

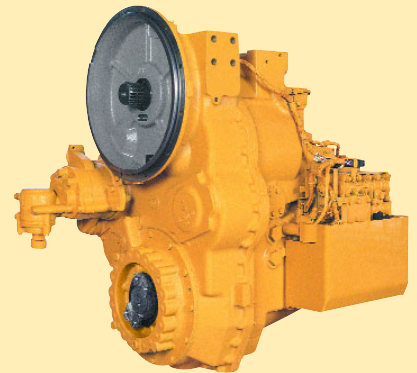
Transmission Maintenance

Management Guide

Caterpillar. The difference counts.™



The transmission is a critical part of a machine's power train. Its function is to take the output from the engine and manipulate it to control speed, direction and torque. Following a planned maintenance program and Caterpillar's recommended maintenance guidelines can help ensure longer life for your transmission and reduce machine downtime.

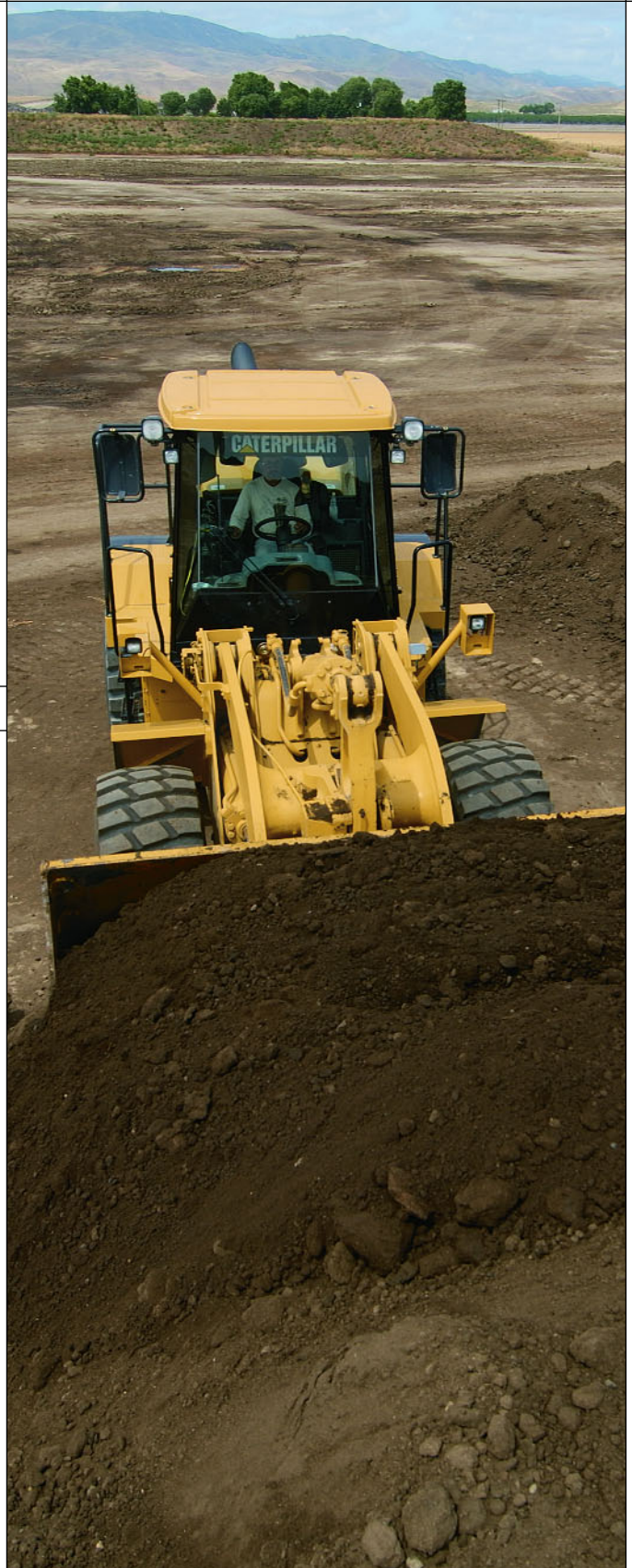


- Importance of S·O·SSM Fluid Analysis
- Planned Maintenance
- Thorough Inspections
- Transmission DOs & DON'Ts
- Training, scheduling and record-keeping
- FAQs

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Introduction

Because of the wide variety of work they do, Caterpillar products use several types of transmissions, including planetary powershift, countershaft powershift, direct drive and hydrostatic. Each is designed to convert engine power into the exact combination of speed, direction and torque required for the particular application. Transmissions do this by various means such as hydraulic clutches or a hydrostatic/hydraulic drive.

Transmissions rely on the engagement of gear groups to provide the transfer of power to your machine components.

Caterpillar designs all parts, including these gear groups, to fall under three levels of wear. By understanding that different components are intended to wear faster than others, you can inspect for signs of wear and keep your transmission running smoother and longer.

For example, gears and shafts, if properly maintained, are designed to last through multiple transmission rebuilds. But components such as friction material, seals, gaskets and bearings are faster wearing. Monitor them for abnormal wear and replace when needed.

To increase productivity and prevent downtime, it's vital to make sure that all drive train components are constantly monitored. Look at their condition to ensure contamination isn't entering their systems and to check that correct operating techniques are being used. This brochure focuses on how to identify problem indicators and how to maximize the performance and life of your transmission.



This **Transmission 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 transmissions and following the recommendations in your Operations and Maintenance Manual, you can maximize productivity, service life and value of your Cat machines.

Importance of S-O-SSM

In recent years it has become apparent that the oil used to achieve maximum engine life would not perform satisfactorily in transmissions. Consequently, Caterpillar developed specifications for transmission oil just as the Company has done with the engine oil for many decades.

Caterpillar designs the transmission oil to maximize the performance and life of Caterpillar products. Since only Caterpillar engineers know exactly what metallurgical specifications were designed into each part and component, it was natural that they developed an oil analysis program to maximize the performance and

life of Caterpillar products. When selecting lab instruments and tests for the Scheduled Oil Sampling (S-O-S) Services, Caterpillar engineers begin by asking what information from used oil samples would best identify the transmission's condition.

Surveys constantly show major benefits for users who regularly use S-O-S Oil Analysis. A 10:1 payback is a common payback ratio when comparing the amount saved on repair costs to the amount invested in S-O-S Services. This figure is probably conservative when you consider reduced downtime, greater productivity and increased used-machine value.

The S-O-S Services testing is quick and easy to do. Sample test analysis is done in your Cat Dealer's laboratory by trained technicians utilizing the most modern technology. These experts know what's happening inside the transmission and how it relates to sample findings. They draw on a large database of information and wear tables developed through years of testing and evaluations. The following wear table outlines transmission failures and their common indicators using the S-O-S Fluid Analysis.

S-O-S Transmission Fluid Analysis

Friction Material

- ✓ Si, Cu, Pb (friction materials)
- ✓ Fe (separator plates)
- ✓ ISO Code (larger particles)
- ✓ Oxidations (caused by overheating the oil)
- ✓ Incorrect fluid (difficult to identify)

Sticking Control Valves

- ✓ ISO Code (larger particles)
- ✓ Fe (debris)
- ✓ Oxidation (caused by overheating the oil)

Bearing or Bushing Failure

- ✓ Cu, Pb and/or Sn (bronze bushing or thrust washer)
- ✓ Cr (rolling element bearing)
- ✓ Fe (rolling element bearing, shaft, iron housing)
- ✓ ISO Code (larger particles)

Dirt Entry

- ✓ Si & Al (dirt)
- ✓ Fe (separator plates, gears)
- ✓ Cu, Pb, Sn (bronze bushings or thrust washers)

Importance of S-O-S

What do these indicators mean?

If excessive amounts of silicate (Si) and aluminum (Al) are found in the transmission fluid, it means the oil is contaminated with dirt. The S-O-S experts might recommend you change your oil right away and to change it more frequently in the future. High levels of copper (Cu), iron (Fe) and lead (Pb) would indicate abnormal wear of the bronze friction discs and steel separator plates. Recommendations would include stopping the machine and inspecting the transmission. Also, you would be advised to cut open and inspect the oil filter for large particles.

What tests are done by S-O-S Services?

- The S-O-S Oil Analysis consists of four standard analysis tests:

- Component Wear Rate—What components are wearing and at what rate?
- Oil Contamination—What contaminants are showing up in the oil?
- Oil Condition—Is the correct transmission oil being used? Has the oil been exposed to excessive heat?
- Oil Identification—Is there coolant or water leaking into the oil? Is the right oil being used?

What are the advantages of using S-O-S Services?

Surveys constantly show major benefits for regular users of S-O-S Services:

- Experts can provide analysis and interpretation of trends and can forecast any wear problems.

- S-O-S Services test results are available within 24 hours after receipt of the sample.
- Evaluation is supplied in an easy-to-understand test report, which calls for specific action and/or makes carefully outlined recommendations.
- Reports can identify problem areas such as careless maintenance or an operator who rides the brakes too much.
- Using S-O-S Services saves time and money because potential trouble spots can be identified before they become major problems.

Consult your Cat Dealer for complete information and assistance on the S-O-S Oil Analysis program.



Preventive Maintenance

Regular preventive maintenance is the most cost-effective way to keep your transmission operating at peak performance. Preventive maintenance focuses on transmission and drive train oils, filters, S-O-S and contamination control. Preventive maintenance:

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

By following a preventive maintenance plan, we have seen an increase in transmission life from 9,000 hours to 15,000 hours!

Proper Oil Use

Oil helps to perform three main functions: cleaning, cooling and lubricating the transmission. Today's transmissions feature new metals, elastomers and paper disc materials that require advanced lubrication. You must use the right oil and change it regularly and properly to achieve top performance.

Use the Right Drive Train Oil

Caterpillar Transmission/Drive Train Oil (TDTO) 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 and increases friction material life up to 45 percent. Cat TDTO surpasses the TO-4 specification requirements and is specified as factory fill for all Caterpillar machine compartments where TO-4 oils are the primary recommendation.

Caterpillar also offers a new multi-season formulation of TDTO called TDTO (TMS). 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. TDTO (TMS) is recommended in climates with widely ranging ambient temperatures to avoid unnecessary oil changes.

Change Oil Properly

Changing oil properly and at correct intervals is critical to realizing maximum component life. Actual oil life is determined by many factors such as operating conditions and applications or contamination control. You can reduce contamination by:

- Washing the transmission tank and drain before removing cap.
- Draining oil as quickly as possible and doing so when it is agitated and warm.
- Using a filtered transfer cart to add new oil.
- Installing and removing filters carefully.
- Keeping filters in package until ready for use.
- Cutting open and inspecting used filters before installing new ones.



Preventive Maintenance

Filters

Caterpillar filters are specifically designed around key factors such as sediment capacity, collapsibility, burst strength and pressure fatigue. By properly and regularly changing filters and by selecting the right filters, you maintain drive train system cleanliness, reduce component wear and lower costs.

In addition to the standard Cat filters, Caterpillar also provides High Efficiency Filters. They use a synthetic media to remove a higher proportion of both large and small particles. High Efficiency Filters should be used for 250 service hours after any maintenance, rebuild or debris invasion, or when suggested by particle count data from S-O-S Services. It's then recommended to switch back to standard filters.

When replacing an old transmission filter it's extremely important to cut open the filter and inspect for signs of component wear or clogging. Pieces of metal may be found in or around the magnetic screen and can indicate a certain component is failing.

Possible Sources of Metal Pieces:

- Aluminum—torque converter
- Bronze colored—transmission clutches



Gray iron—transmission housing or pistons

Brass—rings in rotating clutches

Shiny metals—gear teeth

Shiny flaky material—bearings

Breathers

Breathers are extremely important in transmission preventive maintenance. If breathers become plugged and temperatures dip down during the evening, the cab becomes a vacuum because the cool air inside the cab shrinks. As the air inside the cab shrinks it draws in air, dirt and other contaminants through the gaskets and seals. If this occurs regularly,

the gaskets and seals may sustain enough damage to allow water and other contaminants into the cab. Dirt and water are especially harmful to the electronics. Solenoids in your electronics control when and how quickly your clutches engage. When the solenoids become contaminated they become sluggish and your clutches may engage too quickly or they may slide.

To get the most use out of this filter, cover the breather before washing your equipment and check your breather for clogging when inspecting other machine components.

Preventive Maintenance

Contamination Control

Customers demand more power, faster cycle times and easier operation. To meet these needs, Caterpillar is responding with higher system pressure and more sophisticated, productive machines.

Controlling contamination is more critical than ever because these high-tech machines require tighter clearances and fluid systems that are more sensitive to contamination. Contamination leads to reduced efficiency, increased cycle times, shortened component and fluid life, and catastrophic failure causing costly downtime and repairs.

In a 55-gallon drum of oil, how much "dirt" is allowed before quality standards are exceeded?

- 1/2 teaspoon

Causes of Contamination

Contamination can be introduced at the refinery, during machine operation or during maintenance. Contaminates include:

- Dirt
- Sealing material
- Metals
- Grease
- Products from oil oxidation
- Weld spatter

- Heat
- Air
- Paint flakes
- Water
- Rag fibers

Effects of Contamination in Transmissions

Contaminants in transmissions cause:

- Shifting problems from plugged control valves.
- Premature clutch wear from spinning.
- Leaks or premature wear.
- Premature bearing wear or bearing failure.
- Premature gear wear.

Preventing Contamination

Prevent contamination by practicing good housekeeping in the shop, using proper oil storage and transfer methods, keeping parts packaged during handling and storage, cleaning components thoroughly during repair and assembly and performing particle count monitoring.

Good Housekeeping Practices:

- Sweep floors daily.
- Clean up spills immediately.

- Keep workbenches uncluttered and free of debris.
- Limit use of floor storage.

Proper Oil Storage and Transfer Methods:

- Filter new oil.
- Store oil drums on their sides.
- Use drum covers.
- Use "kidney loop" system.
- Use high efficiency filters for extra filtration.

Repair and Assembly:

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

Particle Count Monitoring:

- Strive for oil cleanliness.
- Test oil in new machines after field assembly or after adding new attachments.
- Test oil before and after service repairs.

Thorough Inspection

A good inspection program combines your daily inspections with our periodic in-depth analysis. By combining both, you can:

- Locate potential problems before they become major repairs.
- Schedule transmission maintenance and service.
- Plan and control your operating costs and downtime.

Your daily visual inspection routine should include a complete visual and operational check of your transmission. The following chart summarizes planned and problem indicators that are associated with the transmission.

Cat Transmission Repair Indicators

Planned Indicators	Description	Problem Indicators	Possible Causes	Options
S-O-S Services	S-O-S Services provide the best insight into internal transmission wear and potential failure.	Hesitation/Slippage	Worn plates and disks Linkage out of adjustment Low fluid level Linkage not free Incorrect pressure settings Wrong oil used	Technical Analysis Inspection Repair Determination Inspection S-O-S Services Customer/Dealer Discussion
Service Meter Hours	Our dealers use service meter hours as a repair indicator.	Unusual Noises	Worn gears/bearings Dirt entry Aeration/cavitation Low fluid levels	Technical Analysis Inspection Repair Determination Inspection S-O-S Services Customer/Dealer Discussion
Operator Discussion	Talking with your machine operator can reveal many potential transmission problems.	Vibration	Bent shaft drive Gear failure Bearing failure	Technical Analysis Inspection Repair Determination Inspection S-O-S Services Customer/Dealer Discussion
		Overheating	Wrong oil used Plugged radiator Worn pump/pressure relief valve Worn or damaged seals Low fluid level Worn or dirty control valve	Technical Analysis Inspection Repair Determination Inspection S-O-S Services Customer/Dealer Discussion
		Debris in Filter/ on Magnetic Screen	Dirt entry Wrong oil used Extended oil change period Worn gears/bearings Disc disintegration	S-O-S Services Customer/Dealer Discussion
		Leaks	Worn, hard or cracked seals	Repair Determination Inspection Customer/Dealer Discussion
		Bent or Damaged Lines	External damage	Technical Analysis Inspection Repair Determination Inspection Customer/Dealer Discussion

Transmission Maintenance DOs & DON'Ts

DOs

1. Make sure the fluid meets ISO standards before pouring it in your machine.
2. Use the correct transmission oil—Caterpillar recommended fluids found in the Operation & Maintenance Manual.
3. Use Caterpillar filters—Caterpillar recommended filters found in the Operation & Maintenance Manual.
4. Cut open old filters to inspect for indications of a problem.
5. Keep accurate records.
6. Follow the proper service hours guidelines.

DON'Ts

1. Do not open your transmission system in a dirty environment.
2. Always keep in mind proper Contamination Control guidelines.
3. Do not abuse your machine (application, operation, etc.).
4. Do not pre-fill filters (fuel or oil).

Training, Scheduling and Record-keeping

Training

Operating technique has a direct impact on drive train wear and maximizing machine life. Proper training is important to identify good and bad operator techniques.

Avoid:

- High-speed direction changes.
- Backing over stumps or off a lowboy.
- Operating with a frozen undercarriage.
- Extreme braking.

Implement:

- Adequate warm-up.
- Periodic and proper shifting.
- Attention to warning signs.
- Daily walk-around inspections.

Drive train life is also impacted by the applications in which a machine operates throughout the year. Key factors include the operating environment and the layout of the jobsite.

Operating Environment:

- Seasonal temperatures often affect fluid choices, change intervals, inspection and operating practices.
- Operating in water increases the chance of water entering and contaminating the

transmission fluid system and may cause a loss of braking ability.

Jobsite Layout:

- Well-paved and maintained haul roads reduce the jarring impact on the drive train and other machine systems.
- Repetitive and high-speed load and carry applications can cause brake overheating.

Scheduling

We can help you develop an effective scheduling system by providing you with time and cost record booklets or software programs.

Use Maintenance Control System (MCS) software to schedule your maintenance and record machine operating costs and time usage. This software allows you to download S-O-S reports from Trend Analysis Module (TAM) software. You can also bring customized checklists from the Planned Maintenance Planner (PMP) software into MCS. Print them when each level of maintenance is due.

Good scheduling means maintenance, inspections and planned repairs are done on time so you can prevent any transmission failures caused by overlooked maintenance.



Record-keeping

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 such as the Preventive Maintenance Planner (PMP) or the Maintenance Control System (MCS). These programs perform scheduling, checklists and other record-keeping functions.

By developing an accurate machine record-keeping system, you can identify high-cost or problem areas, track work flow, control costs and increase machine sale value.

Frequently Asked Questions

What are some of the subtle signs that you may have transmission problems?

Overheating, slippage or jerky shifting can signify a problem with a transmission component. If this occurs, take your machine into your local dealer to have a thorough inspection and S·O·S sampling done on the machine.

What are some of the primary causes of transmission failure and/or reduced power output or performance?

Low oil pressure can cause clutch slippage. Check your transmission filter and oil levels in the transmission. They may need replaced.

Incorrect pressure may cause transmission failure or reduced power output or performance. Transmissions are designed to run at around 200 lbs of pressure. Check all pressures to ensure correct levels.

Contamination from other failing parts can cause plugged filters. Check all parts for contamination.

Are construction company shops equipped to handle most transmission problems? Or, as with automobiles, are these maintenance and repair chores better left to dealers or specialists?

Most construction company shops are not equipped to handle transmission maintenance or repairs. Our service shops have technicians who are well trained with many years of experience in identifying and fixing a transmission failure. We also provide technicians with many resources such as reusability guidelines and continuous, up-to-date training that construction company shops do not have access to. For example, to determine the reusability of a bearing, our technicians can use reusability guidelines as well as accurate tools to help them distinguish between damaged bearings and good bearings. Construction shops may guess on the quality of the bearing because they may not have access to tools that help them identify possible damage. Finally, these construction shops do not have the cleanliness standards Cat requires in all dealer service locations. Because contamination is a common cause for component failure, a clean environment for maintenance or repairs is a must.

Are oil additives usually recommended?

Cat doesn't recommend any additives; they are already in the lubricant.

What have been the major technological changes to transmission design in recent years and how have these affected the maintenance and upkeep of transmissions?

As the expectations of life and durability of machines increase, Caterpillar engineers have responded by making many mechanical and electrical changes that allow increased productivity and longer life of your product. However, these changes require smaller tolerances and increases in pressure in your machine that make maintenance and the upkeep of your transmission essential. Because these mechanical and electrical changes are advanced, they often require unique testing and repair that only your local Caterpillar Dealer can provide accurately.

When a company with a diverse fleet uses just one or two lubricating oils, what is the effect?

Using the incorrect lubricating oil can cause incorrect pressure, faster wear or slippage.

Are shared oil reserves with implement cylinders (vane or gear pumps) a problem?

Shared oil reserves can cause cross contamination. Newer machines are being designed without them.

Do different types of equipment wear out transmissions at different times? For example, how does a transmission wear in load-and-carry operations vs. stay-at-home operations?

Transmissions do wear out at different intervals due to the applications they are in. If you are constantly shifting from gear to gear or from forward to reverse, your clutches and gears may wear out faster.

Can cutting open a filter help you diagnose a problem?

Yes. Cutting open a filter is very important to determine the root cause of a problem. By finding pieces of metal in the filter, you can determine what is failing. Refer to the filter section of planned maintenance.

What happens to the transmission when fluid becomes too hot?

The transmission oil additives deteriorate and lose their ability to control wear. Oil samples results will show high oxidation and an increase in viscosity.

Expect More from the Experts



Maximize the Life of Your Transmission

For any machine to be safe, reliable and productive, regular preventive maintenance is vital. It is the most cost-effective way to keep your transmission operating at peak performance. If you take care of your transmission, then gears and shafts can last through multiple rebuilds and the overall transmission 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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Caterpillar. The difference counts.™

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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