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Service Notes

This publication provides a parts analysis process to help you determine why parts failed during operation, what to look for when you inspect parts, and how to help prevent failures from occurring again.

Section 1 is an overview of parts analysis, and Section 2 provides guidelines for using an investigative approach during the analysis process.

Section 3 contains descriptions of failure types that affect parts, as well as parts analysis terminology that's used in the field to describe conditions that cause components to fail.

Section 4, Section 5, Section 6, Section 7, Section 8, Section 9 and Section 10 include parts analysis information for the following components.

• Automatic Slack Adjusters
• Brakes
• Drive Axles
• Drivelines
• Trailer Axles
• Transmissions
• Transfer Cases

DANGER

Installation, maintenance, and replacement of such products requires a high degree of skill and experience. The consequences of improper installation, maintenance, or replacement (including the use of inferior or substandard components) are grave and can result in product failure and resulting loss of control of the vehicle, possible injury or death of persons, and/or possible future or additional product damage.

AxleTech does not authorize anyone, other than highly skilled and experienced individuals, to attempt to utilize the instructions contained in this manual for the installation, maintenance, or replacement of the product described herein, and AxleTech shall have no liability of any kind for damages arising out of (or in connection with) any other use of the information contained in this manual.

Updates

For the latest version of this manual, please visit the AxleTech web site at www.axletech.com. AxleTech Customer Service can be reached at 800-540-2794 or via email at service.na@axletech.com.

Notations

AxleTech International uses the following notation to warn the user of possible safety problems and to provide information that will prevent damage to equipment and components:

⚠️ DANGER

A DANGER indicates a procedure that you must follow exactly or it will cause death or serious injury.

⚠️ WARNING

A WARNING indicates a procedure that you must follow exactly or it may cause death or serious injury.

⚠️ CAUTION

A CAUTION indicates a procedure that you must follow exactly to avoid damaging equipment or components.

NOTE

A NOTE indicates an operation, procedure, or instruction that is important for proper service. A NOTE can also supply information that will help to make service quicker and easier.
Asbestos and Non-Asbestos Fibers Warning

OSHA* Toxic and Hazardous Substances 29 CFR 1910.1001

Work practices and engineering controls for automotive brake and clutch inspection, disassembly, repair and assembly -- Mandatory

This mandatory appendix specifies engineering controls and work practices that must be implemented by the employer during automotive brake and clutch inspection, disassembly, repair, and assembly operations.

Proper use of these engineering controls and work practices by trained employees will reduce employees’ asbestos exposure below the permissible exposure level during clutch and brake inspection, disassembly, repair, and assembly operations. The employer shall institute engineering controls and work practices using either the method set forth in paragraph [A] or paragraph [B] of this appendix, or any other method which the employer can demonstrate to be equivalent in terms of reducing employee exposure to asbestos as defined and which meets the requirements described in paragraph [C] of this appendix, for those facilities in which no more than 5 pairs of brakes or 5 clutches are inspected, disassembled, reassembled and/or repaired per week, the method set forth in paragraph [D] of this appendix may be used:

[A] Negative Pressure Enclosure/HEPA Vacuum System Method

(1) The brake and clutch inspection, disassembly, repair, and assembly operations shall be enclosed to cover and contain the clutch or brake assembly and to prevent the release of asbestos fibers into the worker's breathing zone.

(2) The enclosure shall be sealed tightly and thoroughly inspected for leaks before work begins on brake and clutch inspection, disassembly, repair, and assembly.

(3) The enclosure shall be such that the worker can clearly see the operation and shall provide impermeable sleeves through which the worker can handle the brake and clutch inspection, disassembly, repair and assembly. The integrity of the sleeves and ports shall be examined before work begins.

(4) A HEPA-filtered vacuum shall be employed to maintain the enclosure under negative pressure throughout the operation. Compressed-air may be used to remove asbestos fibers or particles from the enclosure.

(5) The HEPA vacuum shall be used first to loosen the asbestos containing residue from the brake and clutch parts and then to evacuate the loosened asbestos containing material from the enclosure and capture the material in the vacuum filter.

(6) The vacuum’s filter, when full, shall be first wetted with a fine mist of water, then removed and placed immediately in an impermeable container, labeled according to paragraph (j)(5) of this section and disposed of according to paragraph (k) of this section.

(7) Any spills or releases of asbestos containing waste material from inside of the enclosure or vacuum hose or vacuum filter shall be immediately cleaned up and disposed of according to paragraph (k) of this section.

[B] Low Pressure/Wet Cleaning Method

(1) A catch basin shall be placed under the brake assembly, positioned to avoid splashes and spills.

(2) The reservoir shall contain water containing an organic solvent or wetting agent. The flow of liquid shall be controlled such that the brake assembly is gently flooded to prevent the asbestos-containing brake dust from becoming airborne.

(3) The aqueous solution shall be allowed to flow between the brake drum and brake support before the drum is removed.

(4) After removing the brake drum, the wheel hub and back of the brake assembly shall be thoroughly wetted to suppress dust.
(5) The brake support plate, brake shoes and brake components used to attach the brake shoes shall be thoroughly washed before removing the old shoes.

(6) In systems using filters, the filters, when full, shall be first wetted with a fine mist of water, then removed and placed immediately in an impermeable container, labeled according to paragraph (j)(4) of this section and disposed of according to paragraph (k) of this section.

(7) Any spills of asbestos-containing aqueous solution or any asbestos-containing waste material shall be cleaned up immediately and disposed of according to paragraph (k) of this section.

(8) The use of dry brushing during low pressure/wet cleaning operations is prohibited.

[C] Equivalent Methods

An equivalent method is one which has sufficient written detail so that it can be reproduced and has been demonstrated that the exposures resulting from the equivalent method are equal to or less than the exposures which would result from the use of the method described in paragraph [A] of CFR 1910.1001. For purposes of making this comparison, the employer shall assume that exposures resulting from the use of the method described in paragraph [A] of this appendix shall not exceed 0.016 f/cc, as measured by the OSHA reference method and as averaged over at least 18 personal samples.

[D] Wet Method

(1) A spray bottle, hose nozzle, or other implement capable of delivering a fine mist of water or amended water or other delivery system capable of delivering water at low pressure, shall be used to first thoroughly wet the brake and clutch parts. Brake and clutch components shall then be wiped clean with a cloth. Any wastewater generated must be captured and properly disposed of without allowing it to dry on any surfaces.

(2) The cloth shall be placed in an impermeable container, labeled according to paragraph (j)(4) of the standard and then properly disposed of as an asbestos waste, or the cloth shall be laundered in a way to prevent the release of asbestos fibers in excess of 0.1 fiber per cubic centimeter of air.

(3) Any spills of solvent or any asbestos containing waste material shall be cleaned up immediately according to paragraph (k) of this section.

(4) The use of dry brushing during the wet method operations is prohibited.

[59 FR 40964, Aug. 10, 1994; 60 FR 33972, June 29, 1995; 77 FR 17778, March 26, 2012]

For more information, visit www.osha.gov, or call OSHA at 1-800-321-OSHA(6742), TTY 1-877-889-5627.

*References to OSHA, NIOSH, MSHA, and EPA, which are regulatory agencies in the United States, are made to provide further guidance to employers and workers employed within the United States. Employers and workers employed outside of the United States should consult the regulations that apply to them for further guidance.
Service Precautions

⚠️ DANGER

• ALWAYS WEAR PROPER EYE PROTECTION AND OTHER REQUIRED PERSONAL PROTECTIVE EQUIPMENT TO PREVENT PERSONAL INJURY WHEN PERFORMING VEHICLE SERVICE.

• WORK IN A WELL-VENTILATED AREA.

• NEVER USE GASOLINE, OR SOLVENTS CONTAINING GASOLINE. GASOLINE CAN EXPLODE.

• DO NOT USE HOT SOLUTION TANKS OR WATER AND ALKALINE SOLUTIONS TO CLEAN GROUND OR POLISHED PARTS. DOING SO WILL CAUSE DAMAGE TO THE PARTS.

• USE HOT SOLUTION TANKS OR ALKALINE SOLUTIONS CORRECTLY. READ THE MANUFACTURER’S INSTRUCTIONS BEFORE USING HOT SOLUTION TANKS AND ALKALINE SOLUTIONS. THEN CAREFULLY FOLLOW THE INSTRUCTIONS.

• SOLVENT CLEANERS CAN BE FLAMMABLE, POISONOUS, AND CAUSE BURNS. EXAMPLES OF SOLVENT CLEANERS ARE CARBON TETRACHLORIDE, EMULSION-TYPE, AND PETROLEUM-BASED CLEANERS. READ THE MANUFACTURER’S INSTRUCTIONS BEFORE USING A SOLVENT CLEANER, THEN CAREFULLY FOLLOW THE INSTRUCTIONS. ALSO FOLLOW THE PROCEDURES BELOW.

• PLACE THE VEHICLE ON A LEVEL FLOOR AND CHOCK THE WHEELS TO HELP PREVENT THE VEHICLE FROM MOVING. NEVER WORK UNDER A RAISED VEHICLE SUPPORTED BY ONLY A FLOOR JACK. ALWAYS SUPPORT A RAISED VEHICLE WITH SAFETY STANDS. CHOCK THE WHEELS AND MAKE SURE THE UNIT WILL NOT ROLL BEFORE RELEASING BRAKES. A JACK CAN SLIP OR FALL OVER. SERIOUS PERSONAL INJURY CAN RESULT.

• IMPROPER JACKING AND SUPPORT METHODS CAN CAUSE STRUCTURAL DAMAGE THAT RESULTS IN LOSS OF VEHICLE CONTROL, SEVERE PERSONAL INJURY OR DEATH. REFER TO THE VEHICLE MANUFACTURER FOR PROPER JACKING AND SUPPORT METHODS.

⚠️ WARNING

FOLLOW THE SPECIFIED PROCEDURES IN THE INDICATED ORDER TO AVOID PERSONAL INJURY OR EQUIPMENT MALFUNCTION/DAMAGE.

BEFORE STARTING A VEHICLE:

• Sit in the driver’s seat
• Place shift lever in neutral
• Set the parking brake

BEFORE WORKING ON A VEHICLE OR LEAVING THE CAB WITH ENGINE RUNNING:

• Place shift lever in neutral
• Set the parking brake
• Chock the wheels

WHEN PARKING THE VEHICLE OR LEAVING THE CAB:

• Place shift lever in neutral
• Set the parking brake

⚠️ CAUTION

• DO NOT RELEASE THE PARKING BRAKE OR ATTEMPT TO SELECT A GEAR UNTIL THE AIR PRESSURE IS AT THE CORRECT LEVEL.

• TO AVOID DAMAGE TO THE TRANSMISSION DURING TOWING:

• Place shift lever in neutral
• Lift the drive wheels off of the ground or disconnect the driveline

• DO NOT OPERATE VEHICLE IF ALTERNATOR LAMP IS LIT OR IF GAUGES INDICATE LOW VOLTAGE.

Omissions

Every effort has been made to ensure the accuracy of all information in this manual. However, AxleTech makes no expressed or implied warranty or representation based on the enclosed information. Any errors or omissions may be reported to AxleTech, 1400 Rochester Road, Troy, Michigan, 48083 USA.
Repair Warnings

DANGER

USE OF OTHER THAN RECOMMENDED TOOLS, PARTS, AND INSTRUCTIONS LISTED IN THIS PUBLICATION MAY PLACE THE SAFETY OF THE SERVICE TECHNICIAN OR VEHICLE DRIVER IN JEOPARDY.

DO NOT WELD REPAIR, HEAT, BEND OR RECONDITION AXLE COMPONENTS. THIS WILL REDUCE COMPONENT STRENGTH, VOID AXLETECH’S WARRANTY, AND CAN RESULT IN SERIOUS PERSONAL INJURY AND DAMAGE TO COMPONENTS. ALWAYS REPLACE DAMAGED OR OUT-OF-SPECIFICATION COMPONENTS.

- When disassembling various assemblies, lay all parts on a clean bench in the same sequence as removed to simplify assembly and reduce the possibility of losing parts.
- Provide a clean work area. Make sure no dirt or foreign material enter the unit during repair and assembly.
- Disconnect the vehicle’s battery before removing or installing electronic parts.
- The location of components varies with each OEM.
- The removal and installation procedure described for each component may vary between vehicles.
- Use a rubber mallet for disassembly and assembly procedures. NEVER hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.
- Remove nicks, marks, and burrs from parts having machined or ground surfaces. Use a fine file, India stone, emery cloth or crocus cloth for this purpose.

Torque Specifications

- Tightening torque specifications indicated in this manual must be adhered to at all times.
- A tightening torque weaker than indicated may lead to a shearing stress and may break the bolt.
- A stronger tightening torque may lead to yielding of the bolt or an increasing risk of cracking.

Damaged Components

- All damaged components must be replaced by new components.
- Clean and repair the threads of fasteners and holes. Use a die or tap of the correct size or a fine file for this purpose.
- Replace any fastener if corners of the head are worn.
- Since the cost of a new part is generally a small fraction of the total cost of downtime and labor, avoid reusing a questionable part that could lead to additional repairs and expense.
- Always use genuine AxleTech replacement parts.

Cleaning

1. Remove gasket material using a gasket scraper taking care not to damage machined surfaces.
2. Steam clean or pressure wash the assembly after plugging all breathers and vents.

NOTE: NEVER direct full pressure at any of the seals (input shaft, wheel hubs, or brakes).
3. Use solvent cleaners or alkaline solutions to clean all metal parts with rough surfaces. Rinse alkaline solution off with water after cleaning.
4. Use solvent cleaners and a brush to clean all metal parts that have ground or polished surfaces.

NOTE: NEVER clean ground or polished surfaces with water, steam, alkaline solution, or place in a hot tank.
5. Dry all parts after washing using clean rags or paper towels.
6. Apply a light oil film to all parts to be reused and reassembled.
7. If parts are being stored after cleaning, apply a corrosion-preventive material to all machined surfaces. Store the parts in a special paper or other material that prevents corrosion.
Introduction to Parts Analysis

This publication provides a parts analysis process to determine why parts failed during operation, what to look for when inspecting parts, and how prevent failures from occurring again. Figure 1.1, Figure 1.2, and Figure 1.3 are examples of failed parts.

Most of the time, answers can be found by visually inspecting a failed component. Sometimes, however, this process may require specialized knowledge or equipment.

Also, why a product failed can be difficult to determine, because a failure can vary in appearance from vehicle to vehicle. Failures in models from the same manufacturer can also vary, so it is important to use the information presented here as a guide, not a rule, when performing parts analysis inspections.

Types of Wear

Normal Wear

Components that are operated correctly, and inspected and maintained at recommended intervals, will eventually wear under normal operating conditions. This is called “normal” wear.

Premature Wear

Components can wear prematurely and fail when a vehicle is operated under the following conditions.
Premature Wear & Component Failure Causes

**A Vehicle is Not Operated Correctly, or is Operated Abusively**

When a driver operates a vehicle incorrectly, or operates it abusively, components can fail immediately. Often, however, damaged components will continue to operate, but fail at a later time — even under normal operating conditions.

For example, when a driver speeds up the engine and rapidly releases the clutch (“popping the clutch”), or allows a vehicle’s spinning wheel to hit dry pavement, it causes an immediate load, or force, to the driveline. Component failure can occur immediately, or at a later time. Figure 1.4 and Figure 1.5.

---

**Improper Maintenance Practices**

Premature wear and damage to components will result if a vehicle is not correctly maintained according to AxleTech recommended maintenance intervals and lubricant specifications. For example, the lubricant is not specified by AxleTech; the lubricant is contaminated; or there’s insufficient lubricant or no lubricant at all in the system.

For example, lubricant contaminated with water, dirt or wear particles will damage the mating surfaces of components, particularly bearing surfaces. Other areas of concern are seals and breathers. Figure 1.6.
**A Vehicle is Operated Outside Application, Equipment, and Load Limits Approved by AxleTech**

Components must be operated within the application guidelines specified by AxleTech. Otherwise, AxleTech must approve applications for vehicles operated outside these guidelines.

AxleTech has four application types: line-haul, general service, heavy service, and restricted service. The descriptions in the table below are typical for these types.

<table>
<thead>
<tr>
<th>Application</th>
<th>Miles Per Year</th>
<th>Operating Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line-haul</td>
<td>High mileage (over 60,000)</td>
<td>A vehicle operates on well-maintained major highways of concrete or asphalt construction with greater than 30 miles between starting and stopping.</td>
</tr>
<tr>
<td>General Service</td>
<td>Less than 60,000</td>
<td>A vehicle operates mostly on-road (less than 10% off-road) and averages two stops and starts per mile.</td>
</tr>
<tr>
<td>Heavy Service</td>
<td>Less than 60,000</td>
<td>A vehicle operates both on- and off-road (10% or more off-road) with moderate-to-frequent stops and starts averaging up to 10 stops per mile.</td>
</tr>
<tr>
<td>Restricted Service</td>
<td>Low mileage</td>
<td>Usually these vehicles are not licensed for highway use, are restricted to 15 mph, and average six stops and starts per mile.</td>
</tr>
</tbody>
</table>
Investigative Guidelines

When visually inspecting damaged components, a common error is to assume the first damaged component found is likely responsible for the failure. Instead of being the cause of the failure, the damaged component may actually be the result of the failure.

A positive way to conduct a failure analysis inspection is to use an investigative approach. Below are guidelines to conduct a failure analysis inspection.

Record Findings

Before beginning, be prepared to record all the results obtained from asking questions, observing, and inspecting damaged parts.

Ask Questions

Speak to People

Try to speak to the vehicle’s operator, the driver who recovered the vehicle, and the repair technician. If an accident occurred, try to talk to those people knowledgeable about the circumstances. A person who’s witnessed the failure can provide important information, but it is important to listen objectively to all reports.

About Damaged Parts

Did components fail over time or instantaneously? Were components stressed by cyclic overload?

What component or part failed first? Was the failure a result of a vehicle system failure? What’s the torque rating of the failed component?

Was the component repaired recently? Is it possible to speak to the technician who repaired the component?

Verify the weather and road conditions at the time of the failure. Was the vehicle involved in an accident? If so, is it possible to see the accident report or talk to witnesses?

About the Vehicle

Determine if the vehicle was towed or driven to a garage for repair. Was it connected to a trailer, or had the vehicle just been connected to a trailer?

What’s the vehicle’s in-service date and application type?

Verify the vehicle’s application and length of service. Check the vehicle’s mileage.

What were the vehicle’s static and dynamic loading conditions? Is there evidence of cyclic loading or torsional vibration?

Was the vehicle maintained correctly? Check the vehicle’s service and maintenance logs, as well as the types and brands of grease and oil used. Are the lubricants the correct specification approved by AxleTech?

Check the vehicle’s overall condition. Look for grease and oil leaks. Look for signs of abuse and recent repair. Check tire wear. Where possible, remove inspection plates, access doors and top covers to find potential component damage in these areas.

Is the vehicle covered with mud? Does it look as if it has recently been powerwashed? If so, the vehicle may have been operated in an application not approved by AxleTech.

Is the vehicle equipped with a lift axle, and was it in use at the time of the failure? Does the vehicle have multiple retarders?

Preparing Parts for Inspection

NEVER clean parts before inspecting them. Parts should be left in their failed condition and position. If possible, the parts should remain with the vehicle; and if outdoors, protected from rain, contaminants, sand, etc.
Inspect Damaged Parts

Collect the damaged parts. This includes AxleTech components, as well as those from other manufacturers. Assemble components into their original working order.

If there’s only one failure point or damaged component, begin the inspection there. If there’s more than one, inspect each component individually.

Inspect the areas around components. Try to determine the failure type. Was it surface or fatigue fracture? Shock load? Was the failure caused by insufficient lubrication or an incorrect lubricant? Was the failure caused by spinout?

Thoroughly inspect components for witness marks indicating why a component failed. Check for signs of vehicle abuse.

When inspecting a gear box that is still assembled, check the end play, backlash, tooth contact pattern, runout, etc.
Failure Types and Terminology

This section provides descriptions of part failure types, as well as, parts analysis terminology used in the field to describe conditions causing components to fail.

Beach Marks

Beach marks result from a fatigue fracture and indicate the progressive positions of an advancing fracture. Beach marks appear as irregular curved rings radiating from one or more origins. They are typically found on fractures caused by periodic or prolonged stress from load applications.

Beach marks represent fatigue cycles that occurred before the component failed completely. Visually, beach marks are often compared to the rippling effect of a stone thrown into calm water. Figure 3.1.

Bending Fatigue (Fatigue Fracture)

Bending occurs when a shaft is subjected to both torsional and bending fatigue at the same time. Beach marks form and usually point toward the origin of the fracture, which represents fatigue fracture cycles that occurred before the component failed completely. Figure 3.2 shows beach marks on an axle shaft as a result of bending fatigue.

Bending fatigue also causes gears to change position, which affects tooth contact patterns. Figure 3.3 shows concentrated loading at gear teeth corners instead of over the entire surface. Figure 3.4 shows two tooth patterns on the ring gear, because bending fatigue caused the gear to change position.
Figure 3.5 shows what happens when parts are under bending fatigue. When the load is large, failure can occur within a few load cycles. As the load becomes smaller, more load cycles are required before failure will occur. When the load becomes even smaller, the part can withstand load cycles without damage. See “Reverse Bending Fatigue (Fatigue Fracture)” on page 15.

**Black Spots**

See “Hot Spotting (Black Spots)” on page 13.

**“Blue” Brake Drum**

Very high operating temperatures can cause the inside of the brake drum to turn a blue color, which usually indicates the drum is damaged.

**Brake Compounding**

The parking brake and service brake apply at the same time, which can occur if a vehicle is not equipped with an anti-compounding valve, or the anti-compounding valve malfunctions.
**Brinelling (Surface Fatigue)**

Brinelling causes bearing rollers to wear deep grooves into the mating surface. Brinelling of a u-joint usually occurs when load applications exceed the vehicle’s rating, which can also cause parts to spall from uneven load application. Figure 3.6.

Brinelling can also be caused by overloads on undersized u-joints and by a breakdown of lubricant between the needle rollers and trunnion. To determine if the condition is brinelling, check the trunnions with fingertips. Can deep grooves be felt? If so, brinelling has occurred.

“False” brinelling, also a type of surface fatigue, causes the needle rollers to polish the trunnion surface, unlike brinelling, which causes the rollers to wear deep grooves into the trunnion surface. To determine if the condition is “false” brinelling, check the trunnion with a fingertip. Can deep grooves be felt? If not, the condition is “false” brinelling, the trunnion isn’t damaged and the u-joint is still usable.

**Bruising (Surface Fatigue)**

Bruising is a type of surface fatigue similar to brinelling, which causes dents in a metal surface. Metal chips or large particles of dirt circulate in the lubricant and become trapped between the bearing cone, cup and rollers. Figure 3.7.

**Burnish (Brakes)**

The process of “breaking-in” new brake pads or shoes, so the linings conform to the disc or drum friction surfaces.

**Chevron Wear Pattern**

A chevron pattern contains V-shaped radial marks on a brittle fracture surface, usually on parts whose widths are considerably greater than their thickness. Also called a herringbone pattern, the points of the chevrons identify a fracture’s path by pointing toward its origin. A chevron pattern is easily visible as a result of an instantaneous failure, but they can be seen on some fatigue failures as well. Figure 3.8.
Crack-Pressure

In a brake system, crack-pressure is the amount of air pressure (in psi) an air valve requires before air is able to flow through it. A vehicle uses air valves with varying crack-pressures to maintain brake balance between all wheel ends.

Crow’s Footing (Surface Fatigue)

Crow’s footing runs lengthwise on hypoid and amboid bevel gear teeth and occurs when the vehicle operates with insufficient or incorrect lubricant.

Metal-to-metal contact occurs, which causes friction to damage parts. Figure 3.9 & Figure 3.10.

Crystalline Wear Pattern

When a sudden, severe impact load occurs, the wear pattern on the surface of the part resembles crystal facets. Figure 3.11.
Etching (Surface Fatigue)

Etching corrodes metal and leaves a dull stain on a part’s surface, because the lubricant was contaminated with water. Water can enter the carrier through breathers, or a damaged or worn seal, or as condensation from humid weather.

Water in lubricant damages bearing races and cups, and causes the hypoid gear set to wear prematurely. Figure 3.12 shows corrosion on the spigot bearing roller ends. Figure 3.13 shows etching damage on the bearing rollers, non-contact surfaces and bearing cage windows.

Figure 3.12

Figure 3.13

Extreme Pressure (EP) Additives

AxleTech axles require lubricants to contain a GL-5 level of extreme pressure (EP) additives, which protect heavily loaded parts from surface fatigue, scoring, and galling.

Fatigue Fracture

Types of fatigue fractures include bending, reverse bending, torsional fatigue and root beam fatigue.

A fatigue fracture can be caused by cyclical torque overloads on a component, torsional vibration, twisting, and bending. A fracture begins at one or more points, identified by the ratchet marks and subsequent beach marks on the part. Figure 3.14.

In an axle assembly, a fatigue fracture is a common failure type. A typical fracture begins when a load cycle is large, and failure will occur after only a few load applications. Reducing torque load will postpone imminent failure; however, repeated load cycles will gradually weaken a component, and it will fail.

Some common types of fatigue in an axle assembly are surface (contact) fatigue, which affects bearings and gear teeth; torsional fatigue, which affects axle shafts; bending fatigue, which affects gear teeth and axle shafts; and root beam fatigue, which affects gear teeth.
Flank Cracking (Surface Fatigue)

Flank cracking is a type of surface fatigue similar to spalling, because it causes metal to break into chips or fragments. When flank cracking occurs, initially cracks form along the length of the gear tooth. Once flank cracking appears, the tooth begins to crumble, and failure rapidly occurs. Figure 3.15.

Fretting (Surface Fatigue)

Fretting is a type of surface fatigue similar to brinelling. Fretting, which is caused by torsional vibration, forms sludge on a gear at or near the vibration point. The color of the sludge depends on the quality of the lubricant and type of iron oxide formed during torsional vibration. “Red mud” or “cocoa” sludge is abrasive and increases component wear.

Inspect the back of the gear teeth on the forward drive axle carrier. If a contact line is found on the rear side of the gear teeth on the forward drive axle carrier, fretting has occurred. Figure 3.16.

Frosting

Frosting is a normal wear condition on spur gear teeth that does not affect performance or gear life. Differences in gear tooth manufacturing tolerances cause teeth in a gear set to have different profiles. During operation, gear teeth attempt to conform to a common gear tooth profile, and frosting wear occurs.

Frosting is a grayish or yellowish white color usually found at the center of the teeth at the mating gear contact position. Light pitting on the gear teeth also may accompany frosting. As the gear continues to operate, sliding friction eventually removes frosting.

Offset frosting has the same characteristics as frosting, but appears at one side of the gear face. Offset frosting is caused by a difference in the gear tooth contact face from one side to the other, or from a slight shift in gear set loading. As the gear continues to operate, sliding friction eventually removes frosting.
Galling (Surface Fatigue)

Galling is a type of surface fatique occurring when two unlubricated metal surfaces rub against each other. Galling is also called “metal transfer.” Figure 3.17.

A similar type of galling is called “scuffing.” Scuffing causes a bearing to wear prematurely and eventually fail. Figure 3.18 shows flat spots on the rollers and scoring on the rest of the assembly, which indicate the scuffing damage.

Gear Ratio and Torque Multiplication

Gear ratio is the relationship between the number of turns made by a driving gear to complete one full turn of a driven gear. If a smaller driving gear has to turn three times to turn a larger driven gear once, the gear ratio is 3:1.

With a 3:1 ratio and an engine torque of 1,600 lb-ft, the gears have multiplied torque to 4,800 lb-ft (3:1) to rotate parts. How much torque is multiplied always depends on the size relationship between the driving and driven gears.

Gross Axle Weight Rating (GAWR)

The gross axle weight rating (GAWR) is an axle’s maximum allowable weight-carrying capacity.

Gross Combined Weight (GCW)

The gross combined weight (GCW) is a vehicle’s total weight plus fuel, driver, trailer, and payload. Figure 3.19.

Gross Combined Weight Rating (GCWR)

The gross combined weight rating (GCWR) is a vehicle’s maximum allowable load rating. A vehicle’s GCWR typically will be higher than its GVWR, because gross vehicle weight ratings are determined by axle ratings, and a trailer has its own axles.

Gross Vehicle Weight (GVW)

The gross vehicle weight (GVW) is the vehicle’s total weight, fuel, fluids, and full payload. Figure 3.19.

Gross Vehicle Weight Rating (GVWR)

The gross vehicle weight rating (GVWR) is a vehicle’s maximum allowable weight rating, which includes a vehicle’s total weight, fuel, fluids, and full payload.
Failure Types and Terminology

Heat Checking

Heat checking is fine lines or cracks on the surface of a brake drum or rotor. Even though heat checking is a normal condition resulting from a friction surface heating and cooling repeatedly, it is important to recognize when cracks on the surface of the drum or rotor indicate damage has occurred.

Under high temperatures or overload conditions, larger cracks can develop and extend below the surface. Several heat checks aligned across the braking surface require drum replacement. Cracks that align and approach the barrel area of the rotor, or lead to the vent area, require rotor replacement.

Hot Spotting (Black Spots)

Hot spotting (black spots) can appear on a brake drum’s surface uniformly (over the entire surface), on only one side or in three equidistant areas. Hot spotting requires drum replacement.

Hypoid Ring Gear Teeth

The “drive” side, or front side, of the ring gear teeth is where the tooth contact pattern is checked, because it is the side of the teeth driving the vehicle down the road under power.

The “coast” side, or back side, of the ring gear teeth, only contacts the pinion when a vehicle is decelerating; for example, when driving down a hill.

Imbalance (Brake)

Brake imbalance occurs when one or more wheel end brakes do not perform to its designed capacity. Brake imbalance can result from pneumatic or mechanical defects in the brake system.

Impact Fracture

See “Shock Load (Impact Fracture)” on page 16.

Load Cycle

A load cycle is the amount of torque delivered by the engine to drivetrain components over a period of time.

Mismatched Tandem Axle Ratios

To function correctly, the forward and rear axles must operate with axle ratios plus or minus one percent of each other. A mismatched tandem axle pair can cause the carrier to overheat, lubricant additives to deplete and axle components to wear prematurely.

Mismatched Tires (Drive Axle)

Mismatched tires can cause excessive differential component wear. AxleTech recommends matching tires to within 1/8” (3.175 mm) of the same rolling radius and 3/4” (19.05 mm) of the same rolling circumference. In addition, the total tire circumference of both driving axles should be matched to each other as closely as possible. Figure 3.20.
Normal Wear

Components that are operated correctly, and inspected and maintained at recommended intervals, will eventually wear under normal operating conditions. This is called “normal” wear.

See “Premature Wear” on page 14.

Offset Frosting

See “Frosting” on page 11.

Origin Point

An origin point is the location where a fracture began. A part can have a single origin point or multiple origin points.

Pitting (Surface Fatigue)

Pitting is a type of surface fatigue that forms pits, or cavities, on metal surfaces. Initially, pits may be the size of a pinhead, or even smaller. If unchecked, pitting will progress until pieces of the surface metal break from a component (“spalling”) and enter the axle lubrication system.

Cyclic overloading and contaminated lubricant can damage bearing cups and rollers, and hypoid gearing. Localized pitting on drive pinion teeth can sometimes indicate another axle component is operating out-of-position. Figure 3.21.

Premature Wear

Premature wear occurs when components are insufficiently or incorrectly lubricated. Operating a vehicle outside of approved equipment, load, and application limits, incorrectly, or abusively are other causes of premature wear.

See “Normal Wear” on page 14.
Ratchet Marks

When more than one fatigue fracture occurs, beach marks form and create a raised, rough “ridge” between the origins of the fractures. This ridge is called a “ratchet mark.” In this figure, the ratchet mark can be seen between the first fracture, (Origin 1), and the second fracture, (Origin 2). Figure 3.23.

Reverse Bending Fatigue (Fatigue Fracture)

Reverse bending is a type of fatigue that breaks a component in two directions, 180° apart. Beach marks occur on each side of the fractured area and move toward the center of the component. Figure 3.24.

Root Beam Fatigue (Fatigue Fracture)

Root beam fatigue causes beach marks to originate at or near the base of a gear tooth. These marks start with a cracked or damaged tooth by an instantaneous shock load or repeated torque overloads, which causes localized cracks in the gear tooth roots. As mileage accumulates, initial hairline cracks expand, and gear teeth weaken progressively and ultimately break.

Figure 3.25 shows a less common root beam fatigue fracture that occurred when shock load was strong enough to crack the tooth, but not to break the entire tooth.

Scoring

Scoring is grooves or deep scratches on the surface of a brake drum caused by metal-to-metal contact from worn brake pads or shoes, or debris caught between the friction material and the friction surface.

Scuffing (Galling)

See “Galling (Surface Fatigue)” on page 12.
Shock Load (Impact Fracture)

Shock load, also called an “impact fracture,” is a sudden and powerful force applied against a component. Shock load can destroy or damage a component immediately. Often, however, a component damaged by shock load will continue to operate, but it will wear prematurely or fail soon after the initial shock load has occurred.

Torsional shock load results when a rapidly-applied twisting motion occurs; for example, when an excessive amount of torque is delivered to an axle shaft.

Some Causes of Shock Load

- An operator backs under a trailer with excessive force. A vehicle’s spinning wheel hits dry pavement. An operator misses a shift.
- An operator speeds up the engine and rapidly releases the clutch (“popping the clutch”), which causes an immediate force, or load, to the driveline.
- An operator locks the inter-axle differential (IAD) when the wheels are spinning, which can damage the clutch collar and mating shaft splines, and other carrier components.

Figure 3.26 shows a pinion gear damaged by shock load. The fracture has a rough, crystalline appearance and is broken at a 45° angle.

Figure 3.27 shows a hypoid gear seat damaged by shock load. Typically, the first tooth breaks at the heel, the second tooth breaks completely, and the third tooth breaks at the toe. The figure shows how two of the teeth were damaged by the pinion rubbing against the area where the teeth broke.

Figure 3.28 and Figure 3.29 show an axle shaft damaged by shock load that fractured perpendicular to its centerline, which caused a rough, crystalline surface to form on the shaft. This type of failure is also called “torsional shear.” If the fracture is at a 45° angle to the centerline, the damage is called “torsional tensile” failure.
Spalling (Surface Fatigue)

When the metal surface of a component breaks into chips or fragments as a result of wear fatigue, the condition is called “spalling.” Spalling is a type of surface fatigue and is evident in the advanced stages of pitting, which is the beginning of surface fatigue. On u-joint trunnions, spalling usually affects those opposite each other. Spalling also damages transmission spur gear teeth. Starting as small pitted areas, spalling can progress rapidly.

Some causes of spalling are prolonged stress from excessive load applications; or the components operate with no lubricant or a lubricant that does not meet the correct specification. Spalling can also occur when components are operated beyond the maximum mileage range. Figure 3.30 and Figure 3.31.

Spinout

Spinout, also called “excessive differentiation,” typically occurs when a tandem axle loses traction, and the IAD is in the unlocked position.

During spinout, the differential pinions spin at a high rate of speed, which causes the pinions to be insufficiently lubricated. Heat created from friction between the differential pinion gears and cross legs can damage the axle.

Other causes of spinout, or excessive differentiation, are mismatched tires and mismatched tandem axle ratios.
Stress Riser

A stress riser is a condition caused by fatigue that deforms metal on a component's surface. For example, welding on an axle creates intense heat changing the characteristics of the metal surrounding the weld, and the incorrect weld caused fatigue to occur. In Figure 3.32, one can see fatigue has created a stress riser, which caused the axle to fail.

Surface (Contact) Fatigue

Surface (contact) fatigue is a broad classification for a number of different types of damage that can occur on the load-carrying surface of a component. Types of surface fatigue include pitting, spalling, flank cracking, galling, crow’s footing, scuffing, etching, bruising, fretting, and brinelling.

Surface fatigue is usually caused by cyclic overloading on bearings or gear teeth, and contaminated lubricant can accelerate surface fatigue. Figure 3.33 and Figure 3.34.

Torque

Torque is a turning or twisting force that may or may not produce motion. For example, engine power applies torque to the driveline; the driveline delivers torque to the drive axles; the vehicle moves. The difference between torque and horsepower: Torque may or may not produce motion. However, motion is always required to produce horsepower. Torque is usually measured in lbs. ft.
Torsional Fatigue (Fatigue Fracture)

Unlike bending fatigue, torsional fatigue causes excessive twisting that weakens components. Usually, beach marks and ratchet marks can be seen at the fracture’s origin point. However, if torsional fatigue occurs on a splined shaft, one will see the fracture started at the base of each spline. Figure 3.36 shows a driveshaft damaged by torsional fatigue. As the splines continued to weaken, the metal formed a star-shaped radial pattern, eventually breaking the shaft at the center.

Figure 3.36

Torsional Vibration

Torsional vibration is a twisting and untwisting action in a shaft caused by the application of engine power (torque) or incorrect driveline phasing or angles. Torsional vibration can cause premature wear damage to all drivetrain components.

Witness Marks

Witness marks are evidence of fatigue (beach marks, ratchet marks, for example), abusive machining, burn marks, corrosion, wear damage, etc.

Working Angle

When two driveline components intersect at a cardan u-joint, the angle formed is called a “working angle.”
Drive Axles

Parts Analysis Overview

⚠️ **DANGER**

**ALWAYS WEAR PROPER EYE PROTECTION AND OTHER REQUIRED PERSONAL PROTECTIVE EQUIPMENT TO PREVENT PERSONAL INJURY WHEN INSPECTING HEAVY VEHICLE COMPONENTS.**

This section provides a parts analysis process to determine why drive axle components fail during operation, what to look for when inspecting parts, and how to prevent failures from occurring again.

Most of the time, answers can be found by visually inspecting a failed component. Sometimes, however, this process may require specialized knowledge or equipment.

Also, why a product failed can be difficult to determine, because a failure can vary in appearance from vehicle to vehicle. Failures in models from the same manufacturer can also vary, so it is important to use the information presented here as a guide, not a rule, when performing parts analysis inspections.

### Causes of Drive Axle Component Failure

<table>
<thead>
<tr>
<th>Application</th>
<th>Operating Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver operates a vehicle incorrectly or abusively</td>
<td>Fatigue fracture, shock load, spinout, overheated lubricant</td>
</tr>
<tr>
<td>Driver excessively “rocks” the vehicle</td>
<td>Fatigue fracture, shock load</td>
</tr>
<tr>
<td>Vehicle’s spinning wheel hits dry pavement</td>
<td>Fatigue fracture, shock load</td>
</tr>
<tr>
<td>Vehicle operated outside AxleTech approved application or vocation capabilities</td>
<td>Fatigue fracture, galling, spalling, shock load, overheated lubricant</td>
</tr>
<tr>
<td>Driver misses a shift</td>
<td>Fatigue fracture, shock load</td>
</tr>
<tr>
<td>Driver speeds up the engine and rapidly releases the clutch (“popping the clutch”)</td>
<td>Fatigue fracture, shock load</td>
</tr>
<tr>
<td>Driver locks the IAD when the wheels are spinning</td>
<td>Fatigue fracture, shock load</td>
</tr>
<tr>
<td>Vehicle operated with mismatched tire ratios, mismatched tandem axle ratios, or both</td>
<td>Spinout, galling, overheated lubricant</td>
</tr>
<tr>
<td>Driver backs under a trailer with excessive force</td>
<td>Fatigue fracture, shock load</td>
</tr>
<tr>
<td>Vehicle modified from its original configuration without AxleTech approval</td>
<td>Fatigue fracture, galling, spalling, shock load, overheated lubricant</td>
</tr>
<tr>
<td>Improper maintenance practices</td>
<td></td>
</tr>
<tr>
<td>Component lubricated with incorrect lubricant</td>
<td>Lubricant overheats, fatigue fracture, galling (crow’s footing), pitting</td>
</tr>
<tr>
<td>Contaminated lubricant</td>
<td>Pitting, etching, spalling, overheated lubricant</td>
</tr>
<tr>
<td>Low lubricant levels</td>
<td>Lubricant overheats, fatigue fracture, galling (crow’s footing), pitting</td>
</tr>
</tbody>
</table>
Vehicle Operated Outside its Application or Vocation

Axles operated under conditions exceeding their design capacity can wear prematurely. Fatigue, which can result from load cycles that exceed the gross vehicle weight rating (GVWR) or gross combined weight rating (GCWR), can cause an axle to fail. Figure 4.1.

Exceeding an Axle’s Maximum Gross Axle Weight Rating (GAWR)

Operating a vehicle at a weight exceeding a carrier’s gross axle weight rating (GAWR) will damage components, because a carrier is rated for a specific application. For example, if a vehicle is operated on an unapproved road surface for the application, rolling resistance increases, and more torque is required to move the vehicle forward. Over a period of time, torque overload occurs and damages components. Figure 4.2.

Operational overload is a main cause of axle housing damage, which occurs when the vehicle is loaded in excess of its GAWR. When GAW increases, axle housing life decreases.

Axle Fatigue

Three types of fatigue are common to axle components: surface (contact) fatigue, which affects bearings and gear teeth; torsional fatigue, which affects shafts; and bending fatigue, which affects gear teeth and shafts.

The type of damage that occurs to components depends on the type of fatigue that occurs. Bearing and gear tooth damage from surface (contact) fatigue is different than damage to axle shafts caused by bending fatigue.

Surface (Contact) Fatigue

When the surface (contact) fatigue load is large, failure can occur within only a few load cycles, as shown by the breakdown line in Figure 4.3. As the load becomes smaller, the number of cycles required to destroy the part increases.

However, smaller load cycles will eventually result in a surface fatigue failure. The fatigue characteristics of bearings subject to surface loads also follow the breakdown line.

Figure 4.4 shows what happens when parts are under bending or torsional fatigue. When the load is large, failure can occur within a few load cycles. When the load becomes even smaller, the part can withstand load cycles without damage.

Gears are subjected to both bending and surface loads. Surface fatigue affects lightly loaded gears. As the load increases, damage is caused by bending fatigue.
Torsional Fatigue (Fatigue Fracture)
Unlike bending fatigue, torsional fatigue causes excessive twisting that weakens components. Usually, beach marks and ratchet marks will be seen at the fracture’s origin point. However, if torsional fatigue occurs on a splined shaft, one will see the fracture started at the base of each spline.

Figure 4.5 shows a shaft damaged by torsional fatigue. As the splines continued to weaken, the metal formed a star-shaped radial pattern, eventually breaking the shaft at the center.

Bending Fatigue (Fatigue Fracture)
Bending is a type of fatigue fracture occurring when a shaft is subjected to both torsional and bending fatigue at the same time. Beach marks form and usually point toward the origin of the fracture, which represents fatigue fracture cycles that occurred before the component failed completely. Figure 4.6 shows beach marks on an axle shaft indicating bending fatigue caused the fracture.

Bending fatigue also causes gears to change position, which affects tooth contact patterns. Figure 4.7 shows concentrated loading at gear teeth corners instead of over the entire surface. Figure 4.8 shows two tooth patterns on the ring gear, because bending fatigue caused the gear to change position.
Figure 4.9 shows what happens when parts are under bending fatigue. When the load is large, failure can occur within a few load cycles. As the load becomes smaller, the number of cycles required to damage the part increases. When the load becomes even smaller, the part can withstand load cycles without damage.
Driver Locks the IAD When the Wheels are Spinning

Spinout

Spinout (also called “excessive differentiation”) typically occurs when a tandem axle loses traction, and the inter-axle differential (IAD) is in the unlocked position. If an operator attempts to lock the IAD when the wheels are spinning, severe damage to the clutch collar, mating shaft splines and other carrier components will occur.

During spinout, the differential pinions turn at almost twice the speed of the driveshaft, which causes the pinions to be insufficiently lubricated. Heat created from friction between the differential pinion gears and cross legs can damage the axle. Figure 4.10 and Figure 4.11.

The inter-axle differential (IAD) is more susceptible to damage from spinout than the main differential, which operates at lower speeds and is submerged in oil.

In axles without an oil pump, centrifugal force displaces all of the oil between the cross and pinions, and heat created by friction causes these parts to seize. Sometimes differential pinions become so hot, they weld to the mating surfaces of the differential assembly.

Other causes of spinout include loss of traction when backing under a trailer, most often on wet and slippery pavement, or unpaved surfaces; starting on a slippery surface; operating on a slippery surface, especially on a hill or grade; and mismatched tire and tandem axle ratios.

Examples of Typical Spinout Damage

Pinion Cross Failure

Figure 4.12, Figure 4.13, Figure 4.14, Figure 4.15 and Figure 4.16 show how spinout caused a pinion cross to fail. Damage progresses from normal wear, to moderate premature wear, and then to heavy wear; and finally, the pinion cross fails.
Helical Gear Journal

Friction from spinout can cause galling at the helical gear journal and the rear side gear journal. Figure 4.17. If spinout damaged the rear side gear, perform this inspection.

Rear Side Gear

Figure 4.18 shows a rear side gear damaged by spinout. If the rear side gear bearing fails, signs of overheating on the outside of the carrier will be found.

Spinout also caused the rear side gear to weld to the input shaft, and the bearing is scored. This damage resulted from a spinning rear wheel and a stationary forward axle, which prevented the forward gear set from lubricating the rear side gear. Look for localized heat damage and burned lubricant. Figure 4.19.

Mismatched Tire Ratios

Mismatched tire ratios can cause spinout to occur. AxleTech recommends matching tires to within 1/8” (3.175 mm) of the same rolling radius and 3/4” (19.05 mm) of the same rolling circumference. In addition, the total tire circumference of both driving axles should be matched to each other as closely as possible. Figure 4.20.
**Mismatched Tandem Axle Ratios**

To function correctly, the forward and rear axles must operate with axle ratios within one percent. A mismatched tandem axle pair can cause the carrier to overheat, the hypoid gear set to wear, metal debris to collect on the magnetic drain plug, lubricant additives to deplete, and the axle to wear prematurely. Mismatched tandem axle ratios can also cause excessive differential component wear.

**Torsional Vibration**

Torsional vibration is a twisting and untwisting action in a shaft caused by intermittent applications of engine power or torque. However, severe torsional vibration can cause premature wear damage to drivetrain components, and incorrect driveline angles or out-of-phase drivelines can increase torsional vibration in a drivetrain.

**Excessive Force Resulting in Shock Load**

Shock load is a sudden and powerful force applied against a component. Shock load can destroy or damage a component immediately. Often, however, a component damaged by shock load will continue to operate, but it will wear prematurely or fail soon after the initial shock load occurred. Shock load causes components to crack and separate from each other. Look for a rough, crystalline finish on the separated parts. Figure 4.21 shows an axle shaft damaged by shock load.

Shock load causes components to crack and separate from each other. Look for a rough, crystalline finish on the separated parts. Torsional shock load results when a rapidly-applied twisting motion occurs; for example, when an excessive amount of torque is delivered to an axle shaft.

Some causes of shock load include:

- An operator backs under a trailer with excessive force. A vehicle’s spinning wheel hits dry pavement. An operator misses a shift.
- An operator speeds up the engine and rapidly releases the clutch (“popping the clutch”), which causes an immediate force, or load, to the driveline.
- An operator locks the IAD when the wheels are spinning, which can damage the clutch collar and mating shaft splines, and other carrier components.
Unapproved Vehicle or Powertrain Modifications

Unapproved modifications to a vehicle’s original configuration — for example, horsepower, torque, vocation, suspension, transmission ratio, axle ratio, retarders and tire size — can result in premature wear and damage to components, as well as unsafe operating conditions.

Improper Maintenance Practices

Premature wear and damage to components will result if a vehicle is not correctly maintained according to AxleTech recommended maintenance intervals and lubricant specifications. For example, the lubricant is not specified by AxleTech, the lubricant is contaminated, or there’s insufficient lubricant in the system.
Incorrect Lubricant

A lubricant not meeting AxleTech specifications will cause components to wear prematurely. AxleTech axles require lubricants to contain a GL-5 level of EP additives, which protect heavily-loaded parts from surface fatigue, scoring, galling, and welding of moving parts.

Installing a lubricant without EP additives causes hypoid gear teeth to wear to a thin edge. If detected early, a crow’s footing pattern will form on the gear teeth. Figure 4.26 and Figure 4.27.

Also, EP additives will deplete when a carrier overheats. For example, the EP additive in drive axle lubricant begins to deplete when the carrier’s temperature is consistently above 250°F (121°C). The higher the temperature, the faster the additive depletes. Crow’s footing, a result of overheating, causes lines and ridges to appear lengthwise on hypoid and amboid bevel gear teeth.

Figure 4.28, Figure 4.29, Figure 4.30, and Figure 4.31 show drive axle components damaged by burned lubricant and melted gear teeth.
Low Lubricant Levels

If a vehicle was insufficiently lubricated, damage can occur shortly afterward. Friction from parts generates heat and causes temperatures to increase considerably. If a vehicle was operated with no lubricant in the system, there will be damaged gear teeth, as well as bluing on parts, which resulted from high operating temperatures due to friction. Figure 4.32.

Low lubricant levels can result from leaking seals, which can be caused by a clogged axle housing breather. Figure 4.33.
Contaminated Lubricant

Lubricant contaminated with water, dirt, or wear particles will damage the mating surfaces of components, particularly bearing surfaces. Figure 4.34 and Figure 4.35. Other areas of concern are seals and breathers.

Inspect the Magnetic Fill/Drain Plug

The magnetic fill/drain plug must be inspected every time the oil is changed. Before reusing a drain plug, verify it can still lift at least 20 ounces of low carbon steel. If it can no longer lift 20 ounces of low carbon steel, the drain plug must be replaced.

Remove the magnetic fill/drain plug. Inspect the metal particles adhering to the plug. Use the guidelines here to determine if the metal particles found are fine (a normal condition) or larger (not a normal condition).

During maintenance procedures it is normal to find fine metal particles adhering to the magnetic fill/drain plug. These particles are generated under normal operating conditions, and the magnets attract the particles and prevent them from passing through the gear mesh or bearings.

However, larger metal particles adhering to the fill/drain plug, such as gear teeth, bearing fragments, thrust washer fragments and metal shavings, are not a normal condition.

It is important to be able to identify the differences between fine and large metal particles to determine how they occurred and what repairs may be required to prevent component damage.
How to Inspect the Magnetic Fill/Drain Plug

Fine Metal Particles

The fine metal particles attached to the magnetic plug in Figure 4.36 are normal. Internal components can shed fine metal wear particles at a steady rate, especially during the break-in period. In addition to the magnetic plugs, AxleTech axles are also equipped with four to six magnets in the housing to capture debris generated during extended maintenance intervals used today.

Thrust Washer Fragments

Figure 4.37 shows a main differential side gear thrust washer fragment. The loss of a fragment from the thrust washer is not detrimental to the operation of the axle and does not require disassembly, inspection and replacement of the axle.

If there is concern about additional fragments or component damage, perform an oil sample analysis. If the iron content of the sample is above 1,000 parts per million (ppm), inspect and repair the carrier as necessary.

Metal Shavings

Figure 4.38 shows metal shavings which are remnants from the housing machining process. Metal shavings adhere to the magnets and are not detrimental to the operation of the axle. It is not necessary to perform further inspections or remove the carrier for cleaning.

Bearing and Gear Tooth Fragments

Figure 4.39 and Figure 4.40 show bearing and gear tooth fragments. Both indicate a significant issue resulting in component damage. Immediately remove the carrier, inspect it, and perform required repairs.
Check the Oil Condition

Most drive axle oils are either golden brown or deep red in color. If the oil looks “milky brown” or has a “copper” color, the oil is contaminated. The oil samples in Figure 4.41 show how the lubricant may appear during inspection.

Sample 1: Red
Sample 2: Golden Brown

Both the red and golden brown samples show the typical appearance of new GL5 EP oils that meet the SAE J2360 specification. They usually are golden brown, but also can be red in color.

Sample 3: Black

This black sample is used-oil with significant time and mileage. The color change from red or golden brown to black is the result of a normal chemical process occurring as the additive package in the oil degrades. The black color does not necessarily indicate the oil’s useful life has been exhausted. Perform a lubrication analysis to verify the oil can still be used in the carrier.

Sample 4: “Milky” Brown

This “milky” brown sample indicates the oil is contaminated with significant moisture well above the allowable change specification of >0.3%. Change the oil immediately. Also try to determine how the moisture entered the assembly and consider extending the breathers on applications where this occurs.

Copper (Sample Not Shown)

A copper color indicates the drive helical support thrust washer may have disintegrated. Use care when evaluating the oil, as a copper color can be confused with the normal color of some oils. Perform a lubrication analysis to determine the amount of copper in the lubricant before performing a physical inspection.

- If the copper level is above 600 ppm: Remove the input shaft assembly and inspect the drive helical support thrust washer.
- If the copper level is 600 ppm or below: Continue to use the oil.

Table B: Used-Oil Analyses (ppm = parts per million)

<table>
<thead>
<tr>
<th>Component</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron (Fe)</td>
<td>If the level is 1000-1500 ppm, re-sample the oil.</td>
</tr>
<tr>
<td></td>
<td>If re-sampling indicates the iron level is above 1000 ppm, drain and replace the oil.</td>
</tr>
<tr>
<td></td>
<td>If the level is above 1500 ppm, drain and replace the oil.</td>
</tr>
<tr>
<td>Silicon (Si)</td>
<td>If the level is greater than 100 ppm, drain and replace the oil.</td>
</tr>
<tr>
<td>Water (H2O)</td>
<td>If the level is greater than 0.3%, drain and replace the oil.</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>If the level is less than 900 ppm, it is possible the oil is not a GL-5 gear oil. Contact the lubricant manufacturer or AxleTech Materials Engineering to determine the expected phosphorus level of a new oil sample. Only GL-5 type gear oils are approved for use in AxleTech differentials.</td>
</tr>
<tr>
<td>Toluene Insolubles</td>
<td>If the level is greater than 0.100 wt.%, drain and replace the oil.</td>
</tr>
</tbody>
</table>

Reasons Components Overheat

- Lubricant is added over the assembly’s fill line during maintenance procedures.
- The engine rating or torque rating was increased from the vehicle’s original specification.
- Air flow is restricted, which decreases ventilation through the system.
- A vehicle is operated with incorrect driveline angles or mismatched tires.
- A vehicle is operated with a low lubricant level or the incorrect lubricant.
Parts Analysis Process

This section provides a parts analysis process to determine why drive axle components failed during operation, what to look for when inspecting parts, and how prevent failures from occurring again. Failures causing primary damage are identified under What To Look For.

Bearing Adjusting Ring

Cause of Failure

Root beam fatigue damaged the drive pinion.

What To Look For

Primary Damage: Root beam fatigue caused the drive pinion teeth to fracture and penetrate the gear teeth. Figure 4.42.

The adjusting ring on the flange side of the carrier pushed outward at the cap-to-case area and bent the main differential bearing cap cotter pin. Figure 4.43.

Prevention

Operate the vehicle within its approved application and weight limits.
**Cause of Failure**

Shock load damaged the ring gear.

**What To Look For**

Primary Damage: Shock load fractured three adjacent teeth, causing them to penetrate the gear mesh. Figure 4.44.

The adjusting ring pushed out of the carrier cap assembly and bent the cotter pin 90°. Figure 4.45.

Marks on the adjusting ring are visible where it was clamped between the main differential bearing cap and the carrier case. Figure 4.46.

**Prevention**

Operate the vehicle within its approved application and weight limits. Teach drivers how to correctly operate a vehicle.
Drive Pinion Gear

Cause of Failure

The lubricant used did not meet AxleTech specifications. As a result, metal-to-metal contact of the ring and pinion gear occurred.

What To Look For

Primary Damage: Ring gear edges are worn thin and knife-like, and the hardened tooth surfaces no longer mesh with the pinion gear. Most likely, the lubricant installed did not meet GL-5 specifications, or high operating temperatures during operation depleted extreme pressure (EP) additives. Figure 4.47 and Figure 4.48.

Indications the correct amount of incorrect lubricant was installed: the gear set is fairly clean with little evidence of heat, burned lube is not observed, and the lubricant contains metal particles.

Prevention

Follow AxleTech recommended maintenance practices and service procedures.
Cause of Failure
Root beam fatigue damaged the drive pinion gear.

What To Look For
Primary Damage: Ring gear teeth are damaged. Figure 4.49.

Drive pinion teeth have fractured and broken from the pinion gear, and deep beach marks are visible starting at the roots. The pinion teeth were moderately overloaded over a period of time, until a final load caused them to break from the shaft. Figure 4.50.

Prevention
Operate the vehicle within its approved application and weight limits. Teach drivers how to correctly operate a vehicle.
Driver-Controlled Main Differential Lock (DCDL) Shift Collar

Cause of Failure
An operator locks the DCDL when the wheels are spinning, which causes shock load and damages the clutch collar and mating shaft splines.

What To Look For
Primary Damage: Axle shaft splines are twisted and distorted. Figure 4.51.
The DCDL collar is broken. Figure 4.52.

Prevention
Teach drivers how to correctly operate a vehicle.

Cause of Failure
An operator locked the DCDL when the wheels are spinning, which caused shock load to occur.

What To Look For
Primary Damage: The DCDL collar is broken into many pieces. Figure 4.53.
The shift fork leg is broken, and a rough, crystalline surface formed on the fracture. Figure 4.54.

Prevention
Teach drivers how to correctly operate a vehicle.
Flange-Side Main Differential Bearing

**Cause of Failure**

Cyclic overloading occurred. Recommended maintenance practices weren’t followed.

**What To Look For**

Primary Damage: Spalling will be present on the main differential bearing rollers and race on the outer side of the rollers. Figure 4.55.

Severe spalling will be present on the under-surface of the drive pinion teeth. Figure 4.56.

**Prevention**

Operate a vehicle within its approved application and weight limits. Follow AxleTech recommended maintenance practices and service procedures.
Axle Housings

Cause of Failure
The axles were loaded above specified limits for the application.

What To Look For
Primary Damage: The axle housings are fractured at the 10 o’clock position of the differential lock clearance notch. Figure 4.57.

The fractures originate at the inner rib flange, and run through the bowl weld and into the axle housing cover. Figure 4.58.

Prevention
Operate a vehicle within its approved application and weight limits.
Hypoid Ring and Drive Pinion Gears

Cause of Failure

The vehicle was operated with insufficient lubricant with depleted EP additives.

What To Look For

Primary Damage: Crow’s footing will be present on both the ring and drive pinion gears, which indicates a low lubricant level or lubricant with depleted extreme pressure (EP) additives. The lubricant is black and has a burned odor. Figure 4.59 and Figure 4.60.

There will be a large accumulation of burned lubricant on non-working surfaces.

Prevention

Follow AxleTech recommended maintenance practices and service procedures.
Hypoid Ring and Drive Pinion Gears

Cause of Failure

Coast or reverse side cyclic overloading occurred due to misapplication/misuse of the vehicle or excessive/incorrect use of the part-time 4x4 or 6x6 capability.

What To Look For

Primary Damage: Gear teeth on the pinion and ring gear are cracked or broken at the root with damage originating from the coast side of the gearing. Secondary damage such as broken gear teeth is present from loose parts entering the gearing. Figure 4.61.

Also, evidence of heavy loading on the coast side of parts may be seen in the following conditions.

The thrust screw, if equipped, is excessively worn, cracked or broken. Figure 4.62. The back face of the ring gear shows excessive contact wear from the thrust screw. Figure 4.63. Fretting is found between the differential case-to-case bolt holes. Figure 4.64.

Prevention

Operate the vehicle within its approved application and weight limits according to AxleTech Axle Application Guidelines and AxleTech Severe-Duty Operating Guidelines. To obtain this publication, refer to “Service Notes” on page ii.
**Drive Pinion Spigot Bearing**

**Cause of Failure**

Coast or reverse side cyclic overloading occurred due to misapplication/misuse of the vehicle or excessive/incorrect use of the part-time 4x4 or 6x6 capability.

**What To Look For**

Primary Damage: The spigot bearing is damaged or broken in pieces. The bearing rollers are deformed or dislodged. Figure 4.65. Closer examination reveals spalling present on the bearing surfaces. The differential case also shows secondary damage from contact with loose parts. Figure 4.66.

Also, evidence of heavy loading on the coast side of parts may be seen in the following conditions.

The thrust screw, if equipped, is excessively worn, cracked or broken. Figure 4.67. The back face of the ring gear shows excessive contact wear from the thrust screw. Figure 4.68. Fretting is found between the differential case-to-case bolt holes. Figure 4.69. Secondary gear damage such as broken gear teeth is present from loose parts entering the gearing. Figure 4.70.

**Prevention**

Operate the vehicle within its approved application and weight limits according to AxleTech Axle Application Guidelines and AxleTech Severe-Duty Operating Guidelines. To obtain these publications, refer to “Service Notes” on page ii.
Inner Drive Pinion Bearing

Cause of Failure

The vehicle was operated with insufficient lubricant with depleted EP additives.

What To Look For

Primary Damage: The inner pinion cage and rollers are destroyed. Insufficient lubricant or a low lubricant level caused friction and heat buildup, which depleted EP additives. Figure 4.71 and Figure 4.72.

Lubricant on the ring gears is black with a burned odor. Figure 4.71 and Figure 4.72.

Crow’s footing will be present on both hypoid sets, and the drive pinion gear is severely distorted. Figure 4.71 and Figure 4.72.

Prevention

Follow AxleTech recommended maintenance practices and service procedures.


**Cause of Failure**

The vehicle was operated with insufficient lubricant.

**What To Look For**

Primary Damage: The inner pinion bearing cup and cone are friction-welded together. Severe crow’s footing will be present on the hypoid set. Figure 4.73.

Lubricant on the surfaces of all interior components is black with a burned odor.

The drive pinion stem contacts the pinion cover and wears a hole into it. Figure 4.74.

**Prevention**

Follow AxleTech recommended maintenance practices and service procedures.
Inter-Axle Differential (IAD)

Cause of Failure
Spinout damaged the IAD.

What To Look For
Primary Damage: In Figure 4.75, galling will be present on the first IAD. On the second, excessive spinout damage will be present possibly caused by mismatched tires axle ratios.

Primary Damage: In Figure 4.76, the third IAD shows a bent spider leg, and a gear seized to another spider leg. The fourth IAD shows the spider legs have broken from the spline collar.

Prevention
Teach drivers how to correctly operate a vehicle. Check for mismatched tires or axle ratios.
**Cause of Failure**

Spinout damaged the IAD.

**What To Look For**

Primary Damage: The drive pinions are excessively loose on the spider legs. The pinions have worn into the IAD case. Figure 4.77.

Fatigue fractured the pinion washers. Figure 4.78. Abrasive particles from spinout have caused one pinion washer to become very thin.

The lubricant is contaminated with metal or other abrasive particles. Fatigue caused the thrust washers to fail. Figure 4.79.

**Prevention**

Teach drivers how to correctly operate a vehicle. Check for mismatched tires or axle ratios.
**Cause of Failure**

Spinout, and possibly shock load, occurred damaging the IAD.

**What To Look For**

Primary Damage: Galling on the spider legs will be found. Figure 4.80.

One pinion is missing from the IAD assembly. The IAD’s inside walls are gouged and scuffed. There is no case separation. Figure 4.81.

**Prevention**

Teach drivers how to correctly operate a vehicle. Check for mismatched tires or axle ratios.
**Cause of Failure**
Spinout damaged the IAD spider.

**What To Look For**
Primary Damage: Severe scoring will be present on the spider legs, as well as, excessive wear on the three non-seized legs. Severe wear damaged one of the spider legs. Figure 4.82.

Primary Damage: Galling, chipping and excessive wear will be present on the pinions. One pinion spins, but won’t slide off its spider leg. Figure 4.83.

**Prevention**
Teach drivers how to correctly operate a vehicle. Check for mismatched tires or axle ratios.
Main Differential

Cause of Failure
Spinout damaged the main differential spider.

What To Look For
Primary Damage: Several main differential spider legs have seized gears. Figure 4.85.
Primary Damage: Three legs have broken from the spider. Two gears have broken legs seized inside. Figure 4.85.
Primary Damage: One thrust washer is distorted and loose inside the main differential case. Figure 4.85. Three washers show excessive abrasive wear. Figure 4.86.

Prevention
Teach drivers how to correctly operate a vehicle. Check for mismatched tires or axle ratios.
Flange-Side Main Differential

Cause of Failure
Contaminated lubricant was installed, or cyclic overloading occurred.

What To Look For
Primary Damage: The flange-side main differential bearing rollers are pitted and spalled. Figure 4.87.

Primary Damage: The bearing cage and rollers are missing from the flange half of the main differential case. Figure 4.87.

Primary Damage: The flange-side differential bearing inner cone is scuffed and galled. Figure 4.88.

Prevention
Follow AxleTech recommended maintenance practices and service procedures. Operate a vehicle within its approved application and weight limits.
Pinion Nut

Cause of Failure
Loss of pinion bearing preload caused the gear contact pattern to shift.

What To Look For
Primary Damage: The threads on the end of the drive pinion show the pinion nut may have lost its specified preload or was not correctly tightened during assembly procedures. It then slowly backed-off, which enabled the drive pinion shaft to move out-of-position. Figure 4.89.

Primary Damage: The drive pinion spline shows wear from a loose yoke.

Primary Damage: The drive pinion contact pattern indicates the assembly was operating out-of-position.

There are two different contact patterns on the drive pinion teeth.

The spigot bearing inner cone is on the shaft and excessively worn. The cage rollers are missing.

Localized spalling will be found on the inside portion of the bearing rollers and a shifting drive pinion contact pattern, which indicates the assembly was operating out-of-position.

Light galling will be found on the bearing contact surfaces.

Prevention
Follow AxleTech recommended maintenance practices and service procedures to correctly tighten the drive pinion nut to specification.
Plain-Half Differential Case

Cause of Failure
The driver-controlled main differential lock (DCDL) was used incorrectly.

What To Look For
Primary Damage: The DCDL splines have worn away. Figure 4.90 and Figure 4.91.

Prevention
Teach drivers how to correctly operate a vehicle.
Main Differential Case-to-Case Joint Separation

Cause of Failure
Cyclic overloading occurred.

What To Look For
Primary Damage: The case-to-case bolts were broken by bending fatigue, which was caused by a forward-reverse motion in the driveline related to heavy loading and rough surface applications. Figure 4.92.

There is galling between the bolt holes at the main differential case joint. Notches on the main differential case halves and bolt holes are often deformed or “wallowed out” from wear to the inside diameter. Figure 4.93.

Prevention
Operate a vehicle within its approved application.
Pump System Screens

Cause of Failure

The lubricant was contaminated, or the vehicle was insufficiently lubricated.

What To Look For

Screen 1 is in normal condition. Figure 4.94.

Screen 2 is severely contaminated with burned lubricant including some silicone gasket material, dirt, and particles. When the screen was removed from the carrier, the lubricant was black and sludge-like, which could affect the oil pump. Figure 4.94.

Screen 3 is filled with metal chips and particles. Figure 4.95.

Prevention

Follow AxleTech recommended maintenance practices and service procedures.

It is important to note when applying silicone gasket material, the bead must not exceed 0.125” (3 mm), or the lubrication passages may be blocked and damage components.
Rear Side Gear

Cause of Failure
Torsional vibration damaged the rear side gear.

What To Look For
Primary Damage: Excessive wear is found on the rear side gear bevel teeth. Figure 4.96.
The IAD pinion teeth are excessively worn. Figure 4.97.

Prevention
Inspect the driveline. Check working angles and phasing are correct. Check suspension air ride height is correct.
Ring Gear

Cause of Failure

Cyclic overloading occurred, or the vehicle was operated under severe conditions.

What To Look For

Primary Damage: The ring gear fractured into many pieces, which indicates severe operating conditions and vehicle overloading. There is also evidence an engine retarder overloaded the coast side of the ring gear teeth during downhill braking. Figure 4.98.

A distinct tooth contact pattern change will be found on the drive pinion. All ring gear teeth show fatigue fractures originating on the coast side of the tooth roots. Figure 4.99.

Prevention

Operate a vehicle within its approved application and weight limits.
Cause of Failure

Root beam fatigue or cyclic overloading occurred.

What To Look For

Primary Damage: The ring gear fractured into many pieces, which indicates severe operating conditions and overloading. There is evidence an engine retarder, used for downhill braking, overloaded the coast side of the ring gear teeth. This is confirmed by the heavy thrust screw contact. Figure 4.100 and Figure 4.101.

Primary Damage: Heavy spalling will be found on the main differential bearing components. Figure 4.102.

The flange of the differential case half separated. Figure 4.103.

The gear-to-case bolts were loose. This condition isn’t related to the gear failure, because the fracture does not originate at the bolt hole, but at the root of the teeth.

Heavy thrust screw contact will be found on the backside of the ring gear.

Prevention

Operate a vehicle within its approved application and weight limits.
Side Gears

Cause of Failure
Most likely, shock load occurred when the vehicle’s spinning wheel hit dry pavement.

What To Look For
Primary Damage: A tooth broke from the main differential and side gear. Several other teeth are cracked.
Primary Damage: The side gear teeth next to the broken tooth are cracked at the base. Figure 4.104.
Primary Damage: A rough, crystalline finish formed on both teeth at the fractures. Figure 4.104.
Carrier noise was reported.

Prevention
Teach drivers how to correctly operate a vehicle.

Axle Shaft & Differential Side Gear Spline

Cause of Failure
The sliding fit required in the axle shaft-to-differential side gear splined coupling allows for a small amount of angular misalignment of the two components before hard contact occurs at the spline ends.

Overload conditions cause angular misalignment at the axle shaft-to-side gear spline interface. As the load on the axle housing continues to increase, the angular misalignment becomes more severe, axle deflection occurs, and the increased contact pressure in the differential side gear spline results in rapid wear.

What To Look For
Primary Damage: Premature wear at the axle shaft-to-differential side gear interface caused by unusually heavy contact at the spline ends. Figure 4.105.

Prevention
Operate a vehicle within its approved application and weight limits. Follow recommended maintenance practices.
Side Gear Thrust Washer

**Cause of Failure**
Spinout damaged the side gear thrust washer.

**What To Look For**
Primary Damage: The thrust washer seized onto the side gear. Figure 4.106. There is burned lubricant and galling areas on the thrust washer.

**Prevention**
Teach drivers how to correctly operate a vehicle.

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Thrust Washers

**Cause of Failure**
Spinout damaged the thrust washer.

**What To Look For**
Primary Damage: One leg broke from the spider and seized within the pinion gear journal. Figure 4.107.

Primary Damage: There is excessive wear and galling on all four spider legs. Figure 4.107.

The thrust washers are worn. Figure 4.108.

**Prevention**
Teach drivers how to correctly operate a vehicle.
**Oil Seals**

If there is moisture, wetness, or oil drips on or around an axle oil seal, it is important to recognize if the seal is leaking, or if it only appears to be leaking.

**Recognizing a Leaking Seal**

Inspect the oil seal and surrounding area for wetness. If the seal and area appear very wet or visibly drip oil, or if oil is dripping from the bottom of the output seal retainer, replace the seal.

Inspect the yoke for wetness. Check for a leak path leading to the rear lip of the seal. If there is wetness around the yoke hub or a leak path leading to the rear lip of the seal, replace the seal.

**Recognizing a Seal that Appears to be Leaking**

Seals come pre-lubricated with grease that melts at low temperatures under normal operating conditions. Melted grease can moisten or wet the area between the lip of the oil seal. When this happens, there will not be a leak path leading to the seal. If there is a moist seal and a leak path is not present, do not replace the seal.

A seal can also become moist from lubricants applied to the yoke or retainer bolts during assembly. When this happens, a leak path leading to the seal will not be present. If there is a moist seal and a leak path is not present, do not replace the seal.

**Seal Test Procedure**

1. Thoroughly clean and dry the area around the entire seal retainer casting, especially at the top.
2. Drive the vehicle for 15-20 minutes at highway speeds.
3. Check for wetness or moisture on or around the seal. Also check for oil dripping from the seal. If either of these conditions is present, replace the seal.

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**Example 1: The Seal is not Leaking**

**Cause of Failure**

None

**What To Look For**

The area around the seal is dry. There is no evidence of displaced packing grease or a leak path. Figure 4.109 and Figure 4.110.

**Prevention**

Follow AxleTech recommended maintenance practices and service procedures.
Example 2: The Seal Appears to be Leaking

Cause of Failure

A failure is possible. Inspect the seal. If a failure has occurred, determine its cause.

What To Look For

Seals are pre-lubricated with packing grease that melts at low temperatures during normal operating conditions. In Figure 4.111, melted grease will be present at the forward output through-shaft area.

Check the lubricant level. If the level is low, replace the seal. If not, monitor the seal for leaks.

Prevention

Follow AxleTech recommended maintenance practices and service procedures.
Example 3: The Seal is Leaking

Cause of Failure

Most likely, dirt or contaminants have entered the seal, or the seal’s service life is expended.

What To Look For

Inspect the oil seal and surrounding area for wetness. If the seal and area appear very wet or visibly drip oil, or if oil is dripping from the bottom of the output seal retainer, the seal requires replacement.

Inspect the yoke for wetness. Check for a leak path leading to the rear lip of the seal. If wetness is present around the yoke hub or a leak path leading to the rear lip of the seal, replace the seal.

Figure 4.112, Figure 4.113, and Figure 4.114.

Prevention

Follow AxleTech recommended maintenance practices and service procedures.
Drivelines

Parts Analysis Overview

⚠️ DANGER

ALWAYS WEAR PROPER EYE PROTECTION AND OTHER REQUIRED PERSONAL PROTECTIVE EQUIPMENT TO PREVENT PERSONAL INJURY WHEN INSPECTING HEAVY VEHICLE COMPONENTS.

This section provides a parts analysis process to determine why driveline components failed during operation, what to look for when inspecting parts, and how to prevent failures from occurring again.

Most of the time, the answers can be found by visually inspecting a failed component. Sometimes, however, this process may require specialized knowledge or equipment.

Why a product fails can be difficult to determine, and a failure can vary in appearance from vehicle to vehicle. Failures in models from the same manufacturer can also vary, so it is important to use the information presented here as a guide, not a rule, when performing parts analysis inspections.

Causes of Driveline Component Failure

A typical driveline consists of yokes, tubing, universal joints — and in some cases, a center bearing. Slip yokes enable a driveline to change in length, and u-joints enable it to operate at a variety of angles. Figure 5.1. Tubing transmits turning torque from one u-joint to another, and the center bearing provides support for longer drivelines.

The main causes of driveline failure during operation are shock load, fatigue, torsional vibration and lubricant issues.

U-Joint

Cause of Failure

Shock load applied a sudden and powerful force to the u-joint, which caused it to fail. For example, the operator backed under a trailer with excessive force, or the vehicle’s spinning wheel hit dry pavement.

What To Look For

A rough, crystalline surface has formed on the u-joint at the fracture point. Figure 5.2.

Prevention

Teach drivers how to correctly operate a vehicle.
Cause of Failure
The u-joint failed because it wasn’t maintained according to AxleTech maintenance practices and intervals. Galling, a type of surface fatigue, can also occur when two unlubricated metal surfaces rub against each other. Galling is also called “metal transfer.”

What To Look For
Heat and friction caused by insufficient lubricant, or installing an incorrect lubricant, caused a u-joint to wear through the side of its bearing cap. A u-joint requires a high-quality extreme pressure (EP) lubricant. Figure 5.3.

Prevention
Operate a vehicle within its approved application and weight limits. Follow AxleTech recommended maintenance practices and service procedures.

Cause of Failure
Excessive stress levels caused a bending fatigue fracture to spread through the trunnion, until the remaining cross section was unable to support the required load.

What To Look For
Inspect the fractured area of the trunnion for a smooth surface and beach marks, which indicate the path of the fracture. The coarse crystalline area is where the final “instantaneous” fracture was completed. Is the u-joint the correct size for the application? Was the vehicle operated under torque overload conditions? Did the driver operate the vehicle correctly? Figure 5.4.

Prevention
Operate a vehicle within its approved application and weight limits. Follow recommended maintenance practices. Teach drivers how to correctly operate a vehicle.
U-Joint Fasteners

**Cause of Failure**

Excessive stress levels caused a bending fatigue fracture on both u-joint fasteners, which indicates the clamp load was under specification. This failure is a result of either under-tightened or overtightened u-joint fasteners during assembly.

U-joint fasteners also can fail as a result of pulling the u-joint into place with an impact gun. Always seat the u-joint by hand. Do not force the u-joint into the locating tabs, which can shave material from the tabs. Excess material can build up between the wing and yoke, prevent the u-joint from seating correctly, and cause the fasteners to loosen during operation.

**What To Look For**

Inspect the fractured area for a smooth surface and beach marks indicating the path of the fracture. The coarse crystalline area is where final “instantaneous” fracture was completed. Figure 5.5.

**Prevention**

Always tighten fasteners to the manufacturer’s torque specification. If driveline fasteners are removed for service, always replace the removed fasteners with new ones.

Operate a vehicle within its approved application and weight limits. Follow recommended maintenance practices.

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Driveshaft Tube

**Cause of Failure**

Figure 5.6 shows the shock load occurred on a driveshaft tube.

**What To Look For**

The tube is twisted and bent, but didn’t fracture or separate from other components, which is the usual result of shock load. The driveshaft tube is the only driveline component affected this way by shock load.

**Prevention**

Teach drivers how to correctly operate a vehicle.
Yokes

Cause of Failure
Instantaneous shock load applied a sudden and powerful force to the yoke, which caused it to fracture and fail. For example, instantaneous shock load occurs when an operator backs under a trailer with excessive force, or when a vehicle’s spinning wheel hits dry pavement.

What To Look For
The yoke fracture is a “clean break,” and a rough crystalline surface has formed at the fracture point. Figure 5.7 and Figure 5.8.

Prevention
Teach drivers how to correctly operate a vehicle.

U-Joint Trunnion

Cause of Failure
Spalling, a type of wear fatigue that breaks the surface of the components into chips or fragments, caused the u-joint to fail.

When the metal surface of a component breaks into chips or fragments as a result of wear fatigue, the condition is called “spalling.” Spalling is a type of surface fatigue and is evident in the advanced stages of pitting, which is the beginning of surface fatigue. Spalling can usually be found on u-joint trunnions that are opposite each other. Starting as small pitted areas, spalling can progress rapidly.

What To Look For
Figure 5.9 shows the effects of spalling on a u-joint trunnion which most likely occurred from cyclic overloading. The surface of the u-joint has broken into chips or fragments.

Prevention
Operate a vehicle within its approved application and weight limits. Follow recommended maintenance practices.
Cause of Failure

Brinelling, which is a type of surface fatigue, caused the needle rollers to wear deep grooves into the trunnion surface, and in some cases, the bearing cap.

What To Look For

This roller bearing shows the effects of brinelling, which causes the needle rollers to wear grooves into the surface of the trunnion. Figure 5.10.

To determine if the condition is brinelling, check the trunnion with a fingertip. Are deep grooves present? If so, brinelling has occurred.

Prevention

Operate a vehicle within its approved application and weight limits. Follow recommended maintenance practices.

Splined Shaft

Cause of Failure

Torsional fatigue caused excessive twisting weakening the splined shaft and causing it to fail.

What To Look For

Torsional fatigue has damaged the splined shaft in Figure 5.11. The fracture started at the base of each spline. As the splines continued to weaken, the metal formed a star-shaped, radial pattern, which eventually broke the shaft at the center.

Prevention

Operate a vehicle within its approved application and weight limits. Follow AxleTech recommended maintenance practices and service procedures.

There is no question that this trunnion has brinelling. The roller bearings have worn deep grooves that are easily detectable by touch.

Figure 5.10

Figure 5.11
Trailer Axles

Parts Analysis Overview

⚠️ DANGER

ALWAYS WEAR PROPER EYE PROTECTION AND OTHER REQUIRED PERSONAL PROTECTIVE EQUIPMENT TO PREVENT PERSONAL INJURY WHEN INSPECTING HEAVY VEHICLE COMPONENTS.

This section provides a parts analysis process to determine why trailer axle components failed during operation, what to look for when inspecting parts, and how to prevent failures from occurring again.

Most of the time, answers can be found by visually inspecting a failed component. Sometimes, however, this process may require specialized knowledge or equipment.

Why a product fails can be difficult to determine, and a failure can vary in appearance from vehicle to vehicle. Failures in models from the same manufacturer can also vary, so it is important to use the information presented here as a guide, not a rule, when performing parts analysis inspections.

Causes of Trailer Axle Failure

Shock load, torsional fatigue, bending fatigue, and incorrect welds are the main causes of trailer axle failure.

Shock load can cause a trailer axle to fail immediately, or it will fracture the axle, which usually depends on how fast the trailer is moving and the weight being hauled. If a fracture occurs, the axle will continue to operate and fail at a later time. For example, if a trailer is overloaded and hits a large pothole, shock load will occur.

AxleTech trailer axles are available in a variety of sizes and configurations, and are designed and rated for specific load applications. Figure 6.1. The gross axle weight rating (GAWR) specifies the maximum load limit for a trailer. Trailer axles operated above their GAWR can be damaged by torsional fatigue and bending fatigue.
**Trailer Axle**

**Cause of Failure**

The camshaft bracket was welded incorrectly to the trailer axle.

**What To Look For**

Welding on an axle creates intense heat that changes the characteristics of the metal surrounding the weld, and an incorrect weld can cause fatigue to occur. In Figure 6.2, fatigue had created a stress riser, which caused the axle to fail.

**Prevention**

All axle weld locations and procedures must follow Axle-Tech Welding Guidelines. To obtain this publication, refer to “Service Notes” on page ii.

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**Cause of Failure**

Bending fatigue occurred, which was caused by an overloaded trailer axle. Under normal loads, a trailer axle will flex slightly as it is loaded and unloaded. However, if the axle’s overloaded and a stress riser is present, beam resistance is reduced, the axle flexes too much, and bending fatigue occurs.

**What To Look For**

Usually, bending fatigue failures are toward the outer edges of the trailer axle. Figure 6.3 shows beach marks begin at the initial fracture point and then move away from it.

**Prevention**

Operate the vehicle within its approved application and weight limits.

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The camshaft bracket incorrectly welded on this trailer axle created a stress riser, which caused the axle to fail.

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This axle failed in a bending fatigue mode that began at a weld location. The beach marks start at the initial fatigue point and move away from it.

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Figure 6.2

**Figure 6.3**
**Cause of Failure**

Torsional fatigue twisted the axle, which can occur when certain suspensions apply excessive loads to axle welds.

**What To Look For**

Beach marks begin at the initial fracture point and then move away from it. When torsional fatigue weakens the axle, the fracture often extends at a 45° angle to the axle’s centerline. Fractures often form as an “S” or “Z” shape. Figure 6.4.

**Prevention**

Operate the vehicle within its approved application and weight limits.

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**Cause of Failure**

Shock load applied a sudden and powerful force to the trailer axle. Shock load can destroy or damage a component immediately. Often, however, a component damaged by shock load will continue to operate, but it will wear prematurely or fail soon after the initial shock load has occurred.

**What To Look For**

Figure 6.5 shows a trailer axle bent by shock load. The axle didn’t fail immediately, but flexed too much and didn’t return to its original shape as it continued to operate. When a trailer axle is damaged this way, the bend usually occurs outside the suspension mounts. A bent axle can affect tire wear and how the trailer handles, and must be replaced.

A bent trailer axle is not the same as a trailer axle damaged by bending fatigue.

**Prevention**

Operate the vehicle within its approved application and weight limits.
Automatic Slack Adjusters

Parts Analysis Overview

**DANGER**

ALWAYS WEAR PROPER EYE PROTECTION AND OTHER REQUIRED PERSONAL PROTECTIVE EQUIPMENT TO PREVENT PERSONAL INJURY WHEN INSPECTING HEAVY VEHICLE COMPONENTS.

This section provides a parts analysis process to determine why automatic slack adjusters failed during operation, what to look for when inspecting the parts, and how to prevent failures from occurring again.

Most of the time, answers can be found by visually inspecting a failed component. Sometimes, however, this process may require specialized knowledge or equipment.

Why a product fails can be difficult to determine, and a failure can vary in appearance from vehicle to vehicle. Failures in models from the same manufacturer can also vary, so it is important to use the information presented here as a guide, not a rule, when performing parts analysis inspections.

Automatic Slack Adjuster

A slack adjuster is vital to correct brake operation. As linings wear, AxleTech automatic slack adjusters automatically adjust clearance between the brake lining, and brake drum, or rotor on cam and air disc brakes. Figure 7.1.

If a slack adjuster is installed at an incorrect angle, the brakes will either have too much clearance, or the brakes will drag. Too much clearance will decrease braking efficiency and cause brakes to be out-of-balance.

The main causes of automatic slack adjuster failure during operation are incorrect installation, maintenance and rebuild practices.
Causes of Slack Adjuster Failure

Pawl Teeth

Cause of Failure
The pawl teeth are damaged.

What To Look For
Figure 7.2 shows damage to pawl teeth occurring when the adjusting nut is turned in the incorrect direction.

Prevention
Follow AxleTech recommended maintenance practices and service procedures.

Automatic Slack Adjuster

Cause of Failure
The slack adjuster was insufficiently lubricated, the lubricant was contaminated, or the incorrect lubricant was installed into the slack adjuster.

What To Look For
Insufficient lubrication can cause internal friction, difficulty turning the adjusting nut, and loss of automatic adjustment. If grease is pumped into the fitting at a pressure too high, it will push the boot off the slack adjuster or rip the rubber boot. Both of these situations will contaminate the grease. Figure 7.3.

Prevention
Follow AxleTech recommended maintenance practices and service procedures.
Automatic Slack Adjuster & Camshaft Splines

Cause of Failure
The slack adjuster was not correctly lubricated.

What To Look For
Figure 7.4 shows slack adjuster and camshaft splines corroded due to insufficient lubricant.

Prevention
Follow AxleTech recommended maintenance practices and service procedures.

These splines were installed without the correct anti-seize lubricant. Corrosion resulting from lack of lubrication often damages splines.

Figure 7.4
Cam & Air Disc Brakes

Parts Analysis Overview

DANGER

ALWAYS WEAR PROPER EYE PROTECTION AND OTHER REQUIRED PERSONAL PROTECTIVE EQUIPMENT TO PREVENT PERSONAL INJURY WHEN INSPECTING HEAVY VEHICLE COMPONENTS.

This section provides a parts analysis process to determine why brake components failed during operation, what to look for when inspecting the parts, and how to prevent failures from occurring again.

Most of the time, answers can be found by visually inspecting a failed component. Sometimes, however, this process may require specialized knowledge or equipment.

Why a product fails can be difficult to determine, and a failure can vary in appearance from vehicle to vehicle. Failures in models from the same manufacturer can also vary, so it is important to use the information presented here as a guide, not a rule, when performing parts analysis inspections.

<table>
<thead>
<tr>
<th>Cause</th>
<th>Cam &amp; Air Disc Brakes</th>
<th>Air Disc Brakes Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorrect slack adjuster angles</td>
<td>√</td>
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<tr>
<td>Spring brake didn’t fully release</td>
<td>√</td>
<td></td>
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<tr>
<td>Excessive wear</td>
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<tr>
<td>Air system problems</td>
<td>√</td>
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<tr>
<td>High operating temperatures</td>
<td>√</td>
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<tr>
<td>Lubricant issues</td>
<td>√</td>
<td></td>
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<tr>
<td>Deep scoring on the rotor</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>Paint or corrosion on caliper slide pins</td>
<td>√</td>
<td></td>
</tr>
</tbody>
</table>

Cam & Air Disc Brakes

Cause of Failure

Automatic slack adjuster angles are not correct.

What To Look For

A slack adjuster is vital to correct brake operation. As linings wear, AxleTech automatic slack adjusters automatically adjust clearance between the brake lining, and brake drum, or rotor on cam and air disc brakes.

If a slack adjuster is installed at an incorrect angle, the brakes will either have too much clearance, or the brakes will drag. Too much clearance will decrease braking efficiency and cause brakes to be out-of-balance. Figure 8.1.

Prevention

Follow service procedures and install the correct slack adjuster for the brake type to prevent over-adjustment and excessive brake clearance. Figure 8.2.
Cause of Failure

The spring brake didn’t fully release.

The spring brake applies braking force when the air system is drained, and it is also used as a parking brake when the vehicle is stationary. During operation, air pressure releases the spring brake to move the vehicle, and the service brake half of the air chamber controls braking. Figure 8.3.

What To Look For

If the spring brake fails to fully release, the brakes will drag and the linings will wear prematurely. Look for damage caused by excessive heat buildup. Check for mechanical problems with the spring brake and problems in the air system. Figure 8.4.

Prevention

Follow AxleTech recommended maintenance practices and service procedures.
**Cause of Failure**

Corroded or plugged air system valves prevented some brakes from operating correctly, causing brake imbalance.

The air system supplies the force to apply and release the brakes. Figure 8.4. If air valves stick because they’re corroded or plugged with contaminants, the brakes may not apply, or they’ll apply with too much force. For example, if a valve malfunctions, the parking brakes and service brakes can apply at the same time and damage components. This is called “compounding.”

Also, incorrect crack-pressure settings on relay valves in the tractor and trailer cause one half of the vehicle to brake most often, or all of the time; while the other half does little or no braking. This imbalance between the tractor and trailer can result in increased brake temperature and premature lining wear.

**What To Look For**

Figure 8.5 shows a brake drum with deep scores and heat checks caused by an air system problem that kept the air chamber partially charged when the trailer brake wasn’t applied. As a result, the cam didn’t fully release, and brake drag occurred during operation.

**Prevention**

Bleed the system’s wet tank daily to prevent moisture buildup that corrodes air valves. Follow AxleTech recommended maintenance practices and service procedures.
Cause of Failure

Excessive wear can occur when a vehicle is overloaded, or when linings drag against the drum or rotor when the brakes should be released.

What To Look For

Figure 8.6 shows metal-to-metal contact damage to the rotor when excessive wear from brake drag removed the linings from the pads.

Prevention

Operate a vehicle within its approved application and weight limits.

Excessive wear removed the linings from these disc brake pads and caused metal-to-metal contact with the rotor. This resulted in not only needing new pads, but a new rotor as well.

Figure 8.6
**Cause of Failure**

High operating temperatures damaged the brake components.

High operating temperature is one of the main causes of premature lining wear. Some reasons why high operating temperatures occur: The brakes are imbalanced, applied often, or they drag against the drum. Premature wear accelerates as operating temperatures increase.

High operating temperatures will eventually cause brake components — usually the linings, drums and rotors — to warp or fracture. Figure 8.7 shows a brake rotor damaged by scoring and heat cracks caused by an air system that wasn’t functioning correctly.

**What To Look For**

Figure 8.8 shows a brake pad with heat checks on the entire friction surface resulting from high operating temperatures.

**Prevention**

Operate a vehicle within its approved application and weight limits.
Air Disc Brakes Only

Cause of Failure

Heavy heat checking damaged the rotor surface.

There are two types of heat checking: light and heavy. Figure 8.9.

What To Look For

Heavy heat checking are surface cracks that are wide and deep. Replace the rotor if heat checks have a width of more than 0.02” (0.5 mm), a depth of more than 0.04” (1 mm), and extend radially across the surface more than 75%. Figure 8.10.

Light heat checks are fine lines or cracks on the rotor surface, a normal condition that results when the rotor friction surface continually heats and cools. A rotor with light heat checking does not need replacement. Figure 8.11 and Figure 8.12.

Prevention

Follow AxleTech recommended maintenance practices and service procedures.
Cause of Failure
The rotor has deep grooves or scores.

What to Look For
Inspect both sides of the rotor. If grooves or scores are present of a depth less than 0.02” (0.5 mm), continue to use the rotor. If the grooves are greater than 0.02” (0.5 mm), the rotor can be resurfaced. If the rotor thickness measured across any groove is less than 1.46” (37 mm), discard and replace the rotor. Figure 8.13.

Prevention
Follow AxleTech recommended maintenance practices and service procedures.

Air Disc Brake Only

Cause of Failure
There’s paint or corrosion on the caliper slide pins.

What To Look For
Slide pins enable the caliper assembly to apply braking pressure on both sides of the rotor. If the slide pins are painted, the caliper can corrode and seize, and only the inboard pad will apply pressure. As a result, the inboard pad wears prematurely. Figure 8.14.

When a caliper assembly is insufficiently lubricated, the slide pins will corrode and cause the brake pads to drag on the rotor. If a caliper assembly is over-lubricated, pressure will build up and prevent the brake pads from retracting. Figure 8.14.

Prevention
Follow AxleTech recommended maintenance practices and service procedures.

Paint or corrosion on the caliper slide pins can cause uneven pad wear and reduced braking ability. These pads show the results of a corroded slide pin, as well as a failure to check the brakes periodically.
Brake Drums

Normal Wear

Brake drums wear evenly under normal operating conditions. Use fleet history, if available, to determine the approximate wear rate of tractor drums. Normal wear is the usual reason a brake drum is removed from service.

Deep, Uniform Wear

Deep, uniform wear at the edge of the drum where the lining path begins can result from brake drag, imbalance, contaminants embedded in the brake lining, no brake retarder, braking with a hand valve, not down-shifting on steep grades, and exceeding a vehicle’s braking capacity. Figure 8.15 and Figure 8.16.

Replace the drum. Install dust shields; or if already installed, remove the shields and operate the vehicle.

Deep Wear on Only One Side of the Drum

Deep wear on only one side of the drum indicates the drum is machined out-of-round, or the drum was dropped or bent. No evidence of hot spotting may be evident. Replace the drum. Figure 8.17.
Heat Checking

Heat checking are fine lines or cracks uniformly covering the drum surface. Heat checking is a normal condition resulting from the drum friction surface heating and cooling repeatedly. However, if the drum operates under high temperatures or overloaded conditions or if the vehicle operates under heavy braking, larger cracks can develop and extend below the surface.

What To Look For

Fine lines and cracks over the entire drum surface less than 1” (25.4 mm) in length.

What To Do

Replace the drum.

Prevention

Follow AxleTech recommended operating guidelines, maintenance practices, and service procedures. Figure 8.18.

Heat Checking One Side of the Drum Only

What To Look For

Look for fine cracks on only one side of the drum surface. However, cracks 1” (25.4 mm) or more are usually deep and require drum replacement. Hot spotting may or may not be evident, and deep wear may be present on the same side of the drum.

Heat checking on only one side of the drum can indicate the drum is machined out-of-round, was dropped or bent, or the drum-to-pilot fit has too much end play. Figure 8.19 and Figure 8.20.

What To Do

Replace the drum.

Prevention

Follow AxleTech recommended operating guidelines, maintenance practices, and service procedures.
Causes of Brake Component Failure

Black Spots (Hot Spotting) on Drum Surface

What To Look For

Black spots are on the entire drum surface (uniform), are on only one side of the drum surface, or are in three equidistant areas of the drum surface.

Some causes of hot spotting are water contacted the overheated drum, causing the drum to cool unevenly; the brake drum’s not centered to the lining; the brake lining and drum mating surfaces burnished too slowly; brake drag occurred during operation; the linings are extremely hard; or the type of lining installed wasn’t approved by the original equipment manufacturer. Figure 8.21, Figure 8.22, and Figure 8.23.

What To Do

Replace the drum.

Prevention

Follow AxleTech recommended operating guidelines, maintenance practices and service procedures. Operate the vehicle within its approved application and weight limits.
Polished (Glazed) Drum

What to Look For
A polished (glazed) drum has a mirror-like finish on the friction surface caused by an incorrect friction material, brake imbalance, low-pressure braking or the type of lining installed wasn’t approved by the original equipment manufacturer. Figure 8.24.

What To Do
Replace the drum.

Prevention
Follow AxleTech recommended operating guidelines, maintenance practices and service procedures. Operate the vehicle within its approved application and weight limits.

Figure 8.24

Scoring

What To Look For
Look for grooves or scratches (scoring) on the surface of a drum deeper than 0.10" (2.54 mm) and wider than 0.030" (0.076 mm), which was caused by metal-to-metal contact from worn brake pads or shoes, or debris caught between the friction material and the friction surface. Figure 8.25.

What To Do
Replace the drum.

Prevention
Follow AxleTech maintenance practices and service procedures. Operate the vehicle within its approved application and weight limits.

Figure 8.25
“Blue” Drum

What To Look For
Very high operating temperatures can cause the brake drum to turn a blue color, and components are damaged.

Some causes of a blue drum are the axle and wheel-end imbalance has occurred, the lining wasn’t approved by the original equipment manufacturer, the braking system is incorrect for the application, or brake drag occurred during operation. Figure 8.26.

What To Do
Replace the drum or rotor.

Prevention
Follow AxleTech maintenance practices and service procedures. Operate the vehicle within its approved application and weight limits.

Broken Bolt Flange (Drum Surface Not Cracked)

What To Look For
The bolt flange is broken, but the drum surface isn’t cracked. This situation usually results when an incorrect drum was assembled onto a hub or spoke wheel. When the fasteners were tightened, the clamping load cracked the flange. Flanges can also break if both brake shoes don’t contact the drum at the same time. Figure 8.27.

What To Do
Replace the drum.

Prevention
Follow AxleTech service instructions for assembly and disassembly procedures.
Broken Bolt Flange (Cracked Drum Surface)

What To Look For
High temperatures caused the expanding brake shoes to separate the bolt flange from the drum with enough force to crack the drum, but the flange remained intact. A cracked drum surface occurs from excessive wear, heat checking or hot spotting, or a combination of these conditions. Figure 8.28.

Sometimes, however, the bolt flange breaks, but the drum does not crack. This condition usually occurs because the drum pilot interfered with the hub or wheel pilot, or the drum was broken before assembly.

What To Do
Replace the drum.

Prevention
Operate a vehicle within its approved application and weight limits.

Cracked Drum

What To Look For
The drum has cracked, but may not show signs of wear, heat checking or hot spotting. A drum can crack when the parking brake is set while the brakes are very hot. The cooling drum contracted on the brake shoes with enough force to crack the drum.

Brake drum pilot interference with the hub or wheel pilot also can cause the entire cross section of the drum to crack, if the drum was forced onto the pilot. Figure 8.29.

What To Do
Replace the drum.

Prevention
Operate the vehicle within its approved application and weight limits. Follow AxleTech maintenance practices and service procedures.
Worn Brake Drum Bolt Holes

What To Look For

Worn bolt holes result because the bolts weren’t tightened to the correct torque specification. Drum pilots also can be worn and damaged, and runout in the brake drum could have occurred. Figure 8.30.

What To Do

Replace the hub and drum.

Prevention

Operate the vehicle within its approved application and weight limits. Follow AxleTech maintenance practices and service procedures.

Oil or Grease Has Penetrated and Discolored the Drum Surface

What To Look For

The brake system has been contaminated with lubricant when the following conditions are evident:

- oil or grease has penetrated the drum surface
- the brake drum is discolored
- lubricant is evident on the components, which resulted from wheel or hub oil seals that leaked

All of these conditions require drum replacement. Figure 8.31.

What To Do

Try to remove the oil or grease from the drum. If it cannot be removed completely, replace the drum.

Prevention

Follow AxleTech maintenance practices and service procedures.
## Causes of Brake Drum Wear

<table>
<thead>
<tr>
<th>Condition</th>
<th>Possible Causes</th>
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<tr>
<td>Brake drag</td>
<td>Worn camshaft bushings</td>
</tr>
<tr>
<td></td>
<td>Damaged or plugged relay valves or air exhaust ports</td>
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<tr>
<td></td>
<td>Incorrect slack adjuster operation</td>
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<tr>
<td></td>
<td>Bent air chamber push rods</td>
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<tr>
<td></td>
<td>Weak or broken air chamber or shoe return springs</td>
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<tr>
<td></td>
<td>Swelling and growth of new linings</td>
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<tr>
<td></td>
<td>Air system imbalance</td>
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<td></td>
<td>Pinched air hoses or tubing</td>
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<tr>
<td>Excessive drum-to-pilot end play</td>
<td>Mating hub or wheel pilot machined under size</td>
</tr>
<tr>
<td></td>
<td>Hub or wheel pilots not centered to bearing bores</td>
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<tr>
<td></td>
<td>Hub pilots are contaminated or corroded</td>
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<tr>
<td></td>
<td>Drum incorrectly assembled onto pilot</td>
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<td></td>
<td>Drum not centered to lining</td>
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<tr>
<td>Drum is incorrectly seated on the hub or pilot wheel</td>
<td>Corroded mounting surface</td>
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<td></td>
<td>Corroded aluminum hub and drum assembly</td>
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<td></td>
<td>Iron or aluminum hub pilot not correctly cleaned prior to installation</td>
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<tr>
<td>Both brake shoes don’t contact the drum at the same time</td>
<td>Brake drum isn’t centered to the hub</td>
</tr>
<tr>
<td>Heavy braking</td>
<td>Braking system incorrect for the application</td>
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<tr>
<td></td>
<td>Linings not approved by the original equipment manufacturer (OEM)</td>
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<tr>
<td></td>
<td>Operator technique</td>
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<tr>
<td></td>
<td>High-temperature applications (city and construction)</td>
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<td></td>
<td>Brake imbalance</td>
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<tr>
<td></td>
<td>Bent spiders</td>
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<td></td>
<td>Bent shoes don’t uniformly contact the brake surface</td>
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<tr>
<td>Brake imbalance</td>
<td>Pneumatic imbalance between the axles</td>
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<td></td>
<td>Plugged or corroded relay valves</td>
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<tr>
<td></td>
<td>Linings not approved by the original equipment manufacturer (OEM)</td>
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<tr>
<td></td>
<td>Incorrect brake power (AL Factor)</td>
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<td></td>
<td>Imbalance between the apply and release threshold pressures</td>
</tr>
</tbody>
</table>
Transmissions

Parts Analysis Overview

⚠️ DANGER

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Causes of Transmission Component Failure

Metal mating surfaces wear as a transmission operates. Transmission oil minimizes spur gear wear, because oil protects components from metal-to-metal contact. The most common types of wear conditions on spur gears are frosting, offset frosting, pitting, spalling, scoring, shock load and fatigue fractures.

Parts Analysis Process

Spur Gears

Cause of Failure

Heavy or deep pitting damaged the spur gear.

Pitting is a type of surface fatigue that forms pits, or cavities, on metal surfaces. If pitting is heavy, it can progress until pieces of surface metal break, or spall, from a component. This is called “spalling.”

What To Look For

Look for heavy or deep pitting on the entire spur gear tooth contact surface. Spur gears damaged by heavy pitting require replacement.

Verify the lubricant installed was the correct specification and viscosity. Were different types of oil mixed together and installed in the vehicle? Was the vehicle operated with sufficient lubricant? Was the vehicle maintained according to AxleTech recommended maintenance practices?

Prevention

Operate the vehicle within its approved application and weight limits. Follow AxleTech recommended maintenance practices and service procedures.
Transmissions

**Cause of Failure**

Spalling damaged the spur gear.

When the metal surface of a component breaks into chips or fragments as a result of wear fatigue, the condition is called “spalling.” Spalling is a type of surface fatigue and is evident in the advanced stages of heavy pitting. Spur gears damaged by spalling require replacement.

**What To Look For**

Spalling on spur gear teeth looks similar to heavy pitting, but the cavities are usually larger in diameter and shallower in depth. Figure 9.1. Was the gear overloaded?

**Prevention**

Operate the vehicle within its approved application and weight limits. Teach drivers how to correctly operate a vehicle.

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**Cause of Failure**

Galling or “metal transfer” damaged the spur gear.

Galling, also called “metal transfer,” occurs when two unlubricated metal surfaces rub against each other, usually as a result of high operating temperatures caused by insufficient lubrication.

Figure 9.2 and Figure 9.3 show how metal separated from the gear teeth and welded to the mating gear teeth. Spur gears damaged by galling require replacement.

**What To Look For**

Verify the correct lubricant was installed, not multi-viscosity engine oil or extreme pressure (EP) GL-5 oil. Also, were different types of oil mixed together and installed into the vehicle? Was the vehicle operated with insufficient lubricant and under high operating temperatures?

Were any seals leaking? Was the vehicle maintained according to AxleTech recommended maintenance practices?

**Prevention**

Follow AxleTech recommended maintenance practices and service procedures.
Cause of Failure

Shock load damaged the spur gear.

Shock load occurs when a sudden and powerful force is applied against a component. Shock load can destroy or damage a component immediately. Often, however, a component damaged by shock load will continue to operate, but it will wear prematurely or fail soon after the initial shock load has occurred.

Shock load causes components to crack and separate from each other. Spur gears damaged by shock load require replacement.

What To Look For

Examine the entire transmission. If teeth have broken from the gear, check for subsequent damage. Look for a rough, crystalline finish on the surface of the spur gear. Figure 9.4, Figure 9.5, and Figure 9.6.

Also try to determine if the operator backed into a loading dock with excessive force, or if the vehicle’s spinning wheel hit dry pavement. Did the operator miss a shift? Did the operator speed up the engine and rapidly release the clutch (“popping the clutch”)?

Prevention

Teach drivers how to correctly operate a vehicle.
Cause of Failure

Fatigue fracture damaged the spur gear.

Fatigue fracture is caused by cyclic torque overloads on a component, torsional vibration, and twisting and bending. A fatigue fracture quickly reduces the overall strength of a gear, reducing its ability to withstand operating load. Figure 9.7.

What To Look For

A fatigue fracture begins at one or more points. Look for ratchet marks and subsequent beach marks on the part. Beach marks represent fatigue cycles that occurred before the component failed completely. Visually, beach marks are smooth, curved radial lines originating from the fracture site. At the failure site, however, beach marks are rough and brittle. Spur gears damaged by fatigue fracture require replacement.

Prevention

Operate the vehicle within its approved application and weight limits.
Cause of Failure
Frosting damaged the spur gear.

What To Look For
Frosting is a grayish or yellowish white color usually found at the center of the teeth at the mating gear contact position. Light pitting on the gear teeth also may accompany frosting. Figure 9.8, Figure 9.9, and Figure 9.10.

Offset frosting has the same characteristics as frosting, but appears at one side of the spur gear face. Offset frosting is caused by a difference in the gear tooth contact face from one side to the other, or from a slight shift in gear set loading.

Prevention
No action is required. Frosting is a normal wear condition on spur gear teeth that does not affect performance or gear life. As the gear continues to operate, sliding friction eventually removes frosting. If frosting is the only wear present on the spur gears, do not replace the gears.
Roller Bearings

Cause of Failure

Heavy pitting damaged the roller bearings and most likely changed bearing adjustment and bearing alignment.

Pitting is a type of surface fatigue that forms pits, or cavities, on metal surfaces. Figure 9.11. If pitting is heavy, it can progress until pieces of surface metal break, or spall, from a component.

What To Look For

Inspect the cup and cone contact areas, cage inner and outer surfaces, cage roller pockets, roller body, and roller end for wear. Verify the lubricant installed was the correct specification and viscosity. Were different types of oil mixed together and installed in the vehicle? Was the vehicle operated with sufficient lubricant?

If pitting is present on the roller bearing, it indicates fatigue damage had begun, and roller bearing replacement is required.

Prevention

Operate the vehicle within its approved application and weight limits. Follow AxleTech recommended maintenance practices and service procedures.

Cause of Failure

Excessive end play loosened the rollers in the bearing cage, causing the bearing rollers to damage the cage.

What To Look For

Look for wider bearing pockets and “skidding” wear on the cup and cone surface. Figure 9.12 and Figure 9.13. “Skidding” wear occurs when the wider bearing pockets enable the rollers to turn at an angle in the pocket, and then snap back into place. A bearing damaged by excessive end play requires replacement.

Prevention

Follow AxleTech recommended service procedures to adjust end play.
**Cause of Failure**

Brinelling displaced the metal on the bearing surface of the cup and cone.

**What To Look For**

Look for machined marks and displaced metal on the bearing cup and cone. Figure 9.14. A bearing damaged by brinelling requires replacement.

**Prevention**

Operate the vehicle within its approved application and weight limits. Teach drivers how to correctly operate a vehicle.

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**Cause of Failure**

Etching, also called “corrosion”, damaged the roller bearings because moisture entered the transmission through a worn seal or by condensation. Etching usually develops before pitting occurs.

**What To Look For**

Etching is a dark surface stain on the roller bearing. Figure 9.15. A bearing damaged by etching requires replacement.

**Prevention**

Follow AxleTech recommended maintenance practices and service procedures.
**Cause of Failure**

The transmission was insufficiently lubricated, which caused the bearing to overheat and seize.

**What To Look For**

A bearing damaged by insufficient lubricant will overheat, and the color has changed from silver to deep blue. If the bearing is black, it is an indication it seized and caused metal to separate from the bearing and weld to other mating components. Figure 9.16 and Figure 9.17. Bearings damaged by insufficient lubricant require replacement.

Look for leaking transmission seals and other damaged transmission components.

**Prevention**

Follow AxleTech recommended maintenance practices and service procedures.

---

**Cause of Failure**

The bearings weren’t correctly aligned, which concentrated the load onto one side of the bearing, instead of distributing it evenly across the entire bearing surface.

**What To Look For**

Look for uneven wear damage on the bearing, as well as spalling on the cup and cone. Both conditions require bearing replacement. Figure 9.18 and Figure 9.19.

**Prevention**

Follow AxleTech recommended service procedures to correctly align bearings.
Main Shaft Washer

Cause of Failure

Insufficient lubricant caused high operating temperatures that damaged the washer. The driver operated the vehicle incorrectly. Figure 9.20. Shock load occurred, which damaged the transmission. Figure 9.21.

Shock load occurs when a sudden and powerful force is applied against a component. Shock load can destroy or damage a component immediately. Often, however, a component damaged by shock load will continue to operate, but it will wear prematurely or fail soon after the initial shock load has occurred.

Shock load causes components to crack and separate from each other. Main shaft washers damaged by shock load require replacement.

What To Look For

Check the main shaft spacing. If it is too tight, metal-to-metal contact occurs, which results in high operating temperatures that damaged the main shaft. Figure 9.22.

Figure 9.20 shows a shift collar forced into gear, because the driver didn’t use the clutch or synchronize the gear shift. The mating gear snap ring, washer, and spacer absorbed the force and caused lubricant between the washer to displace. High operating temperatures occurred damaging the main shaft washer; and if enough force is applied, the spacer and snap ring could break. Shock load also causes components to crack and separate from each other. Look for a rough, crystalline finish on the separated parts.

Look for fractured teeth on the main shaft gear, which occurs when the gear does not contact the mating counter-shaft gears.

Figure 9.21. The fracture didn’t occur on the entire surface of the teeth, and the gear will be out-of-position. Check the sliding shift collars and the teeth on the clutch collar for fractures and excessive wear, which are signs of grinding gears. Figure 9.23.

Try to determine if the driver either coasted with the transmission in gear and the clutch disengaged, or with the transmission in neutral and the auxiliary case in low range. Was the vehicle towed; and if so, was it towed correctly?

If the main shaft washer is fractured, was it dropped during assembly? Figure 9.24. Is there evidence of heat checking? Did shift lever slip out (not jump out) occur? Is the snap ring damaged?

Prevention

Teach drivers to correctly operate a vehicle. Follow AxleTech recommended maintenance practices and service procedures.
Main Shaft Gear Float Clearance

Cause of Failure

The main shaft gear float clearance is not within the correct specification. The washers and spacers were damaged by insufficient lubricant; or the operator used “float shifting,” which loaded the washers and spacers. Float shifting forces lubricant from between the washer and spacer, which damages these parts.

What To Look For

Gear Float Clearance

Gear float is the clearance between the main shaft gear mating hubs. New transmissions are factory-set with a gear float clearance of 0.006 — 0.012” (0.152 — 0.304 mm).

Gear float is important, because when it is correctly set, it enables lubricant to pass between the mating gears to lubricate the gear hubs, washers and spacers. If clearance is too tight, the gear hubs, washers and spacers will score, gall and burn.

Excessive clearance causes the transmission gears to rattle from torsional vibration and requires the main shaft to be rebuilt to the original factory-set clearance.

Washers and Spacers

It is normal to find wear on washers and spacers in high-mileage units. Figure 9.25. However, inspect parts for excessive wear or a “burned” look occurring from insufficient lubricant and high operating temperatures. Figure 9.26.

The Transmission Wasn’t Shifted Correctly

Try to determine if the driver shifted the transmission correctly and didn’t use “float shifting.” During float shifting, the driver does not use the clutch, but “floats” the shift collar into gear. Look for scoring, galling, burning, and fractures on the washers and spacers. Figure 9.27.

If a driver is having difficulty shifting the transmission, check for correct clutch adjustment and wear in the clutch linkage, shift linkage, shift tower and top cover. All of these conditions can damage the shift collars, washers, and spacers.
Prevention

Check the gear float clearance is correct. In-service float clearance must not exceed 0.024” (0.068 mm), or two times the maximum factory-set clearance of 0.006” — 0.012” (0.152 — 0.304 mm). Figure 9.28 and Figure 9.29.

Gear float outside of specification is beyond the service limits. Use new selective washers, snap rings, and spacers to adjust the float. Optimal clearance on a rebuild is 0.012” (0.304 mm).

Follow AxleTech recommended maintenance practices and service procedures.

Teach drivers to shift a transmission correctly.
Gear Teeth

Cause of Failure
Shock load occurred damaging the gear teeth.

Shock load occurs when a sudden and powerful force is applied against a component. Shock load can destroy or damage a component immediately. Often, however, a component damaged by shock load will continue to operate, but it will wear prematurely or fail soon after the initial shock load has occurred.

Shock load causes components to crack and separate from each other. Gears damaged by shock load require replacement.

What To Look For
Look for fractures on gear teeth at 180° intervals.

Figure 9.30. If the shock load is severe, damage can extend to the main shaft and bearing, as well as other transmission components. Try to determine if the driver shifted the transmission incorrectly. Figure 9.31, Figure 9.32, Figure 9.33, Figure 9.34, and Figure 9.35.

Prevention
Teach drivers to correctly operate a vehicle.
Cause of Failure

The lubricant was contaminated or the transmission was operated with insufficient lubricant.

What To Look For

Is the lubricant blackened, or has it started to solidify? If the lubricant looks blackened, does it have a burned smell? If so, it is an indication the transmission was operated with insufficient lubricant and under high temperatures. Under these conditions, lubricant breaks down and becomes blackened and sludge-like.

Remove the top cover. Check the internal walls of the transmission case for burned lubricant residue, which bakes into the case when the transmission is operated with insufficient lubricant. If residue is present, is it contaminated with metal particles or debris?

Look for leaking transmission seals. Look for a common wear pattern on the gear teeth called “apple coring,” which occurs when metal melts at high temperatures and leaves a central, concave depression in the gear teeth. Figure 9.36, Figure 9.37, Figure 9.38, Figure 9.39, Figure 9.40, and Figure 9.41.

If possible, determine if the transmission became difficult to shift, or if it was grinding or “growling” when in gear. Gears damaged by insufficient lubricant require replacement.

Prevention

Follow AxleTech recommended maintenance practices and service procedures. Operate the vehicle within its approved application and weight limits. Teach drivers how to correctly operate a vehicle.
Synchronizer Pin

Cause of Failure

Torsional vibration in the drivetrain damaged the synchronizer assembly.

Torsional vibration is a twisting and untwisting action in a shaft caused by the application of engine power (torque) or incorrect driveline phasing or angles. Torsional vibration is most likely absorbed at the transmission synchronizer and causes premature wear damage to all drivetrain components.

What To Look For

Check the synchronizer assembly and pins. When torsional vibration occurs, pins can be fractured. Figure 9.42, Figure 9.43, and Figure 9.44. A synchronizer damaged by torsional vibration require replacement.

Prevention

Follow AxleTech recommended service procedures to verify driveline angles and phasing are correct.
Shift Collar Wear

Cause of Failure
Shift collar teeth are worn and damaged, and full engagement does not occur. Replace the shift collar.

What To Look For
Shift collar teeth surfaces are worn and rounded instead of flat and trapezoid shape. Figure 9.45. Are the sides of the teeth surfaces polished? This indicates the collar is fully engaged into the mating gear. If wear does not extend to the end of the tooth, the collar isn’t engaging fully into the gear.

Is there a trapezoid shape on the ends of the teeth? Are teeth surfaces polished? If so, the shift collar is fully engaging and does not require replacement. Figure 9.46 and Figure 9.47.

It is normal to find shift collar damage in high-mileage transmissions. However, in lower-mileage transmissions, damage can occur if the manual shift mechanism malfunctions, the clutch is out-of-adjustment, or a driver didn’t shift the transmission correctly.

Check for a bent or twisted shift fork, worn or broken top cover, worn shift tower or twisted main shaft. Verify the shift lever motion isn’t restricted.

Try to determine if the driver had difficulty shifting the transmission. Worn collars cause raking and grinding during shifting.

Prevention
Follow AxleTech recommended maintenance practices and service procedures. Operate the vehicle within its approved application and weight limits. Teach drivers to correctly shift a transmission.
Oil Seals

If moisture, wetness, or oil drips on or around an axle oil seal, it is important to recognize if the seal is leaking, or if it only appears to be leaking.

Recognizing a Leaking Seal

Inspect the oil seal and surrounding area for wetness. If the seal and area appear very wet or visibly drip oil, or if oil is dripping from the bottom of the output seal retainer, replace the seal.

Inspect the yoke for wetness. Check for a leak path leading to the rear lip of the seal. If wetness is around the yoke hub or a leak path leading to the rear lip of the seal, replace the seal.

Recognizing a Seal that Appears to be Leaking

Seals come pre-lubricated with grease that melts at low temperatures under normal operating conditions. Melted grease can moisten or wet the area between the yoke and the oil seal lip. When this happens, a leak path leading to the seal will not be present. If the seal is moist seal and a leak path is not present, do not replace the seal.

A seal can also become moist from lubricants applied to the yoke or retainer bolts during assembly. When this happens, a leak path leading to the seal will not be present. If the seal is moist seal and a leak path is not present, do not replace the seal.

Seal Test Procedure

1. Thoroughly clean and dry the area around the entire seal retainer casting, especially at the top.
2. Drive the vehicle for 15-20 minutes at highway speeds.
3. Check for wetness or moisture on or around the seal. Also check for oil dripping from the seal. If either of these conditions is present, replace the seal.

Example 1: Seal is Not Leaking

Cause of Failure
None

What To Look For
There is slight moisture from packing grease at assembly, but the area around the seal is dry. Figure 9.48.

Prevention
Follow AxleTech recommended maintenance practices and service procedures.
**Example 2: Seal Appears to be Leaking**

**Cause of Failure**
A failure is possible. Inspect the seal. If a failure has occurred, determine its cause.

**What To Look For**
Check for an oil path from the speedometer sensor to the yoke area. If an oil path is present, the seal is leaking. If an oil path is **not** present, but oil is around the seal, the seal requires replacement. Both of these conditions can occur at the same time. Figure 9.49.

Check the lubricant level. If it is low, replace the seal. If not, monitor the seal for leaks.

**Prevention**
Follow AxleTech recommended maintenance practices and service procedures.

**Example 3: Seal Appears to be Leaking**

**Cause of Failure**
A failure is possible. Inspect the seal. If a failure has occurred, determine its cause.

**What To Look For**
Check for an oil path from the cover bolts to the yoke area. If an oil path is present, the seal is leaking. If an oil path is **not** present, but oil is around the seal, the seal requires replacement. Both of these conditions can occur at the same time. Figure 9.50.

Clean oil and dirt from the carrier. Check the lubricant level. If it is low, replace the seal. If not, monitor the seal for leaks.

**Prevention**
Follow AxleTech recommended maintenance practices and service procedures.
Example 4: The Seal is Leaking

**Cause of Failure**

Most likely, dirt or contaminants have entered the seal, or the seal’s service life is expended.

**What To Look For**

Inspect the yoke hub for wetness. Look for an oil leak path leading to the rear lip of the seal, which indicates that the seal is leaking and requires replacement.

The seal requires replacement, even if an oil path is not present from the speed sensor, shift tower, and retainer bolts. Figure 9.51.

**Prevention**

Follow AxleTech recommended maintenance practices and service procedures.

Troubleshooting and Diagnostics

**Types of Problems**

When checking a problem with a manual transmission, the first thing to do is to verify the service condition. Talk to the driver, the mechanic or the service manager. If possible, take the vehicle for a test drive.

There are three main types of problems:

- Leaks
- Noise and/or vibration
- Operating conditions

Use the diagnostic tables and charts provided in this section as a starting point to diagnose the root cause of the problem. The information contained in these resources is not completely inclusive. Technicians should call AxleTech Customer Service at 800-540-2794 or via email at service.na@axletech.com for further assistance.
Leaks

Check the transmission for transmission oil leaks. If oil is on or under the transmission, verify the leak is transmission oil and not engine oil, coolant, or other lubricants.

Noise

If a noise is the problem, find out the sound of the noise.

- Growling or humming, or grinding
- Hissing, thumping or bumping
- Rattles
- Squealing
- Whining

Vibration

When checking a noise or a vibration, find out when the problem occurs.

- When the transmission is in neutral or in gear
- During upshifts or downshifts
- In all gears or specific gears
- In the high range or low range
- In direct range or overdrive range, 13-speed transmission only
- During coast or acceleration
- With the vehicle loaded or unloaded

Operating Conditions

When the transmission is not operating correctly, find out when the problem occurs.

- In neutral or in gear
- During upshifts or downshifts
- In high range or low range
- In direct range or overdrive range, 13-speed transmissions only

Also, find out what the transmission does during the problem.

- Does not stay in the selected gear
- Does not stay in the selected range
- Does not select all gears
- Does not select all ranges
- Overheats
- Does not operate
# Troubleshooting Other Systems

Verify the transmission is the cause of the problem.

<table>
<thead>
<tr>
<th>System</th>
<th>Check For</th>
<th>Repairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Systems</td>
<td>1. Loose or missing fasteners</td>
<td>1. Replace missing fasteners.</td>
</tr>
<tr>
<td></td>
<td>2. Engine idle speed out-of-specifications</td>
<td>2. Adjust the idle speed to the specified range.</td>
</tr>
<tr>
<td></td>
<td>3. Loose or damaged engine mounts</td>
<td>3. Tighten the fasteners to the specified torque. Replace the damaged mounts.</td>
</tr>
<tr>
<td></td>
<td>5. Damaged engine fan</td>
<td>5. Repair or replace as required.</td>
</tr>
<tr>
<td>Clutch Systems</td>
<td>1. Loose or missing fasteners</td>
<td>1. Replace the missing fasteners.</td>
</tr>
<tr>
<td></td>
<td>4. Worn or damaged pilot bearing</td>
<td>4. Replace the pilot bearing.</td>
</tr>
<tr>
<td>Driveshaft Systems</td>
<td>1. Driveshaft system requires lubrication</td>
<td>1. Lubricate the driveshaft system.</td>
</tr>
<tr>
<td></td>
<td>2. Worn or damaged u-joints and/or yokes</td>
<td>2. Replace the u-joints and/or yokes.</td>
</tr>
<tr>
<td></td>
<td>3. Driveshaft out-of-balance</td>
<td>3. Balance the driveshaft correctly or replace the driveshaft.</td>
</tr>
<tr>
<td></td>
<td>4. Center bearings not installed correctly or damaged</td>
<td>4. Install the center bearings correctly or replace.</td>
</tr>
<tr>
<td></td>
<td>5. Driveline angles not correct</td>
<td>5. Adjust the driveline angles to the manufacturer’s specifications.</td>
</tr>
<tr>
<td>Suspension Systems</td>
<td>1. Loose or missing fasteners</td>
<td>1. Replace the missing fasteners.</td>
</tr>
<tr>
<td></td>
<td>2. Damaged suspension components</td>
<td>2. Repair or replace the damaged suspension components.</td>
</tr>
<tr>
<td></td>
<td>3. Driveline touching frame</td>
<td>3. Adjust driveline to not touch frame.</td>
</tr>
<tr>
<td></td>
<td>4. Loose or damaged cab mounts</td>
<td>4. Tighten loose fasteners to the specified torque. Replace any damaged mounts.</td>
</tr>
<tr>
<td></td>
<td>5. Leaks in air suspension system</td>
<td>5. Repair the air leaks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check all valves for correct operation.</td>
</tr>
<tr>
<td>Remote Shift Systems</td>
<td>1. Low lubricant level</td>
<td>1. Fill to the specified level.</td>
</tr>
<tr>
<td></td>
<td>2. Linkage out of adjustment</td>
<td>2. Adjust the linkage.</td>
</tr>
<tr>
<td></td>
<td>3. Linkage binding or unable to move</td>
<td>3. Lubricate, repair, or replace the linkage.</td>
</tr>
</tbody>
</table>
# Troubleshooting Leaks

Before troubleshooting a leak condition, perform the following conditions. Refer to the table below for diagnostics.

1. Clean the outside of the transmission to remove all the dirt.
2. Operate the vehicle to verify the leak is coming from the transmission.
3. Verify the fluid is transmission oil.
4. Verify the transmission housings are not cracked or broken.

## System Check For Repairs

<table>
<thead>
<tr>
<th>Leaks — In-Vehicle Repair</th>
<th></th>
<th>Repairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Missing fasteners</td>
<td></td>
<td>1. Replace the missing fasteners.</td>
</tr>
<tr>
<td>2. Loose fasteners</td>
<td></td>
<td>2. Tighten to the specified torque.</td>
</tr>
<tr>
<td>3. High oil level</td>
<td></td>
<td>3. Drain to the specified level.</td>
</tr>
<tr>
<td>4. Unspecified oil in transmission</td>
<td></td>
<td>4. Drain the oil. Install the specified oil.</td>
</tr>
<tr>
<td>5. Clogged or dirty breather vent</td>
<td></td>
<td>5. Clean the breather vent.</td>
</tr>
<tr>
<td>7. Damaged output shaft seal</td>
<td></td>
<td>7. Replace the output shaft seal.</td>
</tr>
</tbody>
</table>

## Leaks — Remove and Disassemble Transmission

| Damage gaskets or sealing material         |  | Replace the gaskets or sealing material.    |
| Cracked or broken housing                  |  | Replace the housing.                       |
| Oil leaking from breather vent.            |  | Replace the piston shaft seal.             |

1 If the transmission continues to leak and the output shaft seal and the yoke have been replaced, remove and replace the output shaft assembly.

2 Place the transmission in Low Range and operate the vehicle. If air leaks from the breather vent, the range shaft seal must be replaced.
# Troubleshooting Noise

For all noise conditions, check the following before disassembling the transmission. Refer to the table below for diagnostics and for an explanation of additional repairs that may be required.

1. Check the oil level is even with the bottom of the fill plug hole.
2. Verify the correct oil is used.
3. Verify the driveline angles of the transmission are correct.
4. Verify the transmission is correctly installed.
5. Remove the drain plug. Check for any metal shavings, gasket material, or any other material in the oil.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cause</th>
<th>Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growling, Humming, or Grinding</td>
<td>1. Worn or damaged gears</td>
<td>1. Replace the gears.</td>
</tr>
<tr>
<td></td>
<td>2. Worn bearings (humming only)</td>
<td>2. Replace the bearings.</td>
</tr>
<tr>
<td>Hissing, Thumping, or Bumping</td>
<td>1. Damaged bearings (hissing only)</td>
<td>1. Replace the bearings.</td>
</tr>
<tr>
<td></td>
<td>2. Damaged gear teeth (thumping or bumping only)</td>
<td>2. Replace the gears.</td>
</tr>
<tr>
<td>Rattles - In-Vehicle Repair</td>
<td>1. Engine idle speed not within specifications</td>
<td>1. Adjust the idle speed to the specified RPM.</td>
</tr>
<tr>
<td></td>
<td>2. Engine does not operate on all cylinders.</td>
<td>2. Adjust or repair the engine.</td>
</tr>
<tr>
<td></td>
<td>3. Clutch intermediate or center plate binding in housing</td>
<td>3. Repair or replace the intermediate or center plate.</td>
</tr>
<tr>
<td></td>
<td>4. Other systems</td>
<td>4. Verify the transmission is the source of the rattle condition.</td>
</tr>
<tr>
<td></td>
<td>5. Incorrect shim installation on the PTO unit</td>
<td>5. Install the correct shims onto the PTO unit.</td>
</tr>
<tr>
<td>Rattles - Remove and Disassemble Transmission</td>
<td>1. Damaged washers between main shaft gears</td>
<td>1. Replace the washers between the main shaft gears.</td>
</tr>
<tr>
<td>Squealing or Whining - In-Vehicle Repair</td>
<td>1. Incorrect shim installation on the PTO unit</td>
<td>1. Install the correct shims onto the PTO unit.</td>
</tr>
<tr>
<td>Squealing or Whining - Remove and Disassemble Transmission</td>
<td>1. Damaged bearings</td>
<td>1. Replace the bearings</td>
</tr>
<tr>
<td></td>
<td>2. End play of countershafts not within specifications</td>
<td>2. Adjust the countershaft end play within specifications.</td>
</tr>
</tbody>
</table>

1 Growling and humming are associated with the first stages of the condition. Grinding is associated with the severe stages of the condition.

2 Hissing is associated with the first stages of the condition. Thumping and bumping are associated with the severe stages of the condition.

3 If the noise occurs when the clutch is engaged and stops when the clutch is disengaged, the intermediate or center plate is the cause of the rattle.

4 Whining is a medium-pitched noise. Squealing is a high-pitched noise.
Troubleshooting Vibration

Before troubleshooting a vibration, perform the following conditions. Refer to the table below for diagnostics.

1. The engine idle speed is within the specified range.
2. The engine is operating correctly.
3. The u-joints, yokes, and driveshafts are in good condition. Check the driveline angles. Correct as necessary.
4. The u-joints, yokes, and driveshafts are correctly aligned and/or balanced. Correct as necessary.
5. Check the air bag height. Correct as necessary.

<table>
<thead>
<tr>
<th>System</th>
<th>Check For</th>
<th>Repairs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration — In-Vehicle Repair</td>
<td>1. Fasteners do not remain tight.</td>
<td>1. Tighten the fasteners. If the fasteners do not remain tight, replace the fasteners or the housing.</td>
</tr>
<tr>
<td>Vibration — Remove and Disassemble Transmission</td>
<td>1. Damaged bearings</td>
<td>1. Replace the bearings.</td>
</tr>
<tr>
<td></td>
<td>2. Cracked or broken housing¹</td>
<td>2. Replace the synchronizer.</td>
</tr>
</tbody>
</table>

¹ If the transmission does not shift correctly into the selected range, broken or loose synchronizer pins are the result of the vibration condition.
## Troubleshooting Operating Conditions

Refer to the table below to troubleshoot operating conditions. For all Range Shift System diagnostics, refer to the flowcharts in this section.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cause</th>
<th>Repair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission Slips Out of the Selected Range - In-Vehicle Repair¹</td>
<td>1. The air lines and fittings are loose.</td>
<td>1. Tighten the air lines and fittings.</td>
</tr>
<tr>
<td></td>
<td>2. Obstructions are in the air lines.</td>
<td>2. Change the routing or replace the air lines.</td>
</tr>
<tr>
<td></td>
<td>3. Check the operation of the filter/regulator assembly</td>
<td>3. Replace the filter/regulator assembly if the pressure at the delivery port is not within specification.</td>
</tr>
<tr>
<td></td>
<td>4. The range piston is damaged</td>
<td>4. Replace the range piston.</td>
</tr>
<tr>
<td></td>
<td>5. The nut fastening the piston to the shift shaft in the range shift cylinder is loose or missing</td>
<td>5. Tighten or replace the nut.</td>
</tr>
<tr>
<td>Transmission Slips Out of the Selected Range — Remove and Disassemble Transmission¹</td>
<td>1. The teeth in the sliding clutch are worn</td>
<td>1. Replace the sliding clutch.</td>
</tr>
<tr>
<td></td>
<td>2. The shift fork is bent or worn</td>
<td>2. Replace the shift fork.</td>
</tr>
<tr>
<td></td>
<td>3. The collar on the range shift fork is worn</td>
<td>3. Replace the collar on the range shift fork.</td>
</tr>
<tr>
<td>Transmission is Slow to Shift or Unable to Shift into the Selected Range — In-Vehicle Repair¹</td>
<td>1. The air lines and fittings are loose or leaking</td>
<td>1. Tighten or replace the air lines or fittings.</td>
</tr>
<tr>
<td></td>
<td>2. Obstructions are in the air lines</td>
<td>2. Change the routing or replace the air lines.</td>
</tr>
<tr>
<td></td>
<td>3. The filter/regulator assembly does not operate correctly</td>
<td>3. Replace the filter/regulator assembly if pressure at the delivery port is not within specification.</td>
</tr>
<tr>
<td></td>
<td>4. The piston or o-rings in the piston housing are damaged</td>
<td>4. Replace the piston or damaged o-rings</td>
</tr>
<tr>
<td></td>
<td>5. The neutral switch is worn or damaged</td>
<td>5. Test and replace the neutral switch</td>
</tr>
<tr>
<td></td>
<td>6. The shift knob is damaged</td>
<td>6. Test and replace the shift knob</td>
</tr>
<tr>
<td>Transmission is Slow to Shift or Unable to Shift into Selected Range - Remove and Disassemble Transmission¹</td>
<td>1. The output shaft is damaged</td>
<td>1. Replace the output shaft.</td>
</tr>
<tr>
<td></td>
<td>2. The synchronizer springs or pins are broken or missing</td>
<td>2. Replace the synchronizer springs or synchronizer</td>
</tr>
<tr>
<td></td>
<td>3. The synchronizer is damaged</td>
<td>3. Replace the synchronizer.</td>
</tr>
<tr>
<td></td>
<td>4. The shift shaft in the range cylinder is bent or broken</td>
<td>4. Replace the shift shaft.</td>
</tr>
<tr>
<td></td>
<td>5. The shift fork in the range cylinder is bent or broken</td>
<td>5. Replace the shift fork.</td>
</tr>
<tr>
<td>Condition</td>
<td>Cause</td>
<td>Repair</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Transmission Slips Out of the Selected Gear - In-Vehicle Repair</td>
<td>1. The clutch is used incorrectly</td>
<td>1. Ensure the driver uses the clutch correctly.</td>
</tr>
<tr>
<td></td>
<td>2. The linkage is binding or does not move freely</td>
<td>2. Lubricate, repair, or replace the linkage.</td>
</tr>
<tr>
<td></td>
<td>3. The clutch is out of adjustment</td>
<td>3. Adjust the clutch and ensure it engages and releases correctly.</td>
</tr>
<tr>
<td></td>
<td>4. The remote shift linkage is out of adjustment</td>
<td>4. Adjust the remote shift linkage</td>
</tr>
<tr>
<td></td>
<td>5. The engine or cab mounts are loose or damaged</td>
<td>5. Tighten the fasteners on the loose mounts to the specified torque. Replace damaged mounts.</td>
</tr>
<tr>
<td></td>
<td>6. The driveline angles are incorrect</td>
<td>6. Adjust the driveline angles</td>
</tr>
<tr>
<td></td>
<td>7. The detent spring in the top cover is weak or broken</td>
<td>7. Replace the detent spring in the top cover assembly.</td>
</tr>
<tr>
<td>Transmission Slips Out of the Selected Gear — Remove and Disassemble Transmission</td>
<td>1. The pads on the shift fork are worn</td>
<td>1. Replace the shift fork.</td>
</tr>
<tr>
<td></td>
<td>2. The teeth in the sliding clutch are worn</td>
<td>2. Replace the sliding clutch.</td>
</tr>
<tr>
<td></td>
<td>3. The fork slot on the sliding clutch is worn</td>
<td>3. Replace the sliding clutch.</td>
</tr>
<tr>
<td></td>
<td>4. The key on the main shaft is broken.</td>
<td>4. Replace the key or main shaft.</td>
</tr>
<tr>
<td></td>
<td>5. The main shaft is twisted</td>
<td>5. Replace the main shaft.</td>
</tr>
<tr>
<td>Transmission is Hard to Shift or Unable to Shift into the Selected Gear — In-Vehicle Repair</td>
<td>1. The vehicle is operated incorrectly</td>
<td>1. Ensure that the driver operates the vehicle correctly.</td>
</tr>
<tr>
<td></td>
<td>2. The clutch is out-of-adjustment</td>
<td>2. Adjust the clutch. Ensure that the clutch engages and releases correctly.</td>
</tr>
<tr>
<td></td>
<td>3. The remote shift linkage is binding or unable to move</td>
<td>3. Lubricate, repair or replace the remote shift linkage.</td>
</tr>
<tr>
<td></td>
<td>4. The cab or engine mounts are loose or damaged</td>
<td>4. Tighten the fasteners of the loose mounts to the specified torque.</td>
</tr>
<tr>
<td></td>
<td>5. The detent spring is too strong or broken</td>
<td>5. Replace the detent springs.</td>
</tr>
<tr>
<td>Transmission is Hard to Shift or Unable to Shift into the Selected Gear — Remove and Disassemble Transmission</td>
<td>1. Bent shift shaft in top cover assembly</td>
<td>1. Replace the shift shaft.</td>
</tr>
<tr>
<td></td>
<td>2. Burr on the shift shaft in the top cover assembly</td>
<td>2. Replace the shift shaft.</td>
</tr>
<tr>
<td></td>
<td>3. Cracked top cover assembly</td>
<td>3. Replace the top cover assembly.</td>
</tr>
<tr>
<td></td>
<td>4. The main shaft is twisted</td>
<td>4. Replace the main shaft.</td>
</tr>
<tr>
<td></td>
<td>5. The key on the main shaft is broken</td>
<td>5. Replace the key or the main shaft.</td>
</tr>
<tr>
<td>Condition</td>
<td>Cause</td>
<td>Repair</td>
</tr>
<tr>
<td>-----------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>Transmission Grinds on Initial Engagement — In-Vehicle Repair</td>
<td>1. The driver does not operate the vehicle correctly</td>
<td>1. Ensure the driver operates the vehicle correctly.</td>
</tr>
<tr>
<td></td>
<td>2. The clutch is out-of-adjustment.</td>
<td>2. Adjust the clutch. Verify that the clutch engages and releases correctly.</td>
</tr>
<tr>
<td></td>
<td>3. The clutch brake is worn, damaged or missing</td>
<td>3. Replace the clutch brake. Verify that the clutch engages and releases correctly.</td>
</tr>
<tr>
<td></td>
<td>4. The clutch or remote shift housing linkage is binding or unable to move</td>
<td>4. Lubricate, repair or replace the linkage.</td>
</tr>
<tr>
<td></td>
<td>5. Worn bushings in side of clutch housing</td>
<td>5. Replace the bushings in the clutch housing.</td>
</tr>
<tr>
<td>Shift Lever Locks or Sticks in Gear — In-Vehicle Repair</td>
<td>1. The remote shift linkage is out-of-adjustment</td>
<td>1. Adjust the remote shift linkage.</td>
</tr>
<tr>
<td></td>
<td>2. The clutch linkage needs adjustment</td>
<td>2. Adjust the clutch linkage.</td>
</tr>
<tr>
<td></td>
<td>3. The linkage is binding or unable to move</td>
<td>3. Lubricate, repair or replace the linkage.</td>
</tr>
<tr>
<td></td>
<td>4. The cab or engine mounts are loose or damaged</td>
<td>4. Tighten the fasteners on the loose mounts to the specified torque. Replace the damaged mounts.</td>
</tr>
<tr>
<td></td>
<td>5. The shift stub lever is not engaged in the shift sleeve</td>
<td>5. Reinstall the shift tower and verify the engagement of the stub lever into the shift sleeve.</td>
</tr>
<tr>
<td>Shift Lever Locks or Sticks in Gear — Remove and Disassemble Transmission</td>
<td>1. The shift fork in the top cover is bent</td>
<td>1. Replace the shift fork.</td>
</tr>
<tr>
<td></td>
<td>2. The shift shaft in the top cover is damaged</td>
<td>2. Replace the shift shaft.</td>
</tr>
<tr>
<td></td>
<td>3. The main shaft is damaged</td>
<td>3. Replace the main shaft.</td>
</tr>
<tr>
<td>Transmission Overheats — In-Vehicle</td>
<td>1. The oil level is incorrect</td>
<td>1. Fill the oil to the specified level.</td>
</tr>
<tr>
<td></td>
<td>2. Incorrect oil</td>
<td>2. Drain the oil. Use the specified oil.</td>
</tr>
<tr>
<td></td>
<td>3. The temperature gauge is damaged</td>
<td>3. Replace the temperature gauge.</td>
</tr>
<tr>
<td>Transmission Does Not Operate — Remove and Disassemble Transmission</td>
<td>1. The free running gears are locked</td>
<td>1. Replace the gears.</td>
</tr>
<tr>
<td></td>
<td>2. The gear sets are mismatched</td>
<td>2. Install the correct gear sets.</td>
</tr>
<tr>
<td></td>
<td>3. The timing marks on the gears are not aligned</td>
<td>3. Align the timing marks on the gears.</td>
</tr>
<tr>
<td></td>
<td>4. The shafts are broken</td>
<td>4. Replace the shaft.</td>
</tr>
</tbody>
</table>

1 Also refer to the Range Shift System diagnostic flowcharts in this section to troubleshoot all range system problems.
2 If a noise is present along with the overheating condition, also refer to the noise troubleshooting table in this section.
3 If the oil is at the specified level and the specified oil is used, but the transmission overheats and the oil smells burned, the transmission must be disassembled and inspected.
4 If the oil does not have a burned smell and the temperature gauge indicates overheating, remove and replace the gauge.
Range Shift System Diagnostics for Platform G Transmissions

These flowcharts provide diagnostic information for ZF-FreedomLine Platform G transmission range shift systems. When using diagnostics to troubleshoot system faults, it is important to follow these flowcharts step-by-step and use the diagnostic procedures in the sequence outlined below. Figure 9.52, Figure 9.53, and Figure 9.54.

**IN-LINE CONFIGURATION**

LOW DIAGNOSTIC PORTS
55-75 PSI IN LOW
0 PSI IN HIGH

HIGH DIAGNOSTIC PORTS
55-75 PSI IN HIGH
0 PSI IN LOW

REGULATED DIAGNOSTIC PORTS, 55-75 PSI

VEHICLE AIR SUPPLY
~ 140 PSI

AIR FILTER REGULATOR

**V CONFIGURATION**

LOW DIAGNOSTIC PORTS
55-75 PSI IN LOW
0 PSI IN HIGH

HIGH DIAGNOSTIC PORTS
55-75 PSI IN HIGH
0 PSI IN LOW

REGULATED DIAGNOSTIC PORTS, 55-75 PSI

VEHICLE AIR SUPPLY
~ 140 PSI

AIR FILTER REGULATOR

**COMPONENT SPECIFICATIONS**

**NEUTRAL SWITCH**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Resistance (Measured Across Pins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Neutral</td>
<td>0.0-0.5 ohms</td>
</tr>
<tr>
<td>In Gear</td>
<td>Open Circuit</td>
</tr>
</tbody>
</table>

**RANGE SOLENOIDS**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Resistance (Measured Across Pins)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>11-21 ohms</td>
</tr>
</tbody>
</table>

**OPTIONAL J2 CONNECTOR**

**REVERSE SWITCH (OPTIONAL)**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Resistance (Measured Across Pins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Reverse</td>
<td>0.0-0.5 ohms</td>
</tr>
<tr>
<td>Not In Reverse</td>
<td>Open Circuit</td>
</tr>
</tbody>
</table>
Troubleshooting Flowcharts

Use the following recommended service procedures to repair and test the system. If a fault still exists, or if a new fault is found, repeat the mechanical checks and both the low-range and high-range electrical checks until all the faults have been repaired.
Follow the mechanical checks flowchart to verify all mechanical systems function correctly. Repair all mechanical issues BEFORE performing electrical checks. Figure 9.55.
Low Range Electrical Checks

Follow the low range electrical checks flowchart to verify the low electrical system functions correctly. Perform low range electrical checks AFTER mechanical checks and BEFORE high range electrical checks. Figure 9.56.

Electric Over Air (EOA) Diagnostic Flowchart
Electrical Checks, Low Range

NOTE: Follow the mechanical flowchart BEFORE the low range electrical flowchart.

FAULT: Slow / No Range Shift (after following mechanical flowchart)

1. Disconnect main transmission harness from OEM harness.
2. Check voltages at OEM harness pins A&B with ignition on.

Voltage is between 9-16 volts

1. Reconnect transmission harness.
2. Disconnect low solenoid connector.
3. Put shifter in Neutral with ignition on. Select low range on shift knob.
4. Measure voltage at pins A&B of low solenoid transmission harness connector.

Voltage is less than 8 volts

Resistance is less than 40 ohms

Resistance is greater than 40 ohms

Remove Neutral switch and top cover; inspect components for wear

Top cover components are not worn

Top cover components are worn

Replace worn components

Check resistance of Neutral switch with ball extended

Voltage is less than 9 volts or greater than 16 volts

Reference OEM procedures to correct switched power issues

Measure resistance across pins A&B of the Neutral switch

Resistance is greater than 40 ohms

Voltage is less than 8 volts

Resistance is less than 40 ohms

Resistance is greater than 11-21 ohms

Go to High Range diagnostic flowchart

Replace low solenoid

Disconnect harness at shift knob and check voltage at pins A&D of the 4-pin connector

Voltage is greater than 6 volts

Test shift knob with SPX Kent-Moore shift knob tester (J-44366)

Fail

Pass

Replace shift knob

Contact Customer Service at 1-800-540-2794

Figure 9.56
High Range Electrical Checks

Follow the high range electrical checks flowchart to verify the high range electrical system functions correctly. Perform high range electrical checks AFTER mechanical checks and low range electrical checks. Figure 9.57.

Electric Over Air (EOA) Diagnostic Flowchart

**Electrical Checks, High Range**

**NOTE:** Follow the low range electrical flowchart BEFORE this flowchart.

**FAULT:** Slow / No Range Shift (after following low range electrical flowchart)

- Voltage is between 9-16 volts
  - 1. Disconnect main transmission harness from OEM harness.
  - 2. Check voltages at OEM harness pins A&B with ignition on.

- Voltage is less than 9 volts or greater than 16 volts
  - Reference OEM procedures to correct switched power issues

- Voltage is greater than 6 volts
  - 1. Reconnect transmission harness.
  - 2. Disconnect high solenoid connector.
  - 3. Put shifter in Neutral with ignition on. Select high range on shift knob.
  - 4. Measure voltage at pins A&B of high solenoid transmission harness connector.

- Voltage is less than 6 volts
  - Measure resistance across pins A&B of the Neutral switch

- Resistance is greater than 40 ohms
  - Remove Neutral switch and top cover; Inspect components for wear

- Resistance is less than 40 ohms
  - Resistance is greater than 40 ohms
  - Resistance is less than 11 ohms or greater than 21 ohms
  - Resistance is between 11-21 ohms

- Resistance is less than 11 ohms or greater than 21 ohms
  - Replace high solenoid

- Resistance is between 11-21 ohms
  - Contact Customer Service at 1-800-540-2794

- Disconnect harness at shift knob and check voltage at pins A&D of the 4-pin connector

- Voltage is greater than 6 volts
  - Test shift knob with SPX Kent-Moore shift knob tester (J-44366)
  - Check wiring harness for damage. Perform continuity checks

- Voltage is less than 6 volts
  - Pass
  - Fail
  - Replace shift knob

- Check resistance of Neutral switch with ball extended
  - Resistance is measurable
  - Resistance is infinite
  - Replace Neutral switch

- Top cover components are not worn
- Top cover components are worn
- Resistance is infinite
- Resistance to measurable

Figure 9.57
Transfer Cases

Parts Analysis Overview

⚠️ DANGER

ALWAYS WEAR PROPER EYE PROTECTION AND OTHER REQUIRED PERSONAL PROTECTIVE EQUIPMENT TO PREVENT PERSONAL INJURY WHEN INSPECTING HEAVY VEHICLE COMPONENTS.

This section provides a parts analysis process to determine why transfer cases failed during operation, what to look for when inspecting parts, and how to prevent failures from occurring again.

Most of the time, answers can be found by visually inspecting a failed component. Sometimes, however, this process may require specialized knowledge or equipment.

Why a product fails can be difficult to determine, and a failure can vary in appearance from vehicle to vehicle. Failures in models from the same manufacturer can also vary, so it is important to use the information presented here as a guide, not a rule, when performing parts analysis inspections.

Causes of Transfer Case Component Failure

Front Idler Bearing

Cause of Failure

Incorrect towing from the front of the vehicle without removing the driveshaft from the rear output shaft of the transfer case to the rear drive axle, or not removing the rear drive axle shafts on the tires that contact with the road.

What To Look For

Damage to the front idler bearing is found caused by a lack of lubrication. Figure 10.1.

Damage to the front idler bearing cone and/or rollers is found caused by heat and/or a lack of lubrication. Figure 10.1 and Figure 10.3.

Damage to the front idler cup is found caused by heat and/or a lack of lubrication. Figure 10.2.

The bearing cage is destroyed. Figure 10.3.

The input shaft surface and phosphate coating for the low gear bearing journal show eccentric wear, which means wear shows on approximately 180° of the bearing journal, but not on the 180° of the opposite side of the input shaft journal. This condition indicates the low gear is rotating, but the input shaft is not rotating; or the input shaft is rotating at a slower speed during towing. Figure 10.4.

There could be signs of gear clash wear at the end of the high/low clutch collar teeth on the high gear side. This is caused by the inclination of the vehicle as it loses air during towing. Figure 10.5 and Figure 10.6.

Usually, there are no other signs of heat present on other bearings. This damage can occur when the transfer case is rotating, and oil is not flowing from the lubrication pump. If the input shaft on the transfer case is not rotating, the oil pump and/or lubricant splash does not reach the bearings during vehicle inclination while towing. Insufficient lubricant resulting from incorrect towing procedures will damage the front idler bearing. The transfer case can fail during towing, or when the vehicle is in operation.
Prevention

Follow AMT-0155 AxleTech Towing Service Manual. To obtain this publication, see “Service Notes” on page ii.
Front Output Shaft

Cause of Failure

Incorrect towing from the rear of the vehicle without removing the prop shaft from the transfer case to the axle with the wheels on the road. This will cause a spinout condition between the front output helical gear and the front output shaft.

What To Look For

Front output shaft and gear spinout damage caused from friction welding. Figure 10.7.

Front output shaft rear bearing cup is damaged from heat. Figure 10.8.

Front output shaft bearing cup and cage is completely destroyed from heat. Figure 10.8.

There is no damage to the All Wheel Drive (AWD) clutch collar because it was not engaged. Heat from the other parts caused slight discoloration of the clutch collar. Figure 10.9.

Spinout between the front output shaft journal and the front output shaft gear caused a friction welding of the two components as well as damage to the front output shaft bearing.

No signs of wear on the front input shaft from the oil pump sealing rings indicate the input shaft was not turning during towing. Figure 10.10.

This damage is caused by the transfer case turning during towing. The transfer case may fail during towing or while driving the vehicle after it has been incorrectly towed.

Prevention

Follow AMT-0155 AxleTech Towing Service Manual. To obtain this publication, see “Service Notes” on page ii.