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## 16 – Power Steering Gears

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16–POWER STEERING GEARS

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16 − 3
PURPOSE OF THIS SECTION
This section is designed as a reference for Haldex Commercial Vehicle Systems new and remanufactured air brake system components and accessories, sold under the Haldex and Midland product names. Products described include all pertinent information needed to replace an OEM installed component or to help design an original installation. If there is a service number for a given part, it is noted in the product number table.

DESIGN FLEXIBILITY
The products presented in this section are described by function and usage. Technical data and mounting configurations are also provided. Throughout this section, reference is made to numerous specific OEM applications. This section is not, however, intended to be a mutually exclusive listing of all part numbers and designs available. Should the need for a design not presented occur, contact your Haldex Commercial Vehicle Systems sales representative for additional information.

WARRANTY INFORMATION
Proper service and repair are important to the safe, reliable operation of any motor vehicle. To prevent personal injury and/or vehicle damage, careful and cautious service procedures recommended by the vehicle manufacturer should be followed by anyone servicing a motor vehicle. For details on warranty of Haldex Commercial Vehicle air brake system components and accessories, refer to L20221 Aftermarket Warranty Policy. For warranty returns, use L90005 Warranty Adjustment Form. To obtain further information, visit the www.haldex.com website, select North America/English in drop down box then search for Warranty.

ORDERING PROCEDURE
Most customers can place electronic orders on the www.haldex.com website by obtaining a username and password or by using EDI. For additional information about electronic orders or to place an order by phone or fax, contact Customer Service in U.S. or Canada at numbers listed below:

U.S. Customer Service:
Phone: 800−643−2374
Fax: 800−533−1941
Mail: Commercial Vehicle Systems
Haldex Brake Products Corporation
Attn: Customer Service Department
10930 N. Pomona Ave.
Kansas City, MO 64153

Canada Customer Service:
Phone: 800−267−9247
Fax: 519−621−3924
Mail: Commercial Vehicle Systems
Haldex Limited
Canadian Distribution Centre
Attn: Customer Service Department
500 Pinebush Road, Unit 1
Cambridge, Ontario N1T 0A5

IMPORTANT NOTICE
The data listed herein is correct to the best of Commercial Vehicle Systems knowledge and belief, having been compiled from reliable and official sources of information. However, COMMERCIAL VEHICLE SYSTEMS CANNOT ASSUME ANY RESPONSIBILITY for possible error or misapplication of the product. Final determination of the suitability of the products for the use contemplated by the Buyer is the sole responsibility of the Buyer. Commercial Vehicle Systems shall have no responsibility in connection with this suitability. It is not our intention to imply that any of the components in this catalog in connection with an engine make or model are made by any engine manufacturer.

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Commercial Vehicle Systems
Haldex Brake Products Corporation
10930 N. Pomona Ave.
Kansas City, MO 64153

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Heavy duty power steering gears have a twelve (12) month, 3,600 hour (whichever comes first) warranty. For further details, refer to L20221 Aftermarket Warranty Policy. For warranty return, use L90005 Warranty Adjustment Form.

**SPECIAL NOTE**

Proper service and repair is important to the safe reliable operation of all motor vehicles. Careful and cautious service procedures recommended by the manufacturers should be taken by anyone servicing a motor vehicle to minimize the risk of personal injury and vehicle damage. All information, illustrations, specifications and schematics contained in this section are based on the latest information available at the time of publication. The right is reserved to make changes at any time without notice.

**WARNING FOR PROPER STEERING GEAR OPERATION**

1. Do not weld, braze or solder any steering gear or system arm components.
2. Maximum flow under any conditions must not exceed vehicle manufacturers specifications.
3. Always inspect any steering component(s) which has been (or is suspected to have been) subject to impact. Replace any part that has been damaged or is questionable.
4. Never mix or use improper oils for units.

**STEERING SYSTEM MAINTENANCE TIPS**

1. Prevent internal bottoming of the steering gear. Carefully check axle stops to be sure that they meet the manufacturer's specifications.
2. Regularly check the fluid and the fluid level in the power steering reservoir.
3. Keep tires inflated to correct pressure.
4. Always use a puller, never a hammer or torch, to remove pitman arms.
5. Investigate and immediately correct the cause of any play, rattle, or shimmy in any part of the steering linkage or steering mechanism.
6. Remove the cause of steering column misalignment.
7. Encourage all drivers to report any malfunctions or accidents that could have damaged steering components.
8. Do not attempt to weld any broken steering component. Replace the component with original equipment only.
9. Do not cold straighten, hot straighten, or bend any steering system component.
10. Always clean off around the reservoir filler cap before you remove it. Prevent dirt or other foreign matter from entering the hydraulic systems.
11. Investigate and correct any external leaks, no matter how minor.
12. Replace filters and pumps in compliance with specification.
13. If extended stationary use of vehicle is developing excessive hydraulic fluid temperatures, consult vehicle manufacturer for auxiliary cooling method.
14. Maintain grease pack applied behind the input and output shaft’s protector seal as a general maintenance procedure.
### Light Duty Steering Gears – Remanufactured

**Specifications:**

- **Approximate Weight**: 30 lbs.

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Bendix® Steering Gear Kit

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Bendix® Steering Gears – Remanufactured

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Saginaw Steering Gears – Remanufactured

**Features:**

- RG78131X – Dual Piston Gear, Metric, GMC–Chev. Application
- RG78132X – Dual Piston Gear, GMC–Chev. Application
- RG78133X – Dual Piston Gear, Metric, GM Topkick Application
- RG78303X – Dual Piston Gear, S–Line Internationals.

**Specifications:**

- Astro Kit RG78001
- Brigadier Kit RG78002
- Dual Kit RG78003

**Notes:**

1) RG78020X not pictured

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<td>SG6001</td>
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Saginaw Cylinders – Remanufactured

Features:

- Need weld to weld measurement to order correct cylinder.

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<th>Core Group</th>
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<tr>
<td>RG40011X</td>
<td>Remanufactured Saginaw Cylinder</td>
<td>Most GMC–Chevrolet trucks with rotary valve Saginaw gears.</td>
<td>11&quot;</td>
<td>SC1001</td>
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<td>RG40113X</td>
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<td>Most GMC–Chevrolet trucks with rotary valve Saginaw gears.</td>
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## Saginaw Service Kits

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<td>Astro Service Kit for Saginaw Power Steering Gear</td>
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<td>RG78002</td>
<td>Brigadier Service Kit for Saginaw Power Steering Gear</td>
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<td>RG78003</td>
<td>Dual Service Kit for Saginaw Power Steering Gear</td>
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<td>RG8295K</td>
<td>710ML Seal Kit for Saginaw Power Steering Gear</td>
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## 292 Series Steering Gears – Remanufactured

### Specifications:
- **Shaft Diameter**: 2”
- **Seal Kit**: RG29210
- **Approximate Weight**: 85 lbs.

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<td>RG29202X</td>
<td>Remanufactured Sheppard 292 Series Steering Gear</td>
<td>80 lbs.</td>
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<td>RG29203X</td>
<td>Remanufactured Sheppard 292 Series Steering Gear</td>
<td>88 lbs.</td>
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<td>RG29204X</td>
<td>Remanufactured Sheppard 292 Series Steering Gear</td>
<td>89 lbs.</td>
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<td>RG29205X</td>
<td>Remanufactured Sheppard 292 Series Steering Gear</td>
<td>87 lbs.</td>
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<td>RG29207X</td>
<td>Remanufactured Sheppard 292 Series Steering Gear</td>
<td>90 lbs.</td>
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<td>292 S−6</td>
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<td>RG29208X</td>
<td>Remanufactured Sheppard 292 Series Steering Gear</td>
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### 392 Series Steering Gears – Remanufactured

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<td>Reman. Sheppard 392 Series</td>
<td>392BR5</td>
<td>392</td>
<td>464027C92</td>
<td>SG7003</td>
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<td>RG39202X</td>
<td>Reman. Sheppard 392 Series</td>
<td>392SCH4</td>
<td>392S−4S−6</td>
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<td>392S−4S−6</td>
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<td>392S</td>
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<td>392S−6</td>
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492 Series Steering Gears – Remanufactured

Specifications:

Approximate Weight 128 lbs.

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<th>SKU#</th>
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<th>Core Group</th>
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<tr>
<td>RG49201X</td>
<td>Reman. Sheppard 492 Series</td>
<td>492SHM6−X3</td>
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<tr>
<td>RG49206X</td>
<td>Reman. Sheppard 492 Series</td>
<td>492SF</td>
<td>–</td>
<td>–</td>
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<td>RG49207X</td>
<td>Reman. Sheppard 492 Series</td>
<td>492SDW</td>
<td>–</td>
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592 Series Steering Gears – Remanufactured

Specifications:
- Approximate Weight: 189 lbs.
- Seal Kit: RG59210

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<td>592SV5</td>
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# M80, M90, M100 Series Steering Gear – Remanufactured

## Specifications:
- **Sector Shaft:** 4.75 Tapered Bolt with Washer
- **Approximate Weight:** 95 lbs.

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<td>RG100PAGX</td>
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### Sheppard Service Kits

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<td>Complete Seal Kit for Sheppard M-100 Series Power Steering Gear</td>
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<td>Seal Kit for Sheppard 592 Series Steering Gear</td>
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<td>RG90K</td>
<td>Seal Kit for Sheppard M-90 Series Power Steering Gear</td>
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HF54 Series Steering Gears – Remanufactured

Specifications:
- Approximate Weight: 60 lbs.
- Seal Kit: RG54001

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<td>RG54042X</td>
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HF64 Series Steering Gears – Remanufactured

Specifications:

- **Approximate Weight**: 84 lbs.
- **Seal Kit**: RG64001

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HFB52 Series Steering Gears – Remanufactured

Specifications:

- **Approximate Weight**: 67 lbs.
- **Seal Kit**: RG52001

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### HFB64 Series Steering Gears – Remanufactured

**Specifications:**
- **Approximate Weight:** 85 lbs.
- **Seal Kit:** RG64002

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# HFB70 Series Steering Gears – Remanufactured

**Specifications:**
- **Approximate Weight:** 110 lbs.
- **Seal Kit:** RG70001

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TAS Series Steering Gears – Remanufactured

Core Group SG4001

Core Group SG8501

Specifications:

- **Seal Kit**: RG65000
- **Approximate Weight**: 85 lbs.

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## TRW/Ross Cylinders – Remanufactured

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### Oil Specifications

#### 16–POWER STEERING GEARS

#### Oil Specifications

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</tr>
<tr>
<td>Ross HFB64 &amp; HFB70</td>
<td>Mack EO–K2 Engine Oil</td>
<td>SAE 30</td>
</tr>
<tr>
<td>Ross HFB64</td>
<td>ATFs</td>
<td>SAE 10W30</td>
</tr>
<tr>
<td>Ross HFB70</td>
<td>ATFs</td>
<td>SAE 15W40</td>
</tr>
</tbody>
</table>

#### Note
- The filter element should always be changed when the oil in the steering system is changed or a unit is changed.
- WARNING: Completely flush the system with recommended fluid only. Do not mix oil types. Any mixture or any unapproved oil could lead to seal deterioration and leaks. A leak could ultimately cause the loss of fluid, which could result in loss of power steering assist.

#### Operating Pressure & Oil Flow

**Ross HF54 & HFB64**
- **Maximum operating pressure**: 2175 PSI
- **Maximum flow rate**: 7 GPM
- **NOTE**: The recommended minimum flow at 1 1/2 hand wheel turns must be no less than 2.5 GPM. If the HF54 gear is operating an assist cylinder, more flow may be required based on size of cylinder and front axle weight.

**Ross HFB52**
- **Maximum operating pressure**: 2000 PSI
- **Maximum flow rate**: 6 GPM
- **NOTE**: The recommended minimum flow at 1 1/2 hand wheel turns must be no less than 2 GPM. If the HFB52 gear is operating an assist cylinder, more flow may be required based on size of cylinder and front axle weight.

**Ross HFB70**
- **Maximum operating pressure**: 2000 PSI
- **Maximum flow rate**: 8 GPM
- **NOTE**: The recommended minimum flow at 1 1/2 hand wheel turns must be no less than 3.4 GPM. If the HFB70 is operating an assist cylinder, more flow may be required based on size of cylinder and front axle weight.

**Ross TAS40, 55 & 65 Series**
- **Maximum operating pressure**: 2175 PSI
- **Maximum flow rate**: 7 GPM
- **NOTE**: The recommended minimum flow at 1 1/2 steering wheel turns per second is as follows: TAS40: no less than 2.2 GPM. TAS55: no less than 2.6 GPM. TAS65: no less than 3.0 GPM. If the gear controlling an assist cylinder, more flow may be required based on size of cylinder and front axle weight.
Whenever steering complaints are encountered it is important that the complete steering system be inspected. Special body or equipment installations should also be considered for their affect on steering performance.

The steering system consists of the Sheppard Integral Power Steering Gear, a hydraulic supply pump with pressure and flow controls and an oil reservoir, the front axle and mechanical components and the steering column or input shaft and connecting linkages, The front tires and wheels must also be considered as part of the total steering system.

Steering performance can be affected by out of line conditions anywhere in the total steering system. Other factors outside the steering system can also contribute to poor steering performance.

Many times a steering gear is removed and disassembled needlessly, because an organized diagnosis procedure has not been followed. Start your diagnosis by:

- **Defining The Complaint**
  1. Talk to and question the driver
  2. Drive the vehicle

- **Visual Inspection**
  1. Look for poor loading practices
  2. Check tires for mismatch and proper air pressure
  3. Check for dry fifth wheel or improper location
  4. Check suspension for sagging or shifting (out of line rear axles will tend to steer the front end of the vehicle)

- **Mechanical Components Inspection**
  1. Check all front axle components for wear, excessive slack, or seizure
  2. Inspect front and rear suspension components
  3. Check steering gear mounting to be sure it is tight and not shifting on the chassis or axle
  4. Inspect steering column components

- **Hydraulic Supply System Inspection**

  Evaluate hydraulic supply system performance. Follow procedures in "Hydraulic Supply−Diagnosis" section. Oil pressure and oil flow must be within the vehicle manufacturer's specification.

The following pages list possible symptoms, causes and corrective action for steering system complaints. Careful and complete diagnosis will enable you to solve steering problems quickly.

**NOTE:** Keep in mind that the same problems that upset manual steering will also affect power steering.
<table>
<thead>
<tr>
<th>SYMPTOM</th>
<th>POSSIBLE CAUSE</th>
<th>REMEDY</th>
</tr>
</thead>
</table>
| Oil leaking at output shaft of steering gear | Damaged sector shaft seal  
Clogged oil filter in reservoir (high back pressure)  
Pinched or restricted oil return line  
Damaged quad ring seal  
Damaged bronze bearings  
Damaged lipseal (Series 5 gears)  
Damaged roller bearings | Replace sector shaft seal  
Replace filter  
Increase change frequency  
Locate and correct  
Check back pressure  
Replace quad ring seal  
Replace bronze bearings  
Polish output shaft or replace to remove bronze deposits  
Replace with replacement seal assy.  
Replace roller bearings  
Polish output shaft or replace to remove pitting & grooving in seal area |
| Oil leaking at actuating shaft of steering gear | Worn or damaged oil seal  
Damaged actuating shaft seal surface | Replace seals  
Replace damaged ports  
Lube bearing cap more often |
| Oil leaking at supply pump drive shaft | Damaged oil seal  
Oil seal–heat damaged  
Loose or damaged bushing on pump drive shaft | Replace oil seal  
Check operating temperature  
Repair pump per pump service instructions |
| Oil leaking between reservoir and pump body | Seal or gasket damaged | Replace damaged parts |
| Lubricant milky or white in appearance | Water entry through reservoir venting system | Clean vent system or replace cap assembly |
| Oil forced out of reservoir or foaming | Clogged oil filter  
Loose pump drive belts  
Air in system  
Faulty supply pump (Cavitation)  
Relief plungers of steering gear not adjusted properly  
Operating temperatures too high | Change oil and oil filter  
Increase change intervals  
Adjust belts or replace  
Bleed air from system  
Check for air leak on suction side of supply pump  
Check supply pump following "Hydraulic Supply–Diagnosis" procedures  
Repair pump per pump service instructions  
Adjust relief plungers (see Final Adjustments)  
Follow "Hydraulic Supply–Diagnosis" procedures |
| Engine oil in power steering reservoir (Gear driven pump) | Faulty seal at pump drive shaft  
Faulty seal at accessory shaft driving supply pump | Repair pump  
Repair accessory drive |
| Lubricating oil discolored or smells bad | Operating temperatures too high  
Change intervals too long  
Incorrect lubricant used | Check and correct cause of over–heating  
Increase oil change frequency  
Drain, flush and refill with 10W40 motor oil |
| High operating temperatures | Oil flow restriction  
Oil flow too high | Check back pressure (Follow "Hydraulic Supply–Diagnosis" procedures)  
Check maximum oil flow (follow "Hydraulic Supply–Diagnosis" procedures) |
<table>
<thead>
<tr>
<th>SYMPTOM</th>
<th>POSSIBLE CAUSE</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil in reservoir foaming</td>
<td>Air leak in suction side of supply pump</td>
<td>Refer to pump servicing instructions</td>
</tr>
<tr>
<td></td>
<td>Pump cavitating</td>
<td>Check for restriction in pump supply</td>
</tr>
<tr>
<td></td>
<td>Oil overheating</td>
<td>See high operating temperatures</td>
</tr>
<tr>
<td></td>
<td>Incorrect lubricant</td>
<td>Change to 10W40 motor oil</td>
</tr>
<tr>
<td>No power steering on cold start</td>
<td>Hydraulic supply pump vanes not extending (Vane type pump only)</td>
<td>Increase engine speed momentarily to extend vanes and start pump action.</td>
</tr>
<tr>
<td>Excessive pump pressure with steering gear in neutral position</td>
<td>Pinched oil return line</td>
<td>Relocate line</td>
</tr>
<tr>
<td></td>
<td>High back pressure</td>
<td>Repair steering column</td>
</tr>
<tr>
<td></td>
<td>Binding steering column</td>
<td>Replace damaged parts as required</td>
</tr>
<tr>
<td>Wheel cuts restricted</td>
<td>Relief plungers misadjusted</td>
<td>Adjust relief plungers (See Final Adjustments section)</td>
</tr>
<tr>
<td>Erratic steering or mechanical steering only</td>
<td>Insufficient volume of oil being metered by flow divider to steering gear induced by foreign particles on flow divider valve, causing the valve to hang up in the bore</td>
<td>Polish flow divider valve to remove foreign particles and burrs</td>
</tr>
<tr>
<td>Hard steering</td>
<td>Loose belts</td>
<td>Tighten or replace belts</td>
</tr>
<tr>
<td></td>
<td>Worn pulley(s) due to belt slipping</td>
<td>Replace pulley(s) and belts (keep belt tight)</td>
</tr>
<tr>
<td></td>
<td>Faulty supply pump</td>
<td>Follow &quot;Hydraulic Supply−Diagnosis&quot; procedures</td>
</tr>
<tr>
<td></td>
<td>Front axle overloaded</td>
<td>Correct loading practices</td>
</tr>
<tr>
<td></td>
<td>Faulty steering geometry</td>
<td>Align front end</td>
</tr>
<tr>
<td></td>
<td>High operating temperature</td>
<td>Locate and correct cause of overheating</td>
</tr>
<tr>
<td>Wheel turns hard in one or both directions</td>
<td>Bent or damaged king pins and tie rods</td>
<td>Repair or replace king pins and tie rods</td>
</tr>
<tr>
<td></td>
<td>Front end load too great for rated axle capacity</td>
<td>Lighten load or install larger steering gear</td>
</tr>
<tr>
<td></td>
<td>Fatigued by−pass valve spring in pump</td>
<td>Replace with flow control valve pump assembly</td>
</tr>
<tr>
<td></td>
<td>Low oil level in steering system</td>
<td>Fill oil reservoir as required</td>
</tr>
<tr>
<td></td>
<td>Air in system</td>
<td>Bleed system and check for cause of air (See Final Adjustments Section)</td>
</tr>
<tr>
<td></td>
<td>Metal or foreign material caught in actuating valve</td>
<td>Remove actuating valve</td>
</tr>
<tr>
<td></td>
<td>Actuating valve worn or chipped by dirt</td>
<td>Clean and check parts for damage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If damage is excessive replace damaged parts as required.</td>
</tr>
<tr>
<td>Wheel steering hard in one direction</td>
<td>Broken reversing springs in steering gear</td>
<td>Replace reversing springs and damaged parts</td>
</tr>
<tr>
<td></td>
<td>Metal or foreign material in relief ball seat in piston of steering gear</td>
<td>Remove piston and clean relief valve seats or replace damaged parts</td>
</tr>
<tr>
<td></td>
<td>Foreign material in relief valve</td>
<td>Clean relief valve</td>
</tr>
<tr>
<td>Steering extremely light in one or both directions(s)</td>
<td>Bent or damaged reversing springs</td>
<td>Check for impact or accident damage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Replace damaged parts</td>
</tr>
<tr>
<td>SYMPTOM</td>
<td>POSSIBLE CAUSE</td>
<td>REMEDY</td>
</tr>
<tr>
<td>---------</td>
<td>---------------</td>
<td>--------</td>
</tr>
<tr>
<td>Steering input not smooth (seizing, binding)</td>
<td>Worn universal joint Lack of lubrication Universal joint not phased properly Low oil flow Pump cavitating Overheating</td>
<td>Check and replace as required Lubricate per vehicle manufacturer’s recommendations See NOTE: Universal Joints below Idle speed too slow Drive belts slipping Supply pump not to specifications (See “Hydraulic Supply–Diagnosis” procedures Correct pump supply Correct cause of overheating</td>
</tr>
<tr>
<td>Dashing, wandering (oversteering)</td>
<td>Oil flow too high Air trapped in steering gear Looseness, worn front end parts Front end alignment not correct Radial tire sidewall flex Excessive wear or damage in steering gear Overloading Steering column universal joint phasing incorrect Mechanical bind in steering gear Tight tie rod ends &amp; drag link sockets</td>
<td>Supply pump not to specifications (See “Hydraulic Supply–Diagnosis” Procedures) Bleed system (See Final Adjustments Section) Check and repair as required Align front end Caster Check tire pressure Check for out of line tread Contact tire manufacturer representative Check and repair as required Reduce loads See NOTE: Universal Joints below Check steering gear mounting for distortion Check for damaged or distorted steering gear components Check rotational torque &amp; replace if necessary</td>
</tr>
<tr>
<td>Excessive backlash</td>
<td>Worn universal joint Worn pins and keys universal joint to actuating shaft and universal to steering shaft Low oil volume Pitman arm ball worn “egg–shaped” Improperly adjusted drag link, pitman arm to drag link and steering arm to drag link Loose bracket frame to bracket or bracket to gear bracket</td>
<td>Replace universal joint Replace pins and keys Check flow divider and pump drive Replace pitman arm assembly where riveted ball is used or only where bolted ball is used (vertical socket) Adjust drag link, drag link to pitman arm and drag link to steering arm Remove bracket, clean frame and bracket Check radius of frame making sure is not bearing on radius surface Check bracket for wear from working Replace bracket and tighten to recommended torque rating according to size and grade of bolts If necessary, replace bracket with new one</td>
</tr>
</tbody>
</table>

NOTE: Universal Joints

Universal joints are designed to operate best when the angle between the drive and driven shafts is a maximum of 20 to 25 degrees. Angles greater than this will cause undesirable velocity changes between the two shafts. This velocity change may upset steering performance. When two universal joints are used, it is in most instances possible to phase the two joints to match a high and low velocity in a manner that will provide equal velocity between the drive and driven shafts. A third universal joint in the shaft arrangement can upset the phasing of the first two joints and it is important that this third joint’s operating angle is limited to a maximum of 20–25 degrees.

Phasing of the universal joints in the steering column can be checked quite easily. Using an inch–pound graduated dial reading type torque wrench, read the variation in the torque reading while steering from lock–to–lock, with a socket on the steering shaft nut under the horn button. Variation of more than 15 in.–lb. indicates improper phasing. This reading is taken with the vehicle stationary and the engine running.

Phasing can usually be accomplished by rotating the two piece intermediate shaft one spline at a time until the torque reading remains the same all the way around the 360 degree rotation of the steering wheel.
<table>
<thead>
<tr>
<th>SYMPTOM</th>
<th>POSSIBLE CAUSE</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rack on piston damaged</td>
<td>Replace parts as required</td>
<td>Replace pinion gear</td>
</tr>
<tr>
<td></td>
<td>Damaged pinion gear on output shaft</td>
<td>Replace output shaft</td>
</tr>
<tr>
<td></td>
<td>Damaged output shaft splines</td>
<td>Replace bushings and polish shaft to remove bronze deposits</td>
</tr>
<tr>
<td></td>
<td>Worn output shaft bushings</td>
<td>Replace worn parts</td>
</tr>
<tr>
<td></td>
<td>Worn pitman arm splines</td>
<td>Replace worn parts as required</td>
</tr>
<tr>
<td></td>
<td>Worn actuating shaft and valve threads</td>
<td>Follow &quot;Hydraulic Supply–Diagnosis&quot; procedures to locate cause of wear</td>
</tr>
<tr>
<td></td>
<td>Free play in miter gears of angle drive</td>
<td>Remove miter gear housing shims to mesh gears</td>
</tr>
<tr>
<td></td>
<td>Damaged reversing springs</td>
<td>Check and repair as required</td>
</tr>
<tr>
<td></td>
<td>Universal joint yoke loose on actuating shaft</td>
<td>Repair or replace damaged parts, check for spline wear</td>
</tr>
<tr>
<td>No attempt to return straight ahead from turns</td>
<td>No positive caster</td>
<td>Set to 4” to 6” positive caster</td>
</tr>
<tr>
<td></td>
<td>Steering column bind</td>
<td>Check and repair universal joints and support bearings</td>
</tr>
<tr>
<td></td>
<td>Steering gear mounting distorted</td>
<td>Shim mounting pads to correct piston to bore interference</td>
</tr>
<tr>
<td></td>
<td>Linkage ball sockets seized or binding</td>
<td>Check and repair or replace</td>
</tr>
<tr>
<td></td>
<td>King pins seized or binding</td>
<td>Repair or replace</td>
</tr>
<tr>
<td></td>
<td>Knuckle clearance misadjust</td>
<td>Adjust clearance to specifications</td>
</tr>
<tr>
<td></td>
<td>Oil flow rate incorrect</td>
<td>Check and correct supply pump or controls</td>
</tr>
</tbody>
</table>

**NOTE: Thread Wear**

Acme thread wear generally comes from inadequate lubrication or excessive manual steering of the vehicle. Manual steering results from inadequate pump pressure or flow, or an overloaded front axle where you need steering forces in excess of the hydraulic design of the steering gear.

**NOTE: Freeplay**

The movement of the shuttle type actuating valve within the piston, along with the normal clearances required between operating parts in the steering gear will produce a certain amount of unresponsive motion at the rim of the steering wheel. This unresponsive motion is inherent to the design and must be considered normal. With recent advances in technology and manufacturing methods it has been possible to considerably reduce the amount of this unresponsive motion. Steering gears in service prior to July 1978 could be expected to have 3 1/2 to 4 inches unresponsive motion. Current production Sheppard steering gears in service will have 1 1/2 to 2 1/2 inches of unresponsive motion. Various combinations of steering gear ratios and steering wheel diameters could effectively reduce these maximum allowances. Nominal unresponsive motion in Series 6 steering gears, measurable at 1/2 to 1 1/2 inches. Unresponsive motion is measured at the rim of the steering wheel. It must, therefore, be noted that any freeplay in the steering column and related components will affect your measurements. The steering gear mounting must be tight and steering linkage wear adjusted out or worn parts replaced. The vehicle should be standing on a smooth shop floor with the engine idling when unresponsive motion is checked. Measurement is made at the rim of the steering wheel, from initial tire and wheel movement left steer, to initial tire and wheel movement right steer.
Normal Noises

- You or the driver may hear a hissing noise from the control valve when it is actuated during a steering maneuver.
- You or the driver may hear a noise as fluid bypasses through the poppets at full turn.
- You or the driver may hear a noise from the system relief valve when it is required to actuate.
- You or the driver may hear pump growl from some types of power steering pumps.

Abnormal Noises

- If the power steering pump is belt driven, a squealing noise may indicate that the belts should be tightened or replaced.
- A clicking noise heard during a turn, or when changing directions, may indicate that some component is loose and shifting under load.
- A change in the normal noise of the pump may indicate that air has been induced into the system or that fluid level is low.

Possible Steering Problems and Causes

Road Wander
- Tire pressure incorrect or unequal left to right.
- Components in steering linkage loose or worn (Steering wheel to road wheel).
- Wheel bearings improperly adjusted or worn.
- Front end alignment out of specification.
- Dry fifth wheel or poor finish on fifth wheel or trailer plate.
- Steering gear mounting bolts loose on frame.
- Steering gear improperly adjusted.
- Looseness in rear axle assemblies or trailer bogies.

No Recovery
- Tire pressure low.
- Front end components binding.
- Front end alignment incorrect.
- Tight front axle king pins.
- Dry fifth wheel or poor finish on fifth wheel or trailer plate.
- Steering column binding.
- Pump flow insufficient.
- Steering gear improperly adjusted.
- Steering gear control valve spool sticking.

Shimmy
- Badly worn or unevenly worn tires.
- Improperly mounted tire or wheel.
- Wheel bearings improperly adjusted or worn.
- Components in steering linkage loose or worn.
- Wheels or brake drums out of balance.
- Front end alignment incorrect.
- Air in the hydraulic system.
3. Possible Steering Problems and Causes, continued

External Oil Leakage
♦ Finding the location of a leak may be difficult, since oil may run away from the leak source, the fittings, hoses, pump, or gear to a low point on the gear or chassis
♦ A leak from the vent plug at the side cover indicates failure of the sector shaft oil seal inside the side cover

Oversteering or Darting
♦ Dry fifth wheel or poor finish on fifth wheel or trailer plate
♦ Front end components binding or loose
♦ Steering gear improperly adjusted
♦ Steering gear control valve spool sticking
♦ Rear axle mounts (rear steer)

High Steering Effort in One Direction
♦ Unequal tire pressure
♦ Vehicle overloaded
♦ Inadequate hydraulic system pressure
♦ Excessive internal leakage in one direction of turn only (verify with internal leakage test)

High Steering Effort in Both Directions
♦ Low tire pressure
♦ Vehicle overloaded
♦ Low hydraulic fluid level
♦ Low pressure or flow from pump
♦ Components of steering system binding
♦ Restriction in return line, or line too small in diameter
♦ Excessive internal leakage (verify with internal leakage test)
♦ Oversized tires (check manufacturer's specifications)

Lost Motion (Lash) at the Steering Wheel
♦ Steering wheel loose on the shaft
♦ Loose connection between the steering gear, intermediate column, and steering column
♦ Steering gear loose on frame
♦ Pitman arm loose on output shaft
♦ Components in steering linkage loose or worn
♦ Steering gear improperly adjusted

Excessive Heat [150F (65.6C) Over Ambient]
♦ Excessive pump flow
♦ Vehicle overloaded
♦ Undersized replacement hose or line
♦ Restricted hose or line that is kinked or severely bent or internally blocked
♦ Restricted recentering of gear valve caused by column bind or side load on the input shaft
♦ Poppet not adjusted properly
♦ Prolonged stationary vehicle operation

WARNING: IF THE HYDRAULIC SYSTEM FLUID BECOMES OVERHEATED, IT CAN CAUSE THE SEALS IN THE STEERING GEAR AND PUMP TO SHRINK, HARDEN, OR CRACK AND LOSE THEIR SEALING ABILITY.
4. **Filling and Air Bleeding The System**

   CAUTION: For steps 1 and 2, do not turn the steering wheel. Otherwise, air may be induced into the system.

   **Step 1.**
   Fill the reservoir nearly full. Crank the engine for 10 seconds without, if possible, allowing it to start. If the engine does start, shut it down immediately. Check and refill the reservoir. Repeat at least three times, each time checking and refilling the reservoir.

   CAUTION: Do not allow the fluid to drop significantly or run out of the reservoir. This may induce air into the system.

   **Step 2.**
   Start engine and let it idle for 2 minutes. Shut the engine off and check the fluid level in the reservoir.

   **Step 3.**
   Start the engine again. Steer the vehicle from full left to full right several times. Add fluid, as necessary, to the fill line on the dipstick.

   NOTE: Poppets, equipped on the gear, must be adjusted so that they relieve pressure at the full left and right turns to aid in the removing of air from the system. At this time, make sure any poppets are properly adjusted. If they are not, adjust them according to specifications in the TRW gear manual.

   The above procedures should remove all the air from the steering system, unless the gear is mounted in an inverted position and is equipped with the manual bleed screw. If this is so refer to Step 4.

   **Step 4.**
   Remove the air from a gear mounted in an inverted position and equipped with a manual bleed screw by following steps 1, 2 and 3 above. Then, with the engine idling, steer the gear from full left to full right several times. Loosen the manual bleed screw about one turn, with the steering gear in neutral (no steering action), allowing air and aerated fluid to "bleed out" around the bleed screw until only clear (non aerated) fluid is bleeding out then close the bleed screw. 4/16” socket required. Check and refill reservoir.

   Repeat this procedure 3 or 4 times starting with the steering maneuver with bleed screw closed, until only clear (non aerated) fluid is discharged when bleed screw is loosened. Torque the manual bleed screw to 27–33 in.lbs. Check and refill reservoir if needed.

   CAUTION: Do not turn steering wheel with bleed screw loosened as this could allow air into the system.
BLEEDING AIR FROM SYSTEM

The steering gear by design is self bleeding; however, in some installations where the gear is positioned at an odd angle or where the piston does not make a full stroke in the cylinder bore air can be trapped in the steering gear. To avoid this possibility the air should be bled from the system anytime the oil has been changed or the steering system is repaired.

After reinstalling the steering gear on the vehicle but prior to connecting the drag link to the pitman arm, bleed the air from the steering system in the following manner:

1. Fill pump reservoir with recommended oil. It will be necessary to continue filling after starting the engine and during the bleeding operation until correct oil level is maintained.
2. Set parking brake or block wheels. Start engine and allow it to operate at fast idle speed.
3. With engine running, turn steering wheel from left to right and return making three complete cycles to remove all air from the steering system.
4. Stop engine. Reconnect the drag link.

Following these procedures will ensure that the piston bottoms in both directions of steer, opens the relief valve in the piston, and allows the air to escape to the reservoir and into the atmosphere. (See Fig. A) Check and adjust the relief valve plungers as required.

ADJUSTING RELIEF VALVE PLUNGERS

The relief valve plunger adjustment is provided to automatically reduce the steering pressure when the road wheels have reached their limits of turn. This keeps the supply pump from operating at maximum relief pressure when the road wheels are at their steering limits. System temperatures are therefore reduced and high stress loads on the mechanical components of the steering system are relieved.

High-pressure oil at either end of the piston will push the relief ball valve off its seat and fill the relief passage with oil at high pressure. At the opposite end of this passage the relief ball valve is held against its seat and holds the high pressure in the relief passage. As the piston moves close to its limits of stroke, the adjustable relief plungers push the relief ball valve off its seat and the pressure is relieved. The distance the piston can move is dependent upon the total front axle/steering system geometry and tire size. The relief valve plungers are adjustable to allow for variations or changes in these areas. Adjust the relief valve plungers as follows:

1. Start the engine and allow it to operate at idle speed.
2. With full weight of the vehicle on all wheels, turn the steering wheel in one direction until a high-pressure hiss is heard or the axle stops contact.
3. Turn the relief valve plunger in or out until the high-pressure hiss is heard when there is 1/8 to 3/16 inch clearance between the axle stops. (See Fig. B)
4. Repeat this procedure for the opposite direction of steer, and adjust the relief valve plunger on the opposite end of the steering gear.

Turning the plungers in will increase the space between the axle stops. Turning the plungers out will decrease the clearance between the stops. Do not turn the slotted plungers out beyond flush with the plunger boss or a leak will occur. Axle stops should only be adjusted in accordance with the vehicle manufacturer’s specifications.

After relief valve plunger adjustment always check to ensure that the road wheels and tires have adequate clearance between suspension, brake and frame components.
Two integral steering gear units are sometimes used where high front axle loads or installation space limitations are encountered.

The secondary gear assembly differs from the master steering gear in that it does not have actuating shaft, nor does the piston have an actuating valve. Both gears are connect to the steering linkage, drag links, pitman arms and rack and pinion gears.

Pressure to operate the secondary, or slave gear, is passed through ports in the cylinder head and bearing cap of the master gear and is routed through high–pressure lines to the proper end of the slave gear. Thus, as the actuating valve of the master gear is moved to cause pressure build up on the piston of the master gear, pressure is also directed to the slave gear piston.

Fluid exhausted from the low pressure end of the master gear is routed through the low pressure pinion gear area of the slave gear and then back to the reservoir.

Early production dual gear systems routed the exhaust fluid from the master gear pinion gear area directly to the reservoir. Later systems route the exhaust fluid from the pinion gear area of the master gear through the pinion gear area of the slave gear and then to the reservoir. The later production method of oil return flow provides faster warm up of the slave gear and offers further assurance that air entrapment in the slave gear is avoided. The pressure relief check valve in the slave gear piston also allows entrapped air to escape to the low pressure side of the piston and be purged from the system. Early slave gear pistons have two check valves. Present versions have only one check valve which might be found on either end of the piston, and is located in the piston end plug.

Pressure relief valve plungers are not required on slave gears as pressure relief is provided by the master gear.

**BLEEDING AIR FROM SYSTEM DUAL STEERING**

To bleed the air from the steering system on the vehicle after installing the steering gears, the pitman arms may be installed if there is a clearance problem with the pitman arm striking any object using the full travel of the gear. Install them by aligning the timing mark on output shaft with the timing mark on the pitman arm. For torquing see pitman arm torquing assembly. Then proceed in the following manner.

1. Fill pump reservoir with recommended engine oil. (Continue filling after starting engine and during the bleeding operation until correct oil level is maintained.)
2. Set parking brake. Start engine and allow it to operate at fast idle speed.
3. With engine running and drag links disconnected, turn steering wheel to the left and hold until the secondary (slave) gear pitman arm moves the full travel. Then turn to the right and hold until the secondary (slave) gear pitman arm again moves the full travel, repeat this process three or more times.
4. Connect the drag link to the master gear. Do not connect the secondary (slave) gear drag link at this time. Turn steering wheel to the left and hold until the secondary (slave) gear pitman arm moves the full travel. Then turn to the right and hold until the secondary (slave) gear pitman arm lines up with the drag link. Then install the pitman arm. (DO NOT move the pitman arm by hand or air will be pulled back into the system.)

**WHEEL SHAKE CONDITION DUAL STEERING**

When two integral steering gear units, of the same size, are applied to a single axle application, the geometry of the vehicle is critical. At no time may the effective length of the slave gear pitman arm be shorter than the master gear. If this situation does occur, the slave will power into the drag link and tie rod mechanism, creating a wheel shake, primarily on a left hand turn. To remedy the problem, contact O.E.M. for correct pitman arm timing and design drag link length necessary to balance the system.
The Sheppard Integral Power Steering Gear is dependent upon adequate supplies of oil pressure and volume of oil flow to enable the steering gear to operate as designed. Oil pressure reacting on a piston creates the force to cause the piston to move and assist steering effort.

As the piston moves it is displaced in the cylinder bore by a volume of oil under pressure. How fast the piston can be displaced is dependent upon adequate oil flow and volume.

Oil pressure and oil flow requirements are engineering considerations that are established during the design of a total power steering installation. When diagnosing power steering problems you must be able to determine that oil pressure and oil flow meet design specifications. Pressure and flow specifications vary considerably and the vehicle manufacturer's recommendations must be followed carefully at all times.

Back pressure and operating temperature are two additional factors that must be considered during the diagnosis of power steering problems. High back pressures will restrict the movement of the piston in the power steering gear and this back pressure must be overcome before steering power is available. Back pressure is caused by restrictions to oil flow. A clogged oil filter, undersized fittings and lines, pinched lines and high flow rates are possible causes of back pressure.

High system oil temperatures reduce the overall efficiency of the steering pump and the steering gear. High temperatures are caused by restriction to flow or inadequate system oil capacity to allow for heat dissipation during normal operation. A supply pump which constantly operates at maximum relief pressure will also generate more heat than can be dissipated.

Various types of pressure gauges and flow meters are available and can be used to diagnose power steering problems. A pressure gauge which reads at least 3000 PSI and a flow meter with a capacity to 10 GPM are used to check pressures and oil flow. A shutoff valve downstream from the pressure gauge makes it possible to isolate the steering pump from the steering gear and by closing the valve, maximum pump relief pressure can be read.

Using the equipment available to you, proceed with your evaluation of the hydraulic supply system.

1. Make necessary gauge/meter connections.
2. Start engine & check system oil level assuring that oil flow is in proper direction through flow meter.
3. Place thermometer in reservoir.
4. Run the engine at correct idle speed and steer from lock–to–lock several times to allow system to warm up. (140 to 160°F)

5. **Pump Maximum Pressure Relief**
   With the engine running at specified idle speed, slowly turn the shutoff valve until closed and read the pressure at which the pressure relief valve opens. (Open the shutoff valve as quickly as possible to avoid heat build–up or possible damage to the steering pump.) This pressure reading should equal the maximum pump pressure specified by the manufacturer of your chassis. Check your specifications.
CAUTION: A malfunctioning pressure relief valve may not relieve pump pressure and closing the shutoff valve may cause severe pump damages or high-pressure hoses to rupture. Constantly observe the pressure gauge while closing the shutoff valve. If pressure rises rapidly or appears to be uncontrolled do not completely close the valve before inspecting the pump and pressure relief valve.

6. Flow Test Minimum Recommended Flow
With the engine running at a specified idle speed, vehicle stationary on the shop floor and with a normal load on the front axle, steer the wheels from full right to full left turn and observe the flow meter. The flow must not fall below the minimum GPM flow specification.

NOTE: It is important that flow be checked at normal operating temperatures and with a load on the front axle, or steering response complaints may not be found. Inadequate flow will cause binding, uneven or intermittent hard steering.

7. Flow Test Recommended Maximum
Increase the engine speed to approximately 1500 RPM and note the flow rate with the steering wheel stationary. Check this reading against the maximum flow rate specifications. Excessive oil flow can cause high operating temperature, and sluggish heavy steering response.

8. Leakage Test
If the supply pump is performing to specification, install a 1/2 inch spacer between the axle stops on one side, and turn the steering wheel hard in the direction necessary to pinch the spacer block. Record the maximum pressure reading. the maximum pressure reading should be within 100 PSI as was recorded in Step 5 for pump relief pressure when the shutoff valve was closed.

Remove the spacer and repeat test in the opposite direction. Record pressure.

If the pressure does not meet the recorded maximum pressure reading, the steering gear is worn internally and must be repaired or replaced.

9. Back Pressure
Normal system back pressure will be 50 to 75 PSI with the engine idling and the steering wheel stationary. Back pressure is checked with the system at normal operating temperature.

10. Operating Temperatures
Steering system oil temperature is best checked after two hours of normal operation. Ideal operating temperature should range between 140F to 160F. Normal operation in this range will allow for intermittently higher temperatures which will be encountered during periods of heavy steering usage.

11. Aerated Oil
Visually check for the presence of air mixed with the oil in the steering system. The oil should be clear. any signs of frothing indicate air entry and steering performance will be affected. Carefully check for leakage on the suction side of the steering pump. Drain and refill the system and bleed for air following the procedure under Final Adjustments section.

Before any steering gear repairs are attempted, the above hydraulic supply evaluation must be completed and corrections made as required. Many times steering gears have been repaired or replaced needlessly because a hydraulic supply system evaluation had not been made.
1. **Wander.** Wander is described as the vehicle not tracking properly on the road surface. The vehicle tends to drift side to side. Continual correction is required to keep the vehicle on the road.

   The driver may describe wander in the following ways:
   
   * Squirrely
   * Continually correcting
   * Constantly fighting the wheel
   * Can't hold it on the road
   * All over the road

2. **Pulls.** Pulling is a term used to describe a constant movement of the vehicle in one direction.

   The driver may describe pulling in the following ways:
   
   * Won't track
   * Pushes to one side
   * Wanders
   * Drives one way
   * Heads for the ditch

   If a directional pull is present, the most probably cause will be misalignment of the rear axle.

3. **Binds.** Binding is an increase in steering wheel effort that is momentary or intermittent.

   The driver may describe binding in the following ways:
   
   * High spot
   * Hangs up
   * Locks up
   * Catches when turning
   * Siezes

   Binding is normally a result of some mechanical problem with steering components. Most often the bind will occur at the same position on the wheel while turning.

4. **No Return** No return is used to describe the lack of wheel coming back to center after a turn or correction is completed.

   The driver may describe no return in the following ways:
   
   * The wheel won't come back
   * Hangs up in turns
   * Wheel sticks

   No return can result from a misaligned front axle or a bind in mechanical components external to the steering gear. Front axle caster angles should be checked in return complaints.
5. **Hard Steering.** Hard steering is experienced when steering wheel effort exceeds 100 inch pounds measured at the steering wheel retaining nut. Hard steering will remain constant through the full turn. Do not confuse hard steering with binding.

The driver may describe hard steering in the following ways:

* No power assist
* Steers like a manual gear
* Won't turn all the way

Hard steering can result from hydraulic and/or mechanical problems. A complete mechanical and hydraulic diagnosis is necessary to determine the cause.

6. **Excessive Free Play / Unresponsive Motion.** Excessive free play is a condition where there is too much steering wheel movement before the steer tires move. A small amount of free play is considered normal.

The driver may describe free play in the following ways:

* Too much slop in the wheel
* Too much backlash
* Slack in the wheel

Free play is normally a function of looseness in the linkage.

7. **Shimmy** Shimmy is a shake or vibration of the front tires that is transmitted through the steering wheel.

The driver may describe shimmy in the following ways:

* Steering wheel shake
* Cab shakes
* Steering wheel chatter
* Steering wheel chatter

Shimmy is a function of looseness in the steering linkage, looseness in front end components or unbalanced tires. Shimmy can also be caused by air trapped in the system.

8. **Noise** Noise in the steering system can come from any number of components. Harmonics or hydraulic noise can be caused by fluid flow. Metallic or grinding noises come from component parts.

The driver may describe noise in the following ways:

* Growls
* Swishes
* Pops when steering
* Moans

When noise is present you must first determine if it is a mechanical or hydraulic noise. Most mechanical noises are a result of looseness or wear in components. Hydraulic noise will normally be associated with problems in pump flow, such as cavitation or low fluid levels.