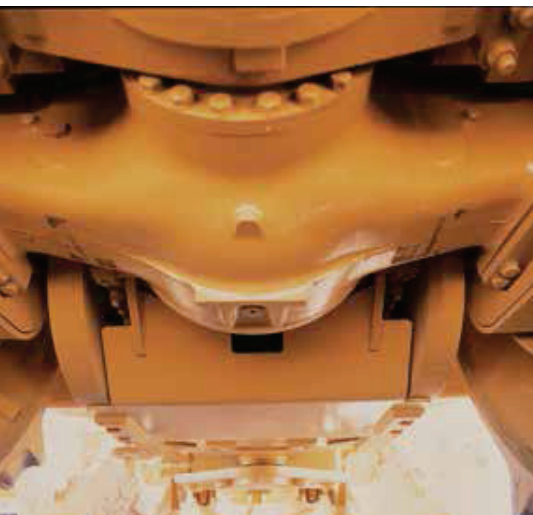


Cat[®] Differential Maintenance



Management Guide

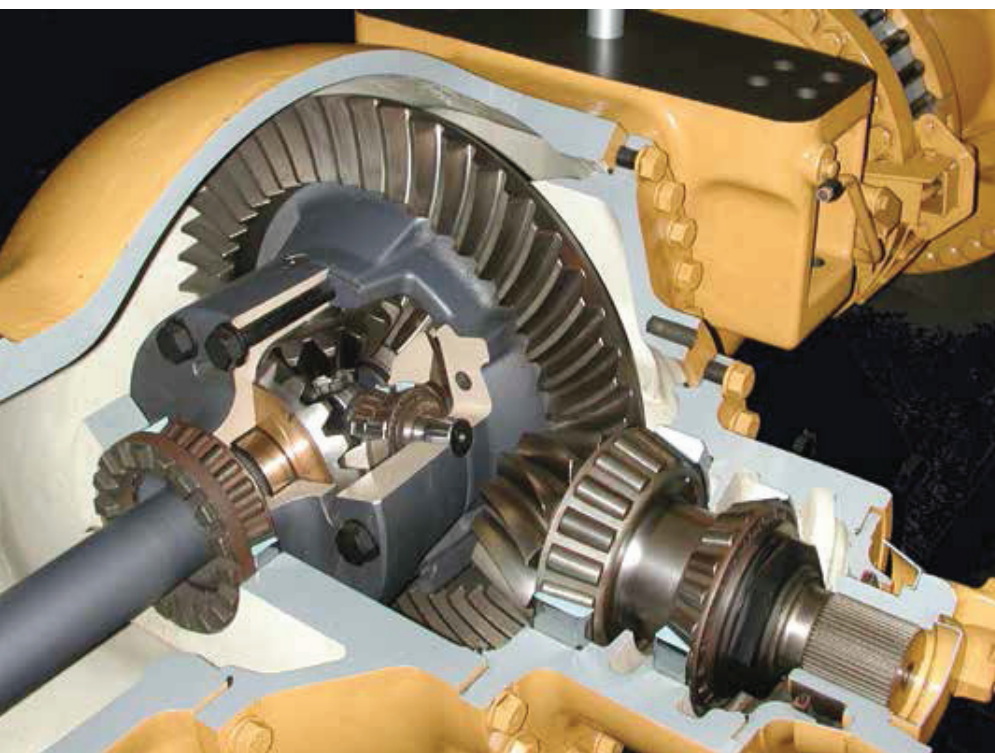
- Overview
- Bearings and Gears
- Preventive Maintenance
- S•O•SSM Fluid Analysis
- Contamination Control
- System Management



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The differential plays a critical role within a machine's drive train by changing the direction of the power coming from the transmission 90 degrees to allow the axles to be driven. They also allow speed and torque differences between the left and right axles. When a machine is turning, the differential lets the outside wheel move at a faster speed than the inside wheel for easier turning and less wear on tires or tracks. The gears in the differential also provide speed reduction and torque increases.

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This management guide offers information, tips, and ideas but is not intended as a technical manual or a substitute for the advice and recommendations of our parts and service experts. By referencing this manual and following the recommendations in your Operations and Maintenance Manual, you can maximize the productivity, service life, and value of your Cat® machines.

Manage it well. Make it last.

This guide gives you the tools to get maximum value from your Cat differential. Understanding the elements of differential management can help you set up a regular maintenance and repair program.

A good differential management program helps you keep productivity up and owning and operating costs down.



Overview

Understanding how differentials work and wear is key to maximizing component life. Differential repair parts can be broken up into three groupings. They are:

Level I—fastest wearing parts, not reusable

- Anti-friction bearings
- Seals and gaskets
- Duo-cone seals

Level II—slower wearing parts, possibly reusable

- Plates
- Discs
- Gears

Level III—longest life, designed not to be replaced

- Housings and axles.

In order to correctly identify failure modes for differentials, it is necessary to understand how the component works, the causes of its premature wear or failure, and the maintenance steps that can be taken to minimize the causes of wear and failure.

The differential will decrease the speed and increase the torque as needed for each wheel's relative motion. When the machine is turning, the differential supplies the needed adjustments to the wheels, allowing the outside wheel to move at a faster pace than the inside wheel. Caterpillar designs and manufactures differential components using testing processes based on actual applications.

Key Functions of a Differential

- Transferring power coming from the transmission to the left and right axle shafts
- Balancing the power according to the demand of each wheel
- To transmit the power to the wheels while allowing them to rotate at different speeds
- Gears in the differential further reduce speed and increase torque to drive the rear wheels

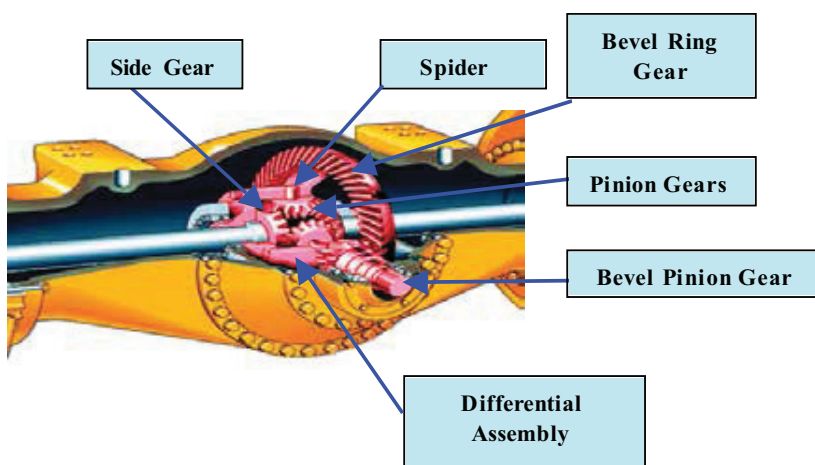


Key Components of the Differential

- **Differential Assembly**—Turns the spider and pinion gears that mesh with the side gears, turning the axle shafts
- **Pinion Gears**—Transmits power from the spider to the side gears that are attached to the axle shafts
- **Side Gears**—Splined to the axles and are driven by the pinion gears
- **Spider**—Serves as the mounting for the pinion gears, and rotates with the differential assembly
- **Bevel Pinion Gear**—Driven by the drive shaft
- **Bevel Ring Gear**—Meshes with the bevel pinion gear and is mounted to the differential assembly

Four Types of Differentials

- Standard—As shown
- Limited Slip
- No Spin
- Locking



Bearings and Gears

Bearings are used in the differentials to maintain position and alignment of gears and shafts, and to minimize friction, heat and wear. They also carry the weight of the vehicle and payload, subjecting them to very high loads and temperatures. Cat bearings have precision surfaces that are separated by a film of lube oil.

It is critical that the surface of the contact areas retains an adequate oil film thickness to prevent metal-to-metal contact with the mating part.

Caterpillar bearing design is application driven, which means we offer the correct bearing for the application.



The basic function of gears in the differential is to transfer power from the drive shaft to the axle shafts.

Loads are transferred through gears by gear teeth pushing against each other. Gears used in the differentials are put through a carburizing and hardening process. This creates a durable outside surface enabling them to carry very high loads for thousands of hours. The gears are machined and precision ground to exact tolerances, making it crucial for the lubricating oil to be at its proper level to avoid metal-to-metal contact. The heat treatment, material and machining processes used on gears are based upon the specific application.



Causes of Premature Bearing Failure

In order to maximize bearing life, it is important to eliminate the four primary causes of premature failure:

- Improper installation—Bearings are not properly installed with the correct pre-load
- Improper tolerances—Width tolerances are incorrect for the application
- Overload (fatigue)—Resulting from machine overloading or long hours of use
- Contaminated lube oil—Causes accelerated surface pitting and premature failure

Causes of Premature Gear Failure

There are five primary causes of premature gear failure:

- Pitting from surface fatigue—Normal end-of-life failure mode; however, consistent overloading accelerates this
- Contaminated lube oil—Causes accelerated surface pitting and cracking
- Gear tooth bending fatigue—Result of severe gear overloading
- Improper alignment—Creates unbalanced loading and contact on gears
- Improper lube oil—Increases surface wear

Preventive Maintenance

The key components in differential preventive maintenance include quality oils and filters, regular S•O•S fluid analysis and contamination control.

Preventive Maintenance

- Allows you to schedule downtime and plan for maintenance and repair costs
- Helps prevent major failures, including failure of related parts
- Saves you money because you can often repair before failure
- Reduces total downtime
- Maximizes parts reusability
- Optimizes equipment life to keep your machine productive and on the job
- Increases machine resale value

Proper Oil Use

The three main functions of oil are to provide cleaning, cooling, and lubrication. Modern Cat drive train systems feature new metals, elastomers and paper disc materials which may have advanced lubrication needs, requiring you to change oil regularly, properly, and use the right drive train oil to achieve top performance.

Use the Right Drive Train Oil

Cat differentials experience high gear and bearing loads and temperatures. In these conditions, it is important gears and bearings are protected.

It is essential that components be run in the correct oil. Always consult your Operations and Maintenance Manual for the specific oil needed. The publication SEBU6250, Caterpillar Machine Fluids Recommendations, can be used for additional verification on oil recommendations.

Cat TDTO (Transmission Drive Train Oil)

This oil is specially formulated to increase the life and performance of your Cat drive train components.

This oil:

- Reduces transmission slippage
- Controls brake chatter
- Provides greater machine rimpull
- Increases friction material life up to 45 percent

Cat TDTO surpasses the TO-4 specification requirement and is specified as factory fill for all Caterpillar machine compartments where TO-4 is the primary recommendation.

Cat TDTO-TMS (Transmission Multi-Season)

This oil is a multi-season formulation of TDTO. This Caterpillar exclusive is a partially synthetic lubricant that eliminates the need to change oil at seasonal intervals. As a result you use the oil for its full life, so there's less used oil disposal and less downtime for maintenance. Cat TDTO (TMS) has shown improved transmission performance in cold weather for machines with electronic controls.

Caterpillar recommends TDTO for transmissions, final drives or differentials, torque converters, and brakes where TO-4 specification oils are recommended for use; and recommends TDTO -TMS to avoid unnecessary oil changes in climates with widely ranging ambient temperatures.

Preventive Maintenance

Cat FDAO (Final Drive Axle Oil)

This oil was developed specifically to protect gears and bearings in bevel gears, differentials, final drives and axles that do not contain friction materials.

Cat FDAO is the preferred lubricant for Cat off-highway truck front wheels, differentials and final drives. It is compatible with Cat final drives and axles that previously specified TO-4 lubricants and do not contain friction material.

Cat FDAO has the following qualities:

- Compatible with Cat Transmission Drive Train Oil (TDTO)
- Excellent protection against rust and copper corrosion
- Minimizes foaming for increased lubrication
- Low oxidation rate for improved oil life
- Maintains desired viscosity and film strength
- Provides reduced wear from debris particles suspended in the oil

Cat gear oil offers maximum protection against the following damage: scoring of the gear teeth, pitting of the gear teeth, and pitting of the parts in roller bearings.

Cat gear oil provides:

- Excellent stability under high temperature conditions
- Superior low temperature performance.
- Protection against rust and corrosion

Some applications require additives for the extreme pressures that can occur at the edges of the components. For these applications, Cat gear oil provides the extra protection. Cat gear oil should not be used in compartments that specify TO-4 or TO-4M oil.



S•O•S Fluid Analysis

S•O•S fluid analysis is a crucial part of machine management. The differential is part of a closed system, so S•O•S fluid analysis is your best window into component condition. Oil sampling at scheduled intervals validates your maintenance procedures, tracks what is going on inside of the equipment, and forecasts wear-related problems. Our S•O•S fluid analysis program is well recognized for its ability to detect potential failures before they occur. Each test is designed to reveal specific information about the condition of Cat products.

There are four types of analysis:

- **Wear Metal**—monitors and tracks metal wear particles, contaminants and oil additive package elements
- **Oil Condition**—compares used oil to new oil to see if it is providing adequate lubrication and protection
- **Oil Cleanliness**—determines if abrasive contaminants are causing accelerated wear
- **Oil Contamination**—detects water, glycol, or fuel in oil



Advantages of Using S•O•S Fluid Analysis

Surveys have shown that there are many benefits to using our S•O•S fluid analysis program:

- Experts can provide analysis and interpretation of trends and can forecast any excessive wear concerns
- Test results are available within 24 hours after receipt of the sample
- Easy-to-understand test report, which calls for specific action and/or makes carefully outlined recommendations
- Saves time and money by identifying trouble spots before they become major failures

S•O•S fluid analysis helps you avoid complete failures. Often an adjustment or replacement of a single part, based on the findings, can prevent a small problem from growing into a major repair. S•O•S fluid analysis is different from other fluid analysis programs because it focuses on component condition, not just oil condition. Since only Caterpillar knows the exact design of your Cat drive train system, we can help you analyze reports, determine what additional tests need to be performed, and recommend the proper corrective action better than other fluid analysis programs.

Particle Count

Particle count is another way of assuring oil cleanliness. When used in conjunction with fluid analysis, particle counting can be a valuable tool in reducing failures in differential systems. The particle count instrument counts the number of particles in several different size ranges, from as small as two microns to over 100 microns. It measures both metallic and non-metallic particles and provides an early warning of abnormal component wear and contaminant ingestion.

S•O•S Fluid Analysis Example: Typical Differential Combinations:

Primary Element	Secondary Element	Potential Wear	Probable Problem Area/Causes
Iron	Chromium	Gears, Anti-friction bearings	Pre-load problem (if no water or dirt is evident)
Aluminum, Chromium	Iron	Sleeve bushings	Wearing out, or previous contamination

Contamination Control

Dirt, sand, grit, and even the finest dust can cause problems when they find their way into the differential. They cause parts to wear faster, making them more prone to premature failure.

There are four ways contamination can get into machine systems:

1. Contaminants can be built-in during manufacturing and assembly operations.
2. Contaminants can enter during servicing and maintenance procedures.
3. Contaminants can enter with new fluid.
4. Contaminants can enter during operation through pitted shafts, broken breathers, worn seals and other trouble spots.

What You Can Do

Fortunately there are steps you can take to prevent fluid contamination. An effective contamination control program is made up of many small steps that help maintain fluid cleanliness and reduce opportunities for contaminants to get in machine systems. Caterpillar recommends a four-part contamination control program consisting of:

1. Clean fluids—filter your oil as you fill the system
2. Clean components
3. Clean facilities
4. Clean shop-repair processes

Good Housekeeping Practices:

- Sweep floors daily.
- Clean up spills immediately.
- Keep workbenches uncluttered and free of debris.
- Limit use of floor storage.

Repair and Assembly:

- Place covers over open compartments.
- Ensure that root cause of failure has been identified and repaired.
- Properly clean component before reassembly
- Use standard parts kits for all component installations.

By following these steps, you will be better prepared to control contamination, reduce overall operating costs, and keep your Cat equipment performing at its best.

Filters

Control contamination inside your differential with Cat fluid filters. By changing filters regularly and properly, and by selecting the right filters, you maintain system cleanliness, reduce component wear, and lower costs.

The use of fluid filters in differentials varies by machine type. Differential oil filters can be found on the 797 and 793 off-highway trucks and on machines using a common oil reservoir system such as backhoe loaders.

For further information on selecting the correct fluid filters, consult your machine's Operation and Maintenance Manual.



System Management

Repair Management

In addition to preventive maintenance, operating technique and application are also critical to the life of your differential.

Operating Technique

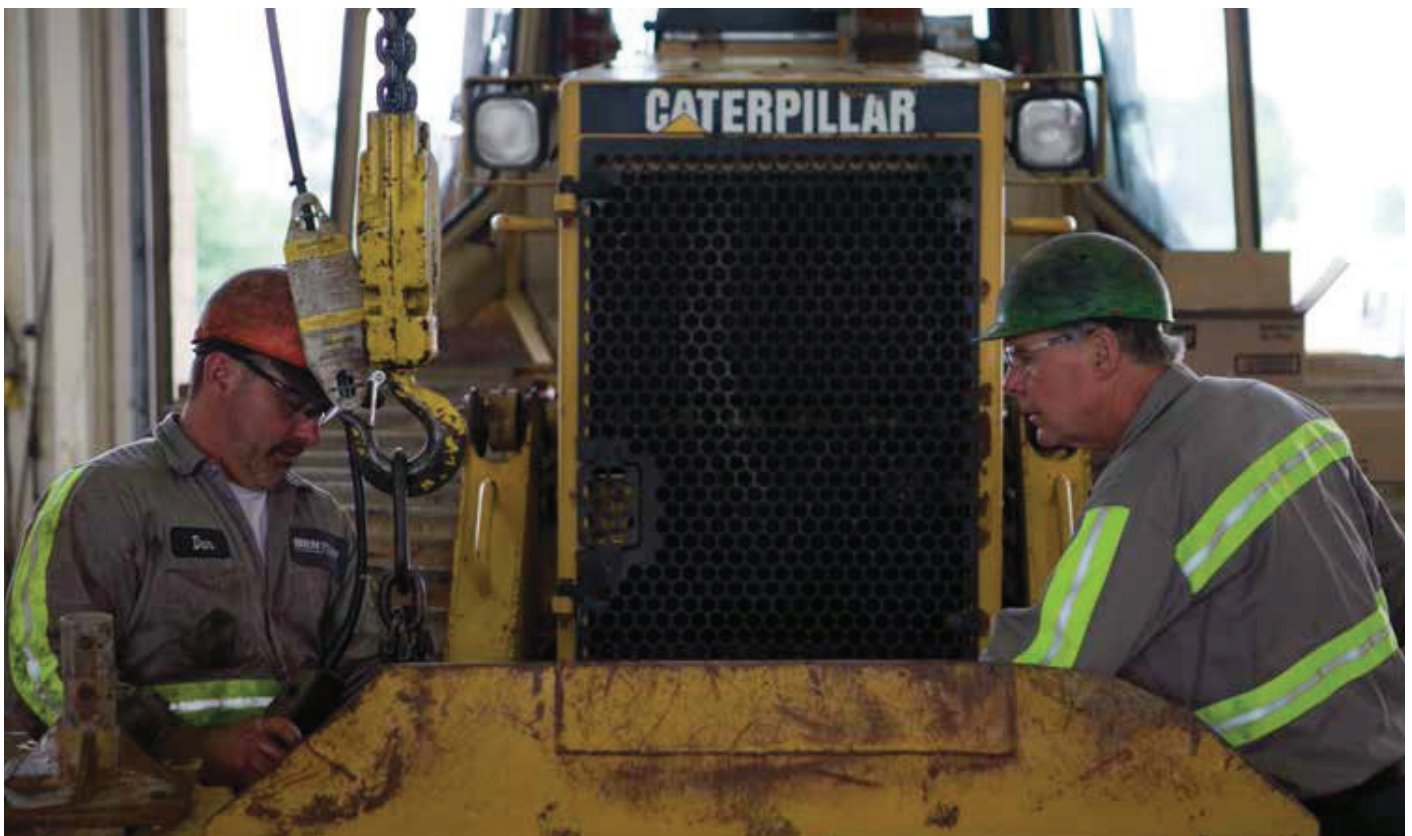
- Avoid high-speed direction changes
- Avoid backing over obstructions
- Avoid extreme braking
- Adequately warm-up the machine
- Pay attention to warning lights
- Do daily walkaround inspections

Application Concerns

- Ambient temperature
- Design of haul roads and repetitiveness of the work

Repair Indicators

There are two types of indicators: planned and problem. Planned indicators are part of a good differential maintenance management program that will give you before-failure repair options to lower your operating costs. Planned indicators are those that are performed or checked routinely such as S•O•S fluid analysis, Technical Analysis, service meter hours, service history and SOMA software. Problem indicators are usually found during inspection and include noises, leaks, overheating, and poor performance. Even with excellent maintenance, eventually repairs will be needed. However, problems can be caught early by performing daily inspections and responding quickly to repair indicators.



Key Steps to Improve Component Durability

Clean Lube Oil

By far, the most common and preventable cause of component failure is due to contaminated lube oil. To ensure components run in clean lube oil, it should be built clean, installed clean, and operated clean.

Correct Lube Oil

It is essential to the component's life to be run in high-quality lube oil. Using the correct lube oil will improve component wear life up to 40% in some applications.

Proper Installation and Assembly

Components are built with specific tolerances and preloads. Proper installation and assembly practices are absolutely essential to component life.

Avoid Overload and Fatigue

Two factors that dramatically accelerate subsurface fatigue and component life are excessive loads and rolling resistance.

Replace Parts Before Failure

Differential piece parts do not have an infinite life. After being run for thousands of hours at high loads and temperatures, the material will eventually fatigue. Thoroughly inspecting the components results in detecting defects and deterioration before they fail completely and damage other vital components.



Differential Repair Indicators

Even with the best preventive maintenance, issues are bound to arise. Following are things to watch for. Your Cat dealer is always available to help with any maintenance or repair.

Planned Indicators	Description
S•O•S Fluid Analysis	Provides the best insight into the internal differential wear and potential failure
Service Meter Hours	Use service meter hours as a repair indicator
Experience -Observation and Discussion	Talking with your machine's operator can reveal many potential differential problems
Service History	Service history indicates how frequently routine maintenance is performed
Fuel Consumption	Indicates when a piece of equipment is operating at less than optimum efficiency
Site Operations Maintenance Advisor (SOMA)	SOMA is a dealer administered software that assesses customers operating and maintenance practices and provides component life estimates

Problem Indicators	Possible Causes
Bent or Damaged Lines	External damage
Unusual Noises (When Traveling Straight)	Worn gears/bearings Ring and pinion require adjustment Dirt entry Low fluid level
Unusual Noises (When Turning)	Worn differential case assembly Worn spider gears
Vibration	Gear failure Spider gear failure Differential failure Bearing failure Bent or damaged drive shaft
Debris on Magnetic Plug	Contamination entry (dirt/debris) Extended oil change period Wrong oil used Worn gears/bearings
Leaks	Worn/damaged seals (pinion/differential) Worn bearings
Overheating	Wrong oil used Low fluid level Worn or damaged seals

Repair Options

Selecting the right repair option is a way to lower owning and operating costs.

Differential Repair Options:

- Reseal—required when oil leaks are discovered during inspections
- Rebearing and reseal—signaled by excessive leaks, elevated S•O•S fluid analysis results or target hours
- Before-failure overhaul—involves rebuilding the entire differential

Before-Failure Repairs

Repairing before failure gets your machine back to work sooner and costs two to three times less than after-failure repairs.

Before-failure repair options:

- Help prevent major failures and failure of related parts
- Maximize parts reusability designed into many differential parts
- Allow you to schedule downtime and plan costs
- Maximize equipment life and productivity

After-Failure Overhaul

This is recommended when large pieces of metal are discovered during magnetic plug inspections, when failure occurs or when broken parts are discovered during before-failure procedures. It includes removal and replacement of the entire differential and axle group.

Based on your repair capabilities to perform certain repairs, there is always Cat dealer service to support you.



Expect more from the experts

Maximize the life of your differentials

Regular preventive maintenance is vital to keep your differential operating at peak performance. If you take care of your differential, gears and shafts can last through multiple rebuilds and the overall differential life increases. Take a proactive approach by planning for scheduled downtime, maintenance, and repair costs

Your Cat dealer is ready to help—with parts and service solutions, or just some advice along the way. We're built to put you in control.

Call your Cat dealer with questions about system operation, maintenance, or service.

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