Final Drive Maintenance

Management Guide

Caterpillar. The difference counts.™

Final drives play a crucial role within a machine's drive train by transferring power to the tires or tracks while providing speed reduction and torque increase. Since final drives are closed components and thus hidden from view, it is easy to overlook their maintenance. However, effective system management leads to fewer failures, less downtime and better machine resale value. This guide discusses preventive maintenance, repair management, and highlights the main components that wear and fail in the final drive systems. By understanding these topics, you could minimize your owning and operating costs while maximizing your productivity.

CATERPILLAR®

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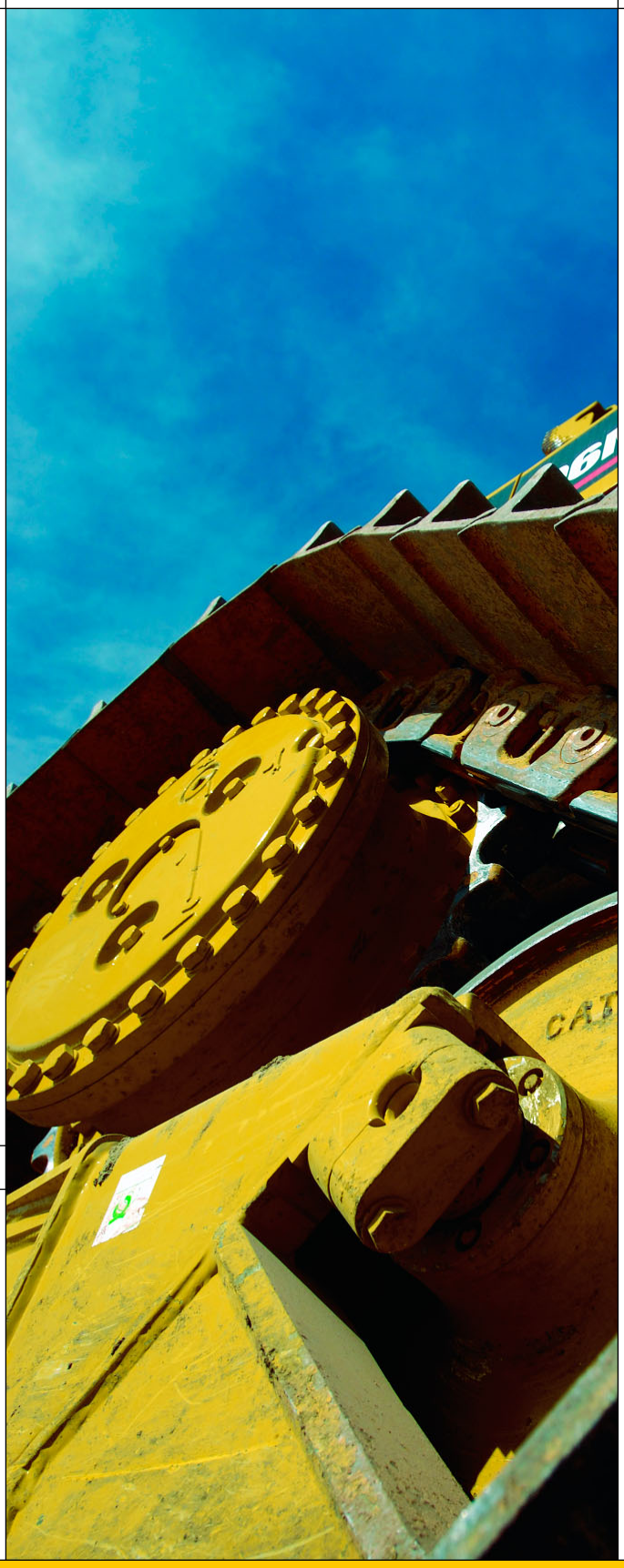


Introduction

Cat® final drive components must endure incredible torque, high-impact loads, and frequent direction and gear changes. In fact, the final drive is where the highest torque increase occurs. Caterpillar designs and manufactures its final drive components with these demands in mind, using testing processes that simulate real-world applications. In order to get the productivity and efficiency you demand, it is important to maximize the life of these components by properly managing and maintaining them.

To withstand the forces of high torque and impact loads, Cat final drive components are:

- Designed to work and wear as a system for smooth, reliable operation
- Manufactured and tested for precise fit and consistent quality
- Heat-treated for durability and long life in their specific application

Controlled manufacturing processes and use of high-quality materials enable Cat final drives to be remanufactured for a second life. Cat Reman final drives offer same-as-new performance, long life and quick turnaround, all at a fraction-of-new prices. Currently, Reman final drives are available for off-highway trucks, large wheel loaders, large wheel dozers, large compactors and specific track-type tractors.

A good drive train management program is a team effort—your regular maintenance program supplemented by our maintenance products and services. Together, we can maximize drive train and component performance, identify and react to any potential problems before they become failures, and lower your owning and operating costs.

This **Final Drive 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 using this manual to help you understand final drives and following the recommendations in your Operations and Maintenance Manual, you can maximize the productivity, service life and value of your Cat® machines.

Preventive Maintenance

The key components in final drive preventive maintenance include quality oils and filters, regular S·O·S℠ Oil 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 final drives, axles and differentials experience high gear and bearing loads and temperatures. In these conditions, it is important gears and bearings are protected. Final Drive and Axle Oil (FDAO) is the preferred lubricant for Cat final drives and axles not containing friction materials. FDAO is used where T0-4 was previously specified, but should not be used in compartments that contain friction material because this oil does not generate a sufficient friction coefficient to satisfy the requirements of most brakes and clutches.

Help your final drives reach a new level of performance with Cat FDAO:

- Compatible with Cat Transmission Drive Train Oil (TDTO)
- Excellent protection against rust and copper corrosion
- Controls 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 FDAO is a factory fill for:

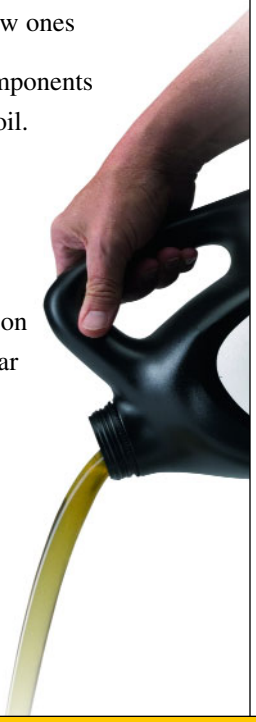
- Off-highway truck front wheels, differentials and final drives
- D6R-D11 TTT, pipelayers (572, 583, 589) and track skidder final drives (steel-tracked machines with elevated final drives, except the D5M and 561M)

Change Oil Properly

It is critical to change oil properly and at the correct intervals. Actual oil life is determined by many factors such as operating conditions, applications and contamination control. To reduce contamination, it is important to:

- Drain oil as quickly as possible, and when it is agitated and warm
- Use a filtered transfer cart when filling with or adding new oil
- Remove and install filters carefully
- Keep filters in package until ready for use
- Cut open and inspect used filters before installing new ones

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.



S·O·S℠ Services

Importance of S·O·S Oil Analysis

S·O·S Oil Analysis is a crucial part of machine management. 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 Oil Analysis program is well recognized for its ability to detect potential failures before they occur. Each S·O·S Services test is designed to reveal specific information about the condition of Caterpillar® products. The four type of analysis are below:

- **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 Services:

Surveys have shown that there are many benefits to using our S·O·S Oil 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 Services help you avoid complete failures. Often an adjustment or replacement of a single part, based on S·O·S Services findings, can prevent a small problem from growing into a major repair. S·O·S Oil Analysis is different from other oil 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 S·O·S reports, determine what additional tests need to be performed, and recommend the proper corrective action.

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 final drive 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 Oil Analysis Example: Typical Final Drive Combinations:

Primary Element	Secondary Element	Potential Wear	Probable Problem Area/Causes
Silicon (Dirt)	Iron, Aluminum, Chrome	Gears	Dry Dirt Contamination, Clay Soils
Iron	Silicon, Sodium, Aluminum, Chrome	Gears, Bearings	Contamination—Water Entry (Muddy Ground Water)

Contamination Control

Dirt, sand, grit and even the finest dust can cause problems when they find their way into the final drive system. 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.

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

2) Clean components

3) Clean facilities

4) Clean shop-repair processes

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 final drive system through the use of 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.

Change Filters Regularly

In order to keep your drive train system running clean and at peak performance, it is important to change the filters regularly. This reduces the chance of contamination, which causes component wear and system failure. We recommend changing fluid filters at least every 500 hours. This change interval will vary with application, environment and type of filter being used.

Change Filters Properly

It is important to remove old filters carefully to ensure the contaminants they hold do not reenter the drive train system. It is also critical to keep new filters in their packaging until you are ready to install them. This protects the filter and reduces the chances of contaminants entering the system, especially on the clean side of the filter media.

Select the Right Fluid Filters

The use of fluid filters in final drive systems varies by machine type. Filters can be found on the 797 and 793 off-highway trucks and machines using a common reservoir system such as backhoe loaders. For further information on selecting the correct fluid filters, consult your machine's Operation and Maintenance Manual.

Repair Management/Repair Indicators

Repair Management
Repair management helps you select before-failure and after-failure repair options that allow you to control repair costs and minimize downtime. Performing daily inspections is an important way to identify small problems before they become major failures.

Inspection
Daily walk-around inspections should include a complete visual and operational check of your machine.You should be aware of any strange noises, leaks, slippage, overheating or brake chatter. When used along side Preventive Maintenance and S·O·S Services, a good inspection program maximizes equipment value by minimizing repair costs and unscheduled downtime.

A preventive inspection plan can:
- Detect potential problems and impending failures before any additional damage occurs
- Help schedule maintenance and any needed repairs to plan for downtime and control costs

Site Operations and Maintenance Advisor
Site Operations and Maintenance Advisor (SOMA) can significantly reduce your owning and operating costs. SOMA is a software tool that can help you identify Repair Before Failure opportunity windows. It is able to provide component life estimates by assessing the machine's operating and maintenance practices. Work with your local dealer to have a SOMA study conducted.

Repair Indicators
There are two types of indicators: planned and problem. Planned indicators are those that are performed or checked routinely, such as S·O·S Oil Analysis, Technical Analysis, service meter hours, service history and SOMA software. Problem indicators are usually found during inspections and include noises, leaks, overheating and poor performance. Even with excellent maintenance, eventually final drive repairs will be needed. However, problems can be caught early by performing daily inspections and responding quickly to repair indicators.

Final Drive Repair Indicators
Below is a list of planned and problem indicators for Cat final drives, along with possible causes and repair options.

Planned Indicators	Description	Options
S·O·S Oil Analysis	S·O·S Services provide the best insight into internal final drive wear and potential failure.	Customer/Dealer Discussion
Final Drive Service Meter Hours	When visiting the customer, be sure to keep track of machine's service meter hours as a repair indicator.	S·O·S Services, Customer/Dealer Discussion
Operator Discussion	Talking regularly with the customer's machine operator can reveal many potential final drive problems.	Repair Determination Inspection

Problem Indicators	Possible Causes	Options
Brake Slippage	Worn plates and discs	Technical Analysis Inspection
	Wrong oil used	Repair Determination Inspection
	Linkage out of adjustment	Customer/Dealer Discussion
	Incorrect pressure settings	
	Low fluid level	
Unusual Noises	Worn gears/bearings	Technical Analysis Inspection
	Dirt entry	Repair Determination Inspection
	Low fluid level	Customer/Dealer Discussion
Overheating	Wrong oil used	Technical Analysis Inspection
	Low fluid level	Repair Determination Inspection
	Worn or damaged seals	S·O·S Services, Customer/Dealer Discussion
Debris on Magnetic Plug	Dirt entry	S·O·S Services
	Wrong oil used	Customer/Dealer Discussion
	Extended oil change period	
	Disc disintegration	
	Worn gears or bearings	
Vibration	Gear failure	Technical Analysis Inspection
	Sprocket failure	Repair Determination Inspection
	Bearing failure	S·O·S Services, Customer/Dealer Discussion
Leaks	Worn, hard or cracked seals	Repair Determination Inspection, Customer/Dealer Discussion

Repair Options

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

Before-Failure Repairs

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

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

Final drive repair options:

- Reseal—required when oil leaks are discovered during inspections
- Rebearing and reseal—signaled by excessive leaks, elevated S·O·S results or target hours
- Upper pinion rebearing and reseal (Low-sprocket TTT)—recommended when an S·O·S report shows elevated results of iron and lead
- Steering clutch and brake reconditioning—addresses worn friction materials to ensure proper steering and brake performance
- Before-failure overhaul—involves rebuilding the entire final drive

After-Failure Repairs

Repairing before failure is the best way to reduce your downtime and costs. However, if your final drive system does fail, we are in the best position to help you control costs and save time. Part replacement costs are kept to a minimum, using Cat Parts Reusability Guidelines and replacing only damaged components. Possible options include using Exchange or Cat Reman components. Cat Reman components are available from inventory, offer same-as-new performance, and carry the same warranty as new components at a lower cost.

After-failure overhaul 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 axle group and a complete rebuild of final drives, the differential and brakes.

A Look at the Key Components

Understanding how final drives work and wear is key to maximizing component life. Final drive 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
- Shafts

Level III—longest life, designed not to be replaced

- Housings, hubs and carriers

In order to correctly identify failure modes for final drives, 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.

Bearings

How Bearings Work

Bearings are used in the drive train system 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. Below are two examples of application-specific bearings:

Textured Anti-Friction Bearings for use in slow-speed, high-load applications

Debris-Resistant Anti-Friction Bearings in high-load, tight-tolerance applications provide twice the life of standard bearings

Causes of Premature 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

Gears

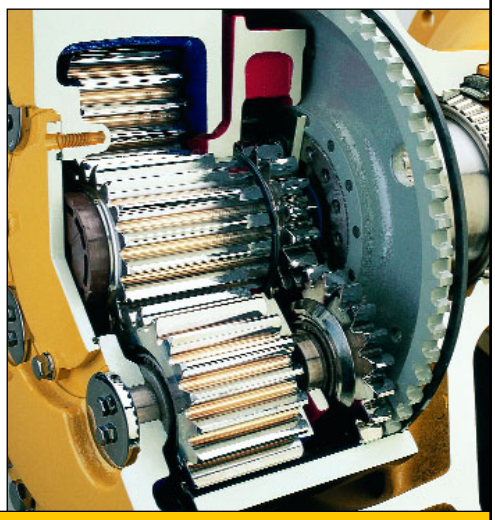
How Gears Work

The basic function of gears in the final drive system is to provide speed reduction and increase torque. Loads are transferred through gears by gear teeth pushing against each other. Gears used in the final drives 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 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



Duo-Cone™ Seals

How Duo-Cone™ Seals Work

Duo-Cone Seals are metal-faced seals used to provide oil sealing in extreme or abrasive rotating applications involving high speed and load. They use two large flexible toric rings to apply force to the opposing metal sealing rings to hold them together. These seals carry the important function of keeping contaminants, dirt and debris out of the drive train and oil in.

Causes of Premature Duo-Cone Seal Wear

There are four primary causes of premature seal wear:

- Improper installation—Caused by uneven or excess seal face load or handling damage
- Polishing housing surfaces—Allows toric rings to slide rather than roll, resulting in inadequate loading of the metal sealing faces
- Contaminated lube oil—Abrasive particles accelerate wear of metal seal rings
- Toric ring compression set from overheating—Overheating lube oil causes the toric ring to lose its ability to apply the correct load to the seal faces

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, such as Cat FDAO. 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.

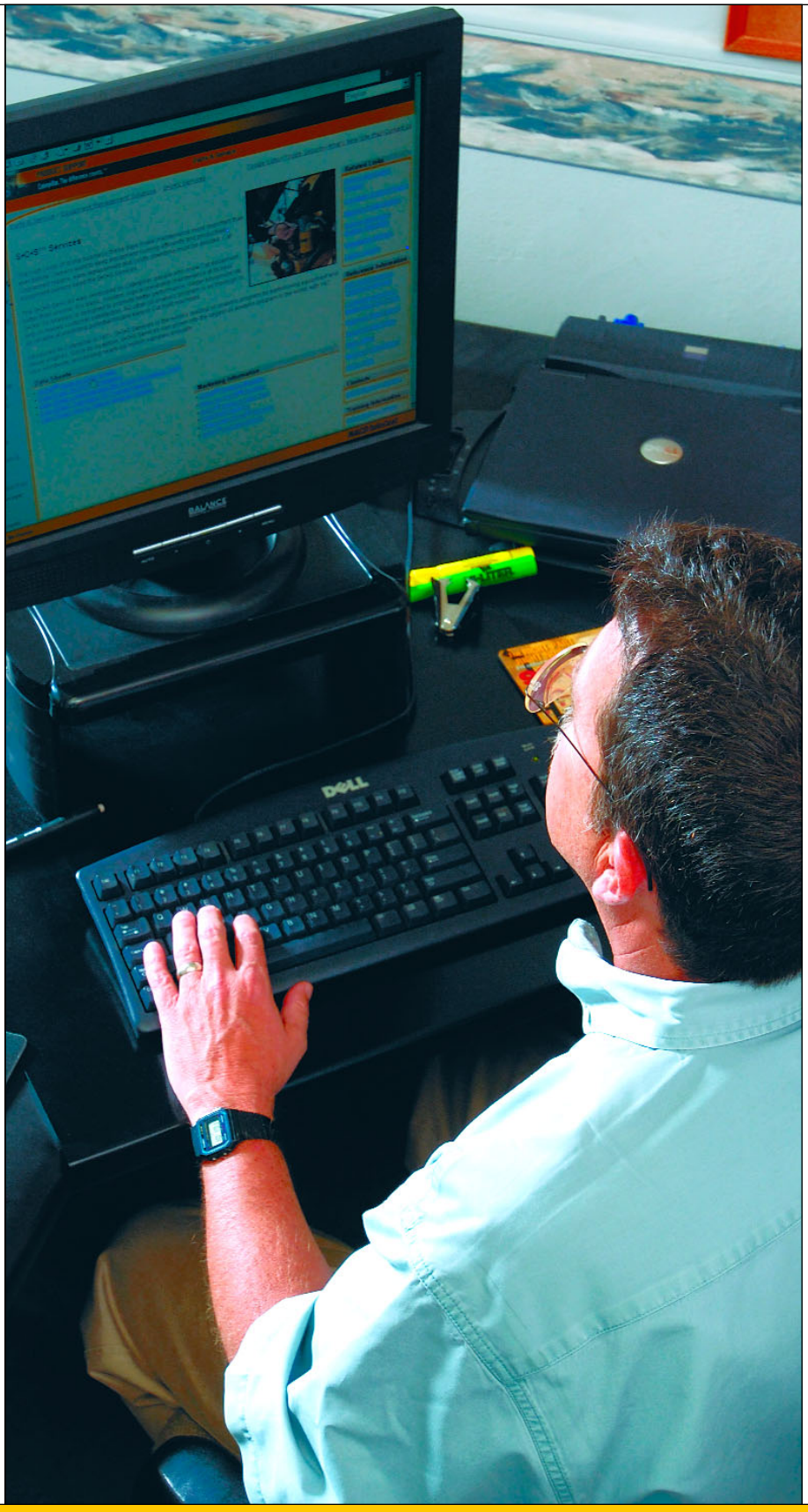
Avoid Overload and Fatigue

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

Replace Parts Before Failure

Final drive 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.

Scheduling and Record-keeping



Scheduling

Good scheduling means maintenance, inspections and planned repairs are done on time to prevent drive train failures caused by overlooked maintenance. You can also view S·O·S Oil Analysis results on-line by using Dealer StoreFront.

Record-keeping

By developing an accurate machine record-keeping system, you can identify high-cost or problem areas, track work flow, control costs and increase machine resale value. An accurate record-keeping system documents drive train history by detailing component life and cost information. We can help you set up manual record-keeping and work order systems, or we can help you install computer software programs to perform scheduling, checklists and other record-keeping functions.

Expect More from the Experts

Maximize the Life of Your Final Drives

For any machine to be safe, reliable and productive, regular preventive maintenance is vital. It is the most cost-effective way to keep your final drives operating at peak performance. If you take care of your final drives, then gears and shafts can last through multiple rebuilds and the overall final drive life increases. Take a proactive approach by planning for scheduled downtime, maintenance and repair costs. When you plan, you save money and time—and who couldn't use more of each?

For more information, see us today or visit our Web site at www.cat.com

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Cat® Dealers define world-class product support. We offer you the right parts and service solutions, when and where you need them.

The Cat Dealer network of highly trained experts keeps your entire fleet up and running to maximize your equipment investment.

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