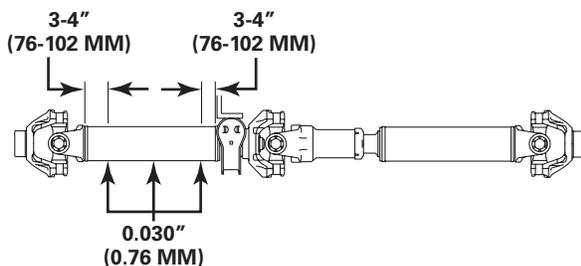
Some vehicles manufactured after January 18, 2002 are equipped with self-aligning center bearings.

- **If you replace a self-aligning center bearing on a vehicle manufactured after January 18, 2002:** You must install a new self-aligning center bearing. Do not install an original-design bearing.



## Driveline Runout

1. Use a jack to raise the rear axle. Support the vehicle with safety stands.
2. Check each driveshaft for dents, bends, twists or other damage.
3. Ensure that the driveshaft is straight within 0.030-inch (0.76 mm) on the tube 3-4-inches (76-102 mm) from the front and rear welds, and 0.030-inch (0.76 mm) at the center of the tube.
  - **If the driveshaft is not within these specifications:** Disconnect the driveshaft at the location it exceeds 0.030-inch (0.76 mm). Rotate the driveshaft 180 degrees and reattach. Check the runout again.
  - **If the driveshaft is still not within the specification:** Remove the driveshaft and repair at a reputable driveline repair facility.

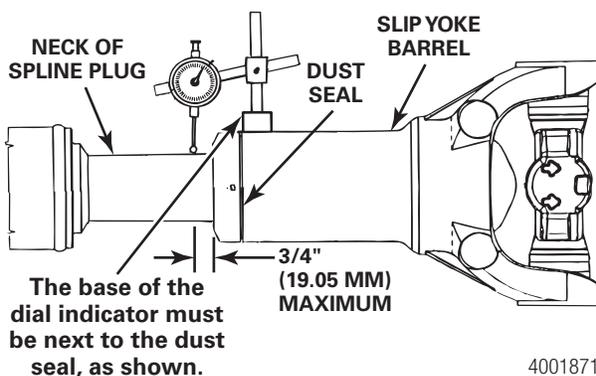


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## Slip Yoke

**NOTE:** For single one-piece driveline systems, check the slip yoke for movement with the driveline installed and the vehicle on a level surface with its wheels on the ground.

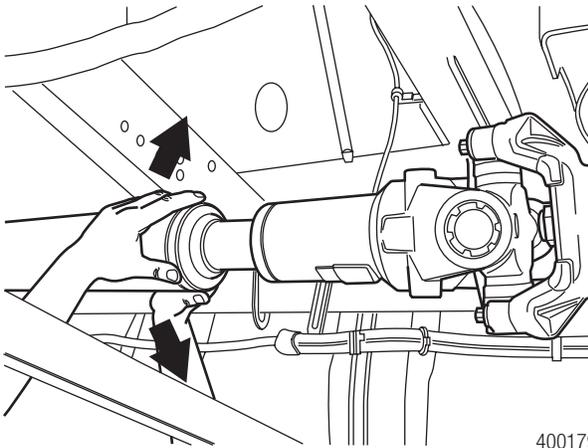
1. Ensure that the vehicle is on a level surface with its wheels on the ground. For single driveline systems, check the slip yoke for movement with the driveline installed.
2. Firmly mount a dial indicator with a magnetic base onto the slip yoke barrel next to the dust seal. You don't want the dial indicator to move when you check the slip yoke for looseness or the measurement will not be correct.



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3. Extend the dial indicator arm from the base, so that it contacts the neck of the spline plug within 3/4-inch (19.05 mm) from the dust seal.

4. With your hands near the center of the driveline, move the slip yoke UP-AND-DOWN. Check the dial indicator measurement. Movement between the spline plug and slip yoke must not exceed 0.020-inch (0.51 mm).
  - **If movement exceeds 0.020-inch (0.51 mm):** Components are worn or damaged. Replace as required.



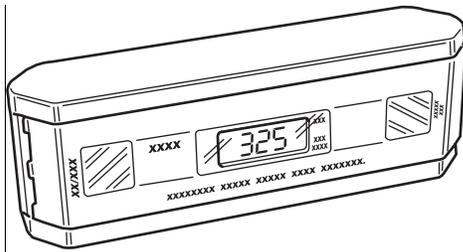
6. Inspect the driveline for damage or bent tubing.
  - **If the driveline is damaged or bent:** Repair the driveline at a reputable driveline repair facility.
7. If necessary, carefully remove mud or road debris from the driveline.
8. Inspect the slip yoke spline seal for grease leakage or seal damage.
9. Inspect for missing balance weights, damaged tubing or a missing welch plug at the slip yoke.

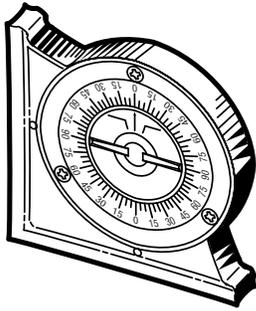
## Measuring Driveline Angles

### Special Tools

#### Tools You'll Need

- An inclinometer or a spirit level protractor to measure driveline angles.





- A tape measure to measure ride height for air-ride-equipped tractors.
- A Data Gathering Worksheet from the Driveline Angle Analysis (DAA) program.

## Overview

### Prepare the Vehicle

#### **WARNING**

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

**Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.**

1. Park the vehicle on a level surface. Do not engage the tractor brakes or the parking brakes.
2. Verify that all tires are on a level surface and inflated to the specified pressure.
3. Block the front tires at both the front and rear.

### For Air-Ride-Equipped Tractors

1. Build air pressure to at least 115 psi (792.35 kPa).
2. Deflate air from the air bags: Use the dash-mounted deflate switch or release air pressure through the air valve at the rear of the tractor.
3. Allow the air bags to inflate completely.
4. Measure ride height with a tape measure or calipers. If necessary, adjust ride height to the correct vehicle manufacturer's specifications.

## Data Gathering Worksheet

### General Information Section

**NOTE:** Worksheets can be located by selecting "Work Sheet" and then "Print" from the DAA software tool bar.

There are individual data gathering sheets for each of the driveline configurations: Select the correct worksheet for the vehicle's driveline configuration.

## Positive (+) and Negative (-) Angle Designations

You must fill in driveline angle measurements on the Data Gathering Worksheet as POSITIVE (+) and NEGATIVE (-) dimensions.

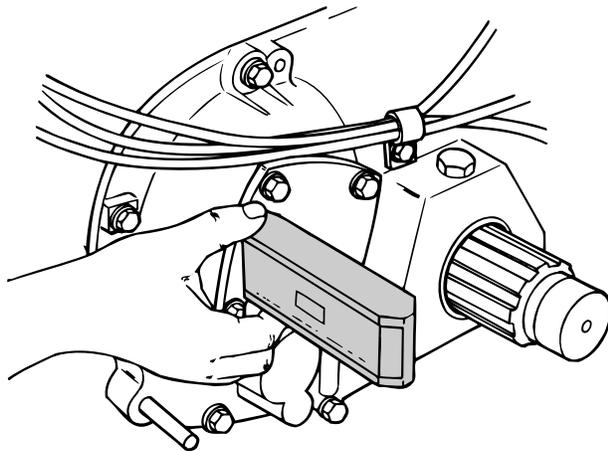
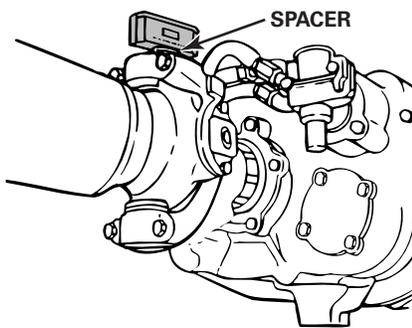
Before you measure a component, go to the side of the vehicle and look at the driveline. If the FRONT of the component is HIGHER than the REAR of the component, the dimension will be POSITIVE (+).

If the FRONT of the component is LOWER than the REAR of the component, the dimension will be NEGATIVE (-).

## Measuring and Recording Driveline Angles — Side View

### Measure the Transmission Angle

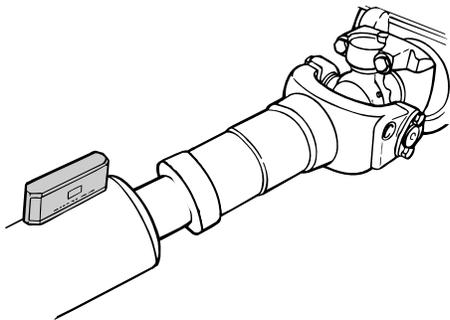
1. Place the inclinometer or spirit level protractor on a spacer and on the transmission output yoke to measure the transmission output yoke angle. If a measurement is difficult to obtain on the yoke, you can measure from a flat transmission surface, including the countershaft bearing covers or the PTO cover.



2. Record the measurement on the Data Gathering Worksheet or data entry screen.

## Measure the First and Second Main Driveline Angles

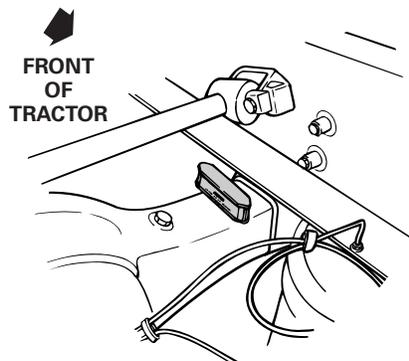
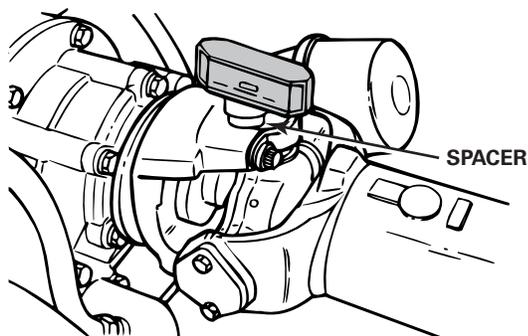
1. Place the inclinometer or spirit level protractor on a smooth, flat portion of the driveline tubing to measure the first and second driveline angles. **Do not measure over welds or balance weights. The measurements will not be valid.**



2. Record the measurements on the Data Gathering Worksheet or data entry screen.

## Measure the Forward Rear Drive Axle Angle

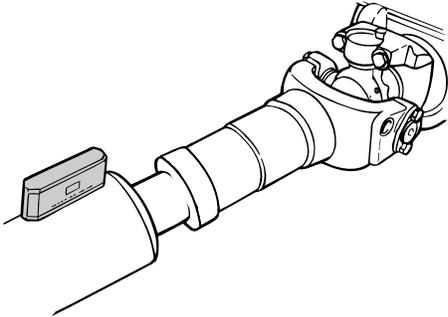
1. Place the inclinometer or spirit level protractor on a spacer and on the output yoke or on a smooth, flat portion of the axle housing tube (the “long” side, away from the bowl and near the suspension U-bolt) to measure the forward rear drive axle angle.



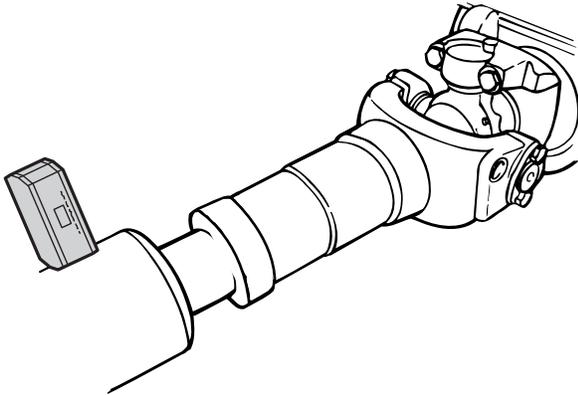
2. Write the measurement on the Data Gathering Worksheet or data entry screen.

## Measure the Inter-Axle Driveline Angle

1. Place the inclinometer or spirit level protractor on a smooth, flat portion of the driveline tubing to measure the inter-axle angle. **Do not measure over welds or balance weights. The measurement will not be valid.**



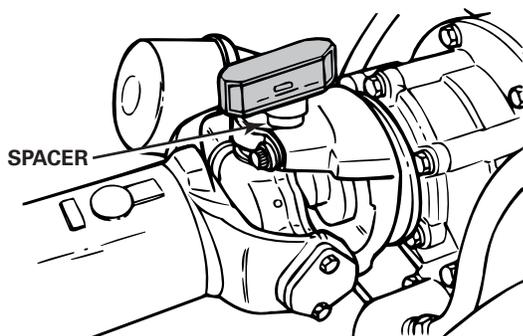
2. If the driveline tubing is too short, place the edge of the inclinometer or spirit level protractor vertically on the tube. Subtract 90 degrees from the reading to determine the correct angle.

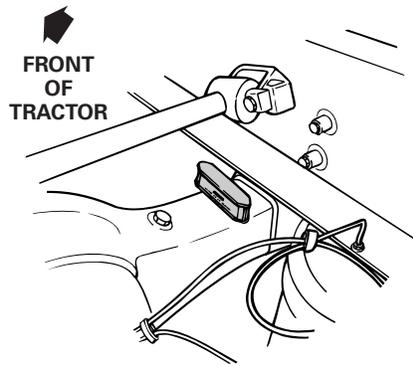


3. Write the measurement on the Data Gathering Worksheet or data entry screen.

## Measure the Rear Axle Driveline Angle

1. Place the inclinometer or spirit level protractor on a spacer and on the input yoke or on a smooth, flat portion of the axle tube (the “long” side, away from the bowl and near the suspension U-bolt) to measure the rear axle angle.





2. Write the measurement on the Data Gathering Worksheet or data entry screen.

### **When You Finish Measuring the Driveline Angles**

1. Set the tractor's parking brake.
2. Remove the blocks from the front tires.
3. You are now ready to enter the dimensions you recorded on the Data Gathering Worksheet into the Meritor Driveline Angle Analysis program.

## **Measuring and Recording Driveline Angles — Top or Plan View**

### **Tools Needed**

- Tape measure
- Carpenter's square or straightedge
- A plumb bob

### **Prepare the Vehicle**

#### **WARNING**

**To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.**

**Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.**

1. Park the vehicle on a level surface. Do not engage the brakes or the parking brake.
2. Verify that all tires are on a level surface and inflated to the specified pressure. Block the front tires at both the front and rear.

## For Air-Ride-Equipped Axles

1. Build air pressure to at least 115 psi (792.35 kPa).
2. Deflate air from the air bags. Use the dash-mounted deflate switch or release the air pressure through the valve at the rear of the vehicle.
3. Allow the air bags to inflate completely.
4. Measure the ride height with a tape measure or calipers. If necessary, adjust the ride height to the correct vehicle manufacturer's specifications.

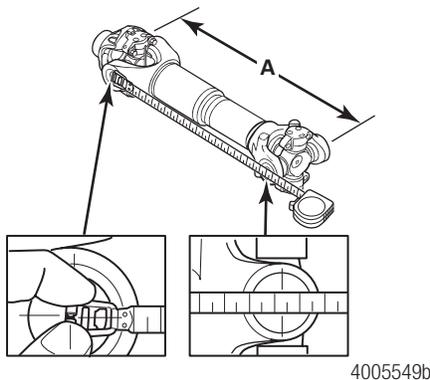
**NOTE:** Sign convention (+) or (-) is the same as referred in the side view measurement, but in respect to the top view.

## Measure Driveline Angles

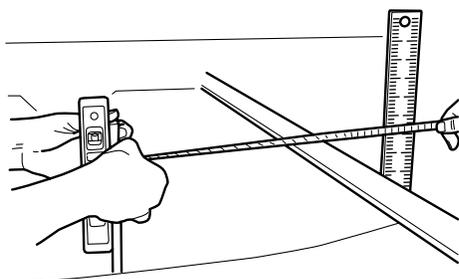
Measure the plan view angles by using either Method 1 or Method 2.

### Method 1

1. Measure and record the side view angles. Refer to the procedure in this section.
2. Measure the length of the driveline (Dimension A) from the center of the transmission universal joint to the center of the carrier universal joint.



3. Measure the distance from the center of the transmission universal joint to the frame rail (Dimension  $L_1$ ). Use a carpenter's square or other straightedge if needed.

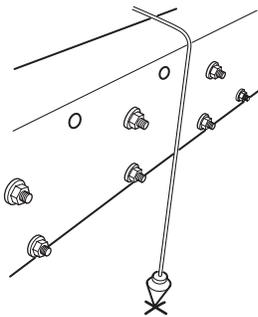


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4. Measure the distance from the center of the carrier universal joint to the frame rail (Dimension  $L_2$ ). Use a carpenter's square or other straightedge if needed.
5. Determine the offset between the universal joint as Dimension B,  $B = L_2 - L_1$ .
6. Determine angle "X" either with formula  $X = \arcsin\left(\frac{B}{A}\right)$  or use the instruction from the Angle Chart to determine the angle size.

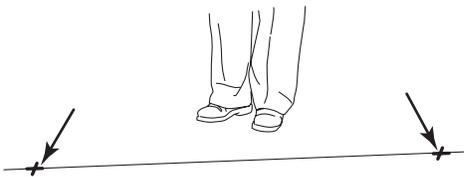
**Method 2**

1. Measure the length of the driveline from the center of the transmission universal joint to the center of the carrier universal joint (Dimension A).
2. Attach a plumb bob to the frame rail in line with the transmission universal joint. Mark a point on the ground just below the plumb bob.



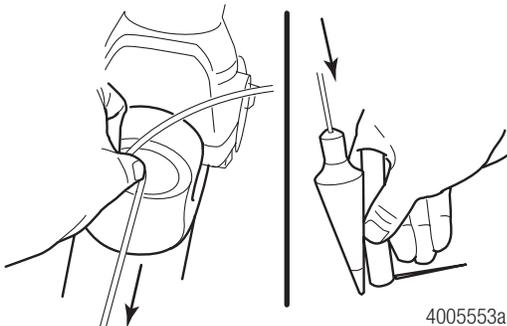
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3. Repeat Step 2 for points in line with the carrier universal joint and a spot in between the universal joints.
4. Draw a straight line connecting the points on the ground.



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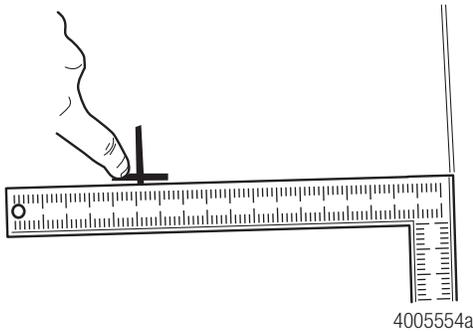
5. Attach a plumb bob to the center of the transmission universal joint. Mark a point on the ground just below the plumb bob.



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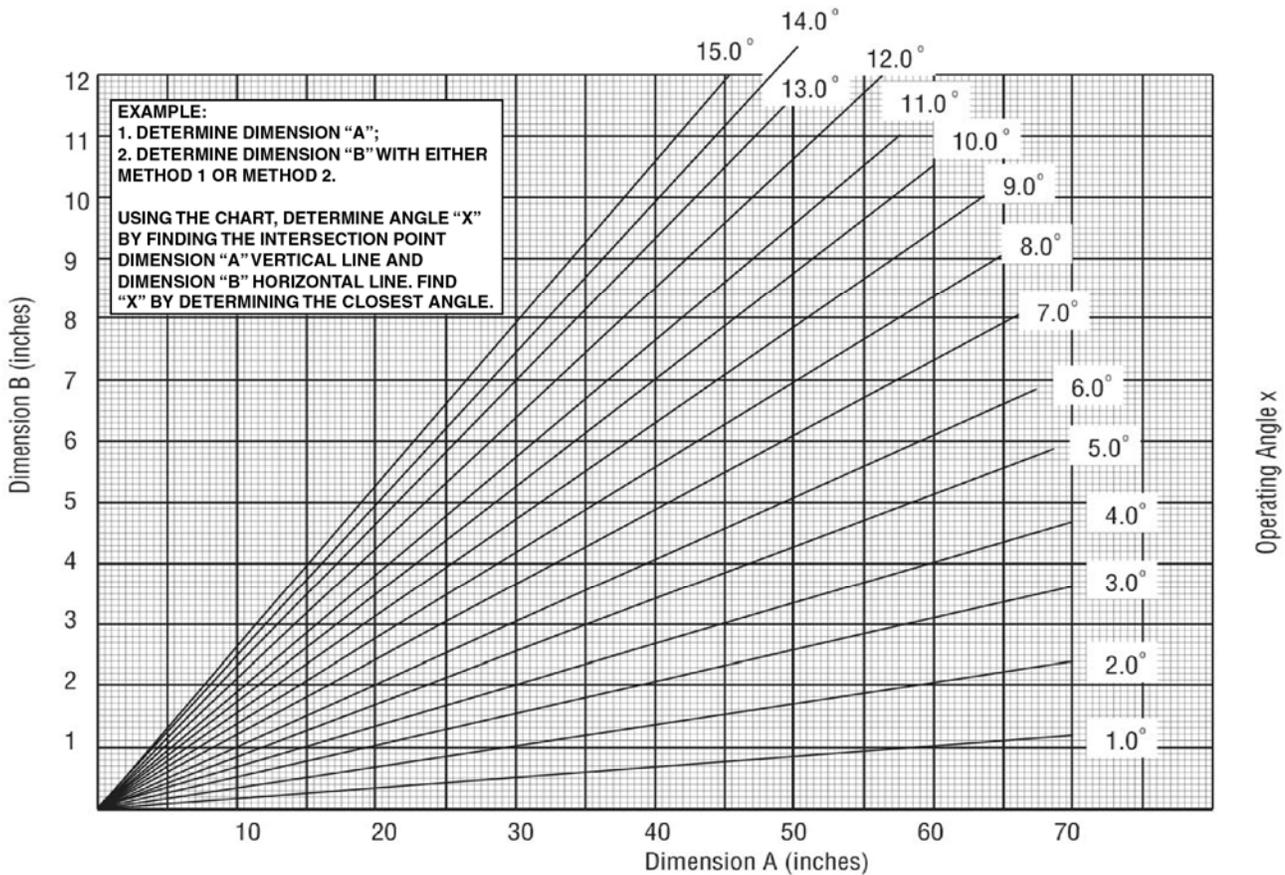
6. Repeat Step 5 for the carrier universal joint.

- Using a carpenter's square, measure the distance from the transmission universal joint point to the frame rail reference line (Dimension C).



- Determine angle "X" either with formula  $X = \arccos\left(\frac{C}{A}\right)$  or determine dimension  $B = \sqrt{A^2 - C^2}$  and determine "X" using the instructions from the Angle Chart.
- Repeat Step 7 for the carrier universal joint.

**Angle Chart**



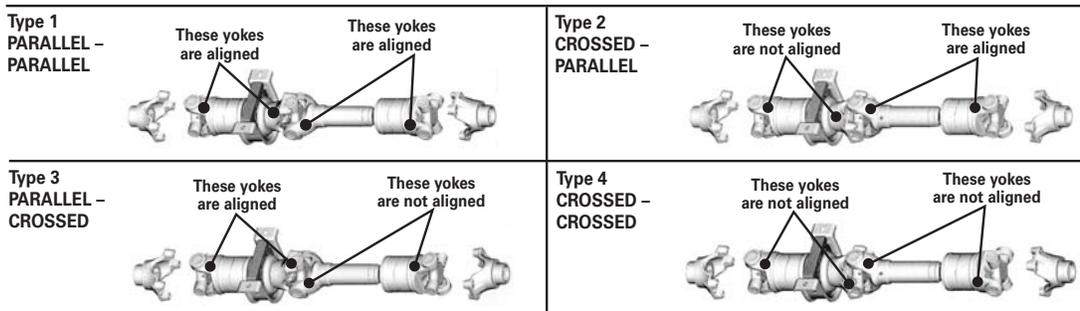
**Calculate Driveline Angles**

The compound universal joint angles (true universal joint operating angles) should not be greater than 5 degrees during vehicle operation, and the difference between the carrier-driveline joint angle and transmission-driveline joint angle should not be greater than 1.5 degrees to ensure optimal operation of the drivetrain.

## Phasing

The original equipment manufacturer (OEM) aligns the yokes on a particular shaft in the best position for that vehicle.

The yoke alignment at each segment of the driveline shaft is either parallel-parallel, crossed-parallel, parallel-crossed or crossed-crossed, which is determined by the position of the yoke ears at either end of the driveline.



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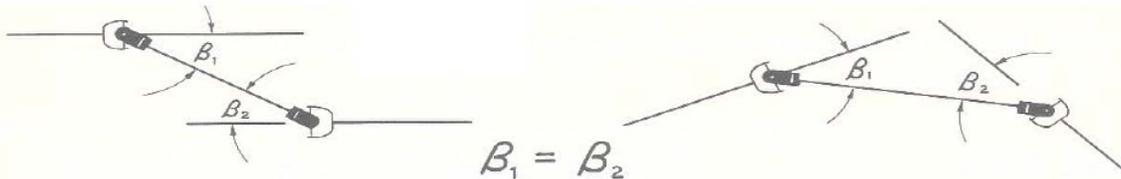
## Inertial and Torsional Acceleration

The effect of continuous fluctuating angular displacement, velocity and acceleration is to produce torsional excitation and inertial excitation.

Torsional Excitation is always present in a single joint system; in a two or more joint system, torsional excitation can sometimes be reduced to practically nothing.

If two universal joints operate together with equal angles, in a common plane, with the joints properly phased to each other, the angular variations will cancel such that the output displacement, velocity and accelerations are uniform with input.

Either condition will allow the output to be uniform with the input. However, the angular variation of velocity and acceleration of the inner yokes and shafts will be a function of the true angle value and input shaft speed.



For the purpose of simplification, the torsional acceleration is generated by the mismatch between the input true universal angle and output true universal angle.

Inertial Excitation is present in single- and multiple-joint systems. In a single-joint system and multiple-joint systems, the inertial excitation is due to acceleration and deceleration of the mass of the driven shafts and driven mechanism or shafts between the input and output yokes.

Inertial acceleration is dependent of the true universal joint angle. In a system with two universal joints, the drive universal joint will generate the drive inertial acceleration, and the driven universal joint will generate the coast inertial acceleration.

Both TORSIONAL AND INERTIAL EXCITATION can cause cycling stress and reduce the life of the parts. In addition, both will cause driveline vibration that might overlap with the sympathetic frequency from other systems, making the vibration level unacceptable.

To minimize the effects of the torsional and inertial excitation the following are MERITOR recommended design practices:

The maximum allowable true joint angle is 6 degrees. With two jointed drivelines, the difference in angles between both joints must not exceed 1.5 degrees.

Where these guidelines can not be met, the following should be the recommended limits for torsional and inertial accelerations resulting from non-constant velocity motion of universal joints operating at angle are as follows:

<b>Application</b>	<b>Torsional Acceleration (rad/sec<sup>2</sup>)</b>	<b>Inertial Acceleration (rad/sec<sup>2</sup>)</b>
<b>Medium Truck and On-Highway Linehaul</b>	<b>300</b>	<b>800</b>
<b>Vocational and Off-Highway</b>	<b>500</b>	<b>1000</b>

These values represent levels where disturbances/vibrations are known to occur. Experience will vary based on vehicle configurations.

## Glossary of Terms

**Bearing Stub:** A splined stub that is pressed into and welded onto the tubing of a non-slip coupling shaft assembly.

**Brinelling:** Grooves worn into a cross and bearing kit trunnion by the needle rollers due to insufficient lubrication, excessive load or incorrect driveline angles.

**Calculate:** Final tabulation of calculations after all driveline measurements have been entered.

**Cardan Universal Joint:** A mechanical device in which a cross and bearing kit connects yokes of a driving and a driven shaft.

**Cross:** The cross-shaped “body” of a universal joint kit.

**Cross and Bearing Kit:** Cross-shaped body with swivel bearings over each end that joins two driveline yokes in a Cardan universal joint. Cross and bearing kits are sometimes referred to as a “universal joint” or “universal joint kit.”

**Directions:** Provides step-by-step instruction on How to Use the DAA program.

**Email:** Provides standard Windows® email icon.

**End Yoke:** A yoke mounted to an input or output transmission shaft or axle shaft and secured by a nut and washer.

**Exit Tool:** Exit to “Choose Driveline Configuration” or exit entirely out of program.

**Galling:** A transfer or displacement of metal. Galling can be caused by lack of lubricant, incorrect lubrication or excessive loads.

**Gear Efficiency (e):** Ratio of power out of a gear set and the power provided into that gear set.

**Hinging-Loose Condition:** Usually within a slip section, which causes vibration through the driveline.

**Menu:** Provides user with pick list of driveline configurations.

**Needle Cup:** A cross and bearing component kit that fits over the trunnion and holds the needle rollers.

**Needle Rollers:** Cylindrical bearings positioned around the bore of the needle cup that enable the bearing to rotate freely on the trunnion.

**Next:** Allows user to toggle to Side View, Top View and Customer Information screens.

**Non-Slip Coupling Shaft Assembly:** A driveline of fixed length consisting of a weld yoke, tubing, bearing stub, center bearing kit and an end yoke with splined hole.

**Operating Angle:** The angle defined by the intersection of the centerlines of two shafts connected by a universal joint.

**Permalube™ Driveline:** A driveline incorporating permanently lubricated universal joints with a permanently lubricated and sealed slip section. The entire assembly does not require regular lubrication.

**Permalube™ Universal Joint:** A permanently lubricated and sealed universal joint that does not require regular lubrication.

**Phasing:** Alignment between yokes at each connecting end of a multiple shaft driveline.

**Print:** Provides standard Windows® print icon that allows user to print saved file to a local or network printer.

**Reference:** How to perform driveline measurements for both top and side views. Highlights any required special tools, measuring techniques, component inspections, specifications and vehicle preparation.

**Reset:** Clears entered driveline measurements in all data entry windows.

**Round Bearing:** A type of bearing cup used in cross and bearing kits for Cardan universal joints.

**Runout:** A condition in which a component's radius dimensions vary when the component is rotated. Excessive runout can negatively affect driveline operation.

**Save As:** Provides standard Windows® icon that allows user to save named file to local hard drive or network.

**Slip Yoke:** A driveline assembly component that allows for driveline length changes by absorbing axial (backward-forward) movement of the driveline caused by axle articulation.

**Standard Slip Assembly:** A driveline assembly consisting of a slip yoke, spline plug, tubing and weld yoke.

**Torsional Acceleration:** Excessive rotation speed in an individual section of the driveline. Usually due to incorrect phasing.

**Torsional Vibration:** A variation in the operating path of each universal joint yoke is called "nonuniform rotation". The input yoke operates in a circular path and at a constant speed; while the output yoke speeds up and slows down twice during each revolution that produces vibration.

**Trunnion:** Ground surfaces of the universal joint crossover in which the bearing cups fit.

**Universal Joint:** A joint providing a flexible coupling that allows torque transmission and rotary motion from one shaft to another, as well as angular changes in shaft alignment.

**Welch Plug:** A plate or cup used to seal the hole in the throat of a slip yoke and retain grease in the spline area.

**Weld Yoke:** A type of permanent fitting, welded to one or both ends of a driveline, designed for a specific combination of tubing and universal joint kit.

**Wing Bearing:** A type of bearing cup used in cross and bearing kits for specific types of yokes in Cardan universal joints. The cup has two flanges through which drilled or threaded holes extend to allow for cross and bearing kit mounting.

**Working Angle:** The angle that is formed when two drivelines intersect at a universal joint.

**Worksheet:** Printable copy of selected driveline which includes: Side View, Top View and Customer Information screens.