SERVICE MANUAL SECTION

STEERING GENERAL SERVICE INFORMATION AND FRONT WHEEL ALIGNMENT

s02001k, Formerly CTS-5027K

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DESCRIPTION

GENERAL SERVICE INFORMATION

Front wheel alignment is part of **Total Vehicle Alignment** which involves both steering and drive axles. Correct front wheel alignment is important. It promotes longer tire wear by reducing lateral forces on tires, better known as side scrub. Reduced side scrub promotes slow tire wear and a greater tread mileage potential. It promotes ease of handling and reduces strain on the steering and axle components.

It is important to recognize the symptoms of proper alignment as well as those of improper alignment. It is also important to be able to recognize treadwear tendencies not related to alignment.

Proper alignment will improve miles per 32nd of tread wear, resulting in higher mileage at the removal stage.

Inspect tires at regular intervals. Unbalanced tread wear patterns may indicate worn front axle and/or steering parts, out-of-balance tires, or an out-of-alignment condition.

The following is a list of symptoms that typically do not require resetting alignment.

A. **Good Tire Mileage** - Indicates proper alignment unless the vehicle has been involved in an accident or has some unusual complaint.

B. **Uniform Tire Wear** - Generally indicates good alignment, but also that the treadwear rate is relatively fast.

C. **Symmetrical Tire Wear** - Both shoulders of both front tires show the same type and magnitude of wear. Shoulder wear (Figure 1), chamfer wear (Figure 2) and river wear (Figure 3) that are equal on each tread half indicates good alignment.

D. **Small Left/Right Tire Wear Difference** - A small wear differential between the left front and right front tire also indicates good alignment. A 15 to 20 percent faster rate on the left front tire is acceptable.

E. **Progressive Erosion or Chamfer Wear** - Late tire life irregular wear that has progressed from a symmetrical to erratic condition does not always signal misalignment. Compare tire mileage to the fleet average.

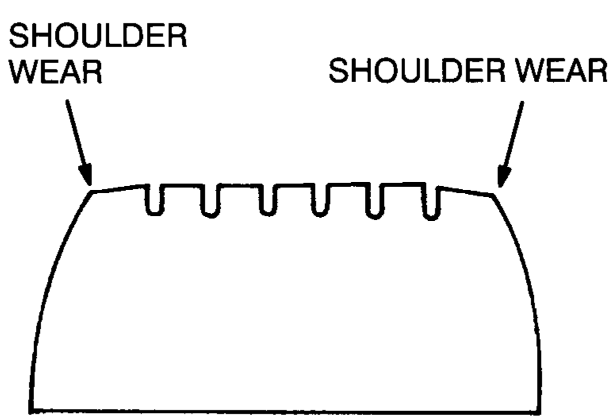

Figure 1 Shoulder Wear

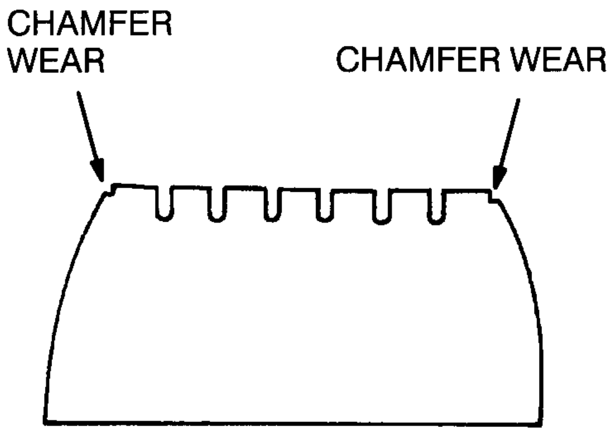

Figure 2 Chamfer Wear

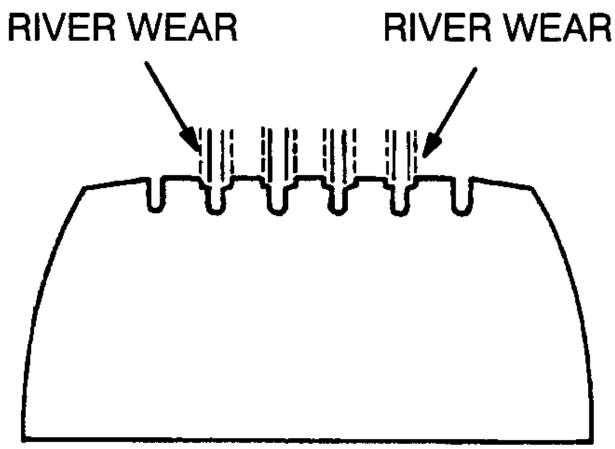

Figure 3 River Wear

P & D Service

In P & D service where a vehicle makes many turns per mile, the left front tire may wear faster than the right front tire. To balance this condition, it is recommended that steer tires be swapped side to side when "half" worn. P & D service may also create what appears as camber wear due to many turns. Bending the axle will not correct this condition.

Line Haul Service

Left front tires in line haul service generally wear slightly faster than right front tires, primarily because of steering gear box locations and the high frequency of steering inputs to the left side. Also, left front tires wear more uniformly than right front tires because the slower-wearing right tires tend to show more irregularity.

IMPORTANT – Try to read the symptoms of proper alignment before the tire is 60 percent worn. Proper diagnosis becomes more difficult during late wear stages because "wear progression" generally does not occur in a uniform fashion.

Before checking and adjusting the alignment, components such as wheel bearings, tie rod and drag link ends, steering gear, shock absorbers and tire inflation should be inspected and corrected where necessary.

INSPECTION

It is impossible to over-stress the importance of careful and thorough inspection of steering components. Thorough visual inspection for indications of wear or stress and the replacement of such parts as are necessary will eliminate costly and avoidable front end difficulties.

A. Inspect the steering knuckle king pin thrust bearing, wheel bearing cones and cups. Replace if rollers or cups are worn, pitted or damaged in any way.

B. If wheel bearing cups are to be replaced, remove from hubs with a suitable puller. Avoid the use of drift and hammers as they may easily mutilate cup bores.

C. Inspect the steering knuckles and replace if indications of weakness or excessive wear is found.

D. Check wear of the king pins and bushings; compare with correct specification. Refer to GROUP 02 - FRONT AXLE in the CTS-5000 Master Service Manual for the type axle being serviced.

E. Check the tightness of the steering connections such as tie rod arms, steering arm, pitman arm to the steering gear, etc.

REPAIR OF FORGED PARTS

In deciding whether to repair or scrap a damaged part, always keep in mind that we, as manufacturers, never hesitate to scrap any part which is in any way doubtful.

IMPORTANT – Do not attempt to straighten bent steering arms or knuckles. These parts must be replaced.

1. TROUBLESHOOTING

Remember that all alignment angles are so closely related that any change of one will automatically change the others. Because of this fact, it will probably be found that there is more than one cause for the complaint. The troubleshooting guide is not all-encompassing but is representative of the more common causes of difficulty encountered in wheel and axle alignment and should also prove of value in locating and correcting complaints on steering or tire wear.

Table 1 Troubleshooting Guide

Complaint	Possible Cause
Shimmy (Bump Shimmy)	1. Shimmy (Bump Shimmy) 2. Worn tires or of unequal size. 3. Wheels or brake drums out of balance. 4. Air in steering system. 5. Shock absorbers worn. 6. King pins and bushings worn. 7. Wheel bearings improperly adjusted. 8. Incorrect caster setting (too high). 9. Tie rod end(s) worn.

Table 1 Troubleshooting Guide (cont.)

Complaint	Possible Cause
	10. Drag link end(s) worn. 11. Spring shackles or pin bushings loose. 12. Steering arms loose. 13. Steering gear loose.
Wander or Weave	1. Steer tire pressure incorrect. 2. Tires of unequal size. 3. Wheel bearings improperly adjusted. 4. Incorrect caster setting (too low). 5. Incorrect toe-in setting. 6. King pins and bushings worn. 7. Pitman arm loose. 8. Steering gear assembly too tight or loose. 9. Dry or poor finish on fifth wheel and/or trailer plate.
Pull One Direction	1. Steer tire pressure incorrect. 2. Radial tire pull, swap. 3. Tandem tram out. 4. Tandem thrust incorrect. 5. Caster lower on side truck pulls to (raise caster 1°).
Hard Steering (Manual Steering Gear	1. Tire pressure low. 2. Lack of lubrication in steering components. 3. Dry or poor finish on fifth wheel and/or trailer plate. 4. Excessive caster. 5. Wheel spindle bent.
Uneven or Unbalanced Tire Wear	1. Tire pressure incorrect. 2. Characteristics of operation (may be normal). 3. Tires overloaded.

Table 1 Troubleshooting Guide (cont.)

Complaint	Possible Cause
	4. Wheels out of balance. 5. Toe-in setting incorrect. 6. Eccentric wheels or rims.

2. TIE ROD

The tie rods are of three-piece construction, consisting of a tie rod and two rod end assemblies. The ends are threaded to the rod and locked with clamp bolts (Figure 4). Right and left hand threads are provided for toe-in adjustment. Tension on ball stud in the rod ends is self-adjusting and requires no attention in service other than periodic inspection to see that ball studs are tight in the steering knuckle arms. Fittings are provided for periodic lubrication.

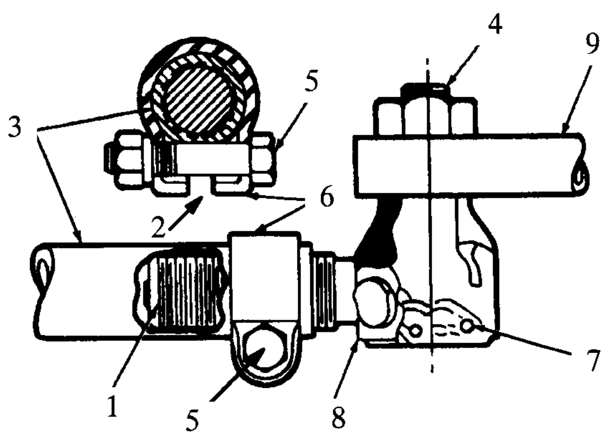

Figure 4 Typical Tie Rod

1. TIE ROD END EXTENDS BEYOND CLAMP ON TIE ROD
2. SLOT
3. TIE ROD
4. BALL STUD
5. BOLT
6. CLAMP
7. SPRING
8. BALL SOCKET ASSEMBLY
9. STEERING ARM

If the tie rod taper joint is loose or the cotter pin is missing, remove, inspect and replace the tie rod arm/tie rod end if the contact surfaces are worn.

Replacement Criteria - tie rod end must be free to rotate within the ball stud socket. Replace the tie rod end if there is any movement in the axial direction (Figure 5) when checked by hand on-vehicle. **Do not pry on steering linkages with a bar as damage may result.**

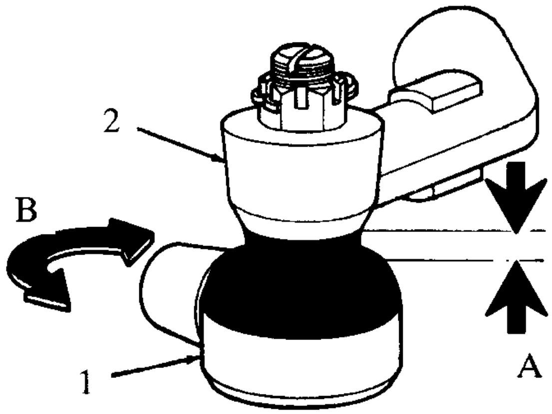

Figure 5 Types of Tie Rod and Drag Link End Movement

A. MOVEMENT IN AXIAL DIRECTION
B. TORQUE TO ROTATE SOCKET
1. TIE ROD/DRAG LINK END
2. STEERING ARM OR PITMAN ARM

Inspection guidelines are as follows:

0 - 1/8" (0 - 3.175 mm) axial movement - Tie rod end or drag link end should be replaced at next service interval.

1/8" (3.175 mm) or more axial movement - Vehicle should not be driven (Dead Lined) until after replacement of the tie rod end and/or drag link end is completed.

An alternate method of evaluating the tie rod end is by rotating the ball stud with the stud removed from the lower steering arm. Torque required to rotate the stud in the end cap should be 5.0 to 250.0 in-lbs. (depending on the ball joint design/ manufacture) (Figure 6).

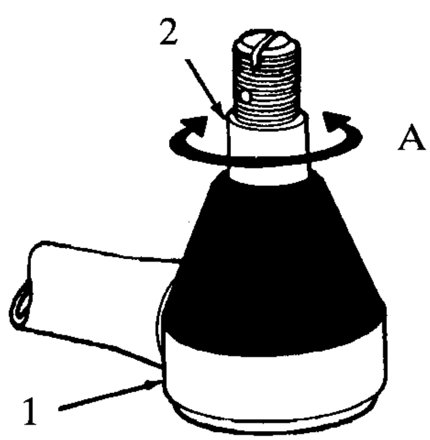

Figure 6 Rotating Tie Rod and Drag Link Ball Stud

A. TORQUE TO ROTATE STUD
1. TIE ROD/DRAG LINK END
2. BALL STUD

At assembly, insure that the slotted nut is tightened according to specified value in TORQUE CHART. If cotter pin cannot be installed, tighten nut to the next slot. **Do not back off** once minimum torque is reached.

2.1. REMOVE TIE ROD ASSEMBLY AND TIE ROD STEERING ARM

This procedure includes removing the tie rod ends from tie rod.

1. Remove the cotter pins and the nuts which secure each tie rod end to the tie rod steering arm.
2. Separate tie rod assembly from the tie rod steering arm, using a tie rod separator tool.
3. Remove the cotter pin and the nut that fastens the tie rod steering arm in the knuckle.
4. Remove the tie rod steering arm from the knuckle. If necessary, tap on the end of the rod with the stud nut assembled loosely on the stud (to avoid damage to the threads) using brass drift and hammer. Remove the key.
5. If necessary, use the following procedure to remove the tie rod ends from the rods.
   a. Mark the position of each tie rod end in the tie rod.
   b. Remove the clamp bolts and nuts from the clamps on the tie rod.
   c. Thread the tie rod ends out of the tie rod.

2.2. INSTALL TIE ROD STEERING ARM AND TIE ROD ASSEMBLY

WARNING – When tie rod, drag link or power steering linkage ends are replaced, they must be threaded into the tie rod or drag link sufficiently to allow positioning of the clamp over the threads if not welded on the ball joint end. Position the clamp bolt so it crosses the slot in the rod end.

This procedure includes installing the tie rod ends to the tie rod.

1. Press key in the slot in the tie rod steering arm.
2. Install the tie rod steering arm in the knuckle (Figure 7).

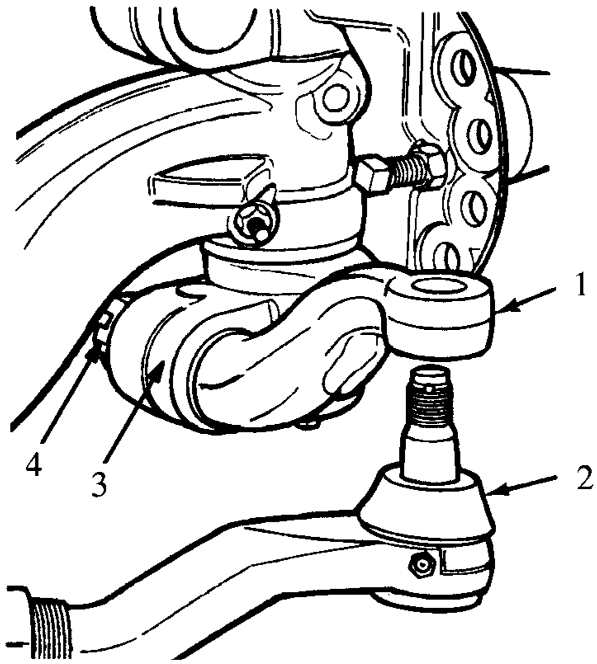

Figure 7 Separate Tie Rod End From Tie Rod Arm

1. TIE ROD STEERING ARM
2. TIE ROD END
3. KNUCKLE
4. NUT

3. Install the nut on the tie rod steering arm. Tighten to the specified value in TORQUE CHART.

4. Install the cotter pins. If necessary, tighten the nut until the holes are aligned. **Do not loosen the nut to install the cotter pin. If the cotter pin cannot be installed, tighten nut to the next stop.**

   NOTE – The tie rod has right hand threads on one end and left hand threads on the other end. Make sure the tie rod ends are installed properly on the tie rod.

   When tie rod ends are replaced or toe-in is adjusted, both ends must be threaded into the tie rod tube far enough to completely cover the slots in the tube. There should be no binding or looseness in the tie rod threads as the tie rod end is being threaded into the tie rod (Figure 8).

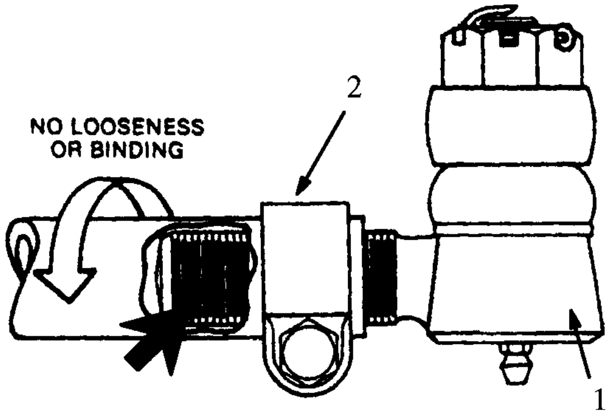

Figure 8 Tie Rod End Threads Extended Through Clamp

1. TIE ROD END
2. CLAMP

5. If removed, install the tie rod ends on the tie rod to the position marked during removal.

   If new tie rod ends are installed, thread the ends equally on the tie rod to the required length.

6. Install the nuts and the bolts in the clamps. Tighten finger tight.

7. Assemble the tie rod ends into the tie rod steering arms. Install the tie rod stud nuts. Tighten to specified value in TORQUE CHART.

8. Install the cotter pins. Tighten the nut until the holes are aligned. **Do not loosen the nut to install the cotter pin.**

9. Lubricate tie rod ends. Refer to GROUP 10 - LUBRICATION in the CTS-5000 Master Service Manual for the proper lubricant.

10. Check and, if necessary, adjust the toe-in. After checking and adjusting the toe-in, be sure the tie rod ends are properly indexed or aligned (left tie rod end parallel to the right tie rod end) (Figure 9). Proper indexing will eliminate restricted movement of the tie rod assembly. Restriction could cause premature failure of tie rod ends. Tighten the tie rod clamp bolts to the value in TORQUE CHART.

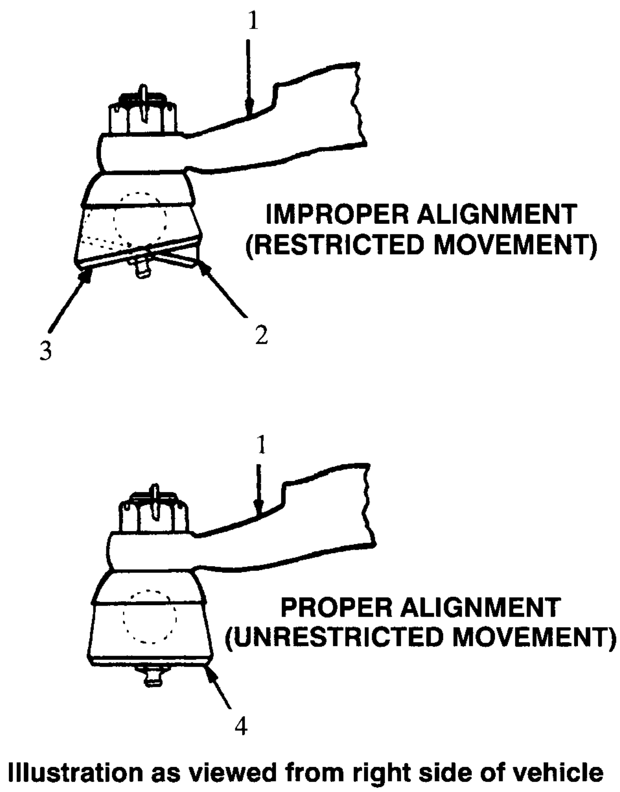

Figure 9 Proper and Improper Tie Rod End Installations

1. TIE ROD STEERING ARM
2. LEFT TIE ROD END
3. RIGHT TIE ROD END
4. BOTH TIE ROD ENDS ALIGNED

Some tie rod clamps will be free to rotate around the tie rod allowing setting of toe-in while avoiding contact of the axle. There are two ways mechanical stops will position the clamps. One style clamp is limited by a spot weld on the tube. The second style clamp is limited by a tab that will lock against the end of tube. Both styles are shown in Figure 10 .

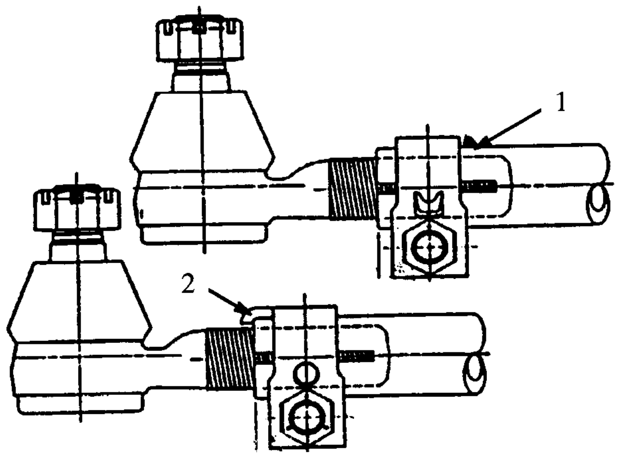

Figure 10 Types of Tie Rod Clamps

1. WELD
2. TAB

WARNING – When repositioning the tie rod clamps, check bolt clearance between the bolt and axle I-Beam at the maximum turn position, right and left (turn). Interference may restrict proper steering linkage movement, and/or cause damage to clamp bolts.

3. DRAG LINKS

Most vehicles have drag links which are similar to those in Figure 11 and Figure 12.

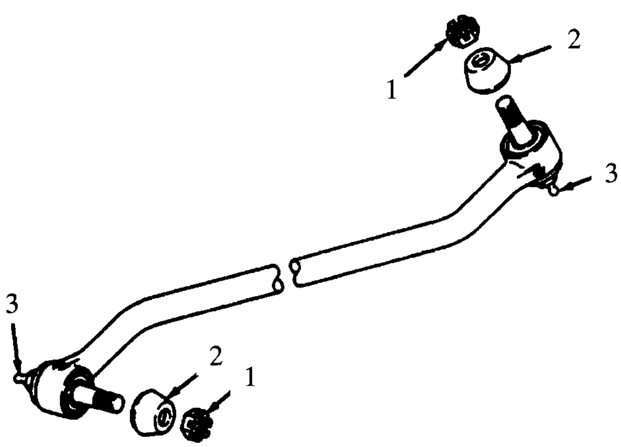

Figure 11 One Piece Drag Link

1. SLOTTED NUT
2. DUST COVER
3. GREASE ZERK

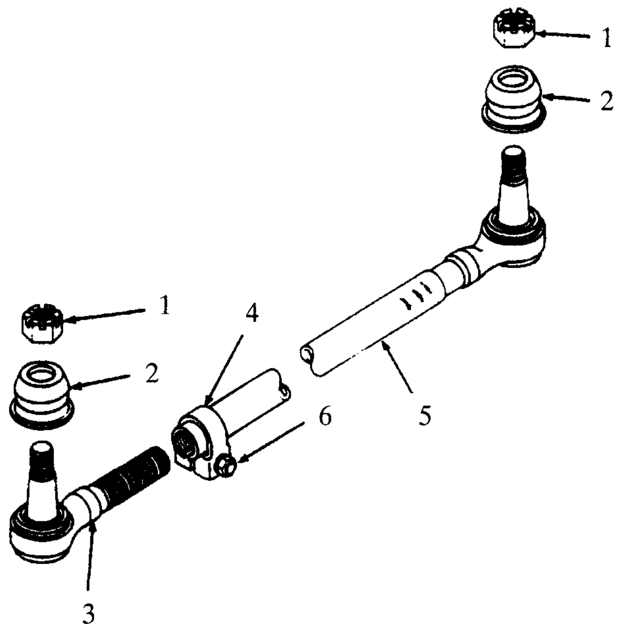

Figure 12 Adjustable Drag Link

1. SLOTTED NUT
2. DUST COVER
3. ADJUSTABLE DRAG LINK END
4. CLAMP
5. FIXED DRAG LINK END
6. CLAMP NUT

Tension on ball stud in the drag link ends is self-adjusting and requires no service other than periodic inspection to see that the ball studs are tight in the steering arms and that the dust/lube cover is in good condition. Fittings are provided for periodic lubrication.

Replacement Criteria - the drag link end must be free to rotate within the ball stud socket. Replace the drag link if there is any movement in the axial direction (Figure 5) when checked by hand on-vehicle. **Do not pry on steering linkages with a bar as damage may result.**

Inspection guidelines are as follows:

0 - 1/8" (0 - 3.175 mm) axial movement - Drag link ends should be replaced at next service interval.

1/8" (3.175 mm) or more axial movement - Vehicle should not be driven (Dead Lined) until after replacement of the drag link ends is completed.

An alternate method of evaluating the drag link ends is by rotating the ball stud with the stud removed from the steering arm and pitman arm. Torque required to rotate the stud in the end cap should be 5.0 to 250.0 in-lbs. (depending on the ball joint design/ manufacture) (Figure 6).

On drag links where one end is adjustable and the other end is fixed (non-adjustable) (Figure 12), the fixed end cannot be removed from the tube. If the fixed end drag link needs to be replaced, it must be replaced as a drag link and tube assembly. **DO NOT REMOVE THE FIXED END DRAG LINK FROM THE TUBE.**

3.1. REMOVE DRAG LINK AND DRAG LINK STEERING ARM ASSEMBLY

1. Remove cotter pins and nuts from drag link ends where they fasten onto the drag link steering arm and pitman arm.

2. Separate drag link from pitman arm and drag link steering arm. Use a removal tool to separate drag link from drag link steering arm.

3. Remove the drag link steering arm from the knuckle in the same manner as the tie rod steering arm. Refer to TIE ROD.

4. Remove key from drag link steering arm.

> CAUTION – **Observe the following precautions in regard to the power steering gear when the drag link or steering linkage is disconnected.**
>
> **A. Do not move the steering gear output shaft by way of the pitman arm when the drag link is disconnected. This may cause air to be introduced into the steering fluid.**
>
> **B. Do not turn steering gear input shaft more the 1.5 turns from center with the steering linkage disconnected on a TRW steering gear. If turned more than 1.5 turns, it may cause the automatic poppets to reset, affecting end of travel pressure relief.**

3.2. INSTALL DRAG LINK STEERING ARM AND DRAG LINK ASSEMBLY

1. Press key in drag link steering arm slot.

2. Install drag link steering arm in knuckle.

3. Install drag link steering arm nut and tighten to specified value in TORQUE CHART.

4. Install cotter pin. Tighten nut if necessary until holes are aligned. **Do not loosen nuts** to install cotter pin. Refer to NOTE 1 in TORQUE CHART.

5. With the steering gear and steering wheel centered and the front wheels in the straight ahead position, assemble the drag link to the pitman arm and drag link steering arm.

6. Install the drag link end stud nuts. Tighten to specifications in TORQUE CHART.

7. Install cotter pins. If necessary tighten nuts until the holes align. If cotter pin cannot be installed after minimum torque has been applied, the nut must be advanced until the cotter pin can be installed. **Do not loosen nut** to install cotter pin.

8. Lubricate drag link ends and check for operation. Refer to GROUP 10-LUBRICATION in the CTS-5000 Master Service Manual.

4. STEERING KNUCKLE STOP ADJUSTMENTS

4.1. I-BEAM AXLES

The steering arm stop bolt should be adjusted to permit maximum turning angle. With power steering, the stop bolt should be adjusted to assure that the power steering unit will not override the axle stop.

1. Adjust the axle steering stops to contact when the maximum turning angle of the specific axle is reached, and lock with jam nut.
2. If required, adjust the power steering gear end of travel poppet relief valves to relieve hydraulic pressure 1/2° to 1° before axle steering stops contact (maximum turning angle).

To prevent overriding, adjust power steering systems and stop bolt so that the power is cut off before contact with the axle stop (Figure 13).

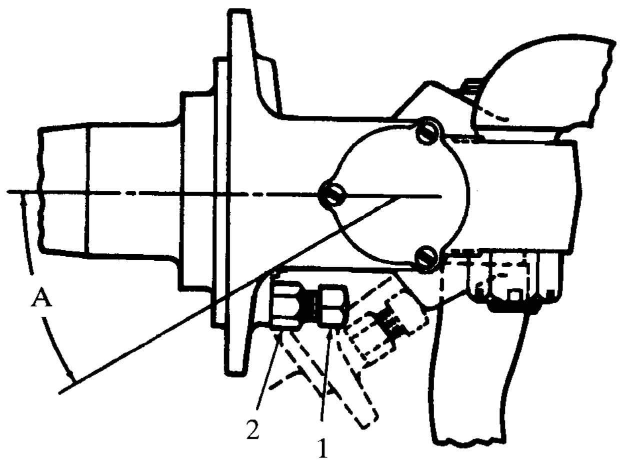

Figure 13 Steering Stop Adjustment

A. MAXIMUM TURNING ANGLE
1. STOP BOLT
2. JAM NUT

NOTE – Maximum turn angle specifications to be checked at the inside wheel.

The adjustment of both axle steering stops and power steering gear should be periodically checked and corrected if necessary.

For more detailed instructions pertaining to wheel stop adjustment, refer to GROUP 05 - STEERING in the CTS-5000 Master Service Manual for the steering gear used on the system being serviced.

4.2. DRIVING FRONT AXLES

There is a stop bolt located on each end of the axle housing for the purpose of limiting the amount of the turning angle of the wheels. These bolts are not adjusted in accordance with the frame and tire interference as in conventional front axles. Instead, these bolts are provided to limit the turning angle of the universal joints in the axles.

5. LUBRICATION

For lubrication intervals and type of lubricant, refer to GROUP 10 - LUBRICATION in the CTS-5000 Master Service Manual.

6. FRONT WHEEL ALIGNMENT

The alignment of the chassis according to the vehicle manufacturer's specifications should provide optimum tire life and vehicle handling. Check front tires at regular intervals. Check front alignment only if tires show incorrect wear or front suspension has been subjected to extremely heavy service or severe impact loads. Before checking and adjusting alignment, components such as wheel bearings, tie rod ends, drag link, steering gear, shock absorbers and tire inflation should be inspected and corrected where necessary.

The toe-in adjustment is the most important alignment factor to check when attempting to extend tire life. **Toe-in should be set only by trained mechanics using calibrated equipment.** The setting should be re-checked after any correction to be sure it is correct.

Incorrect toe-in will result in rapid tire wear. Tire wear on radial tires due to excessive toe-in shows up initially as irregular wear; more so on the outside grooves than the inside grooves of the tire and more so on the right front than on the left front tire. Excessive toe-out will show a reversed effect: more wear on the inside than the outside grooves and more so on the left front than the right front tire.

At large values of toe-in or toe-out and at relatively early mileage, the tread of the outside or inside ribs can be completely worn away. For a 5/16-inch toe-in condition, this can occur after only 19,000 miles of highway travel.

If front axle tire wear pattern has **heavy** wear on the outside of one tire tread and on the inside tread of its mate, the tandem rear axle suspension alignment should be inspected as indicated in GROUP 03 - SPRINGS, SUSPENSION ALIGNMENT in the CTS-5000 Master Service Manual.

The caster, camber and toe-in dimensions are for vehicles at no-load (no payload condition). If the frame is not level, the frame angle must be considered. This is especially important when making a caster check. The frame angle must be added to or subtracted from the caster angle to obtain a true caster reading.

6.1. TOE-IN

Toe-in is the amount in fractions of an inch (mm) that the front wheels are closer together at the front than at the back (Figure 14).

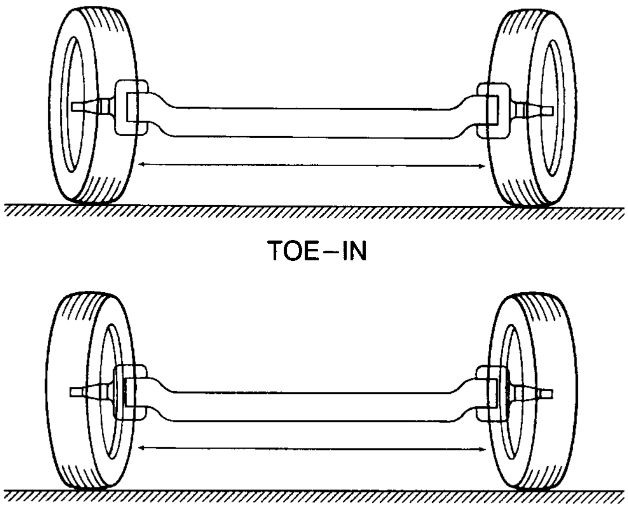

Figure 14 Toe Setting (Front View)

Another reason for toe-in, and the most familiar, is that when the vehicle is being driven, the forces acting on the front wheels tend to make the wheels toe-out.

Toe-In Adjustment

If electronic alignment equipment is used to set the toe-in, it is very important that the equipment be in calibration to insure an accurate toe reading.

The following procedure may be used to set the toe-in when electronic alignment equipment is not available. To obtain an accurate toe reading, two mechanics are required to insure that the pointers are always placed or adjusted to be exactly in front of the line scribed on both front tires.

Turn the front wheels to the exact straight-ahead position.

1. Block rear wheels.
2. Jack up front axle.
3. Wipe off excess dirt and moisture from the center of both front tire treads (360°). Use a piece of chalk to mark the center area of both front tires around the complete circumference.
4. Put a scribe or pointed instrument against the center of the whitened part of each tire and rotate the tires 360°. The scribe must be held in place so that a single straight line is marked all the way around the tires.
5. Put a full floating radius gauge plate under each wheel. Lower the vehicle and remove the lock pins from the radius gauge plates to allow the front wheels to return to the normal operating position. If full floating radius gauge plates are not available, lower the vehicle to the floor and roll it forward 12 to 15 feet (3.65 to 4.57 m) to neutralize the front suspension. Neutralizing the front suspension is extremely important especially if the vehicle has been jacked up to scribe the tires; otherwise, the front wheels will not return to the normal operating position due to the tires gripping the floor surface when the vehicle is lowered.
6. Set the sliding scale end of a trammel bar to zero (0) (Figure 15) and lock the scale in place.

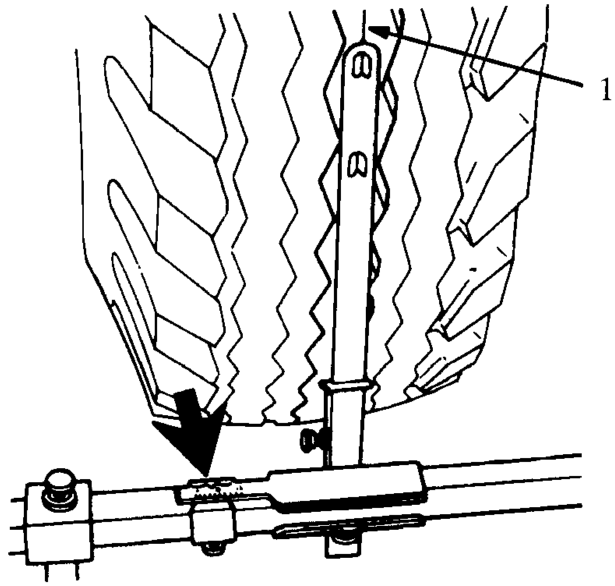

Figure 15 Sliding Scale Set to Zero

1. SCRIBED LINE

7. Put the trammel bar at the rear of the front tires so that the sliding scale that was set to zero in step 6 is centered against the scribed line on one of the tires (Figure 15).

8. Adjust the pointer on the end of the trammel bar opposite the sliding scale so it lines up with the scribed line on the rear of the opposite front tire. Lock the pointer in place on the trammel bar.

9. Put the trammel bar against the front of the tires so the pointer end is against the scribed line on the front tire. Loosen and move the sliding scale pointer on the opposite end of the trammel bar so it is against the scribed line on the opposite tire. Lock the scale in place (Figure 16).

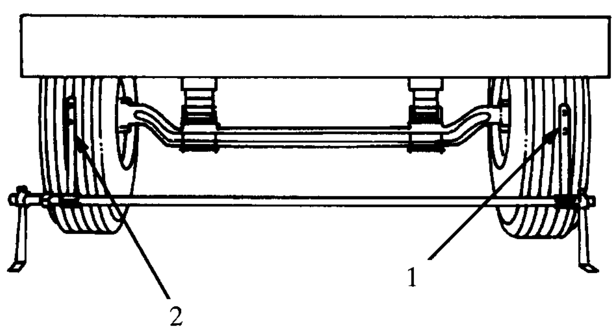

Figure 16 Trammel Bar Against Front of Tires

1. POINTER END
2. SLIDING SCALE END ADJUSTED TO SCRIBED LINE TO INDICATE ACTUAL TOE SETTING

10. Read the toe-in or toe-out on the sliding scale. If toe-in is correct, it will read 1/16 inch ± 1/16 inch.

If toe-in adjustment is necessary, use the following procedure:

11. Loosen the tie rod clamps that secure the tie rod ends in position in the tie rod. Refer to Figure 10.

12. Set the sliding scale on the trammel bar to read 1/16 inch toe-in.

13. Turn the tie rod to set the toe-in. After the toe-in is set, the sliding scale and the pointer should both be on the scribed line of the tire each is in front of.

14. Turn the steering wheel in each direction to center the steering linkage (if the vehicle has power steering, start the engine before turning the wheel). Make sure the front wheels are in a straight ahead position (stop engine), and re-check the toe-in setting. Make any necessary adjustments.

15. Repeat step 4 until the toe-in reading is 1/16 inch ± 1/16 inch.

16. Position and tighten the tie rod clamp bolts to the value found in the TORQUE CHART.

> ⚠ WARNING – **When repositioning the tie rod clamps, check bolt clearance between the bolt and axle I-Beam at the maximum turn position, right and left (turn). Interference may restrict proper steering linkage movement, and/or cause damage to clamp bolts.**

Be sure the tie rod ends are properly indexed or aligned (left tie rod end parallel to the right tie rod end) (Figure 9). Proper indexing will eliminate restricted movement of the tie rod assembly. Restriction could cause premature failure of tie rod ends.

> ⚠ WARNING – **When the tie rod, drag link or power steering linkage ends are replaced, they must be threaded into the tie rod sufficiently so that when the clamp is applied, the clamping action will be directly over the threads on the ball joint end (Figure 8). Be sure that the end is in far enough (past the clamp) to provide adequate clamping.**

6.2. CASTER ANGLE

NOTE – Keep in mind that if the caster is changed, the toe adjustment must be re-checked.

Caster is the amount in degrees the top of the kingpin is tilted toward the front or rear of the truck, as viewed from the side of the truck. The caster angle can range from a positive angle to a negative angle (Figure 17).

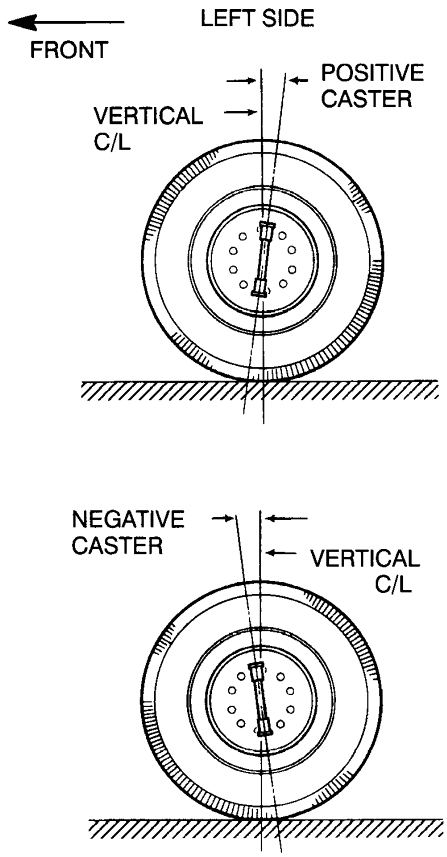

Figure 17 Caster

Positive caster is the tilting of the top of the king pin toward the rear of the truck (Figure 17), while negative, or reverse caster, is the tilting of the top of the king pin toward the front of the truck (Figure 17).

Positive caster imparts a trailing action to the front wheels, while negative, or reverse caster, causes a leading action. The correct amount of caster helps to keep the front wheels in the straight-ahead position. When in a turn, caster acts as a lever, assisting the driver to return the front wheels to the straight-ahead position.

Caster specifications are based on vehicle design load, which will usually result in a level frame. If the frame is not level when alignment checks are made, this must be considered in determining whether the caster setting is correct.

With the vehicle on a smooth, level surface, frame angle should be measured with a bubble protractor placed on the frame rail (Figure 18). The degree of tilt from the level frame position is the angle that must be used in determining a correct caster setting. Positive frame angle is defined as forward tilt (front end down) and negative angle as tilt to rear (front end height).

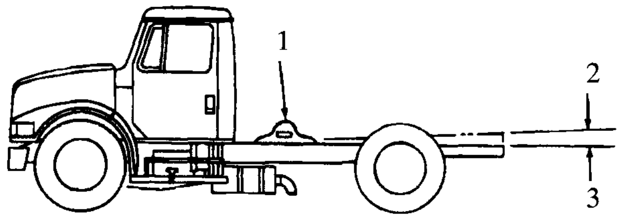

Figure 18 Measuring Frame Angle

1. PLACE PROTRACTOR HAVING LEVEL INDICATOR ON TOP OR BOTTOM OF FRAME
2. TYPICAL POSITIVE FRAME ANGLE "FA"
3. LEVEL

Adjusting For Frame Angle

The measured frame angle should be added to or subtracted from, as required, the specified level frame caster setting to obtain the caster that should actually be measured on the vehicle.

A. Positive frame angle should be subtracted from specified setting.

B. Negative frame angle should be added to specified setting.

As an example, if the specified caster setting is a positive 1 degree and it is found that the vehicle has a positive 1 degree frame angle, then the measured caster should be 0± ½ degree. This would result in the desired 1 degree ±½ degree caster angle when the chassis settled to level frame under load.

Possible causes of incorrect caster are sagging springs, bent or twisted axle, or unequally tightened spring U-bolts. In most cases a twisted axle would be the cause if caster varies more than the specified ½ degree between left and right side.

If the vehicle drifts or pulls to the right, raise the caster on that side ½ to 1 degree to correct the condition.

Caster adjustment is made by inserting a wedge between spring and axle.

To increase caster, insert the wedge so the thick part faces the rear of the truck (to front for underslung axles).

To decrease caster, place the wedge so that the thick end is toward the front of the truck (to rear for underslung axles).

If an excessively thick wedge is required for a truck that has high mileage, check the contour of the springs and replace springs if necessary. Be sure center bolt drops into I-beam.

The truck will lead to the side that has the most negative or lowest caster setting.

Spring U-bolts should be tightened evenly and to specified torque listed in TORQUE CHART, after the addition or removal of shims.

NOTE – Be sure spring center bolt drops into I-beam pilot. Also, when tightening U-bolt nuts, be sure at least one full thread of U-bolt is visible when nut is tightened to specified torque. If not visible, use longer U-bolts.

CAUTION – When U-bolts are replaced, the new U-bolt must be Grade 7 minimum incorporated rolled threads. U-bolt nuts are to be flanged head type or those having a nylon insert locking feature, Grade 7 minimum.

6.3. CAMBER ANGLE

Camber is the amount in degrees that the wheel tilts in or out from vertical at the top, as viewed from the front of the truck (Figure 19).

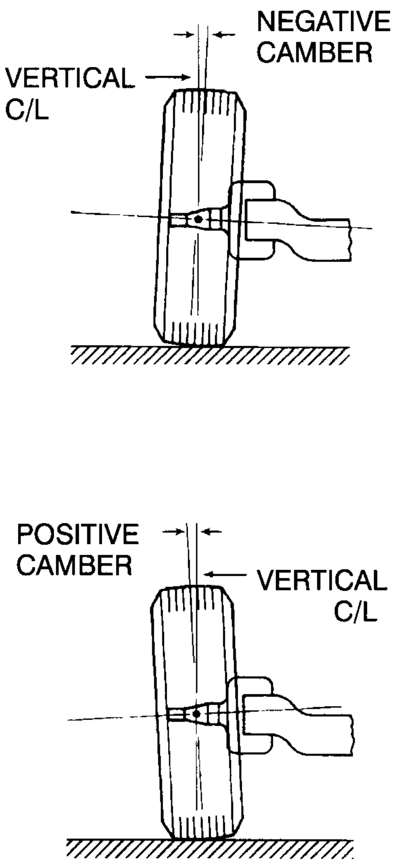

Figure 19 Camber (Viewed from Front)

"Positive" camber is the outward tilt of the wheel at the top (Figure 19).

"Negative" camber is the inward tilt of the wheel at the top (Figure 19).

The camber angle is set when the vehicle is manufactured. It is not recommended that the front axle be bent to change the camber angle.

7. KING PIN ANGLE (INCLINATION)

King pin inclination (angle) is the amount in degrees that the top of the king pin tilts away from the vertical toward the center of the truck as viewed from the front of the truck.

King pin inclination working together with the camber angle puts the approximate center of the tire tread in contact with the road. King pin inclination has the effect of reducing steering efforts and improves directional stability in the vehicle.

There is no means of adjusting this angle; therefore, it will not change unless the front axle has been bent. Corrections or changes to this angle are accomplished by replacement of broken, bent or worn parts.

7.1. TURNING ANGLE

Turning angle is the degree of movement from a straight-ahead position of the front wheels to either an extreme right or left position. Two factors of major importance when adjusting the angle are: tire interference with chassis and steering gear travel.

To avoid tire interference or bottoming of the steering gear, adjustable stop bolts are located on the steering knuckles. Refer to STEERING KNUCKLE STOP ADJUSTMENT.

Turning Angle (Wheel Cut) Charts are located in ALIGNMENT SPECIFICATIONS for special applications. Use the turning radius plates as outlined in ACKERMAN ANGLE (TOE-OUT ON TURNS), and adjust the turning angle.

Manual Steering Gear

If the specifications chart does not include the particular vehicle being aligned, proceed as follows. Loosen the jam nuts and turn the steering knuckle stop bolts in. Position support stands under the front axle so that the wheels are off the floor. Turn the wheels to extreme right turn until the steering gear bottoms or contact of the tire to chassis is made. Then back off the steering wheel ¼ turn or back off the steering wheel until ½ to 1 inch (12.7 to 25.4 mm) clearance is obtained between the tire and chassis.

Be sure to check both front tires for clearance. When the proper clearance is determined, back the wheel stop bolt out and tighten the jam nut.

Repeat the same procedure on the left extreme turn and adjust the left steering knuckle stop bolt.

Power Steering

NOTE – If vehicle is equipped with power steering, adjust the steering gear end of travel relief valves to relieve pressure before contact is made with the knuckle stop bolt.

WARNING – Hydraulic pressure relief must occur prior to contact between the knuckle stop bolt and I-beam pad to avoid potential overstressing of steering linkage components. If linkage is overstressed repeatedly, subsequent damage may result in failure of linkage components and steering control of the vehicle.

Refer to GROUP 05-STEERING in the CTS-5000 Master Service Manual for the steering gear being serviced.

The adjustment of both axle steering stops and power steering unit should be periodically checked and corrected if necessary.

7.2. ACKERMAN ANGLE (TOE-OUT ON TURN)

Ackerman angle is measured in degrees and is the amount one front wheel turns sharper than the other on a turn.

When a vehicle is turned either to the right or left, the inner wheel is required to turn in a smaller circle than the outside wheel (Figure 20).

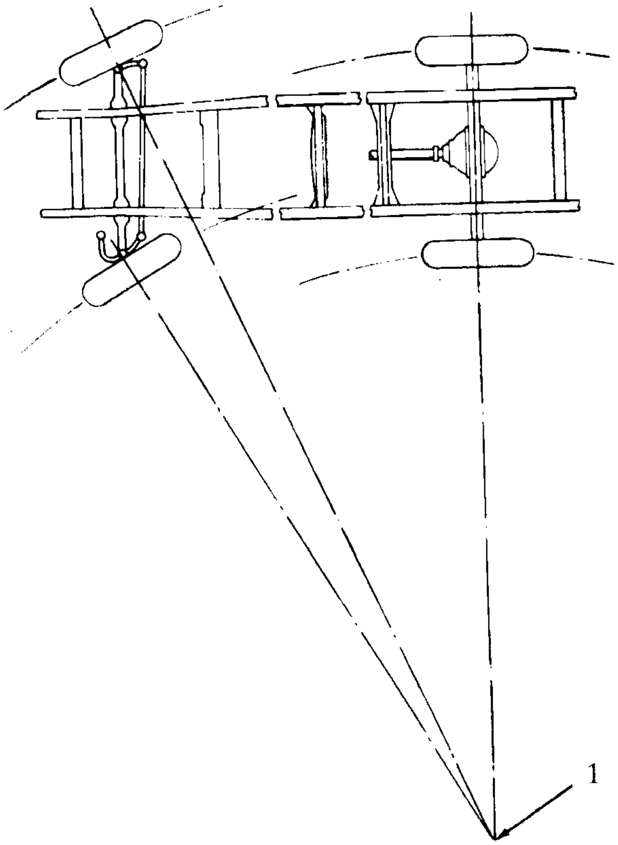

Figure 20 Inner Wheel Turns in a Smaller Circle Than Outside Wheel

1. COMMON CENTER POINT (ALL WHEELS)

If the inner wheel is not permitted to turn in a smaller circle or at a greater angle, tire scuffing will result. Therefore, it is necessary for the front wheels to assume a toed-out position during a turn.

Toe-out on turns is accomplished by having the ends of lower steering arms (tie rod arms) closer together than the king pins as shown in Figure 21 . The amount of toe-out depends on the length and angle of the steering arms. Toe-out in turns varies with the wheelbase. Typically there is more toe-out in turns with shorter wheelbase vehicles and less with longer wheelbase vehicles.

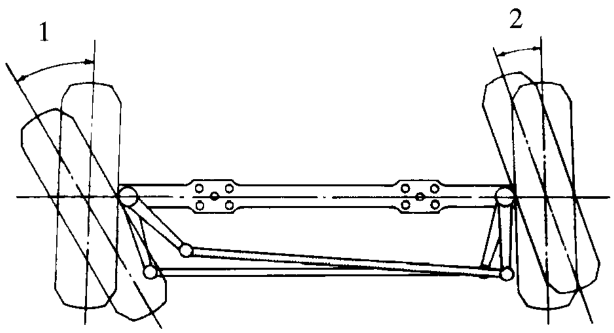

Figure 21 Inside Wheel Turns at a Greater Angle

1. GREATER ANGLE
2. SMALLER ANGLE

Even though the toe-in with the wheels in the straight-ahead position may be adjusted correctly, a bent steering arm may cause the toe-out on a turn to be incorrect, causing scuffing of tires.

The Ackerman angle is checked using turning radius plates.

To check the Ackerman angle, position the front wheels on the plates and in the straight-ahead position. After removing the locking pins from each plate, adjust the scale on the edge of the plates so that the pointers read "zero." Turn the wheels to the right until the gauge at the right wheel reads 20°. Then read the angle of the left wheel. Turn the wheels to the left until the gauge at the left wheel reads 20°. Then read the angle on the right gauge. The right wheel should be at the same angle as the left wheel was when the wheels were turned to the right.

8. ALIGNMENT SPECIFICATIONS

8.1. ALIGNMENT PROCEDURE RULES

When performing front wheel alignment procedures, observe the following rules:

1. Caster angles are for an unladen (no payload) vehicle. If frame is not level, the frame angle must be added to - front low - or subtracted from - front high - the caster angle to obtain true caster reading. Refer to Adjusting For Frame Angle.
2. Caster angle difference between left and right wheel not to exceed one (1) degree.
3. Toe-in dimension may be measured from center of tread, or from inside of tire.
4. Tolerance unless otherwise noted:
   a. Caster - plus or minus ½ (.5) degree.
   b. Toe-in - plus or minus 1/16 inch (1.59 mm).
   c. Camber - plus or minus 7/16 degree.
5. Axle manufacturers do not recommend bending axles to change camber angles.

8.2. TOE-IN FOR ALL STEER AXLES

ACCEPTABLE SERVICE RANGE - Unloaded:

A. 0 to 1/8 Inch

B. 0 to .125 Inch

C. 0 to .180 Degree

IF OUT OF ACCEPTABLE SERVICE RANGE - Unloaded, reset to:

A. 1/32 to 3/32 Inch

B. .03 to .09 Inch

C. .05 to .13 Degree

8.3. CAMBER, (CAMBER RANGE), AND KING PIN INCLINATION KPI

Table 2 **Camber, (Camber Range), and King Pin Inclination KPI**

Axle	Degrees	
	Left	Right
International by Spicer 02ADA (I60S) 02ADB (I80S)	½ (0 to 1) 4¼ KPI	¼ (-¼ to +¾) 4 ½ KPI
International by Spicer 02ADC (I100S), 02ADD (I120S) 02ADE (I140S), 02ADG (I120S)	1/16 (0 to 7/8) 7¾ KPI	-1/16 (-½ to +3/8) 7¾ KPI
Eaton 02250 (EFA-12) 02AEA (EFA-13.2)	½ (1/16 to 15/16) 5¼ KPI	0 (-7/16 to +7/16) 5¾ KPI
Rockwell 02ARA (FF961), 02226 (FF941) 02227 (FF941)	0 (1/16 to 15/16) 6¼ KPI	0 (-7/16 to +7/16) 6¼ KPI
International by Spicer 02ADH (I160S), 02ADJ (I180S) 02ADK (I200S)	½ (1/16 to 15/16) 5¾ KPI	0 (-7/16 to +7/16) 6¼ KPI

Table 2 Camber, (Camber Range), and King Pin Inclination KPI (cont.)

Axle	Degrees	
	Left	Right
Rockwell 02231 (FL941), 02232 (FL941) 02233 (FL941)	0 (1/16 to 15/16) 6¼ KPI	0 (-7/16 to +7/16) 6¼ KPI
Rockwell and Spicer left camber is revised effective April, 1993.		

8.4. CASTER RANGE FOR INTERNATIONAL TRUCK MODELS

CASTER

NOTE – Caster is controlled by factory installed wedges between the springs and axle. Caster set too low for a specific vehicle may result in wander or returnability complaints.

Table 3 Front Non-Drive Steer Axle Caster Specifications

Axle Rating	Degrees	
	Left	Right
6K	3.5–5.0	4.0–5.5
7K	3.5–5.0	4.0–5.5
8K	3.5–5.0	4.0–5.5
8.5K	4.5–6.0	5.0–6.5
9K	4.5–6.0	5.0–6.5
10K	4.5–6.0	5.0–6.5
11K	4.5–6.0	5.0–6.5
12K	4.5–6.0	5.0–6.5
13.2K	4.5–6.0	5.0–6.5
14K	4.5–6.0	5.0–6.5
14.6K	4.5–6.0	5.0–6.5
16K	4.0–5.5	4.5–6.0
18K	4.0–5.5	4.5–6.0
20K	4.0–5.5	4.5–6.0
22K	4.0–5.5	4.5–6.0

NOTE – The right caster angle should be equal to or greater (more positive) than the left caster angle, but not exceeding 1 degree greater.

Table 4 Front Drive Steer Axle Caster Specifications

Axle Rating	Degrees Left/ Right
9K	2.0–4.0
10K	4.0–5.5
12K	4.0–5.5
14K	4.0–5.5
16K	5.0–6.5
18K	5.0–6.5
21K	5.0–6.5
23K	4.0–5.5

8.5. FRONT ALIGNMENT SPECIFICATIONS (RIGHT HAND DRIVE)

The camber setting for right hand drive vehicles is the same as left hand drive except as listed below.

Table 5 Front Alignment Specifications (Right Hand Drive)

Chassis Model	Axle Code	Camber Degree (+)
1000, 3000, 4000, 7000 Series (1989)	02ADA, 02ADB	LT ½ (.5) RT ¼ (.25)

8.6. CONVERSION CHART

Toe Readings - Degrees to Inches Conversion

Table 6 Toe Readings - Degrees to Inches Conversion

WHEEL ANGLE DEGREES	TIRE OUTSIDE DIAMETER (IN INCHES) TOE-IN PER WHEEL (IN INCHES)							
	38.0	39.0	40.0	41.0	42.0	43.0	44.0	45.0
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
.010	.007	.007	.007	.007	.007	.008	.008	.008
.020	.013	.014	.014	.014	.015	.015	.015	.016
.030 (1/32")	.020	.020	.021	.021	.022	.023	.023	.024
.040	.027	.027	.028	.029	.029	.030	.031 (1/32")	.031
.050	.033	.034	.035	.036	.037	.038	.038	.039
.060	.040	.041	.042	.043	.044	.045	.046	.047
.070	.046	.048	.049	.050	.051	.053	.054	.055

Table 6 Toe Readings - Degrees to Inches Conversion (cont.)

WHEEL ANGLE DEGREES	TIRE OUTSIDE DIAMETER (IN INCHES) TOE-IN PER WHEEL (IN INCHES)							
	38.0	39.0	40.0	41.0	42.0	43.0	44.0	45.0
.080	.053	.054	.056	.057	.059	.060 (1/16")	.061	.063
.090	.060 (1/16")	.061	.063	.064	.066	.068	.069	.071
.100	.066	.068	.070	.072	.073	.075	.077	.079
.110	.073	.075	.077	.079	.081	.083	.084	.086
.120	.080	.082	.084	.086	.088	.090	.092	.094
.130	.086	.088	.091	.093	.095	.098	.100	.102
.140	.093	.095	.098	.100	.103	.105	.108	.110
.150	.099	.102	.105	.107	.110	.113	.115	.118
.160	.106	.109	.112	.114	.117	.120	.123	.126
.170	.113	.116	.119	.122	.125 (1/8")	.128	.131	.134
.180	.119	.123	.126	.129	.132	.135	.138	.141
.190	.126 (1/8")	.129	.133	.136	.139	.143	.146	.149
.200	.133	.136	.140	.143	.147	.150	.154	.157
.210	.139	.143	.147	.150	.154	.158	.161	.165
.220	.146	.150	.154	.157	.161	.165	.169	.173
.230	.153	.157	.161	.165	.169	.173	.177	.181
.240	.159	.163	.168	.172	.176	.180	.184	.188
.250 (1/4")	.166	.170	.175	.179	.183	.188	.192	.196

8.7. TIRE GROUP CHART

Table 7 Tire Group Chart

Group	Tire Size
A	7.50x20, 8.25x20, 9.00x20, 8-19.5, 8-22.5, 9-22.5, 10-22.5, 245/70R19.5, 245/75R22.5, 265/75R22.5, 295/75R22.5, 255/70-22.5, 235/80-22.5, 255/80-22.5, 275/80-22.5, 225/70R19.5
B	10.00x20, 11-22.5, 285/75R24.5, 275/80-24.5, 10.00/90R20
C	11.00x20, 12-22.5, 315/80R22.5, 315/75R22.5
D	10.00x22, 11-24.5
E	12.00x20

Table 7 Tire Group Chart (cont.)

Group	Tire Size
F	11.00x22, 12-24.5
G	13/80x20
H	14/80x20
J	15-22.5, 365/80R20, 385/65R22.5
K	16.5-22.5, 425/65R22.5
L	18-22.5, 445/65R22.5
M	14.00x20
N	295/80R22.5
P	1200x24
R	1100x24
S	16.00x20

8.8. TURNING ANGLE (WHEEL CUT) CHARTS

Table 8 Turning Angle (Wheel Cut) Chart #1

Maximum Turn Angle (Wheel Cut) as Related to Wheel Base (W/B)				
Chassis Code	Axle Code	Tire Group*	Up to 185" W/B (Degrees)	More Than 185" W/B (Degrees)
1452, 3800, 49006x4	02ADA 02ADB	A, B	43 to 45	43 to 45
1652, 4000 4x2	02ADA 02ADB	A	48 to 50 (1)	48 to 50 (1)
2554, 2554 6x4, 2574 6x4	02ADC	A	43 to 45	43 to 45
		B	43 to 45	38 to 40
		C	38 to 40	33 to 35
	02ADD	A, B	38 to 40	38 to 40
		C	38 to 40	33 to 35
	02ADE	A, B, C	33 to 35	33 to 35
2654, 2654 6x4, 2674, 2674 6x4	02ADD	A, B, C	38 to 40	38 to 40
		D, F, G	33 to 35	33 to 35
	02ADE	A, B, C, D, F, G, J	33 to 35	33 to 35

Table 8 Turning Angle (Wheel Cut) Chart #1 (cont.)

Maximum Turn Angle (Wheel Cut) as Related to Wheel Base (W/B)				
Chassis Code	Axle Code	Tire Group*	Up to 185" W/B (Degrees)	More Than 185" W/B (Degrees)
3700, 3800, 4600, 4700, 4900, 4900 6x4	02ADC	A	43 to 45	43 to 45
		B	43 to 45	38 to 40
		C	38 to 40	33 to 35
	02ADD	A, B	38 to 40	38 to 40
		C	38 to 40	33 to 35
	02ADE	A, B, C, D, F, G	33 to 35	33 to 35
		J	31 to 33	31 to 33
7100, 7100 6x4, 8100, 8100 6x4	02ADB**	A, B	43 to 45	43 to 45
	02ADC	A	43 to 45	43 to 45
		B	43 to 45	38 to 40
		C	38 to 40	33 to 35
	02ADD	A, B	38 to 40	38 to 40
		C, D	38 to 40	33 to 35
4800 4x4, 4900 6x6	02064	A, B, C	33 to 35	
		J	28 to 30	
		M	33 to 35	
8200, 8200 6x4, 8300, 8300 6x4	02ADD	A, B, D	43 to 45	
		C	39 to 41	
	02ADE**	A, B	43 to 45	
		C	39 to 41	
* Refer to Tire Group Chart ** Power Steering Shown - Manual Steering = 33 to 35 (1) Effective February 1, 1993				

Table 9 Turning Angle (Wheel Cut) Chart #2

Chassis Code	Axle Code	Tire Group*	Turn Angle (Degrees)
5000 SBA	02ADH, 02ADJ, 02ADK, 02231, 02232, 02233	A, B, C, D, E, F, G, H, J, K, M, N, P, R	34
	02ADH, 02231	L	31
	02ADJ, 02232, 02233	L	29
	02EYD, 02EYE	ALL	35

Table 9 Turning Angle (Wheel Cut) Chart #2 (cont.)

Chassis Code	Axle Code	Tire Group*	Turn Angle (Degrees)
	02EYC	ALL	34
5000 SFA	02ADJ, 02ADK, 02232, 02233	A, B, C, D, E,D F, G, H, J, M, N, R	34
	02ADJ, 02ADK, 02232, 02233	P	33
	02ADJ, 02ADK, 02232, 02233	K	31
	02ADJ, 02ADK, 02232, 02233	L	26
* Refer to Tire Group Chart			

Table 10 Turning Angle (Wheel Cut) Chart #3

Chassis Code/Steering Gear	Axle Code	Tire Group*	Degrees	Remarks
9300 SFA Sheppard M100 Ross TAS65	02ADD, 02ADE	B, C, D	35	AL DISC WHL
	02ADD	C	30	STL DISC WHL
	02ARA, 02227	B, D, C	35	AL DISC WHL
			33	STL DISC WHL
		C	30	STL DISC WHL
9300 SFA Ross TAS65	02ADH, 02ADJ, 02231, 02332, 02337	B, D, F, J	25	CAST WHL
		B, E, F, J	25	DISC WHL
		K	24	DISC WHL
		K	25	All Except DISC WHL
		B	25	DISC WHL
9300 SFA Sheppard M100 Ross TAS65	02250	B, C, D	35	DISC WHL
9300 SBA Ross TAS65	02ADJ, 02232	J	30	CAST WHL
		J	28	DISC WHL
		C, H	30	DISC WHL
		K	25	DISC WHL
	02ADH, 02231	A, B, C, D, F	32	CAST WHL
		A, B, C, D, E, F, G	30	DISC WHL
		J	30	CAST WHL
		J, H	28	DISC WHL

Table 10 Turning Angle (Wheel Cut) Chart #3 (cont.)

Chassis Code/Steering Gear	Axle Code	Tire Group*	Degrees	Remarks
		K	25	All WHLS
9370 Ross TAS65	02ADA, 02ARA	All	35	All WHLS
9200, 9400 Sheppard M100 Ross TAS65	02ADD, 02ADE, 02AEA, 02ARA, 02227, 02250	A, B, D	40	All WHLS
		C	38	All WHLS
		J	36	All WHLS
9600 SFA Sheppard M100	02ADD	B, C, D	35	AL DISC WHL
		C	30	STL DISC WHL
	02ADE	All	30	All WHLS
	02ARA, 02227	B, D	35	AL DISC WHL
		B, D	33	STL DISC WHL
		C	33	AL DISC WHL
		C	30	STL DISC WHL
	02250	A, B, D	35	8 Stud AL DISC WHL
9600 Ross TAS65	02ADD	B, D	35	All WHLS
		C	30	STL DISC WHL
		C	35	AL DISC WHL
	02ARA	B, D	33	STL DISC WHL
		C	30	STL DISC WHL
		B, D	35	AL DISC WHL
		C	33	AL DISC WHL
	02250	A, B, D	35	All DISC WHLS
9600LP SFA Sheppard M100	02ADG	A	35	All WHLS
9700 Sheppard M100 Ross TAS65	02ADD, 02ADE. 02ARA, 02227	All	40	All WHLS
9700 Sheppard M100	02226	All	40	All WHLS

* Refer to Tire Group Chart

TORQUE

Table 11 Torque Chart

LOCATION	SIZE		TORQUE			
	Diameter (Inches)	No. Threads	FT-LBS.		N·M	
			Min.	Max.	Min.	Max.
Tie Rod End Nut and Drag Link End Nut (Note 1)	3/4	16	85	105	116	143
	7/8	14	120	160	163	218
Tie Rod Clamp Bolt	1/2	13	40	50	54	68
	5/8	11	45	65	61	88
Steering Arm Nut & Tie Rod Arm Nut (Note 1)	1-1/8	12	300	400	407	544
	1-1/4	12	775	1050	1054	1428
U-Bolt Nuts	3/4 Flg	16	260	300	192	222
	5/8 Hex	18	130	160	96	118
	7/8 Hex	14	260	300	192	222
NOTE 1: If cotter pin cannot be installed after minimum torque is attained, the nut must be advanced until cotter pin can be installed. Torque specified is for taper and threads which are clean and oil free. **DO NOT LOOSEN THE NUT TO INSTALL THE COTTER PIN.**						